AREVA

Kiggavik Project

Environmental Impact Statement

Tier 3 Technical Appendix 4B

Air Dispersion Assessment

December 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

1 INTRODUCTION

1.1 BACKGROUND

Operated by AREVA Resources Canada Inc. (AREVA), the Kiggavik Project (Project) is a proposed uranium ore mining and milling operation located in the Kivalliq region of Nunavut, approximately 80 km west of the community of Baker Lake.

The Kiggavik Project will mine three shallow ore deposits at the Kiggavik mine site (East Zone, Centre Zone and Main Zone), and one shallow (Andrew Lake) and one deep uranium ore deposit (End Grid) at the Sissons mine site. The two sites are located some 20 km apart. Open pit mining will be used to extract the Kiggavik deposits as well as the Andrew Lake deposit. In contrast, the End Grid deposit will be extracted via underground mining using overhand drift-and-fill methods. A purpose-built pit will also be constructed at the Kiggavik site to be used as a water reservoir.

All ore extracted from the two mine sites will be processed through a mill located at the Kiggavik site using a Resin-in-Pulp (RIP) process. Mined out pits at Kiggavik will be used as tailings management facilities (TMFs) with East Zone being the initial TMF. The uranium product (yellowcake) will then be packaged and transported via aircraft to refining facilities. Mill reagents, fuel and other supplies will be transported by barge to Baker Lake and then by truck to the mine development area over a preferred winter access road. An all-season access road between Baker Lake and the Kiggavik Site is a secondary option under consideration as outlined in the Project Description (Volume 2).

Final closure of the Project will include demolition of the site infrastructure and clean up and reclamation of any contaminated areas. Type III mine rock will be backfilled into the Main Zone TMF at Kiggavik and into Andrew Lake open pit at Sissons. Closure of the TMFs will consist of consolidating the tailings and covering them with layer(s) of mine rock and overburden; the final cover will be contoured to blend in with the existing topography. Finally, Type II mine rock stockpiles will be stabilized. For example, they could be covered and re-graded to promote vegetative growth and to blend in with the existing topography.

The Kiggavik Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement (NLCA) (NIRB 2011). The Minister of Indian and Northern Affairs Canada (the Minister) referred the Kiggavik Project to the Nunavut Impact Review Board (NIRB) for a Review under Part 5 of Article 12 of the NLCA in March of 2010. Pursuant to Section 12.5.2 of the Nunavut Land Claims Agreement (NLCA):

> *"When a project proposal has been referred to NIRB by the Minister for review, NIRB shall, upon soliciting any advice it considers appropriate, issue guidelines to the Proponent for the preparation of an impact statement. It is the responsibility*

of the Proponent to prepare an impact statement in accordance with any guidelines issued by NIRB..." (NIRB 2011)

The final NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.'s Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) were issued in May of 2011, which form the basis of this air dispersion assessment.

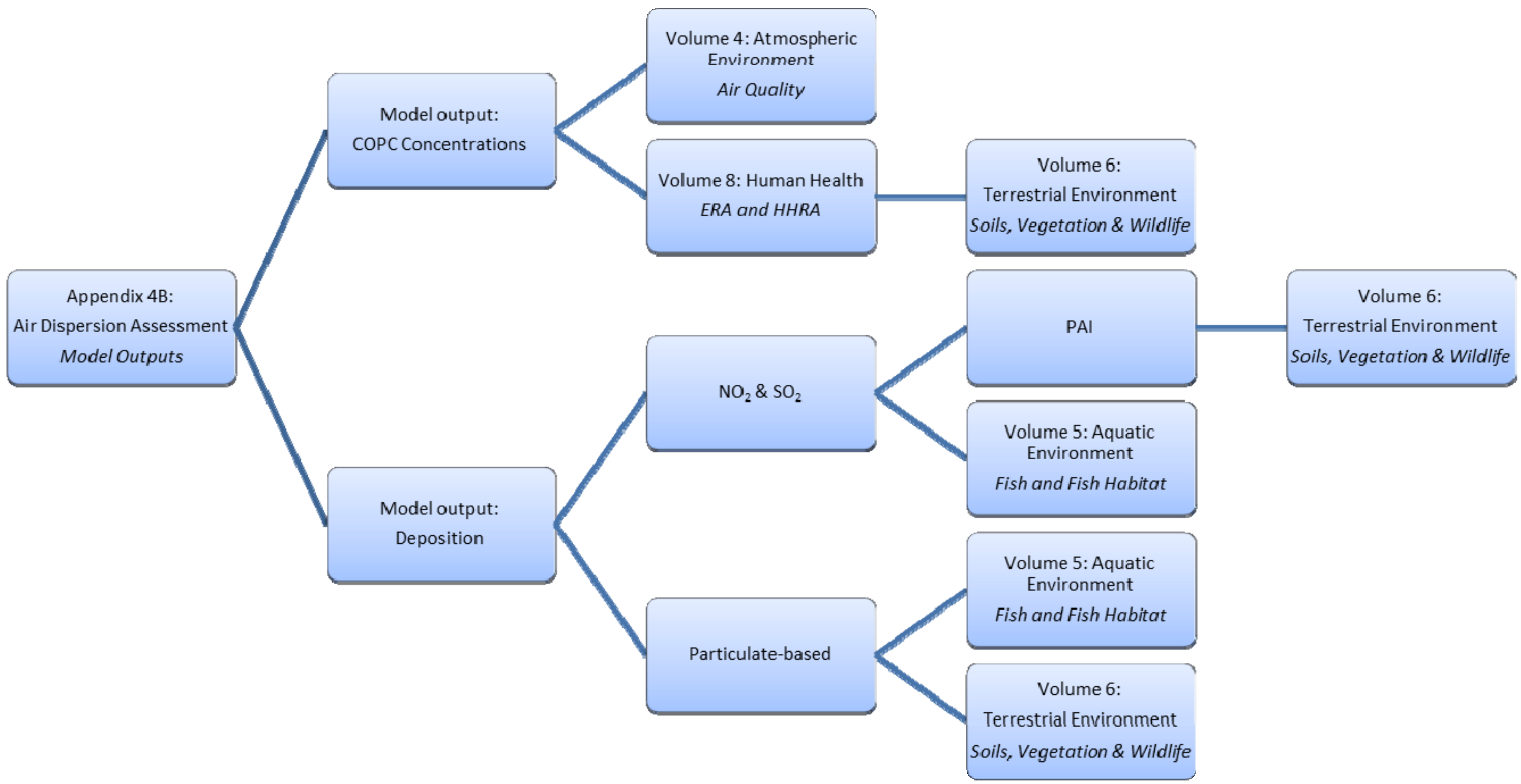
1.2 PURPOSE AND OBJECTIVES

Various activities associated with the Project, in particular it's two mine sites, Kiggavik and Sissons, have the potential to generate emissions of airborne dust (consisting of associated radioactive and non-radioactive constituents), radionuclides (e.g., radon-222), as well gaseous compounds (e.g., NO_x, SO_2) and greenhouse gases (GHGs). The purpose of this report is to characterize the emissions sources, outline the approach used for atmospheric dispersion modelling, and evaluate the predicted incremental air concentrations resulting from the Project's proposed activities using applicable ambient air quality criteria, standards, objectives or guidelines. The objectives of the air dispersion assessment are:

1. To discuss background or baseline air quality conditions within the Local and Regional Assessment Areas (LAA and RAA) where relevant data exists;
2. To identify the principal sources of radiological and non-radiological emissions of Constituents of Potential Concern (COPCs) and complete an emissions inventory for both radiological and non-radiological compounds for the various stages of the Project including the construction, operation, final closure and post-closure. To facilitate the assessment of the atmospheric emissions, a theoretical maximum emissions bounding scenario was also developed;
3. To evaluate the various emissions sources using appropriate air dispersion modelling within the LAA and RAA;
4. To predict effects of the Project to air quality within the LAA and RAA during the various Project stages for selected radiological and non-radiological COPCs;
5. To evaluate the effects of acidic deposition resulting from the Project using accepted air dispersion modelling; and,
6. To develop a Greenhouse Gas (GHG) emission inventory and assess the Project's contribution to Nunavut and Canada GHG emissions.

Selected results of the air dispersion assessment were subsequently used to assess the potential effects to air quality (Volume 4, Part A), the aquatic environment (Volume 5) and the terrestrial environment (Volume 6), and were also used to complete the ecological and human health risk assessments (Volume 8). A graphical representation of how the air dispersion modelling outputs were used is as follows:

Road Map to Air Dispersion Modelling Results



1.3 OVERVIEW OF THE REPORT

1.3.1 General Structure

In addition to this introductory chapter, the air dispersion assessment report includes 6 other chapters as outlined in the table below. Chapter 2 provides an overview of scope of the assessment and Chapter 3 provides baseline information including background air quality. Chapter 4 discusses the air emissions inventory and Chapter 5 describes the air dispersion modelling approach. Modelling results are presented and discussed in Chapter 6 and key conclusions of the air quality assessment are outlined in Chapter 7.

2 SCOPE OF THE ASSESSMENT

2.1 ASSESSMENT BASIS

The following sections outline the assessment basis including descriptions of the assessment scenarios included and the spatial and temporal boundaries considered.

2.1.1 Assessment Approach

For each of the scenarios outlined in below, the following general assessment approach was applied:

- identify emissions sources and develop an emissions inventory for constituents of potential concern (COPCs) and Greenhouse Gases (GHGs);
- evaluate the need for air dispersion modelling versus an emissions burden assessment, which is an accounting of the total emissions of key COPCs; and
- where appropriate, complete CALPUFF air dispersion modelling using the developed emission inventories and assess the potential effects to air quality using Nunavut/NWT and federal guidelines where available or reference guidelines established by other jurisdictions.

2.1.2 Assessment Scenarios

Various phases of development were assessed over the lifetime of the Project including construction, operation (i.e., mining and milling), final closure and post-closure. In addition, a theoretical maximum operation scenario was developed and assessed. This maximum scenario was used to ensure that the estimated atmospheric emissions are adequately conservative so as to allow flexibility in the event that modifications are made to the proposed mining and milling schedule. If changes to production result in higher emissions than those assessed in each of the phased operation scenarios outlined below, the maximum operation scenario will capture the increase in emissions. An overview of each of the scenarios assessed is provided below.

2.1.2.1 Construction

Project-related effects from construction activities were considered in the assessment. This scenario includes construction of buildings and other ancillary facilities (e.g., the mill, accommodation complex, power plant, Baker Lake dock facility, etc.) and mine site preparation (e.g., land clearing, earth movement, etc.). As well, it considers the construction of the access roads, including the possible extraction of bedrock material from short-term quarries specifically developed to supply the necessary road base. Further details are provided in Section 4.2.1.

2.1.2.2 Phased Operation Scenarios

Project-related effects were considered for operation scenarios that are representative of planned mining and milling activities over the lifetime of the Project. In air dispersion modelling, it is generally not practical to model every year of scheduled production due to the excessive amount of computational time involved in carrying out the model runs and in processing the output data. Hence, it is common practice to select certain years for modelling purposes that are considered to be representative of mining and milling activities over consecutive periods spanning the operating life of the Project. The years chosen for modelling are generally selected on the basis that they are expected to yield the highest amount of emissions during each of the chosen periods. The specific scenarios and the operational time periods that they represent are discussed further below.

Long-term air quality effects were assessed for four (4) production scenarios associated with the scheduled activities of the Project over its lifetime. These scenarios assess the development of the three open pit mines (East Zone, Centre Zone and Main Zone) at the Kiggavik site and both the Andrew Lake open pit mine and End Grid underground mine at the Sissons site. Production schedules for mining and milling (Table 2-1) were both considered in deriving the modelling scenarios to consider a range of operating conditions. The table highlights the years selected for modelling along with anticipated production levels. A more detailed description of each of the modelled scenarios are as follows:

- **Scenario 1:** (Year 0 and 1), modelled for Year 0 and 1 combined, this scenario includes development of Purpose Built and open pit mining of East Zone, Centre Zone and Main Zone East pits. Ore removed from East Zone and Centre Zone is stockpiled until milling begins the following year.

- **Scenario 2:** (Year 2-5), modelled for Year 4 (Main Zone) and Year 5 (all other activities), includes open pit mining of Main Zone West pit at Kiggavik and Andrew Lake at Sissons as well as the milling of ores from East Zone, Centre Zone and Main Zone pits. In this scenario, East Zone and Centre Zone are no longer being mined, and become tailings management facilities. Around year 4, the Main Zone East pit is also converted to a TMF and was considered as such.

  Year 4 was selected for Main Zone West pit since mining rates are highest compared to all other years during the period. Year 5 was chosen to represent mining activities at Andrew Lake open pit and End Grid mine as well as for milling activities since production rates are highest in Year 5.

- **Scenario 3:** (Year 6-13), modelled for Year 6 (Andrew Lake) and Year 9 (all other activities), this scenario includes the mining of Andrew Lake open pit and End Grid underground mine as well as the milling of ores from Main Zone, Andrew Lake and End Grid deposits. During this scenario, Main Zone West pit is converted into the final TMF.

  Year 6 was selected to represent the Andrew Lake open pit since mining activities are highest compared to all other years during this period. Year 9 was chosen for End Grid mining activities and for milling activities since production rates are highest in Year 9.

- **Scenario 4:** (Year 14), includes only the milling of any remaining ore. All mining has ceased.

Table 2-1 Proposed Mine and Mill Production Schedule for the Kiggavik Project

Scenario Name	Year	East Zone Pit total bcm	Purpose Built Pit total bcm	Centre Zone Pit total bcm	Main Zone Pit total bcm	Andrew Lake Pit total bcm	End Grid UG Mine total bcm	Ore Stockpile Kt ore	Mill Feed Kt ore	Uranium Production t U
Operations										
1	0	0	***349,058***	0	0	0	0	0	0	0
	1	***2,685,451***	0	***6,853,468***	***2,063,761***	**0**	**0**	***844***	***69***	***317***
2	2	0	0	0	9,066,125	1,989,514	5,856	480	752	3,419
	3	0	0	0	4,923,257	6,607,111	35,153	217	668	3,502
	4	0	0	0	***8,893,611***	1,397,113	55,510	432	906	3,331
	5	0	0	0	3,794,072	***6,473,721***	***143,008***	***486***	***946***	***3,388***
3	6	0	0	0	0	***10,211,045***	165,949	8	920	3,186
	7	0	0	0	0	3,241,462	157,274	214	738	3,790
	8	0	0	0	0	2,302,182	158,540	204	842	3,724
	9	0	0	0	0	2,306,237	***163,020***	283	***823***	***3,691***
	10	0	0	0	0	2,322,251	156,250	***600***	741	3,691
	11	0	0	0	0	1,101,935	112,690	399	957	3,430
	12	0	0	0	0	469,412	20,852	81	937	3,509
4	13	0	0	0	0	0	0	0	***81***	***542***
	Total	**2,685,451**	**349,058**	**6,853,468**	**28,740,826**	**38,421,981**	**1,174,102**	**4,248**	**9,382**	**39,519**
Maximum Bounding Operations										
	Total	**0**	**0**	**0**	**9,066,125**	**10,211,045**	**165,950**	**900**	**1,042**	**4,000**
Post-operations										
Closure*	14				***222,790***	***255,316***				
	15				222,790	255,316				
Post-Closure	16									
	17									
	18									
	19									
	20									

- Notes:
- bcm = bank cubic meter; t = tonnes; *assumes all special waste placed back into Main Zone TMF and Andrew Lake at Kiggavik and Sissons, respectively over 2 years

2.1.2.3 Maximum Operation Scenario

Project-related effects were also considered for a maximum operation scenario, which is an artificial scenario which represents the maximum bounding emission rates, assuming that each Project component occurs at the same time at its maximum level of operation. This is unlikely to occur in reality, but was simulated to assess the maximum envelope of operations.

The characterization of air emissions and air dispersion modelling was completed for a theoretical production scenario representing maximum daily operating conditions. This assessment provides an upper bound estimate of air emissions from mining activities and the predicted atmospheric concentrations are used to assess the largest possible short-term (i.e., 1-hour or 24-hour) effects of site activities on local air quality. If modifications to the proposed mining and milling schedule are made, this scenario ensures that potential atmospheric emissions are adequately captured.

2.1.2.4 Final Closure

Final closure activities will begin following operations in an effort to restore the Mine Development Area back to a near undisturbed state. The first phase of closure will take approximately 2 years to complete and will involve the progressive rehabilitation of the mine site. Activities considered include backfilling Type III mine rock (special waste) at Kiggavik and Sissons mine site into Main Zone TMF and Andrew Lake open pit, respectively as well as covering Centre Zone TMF with a layer of Type II mine rock (clean waste) from the north Type II mine rock stockpile.

2.1.2.5 Post-Closure

At this stage of the project, all closure operations are assumed to have been completed and only passive emissions of radon from the permanent Type II mine rock stockpiles and covered TMFs (East Zone, Centre Zone and Main Zone TMFs) are expected to occur.

2.1.3 Spatial Boundaries

The Project footprint consists of three components: the Kiggavik and Sissons mine sites and interconnecting Kiggavik-Sissons access road (collectively referred to as the Mine Development Area), the Baker Lake dock and storage facility, and the access road between Baker Lake and the Mine Development Area. For the purpose of this assessment, the preferred alternative for the access road is the South Winter Road. However, the North All-Season Road and North Winter Road options have also been assessed as alternatives.

The Kiggavik mine site, located approximately 80 km west of the community of Baker Lake, includes three open pit mines (East Zone Pit, Center Zone Pit and Main Zone Pit), mine rock and ore stockpiles, the mill and auxiliary facilities. The Sissons mine site, located approximately 17 km southwest of the Kiggavik mine site, includes one open pit mine (Andrew Lake Pit), one underground mine (End Grid Ore Zone), mine rock and ore stockpiles, and auxiliary facilities.

The Kiggavik and Sissons mine sites are connected by a 20 km Kiggavik-Sissons access road used to transport ore from the Sissons mine site to the Kiggavik mine site for ore processing or to transport personnel to and from the Sissons mine site.

The Baker Lake dock and storage facility, located approximately 2.5 km southeast of the community of Baker Lake, will act as a transfer station between the marine and road transportation routes. The preferred option for the transportation route between the Mine Development Area and Baker Lake is the 100 km long South Winter Road. The Project footprint is illustrated in Figure 1.

2.1.3.1 Local Assessment Area

The Local Assessment Area (LAA) is defined as an area which is represented by approximately a 25 km by 25 km area centered over the project footprint of the Mine Development Area and a 5 km by 5 km area centered over the Baker Lake dock and storage facility where measureable effects from project specific activities are most likely to occur. The LAA is illustrated in Figure 2.

2.1.3.2 Regional Assessment Area

The Regional Assessment Area (RAA) extends beyond the LAA to encompass a 117 km by 65 km area that extends from Samarook Lake to just east of Whitehills Lake, and includes the Mine Development Area, the Kiggavik-Sissons access road, the access road between the Baker Lake dock and storage facility and Kiggavik, as well as the community of Baker Lake itself. This captures the full extent of potential emissions from the entire Project footprint through all development phases. The RAA is also illustrated in Figure 2.

2.1.4 Temporal Boundaries

The temporal boundaries for the air dispersion assessment have been defined based on the timing and duration of potential Project–related effects to the atmospheric environment. The assessment covers the period of all major Project phases including construction, mining and milling operations, final closure and post-closure. According to the Project Description (Volume 2), the operational life of the mine (including milling) will be approximately 14 years, while is it is expected that pre-operational construction will require 3 to 4 years, and that final closure and post-closure activities will require about 5 and 10 years, respectively. For the purposes of this assessment however, different durations from the Project Description were assumed as outlined in Table 2-2:

Table 2-2 Duration of Project Phases used in the Air Dispersion Assessment

Project Phase	Duration (Years)	
	Project Description	Air Dispersion Assessment
Construction	3 to 4	2
Operational Mining and Milling Phase	14	15
Final closure	5	2
Post-closure	10	1
Total Project Lifetime (including construction)	**up to 33**	**20**

As outlined in the table above, it was conservatively assumed that construction will occur over a 2 year period instead of 3 to 4 years. By assuming construction activities are condensed into a shorter time period, emissions will be greater than if they were calculated over a longer period of time. Using the same rationale, key closure activities (outlined in Section 2.1.2.4), were assumed to occur over a 2 year period. Although post-closure is expected to last 10 years according to the Project Description, only a single year was modelled. This is considered to be sufficient to capture the maximum effects since the same sources of emissions (i.e., radon from permanent Type II stockpiles) will be present for the duration of this Project phase. Radon emissions are expected to be the greatest in the first year of post-closure, and will progressively decrease overtime. As a result, it was only necessary to capture the first year of this final project phase.

As shown in Table 2-1, Year 0 activities will primarily include excavating the Purpose Built pit. Since these activities were included as part of Scenario 1 (2.1.2.2), it added an additional operation year to the dispersion assessment, making the mine life 15 years instead of 14.

For the purpose of this assessment, the life of the Project during which emissions to air will occur from Project-related activities is expected to be 20 years (including construction and post-closure).

2.2 CONSTITUENTS OF POTENTIAL CONCERN

Ambient air quality is described by measurable air concentrations of Constituents of Potential Concern (COPCs). For the purpose of this assessment, the following compounds have been considered COPCs:

- Total suspended particulate (TSP);
- Particulate Matter Less than 10 microns (μm) in diameter (PM_{10});
- Particulate Matter Less than 2.5 microns (μm) in diameter ($PM_{2.5}$);
- Uranium (U);
- Metal constituents in particulate, including:
  - Copper (Cu);
  - Nickel (Ni);
  - Cobalt (Co);

- Molybdenum (Mo);
    - Arsenic (As);
    - Lead (Pb);
    - Zinc (Zn);
    - Selenium (Se);
    - Cadmium (Cd);
    - Chromium (Cr);
- Nitrogen Oxides (specifically, NO_2);
- Sulphur Dioxide (SO_2);
- Radon (Rn-222);
- Lead-210 (Pb-210); and
- Polonium-210 (Po-210).

In addition to the COPCs identified above, particulate-based and gaseous compounds such as NO_2 and SO_2 can deposit on surfaces at far distances from the original source. Deposited particles have the potential to become a nuisance (i.e., dust covered surfaces) and NO_2 and SO_2 have the potential to acidify the environment. There is also the potential for deposited COPCs to be taken up by vegetation which can affect the growth of the plant and possibly lead to bioaccumulation within the food chain. As a result, dust deposition and Potential Acid Input (PAI) were included in the air dispersion assessment; however, the deposition model outputs were not used to assess potential effects to air quality (Volume 4, Part A). Instead, these were used as inputs to other environmental effects assessments including the aquatic and terrestrial environments (see Volumes 5 and 6, respectively).

2.3 AIR QUALITY CRITERIA, STANDARDS AND GUIDELINES

The quantitative criteria, standards or air quality objectives used to assess the potential effects of the Project on the atmospheric environment are described in the following sections.

2.3.1 Total Suspended Particulate (TSP)

TSP guidelines are outlined in Nunavut's Environmental Guideline for Air Quality – Sulphur Dioxide and Suspended Particulates (Government of Nunavut 2002) which has established standards respecting the maximum desirable levels of TSP and SO_2 in ambient air throughout all of the Northwest Territories and Nunavut. The TSP guideline is outlined in the Table 2-3 below.

Table 2-3 Nunavut Guidelines for Total Suspended Particulates

Pollutant	1-hour	24-hour	Annual (1)
Total Suspended Particulates	-	120 μg/m^3	60 μg/m^3

Notes:

(1) Where the annual value is the calculated geometric mean of the measured 24-hour values.

In addition, the federal government develops guideline values for airborne COPCs under the Canadian Environmental Protection Act (CEPA 1989). These guidelines are referred to as the National Ambient Air Quality Objectives (NAAQOs) and are subject to periodic reassessment. NAAQOs are established to provide a measure of protection to people and the environment from adverse effects due to airborne COPCs (Health Canada 1998). The existing desirable and acceptable NAAQOs for TSP as set out in Table 2-4.

Table 2-4 National Ambient Air Quality Objectives for Total Suspended Particulates

COPC	Averaging Time Period	Maximum Desirable Level (µg/m³)(1)	Maximum Acceptable Level (µg/m³)(2)
Total Suspended Particulates (TSP)	1-year	60(3)	70(3)
	24-hour	120	400

Notes:
(1) Defines the long-term goals for air quality
(2) Intended to provide adequate protection against effects on soil, water, vegetation, etc.
(3) Calculated as geometric mean

2.3.2 PM_{10} and $PM_{2.5}$

Many studies over the past few years have indicated that fine particulate matter (PM_{10} and $PM_{2.5}$) in the atmospheric environment is associated with various adverse health effects in people who have compromised respiratory systems and suffer from conditions such as asthma, chronic pneumonia or cardiovascular disease. The Ontario Ministry of Environment (MOE) has established an interim ambient air quality criterion for PM_{10} (MOE 2008) and many other provinces such as B.C., Newfoundland and Manitoba have also adopted this guideline. The Canadian Council of Ministers of the Environment (CCME) has established a Canada-Wide Standard (CWS) for fine particulate matter ($PM_{2.5}$) (CCME 2000) which has been adopted in several provinces. The reference levels used by these jurisdictions for PM_{10} and $PM_{2.5}$ are outlined in Table 2-5.

Table 2-5 Reference Levels for PM_{10} and $PM_{2.5}$

COPC	Averaging Time Period	Jurisdiction	Guideline Level (µg/m³)
PM_{10}	24-hour	Ontario, BC, Manitoba & Newfoundland AAQC	50
$PM_{2.5}$	24-hour	CWS (1)	30

Notes:
(1) Canada-Wide Standard based on the 98th percentile ambient measurement annual, averaged over 3 consecutive years

2.3.3 Metals in Suspended Particulate

Currently, there are no standards or guidelines available in Nunavut or the Northwest Territories for metals, therefore, other provincial levels were considered in this assessment. Most reference levels for metals used in this assessment were developed from the document entitled "Ontario's Ambient Air Quality Criteria" prepared by the Standards and Development Branch of the Ontario Ministry of the Environment (MOE) in February of 2008. Other provinces such as Manitoba and Newfoundland & Labrador, have adopted the same levels for selected metals whereas provinces like Alberta have adopted values from US states. As such, Ontario levels were given preference.

Ontario's AAQC are based on 24-hour exposure levels and are presented in Table 2-6. Recently, MOE standards for Chromium and Nickel were updated; however, the appropriate documentation has not been revised yet. These revised standards were considered in the assessment.

Annual values were derived for use in the current assessment from 24-hour Ontario AAQC values based on the following equation:

$$C_{long}/C_{short} = (t_{long}/t_{short})^{P}$$

The value of coefficient "p" equal to 0.28 is recommended by the MOE's Air Dispersion Modelling Guideline for Ontario (ADGMO 2009).

Table 2-6 Ontario 24-hr Air Quality Criteria and Derived Annual Levels for Metals

Metal	24–hour Ontario Ambient Air Quality Criteria (μg/m^3)	Annual-Derived Air Quality Levels (μg/m^3)
Arsenic	0.3	0.06
Cadmium	0.025	0.005*
Chromium	0.5	0.10*
Cobalt	0.1	0.02
Copper	50	9.6
Lead	0.5	0.10
Molybdenum	120	23
Nickel	0.2	0.04
Selenium	10	1.9
Zinc	120	23

Notes:

*Annual Ontario AAQC value

For reference, other provincial ambient air quality criteria and standards are provided in the Table 2-7 below. Unless otherwise stated, the averaging period is 24-hours.

Table 2-7 Other Provincial Air Quality Criteria, Standards or Guidelines

Metal	Ambient Air Quality Criteria or Standards (µg/m³)			
	British Columbia	Alberta	Manitoba[1]	Newfoundland & Labrador [1]
Arsenic	-	24-hr 0.1 Annual 0.01	0.3	0.3
Cadmium	-	-	2	2
Chromium	-	-	-	-
Cobalt	-	-	-	-
Copper	-	-	50	50
Lead	24-hr 4 Annual 2	-	2	2
Molybdenum	-	-	-	-
Nickel	-	24-hr 6 Annual 0.05	2	2
Selenium	-	-	-	-
Zinc	-	-	120	120

Notes:
[1] 24-hour averaging period

2.3.4 Gaseous COPCs

Nitrogen oxides (NO_x) and sulphur dioxide (SO_2) are referred to as "criteria contaminants". Both the Nunavut and Canadian governments have established limits for SO_2. The Nunavut (2002) limits for SO_2 are presented in Table 2-8.

Table 2-8 Nunavut Air Quality Guidelines for Sulphur Dioxide

Pollutant	1-hour	24-hour	Annual [1]
Sulphur Dioxide	450 µg/m³	150 µg/m³	30 µg/m³

Notes:
[1] Annual value is the calculated geometric mean of the measured 24-hour values.

The federal government desirable and acceptable NAAQOs for SO_2 and NO_2 are provided in Table 2-9.

Table 2-9 National Ambient Air Quality Objectives for Nitrogen Oxides and Sulphur Dioxide

Pollutant	Averaging Time Period	Maximum Desirable ($\mu g/m^3$)	Maximum Acceptable ($\mu g/m^3$)
Nitrogen Oxides (NO_x)	1-year [(1)]	60	100
	24-hour		
	1-hour		400
Sulphur Dioxide (SO_2)	1-year [(1)]	30	60
	24-hour	150	300
	1-hour	450	900

Notes:

[(1)] Calculated as an arithmetic mean.

2.3.5 Airborne Radioactivity

There are currently no air quality standards for radioactivity. Radioactive air emissions are conventionally assessed through an exposure pathways analysis [Volume 8]. In addition, in this report, reference air concentrations were developed based on current radiation protection limits and using recognized dose conversion factors.

The calculation of the reference concentrations assumed an annual dose of 1 mSv/yr for a member of the public, continuous exposure for an entire year (8,760 h/yr) and an annual inhalation rate of 8400 m^3/yr. No reduction in airborne dust concentrations for time spent indoors was considered. The dose factors were taken from ICRP 72 (1996) assuming particle sizes of 1 µm and slow rate of clearance from the lungs (category "a"). This is almost always the most restrictive category and results in an overestimate of exposure.

The resulting reference concentrations are tabulated below (Table 2-10). These reference concentrations are meant only to assist in understanding the magnitude of the predicted radionuclide concentrations. More refined dose estimates consider actual exposure times and other specifics for each receptor, and can be found in the Human Health and Environmental Risk Assessment (Volume 8).

Table 2-10 Reference Levels for Radioactivity

Radionuclide	Reference Level (Bq/m^3)
U-natural	0.014 (0.56 $\mu g/m^3$)
Pb-210	0.021
Po-210	0.028

The Ontario MOE has recently finalized a decision for a proposed 24-hour Ambient Air Quality Criterion for uranium of 0.3 µg/m^3 and annual uranium standard of 0.03 µg/m^3. In lieu of the calculated U-nat provided in the table above, the more stringent Ontario MOE 24-hour AAQC and annual standard will be used as a conservative alternative.

For radon-222 (Rn-222), the Radiation Protection Regulations of the Canadian Nuclear Safety Commission (CNSC 2000) provide two alternatives for assessing radon-222 attributable to a licenced facility:

- incremental (i.e., above baseline/background) level of 60 Bq/m^3 of Rn; or
- exposure to 4 working level month (WLM) of radon progeny (short lived radon decay products).

In order to provide a context for Rn levels predicted in the air quality assessment, the 60 Bq/m^3 (incremental) value was adopted for the purposes of this assessment.

2.3.6 Dust Deposition

Table 2-11 identifies dust deposition criteria for Alberta and Ontario. These criteria are nuisance based. For the purpose of this assessment, the Ontario Ambient Air Quality Criteria were selected as the applicable Indicator Thresholds.

Table 2-11 Dust Deposition Criteria

Averaging Time	Alberta Residential and Recreational Areas	Alberta Commercial and Industrial Areas	Ontario Ambient Air Quality Criteria	Indicator Threshold
Monthly	5.3 g/m²/30 days	15.8 g/m²/30 days	7 g/m²/30 days	7 g/m²/30 days
Annual Average	-	-	4.6 g/m²/30 days	4.6 g/m²/30 days
Annual Loading	-	-	55 g/m²/year	55 g/m²/year

Sources: Alberta Environment (2011) and Ontario Ministry of Environment (MOE 2008)

2.3.7 Potential Acid Input

Table 2-12 presents the suggested loading thresholds for Potential Acid Input (PAI) based on the sensitivity of the receiving environment. For the purpose of this assessment, the loading levels for sensitive environments were selected as the criteria to evaluate potential effects.

Table 2-12 Potential Acid Input Loading Thresholds

Sensitivity of Environment	Deposition Load	LoadingThreshold
Sensitive	Monitoring	0.17 keq/ha/yr
	Target	0.22 keq/ha/yr
	Critical	0.25 keq/ha/yr
Moderately Sensitive	Critical	0.50 keq/ha/yr
Low Sensitivity	Critical	1.00 keq/ha/yr

Source: Clean Air Strategic Alliance and Alberta Environment (1999)

3 BASELINE INFORMATION

3.1 EXISTING AIR QUALITY

Air quality in the vicinity of the Mine Development Area and in the Kivalliq Region in general, can be characterized as being typical of northern rural areas in that the air is relatively pristine, having very low concentrations of the COPCs of interest in this assessment. However, baseline air concentrations of some COPCs can be expected to be slightly higher in and around the community of Baker Lake due to increased emissions from anthropogenic activities like heating and transportation.

Baseline COPC concentrations used in this assessment were obtained through a combination of on-site measurements and from literature reviews of Environmental Impact Statements for other projects in Nunavut. A summary of the existing local and regional air quality is provided below.

3.1.1 Local Air Quality

A series of high volume air samplers (Hi-Vols) were used to collect on-site measurements of metals and radionuclides during the 2010 summer field season (June to August) at the Kiggavik mine site. Hi-Vols were deployed on June 29 (Campaign 1) and July 20 (Campaign 2) and ran continuously for 20 and 28 days, respectively. This approach was used to collect a sufficient amount of sample for analysis, which was expected to contain very low levels of the target COPCs. **Error! Reference source not found.** provides the concentrations measured during each sampling campaign.

As shown in Table 3-1, during Campaign 1, metal concentrations ranged from a low of 1.28E-05 µg/m^3 (Uranium) to a high of 1.645E-01 µg/m^3 (Boron). Metal concentrations during Campaign 2 were slightly lower, ranging from 6.86E-06 µg/m^3 (Cobalt) to 1.15E-02 µg/m^3 (Copper). With regard to radionuclides, Lead-210 had the highest overall concentration at 1.37E-04 µg/m^3 during Campaign 1 and during Campaign 2 at 1.67E-04 µg/m^3. Polonium-210, Radium-226, Thorium-230 and Thorium-232 were all less than 3.60E-05 µg/m^3 in both Campaign 1 and 2. Overall, the concentrations of metals and radionuclides were very low considering the extended sampling period used in each campaign.

Another ambient air quality program was carried out near the proposed mine site using low volume air samplers (PQ-100s) to collect samples for analysis of TSP, PM10 and PM2.5 about every three days throughout July 2009 and 2010. The results are presented in Table 3-2. As can be seen in the table, the baseline particulate concentrations are all very low, which is expected due to the nature of the area. However, a number of unforeseen challenges were experienced with the equipment, which compromised the reliability of the data that was collected. Therefore, the results are not presented. Additional monitoring was undertaken during the 2010 and 2011 monitoring season; however, this data was not available at the time of preparation of the EIS.

Table 3-1 Measure Metals and Radionuclides at Kiggavik in July and August 2010

Metal	Campaign 1 (June 29-July 19) Concentration (µg/m^3)	Campaign 2 (July 20 – August 17) Concentration (µg/m^3)
Aluminum	5.24E-02	8.09E-03
Antimony	1.28E-04	1.92E-04
Arsenic	4.11E-05	3.43E-05
Barium	3.34E-03	3.15E-04
Berylium	1.28E-05	6.86E-06
Boron	1.64E-01	6.86E-04
Cadmium	3.34E-05	1.78E-05
Chromium	2.57E-04	1.37E-04
Cobalt	1.28E-05	6.86E-06
Copper	1.49E-02	1.15E-02
Iron	2.80E-02	6.31E-03
Lead	2.47E-03	7.96E-04
Manganese	1.03E-03	6.31E-04
Molybdenum	2.57E-05	7.27E-04
Nickel	1.77E-04	8.50E-05
Selenium	4.37E-05	2.61E-05
Silver	3.85E-05	2.74E-05
Strontium	1.59E-03	1.23E-04
Thallium	1.28E-05	6.86E-06
Tin	3.60E-04	7.13E-05
Titanium	6.42E-04	2.47E-04
Uranium	1.28E-05	6.86E-06
Vanadium	1.80E-05	1.78E-05
Zinc	5.65E-03	6.72E-03
Lead-210	1.67E-04 *	1.37E-04
Polonium-210	3.60E-05 *	2.74E-05
Radium-226	2.57E-06 *	2.74E-06
Thorium-230	5.14E-06 *	2.74E-06
Thorium-232	5.14E-06 *	2.74E-06

NOTES:
* Concentrations in Bq/m^3.

Table 3-2 TSP, PM_{10} and $PM_{2.5}$ Measurements at Kiggavik in July, 2010

Sampling Date	Particulate Concentration (µg/m³)		
	TSP	PM_{10}	$PM_{2.5}$
09-Jul-10	2	-	2
12-Jul-10	3	3	-
15-Jul-10	6	-	5
18-Jul-10	*4*		-

Additional sampling was also carried out to measure baseline levels of radon during the summer months of 2008, 2009 and 2010. Three dosimeters (located in Baker Lake, the Kiggavik site and the Sissons site), were used to measure alpha emissions of short life daughter products of radon 222 (Rn-222). Measured potential alpha energies (nJ/m³) of Rn-222 were converted to an activity or concentration (Bq/m³) of radon gas. The results of this sampling program are summarized in Table 3-3. As can be seen in the table, average radon concentrations are in the range of 1.4 to 2.4 Bq/m³. Overall, the baseline concentration of radon is considered to be low.

Table 3-3 Measured Potential Alpha Energies of Radon-222 and Resulting Activity (Bq/m³)

Parameter	Location	June 2008	July 2008	Sept 2008	June 2009	July 2009	August 2009	July 2010	August 2010	Average
Rn-222 PAE (nJ/m³)	Baker Lake	3	5	5	3	5	6	bdl	NA	4.5
	Kiggavik	bdl	8	bdl	5	8	6	9	8	7.3
	Sissons	bdl	7	bdl	5	7	7	13	10	8.2
Rn222 Activity (Bq/m³)	Baker Lake	0.90	1.50	1.50	0.90	1.50	1.80	bdl	NA	1.3
	Kiggavik	bdl	2.40	bdl	1.50	2.40	1.80	2.70	2.40	2.2
	Sissons	bdl	2.10	bdl	1.50	2.10	2.10	3.90	3.00	2.4

Notes:

PAE = potential alpha energy

bdl = below detection limit

NA = not available

3.1.2 Regional Air Quality

There were no regional monitoring sites located in close proximity to the Project site which could characterize regional air quality. As a result, data obtained from other Environmental Impact Statements submitted to NIRB were used to assist in the characterization of regional air quality. The findings are summarized in the following section.

3.1.2.1 NIRB Literature Review

A review of atmospheric effects assessments previously submitted to NIRB as part of EIS documents for other projects within Nunavut was completed to identify ambient levels of target COPCs in similar environments. The following projects were identified during this review:

Project	**Proponent**	**Year Submitted**
Meadowbank Gold	Cumberland Resources Ltd.	2005
Doris North Lake	Miramar Hope Bay Ltd.	2005
Mary River	Baffinland Iron Mines Corporation	2010

Air quality monitoring data presented in the Meadowbank Gold project Air Quality Impact Assessment (Cumberland Resources Ltd. 2005) noted that existing PM_{10} concentrations reported by the Environment Protection Service of the Government of NWT were less than 10 μg/m^3 for a 24-hour period for undisturbed areas of Northwest Territories (NWTWRED 2004). Concentrations of SO_2, NO_x, and CO were expected to be very low.

The Doris North Lake Atmospheric Environment Technical Report (Golder Associates 2005) indicated that a baseline particulate (TSP) monitoring program was conducted at the site using a high volume air sampler; however, a very limited dataset was collected (3 samples). The measured TSP values ranged from 3.9 μg/m^3 to 5.5 μg/m^3 for a 24-hour period. Concentrations in this range are consistent with those expected for an undisturbed, remote environment, and are also consistent with those measured at the Kiggavik site.

An ambient air monitoring program was also conducted as part of the Baffinland Mary River project, where measurements of TSP and PM_{10} were collected over 24-hour periods. SO_2, NO_2 and dust deposition (including metal constituents) were also measured (Knight Piésold Consulting 2010). The average 24-hour concentration of TSP and PM_{10} were 7.0 and 3.8 μg/m^3, respectively as shown in Table 3-4. This data is also consistent with the measurements made at the Kiggavik site. Additionally, the table shows that over a 30-day period, the SO_2 and NO_2 concentrations at Mary River were 0.26 and 0.19 μg/m^3, respectively.

Table 3-4 Measured Baseline Concentrations at Mary River (µg/m³)

Constituent	Averaging Period	Concentration (µg/m^3)
TSP	24-hour	7.0
PM_{10}	24-hour	3.8
SO_2	30-day	0.26
NO_2	30-day	0.19

Table 3-5 shows that the total dustfall amount was 0.40 mg/100cm^2/30-days. The measured 30-day metal deposition rates ranged from a low of 0.3 mg/100cm^2/30-days (Chromium) to a high 30.6 mg/100cm^2/30-days (Iron). Similar to the findings of the previous studies, the measured baseline concentrations and metal deposition rates are generally low compared to those from more urbanised and disturbed areas in the southern regions of Canada.

Table 3-5 Baseline Dustfall and Metal Deposition Rates at Mary River

Constituent	Deposition (mg/100 cm^2/30-days)
Total Dustfall	0.40
Alumium	25.9
Cobalt	0.5
Chromium	0.3
Iron	30.6
Magnesium	23.9
Manganese	1.7

3.1.3 Selected Baseline COPC Concentrations

Overall, very little long-term information is available regarding ambient air concentrations of COPCs in the LAA and RAA. Available short term measured data suggests that concentrations of COPC are very low. Measurements at such low levels could be considered to be at the lower sensitivity range of the sampling equipment. This is not unexpected given the remote nature of the Project site and the relatively pristine environment of the area.

As such, it was assumed that annual and 24-hour baseline concentrations of the various COPCs considered in this assessment would have a minimal contribution relative to the predicted COPC concentrations from the Project and thus were not added to model predicted concentrations.

3.2 GREENHOUSE GASES

As of 2010, Canadian facilities that emit more than 25,000 tonnes of CO_2-equivalent must report their emissions to Environment Canada's Greenhouse Gas Inventory. In previous reporting years, the threshold was 50,000 tonnes of CO_2-equivlent. According to the Inventory, the total amount of facility-reported greenhouse gases emissions in Canada in 2009 (the most recent available year) was 250,454 kilotonnes (kt) of CO_2-equivalent. There were no facility-reported GHG emissions in Nunavut (NU) in 2009; however, in the Northwest Territories, facility-reported GHG emissions totalled 519 kt of CO_2-equivalent.

Environment Canada also generates a National Inventory Report which is submitted to the UN Framework Convention on Climate Change. This report provides a summary of both national and provincial/territorial estimates of GHG emissions and includes sources which did not necessarily meet the reporting threshold for the GHG Inventory described above. According to the latest submission, Canada-wide GHG emissions were calculated to be 734,000 kt of CO_{2-}equivlant in 2008. For the same year, GHG emissions in Nunavut were 361 kt of CO_{2-}equivalent. Therefore, GHG emissions in Nunavut were approximately 0.05% of the 2008 total for Canada.

The Meadowbank Gold Mine is currently, and will continue to be in operation when the Kiggavik Project is commissioned and as a result, GHG emissions from this project should be included as part of the baseline GHG levels in Nunavut. Since the Meadowbank Gold Mine was not yet commissioned in 2008, the Nunavut level as reported by Environment Canada did not include emissions from this facility. As a result, the GHG emissions estimate of 191 kt of CO_2-equivalent as provided in the Meadowbank Gold Mine Environmental Assessment (Cumberland Resources Ltd. 2005), was added to the reported 2008 GHG emissions in Nunavut. Therefore, the baseline level of GHG emissions in Nunavut was considered to be 552 kt of CO_2-equivalent which will be used as a measure of comparison to Project-related emissions of CO_2-equivalent.

3.3 POTENTIAL ACID INPUT (PAI)

Background PAI levels in the RAA were calculated based on data from the National Atmospheric Chemistry Precipitation Database (NAtChem) (Environment Canada 2008). Current sources of acidic precipitation would include sources which emit precursors to acidic precipitation; primarily NO_x and SO_2. Such sources would include fuel combustion. The annual average background PAI was calculated to be 0.093 keq/ha/yr. As per the PAI calculation methodology, this background component was added to the Project-related contribution to PAI. Details of the derivation of the baseline PAI are provided in Attachment A.

4 AIR EMISSIONS INVENTORY

This section of the report discusses the various sources of COPCs that have been considered in this assessment and provides a summary of the emission rates for each of the scenarios as described in Section 2.1.2. In general, emissions were estimated using the US EPA's Compilation of Air Pollutant Emissions Factors (commonly known as AP-42 emission factors); however, guidance from other organizations such as the Air and Waste Management Association (AWMA) and the Colorado Department of Health (CDOH) was also used. A summary of all emission factors and equations used to generate the emissions inventory is provided in Table 4-1.

Table 4-1 Summary of Emission Factors used in the Air Dispersion Assessment

Emission Source	Emission Factor or Equation		Reference
Drilling	0.59 kg TSP/hole		AP-42 Chapter 11.9 – Western Surface Coal Mining, Table 11.9-4 (US EPA 1998)
Blasting	TSP	38.7 kg/blast	Colorado Department of Health (Tistinic 1981)
	NO_x SO_2 CO	8 kg/tonne ANFO 1 kg/tonne ANFO 34 kg/tonne ANFO	AP-42 Chapter 13.3 – Explosives Detonation, Table 13.3-1 (US EPA 1980)
Transfer of material (i.e., loading and unloading of material)	$E = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$ Where: E = emission factor in kg/tonne of material k = particle size multiplier (0.74 for particles ≤ 30 μm) U = mean wind speed (m/s) M = moisture content (%)		AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles, Equation 1 (US EPA 2006a)
Vehicular Road Dust – Unpaved Industrial Roads	$E = k \times \left(\frac{s}{12}\right)^{a} \times \left(\frac{W}{3}\right)^{b}$ Where: E = emission factor in lb/VMT k = 4.9 lb/VMT s = silt content (%) W = vehicle weight (tons) a and b= constants VMT = vehicle miles travelled		AP-42 Chapter 13.2.2 – Unpaved Roads, Equation 1a (US EPA 1995)
Non-Road Diesel Engines	Various		US EPA (2004). *Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling--Compression-Ignition.* EPA420-P-04-009, April.

Emission Source	Emission Factor or Equation	Reference
On-Road Vehicle Tailpipe	Various	MOBILE6C emission factors
Bulldozing	$E = K \times \frac{s^{1.2}}{M^{a}}$ Where: E = emission factor In kg dust/hr K = constant (assumed 2.6 for material similar to overburden) s = silt content (%) M = moisture content (%) a = constant (assumed 1.3 for material similar to overburden)	AP-42 Chapter 11.9 – Western Surface Coal Mining, Table 11.9-2 (US EPA 1998)
Grading	$E = 0.0034 \times S^{2.5}$ Where: E = emission factor in kg/VKT S = mean vehicle speed (km/h) VKT = vehicle kilometers travelled	AP-42 Chapter 11.9 – Western Surface Coal Mining, Table 11.9-2 (US EPA 1998)
Wind erosion	$E = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{f}{15}\right)$ Where: E = emission factor in kg dust/ha/day s = silt content (%) f = percentage of time that the wind speed is greater than 5.4 m/s at the mean pile height	Air and Waste Management Associating Air Pollution Engineering Manual (AWMA, 1992)
Ore Crushing and Grinding	Scaled using McClean Lake stack testing data	Source Testing of AREVA Resources Canada Inc. McClean Lake Yellowcake Calciner, Packaging Area, Grinding, Crystallizer and Acid Plant Stacks, June 2008
Yellowcake Drying and Packaging	Scaled using McClean Lake stack testing data	Source Testing of AREVA Resources Canada Inc. McClean Lake Yellowcake Calciner, Packaging Area, Grinding, Crystallizer and Acid Plant Stacks, June 2008

Emission Source	Emission Factor or Equation		Reference
Acid Plant	SO_2	75 g SO_2/tonne acid produced	Initial Feasibility Study, Section 8.4.11.1 (AREVA 2011)
	NO_x and CO	Scaled using McClean Lake stack testing data	Source Testing of AREVA Resources Canada Inc. McClean Lake Yellowcake Calciner, Packaging Area, Grinding, Crystallizer and Acid Plant Stacks, June 2008
Backfill Plant (Cement Unloading)	TSP PM_{10}	0.0005 kg/Mg 0.00017 kg/Mg	AP-42 Chapter 11.12 – Concrete Batching, Table 11.12-1 (US EPA 2006c)
Backfill Plant (Concrete Mixing)	TSP PM_{10}	0.0087 kg/Mg 0.0024 kg/Mg	AP-42 Chapter 11.12 – Concrete Batching, Table 11.12-1 (US EPA 2006c)
Power Plant	TSP	7.0E-04 lb/hp-hr	AP-42 Chapter 3.4 – Large Stationary Diesel and all Stationary Dual-Fuel Engines, Table 3.4-1 (US EPA 1996)
	NO_x	13.6 g/kWh	Caterpillar Engine Performance Report, Model No. 9CM32
	CO	0.06 g/kWh	Caterpillar Engine Performance Report, Model No. 9CM32
Waste Incinerator	TSP PM_{10} $PM_{2.5}$ NO_x SO_2 CO CDD/CDF	20.0 mg/m^3 15.8 mg/m^3 9.0 mg/m^3 22.0 mg/m^3 50 mg/m^3 7 mg/m^3 8.0E-11 mg/m^3	Eco Waste Solutions Technical Specifications, Model No. 1.75TN 1P MS 60L
Construction	2.69 Mg of TSP/ha/month		AP-42 Chapter 13.2.3 – Heavy Construction Operations (US EPA 1995)

4.1 AIR EMISSIONS SOURCES

The sources of air emissions or emission-generating activities for each Project phase are summarized below. Beginning in Section 4.1.1, brief descriptions of each of the sources subsequently identified are provided. These sections are categorized according to the three main types of COPCs: dust (i.e. particulate-based COPCs), gaseous emissions and radionuclides. Complete descriptions of the emissions sources as well as all variables and assumptions used in the emissions calculations are provided in Attachment A.

Construction

The emissions generating activities associated with on-land construction include the following:

- Preparation of the Kiggavik and Sissons mine sites. Dust generating activities may include land clearing (e.g., bulldozing, grading), excavating (i.e., earth moving), material handling and building infrastructure such as the mill, the accommodation complex, the power plant, etc.
- Development of the access roads which includes quarrying to supply road bed materials. Activities like material handling along with aggregate crushing and screening are significant emission sources from quarrying.
- Heavy-duty diesel-powered construction equipment used for site preparation, construction of infrastructure, quarrying, etc., is a source of gaseous COPCs.

Operation

During operational years of the Project, emission sources include:

- Open pit and underground mining activities, including:
    - Drilling;
    - Blasting;
    - Ore and mine rock handling;
    - Stockpile and road maintenance (i.e., dozing and grading);
    - Wind erosion of stockpiles;
    - Haulage of ore and mine rock (i.e., vehicle movement); and,
    - Supporting activities such as the backfill plant serving the underground mine.
- Combustion sources such as the power plant in addition to diesel-powered equipment and vehicles located within the Mine Development Area and at the Baker Lake dock and storage facility, including heavy-duty mining equipment, trucks and marine vessels.

- Truck transportation along the access road between the Kiggavik mine site and Baker Lake.
- Milling, including ore handling, ore crushing and grinding, in-process agitated storage, yellowcake drying and packing as well acid production.
- Emissions of radon from tailings management facilities (TMFs).

Final Closure

Sources of emissions or emission generating activities during the final closure phase include:

- Backfilling Type III mine rock at Kiggavik and Sissons into Main Zone TMF and Andrew Lake open pit, respectively and covering Centre Zone TMF with a layer of Type II mine rock (i.e., material handling).
- Emissions of radionuclides from tailings management facilities (TMFs).
- Fuel combustion sources such as diesel-powered equipment and vehicles.

Post-Closure

Sources of emissions during post-closure include:

- Continuous radon emissions from the remaining permanent Type II (clean) mine rock stockpiles and covered TMFs.

4.1.1 Sources of Dust

4.1.1.1 Drilling and Blasting

In preparation for blasting, holes are drilled into the rock face and subsequently filled with explosive material. Drilling rock results in emissions of dust and its constituents; however, modern drilling equipment and current drilling practices are designed to minimize the release of particulate matter. Consequently, drilling is not typically a significant source of dust compared to other mining sources.

During blasting, rock is broken into smaller pieces which inherently become airborne and easily dispersed by the wind. Experience with similar mining projects has shown that like drilling, blasting tends to be a trivial source of dust relative to other mining activities. As well, blasting emissions typically only last 10 to 15 minutes per blast and thus tend to have the greatest effect over shorter averaging periods (i.e., 1-hour).

The blasting agent (typically Ammonium Nitrate-Fuel Oil [ANFO]) is a source of gaseous emissions including NO_x and to a lesser extent, SO_2. Upon detonation, ammonium nitrate reacts with the hydrocarbons in the fuel oil to produce nitrogen, carbon monoxide and water. If excess oxygen is present, moderate amounts of NO_x can be formed. As a result, blasting can be a significant source of NO_x emissions on a short-term basis. The amount of ANFO required for blasting varies depending on the material being blasted. For example, in this assessment, the powder factor for open pit mining is 0.25 kg ANFO per tonne of rock whereas for underground mining, the powder factor is 2.5 kg ANFO per tonne of rock.

4.1.1.2 Material Handling

Examples of material handling activities include loading ore and mine rock into haul trucks via front-end loaders as well as unloading ore and mine rock to designated stockpiles. When newly processed or disturbed material is loaded (or unloaded), dust and its radioactive and non-radioactive constituents are emitted upon exposure to winds, either from the material transfer itself or from re-suspension due to the occurrence of high winds (US EPA 2006a). The emission rates depend on both the silt and moisture content of the material as well as the local wind speed at the time of handling.

4.1.1.3 Dozing and Grading

Bulldozers are typically used in the formation and maintenance of large piles like the mine rock stockpiles, but may also be used to facilitate the use of front-end loaders during material handling activities. Graders are used for maintaining roads as well as for removing blasted material from open pit ramps. Bulldozers and graders travelling or working on unpaved surfaces and stockpiles cause the release of dust and its radioactive and non-radioactive constituents. Emissions from dozing depend on both the silt and moisture content of the surface material whereas grading emissions depend on the speed at which the grader travels.

4.1.1.4 Unpaved Roads

Unpaved roads considered in this assessment include: open pit ramps; mine site roads connecting the open pits and underground mine to stockpiles and/or the mill; the Kiggavik-Sissons access road; and finally, an access road connecting Baker Lake to the Kiggavik mine site.

The mechanism by which dust and its constituents are generated from unpaved roads is complex; however, in general, emissions can be attributed to the re-suspension of surface dust by: 1) the action of tires on the surface, and 2) the wake created by the passing of the vehicle. As a result, emissions per vehicle kilometre travelled from unpaved roads are a function of the silt content of the surface material and the size of the vehicle passing over it.

It is important to note that as open pits become more developed, haul trucks must travel longer distances to get in and out of the pits. Since the level of dust generation from each mine site depends on the number of vehicle kilometres travelled (VKT) (**Error! Reference source not found.**), emissions of re-suspended vehicle dust within an open pit tend to increase as production progresses.

The dust generation rate from pit ramps as well as any other unpaved transportation routes can be controlled through operational practices such as reducing speeds below 25 mph (44 km/h), regular watering or the application of chemical dust suppressants. During winter, frozen surfaces and/or snow pack also help to reduce emissions of dust. For this assessment, a reduction factor was applied to roadway generated emissions to account for slower vehicle travel speeds, watering during summer and the existence of frozen surfaces during winter (which acts as a mild dust suppressant). See Attachment A for more details.

4.1.1.5 Wind Erosion

Dust and its constituents are emitted via wind erosion of uncovered stockpiles and other exposed surfaces. The release of dust from wind erosion depends on the amount of erodible fines (i.e., silt) present in the material and the wind speed. The threshold wind speed for the release of dust was assumed to be 5.4 m/s, as per (AWMA 1992); therefore, the frequency at which wind speeds are greater than this threshold is a determining factor for the level of dust generated from wind erosion. For this assessment, the frequency was determined using the outputs of the CALMET model, which incorporates site-specific and other local meteorological data (Section 5.1).

The amount of erodible material in a stockpile is finite, meaning that the potential for erosion is limited if a stockpile is left undisturbed. In other words, if no mechanical actions occur to replenish silt levels, natural crusting of the surface will occur and the potential for erosion will be negligible. For this assessment, it was conservatively assumed that a stockpile had to be undisturbed for a minimum of three (3) years before erosion emissions became negligible. Additionally, during periods of rainfall, snow cover or frozen conditions, emissions are greatly reduced for undisturbed surfaces. Conservatively, no credit was taken for such reductions when estimating dust emissions from wind erosion in this assessment.

4.1.1.6 Mill Operations

The Kiggavik mill will be composed of a number of unit processes or circuits that extract uranium from ore and produce the packaged uranium product commonly referred to as yellowcake. The preferred process utilizes resin-in-pulp (RIP) technology which involves the use of small beads coated with a resin that is selective for aqueous phase uranium complexes. Alternative processes include counter-current decantation (CCD)/solvent extraction which would be similar to the milling process used at AREVA’s McClean Lake operation. Regardless of which process is used, there are four (4) main sources of dust (and its radioactive and non-radioactive constituents) during the milling process: ore handling; ore crushing and grinding; calcining or drying; and, yellowcake packaging.

4.1.1.7 Backfill Plant

Cemented rock fill is the proposed backfill material for the End Grid underground mine. To produce the backfill, crushed mine rock will be mixed with cement in a concrete batching plant located near the End Grid underground mine. Dust and its constituents are emitted during this process.

4.1.1.8 Quarrying

Depending on the option being considered, the access road between the Kiggavik site and Baker Lake may be constructed using quarried bedrock material from along the access routes. The All-Season Road option would be constructed entirely of quarried material, whereas only segments of the Winter Road option would require granular fill.

Typical aggregate handling and processing activities as described in AP-42 Chapter 11.19.2 – Crushed Stone Processing were assumed for quarrying. Sources of emissions include material handling as described above, in addition to the crushing and screening of extracted quarry materials.

4.1.1.9 Radioactive Dust and Metals

The term “radioactive dust” refers to the fraction of dust which is comprised of uranium-238 series radionuclides. For this assessment, it was assumed that the particles released into the atmosphere will have the same composition as the in-situ surface material from which it is emitted. The emissions of radioactive dust and metals were therefore calculated by scaling the emissions of total suspended particulate matter (TSP) using the percentage of uranium-238 and metals in the parent material. Compositional sampling results were used to derive representative uranium and metal contents of the various sources of parent material (i.e., ore or Type I, II and III mine rock). The uranium-238 and metal contents of the ore and various rock types are outlined in Table 4-2 through Table 4-5. Details regarding the derivation of these values and how they were applied to the various sources of dust are provided in Attachment A.

4.1.2 Sources of Gaseous Emissions

4.1.2.1 Mining Equipment and Vehicles

Diesel-powered mining equipment such drills, loaders, shovels, haul trucks, etc. as well as on-road transport trucks and marine vessels powered by diesel fuel are all sources of NO_x and SO_2, and to a lesser extent, fine particulate matter (PM_{10} and $PM_{2.5}$). Emissions depend on factors such as the engine year, engine size (i.e., horsepower rating), emissions control equipment, age of the equipment and sulphur fuel content for SO_2 emissions.

4.1.2.2 Acid Plant

In the milling process, sulphuric acid (H_2SO_4) is used to leach uranium from ore. An on-site acid plant located adjacent to the mill will be operated to generate the required H_2SO_4. The acid plant is a significant source of SO_2 which will be exhausted into the atmosphere through a single stack controlled by a wet scrubber.

4.1.2.3 Power Generation

Electrical power will be generated using diesel-powered generators at the Kiggavik site for the primary purpose of operating the mill and for supplying electricity and some heat to the Accommodation Complex and offices. At Sissons, power is mainly required for ventilating the underground mine. As with all combustion equipment, emissions include NO_x, SO_2 and fine particulate matter.

Emergency generators will also be installed for the Kiggavik and Sissons sites, but were not considered to be part of typical operations and as a result, were not included in the assessment.

4.1.2.4 Waste Incineration

All food waste generated from the Kiggavik Project will be incinerated to minimize interactions with wildlife. An incinerator will be located and operated at both the Kiggavik and Sissons mine sites in compliance with all applicable federal, territorial and local regulations.

Incinerators similar to Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L will be used at the Project sites; however, the incinerator used at Sissons will be significantly smaller than that used at Kiggavik. According to technical specifications for this model, atmospheric emissions include NO_x, SO_2 and fine particulate matter from fuel combustion.

4.1.3 Sources of Radionuclides

Radon gas (radon-222) is created when its precursor, radium-226, decays. This decay process is continuous, resulting in the ongoing release of radon into the pores and fissures of the radium bearing material. A portion of the radon will be released into the atmosphere when these radium bearing materials are being mined or processed in the mill. Whenever there is an inventory of radium bearing material in agitated storage in the mill, radon will be produced on a continual basis. General ventilation of the mill work areas also causes the release of any fugitive workplace radon-222 to the atmosphere. Radon-222 will also be released passively from exposed surfaces of ore and mine rock stockpiles and pit walls and floors.

Lead-210 (Pb-210) and its decay product polonium-210 (Po-210) result from the presence of Pb-210 in uranium bearing dust or from the decay of radon in air. From SENES' experience with similar mining projects, ingrowth of Pb-210 (and thus Po-210) from radon is insignificant relative to Pb-210 originating from uranium dust. For the purpose of this assessment it was assumed that Pb-210 is in equilibrium with uranium-238.

4.1.3.1 In-Pit Tailings Disposal

During operation, tailings produced in the mill will be treated and stored within mined-out pits (East Zone, Centre Zone and Main Zone) and covered with water. Tailings which are both treated and discharged below water are known to have negligible emissions of radon gas relative to other sources, but were nonetheless included in this assessment. Since the tailings will be covered with water, no dust will be released from the TMFs.

Table 4-2 Uranium Ore Grade over the Project Lifetime

Year	Uranium Ore Grade (%)				
	East Zone	Centre Zone	Main Zone	Andrew Lake	End Grid
0					
1	0.258%	0.476%			
2			0.512%		
3			0.681%		
4			0.350%		
5			0.346%		0.345%
6				0.511%	0.309%
7				0.632%	0.303%
8				0.536%	0.288%
9				0.546%	0.320%
10				0.516%	0.335%
11				0.332%	0.416%
12				0.436%	0.501%

Table 4-3 Metal Content of Ore use in the Assessment

Mine	Ore Content of Ore (ppm)									
	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
Main Zone Pit	5.7	17	31	503	287	66	2.0	39	1.2	154
Centre Zone Pit	25	19	73	283	31.0	78	0.2	98	1.4	178
East Zone Pit	25	19	73	283	31.0	78	0.2	98	1.4	178
Purpose Built Pit	0.8	10	9.4	25.8	12.0	21	0.2	27	0.1	56
Andrew Lake Pit	17	8.3	51	355	55.7	95	0.5	34	1.1	961
End Grid	55	21	47	208	64.6	66	5.5	41	1.2	113

Notes:
Metal content was not varied by assessment scenario.

Table 4-4 Uranium Grade Summary for Mine Rock

Parameter	Andrew Lake Rock			End Grid Rock			Main Zone Rock			Centre Zone Rock			East Zone Rock		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
# of Samples	39	7	5	41	0	1	40	10	5	19	2	1	16	0	0
U Geomean (ppm)	9.9	104.6	323.1	3.5	-	1370.0	11.0	106.2	390.8	7.4	55.7	500.0	4.2	-	-
U Geomean*Geometric Stdev	21.5	207.0	425.3	7.5	-	1370.0	27.3	172.9	619.3	20.2	62.0	500.0	1.5	-	-

Notes:

Type 1 (Construction material): U <40 ppm
Type 2 (Clean waste): U 40-250 ppm
Type 3 (Special waste): U ≥250 ppm
Calculated using EcoMetrix data (Ecometrix 2010, memorandum)

Table 4-5 Metal Content Summary for Mine Rock

Metal	Units	Type I Mine Rock		Type II Mine Rock		Type III Mine Rock	
		Kiggavik	Andrew Lake	Kiggavik	Andrew Lake	Kiggavik	Andrew Lake
As	ppm	0.80	3.69	0.92	3.28	0.73	1.92
Co	ppm	11.17	3.76	9.63	3.73	10.86	2.63
Cu	ppm	13.52	7.40	11.96	6.72	45.09	5.64
Pb	ppm	10.06	7.63	12.41	8.70	30.17	14.12
Mo	ppm	1.90	0.67	1.91	0.69	14.65	0.84
Ni	ppm	26.97	27.05	26.16	28.04	22.19	27.90
Se	ppm	1.13	1.33	1.14	1.28	1.43	1.10
Zn	ppm	35.50	13.57	30.14	13.43	35.24	9.95
Cd	ppm	0.05	0.08	0.04	0.09	0.05	0.11
Cr	ppm	46.28	86.59	45.77	84.50	42.14	77.05

Source: Initial Feasibility Study Table 7.2-3 (AREVA 2011)
Notes:
Type 1 (Construction material): U <40 ppm
Type 2 (Clean waste): U 40-250 ppm
Type 3 (Special waste): U ≥250 ppm

4.2 AIR EMISSION RATES

Air emissions have been estimated for each of the scenarios described in Section 2.1.2 of this report. A description of the emissions by scenario and by source is provided in the following sections and emission rate summaries for particulate matter, uranium, gaseous emissions and radon are provided in Tables 9 to 18. Note that for all assessments except construction and quarrying, emission rates were calculated and varied on a monthly basis for the key purpose of generating average monthly inputs for the pathways model used to complete the Ecological and Human Health Risk Assessments (Volume 8). As such, the values provided in the tables represent the month with the highest emission rate for each source. Sources may not have maximum emissions occurring during the same month, therefore, site-wide totals and source contributions should be considered on a month-to-month basis.

It should also be noted that in many cases, assumptions have been made that result in conservative emissions estimates. As such, the emission rates presented herein are likely an overestimate of actual emissions. Detailed emissions summaries including all metal emission rates are provide in Attachment B.

4.2.1 Construction

4.2.1.1 Construction of the Mine Development Area

Construction of the Mine Development Area (i.e., the Kiggavik and Sissons mine sites) was evaluated through an emissions burden analysis, which is an accounting of the total emissions of key COPCs. Since construction emissions are generated within the same footprint as operation emissions in the Mine Development Area, the emission rates for construction can be compared to the emissions for the maximum operation assessment to determine the potential effect of construction relative to maximum operations. If the emissions from construction are less than or equal to the maximum operation emissions, it can be inferred that the potential change in ambient air concentrations will be the same or less and modelling is not required.

As shown in Table 4-1, particulate matter emissions from construction of the mine sites were calculated based on the AP-42 emission factor for general construction activities. Emission rates are summarized in Table 4-6. The daily average emission rate of TSP from construction of Kiggavik mine site was calculated to be 12.5 g/s, and 21.2 g/s for the construction of Sissons. Exhaust emissions from diesel-powered equipment were calculated to be 14.4 g/s for NO_x and 0.08 g/s for SO_2 at each mine site. All emissions from the construction scenario are less than those calculated for each mine site for the maximum operation scenario (Section 4.2.2.2) and thus it is expected that construction will have less of an effect than operations. As a result, the assessment of the maximum operation scenario adequately encompasses construction emissions. Therefore, construction was not carried through to modelling.

Table 4-6 Construction Emission Rate Summary

Site	Emission Rate (g/s)					
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
Kiggavik Mine Site	12.50	12.50	12.50	14.40	0.08	3.06
Sissons Mine Site	21.20	21.20	21.20	14.40	0.08	3.06
Quarry (one)	2.87	1.18	0.89	2.59	0.03	0.71

4.2.1.2 Access Road Construction

The primary activity occurring during construction of the access roads is quarrying. Typical aggregate handling and processing activities were assumed to occur, including:

- material extraction and handling;
- primary crushing;
- screening; and,
- secondary crushing.

A conservatively high processing rate of 300 tonnes of aggregate per hour was assumed for a 10 hour working day (7 a.m. to 5 p.m.).

Dust and gaseous emission rates from quarrying activities are also provided in Table 4-6. A comparison of emissions between quarry activities and emissions from the maximum operation scenario would not be appropriate in this case since potential effects from the quarries would be expected to affect areas far removed from the area affected by on-site mining activities. As a result, the quarries were modelled separately.

4.2.2 On-Site Operation

The on-site operation assessments (both the phased scenarios and the maximum operation scenario) included operations occurring in the Mine Development Area (i.e., the Kiggavik and Sissons mine sites). Note that on-site also encompasses the 20 km Kiggavik-Sissons access road.

4.2.2.1 Phased Operation Assessment

Period 1 – Represented by Year 0 and 1

During Year 0, construction of the Purpose Built pit is scheduled to occur. However, as a conservative measure it was assumed that activities associated with developing the Purpose Built pit will occur simultaneously with the activities scheduled for Year 1. Year 1 marks the first year of mining operations at the Kiggavik site. The mining of both the East Zone and Centre Zone pits will both begin and end in Year 1 while the mining of the Main Zone East pit will only begin by years end. The mined-out pits will then be prepped and converted to TMFs.

At the end of Year 1, approximately 900 kt of ore is estimated to be removed. All ore removed from the pits will be stockpiled until mill production begins (by the end of the period). The total annual uranium production is estimated to be marginally greater than 300 tonnes. The average grade of mill feed was estimated to be 0.46% uranium.

Table 4-7 provides a summary of air emissions for all major sources active in Period 1. The principal sources of dust during this period are related to activities at the north clean mine rock pile and Centre Zone pit, followed by on-site roads. The main contributors to uranium emissions during this period are mining activities at East Zone and Centre Zone pits followed by the north Type II mine rock stockpile and the ore pile.

Period 2 (Year 2-5) - Represented by Year 4 and 5

During this period, operations at the Kiggavik mine site will include mining of Main Zone pit and ramping up production at the mill. Mid-way through this period, mining at Main Zone East pit is scheduled to be completed and preparations will begin to convert the pit into a third TMF. Since the latter half of this period (Years 4 and 5) were selected as the representative years, Main Zone East pit was considered be a TMF while Main Zone West pit was considered to be actively mined.

At Sissons, the development of the Andrew Lake open pit and End Grid underground mine will commence in Year 2. Only overburden and mine rock will be removed from Andrew Lake pit during this time. At End Grid mine, primarily mine rock will be removed until Year 5 when it is expected that the ore deposit will be reached.

Ore stockpiled in Year 1 as well as ore removed from Main Zone pit during this period will be processed consecutively. It was assumed that End Grid ore will be stockpiled at the mill until Year 6. Mill production will be ramped up during Year 2 and during this period it is estimated that 13,640 tonnes of uranium will be generated. The average uranium grade was estimated to be 0.49% for this period.

Table 4-8 summarizes air emissions for all sources active in Period 2. The main sources of uranium emissions at Kiggavik are Main Zone West pit, the south Type II mine rock stockpile and the ore pile. At Sissons, Andrew Lake pit, the End Grid ventilation exhaust and the Type II mine rock stockpile are the largest uranium sources. Dust emissions at Kiggavik are principally associated with Main Zone West pit activities and the south Type II mine rock stockpile, followed by unpaved roads, particularly open pit ramps. Similarly, the main sources of dust at Sissons are mining activities associated with Andrew Lake pit, the Type II mine rock stockpile and unpaved roads.

Period 3 (Year 6-13) - Represented by Year 6 and 9

By the end of Year 5, mining of the Main Zone West pit will be complete and preparations will begin to convert this pit into the final TMF. The Andrew Lake and End Grid ore deposits will continue to be mined and by the end of the period, extraction will be complete. Any remaining ore from the Main Zone pit as well as ore extracted from Andrew Lake and End Grid will be processed in the mill. The average grade of mill feed was estimated to be 0.47%.

Table 4-9 summarizes air emission rates for all sources active in Period 3. Uranium emissions are predominantly associated with the ore pile and milling activities at the Kiggavik site. At the Sissons site however, emissions of uranium can be attributed to mining activities associated with Andrew Lake pit and End Grid. Dust at Sissons is emitted primarily from Andrew Lake pit, the Type II mine rock stockpile and unpaved roads.

Period 4 (Year 14)

During this period, operations will include only the processing of remaining ore from Andrew Lake pit and End Grid mine. The average grade of mill feed was assumed to be 0.67% uranium.

Table 4-10 provides a summary of the air emission estimates for all relevant sources for Period 4. Emissions are mostly associated with mine rock stockpiles as well as the Kiggavik power plant.

Table 4-7 Period 1 (Year 0 - 1) Emission Rate Summary

Location	Source	Emission Rate (g/s)							
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	3.0E+00	1.2E+00	2.9E-01	3.8E-04	2.7E+00	3.8E-01	1.3E+01	2.3E+05
	Main Zone West Open Pit	-	-	-	-	-	-	-	-
	Centre Zone Open Pit	1.4E+01	4.3E+00	6.9E-01	4.5E-03	5.7E+00	4.0E-01	1.4E+01	4.2E+05
	East Zone Open Pit	4.6E+00	1.7E+00	3.6E-01	1.1E-02	3.1E+00	3.8E-01	1.3E+01	1.7E+06
	Purpose Built Open Pit	1.7E+00	8.3E-01	2.4E-01	4.3E-04	2.0E+00	3.7E-01	1.3E+01	3.1E+04
	Kiggavik Clean Rock Pile - South	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - North	2.8E+01	7.7E+00	1.0E+00	4.3E-03	2.0E+00	1.0E-02	6.3E-01	7.0E+05
	Kiggavik Overburden Pile	5.7E+00	1.7E+00	2.8E-01	5.7E-05	5.7E-01	5.6E-03	1.7E-01	1.2E+04
	Kiggavik Ore Stockpile	5.4E-01	2.7E-01	9.8E-02	2.5E-03	2.6E-02	7.5E-03	7.2E-03	1.3E+06
	Kiggavik Mine rock Pile	8.4E-01	2.7E-01	1.1E-01	7.6E-04	3.9E-01	1.4E-02	1.9E-02	7.1E+05
	Mill	8.8E-02	4.5E-02	1.3E-02	1.2E-04	1.1E-02	2.9E-04	5.6E-03	8.4E+04
	Acid Plant	-	-	-	-	3.9E-03	2.4E-02	6.2E-03	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	-
	On-Site Roads at Kiggavik	9.5E+00	2.5E+00	2.8E-01	9.5E-05	1.2E+00	1.8E-03	3.7E-01	-
Sissons Site	Andrew Lake Open Pit	-	-	-	-	-	-	-	-
	Andrew Lake Mine rock Pile	-	-	-	-	-	-	-	-
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-
	Andrew Lake Ore Stockpile	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	-	-
	End Grid Ore Stockpile	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	-	-	-	-	-	-	-	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	-	-	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	5.5E-04	-

Table 4-8 Period 2 (Year 2 - 5) Emission Rate Summary

Location	Source	Emission Rate (g/s)							
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	-	-	-	-	-	-	-	3.0E+02
	Main Zone West Open Pit	3.8E+01	1.1E+01	1.4E+00	2.0E-02	8.6E+00	4.0E-01	1.5E+01	1.4E+06
	Centre Zone Open Pit	-	-	-	-	-	-	-	9.0E+02
	East Zone Open Pit	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Open Pit	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - South	2.1E+01	6.1E+00	9.8E-01	4.2E-03	1.4E+00	7.3E-03	4.4E-01	1.3E+06
	Kiggavik Clean Rock Pile - North	1.6E+00	8.1E-01	3.3E-01	2.5E-04	-	-	-	6.7E+05
	Kiggavik Overburden Pile	5.3E-01	2.6E-01	1.1E-01	5.3E-06	-	-	-	1.4E+04
	Kiggavik Ore Stockpile	7.0E-01	3.5E-01	1.1E-01	3.4E-03	2.0E-01	1.1E-02	5.4E-02	1.8E+06
	Kiggavik Mine rock Pile	8.2E-01	2.7E-01	1.1E-01	7.4E-04	3.8E-01	1.4E-02	1.7E-02	7.6E+05
	Mill	9.4E-01	4.8E-01	1.4E-01	1.3E-03	1.2E-01	3.0E-03	5.9E-02	1.2E+06
	Acid Plant	-	-	-	-	4.1E-02	2.6E-01	6.6E-02	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	-
	On-Site Roads at Kiggavik	9.9E+00	2.6E+00	2.9E-01	9.9E-05	1.2E+00	1.8E-03	3.8E-01	0.0E+00
Sissons Site	Andrew Lake Open Pit	9.2E+00	3.0E+00	5.4E-01	1.8E-03	4.2E+00	3.9E-01	1.3E+01	5.9E+05
	Andrew Lake Mine rock Pile	-	-	-	-	-	-	-	-
	End Grid Special Waste Pile	6.3E-01	1.9E-01	8.8E-02	1.3E-03	-	-	-	2.0E+05
	End Grid Clean Waste Pile	6.4E-01	2.0E-01	8.9E-02	1.6E-04	-	-	-	3.1E+04
	Andrew Lake Ore Stockpile	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	5.0E-01	2.5E-01	1.0E-01	5.0E-06	-	-	-	1.3E+04
	Andrew Lake Clean Rock Pile	1.9E+01	5.7E+00	1.0E+00	3.7E-03	1.2E+00	5.8E-03	3.7E-01	1.8E+06
	End Grid Ore Stockpile	-	-	-	-	-	-	-	-
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	7.0E-02	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	3.9E-03	-
	Backfill Plant	1.7E-01	5.5E-02	1.2E-02	2.5E-06	-	-	-	-
	End Grid Underground Mine Exhaust	2.0E+00	1.0E+00	3.4E-01	2.2E-03	6.2E+00	9.0E-02	1.1E+00	1.4E+05
	On-Site Roads at Sissons	8.1E+00	2.1E+00	2.4E-01	8.1E-05	1.0E+00	1.5E-03	3.2E-01	-
Roads	Haul road b/n Kiggavik and Sissons	4.9E+00	1.3E+00	1.3E-01	4.9E-05	6.8E-02	4.8E-04	3.4E-03	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.2E-03	6.0E-05	2.9E-04	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	5.5E-04	-

Table 4-9 Period 3 (Year 6 – 13) Emission Rate Summary

Location	Source	Emission Rate (g/s)							
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Open Pit	-	-	-	-	-	-	-	1.6E+03
	Centre Zone Open Pit	-	-	-	-	-	-	-	9.0E+02
	East Zone Open Pit	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Open Pit	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - South	2.3E+00	1.2E+00	4.7E-01	4.7E-04	-	-	-	1.2E+06
	Kiggavik Clean Rock Pile - North	-	-	-	-	-	-	-	6.7E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	1.4E+04
	Kiggavik Ore Stockpile	5.7E-01	2.8E-01	1.0E-01	2.7E-03	9.1E-03	7.3E-03	2.5E-03	1.7E+06
	Kiggavik Mine rock Pile	3.2E-01	1.6E-01	6.3E-02	2.8E-04	-	-	-	7.6E+05
	Mill	1.0E+00	5.3E-01	1.6E-01	1.4E-03	1.3E-01	3.4E-03	6.6E-02	1.1E+06
	Acid Plant	-	-	-	-	4.6E-02	2.9E-01	7.4E-02	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	-
	On-Site Roads at Kiggavik	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.9E-03	1.0E-04	6.9E-04	-
Sissons Site	Andrew Lake Open Pit	5.8E+01	1.6E+01	2.0E+00	2.3E-02	1.1E+01	4.2E-01	1.5E+01	9.9E+05
	Andrew Lake Mine rock Pile	7.2E-01	2.3E-01	1.1E-01	6.5E-04	2.3E-01	1.4E-02	8.2E-03	7.4E+05
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.8E-04	-	-	-	2.6E+05
	End Grid Clean Waste Pile	2.3E-01	1.2E-01	4.6E-02	5.8E-05	-	-	-	3.1E+04
	Andrew Lake Ore Stockpile	2.4E-01	1.2E-01	4.7E-02	1.4E-03	-	-	-	4.4E+05
	Andrew Lake Overburden Pile	5.0E-01	2.5E-01	1.0E-01	5.0E-06	-	-	-	1.3E+04
	Andrew Lake Clean Rock Pile	2.8E+01	8.3E+00	1.4E+00	5.6E-03	1.8E+00	1.6E-02	5.7E-01	2.0E+06
	End Grid Ore Stockpile	2.6E-01	1.3E-01	4.8E-02	1.1E-03	-	-	-	1.3E+05
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	7.0E-02	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	3.9E-03	-
	Backfill Plant	1.9E-01	6.2E-02	1.3E-02	5.0E-06	-	-	-	-
	End Grid Underground Mine Exhaust	2.2E+00	1.1E+00	3.7E-01	7.9E-03	6.2E+00	9.2E-02	1.2E+00	3.5E+05
	On-Site Roads at Sissons	1.3E+01	3.4E+00	3.8E-01	1.3E-04	1.6E+00	2.8E-03	5.1E-01	-
Roads	Haul road b/n Kiggavik and Sissons	1.3E+01	3.3E+00	3.3E-01	1.3E-04	7.8E-02	1.0E-03	5.5E-03	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.2E-03	6.0E-05	2.9E-04	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	5.5E-04	-

Table 4-10 Period 4 (Year 14) Emission Rate Summary

Location	Source	Emission Rate (g/s)							
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Open Pit	-	-	-	-	-	-	-	1.6E+03
	Centre Zone Open Pit	-	-	-	-	-	-	-	9.0E+02
	East Zone Open Pit	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Open Pit	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - South	-	-	-	-	-	-	-	1.2E+06
	Kiggavik Clean Rock Pile - North	-	-	-	-	-	-	-	6.7E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	1.4E+04
	Kiggavik Ore Stockpile	4.7E-01	2.4E-01	1.0E-01	3.1E-03	3.8E-01	2.1E-02	1.0E-01	2.1E+06
	Kiggavik Mine rock Pile	-	-	-	-	-	-	-	7.6E+05
	Mill	1.5E-01	7.7E-02	2.3E-02	2.0E-04	1.9E-02	4.9E-04	9.6E-03	1.5E+05
	Acid Plant	-	-	-	-	6.7E-03	4.2E-02	1.1E-02	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	-
	On-Site Roads at Kiggavik	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.9E-03	1.0E-04	6.9E-04	-
Sissons Site	Andrew Lake Open Pit	-	-	-	-	-	-	-	7.5E+05
	Andrew Lake Mine rock Pile	3.1E-01	1.5E-01	6.2E-02	2.8E-04	-	-	-	7.4E+05
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-
	Andrew Lake Ore Stockpile	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	1.3E+04
	Andrew Lake Clean Rock Pile	3.7E+00	1.9E+00	7.5E-01	7.5E-04	-	-	-	2.0E+06
	End Grid Ore Stockpile	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	-	-	-	-	-	-	-	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.2E-03	6.0E-05	2.9E-04	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	5.5E-04	-

4.2.2.2 Maximum Operation Assessment

For this scenario, operations include the mining of Main Zone West open pit, Andrew Lake open pit and End Grid underground mine. All remaining open pits (East Zone, Centre Zone and Main Zone East) were considered to be TMFs. Approximately 90,000 to 100,000 tonnes of ore and mine rock were conservatively assumed to be removed from Main Zone and Andrew Lake open pits, respectively on a daily basis. In addition, it was assumed that 1,100 tonnes of ore was removed from End Grid underground mine on a daily basis. All mining and supporting activities were conservatively assumed to occur simultaneously.

The ore processed in the mill was conservatively assumed to have the highest estimate of uranium at 0.67%. The mill production rate assessed was 4,000 tonnes of uranium per year.

Table 4-11 provides a summary of COPC emission rates for all sources considered in the maximum operation assessment scenario. Uranium emissions are predominantly associated with the ore pile and milling activities at the Kiggavik site. At the Sissons site however, emissions of uranium can be attributed to mining activities associated with Andrew Lake pit and End Grid. Dust is emitted primarily from unpaved roads, particularly open pit ramps, as well as the Type II mine rock stockpiles.

Table 4-11 Maximum Bounding Scenario Emission Rate Summary

Location	Source	Emission Rate (g/s)								
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	-	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Open Pit	4.4E+01	1.2E+01	1.7E+00	2.4E-02	1.3E+01	9.1E-01	3.2E+01	-	1.1E+06
	Centre Zone Open Pit	-	-	-	-	-	-	-	-	9.0E+02
	East Zone Open Pit	-	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Open Pit	-	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - South	2.1E+01	6.2E+00	9.9E-01	4.2E-03	1.9E+00	2.1E-02	5.0E-01	-	1.3E+06
	Kiggavik Clean Rock Pile - North	1.3E+01	3.6E+00	5.7E-01	2.0E-03	7.5E-01	1.1E-03	2.4E-01	-	6.7E+05
	Kiggavik Overburden Pile	4.3E+00	1.3E+00	2.4E-01	4.3E-05	4.9E-01	7.7E-03	1.2E-01	-	1.5E+04
	Kiggavik Ore Stockpile	7.0E-01	3.5E-01	1.1E-01	4.7E-03	2.9E-02	7.5E-03	8.0E-03	-	2.5E+06
	Kiggavik Mine rock Pile	8.2E-01	2.7E-01	1.1E-01	7.4E-04	2.3E-02	3.5E-04	5.7E-03	-	7.6E+05
	Mill	1.1E+00	5.6E-01	1.6E-01	1.5E-03	1.4E-01	3.6E-03	7.0E-02	-	1.8E+06
	Acid Plant	-	-	-	-	4.9E-02	3.0E-01	7.8E-02	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	1.6E+01	4.1E+00	4.6E-01	1.6E-04	2.0E+00	3.0E-03	6.3E-01	-	-
Sissons Site	Andrew Lake Open Pit	6.7E+01	1.8E+01	2.4E+00	2.8E-02	1.6E+01	9.1E-01	3.3E+01	-	1.6E+06
	Andrew Lake Mine rock Pile	7.6E-01	2.5E-01	1.1E-01	6.8E-04	1.4E-02	2.9E-04	3.2E-03	-	7.5E+05
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.9E-04	-	-	-	-	2.6E+05
	End Grid Clean Waste Pile	2.4E-01	1.2E-01	4.7E-02	6.1E-05	-	-	-	-	3.1E+04
	Andrew Lake Ore Stockpile	2.9E-01	1.4E-01	5.0E-02	1.8E-03	-	-	-	-	5.4E+05
	Andrew Lake Overburden Pile	2.7E+00	8.0E-01	1.9E-01	2.6E-05	2.9E-01	4.7E-03	6.9E-02	-	1.4E+04
	Andrew Lake Clean Rock Pile	3.4E+01	9.8E+00	1.5E+00	6.7E-03	2.8E+00	2.6E-02	7.7E-01	-	2.0E+06
	End Grid Ore Stockpile	2.5E-01	1.3E-01	4.8E-02	1.3E-03	-	-	-	-	1.5E+05
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	7.0E-02	-	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	3.9E-03	4.5E-14	-
	Backfill Plant	1.9E-01	6.2E-02	1.3E-02	5.0E-06	-	-	-	-	-
	End Grid Underground Mine Exhaust	6.4E+00	3.3E+00	1.0E+00	2.1E-02	6.4E+00	1.3E-01	2.3E+00	-	2.8E+05
	On-Site Roads at Sissons	1.5E+01	4.0E+00	4.4E-01	1.5E-04	1.8E+00	2.8E-03	5.8E-01	-	-
Roads	Haul road b/n Kiggavik and Sissons	3.5E+01	9.0E+00	9.0E-01	3.5E-04	1.1E-01	3.0E-03	1.3E-02	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.1E-03	5.6E-05	2.8E-04	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.0E-03	1.8E-06	1.3E-02	3.7E-05	4.8E-04	-	-

4.2.3 Off-Site Operation

4.2.3.1 Access Roads Assessment

An access road will be required for transporting mill reagents, fuel and other supplies to the Kiggavik Project site from Baker Lake. Currently, there are two proposed options carried forward in the air dispersion assessment: a winter access road and an all-season road. There are presently two potential routes for the winter road, a south route and a north route.

The measurable effect of re-suspended road dust is typically limited to within approximately 500 m from the right-of-way. Due to computational constraints as well as the isolated effect of the roadways, each road option was assessed separately from operations within the Mine Development Area (i.e., on-site operations).

Preferred Option: Winter Road

Two potential routes for a winter road were assessed with the south route being the most feasible alternative (see Project Description in Volume 2). Both options are shown in Figure 3. Most of the north route will utilize ice surfaces provided by existing lakes and estuaries, whereas approximately 50% of the south route will cross over land. Over-land crossings will require the construction of either a snow/ice pad over frozen subgrade or a thin pad of granular fill over frozen subgrade. It is estimated that eventually 50% of over-land crossings may consist of granular fill, which was taken into account in the emissions estimates. Table 4-12 summarizes the emission rates calculated for the north and south winter routes.

All-Season Access Road Option

As an alternative to the winter road option, an All-Season Road option was also assessed (see Figure 3). This road will be constructed using granular fill excavated from bedrock quarries located at various locations along the route. Emission rates for the all-season access road can also be found in Table 4-12.

4.2.3.2 Baker Lake Dock Assessment

At the Baker Lake dock and storage facility, sea-containers containing fuel and other supplies will be unloaded from docked barges using a mobile crane. Other equipment required at the dock site includes:

- a shunt/rigging truck;
- a sea-container handler;
- a heavy lift truck; and
- a reach stacker.

Emissions from the operations of the Baker Lake Facility are summarized in Table 4-13.

Table 4-12 Access Road Options Emission Rate Summary

Source	Emission Rate (g/s)					
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
North All-Season Access Road	8.4E+01	2.6E+01	5.5E+00	1.1E-01	5.2E-03	1.8E-02
South Winter Access Road	3.1E+01	7.6E+00	7.6E-01	3.9E-01	2.1E-02	1.2E-01
North Winter Access Road	7.4E+01	1.8E+01	1.8E+00	7.9E-01	4.3E-02	2.4E-01

Table 4-13 Baker Lake Facility Operations Emission Rate Summary

Source	Emission Rate (g/s)					
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
Yard Operations	3.7E-04	3.7E-04	3.6E-04	1.0E-01	1.7E-02	3.2E-03
2 Docked Tug-Barges	1.6E-01	1.6E-01	1.4E-01	3.4E+00	2.1E-01	5.5E-02

4.2.4 Final Closure Assessment

Beginning in Year 14, final closure activities will begin to restore the Project sites back to a near undisturbed state. The first phase of final closure will take approximately two years to complete and will involve the progressive rehabilitation of the mine sites. Activities will include backfilling Type III mine rock (special waste) at Kiggavik and Sissons into Main Zone TMF and Andrew Lake pit, respectively. Other activities include covering Centre Zone TMF with a layer of Type II mine rock (clean waste) from the north Type II mine rock stockpile.

Table 4-14 provides a summary of the air emission estimates for all relevant sources during the final closure phase. Emissions of uranium and radon are mostly associated with the pits being backfilled (Main Zone and Andrew Lake) and with mine rock stockpiles.

4.2.5 Post-Closure Assessment

During the post-closure phase, air emissions are assumed to consist of only radon gas released from the surfaces of Type II mine rock stockpiles and decommissioned TMFs which will be covered with a layer of Type II rock and overburden. Where possible, permanent mine rock stockpiles be stabilized to minimize the release of long-term dust emissions. For the purpose of this assessment, it was assumed that the piles and TMFs will be well compacted and undisturbed such that they are no longer a source of dust emissions. Eventually, vegetation will re-establish which also prevents dust emissions. As such, dust emissions were not considered during this phase.

Table 4-15 provides a summary of the radon emission rates from the permanent Type II mine rock stockpiles and the covered TMFs.

Table 4-14 Final closure Emission Rate Summary

Location	Source	Emission Rate (g/s)							
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	CO	Radon (Bq/s)
Kiggavik Site	Main Zone West Pit	7.4E-01	2.2E-01	8.6E-02	6.7E-04	1.5E-01	2.0E-03	9.0E-03	1.4E+06
	Main Zone East Pit	8.3E-01	2.4E-01	9.4E-02	7.4E-04	1.5E-01	2.0E-03	9.0E-03	8.9E+05
	Centre Zone Pit	7.9E-01	2.3E-01	9.4E-02	1.4E-04	1.7E-01	2.4E-03	8.9E-03	6.8E+04
	East Zone Pit	-	-	-	-	-	-	-	6.2E+04
	Purpose Built Pit	-	-	-	-	-	-	-	-
	Kiggavik Clean Rock Pile - South	-	-	-	-	-	-	-	1.2E+06
	Kiggavik Clean Rock Pile - North	4.8E-01	1.8E-01	5.9E-02	7.4E-05	2.7E-01	2.4E-03	7.6E-02	6.6E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	-
	Kiggavik Ore Pile	-	-	-	-	-	-	-	-
	Kiggavik Mine rock Pile	3.6E-01	1.8E-01	7.1E-02	3.2E-04	2.2E-01	2.0E-03	5.9E-02	7.6E+05
	Mill	-	-	-	-	-	-	-	-
	Acid Plant	-	-	-	-	-	-	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	2.8E-01	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	7.8E-03	-
	On-Site Roads at Kiggavik	2.8E-01	7.2E-02	8.1E-03	2.8E-06	3.6E-02	5.3E-05	1.1E-02	-
Sissons Site	Andrew Lake Pit	1.9E+00	5.4E-01	1.3E-01	8.9E-04	3.3E-01	2.8E-03	5.7E-02	1.8E+05
	Andrew Lake Mine rock Pile	3.7E-01	1.9E-01	7.2E-02	3.2E-04	2.8E-01	2.6E-03	7.5E-02	7.5E+05
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-
	Andrew Lake Ore Pad	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	-	2.0E+06
	End Grid Special Ore Pile	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	3.0E-01	7.9E-02	8.9E-03	3.0E-06	4.0E-02	5.8E-05	1.2E-02	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	-	-	-	-	-	-	-	-
	Road to Airstrip	-	-	-	-	-	-	-	-

Table 4-15 Post-closure Radon Emission Rates

Location	Source Description	Emission Rate (Bq/s)
		Radon
Kiggavik Site	Main Zone East Pit	9.9E+04
	Main Zone West Pit	1.6E+05
	Centre Zone Pit (CZ)	6.8E+04
	East Zone Pit (EZ)	3.1E+04
	Purpose Built Pit (PB)	1.3E+04
	Kiggavik Clean Rock Pile - South	1.2E+06
	Kiggavik Clean Rock Pile - North	6.6E+05
	Kiggavik Overburden Pile	-
	Kiggavik Ore Pile	-
	Kiggavik Mine rock Pile	-
	Mill	-
	Acid Plant	-
	Power Plant at Kiggavik	-
	Incinerator at Kiggavik	-
	On-Site Roads at Kiggavik	-
Sissons Site	Andrew Lake Pit	-
	Andrew Lake Mine rock Pile	-
	End Grid Special Waste Pile	-
	End Grid Clean Waste Pile	-
	Andrew Lake Ore Pad	-
	Andrew Lake Overburden Pile	-
	Andrew Lake Clean Rock Pile	2.0E+06
	End Grid Special Ore Pile	-
	Power Plant at Sissons	-
	Incinerator at Sissons	-
	Backfill Plant	-
	End Grid Underground Mine Exhaust	-
	On-site Roads at Sissons	-
Roads	Haul road b/n Kiggavik and Sissons	-
	Road to Baker Lake (1 km segment modelled)	-
	Road to Airstrip	-

4.2.6 Greenhouse Gas Emissions

The Kiggavik Project will rely on large diesel engines (i.e. in the power plant) to provide electricity, since electric power is not available in such a remote area. It will also require diesel fuel to operate mining equipment and other vehicles such as transport trucks. The combustion of diesel produces greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The main sources of GHGs for the Kiggavik Project include:

- Diesel engines;
- Diesel-powered mine equipment and vehicles; and
- Marine vessels.

Over the lifetime of the Project, fuel usage is estimated to be about 845 million litres and during peak mine production, annual fuel usage is expected to be 65 million litres per year. The following table shows the associated emission factors adapted from Environment Canada (Environment Canada 2011) and estimated GHG emissions from the Project. During peak consumption, annual GHG emissions from the Project were calculated to be 181 tonnes of CO_2 equivalent per year.

Table 4-16 Project Greenhouse Gas Emissions during the Peak Production Year

Greenhouse Gas	Emission Factor[(a)]	GWP[(b)]	Estimated GHG Emissions (kt CO_2 eq)
CO_2	2,663	1	173
CH_4	0.133	25	0.22
N_2O	0.4	298	7.7
Total	-	-	**181**

Notes:
[(a)] Emission factors from Environment Canada's GHG Emissions Quantification Guidance available at www.ec.gc.ca/ges-ghg/
[(b)] GWP = global warming potential. As per values indicated in the IPCC's 4th Assessment Report, 2007

Project-related GHG emissions were compared to the baseline levels outlined in Section 3.2. This comparison is presented in the table below. On an annual basis, the Project represents a 25% increase in the baseline GHG emissions for Nunavut and a 0.02% increase in the baseline GHG emissions for Canada.

Table 4-17 Project Contribution to Canada and Nunavut Greenhouse Gas Emissions

Region[(a)]	Baseline GHG Emissions (kt CO_2 eq)	Total GHG Emissions[(b)] (kt CO_2 eq)	Contribution of Project to Total GHG Emissions
Canada[(a)]	734,191	734,372	0.02%
Nunavut	552	733	25%

Notes:
[(a)] Includes 2008 Environment Canada reported GHG emissions and Meadowbank Gold Mine GHG emissions estimate of 191 kt of CO_2-equivalent
[(b)] Baseline GHG emissions + peak annual emissions from the Project

In general, it is expected that the Project will noticeably contribute to Nunavut's overall GHG emissions total. However, it is also expected that other proposed projects will be operational when the Project commences operations, therefore, the contribution to Nunavut GHG emissions will likely be a smaller fraction relative to the total emissions.

5 AIR DISPERSION MODELLING

Air dispersion modelling of atmospheric emissions from the Kiggavik Project was undertaken to predict the potential air quality effects due to activities occurring over the lifetime of the Project up to and including the post-closure phase. As discussed in Section 1.2, modelling results were also used to assess the potential effects to the aquatic environment (Volume 5) and terrestrial environment (Volume 6), and to assess the potential risk to ecological and human health (Volume 8).

This section of the report provides an overview of the CALMET/CALPUFF modelling package and outlines how air dispersion modelling was carried out for the various scenarios considered in the assessment. Additional details about each modelling assessment are provided in Attachment C.

5.1 CALMET/CALPUFF MODELLING PACKAGE

To evaluate the effects of the Kiggavik Project on the local and regional atmospheric environment, air dispersion modelling was performed using the CALMET/CALPUFF modelling package, a current, state-of-the-art dispersion model. The CALPUFF model was selected for this study because of the model's ability to handle both complex meteorology and an array of multiple emissions sources from facilities and activities located over a large area. Also, the meteorological conditions in the LAA and RAA are unique and the CALMET/CALPUFF model set is better able to simulate the meteorology and dispersion in this area. CALPUFF is also one of the air dispersion models currently accepted by the US EPA for regulatory compliance modelling.

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of varying meteorological conditions in time and space on COPC transport (Scire et al. 1999). CALMET is an advanced non-steady-state diagnostic meteorological model that produces hourly three-dimensional gridded wind fields from available meteorological, terrain and land use data (Scire et al. 2000a). CALPUFF runs in conjunction with CALMET to estimate the concentration or deposition value for each source-receptor combination for each hour of input meteorology. It can calculate short-term averages such as 1-and 24-hour or annual averages for COPCs of interest. In this assessment, Version 6.326 of the CALMET model and Version 6.262 of the CALPUFF model were used (which are the most recent versions at the time the modelling was undertaken).

5.1.1 Model Uncertainty

Air dispersion modelling is used to predict the incremental level of selected COPCs within a modelling region or domain; however, there are often uncertainties regarding a model's ability to predict concentrations accurately. The processes of atmospheric motions and turbulence are simplified in dispersion models. This is a limitation of a model's ability to accurately predict atmospheric concentrations and deposition rates, and therefore introduces uncertainty. In general, air dispersion models accurately but conservatively predict atmospheric concentrations and deposition levels so that model results are often interpreted with the understanding that the predicted effects are likely overestimated. Model capability to predict an ensemble average for a given set of meteorological conditions is also restricted by limitations in the meteorological input data.

An accepted dispersion model (i.e., CALPUFF) was selected for this assessment to minimize some of these uncertainties. The main reasons for choosing a model set like CALMET/CALPUFF are:

- it is applicable to spatial scales ranging from a few kilometres to more than 100 kilometres;
- it includes wet and dry removal processes (i.e., deposition);
- it includes both SO_2 and NO_x chemistry which is required to predict Potential Acid Input (PAI);
- wind speed and wind direction vary in three (3) spatial dimensions and in time, providing for a more realistic simulation of plume movement;
- its ability to handle calm wind conditions (wind speeds less than 0.5 m/s); and
- it is based on sound, openly documented physical principles that have undergone independent review.

5.2 AIR DISPERSION METEOROLOGY

The CALMET meteorological model was used to simulate meteorological conditions in the assessment area (LAA and RAA) for a one year period (August 15, 2009 to August 14, 2010). This period was selected to correspond with local meteorological observations collected at the site specific Pointer Lake station. The CALMET simulation was initialized with Nonhydrostatic Mesoscale Model (NMM) analysis data obtained from the National Centre for Environmental Prediction (NCEP). This data was modified using surface observations (i.e., weather data) from the local Pointer Lake meteorological station and a combined dataset utilizing data from two regional Environment Canada stations: the Baker Lake Airport station; and the Baker Lake climate station.

CALMET requires geophysical data in order to develop the wind fields and other meteorological parameters required for air dispersion modelling. Geophysical data includes:

- Terrain elevation data
- Land use data
- Surface roughness length
- Albedo
- Bowen ratio
- Soil heat flux
- Vegetation leaf area index
- Anthropogenic heat flux

These parameters and other details about the development of the meteorological dataset are described in Attachment C.

5.3 MODELLING APPROACH

The following sections describe the general approach taken, including source setup, for each of the assessment scenarios. The source parameters used and additional details are provided in Attachment C.

5.3.1 Mine Development Area

A similar source setup and modelling domain were used to model the Kiggavik and Sissons mine sites for both the operation phase of the Project as well as the final closure and post-closure phases. An overview of the modelling approach is provided below.

5.3.1.1 Source Setup

Three types of sources were used to assess emissions from the Kiggavik and Sissons mine sites: area sources; volume sources; and point sources. An area source is typically used to represent emissions released from a flat surface or elevated area, with little or no vertical depth. Conversely, volume sources generally represent emissions released from sources with vertical depth, where the emissions are released along the entire height (such as a stockpile). Point sources are used to represent emissions from defined exhaust points such as stacks and/or vents.

The open pits at each site were modelled as area sources, whereas ore and mine rock stockpiles, roads and the mill were modelled as volume sources. Point sources include the stacks on the acid plant, power plants, incinerators, the backfill plant and the underground mine ventilation exhaust. Figure 4 and Figure 5 show the modelled source configuration superimposed on the Kiggavik and Sissons site layouts, respectively.

Area sources

Emissions from open pits are typically released at ground-level and are therefore best represented by area sources. Due to limitations in the area source module in CALPUFF, the source is restricted to being a 4-sided polygon and cannot be larger than the meteorological grid dimensions (i.e., 1 km). As a result, the larger open pits including Main Zone, Andrew Lake and Centre Zone were subdivided into several smaller area sources to accommodate these limitations. The total emissions for each open pit were divided by the total area of the sources for input into the model.

The CALPUFF model lacks an algorithm that properly represents emissions released from an open pit. A portion of the emissions released in an open pit are generally retained within the pit, due to reduced circulations and impaction on the pit walls. As a result, emissions of particulate-based COPCs such as TSP and metals were reduced by a factor of 2 to account for pit retention. In other words, it was assumed that 50% of the particles emitted are retained in the pit.

Volume Sources

In this assessment, stockpiles and the mill were modelled using the volume source module. The volume source module in CALPUFF offers an advantage from an applications perspective compared to the area source module since there are no limitations related to the source size relative to the meteorological grid. However, volume sources are characterized as equal-sided areas with varying height. Thus in order to properly represent the area of larger sources such as the permanent Type II mine rock stockpiles, it was necessary to use several volume sources to represent a single source.

Emissions from the unpaved roads (expect pit ramps) were modelled as a series of volume sources. Emissions from pit ramps were included as part of the open pit area sources. The spacing of the volume sources along a road (and thus the ultimate number of volume sources used to represent each road) depended on the length of the road being modelled. The criteria used to determine the volume source spacing is shown in Table 5-1.

Table 5-1 Volume Source Spacing Criteria for Modelling Unpaved Roads

Roadway Length (m)	Volume Source Spacing (m)
< 100	10
101 - 499	20
500 -1000	50
> 1000	100

Point Sources

Stack emission sources (i.e., point sources) include the underground mine ventilation exhaust, the acid plant, the power plants, the incinerators and the backfill plant. Stack parameters were either obtained from information provided by the design team where available, or estimated using engineering estimates (see Attachment C).

Buildings or other solid structures may affect the flow of air in the vicinity of a point source and cause eddies to form on the downwind side of a building during certain meteorological conditions (known as downwash). CALPUFF possesses a building downwash algorithm called the Plume Rise Model Enhancement (PRIME) for point sources. PRIME is designed to incorporate the two fundamental features associated with building downwash: 1) enhanced plume dispersion coefficients due to the turbulent wake; and 2) reduced plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake. The point sources and the main buildings located at the Project site which influence building downwash are presented in Figure 6.

Variable Emissions Option

As previously mentioned, monthly average concentrations were required as inputs to the pathways model (Volume 8) and as a result, emissions were varied on a monthly basis. To model changing emissions, the variable emissions option was selected in CALPUFF for all applicable sources/COPCs.

5.3.1.2 Modelling Domain and Receptors

The modelling domain includes the LAA and RAA as defined previously in Section 2.1.3 – Spatial Boundaries. Both study areas were also depicted in Figure 2.

Ground-level concentrations and deposition rates were modelled at defined receptor locations within the modelling domain. A 5 km receptor grid spacing (i.e. the distance between the receptors) was used within the RAA or areas in the domain which are further from major emission sources. Within the LAA, a receptor grid with a spacing of 1 km was used; however, a denser 500 m grid was used over the Kiggavik and Sissons mine sites. This was done to better predict any potential effects in the immediate vicinity of the major emission sources. In addition, receptors were placed at a distance of 50 m and 200 m from all roadways except the on-site mine roads (i.e. those located within the project footprint). Since the configuration of the on-site mine roads is more complex and the roads are particularly close to other emission sources (e.g., stockpiles), this type of spacing cannot be used as it often results in an erratic receptor grid. Collectively, this group of receptors is known as the receptor grid.

Air quality concentrations were also predicted at three (3) sensitive points of reception (POR) for the purpose of completing the ecological and human health risk assessments (Volume 8) and presented in Table 5-2. All receptors, including the receptor grid and sensitive POR are shown graphically in Figure 7.

Table 5-2 Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)	
	Easting	Northing
Kiggavik Accommodation Complex	564900	7148433
Community of Baker Lake	644179	7135840
Judge Sissons Lake Cabin	566550	7137729

5.3.2 Access Roads

As mentioned previously, the effect of emissions of surface suspended road dust is typically limited to within about 500 m from the road right-of-way. As a result, the effects of the access roads are expected to be isolated to within a few hundred metres extending on either side of the roadway. Due to computational limitations, the Kiggavik-Baker Lake access road options were modelled separately from activities occurring within the Mine Development Area. However, a 1 km stretch of Kiggavik-Baker Lake access road was included in the modelling of the Mine

Development Area in order to capture any localized effects of this roadway in the immediate vicinity of the Kiggavik site. Combined effects from the remainder of the roadway and on-site mine operations are not expected, particularly in the LAA.

Since only one road option will ultimately be chosen for the Project, each of the three options was assessed independently. Only TSP, PM_{10}, $PM_{2.5}$ and tailpipe exhaust gases were assessed since the road fill is considered clean and uranium and metals bearing materials will not be transported on this road. An overview of the modelling approach is provided below.

5.3.2.1 Source Setup

Similar to the on-site mine roads and the Kiggavik-Sissons access road, volume sources were used to model emissions from the Kiggavik-Baker Lake access road options. The volume sources were spaced at a distance of 500 m apart covering the length of the entire roadway. Calculated emissions were distributed equally among the sources. In all, there were 226 sources for the All-Season Access Road, 212 for the South Winter Road and 257 for the North Winter Road.

Variable emissions were also applied to the emission sources in this assessment to account for differing summer/winter dust control options for the All-Season Road and to represent the limited operating window for the Winter Road Options. It was assumed that emissions would only occur for the months December through March for the winter options (i.e. the total amount of traffic would be compressed into a 4 month period). In all other months emissions were set to zero in the model.

5.3.2.2 Modelling Domain and Receptors

The same RAA that was used to model the Mine Development Area was used to model the access road options. The same 5-km receptor spacing was also used in the RAA as well as the sensitive POR shown previously in Table 5-2. Receptors were also placed parallel to the roadway at a distance 500 m apart for varying distances of 50 m, 100 m, 250 m and 500 m from the roadway. The modelling domain and receptors for each of the road options are shown in Figure 8.

5.3.3 Quarries

As discussed in Section 4.2.3 above, the All-Season Road option, as well as sections of the Winter Road options will be constructed using quarried bedrock material from locations along the access routes. The possible quarry locations are shown in Figure 9. Since most of these quarries are quite removed from the mine site, their effects were assessed separately. As well, only TSP, PM_{10}, $PM_{2.5}$ and tailpipe gases were assessed since quarried bedrock material is considered to be clean (EcoMetrix 2010).

The quarrying assessment was based on the assumption that activities (and emissions of COPCs) will be the same for each quarry, regardless of the location (Section 4.1.1.8). Therefore, any differences in the predicted potential effects to air quality will occur as a result of localized differences in meteorology and terrain. As a result, three separate quarry locations, Q2, Q10 and Q18, were chosen for assessment to demonstrate possible localized effects of terrain and meteorology. Note that Q18 is also the closest quarry to the community of Baker Lake.

Even though the quarries will be developed one at a time as road construction progresses, they were modelled together. Since the quarries are located relatively far apart any effects are expected to be isolated. Additionally, quarry activities will be of short duration (i.e., months) therefore, annual effects were not assessed. Furthermore, quarrying activities were also assumed to occur over a typical 10 hour working day.

5.3.3.1 Source Setup

Each of the three quarries was modelled as 30 m by 30 m volume sources each having the same emission rates. The size was chosen to reflect a typical working area.

The hourly emissions profile was also selected to reflect a typical 10 hour working day from 7 a.m. to 5 pm.

5.3.3.2 Modelling Domain and Receptors

The RAA having a 5 km receptor spacing was used since this area encompasses all of the quarries. Additionally, a localized receptor grid with 500 m spacing was placed over top of each of the quarry locations. Sensitive POR as shown in Table 5-2 were also included. The modelling domain and receptors used for the quarry assessment are shown in Figure 10.

5.3.4 Baker Lake Dock Facility

A model run was completed to assess the air quality effects from the day-to-day operations occurring at the Baker Lake dock and storage facility. Typical operations assessed include dock yard activities (i.e., stacking sea-containers) and tug-barge manoeuvring. An overview of the source setup and modelling domain is provided below.

5.3.4.1 Source Setup

Emissions from the dock yard were represented by a series of volume sources. Two manoeuvring tug-barges were also modelled as volume sources assuming they were near the dock site in the water. Due to limited available information, many of the source parameters were based on assumptions and engineering estimates.

It is anticipated that sea-containers will only be delivered to the Baker Lake dock during a 60 day window during August and September when guaranteed ice-free conditions exist. As a result, the model was only run using August and September meteorology. Operations during these periods were assumed to occur over a 24 hour working day.

5.3.4.2 Modelling Domain and Receptors

The RAA having a 5 km receptor spacing was used to assess the Baker Lake dock and storage facility. Additionally, a receptor grid of 500 m spacing was superimposed over the Facility to assess the potential for local effects. The sensitive POR representing the community of Baker Lake was also included (Table 5-2). The modelling domain and receptors used for assessing the Baker Lake dock and storage facility are shown in Figure 11.

5.3.5 Potential Acid Input

Potential Acid Input (PAI) was estimated using CALPUFF modelling of SO_2 and NO_x with chemical transformation. Emission rates of SO_2 and NO_x from Period 2 (Year 2 to 5) were used in this assessment (see Table 4-8). Since PAI is an annual parameter, one of the modelling scenarios representing the phased operation assessment was selected to determine PAI. This was done since the maximum operation assessment greatly overestimates annual emissions and resulting concentrations. Of all of the phased operational scenarios, Period 2 had the highest SO_2 and NO_x emission rates and as such was selected for this assessment.

Both wet and dry deposition was modelled using the MESOPUFF II chemistry scheme in CALPUFF and expressed as a flux in units of kilograms per hectare per year (kg/ha/yr) (Scire et al. 2000b). The methods used to calculate PAI and sample calculations are provided in Attachment A.

6 MODEL RESULTS AND DISCUSSION

The output from the CALPUFF model is the 1-hour average COPC concentration at each of the modelled receptor points, for each hour of meteorology included in the CALMET data file. This assessment was based on a full year of meteorological data (i.e., 8760 simulated hours). Hourly data is then post-processed to determine the maximum predicted 1-hour average, 24-hour average, monthly or annual concentrations at each of the receptors. Annual particle and gaseous (NO_x and SO_2) deposition (i.e., g/m²/s) can also be determined.

The results from the air dispersion modelling have been presented in graphical format with complete results provided in Attachment D. Contour plots have been created for all modelled scenarios including phased operations, maximum operations, and the access road, Baker Lake dock and quarry assessments. For selected COPCs, the results have also been presented in tabular form for the three sensitive points of reception (POR) (Table 5-2) and compared to applicable criteria, standards, objectives or guidelines.

Concentrations presented and discussed herein are incremental concentrations above and beyond existing baseline air quality conditions. As discussed in Section 3.1.3, due to the pristine nature of the existing environment at the Project sites, it was assumed that annual and 24-hour baseline concentrations of the various COPCs considered in this assessment would have a minimal contribution to the total predicted COPC concentrations from the Project.

Graphical and tabular results for the construction assessment (i.e., quarrying) are presented in Section 6.1 below. Operations assessments including the access road options and Baker Laker dock and storage facility assessments are presented in Section 6.2. Results for Potential Acid Input (PAI) are also presented in this section. Finally, results from the final closure and post-closure assessments are outlined in Section 6.3 and 6.4, respectively.

6.1 CONSTRUCTION ASSESSMENT

6.1.1 Quarrying

The effects from three quarries, Q2, Q10 and Q18 were assessed using separate model runs. Since emission rates were assumed to be the same from each quarry, the only differences observed in the predicted concentrations arise from the effects of terrain and meteorology. Furthermore, only short-term effects were assessed since it will likely take only weeks to months to fully extract and process the bedrock material from individual quarries, as discussed in Section 4.2.1.2.

Table 6-1 presents the overall maximum predicted incremental concentration for each of the COPCs assessed. The results from the three selected quarries reflect the potential maximum local effects of any of the individual quarry sites for the project. As can be seen in the table, all

COPCs are well below their respective criteria. Figure 12 presents the maximum predicted 24-hour TSP concentrations in the vicinity of each of the quarries included in the dispersion modelling assessment. The figure shows that the TSP concentrations drop rapidly with distance away from each quarry, with measurable changes in concentration limited to less than 1 km from the edge of each quarry.

Table 6-1 Maximum Incremental COPC Concentrations at 500 m from Selected Quarries

Quarry	UTM Coordinates (m)		Maximum Incremental Concentration at a distance of 500 m from the Quarry						
	Easting	Northing	TSP	PM_{10}	$PM_{2.5}$	NO_2		SO_2	
			24-hour Maximum	24-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum
Q2	573460	7152497	14.6	7.9	6.0	38.6	10.6	0.8	0.2
Q10	615476	7150167	9.5	5.6	4.3	37.2	7.5	0.7	0.1
Q18	642133	7138389	9.9	5.4	4.1	34.1	7.2	0.7	0.1
Air Quality Criteria (µg/m^3)			**120**	**50**	**-**	**400**	**200**	**450**	**150**

6.2 OPERATION ASSESSMENTS

Graphical and tabular results are presented below for the following modelling scenarios:

- phased site operations;
- maximum operations;
- potential acid input (PAI);
- access road options; and
- Baker Lake dock and storage facility operations.

Since the results of the phased operation assessment feed into the pathways model used in the Human Health and Environmental Risk Assessment (Volume 8), it was important to capture the potential effects over longer averaging periods (i.e., annual averages). As a result, emissions for these scenarios represent annual average emission rates and underestimate 1 and 24-hour concentrations. Therefore, only annual averages are presented for the phased operation assessments. On the other hand, the maximum operation assessment was designed to capture potential short-term effects (1- and 24-hour) and represent maximum expected hourly or daily emission rates. This means that annual averages from the maximum operation assessment are greatly overestimated and thus are not presented in this report. As a result, COPCs with only an annual criterion (i.e. radon) are not presented for the maximum operation assessment.

6.2.1 Phased Operation Assessment

The predicted incremental annual concentrations of TSP, NO_2, uranium, and radionuclides (radon, lead-210 and polonium-210) for all phased operational scenarios (Periods 1 – 4, Year 0 to 14) are presented in Tables 6-2 through 6-6 for the sensitive POR. The modelled annual concentrations for these same COPCs for all of the phased operations scenarios are also presented as concentration isopleths over a base map in Figures 13 through 28. As previously mentioned, these are incremental concentrations and do not include background values.

As can be seen in both the tables and figures, all COPCs are well below their respective annual criteria. At the Accommodation Complex, annual TSP and NO_2 concentrations are highest during Period 1 (Year 1 and 0); however, annual concentrations of uranium and radon, are highest during Period 2 (Year 2-5). The Type II mine rock stockpile located at the north end of the mine site has the most influence on TSP and NO_2 concentrations at the Accommodation Complex. This is due to its close proximity to the Complex in addition to the assumed level of activity at this source. The highest level of activity for this stockpile occurred in Year 1, due to the amount of Type II materials removed during the development of the pits, in comparison to the materials removed during all other years. Therefore, it is to be expected that TSP and NO_2 emissions were highest in this year for this particular source.

The main contributors to uranium and radon concentrations at the Accommodation Complex are the Kiggavik ore pile and mill complex. In Year 2, mill production is ramped up and as a result, emissions from both the ore pile and mill are increased compared to Year 1. Year 2 also has a relatively high uranium grade (0.49%). Although Year 14 had the highest uranium grade (0.67%), mill production was assumed to be much less than Year 2.

The concentration contours for TSP are shown in Figures 13 through 16. As can be seen, the concentration values and contour patterns vary depending on the period being assessed. This reflects the dependence of TSP emissions on specific mining activities, particularly haul truck movement in the open pit mines. This effect can be seen when comparing TSP concentrations between Period 2 and 3 at Sissons. The effect of the Andrew Lake open pit greatly increases between Period 2 and 3 due to the increase in development of the pit. Also, in Period 3, the influence of unpaved road dust emissions along the Kiggavik-Sissons access road is more apparent.

In general, there are two main emission sources which influence annual NO_2 contour patterns in the LAA. These are the power plant and emissions from mining equipment and vehicles. The contour patterns for Period 1 and 2 at Kiggavik reflect a combination of power plant emissions and equipment exhaust whereas Period 3 and 4 show the effect of the power plant. Other sources of NO_2 are also present, but are only minor contributors to the off-site NO_2 concentrations. A similar effect can be seen at Sissons. Between Period 2 and 3, NO_2 concentrations increase, reflecting the increase in mining activities at this site. Note that during Period 1 and 4, neither mining activities nor the power plant were assumed to be active at Sissons.

Uranium and radon contour plots during Period 1 and 2 at Kiggavik show the influence of both mining activities and mill operations. During Period 3 and 4, uranium and radon concentrations are primarily a result of mill emissions including the ore pile. At the Sissons site, uranium and radon emissions are simply a result of mining activities during Period 2 and 3.

The remaining contour plots for PM_{10}, $PM_{2,5}$, SO_2, metals, Po-210 and Pb-210 are provided in Attachment D with metals demonstrating similar trends to TSP, and Po-210 and Pb-210 having a similar contour pattern to that of uranium.

Table 6-2 Incremental Annual TSP Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Annual TSP Concentration ($\mu g/m^3$)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	19.6	14.3	4.82	1.40
Community of Baker Lake	644179	7135840	0.01	0.02	0.01	0.00
Judge Sissons Lake Cabin	566550	7137729	0.53	0.77	0.41	0.05
Air Quality Criteria ($\mu g/m^3$)			**60**			

Notes:
TSP AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.

Table 6-3 Incremental Annual NO_2 Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Annual NO_2 Concentration ($\mu g/m^3$)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	13.6	10.4	6.22	6.60
Community of Baker Lake	644179	7135840	0.03	0.04	0.04	0.03
Judge Sissons Lake Cabin	566550	7137729	0.78	0.80	0.59	0.40
Air Quality Criteria ($\mu g/m^3$)			**100**			

Notes:
NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table 6-4 Incremental Annual Uranium Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Annual Uranium Concentration ($\mu g/m^3$)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	1.20E-02	1.70E-02	1.00E-02	6.60E-03
Community of Baker Lake	644179	7135840	1.10E-05	1.70E-05	1.60E-05	2.40E-06
Judge Sissons Lake Cabin	566550	7137729	4.30E-04	6.30E-04	4.10E-04	8.30E-05
Air Quality Criteria ($\mu g/m^3$)			**0.03**			

Notes:
Uranium AQ criteria adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table 6-5 Incremental Annual Radon Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Annual Radon Concentration (Bq/m^3)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	7.70E+00	1.20E+01	1.10E+01	9.10E+00
Community of Baker Lake	644179	7135840	5.10E-03	8.20E-03	7.90E-03	6.50E-03
Judge Sissons Lake Cabin	566550	7137729	1.90E-01	2.90E-01	2.40E-01	2.00E-01
Air Quality Criteria (Bq/m^3)			**60**			

Table 6-6 Incremental Annual Pb-210 or Po-210 Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Annual Pb-210 or Po-210 Concentration (Bq/m^3)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	1.5E-04	2.1E-04	1.3E-04	8.2E-05
Community of Baker Lake	644179	7135840	1.4E-07	2.1E-07	2.0E-07	3.0E-08
Judge Sissons Lake Cabin	566550	7137729	5.3E-06	7.8E-06	5.1E-06	1.0E-06
Air Quality Criteria (Bq/m^3)			**0.021 (Pb-210) and 0.028 (Po-210)**			

6.2.1.1 Dust Deposition

Table 6-7 presents the predicted average annual and total annual dust deposition levels at the sensitive POR locations for Year 2-5 (Period 2). As is shown in the table, dust deposition values did not exceed the criteria at the sensitive POR locations. These deposition values are further evaluated in Volume 6 – Terrestrial Environment.

6.2.1.2 Potential Acid Input

Table 6-8 provides the estimated annual Potential Acid Input (PAI) values in the LAA. As is shown in the table, PAI values did not exceed either the 0.5 keq/ha/yr or 1.0 keq/ha/year thresholds for moderately sensitive and insensitive ecosystems, respectively (WHO 2000). However there were exceedances of the 0.25 keq/ha/year threshold for sensitive ecosystems to within approximately 1 km of the Project Footprint at the Kiggavik site. These PAI values are further evaluated in Volume 6 – Terrestrial Environment.

Table 6-7 Incremental Annual Average and Total Annual TSP Deposition for Operation Period 2

Receptor Name	UTM Coordinates (m)		TSP Deposition	
	Easting	Northing	Average Annual (g/m²/30 days)	Total Annual (g/m²/year)
Camp	564900	7148433	5.20E-01	6.32E+00
Baker Lake	644179	7135840	1.78E-04	2.17E-03
Judge Sissons Lake	566550	7137729	3.21E-02	3.91E-01
		Air Quality Criteria (µg/m³)	**4.6 g/m²/30 days**	**55 g/m²/year**

Table 6-8 Estimated Annual Potential Acid Input based on Period 2 (Year 2-5) NO_2 and SO_2 Emissions

Parameter	Background PAI (keq/ha/yr)	Total PAI (keq/ha/yr)		Mine Contribution to PAI (%)
		Kiggavik	Sissons	
Max. Annual Average Deposition	0.093	0.294	0.172	68%
Area above 0.17 keq/ha/yr (ha)	0	2200	0	100%
Area above 0.22 keq/ha/yr (ha)	0	730	0	100%
Area above 0.25 keq/ha/yr (ha)	0	225	0	100%
Area above 0.50 keq/ha/yr (ha)	0	0	0	n/a
Area above 1.00 keq/ha/yr (ha)	0	0	0	n/a

Notes:
Thresholds of 0.5 and 1.0 keq/ha/yr correspond to critical loadings for ecosystems moderately sensitive and insensitive to acid input according to the World Health Organization (WHO 2000).
Mine contribution refers to both mine sites, Kiggavik and Sissons.

6.2.2 Maximum Operation Assessment

The predicted incremental concentrations of COPCs are presented in Tables 6-9 through 6-12 for the maximum operation assessment along with their applicable criteria. Contour plots (averaging period depends on the COPC) have also been created. Dust, gaseous compounds and uranium contour plots are presented here. Contour plots for metals generally have similar patterns to that shown for TSP and are thus presented in Attachment D.

It is important to note that the 1-hour and 24-hour isopleths presented do not represent a snapshot in time as the maximum concentrations at each receptor typically occur during different meteorological conditions (i.e., different hours and/or days) and do not occur simultaneously. For example, at a point south of a source, winds blowing from the north in December may give rise to the maximum 24-hour concentration, whereas for a point north of the source, the worst meteorological conditions may occur in January with a different wind direction.

6.2.2.1 Dust (TSP, PM_{10} and $PM_{2.5}$)

The maximum incremental 24-hour average concentrations of TSP, PM_{10} and $PM_{2.5}$ are presented graphically in Figure 29, Figure 30 and Figure 31, respectively. Note that these figures do not represent a snapshot in time since the maximum concentrations at each receptor typically occur during different meteorological conditions (i.e., different hours and/or days) and thus do not occur simultaneously. Results are also presented in tabular format (Table 6-9).

As can be seen in both the tables and figures, concentrations are above applicable criteria for all three size fractions of dust in and around the Kiggavik and Sissons mine sites. Exceedances can be attributed large emissions of dust from open pit mining activities, in particular unpaved road dust generated on the in-pit ramps.

To examine the nature of the predicted exceedances, a frequency analysis was completed for each particulate fraction and the results are presented graphically in Figures 32 through 34. As can be seen in the figures, there are very few exceedances of the criteria for TSP, PM_{10} and $PM_{2.5.}$ In particular, there are no more than 10 days of exceedances per year beyond the footprint of the mine sites (otherwise known as off-site) for TSP, 15 days for PM_{10} and 1 day for $PM_{2.5}$. Additionally, at the Accommodation Complex, there are only 8 out of 365 days where the TSP criterion of 120 $\mu g/m^3$ is exceeded. There are 12 days of exceedances for PM_{10} at the Accommodation Complex and zero days for $PM_{.2.5}$.

6.2.2.2 NO_2 and SO_2

The maximum incremental 1- and 24-hour average concentrations of NO_2 and SO_2 are presented graphically in Figure 35 (1-hour NO_2), Figure 36 (24-hour NO_2), Figure 39 (1-hour SO_2) and Figure 40 (24-hour SO_2). As outlined in Section 6.2.2.1 above, these maximum concentrations do not occur simultaneously, but are the maximum 1- and 24-hour concentrations predicted at each grid point during a one year period. Results are also presented in tabular format (Table 6-10).

As can be seen in both the tables and figures, 1- and 24-hour maximum concentrations of SO_2 are well within the limits of applicable criteria. Similarly, 24-hour NO_2 concentrations meet applicable criteria at most receptor locations except for the areas south of the Main Zone and Andrew Lake open pits (Figure 36). Figure 35 shows that 1-hour NO_2 concentrations are above the criterion of 400 $\mu g/m^3$ in the area surrounding both the Kiggavik and Sissons mine sites. Exceedances can be attributed to large emissions of NO_x from open pit mining activities, including diesel-powered mining equipment and blasting.

As noted in Section 4.1.1.1, blasting emissions tend to only last about 10 to 15 minutes. The tabular results and contours therefore present overestimates of 1-hour NO_2 concentration since the model assumed that emissions from regular mining activities and blasting occurred concurrently each hour for 24 hours a day. In reality, blasting will occur independently of all other mining activities and last a fraction of the time. To better estimate 1-hour NO_2 concentrations from blasting, a separate model run was completed. The day having the maximum 24-hour NO_2 concentration at the Accommodation Complex receptor from the previous assessment was used. The results of this assessment are presented in Table 6-11. As can be seen in the table, the effects from blasting are small compared to regular mining activities which last for several hours a day.

To examine the nature of the predicted exceedances, a frequency analysis was completed for 1- hour and 24-hour NO_2 and the results are presented graphically in Figure 37 and Figure 38, respectively. As Figure 37 shows, there are a limited number of hours where the 1-hour NO_2 concentration is exceeded. The maximum number of exceedances of the 1–hour criterion predicted at an off-site receptor location was 80 hours (about 1% of the time). Also, estimates are conservative since all sources of NO_2 were assumed to be operating simultaneously for all hours of operation. In reality, activities such as blasting do not occur concurrently with other mining activities, and thus the number of one hour exceedances is overestimated as a result (i.e. in reality the emissions occur sporadically for a short period of time, and in order for the exceedance to occur, the emission source would have to be active during that particular hour). There are also very few days (about 1 to 2 days) where 24-hour NO_2 concentrations exceed the criteria of 200 $\mu g/m^3$ beyond the mine footprints.

6.2.2.3 Uranium and Metals

The maximum incremental 24-hour average concentration of uranium is presented graphically in Figure 41. The metal isopleths tend to follow a similar pattern to the 24-hour maximum TSP contour plot (Figure 29) and are provided in Attachment D as a result. As outlined in Section 6.2.2.1 above, these maximum concentrations do not occur simultaneously, but are the maximum 1- and 24-hour concentrations predicted at each receptor point during a one year period. Results are also presented in tabular format (Table 6-12).

All predicted maximum 24-hour metal concentrations are well below applicable criteria. In contrast, predicted maximum 24-hour uranium concentrations are marginally above the recently promulgated Ontario Ambient Air Quality Criterion (AAQC) of 0.3 $\mu g/m^3$. To examine the nature of the predicted exceedances, a frequency analysis was completed and the results are presented in Figure 42. At the Accommodation Complex, the 24-hour uranium AAQC is only exceeded once out of 365 days (Table 6-12). Figure 42 also indicates that the number of exceedances within about 1 km of the Kiggavik mine site is limited to 1 day. Similarly, within about 500 m or less of the Sissons site, exceedances are also limited to 1 day out of 365.

Table 6-9 Incremental Maximum 24-hr Concentrations of TSP, PM_{10} and $PM_{2.5}$ at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		TSP ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)		$PM_{2.5}$ ($\mu g/m^3$)	
	Easting	Northing	Incremental 24-hr Maximum	Frequency of Exceedances 24-hr Max (days per year)	Incremental 24-hr Maximum	Frequency of Exceedances 24-hr Max (days per year)	24-hr 98th Percentile	Incremental 24-hr Maximum
Accommodation Complex	564900	7148433	**283.2**	8	**115.2**	12	14.13	22.5
Community of Baker Lake	644179	7135840	0.7	n/a	0.6	n/a	6.1E-02	0.2
Judge Sissons Lake Cabin	566550	7137729	12.8	n/a	11.1	n/a	0.88	2.0
Air Quality Criteria ($\mu g/m^3$)			**120**	-	**50**	-	**30***	-

Notes:
Red text indicates that a value is greater than the air quality criteria.
TSP AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} AQ criteria adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
* Canada-Wide Standard for $PM_{2.5}$ based on the average 98th percentile over 3 consecutive years. Note that modelling only occurred over 1 year.

Table 6-10 Incremental Maximum 1- and 24-hr Concentrations of NO_2 and SO_2 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		NO_2 ($\mu g/m^3$)			SO_2 ($\mu g/m^3$)	
	Easting	Northing	Incremental 1-hr Maximum	Frequency of Exceedances 1-hr Max (days per year)	Incremental 24-hr Maximum	Incremental 1-hr Maximum	Incremental 24-hr Maximum
Accommodation Complex	564900	7148433	380.7	n/a	171.9	41	15.4
Community of Baker Lake	644179	7135840	3.8	n/a	1.0	1.6E-01	3.8E-02
Judge Sissons Lake Cabin	566550	7137729	36.5	n/a	12.9	2.7	0.8
Air Quality Criteria ($\mu g/m^3$)			**400**	-	**200**	**450**	**150**

Notes:
Concentrations predicted as a result of all sources, including blasting.
SO_2 AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table 6-11 Incremental Maximum 1-hour Concentration of NO_2 at Sensitive Points of Reception due to Blasting

Sensitive Point of Reception	UTM Coordinates (m)		NO_2 (µg/m^3)	
	Easting	Northing	1-hr Maximum	Frequency of Exceedances 1-hr Max (days per year)
Accommodation Complex	564900	7148433	37.0	n/a
Community of Baker Lake	644179	7135840	0	n/a
Judge Sissons Lake Cabin	566550	7137729	0	n/a
Air Quality Criteria (µg/m^3)			**400**	-

Notes:
Concentrations predicted as a result of blasting only
NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table 6-12 Incremental Maximum 24-hr Concentrations of Metals at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		24-hour Maximum Concentration (µg/m^3)										
	Easting	Northing	U	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	**3.1E-01**	8.1E-04	5.3E-05	2.6E-02	3.6E-03	6.1E-03	1.8E-02	7.6E-03	1.1E-02	4.9E-04	1.1E-02
Community of Baker Lake	644179	7135840	9.7E-04	8.3E-06	2.7E-07	1.6E-04	1.5E-05	2.8E-05	5.6E-05	1.8E-05	6.0E-05	2.9E-06	4.6E-05
Judge Sissons Lake Cabin	566550	7137729	1.7E-02	1.6E-04	5.7E-06	4.6E-03	2.4E-04	5.0E-04	9.7E-04	3.7E-04	1.3E-03	6.0E-05	7.1E-04
Air Quality Criteria (µg/m^3)			**0.3**	**0.3**	**0.025**	**0.50**	**0.10**	**50**	**0.50**	**120**	**0.2***	**10**	**120**

Notes:
Red text indicates that a value is greater than the air quality criteria. Only one (1)of exceedance was predicted at the Accommodation Complex.
24-hour criteria provided in Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
*Nickel AQ criteria adopted from the Ontario Ministry of Environment's new standard under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.
Uranium AQ criteria adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

6.2.3 Access Roads Assessment

Three separate modelling runs were completed to assess the effects of the proposed access road options for connecting the Project site to the Baker Lake dock and storage facility. All of the predicted particulate matter fractions (TSP, PM_{10} and $PM_{2.5}$) and gaseous compounds (NO_2 and SO_2) were well within the limits of applicable criteria. The overall maximum incremental concentration for each COPC is presented in Table 6-13.

All contour plots are provided in Attachment D, however, for the purpose of comparing and discussing the differences between road options, the predicted incremental annual and 24-hour maximum concentrations of TSP for all road options are presented graphically in Figures 43 through 48. As noted in Section 6.2.2.1, the 24-hour isopleths do not represent a snapshot in time as the maximum concentrations at each receptor typically occur during different meteorological conditions (i.e., different hours and/or days) and do not occur simultaneously.

It can be seen in Table 6-13 and in the figures that the least favourable option in terms of dust concentrations is the All-Season Access Road for either long term (annual) or short term (1- and 24-hour) periods. This roadway will be completely constructed with granular fill, and as such dust emissions are greater than the winter road options. The winter road options have a lower potential for emissions, since only limited sections of these roadways are constructed with granular fill over a frozen subgrade and the remainder of the roadway consists of ice. In contrast, gaseous compounds have higher 1- and 24-hour concentrations predicted for the Winter Access Road Options. This a result of higher daily traffic counts compared to the All-Season Road. Daily traffic volumes were higher for both of the Winter Road Options because of a narrower operating window of 90 days.

Table 6-13 Overall Maximum Incremental Dust and Gaseous Concentrations predicted for each Access Road Option

Access Road Option	Overall Maximum Incremental Concentration											
	TSP (µg/m^3)		PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)		NO_2 (µg/m^3)			SO_2 (µg/m^3)		
	24-hr Maximum	Annual	24-hr Maximum	Annual	24-hr Maximum	Annual	1-hr Maximum	24-hr Maximum	Annual	1-hr Maximum	24-hr Maximum	Annual
North All-Season Road	54.92	5.11	20.22	1.61	4.36	0.25	1.4E-01	7.0E-02	8.8E-03	1.0E-02	5.4E-03	6.7E-04
North Winter Road	52.76	3.25	17.34	1.01	1.83	0.11	8.4E-01	4.8E-01	2.8E-02	7.3E-02	4.1E-02	2.4E-03
South Winter Road	44.95	1.83	13.10	0.51	1.37	0.05	6.5E-01	4.3E-01	1.7E-02	5.6E-02	3.7E-02	1.4E-03
Air Quality Criteria (µg/m^3)	**120**	**60**	**50**	-	-	-	**400**	**200**	**100**	**450**	**150**	**30**

TSP and SO_2 AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} AQ criteria adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

6.2.4 Baker Lake Dock Assessment

A separate model run was also completed to assess the effects of day-to-day operations at the Baker Lake dock and storage facility. The predicted incremental concentrations of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and gaseous compounds (NO_2 and SO_2) at the receptor representing the community of Baker Lake are provided in Table 6-14. At this sensitive POR, incremental concentrations for all contaminants are well below applicable criteria.

Contour plots showing the incremental concentrations of TSP and NO_2 over short-term averaging periods in and around the Baker Lake dock are provided in Figure 49, Figure 50 and Figure 51. Since the Facility only operates over a 60 day period in August and September, annual concentrations are low (less than 10% of applicable criteria) and are therefore only presented in Attachment D.

Figure 49 shows that incremental 24-hour TSP concentrations are well below the 24-hour criterion of 120 μg/m^3. In contrast, there are exceedances of the 1- and 24-hour NO_2 criteria extending to about 1 km southwest of the Baker Lake dock over the water. These exceedances are a result of NO_x emissions from two manoeuvring tug-barges assumed to be located in and around the dock. However, since it was conservatively assumed that emissions occurred from two tug-barges continuously over 24-hours during the shipping season, concentrations of NO_2 are likely to be overestimated. Nonetheless, the nature of the predicted exceedances for each averaging period was examined. The results for the 1-hour NO_2 frequency analysis are presented in Figure 52 and the results of the 24-hour NO_2 analysis are presented in Figure 53. In all, the maximum number of 1-hour exceedances at any given receptor was 59 hours (or 4% of the time) and the maximum number of predicted 24-hour exceedances was 3 days at the same receptor location. Again, since it was conservatively assumed that two tug-barges were operating continuously over the shipping season, the actual number of exceedances is expected to be much lower.

Table 6-14 Baker Lake Facility Incremental Dust and Gaseous Concentrations predicted at the Community of Baker Lake Point of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Incremental Concentration									
			TSP (µg/m^3)		PM_{10} (µg/m^3)	PM2.5 (µg/m^3)	NO_2 (µg/m^3)			SO_2 (µg/m^3)		
	Easting	Northing	24-hour Maximum	Annual	24-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual
Community of Baker Lake	644179	7135840	8.8E-01	7.7E-05	8.7E-01	8.0E-01	59.86	11.70	0.19	5.51	1.11	0.02
Air Quality Criteria (µg/m^3)			**120**	**60**	**50**	**-**	**400**	**200**	**100**	**450**	**150**	**30**

Notes:

TSP and SO_2 AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} AQ criteria adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.

NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011

6.3 FINAL CLOSURE ASSESSMENT

The predicted incremental annual concentrations of TSP, NO_2, uranium and radon for the final closure phase of the Project are presented in Table 6-15. Contour plots for each of these COPCs are presented in Figure 54, Figure 55, Figure 56 and Figure 57, respectively. Incremental annual concentrations for metals are shown in Table 6-16 however, contour plots for metals are provided in Attachment D since the isolines for metals follow a similar pattern to annual TSP. Note the plots also show incremental concentrations and do not include background values.

As can be seen in both the tables and figures, all COPCs were well below applicable criteria during the final closure phase. Compared to the operational phase, incremental TSP and uranium concentrations are much lower during final closure. Although the amount of Type III mine rock (special waste) handled is comparable to the operation phase, the overall amount of mine rock handled is less. Also, emissions from unpaved roads are not as prevalent during the final closure period.

On the other hand, predicted annual NO_2 concentrations at the Accommodation Complex during this Period are comparable to Period 3 and 4 concentrations. This is due to the fact that the power plant was also conservatively included in the final closure scenario. In reality, power will only be required for the Accommodation Complex and perhaps supporting offices and the concentrations predicted are likely overestimated. Similarly, the radon concentration predicted at the Accommodation Complex during final closure is of the same order of magnitude as radon concentrations predicted during the operation phase of the Project. This is due to the increase in the amount of exposed surface area of special waste. As well, covered TMFs have increased radon emissions compared to unconsolidated and water covered TMFs. Therefore, at this phase of the Project, radon concentrations are comparable to the operation or active mining and milling phase of the Project.

6.4 POST-CLOSURE ASSESSMENT

The only COPC assessed for post-closure was radon, since it was assumed that all final closure activities will be complete and all TMFs consolidated and covered. The incremental annual radon concentrations predicted at sensitive POR during post-closure are presented in Table 6-17 and the annual radon contour plot is provided in Figure 58. As can been seen in both table and figure, the predicted incremental radon concentrations are well below applicable criteria.

Table 6-15 Incremental Annual TSP, NO_2, Uranium and Radon Concentrations during Final closure

Receptor Name	UTM Coordinates (m)		Incremental Annual Concentration			
	Easting	Northing	TSP (µg/m^3)	NO_2 (µg/m^3)	Uranium (µg/m^3)	Radon (Bq/m^3)
Camp	564900	7148433	1.1E+00	6.4E+00	6.7E-04	6.4E+00
Baker Lake	644179	7135840	2.0E-03	6.9E-03	1.0E-06	6.9E-03
Judge Sissons Lake	566550	7137729	5.2E-02	4.3E-01	3.9E-05	4.3E-01
Air Quality Criteria			**60 (µg/m^3)**	**100 (µg/m^3)**	**0.03 (µg/m^3)**	**60 (Bq/m^3)**

Notes:
TSP AQ criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
NO_2 AQ criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.
Uranium AQ criteria adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table 6-16 Incremental Annual Metals Concentrations during Final closure

Receptor Name	UTM Coordinates (m)		Incremental Annual Concentration (µg/m^3)									
	Easting	Northing	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	1.3E-06	6.1E-08	5.6E-05	1.1E-05	3.5E-05	2.5E-05	1.1E-05	2.7E-05	1.5E-06	3.5E-05
Community of Baker Lake	644179	7135840	3.6E-09	1.5E-10	1.3E-07	1.5E-08	4.0E-08	3.5E-08	1.1E-08	5.3E-08	2.7E-09	4.8E-08
Judge Sissons Lake Cabin	566550	7137729	1.3E-07	5.1E-09	4.5E-06	5.3E-07	1.6E-06	1.3E-06	4.5E-07	1.8E-06	9.6E-08	1.8E-06
Reference Level (µg/m^3)			0.06	0.005	0.3	0.02	9.6	0.10	23	0.4	1.9	23

Notes:
24-hour criteria provided in Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
*Nickel AQ criteria adopted from the Ontario Ministry of Environment's new standard under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table 6-17 Post-closure Incremental Annual Radon Concentration

Receptor Name	UTM Coordinates (m)		Radon (Bq/m^3)
	Easting	Northing	Annual Concentration
Accommodation Complex	564900	7148433	1.1E+00
Community of Baker Lake	644179	7135840	3.1E-03
Judge Sissons Lake Cabin	566550	7137729	8.4E-02
Air Quality Criteria (Bq/m^3)			**60**

7 SUMMARY AND CONCLUSIONS

Air emissions inventories were developed and air dispersion modelling was carried out using the CALMET/CALPUFF modelling system. Model results will be used to evaluate the effects of the Kiggavik Project on the atmospheric environment (Volume 4), the aquatic environment (Volume 5), and the terrestrial environment (Volume 6) and will also be used as inputs to the pathways model used to complete the ecological and human health risk assessments (Volume 8).

Over the life of the Project, none of the predicted incremental annual concentrations of dust, uranium, metals, gases or radionuclides exceeded their respective criteria at any of the sensitive points of reception or at receptors located beyond the Project footprint. However, short term (1- and 24-hour) exceedances of particulate (TSP, PM_{10} and $PM_{2.5}$), uranium and NO_2 criteria were predicted as a result of operations including mining and milling activities occurring at the Kiggavik and Sissons sites.

Frequency analyses showed that the number of exceedances resulting from mining and milling operations were limited for each COPC. Specifically, model predicted concentrations at the Accommodation Complex showed 8 days of exceedances of the TSP criterion of 120 µg/m^3 and 12 days of exceedances of the PM_{10} criterion of 50 µg/m^3. There were no predicted exceedances of $PM_{2.5}$ at this location and at off-site locations the number of exceedances of was limited to 1 day. For uranium, exceedances of the 24-hour criterion were limited to 1 day both at the Accommodation Complex and at off-site receptor locations.

In addition, the modelling results show that neither the 1-hour (400 µg/m^3) nor the 24-hour criteria (200 µg/m^3) for NO_2 were exceeded at the Accommodation Complex during mining and milling operations. A maximum of 80 hours of exceedances of the 1-hour criterion occurred (about 1% of the time) and a maximum of 2 days of exceedances of the 24-hour criterion occurred at off-site receptor locations.

The Kiggavik-Baker Lake Access Road options, Baker Lake dock and storage facility operations, and the bedrock quarries were all assessed using separate model runs. With the exception of NO_2 concentrations resulting from dock operations, all predicted incremental annual, 1-hour and 24-hour COPC concentrations for all of these scenarios were well below applicable criteria. A frequency analysis was completed to examine the nature of the 1- and 24-hour NO_2 exceedances resulting from dock operations. The results showed that 1-hour exceedances were limited to 59 hours and 24-hour exceedances, about 3 days.

In general, conservative estimates of particulate matter and nitrogen oxide emissions were used in this assessment and as a result, the number of exceedances is likely to be less than what is predicted in this assessment. Based on the results presented herein, the potential effects to air quality from the proposed Project are expected to be minimal within the Local and Regional Assessment Areas.

7.1 POTENTIAL DUST MITIGATION MEASURES

The exceedances of TSP, PM_{10} and $PM_{2.5}$ criteria can generally be attributed to emissions from unpaved roads at the mine site, including in-pit ramps. Controls such as watering and low vehicle speeds have already been considered in this assessment. Therefore, it is recommended that monitoring of TSP or PM_{10} take place at the Accommodation Complex and other locations proximate to the sites to verify model results. If exceedances are observed, enhanced dust controls such as the application of chemical dust suppressants should be considered at that time.

8 FIGURES

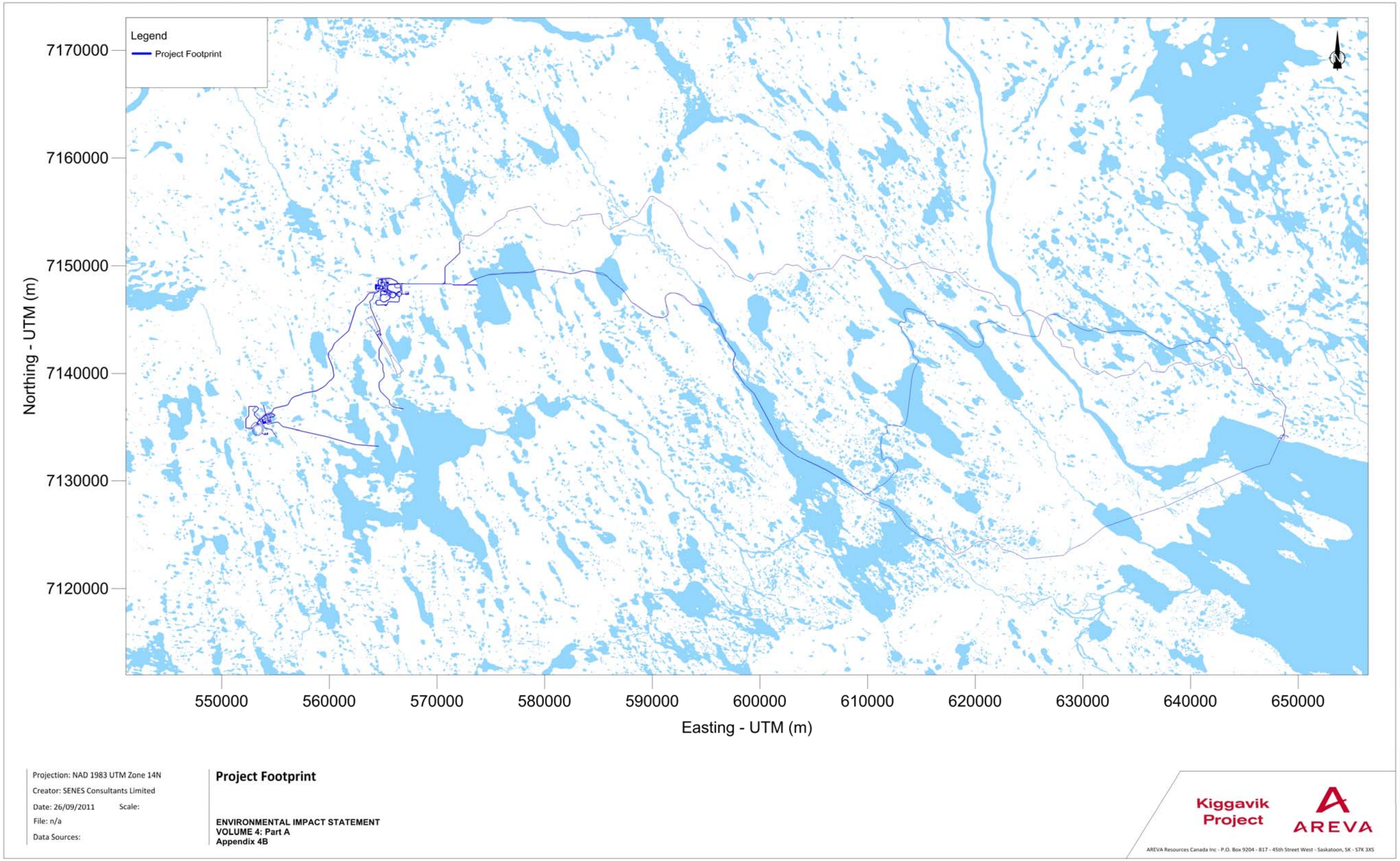


Figure 1 **Project Footprint**

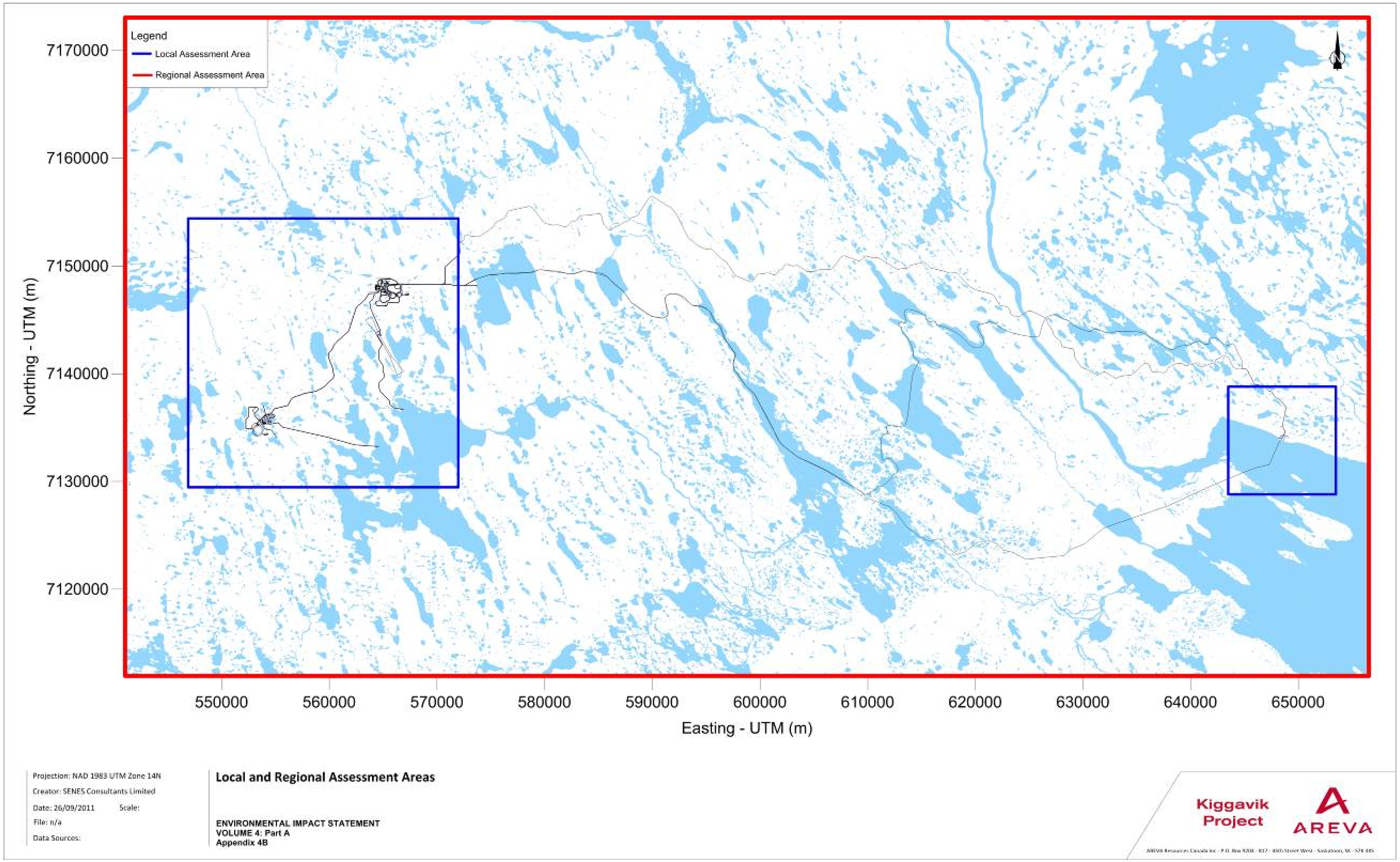


Figure 2 **Local and Regional Assessment Areas**

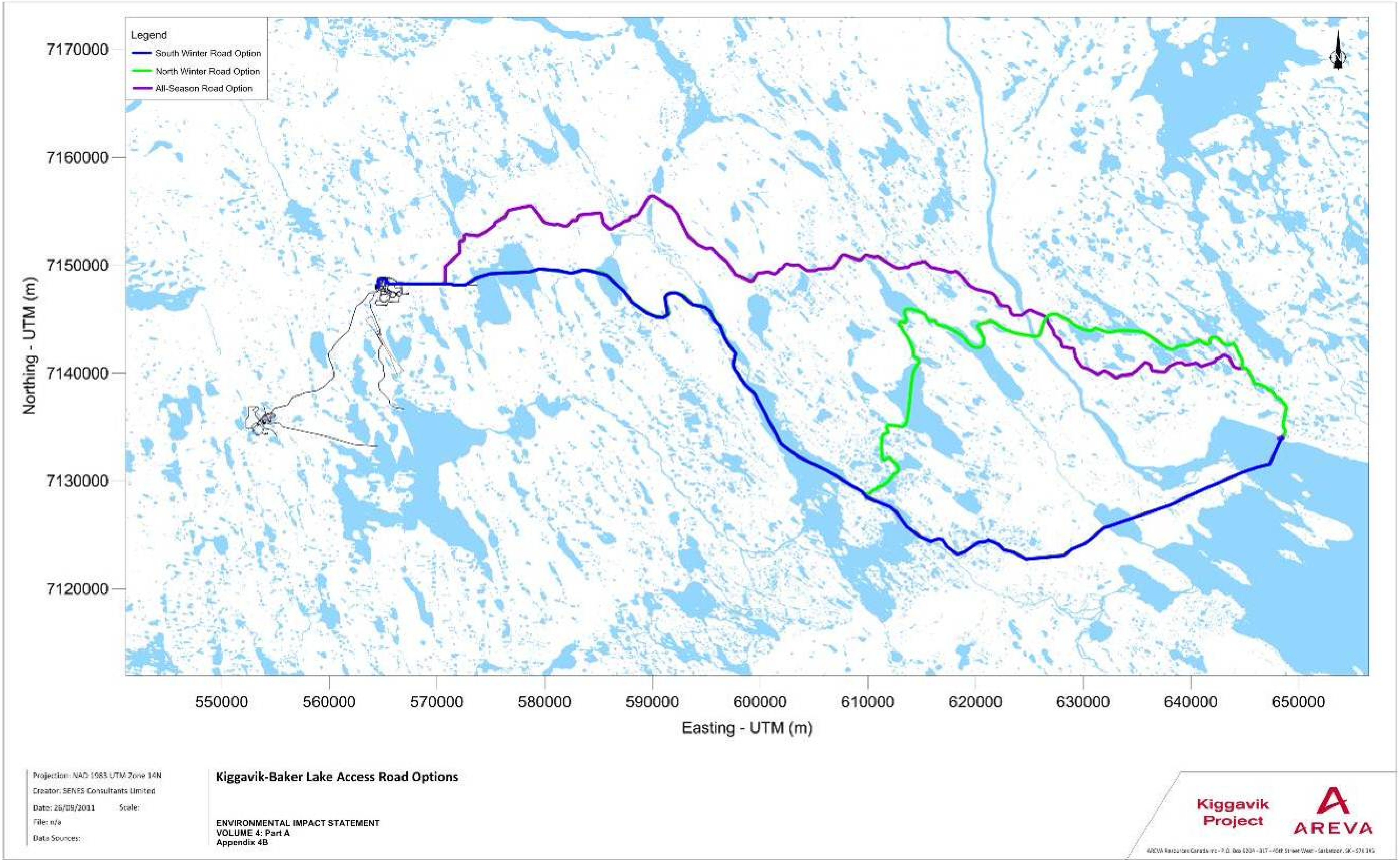


Figure 3 **Road Options between Kiggavik and Baker Lake**

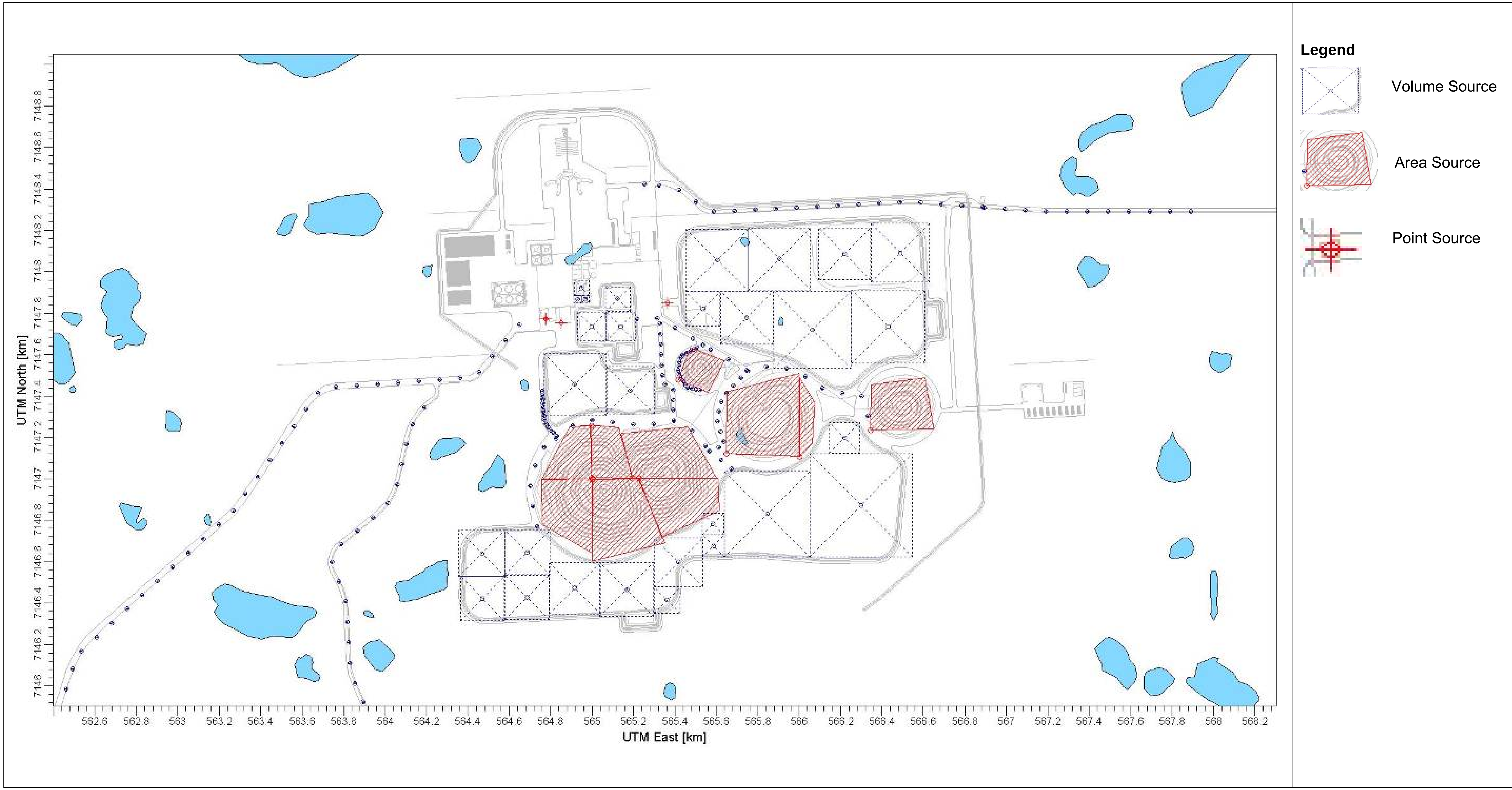


Figure 4 CALPUFF Model Setup for the Kiggavik Mine Site

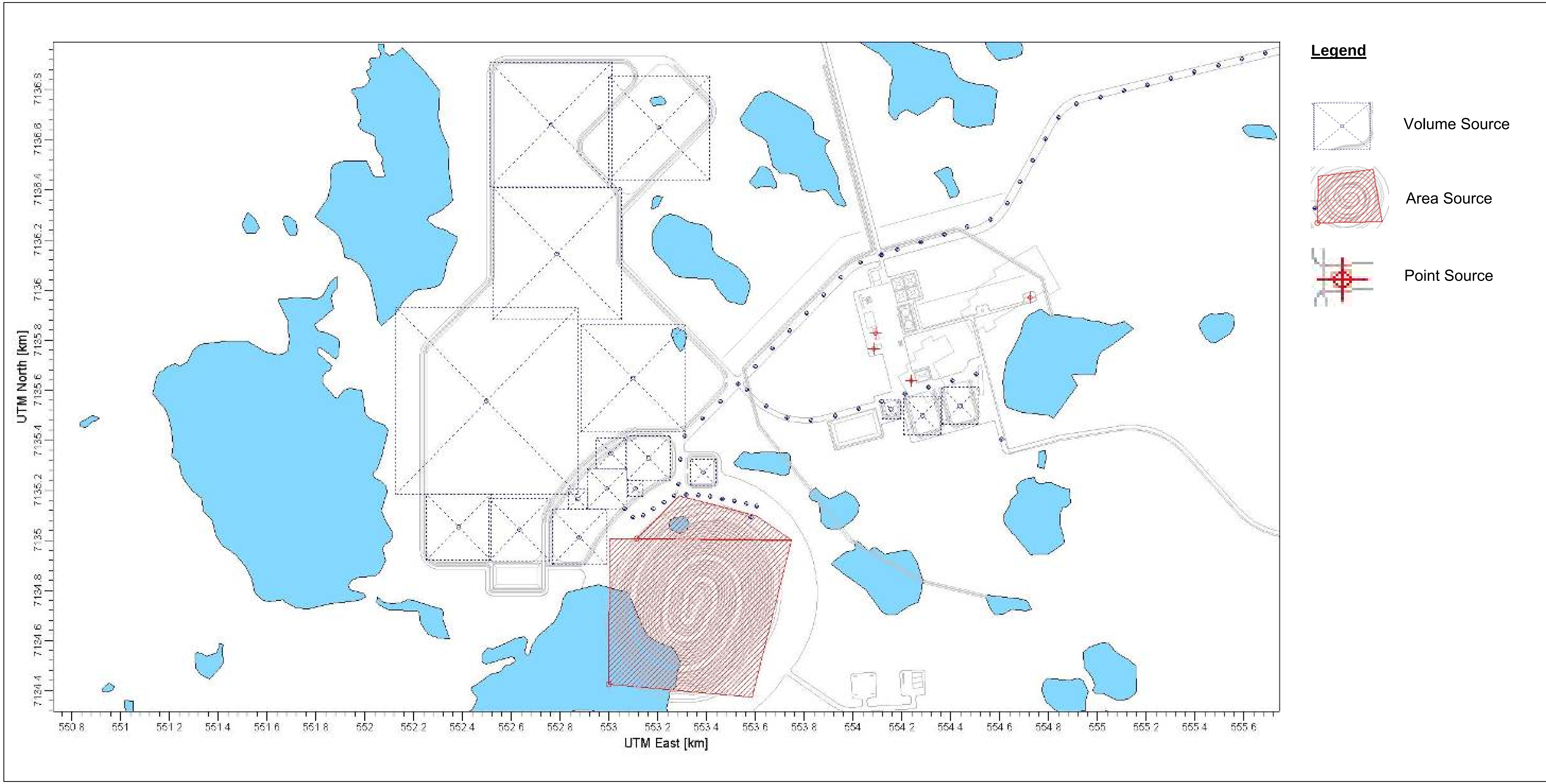
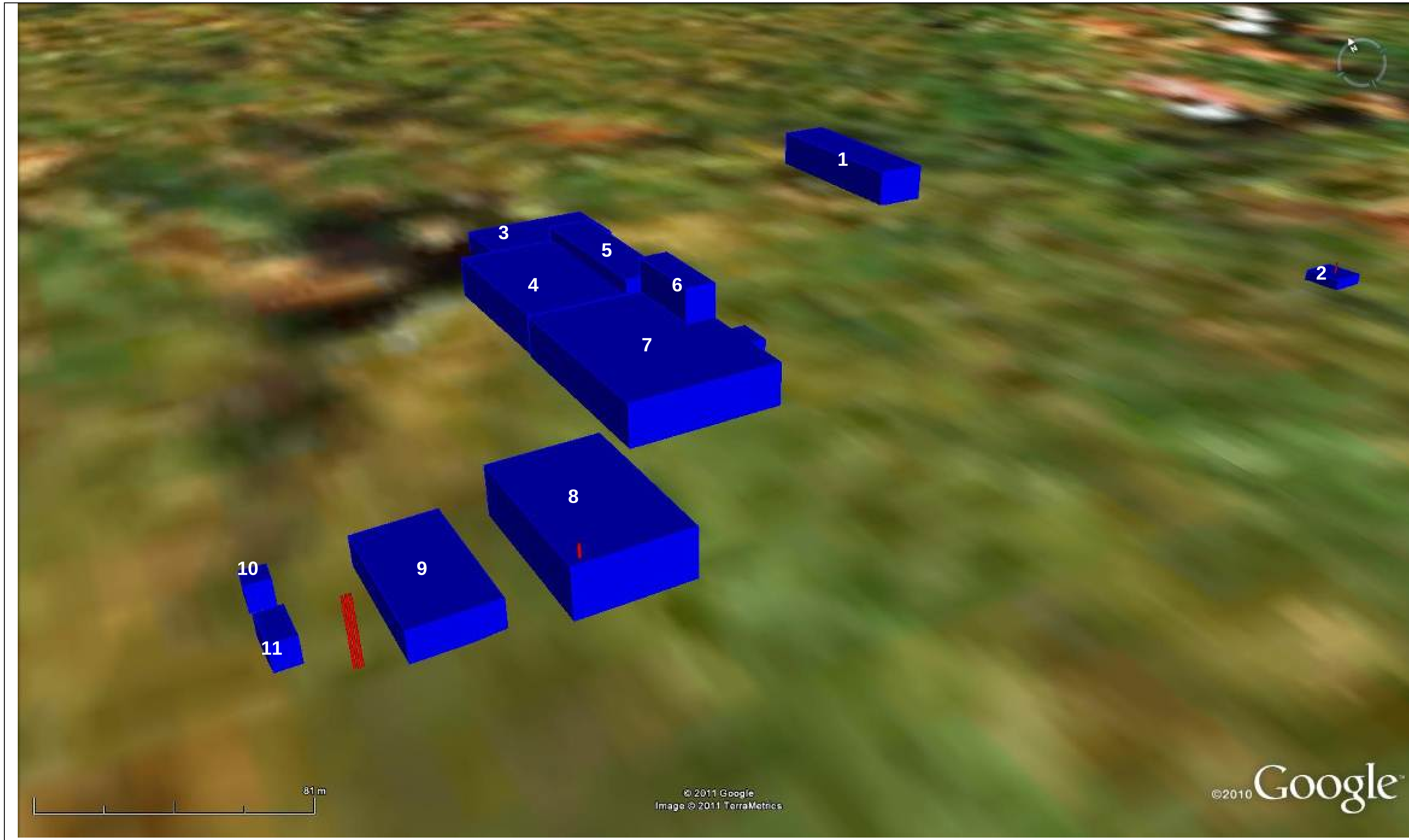


Figure 5 **CALPUFF Model Setup for the Sissons Mine Site**



Building Number	Building Name	Height (m)
1	Mine Shop	23
2	Incinerator	6.4
3	WTP	12
4	Admin	22
5	RIP	30
6	Leaching	40
7	Mill Complex	22
8	Acid Plant	23
9	Power Plant	23
10	H_2O_2 Plant	12
11	O_2 Plant	12

Figure 6 CALPUFF Model Building Configuration for the Kiggavik Mine Site

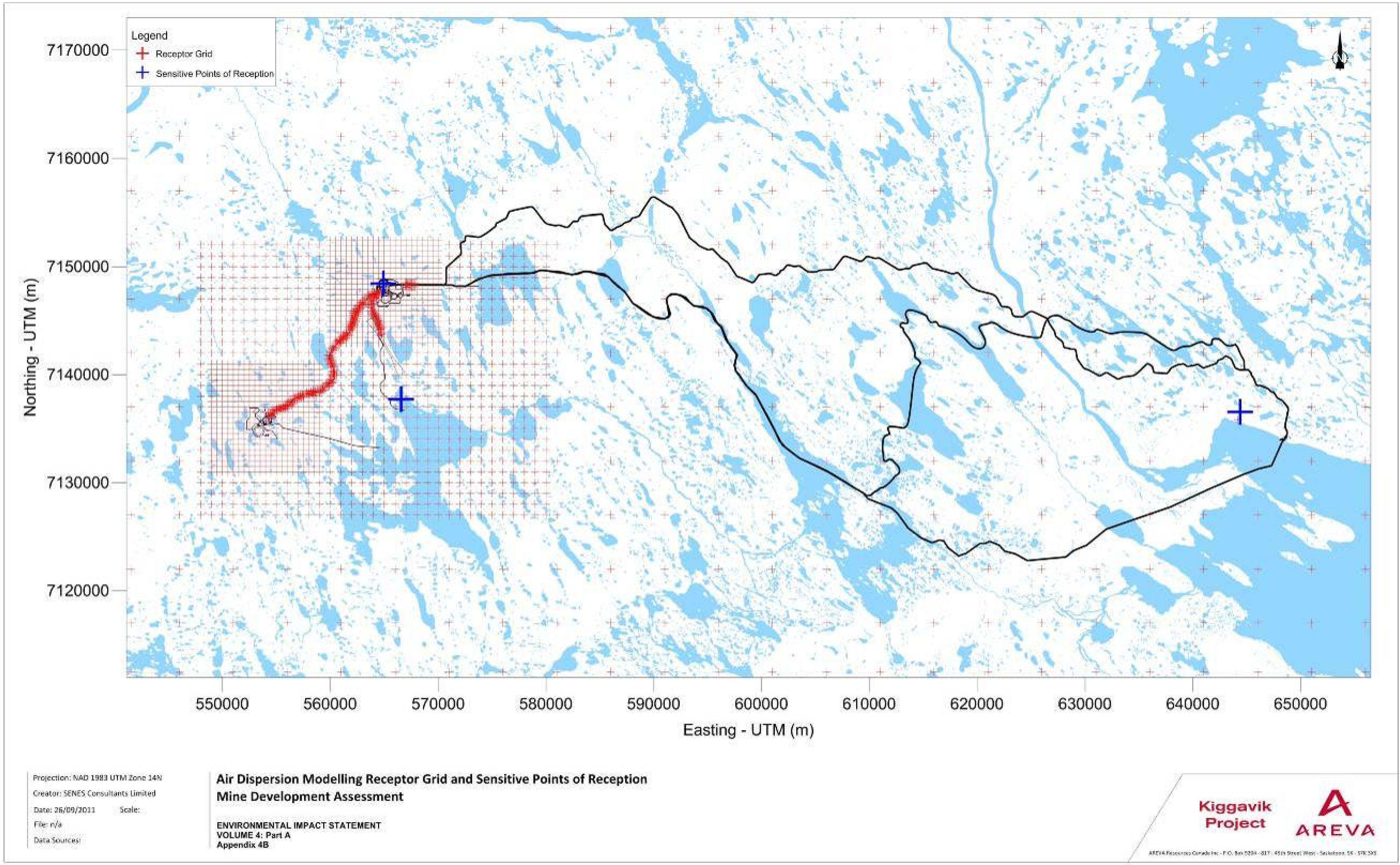


Figure 7 **Air Dispersion Modelling Receptor Grid and Sensitive Points of Reception used for the Mine Development Area Assessment**

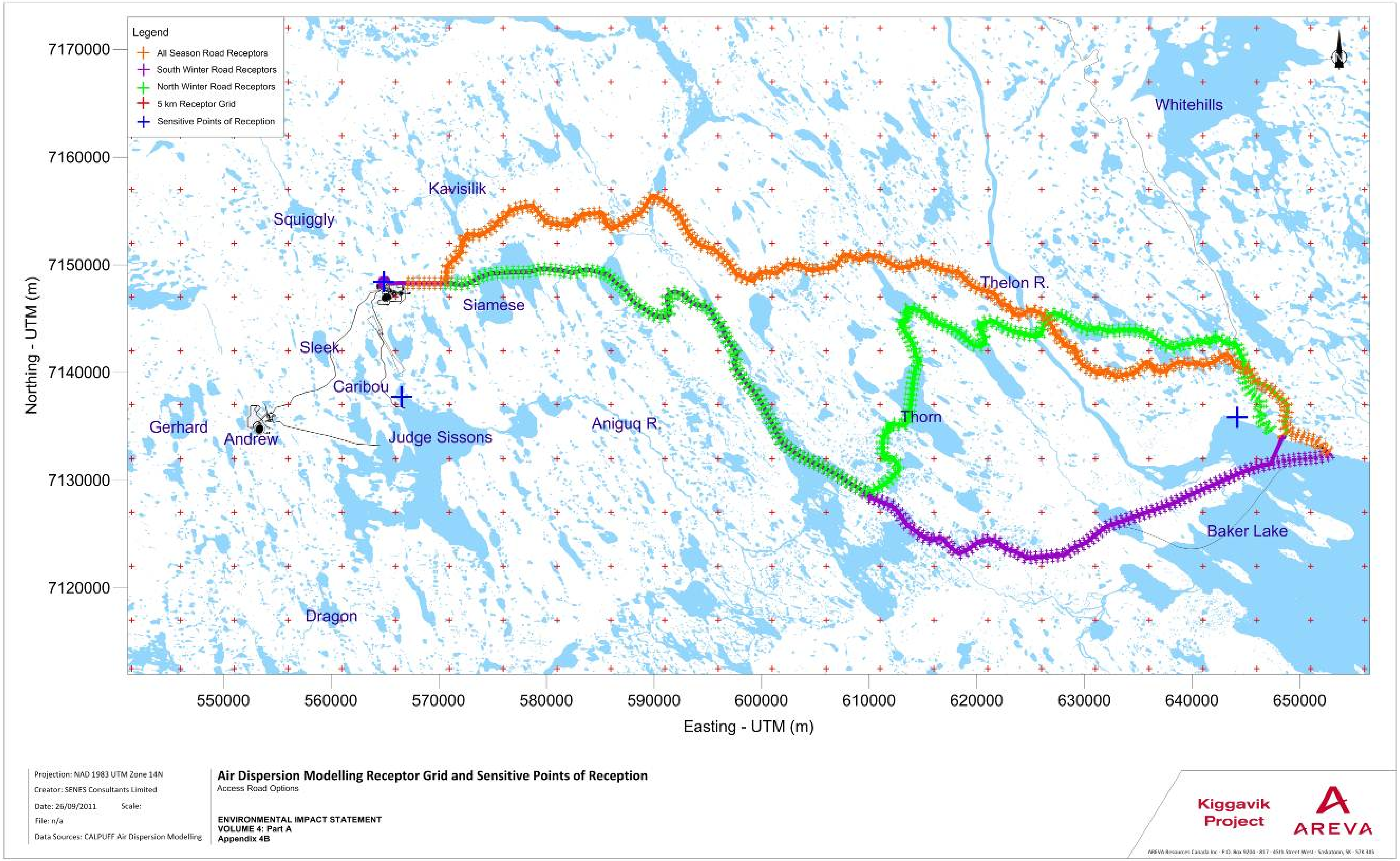


Figure 8 Air Dispersion Modelling Receptor Grid and Sensitive Points of Reception used for the Access Roads Options Assessment

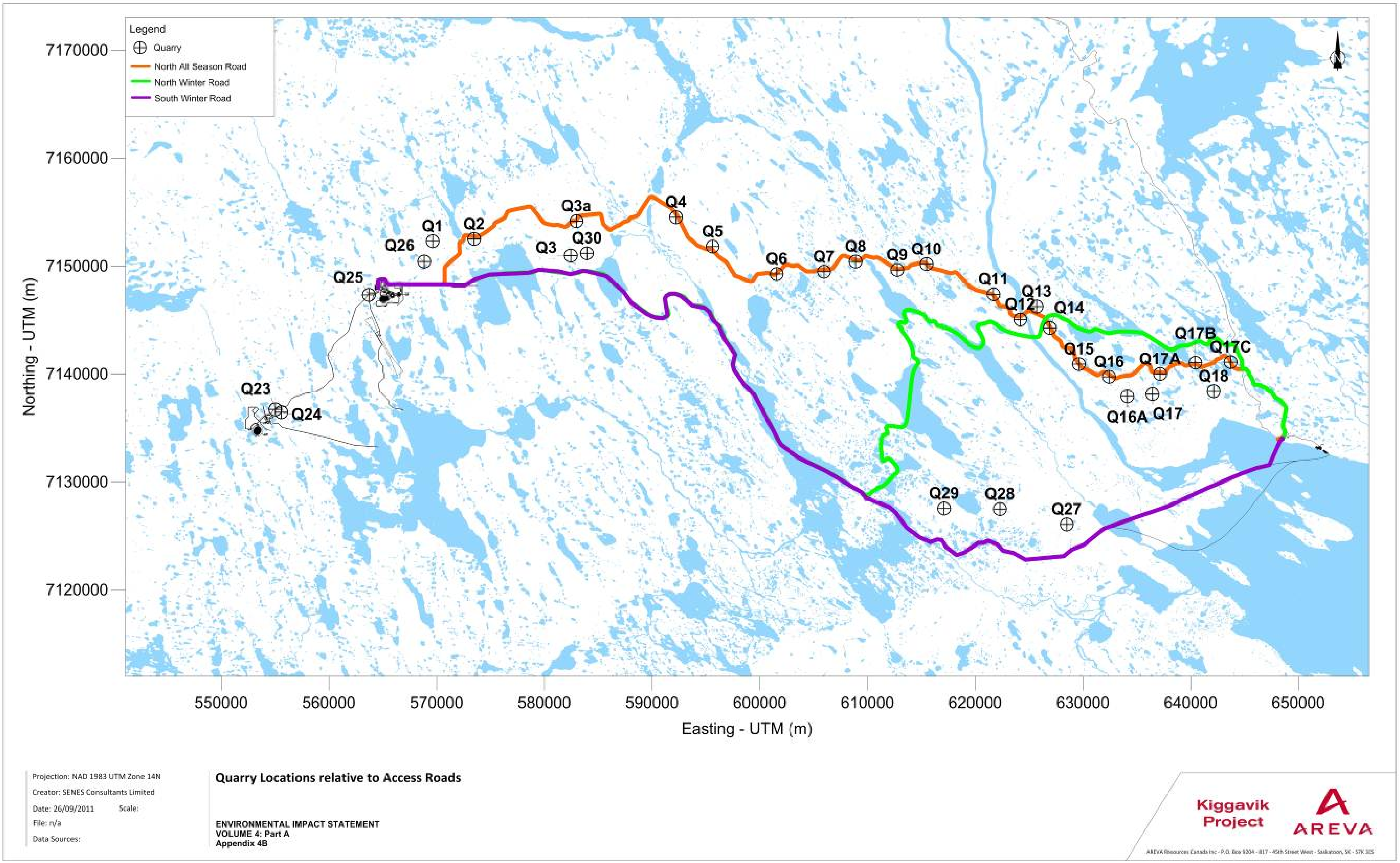


Figure 9 Quarry Locations

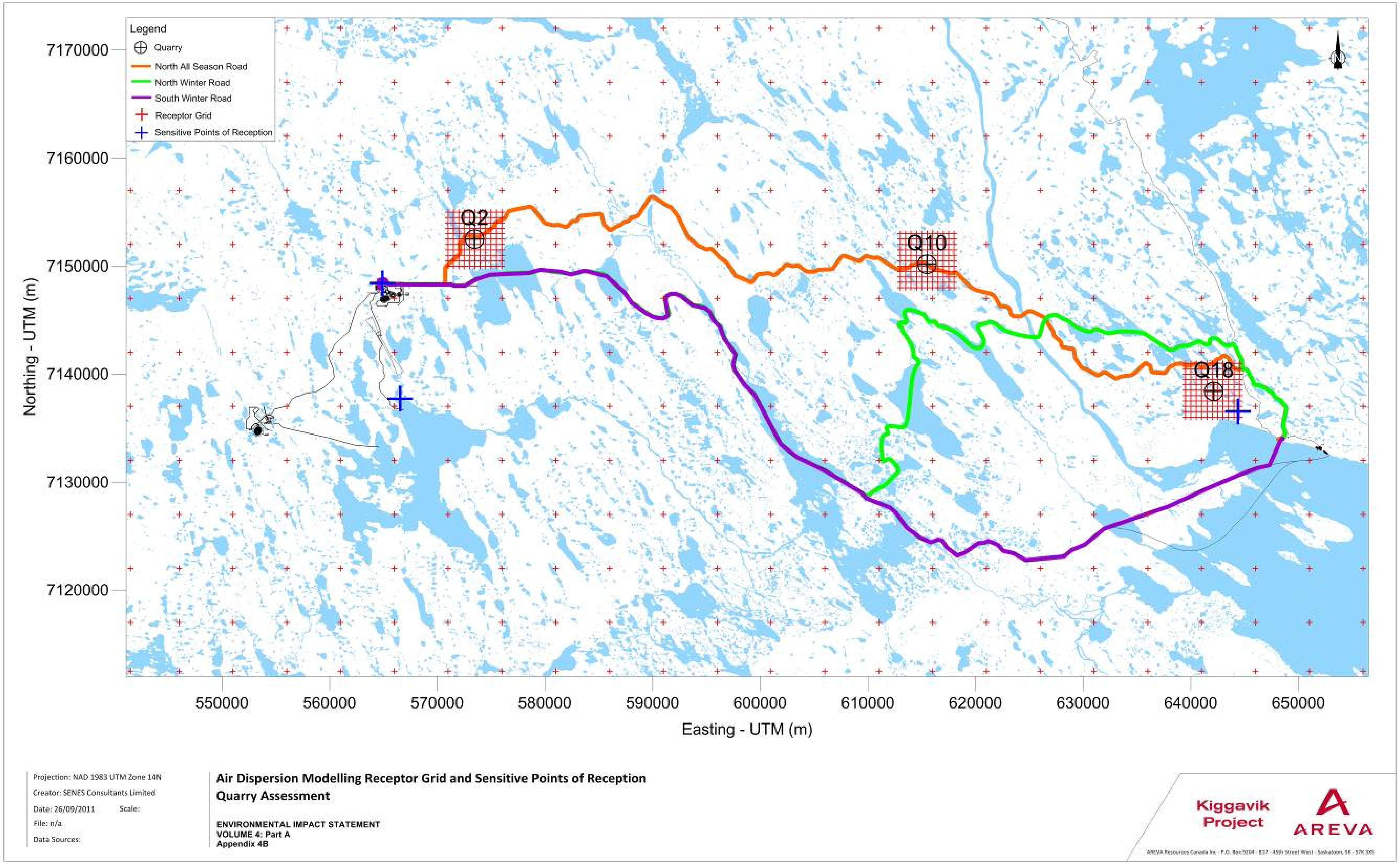


Figure 10 Air Dispersion Modelling Receptor Grid and Sensitive Points of Reception used for the Quarry Assessment

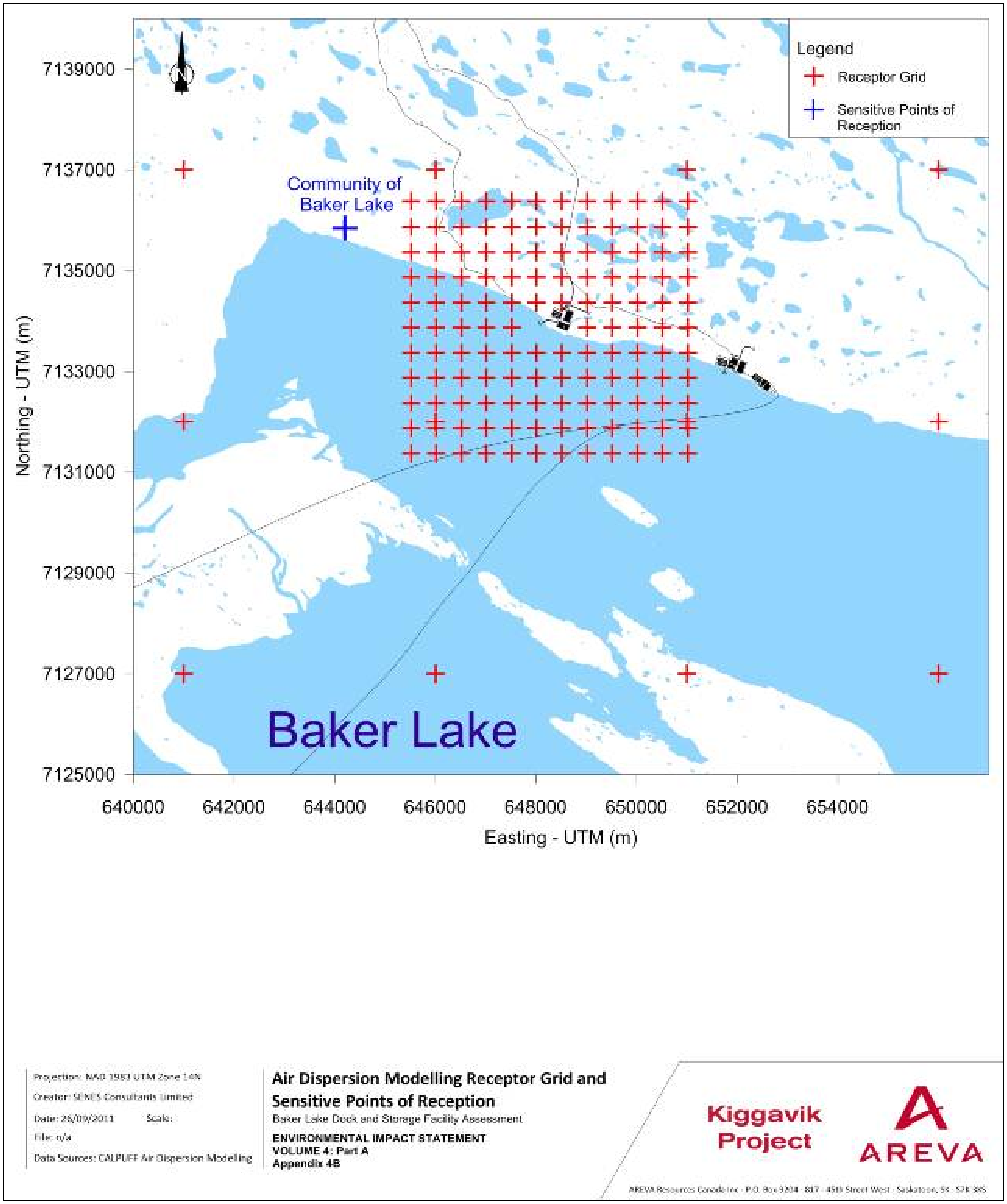


Figure 11 **Air Dispersion Modelling Receptor Grid and Sensitive Points of Reception for Baker Lake Facility Assessment**

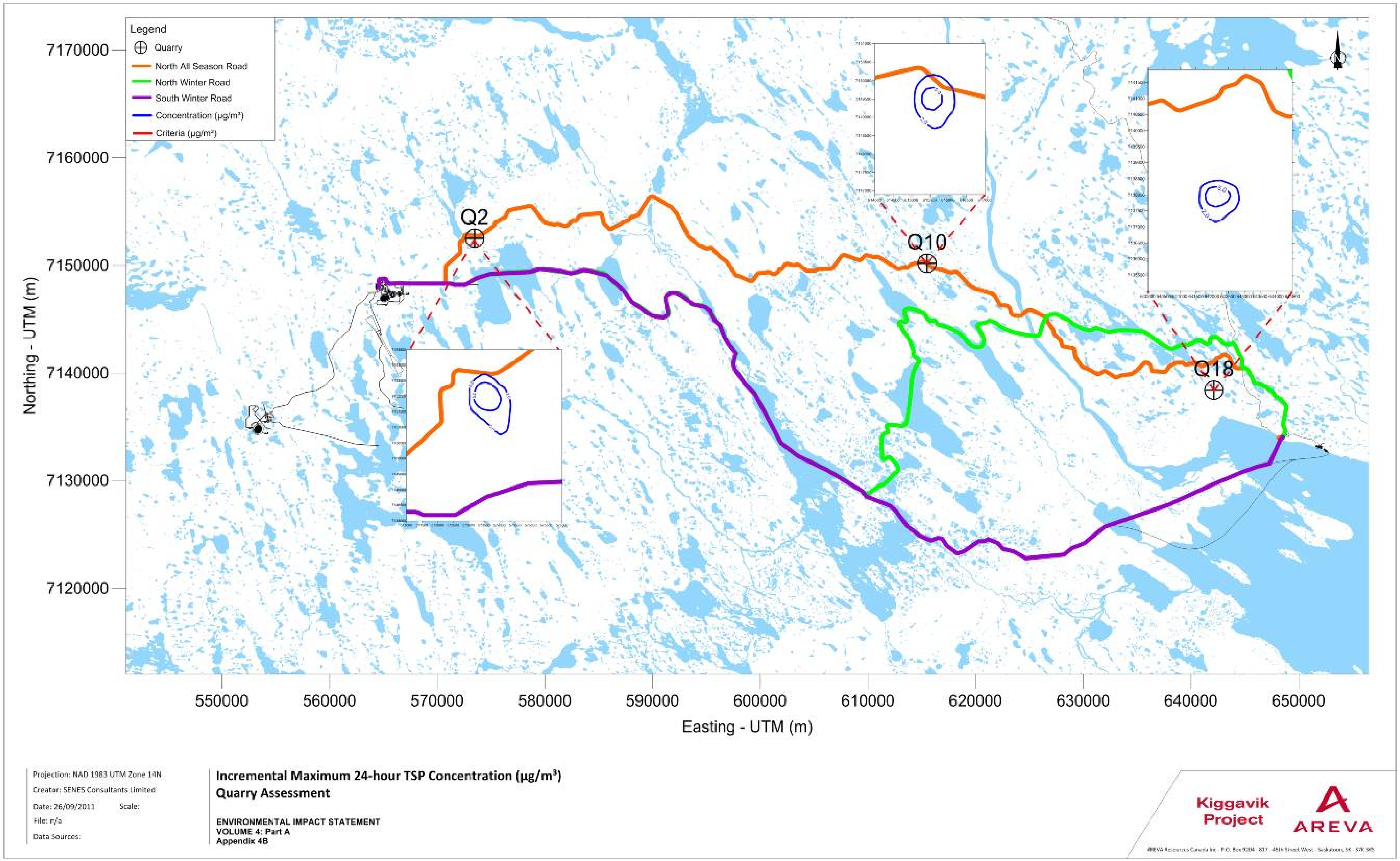


Figure 12 **Incremental Maximum 24-hour TSP Concentrations for Quarry 2, Quarry 10 and Quarry 18**

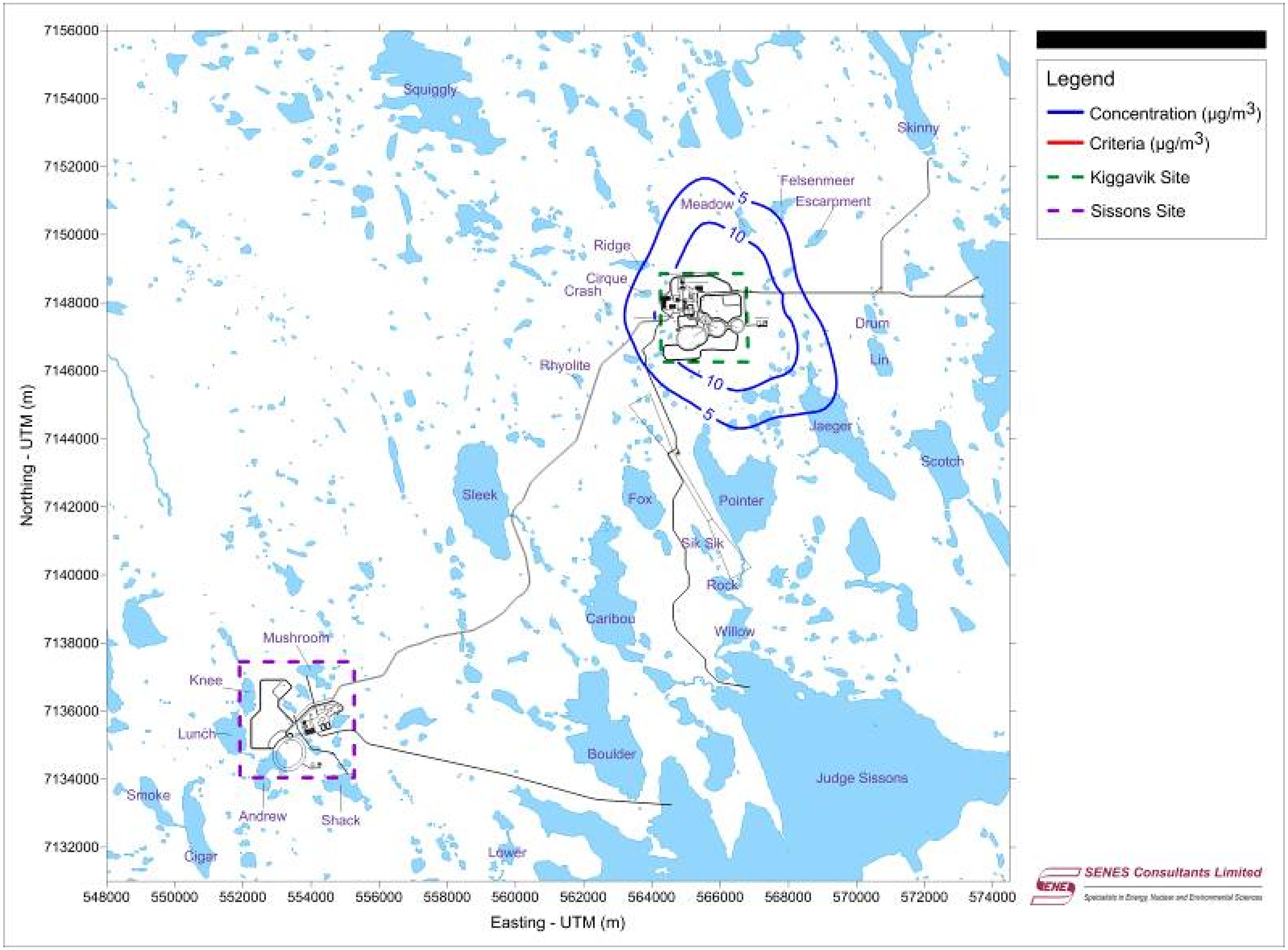


Figure 13 Period 1 (Year 0 and 1) Incremental Annual TSP Concentration

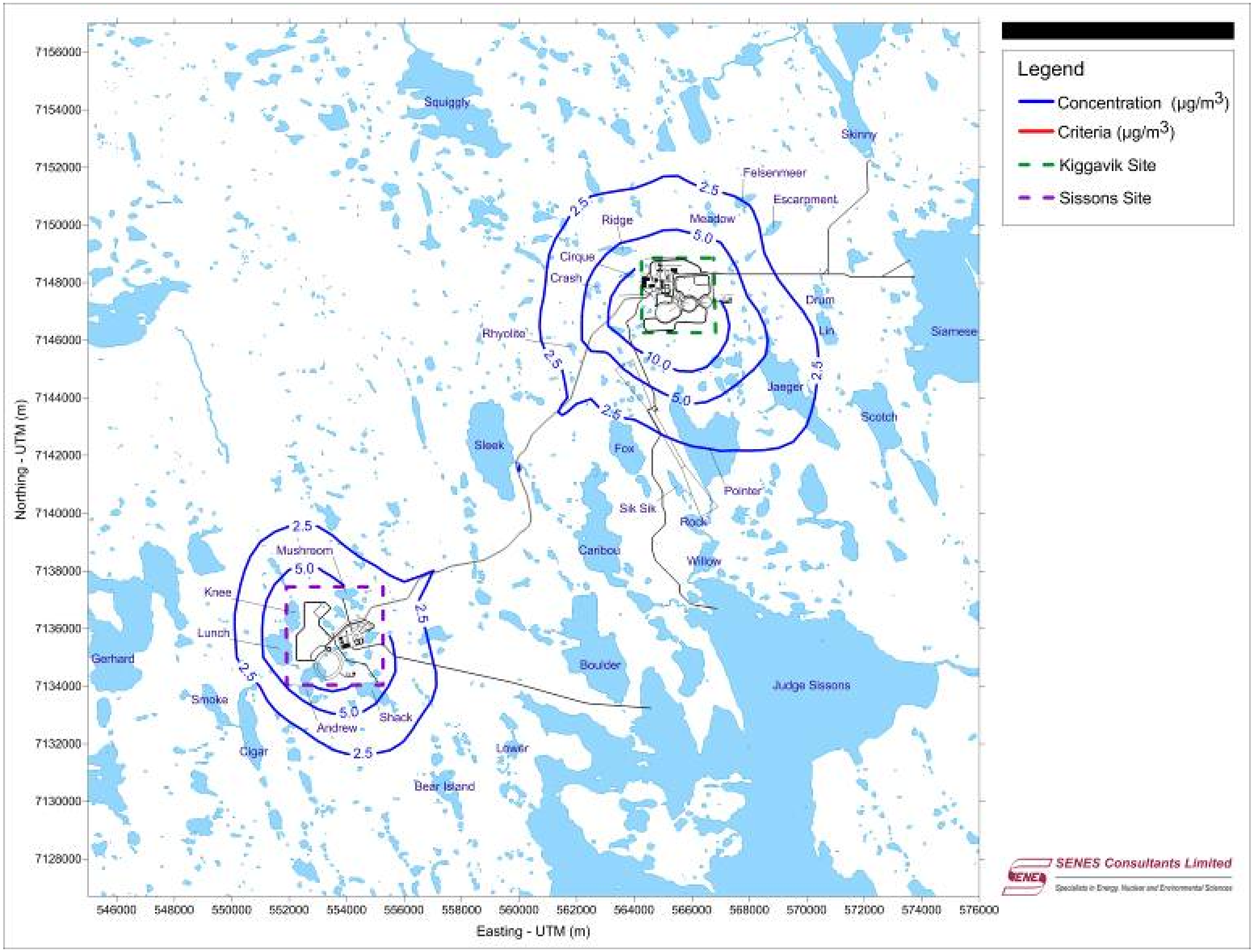


Figure 14 Period 2 (Year 2-5) Incremental Annual TSP Concentration

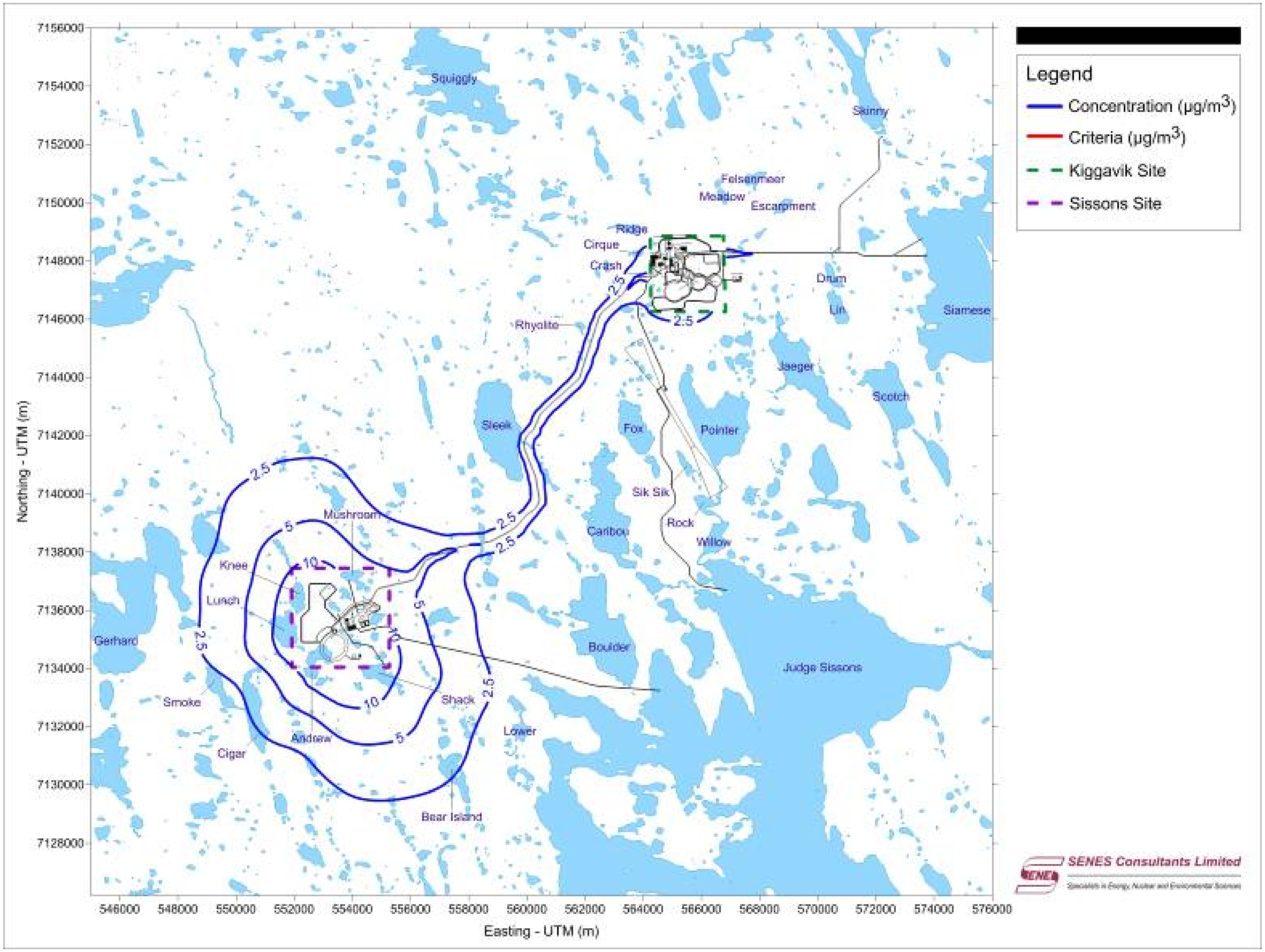


Figure 15 **Period 3 (Year 6-13) Incremental Annual TSP Concentration**

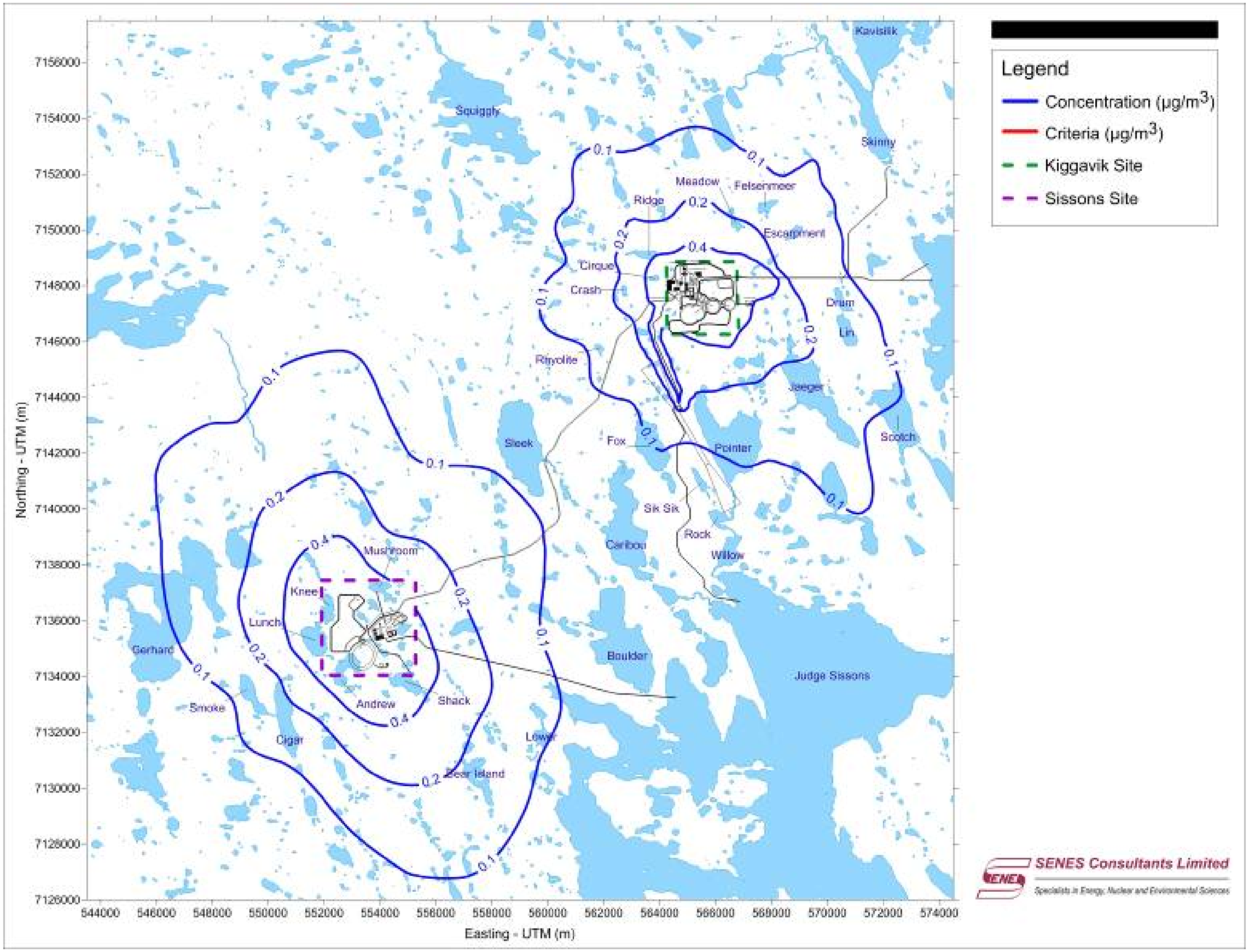


Figure 16 **Period 4 (Year 14) Incremental Annual TSP Concentration**

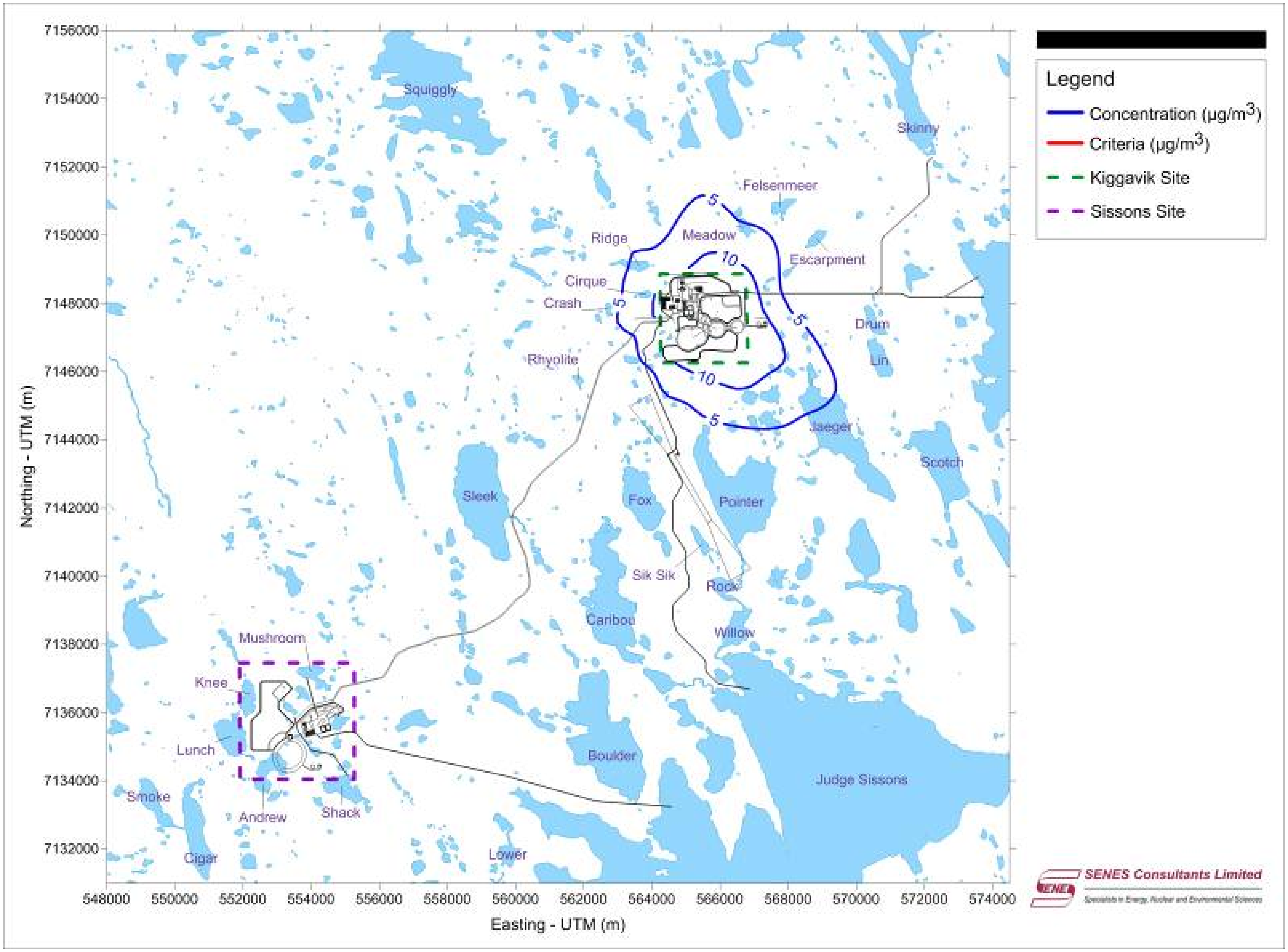


Figure 17 **Period 1 (Year 0 and 1) Incremental Annual NO_2 Concentration**

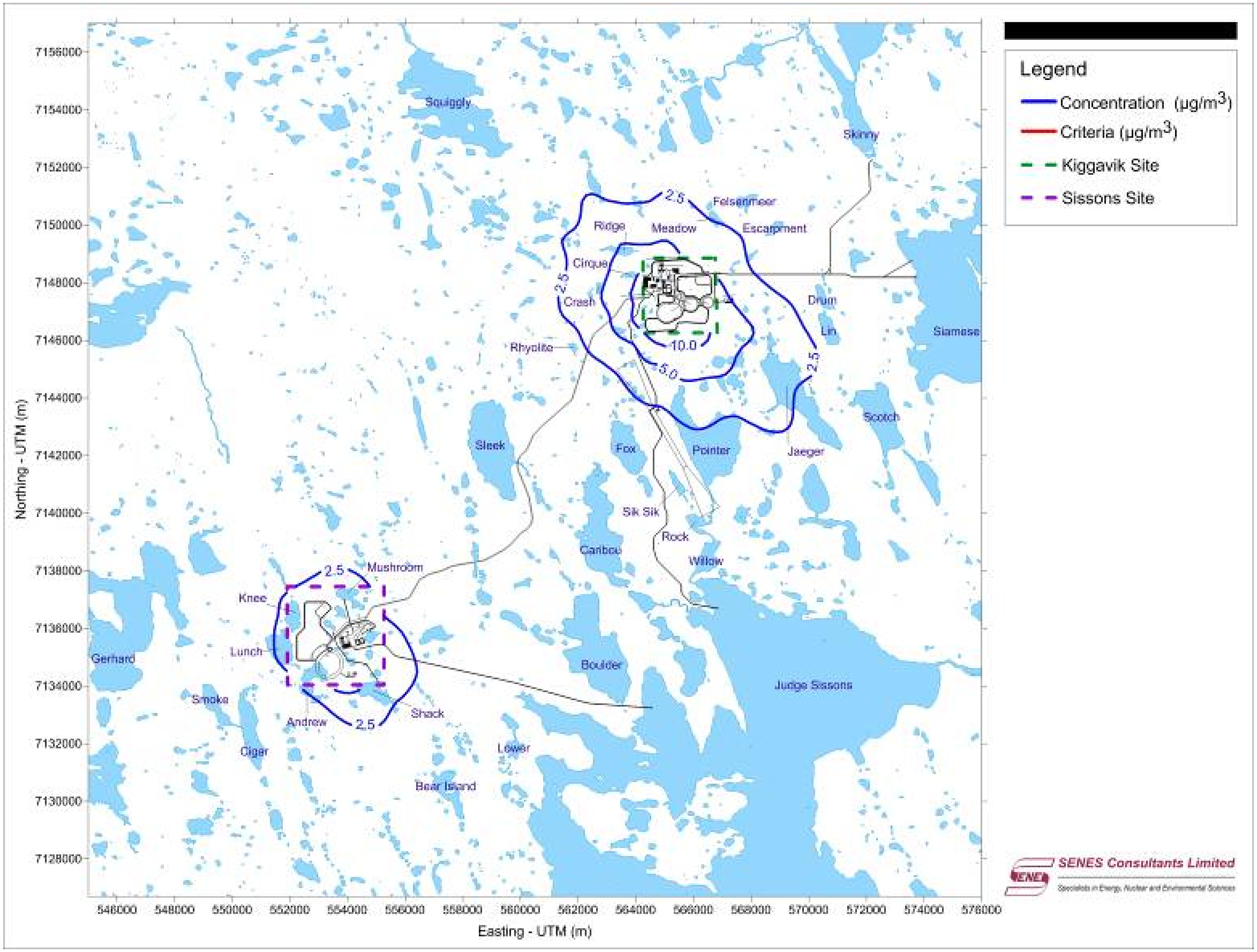


Figure 18 **Period 2 (Year 2-5) Incremental Annual NO_2 Concentration**

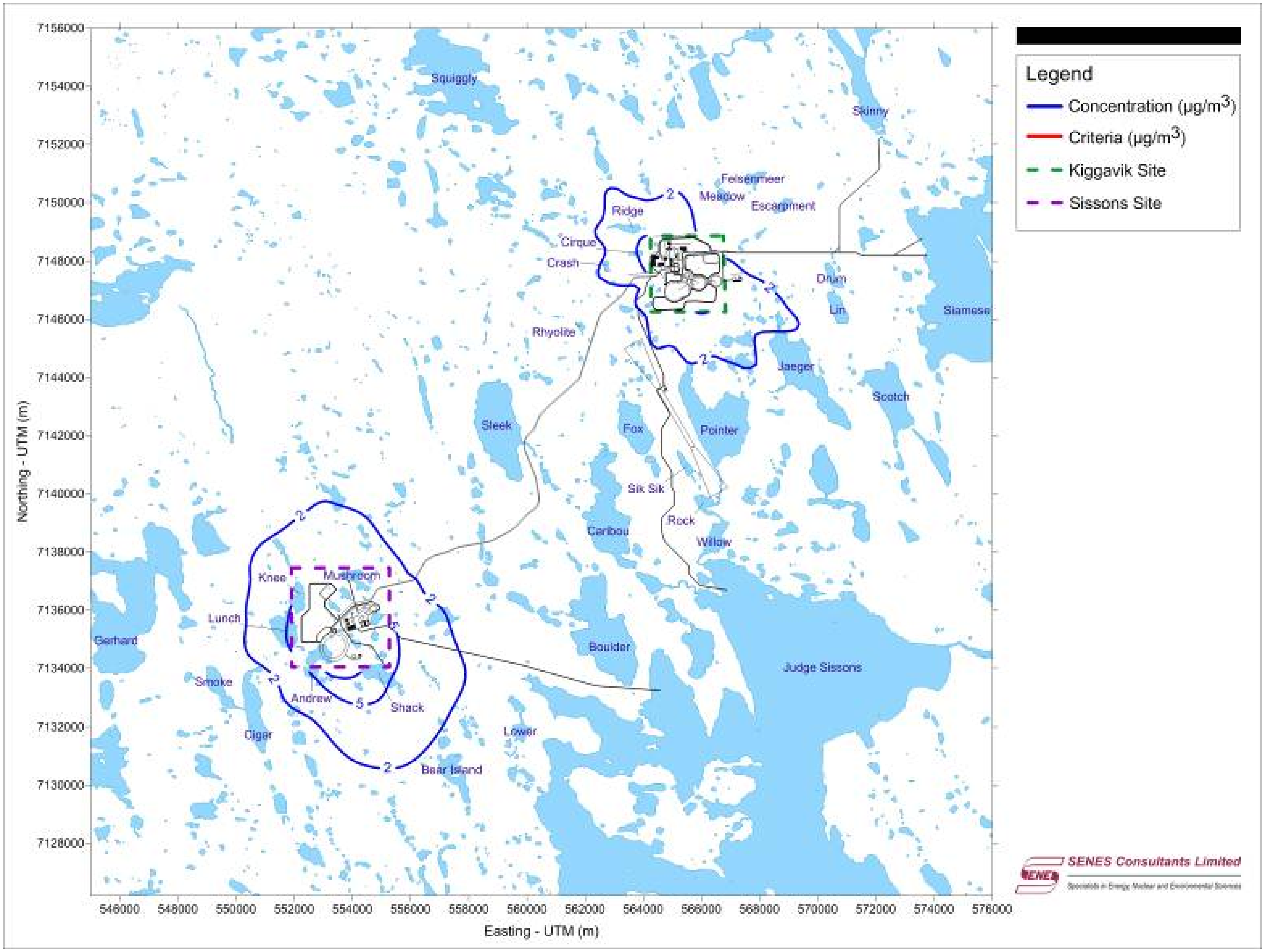


Figure 19 Period 3 (Year 6-13) Incremental Annual NO_2 Concentration

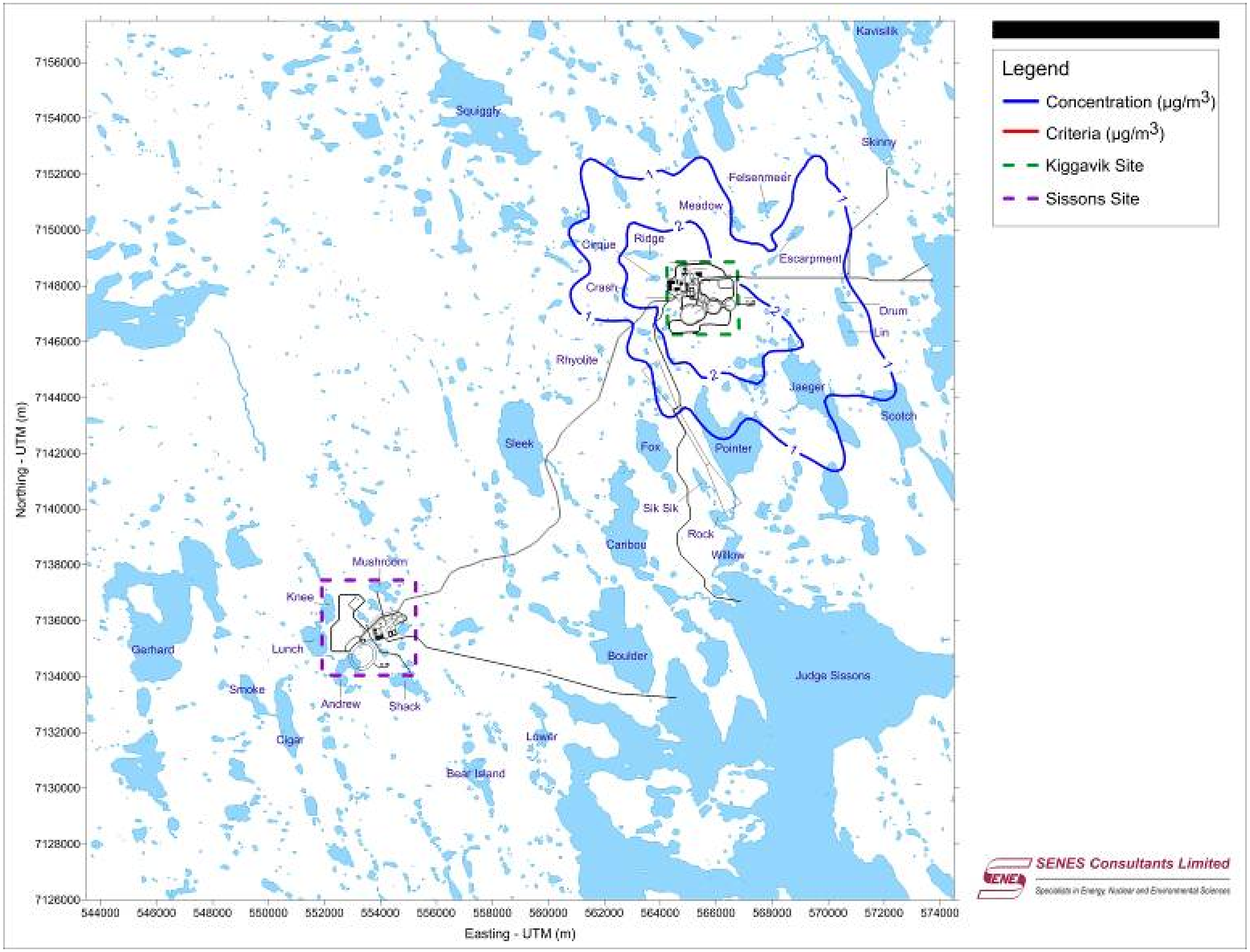


Figure 20 **Period 4 (Year 14) Incremental Annual NO_2 Concentration**

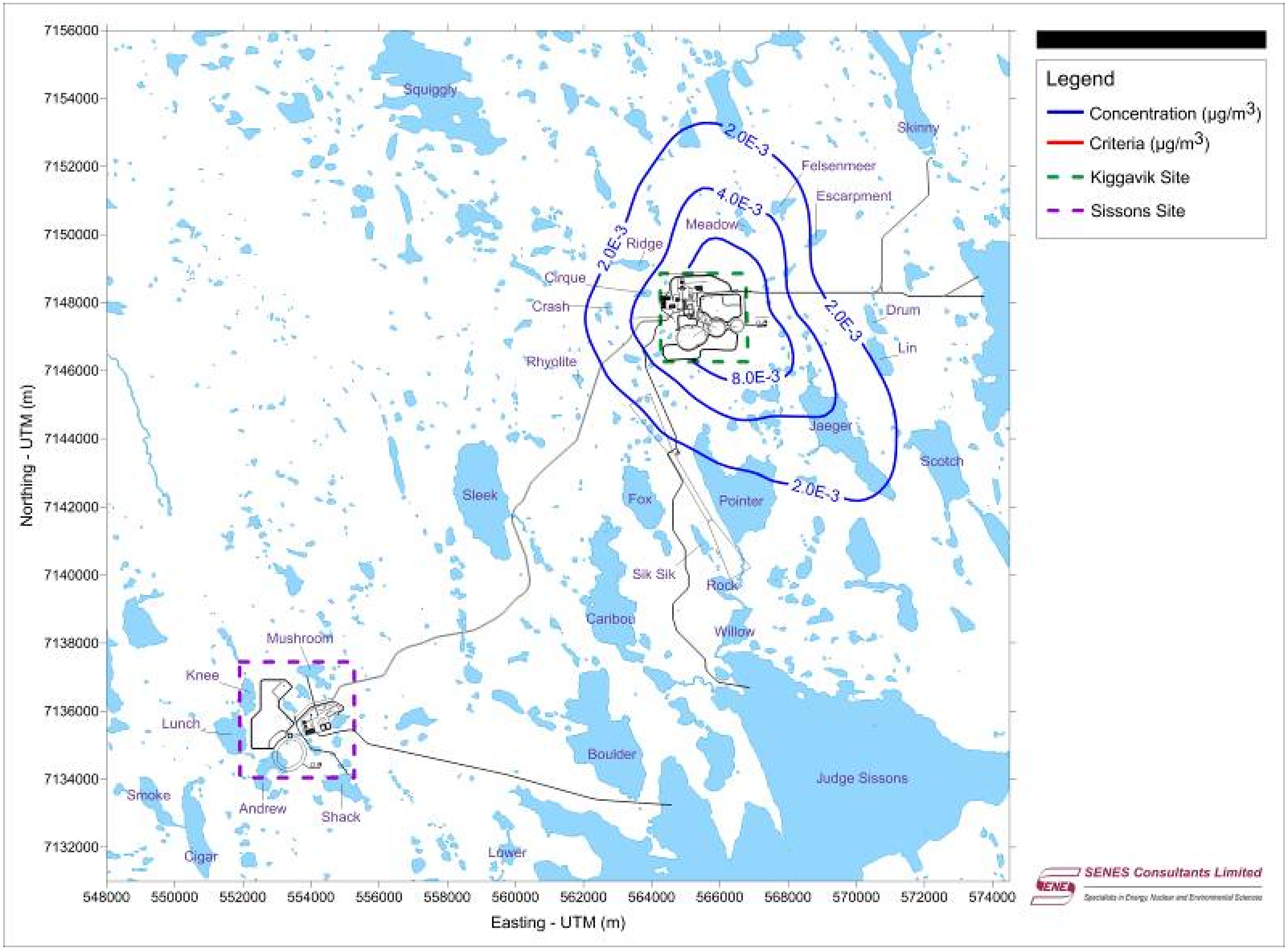


Figure 21 Period 1 (Year 0 and 1) Incremental Annual Uranium Concentration

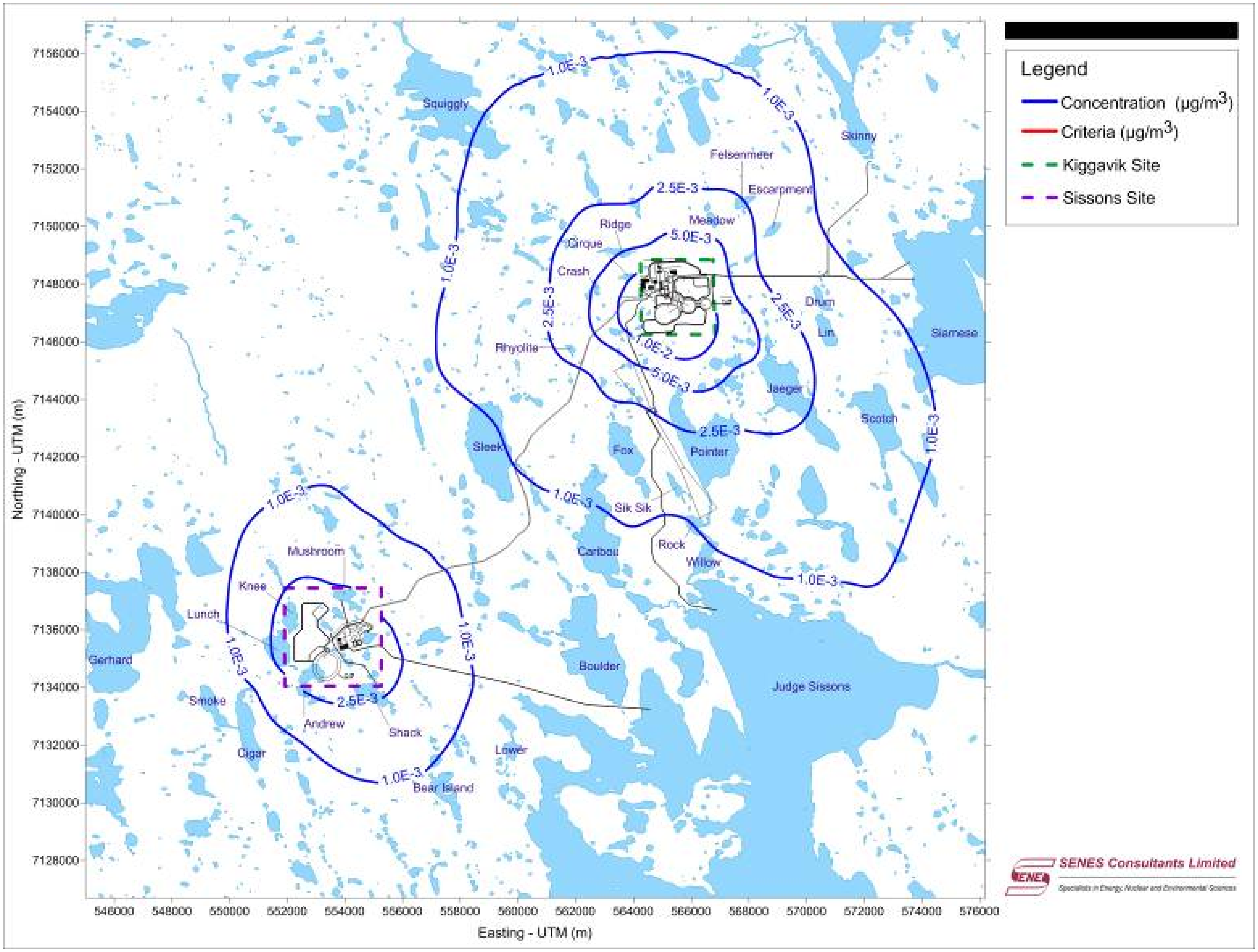


Figure 22 **Period 2 (Year 2-5) Incremental Annual Uranium Concentration**

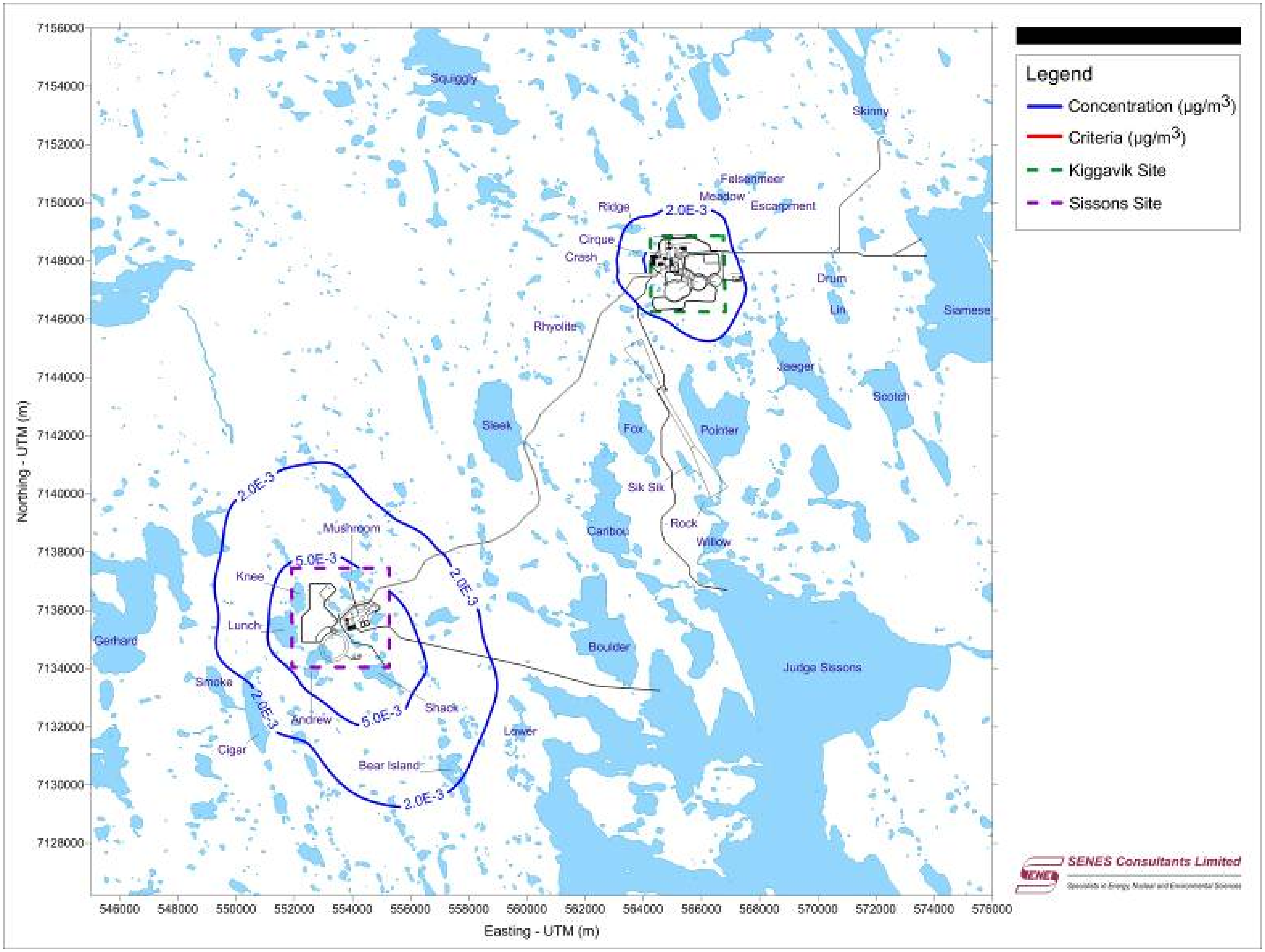


Figure 23 **Period 3 (Year 6-13) Incremental Annual Uranium Concentration**

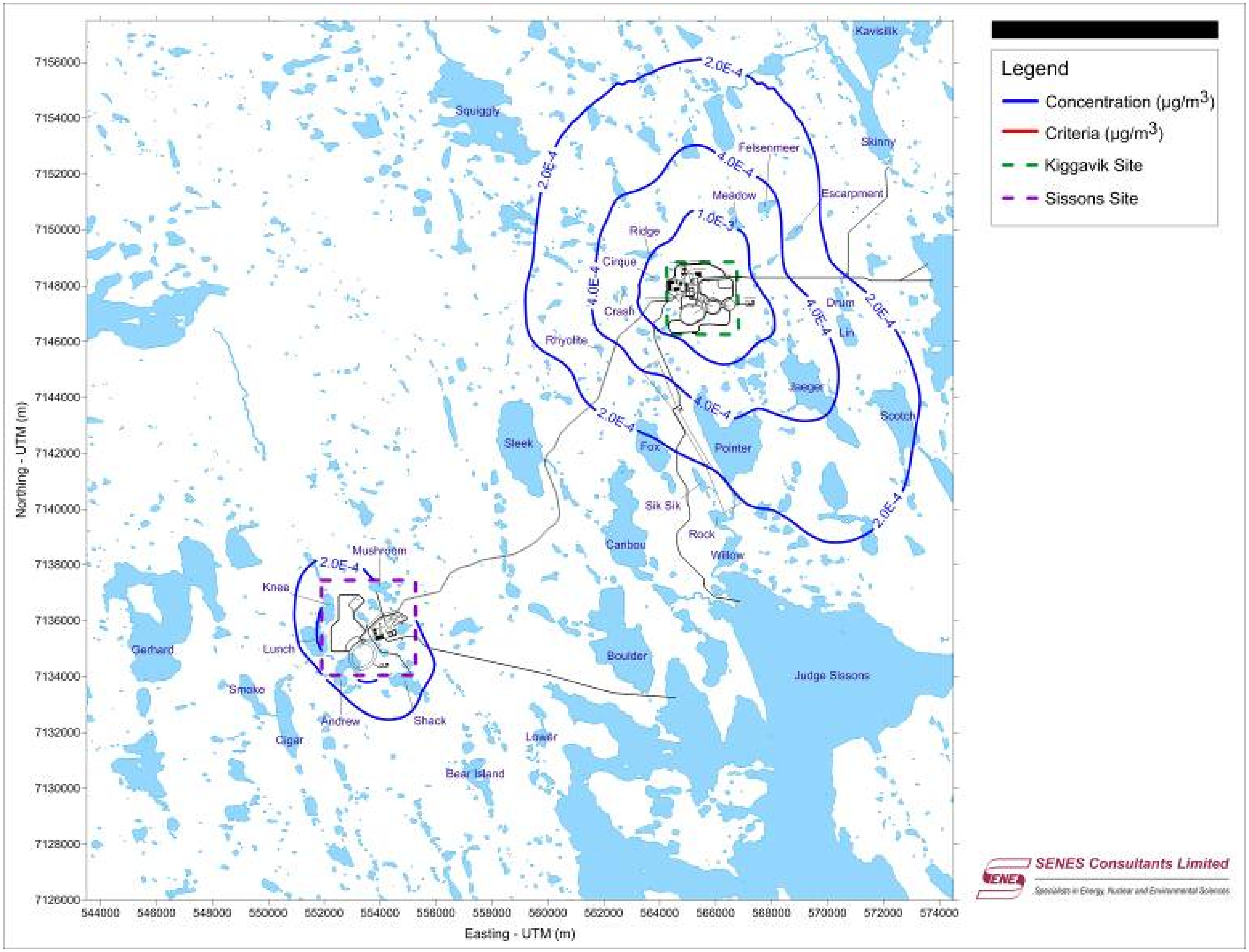


Figure 24 **Period 4 (Year 14) Incremental Annual Uranium Concentration**

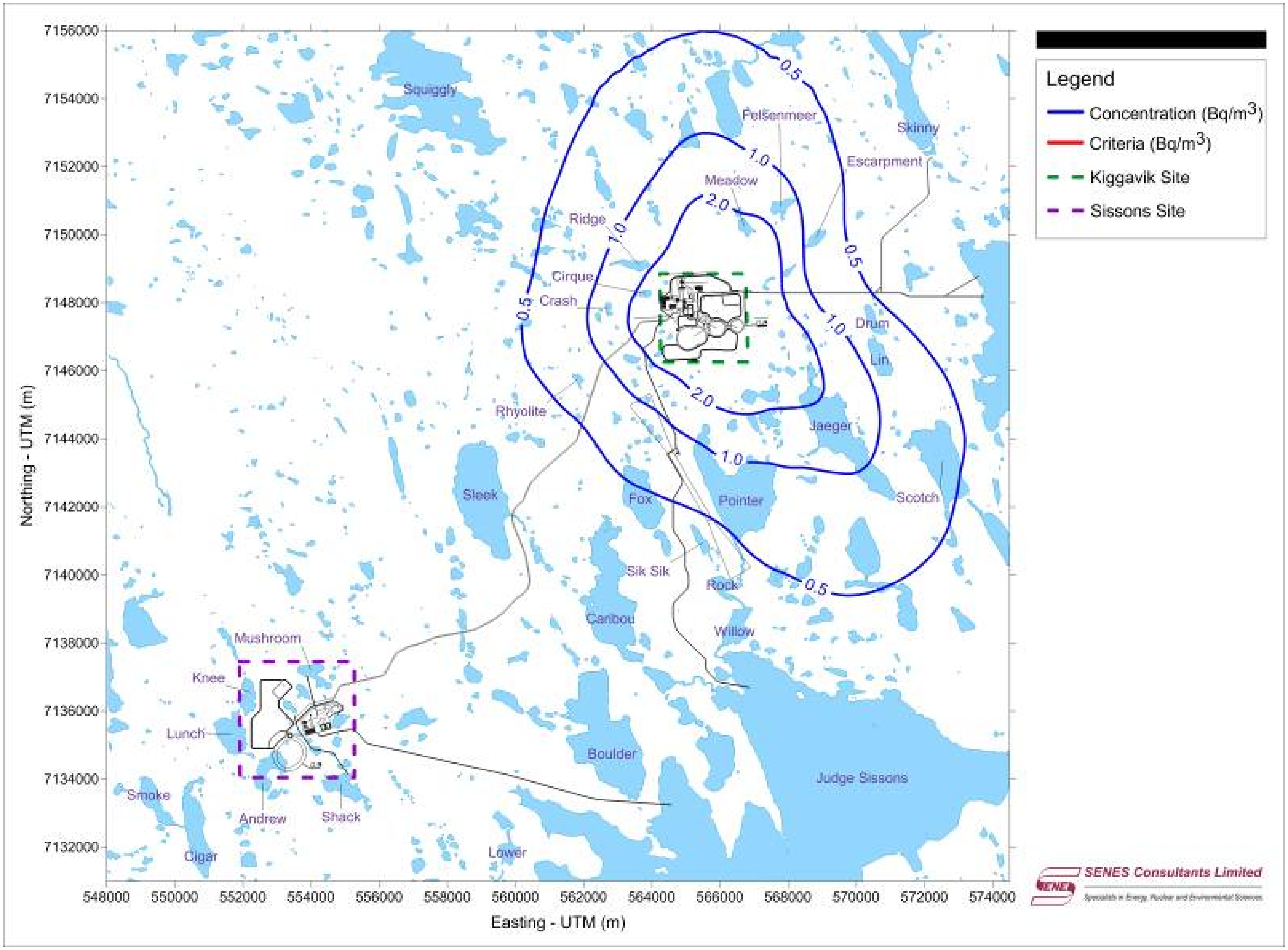


Figure 25 **Period 1 (Year 0 and 1) Incremental Annual Radon Concentration**

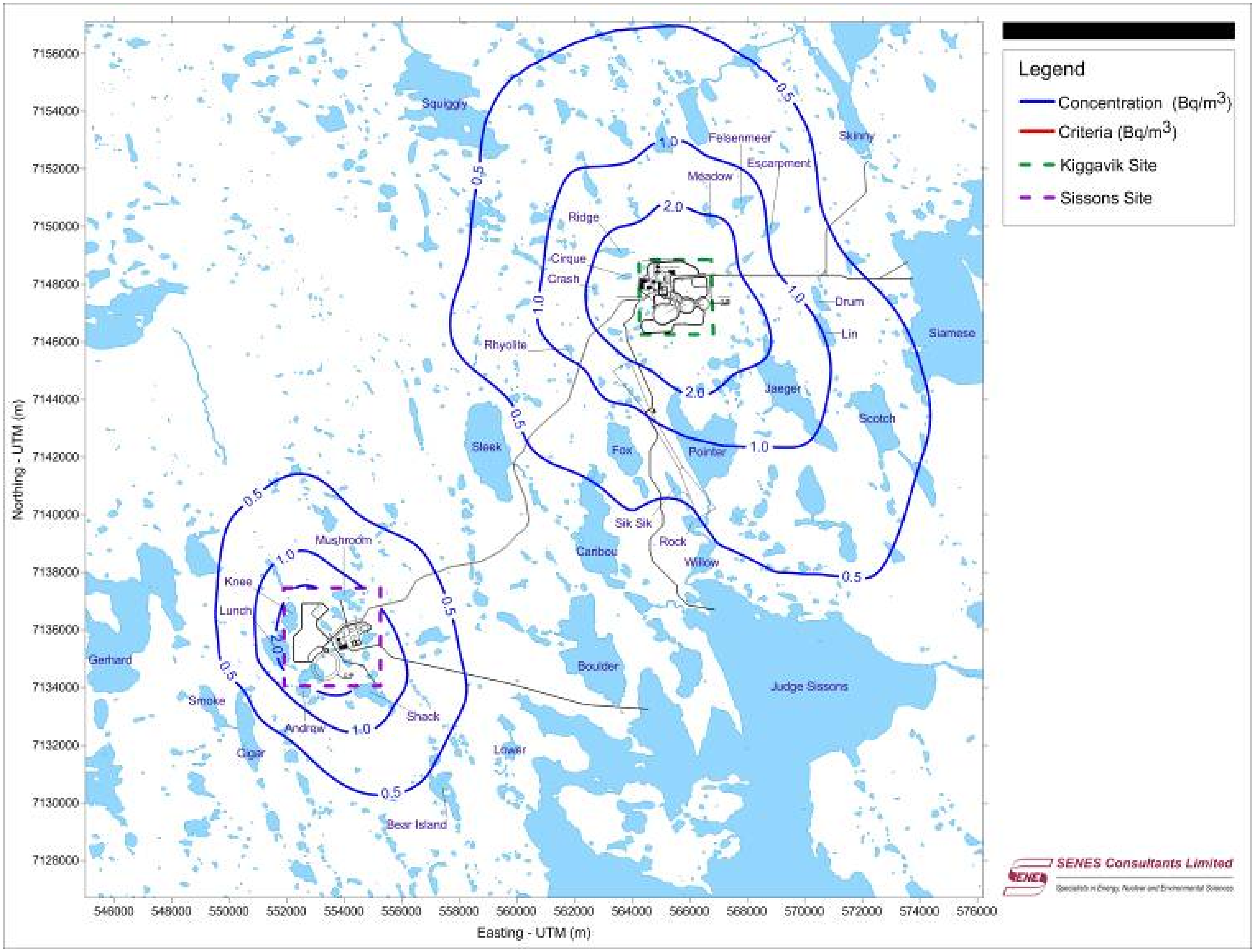


Figure 26 **Period 2 (Year 2-5) Incremental Annual Radon Concentration**

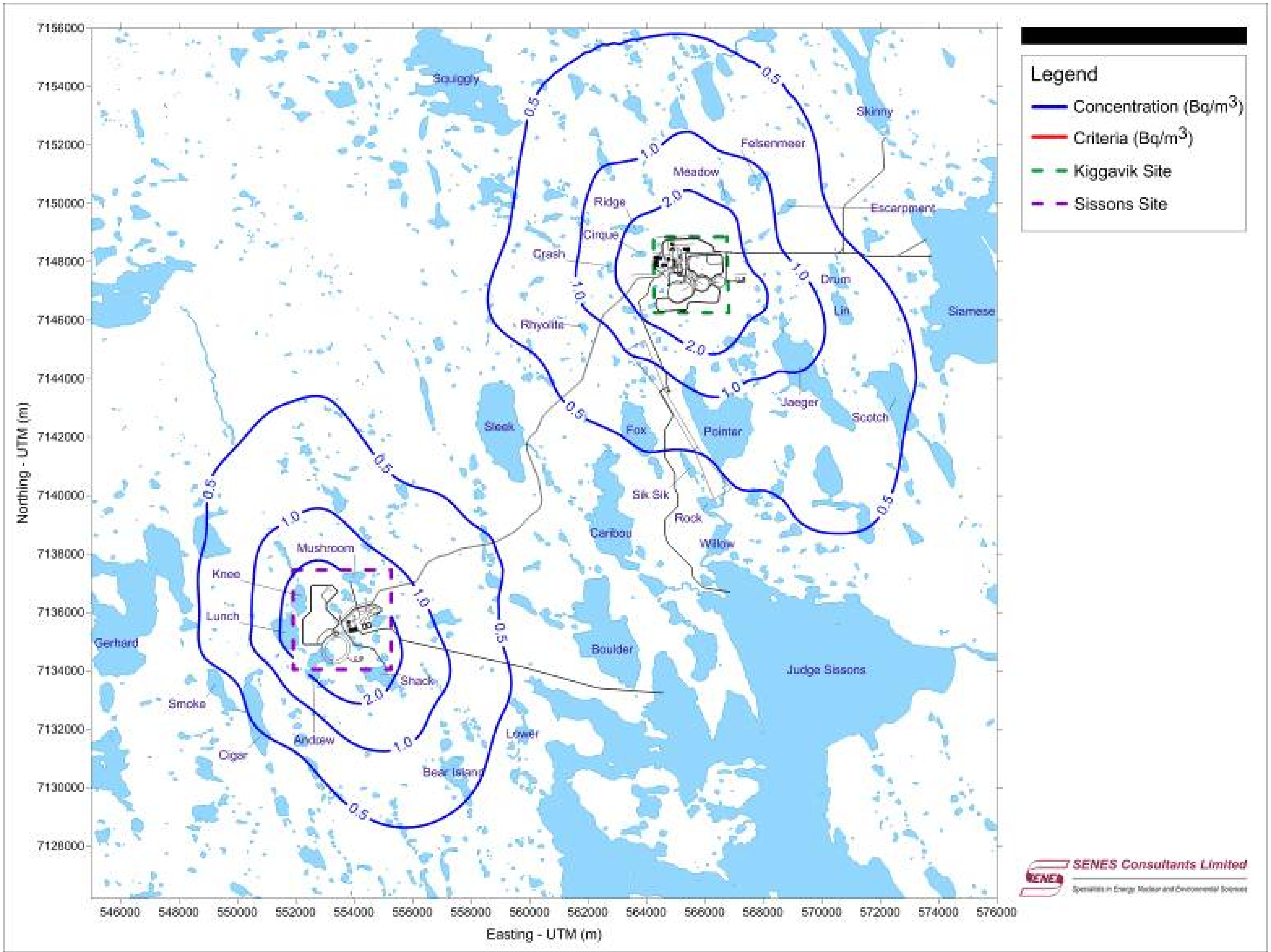


Figure 27 **Period 3 (Year 6-13) Incremental Annual Radon Concentration**

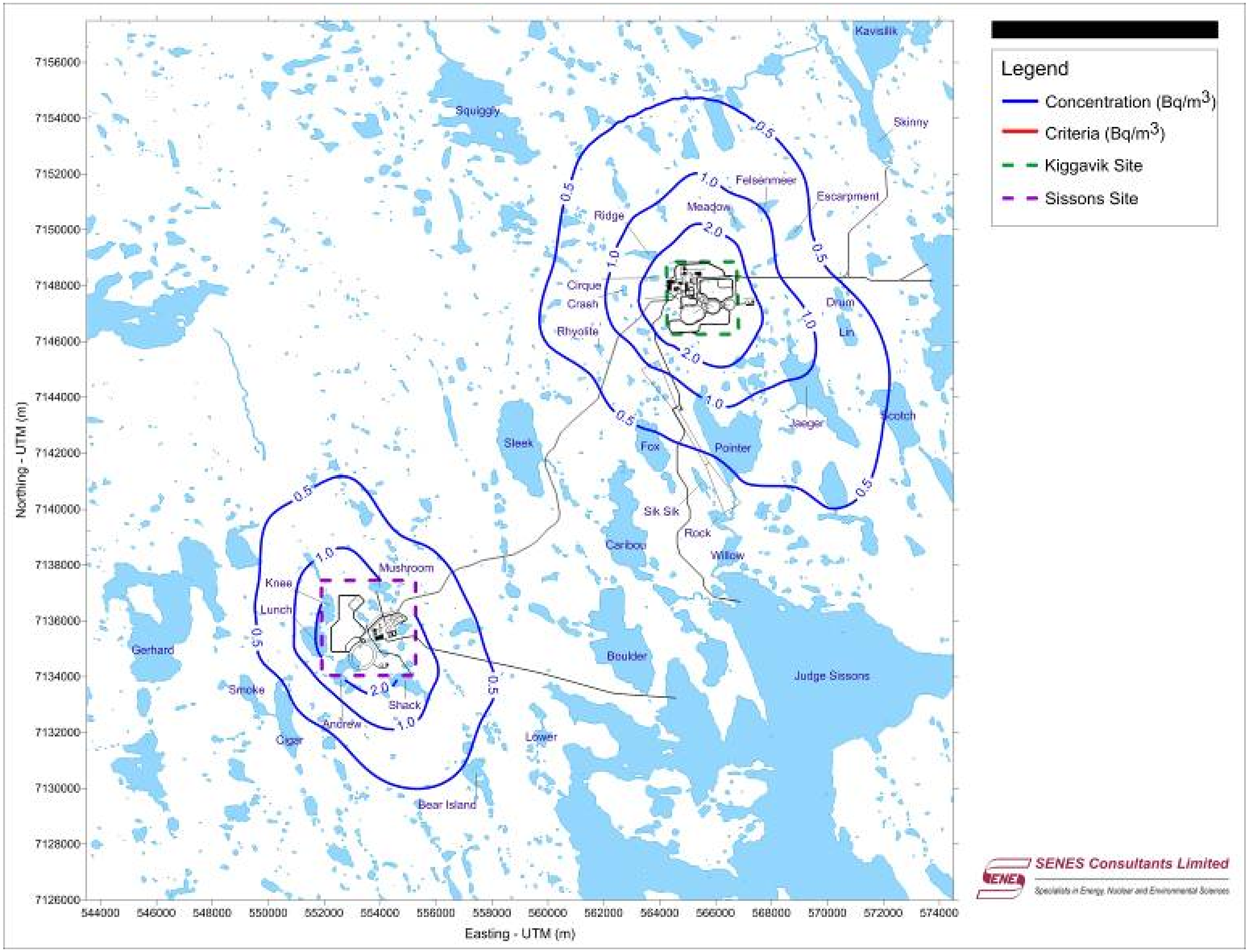


Figure 28 **Period 4 (Year 14) Incremental Annual Radon Concentration**

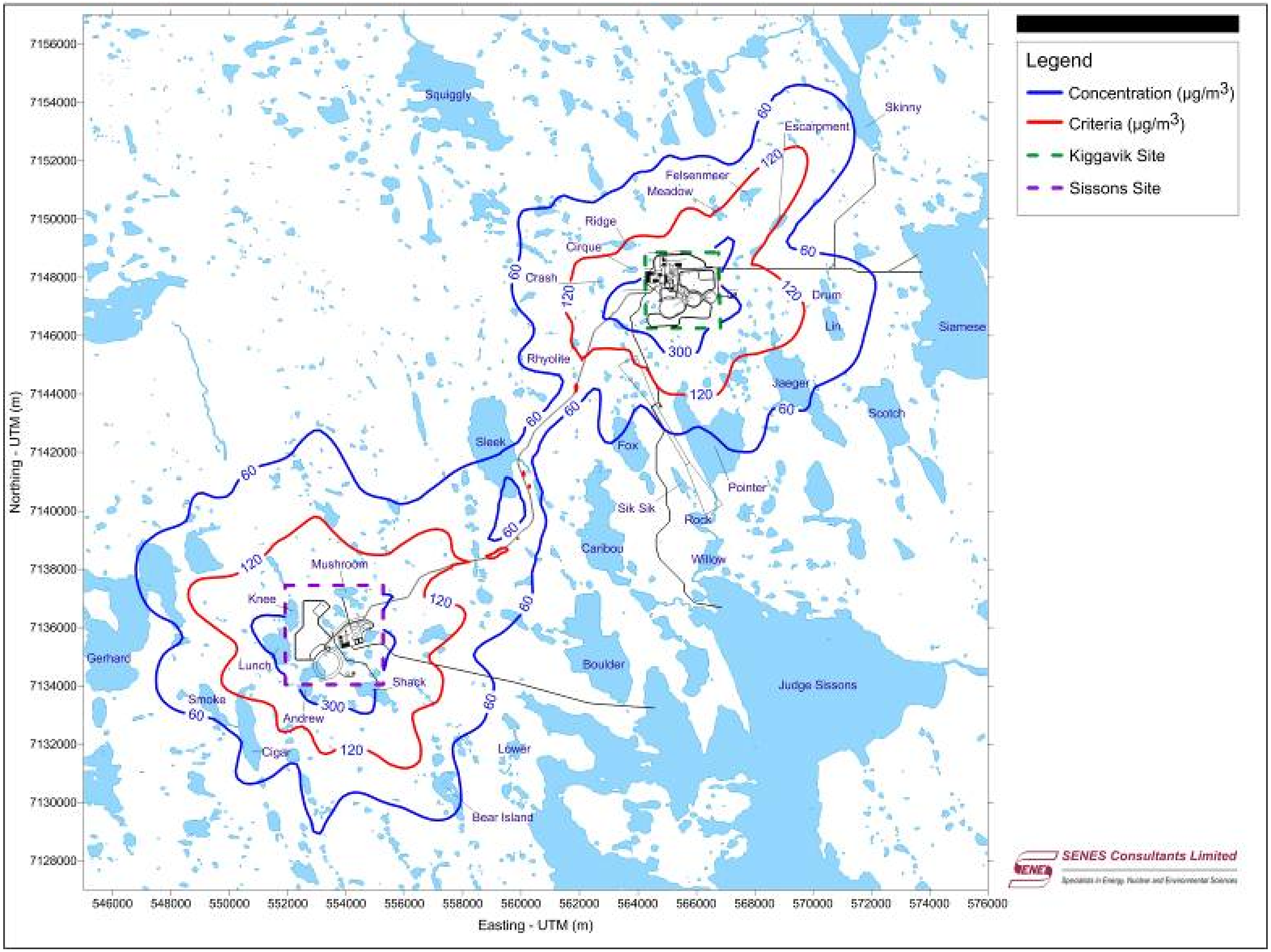


Figure 29 Maximum Operation Assessment Incremental Maximum 24-hour TSP Concentration

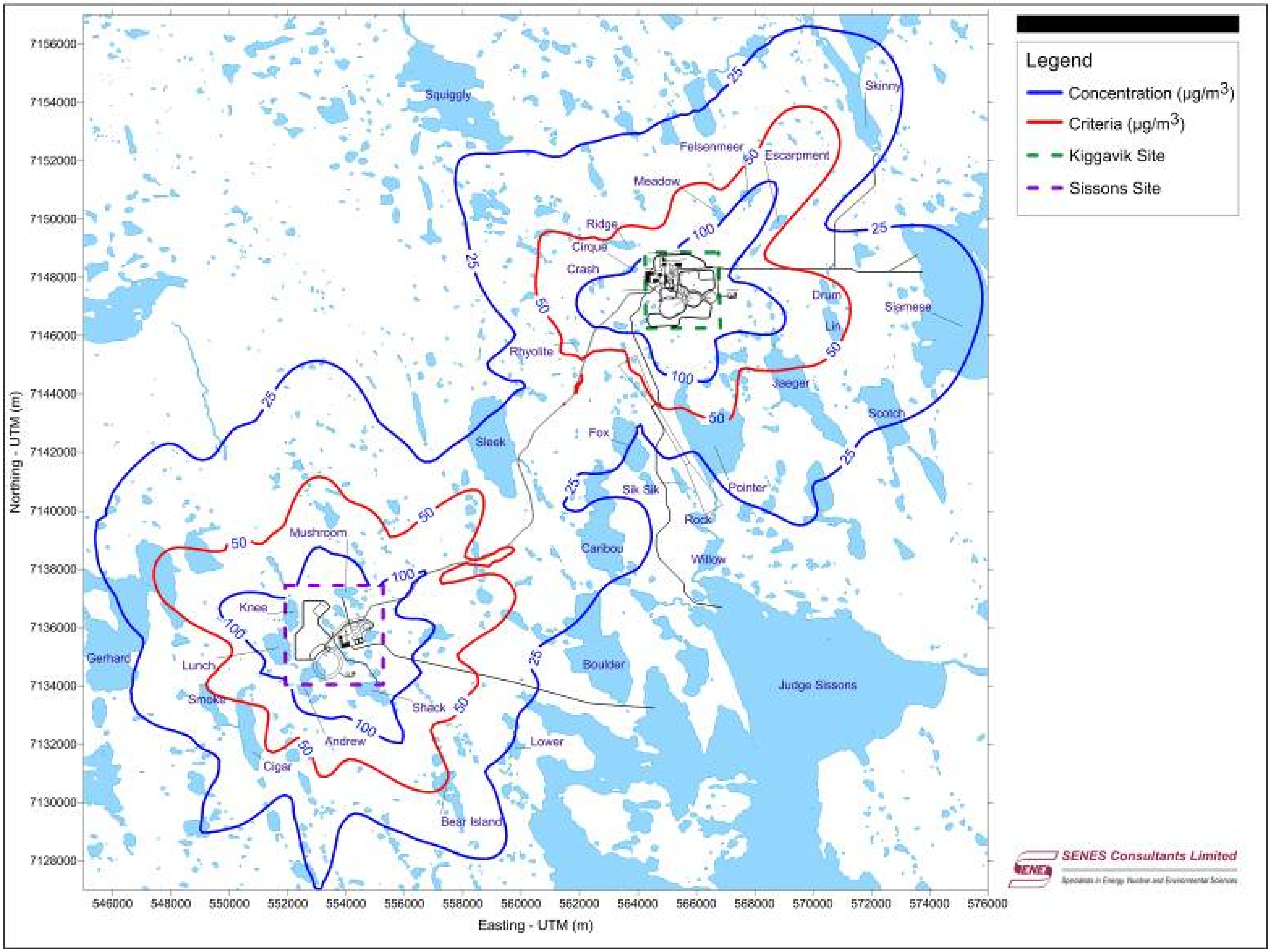


Figure 30 Maximum Operation Assessment Incremental Maximum 24-hour PM_{10} Concentration

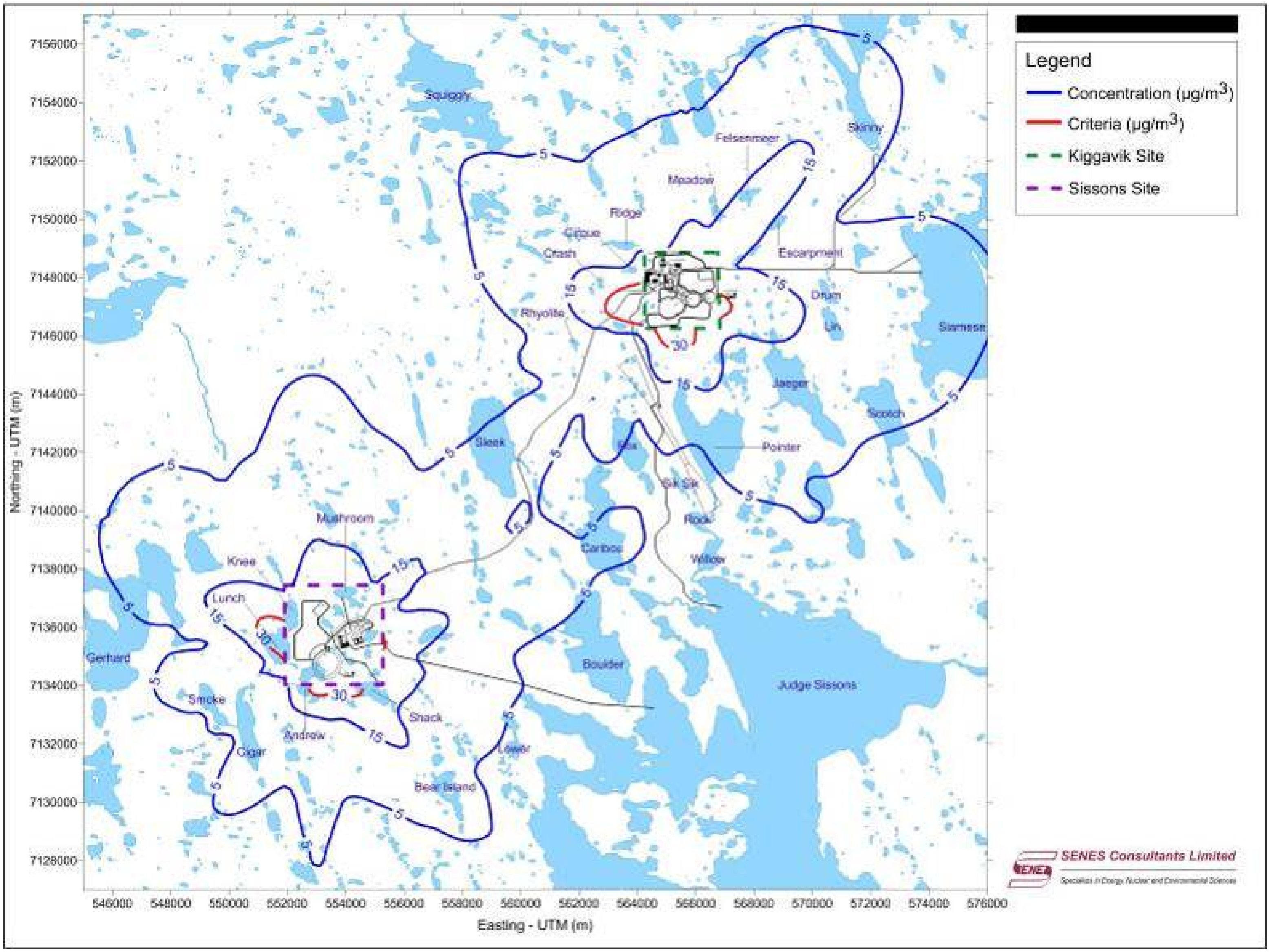


Figure 31 **Maximum Operation Assessment Incremental Maximum 24-hour $PM_{2.5}$ Concentration**

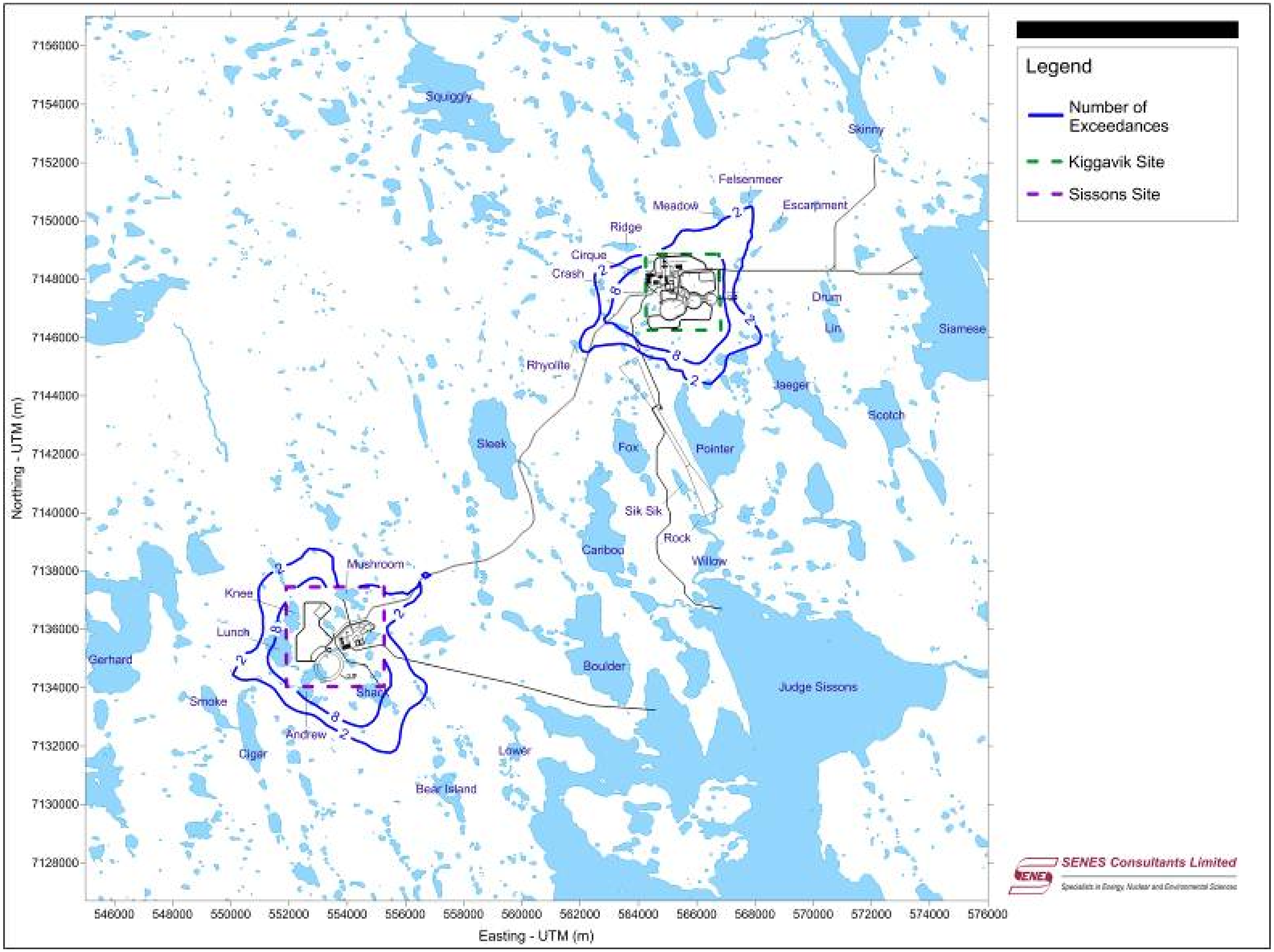


Figure 32 **Maximum Operation Assessment 24-hour TSP Exceedances**

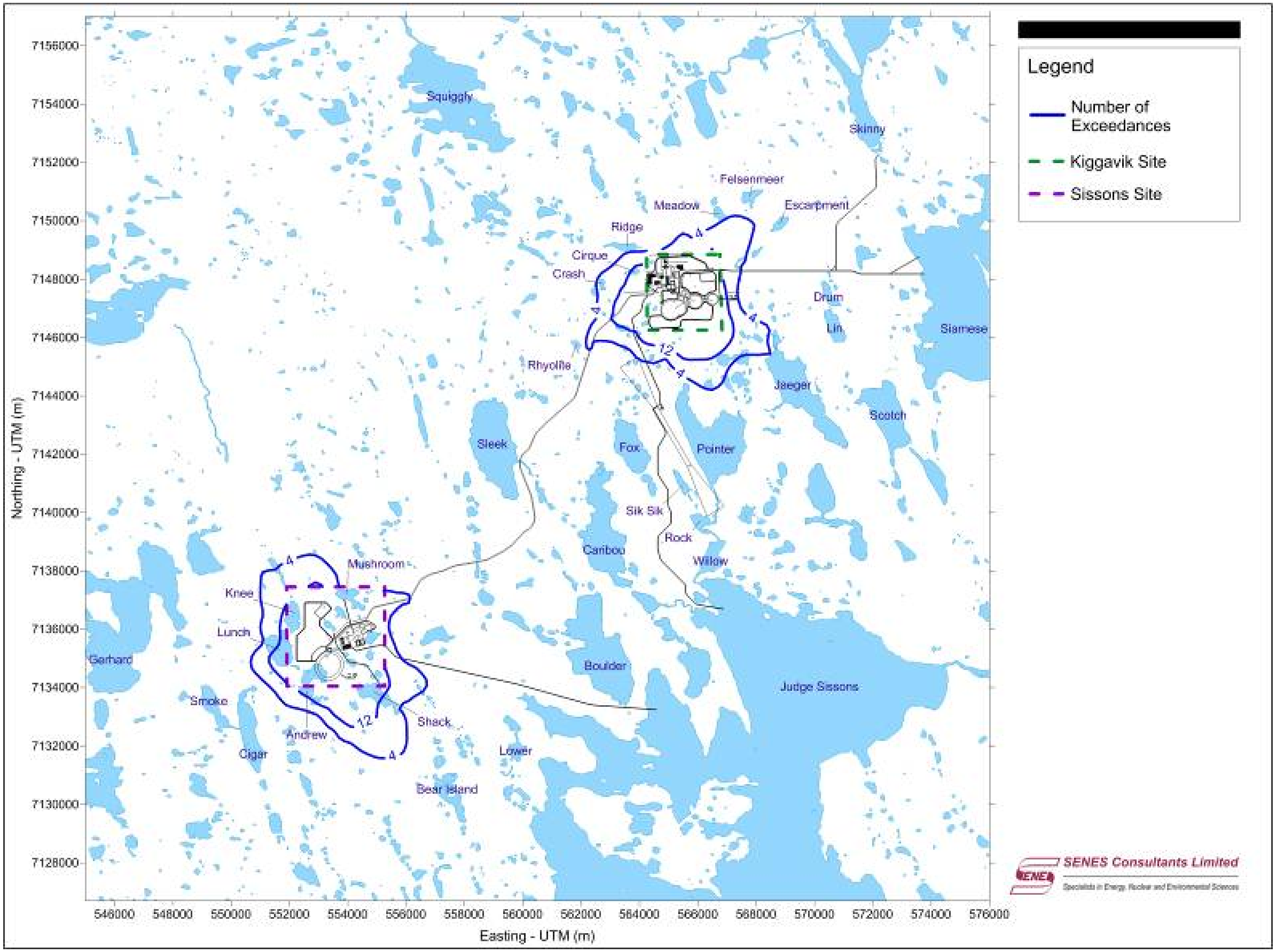


Figure 33 **Maximum Operation Assessment 24-hour PM_{10} Exceedances**

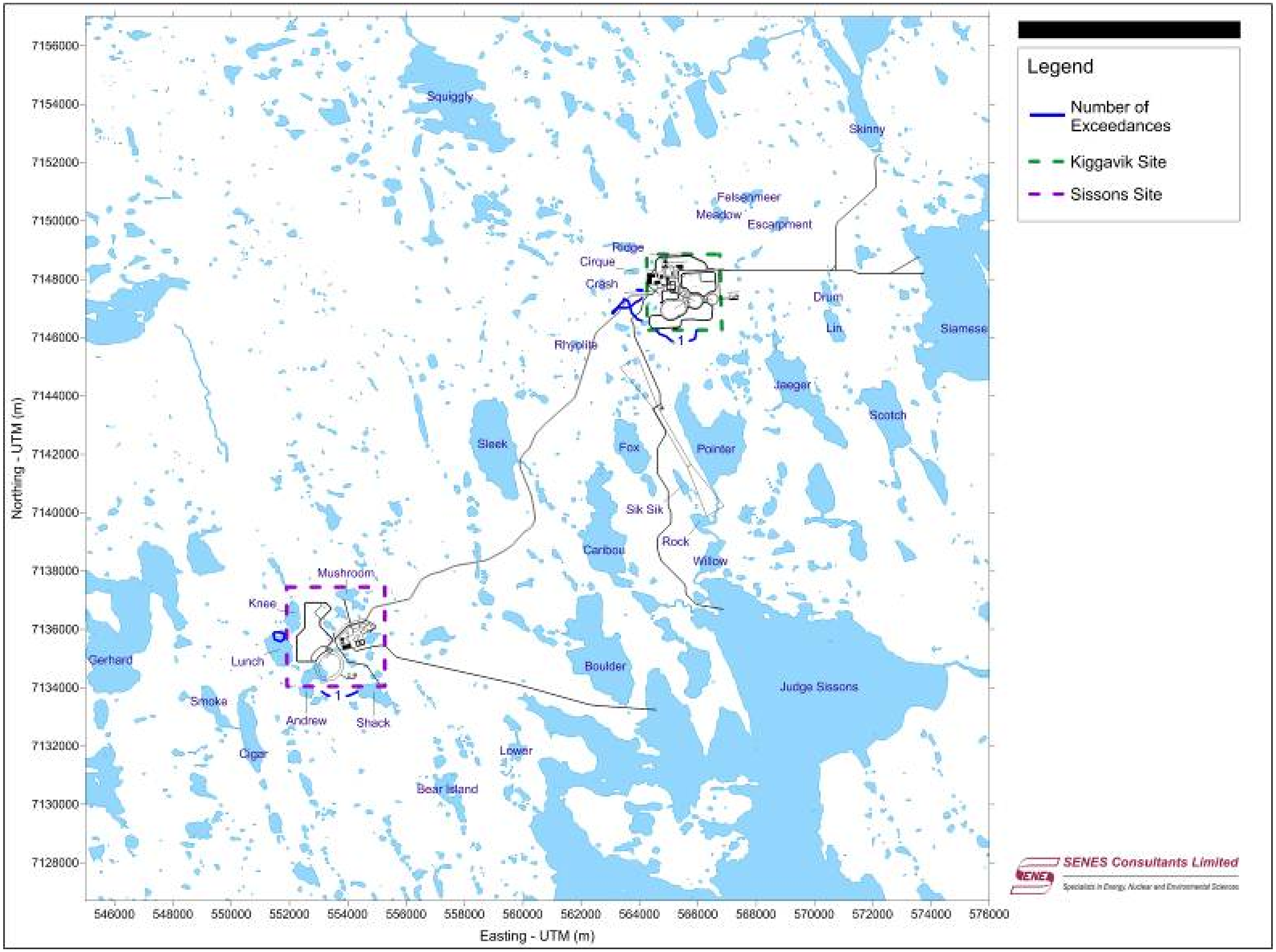


Figure 34 **Maximum Operation Assessment 24-hour $PM_{2.5}$ Exceedances**

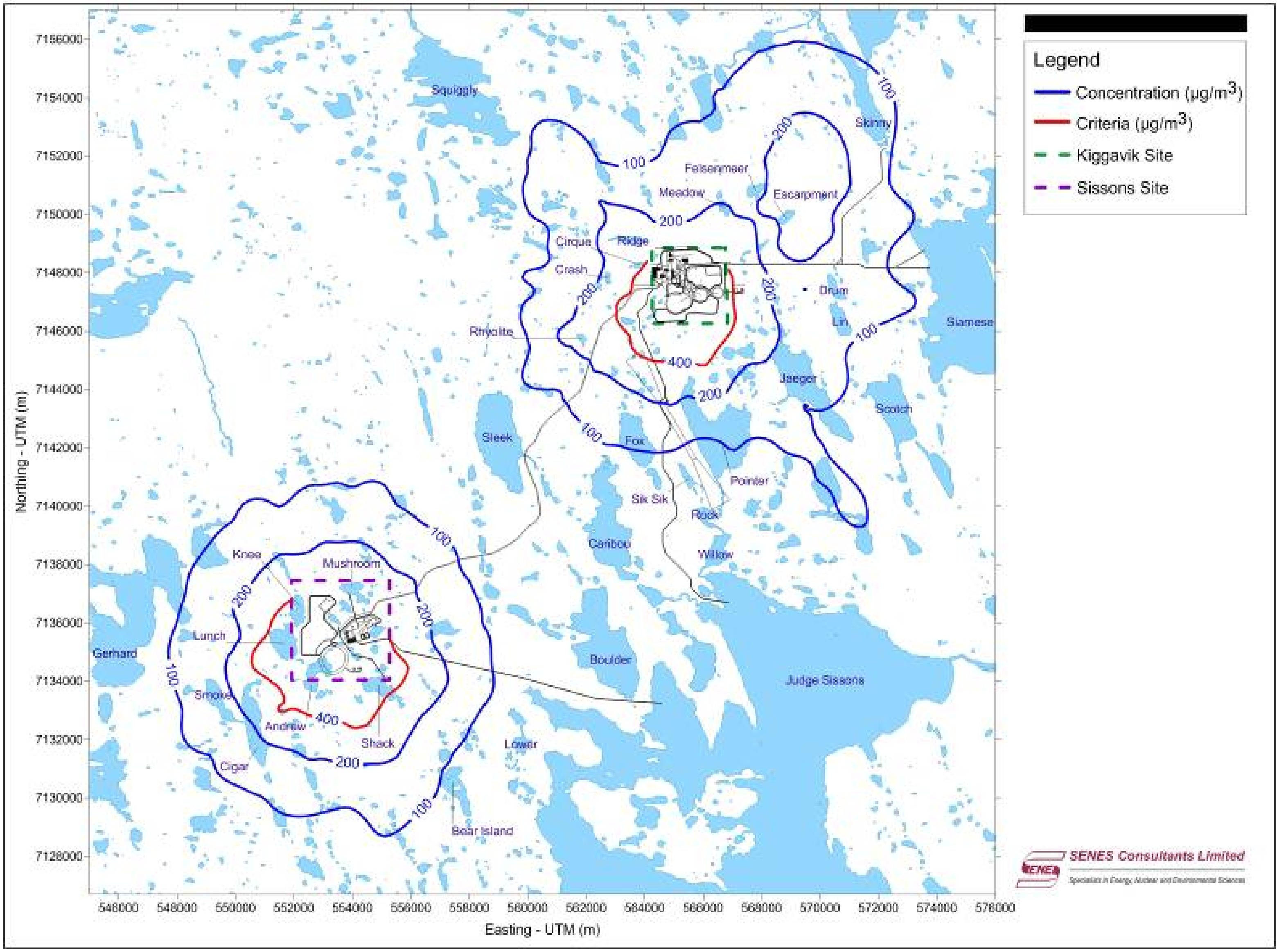


Figure 35 Maximum Operation Assessment Incremental Maximum 1-hour NO_2 Concentration

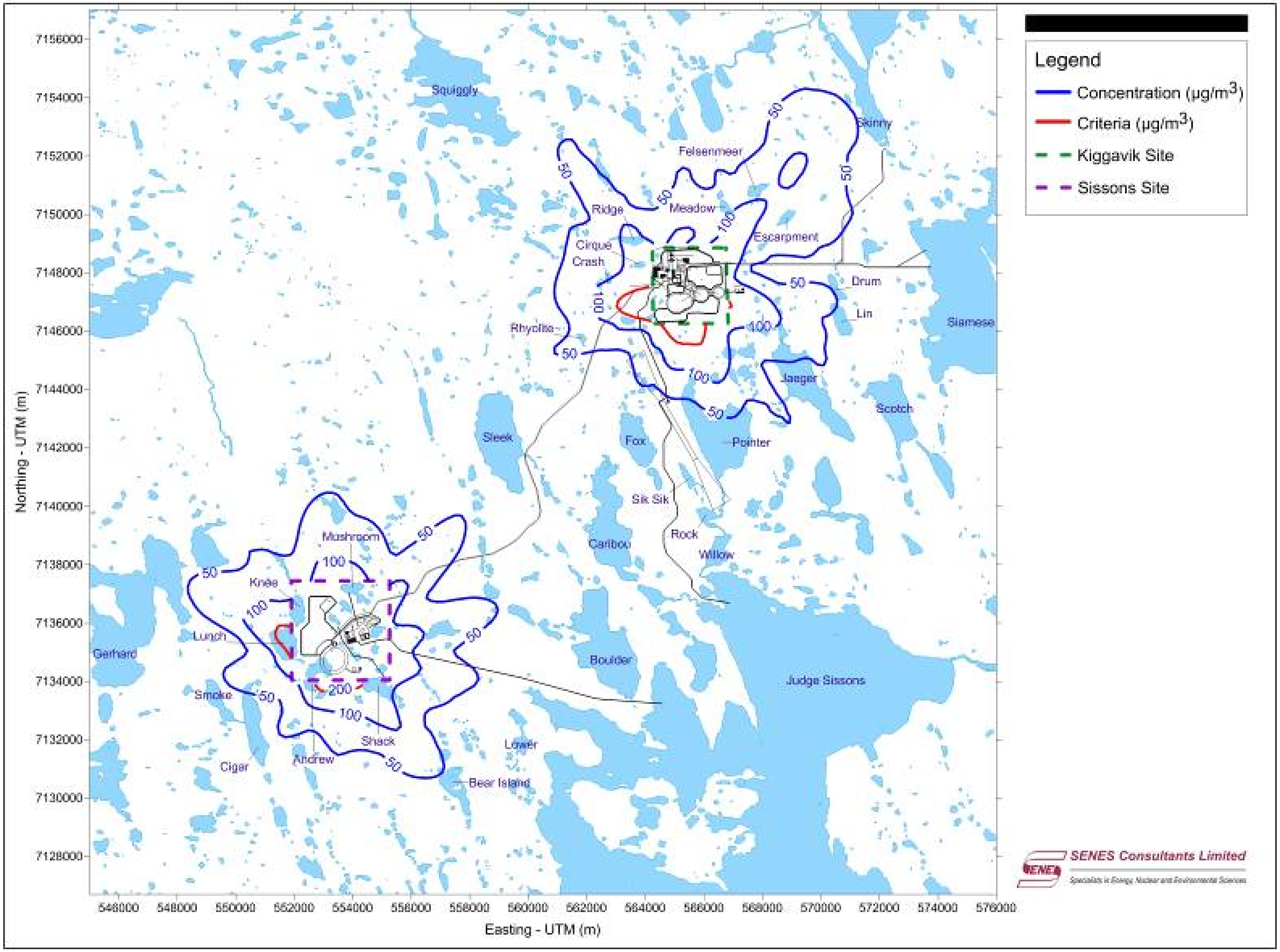


Figure 36 **Maximum Operation Assessment Incremental Maximum 24-hour NO_2 Concentration**

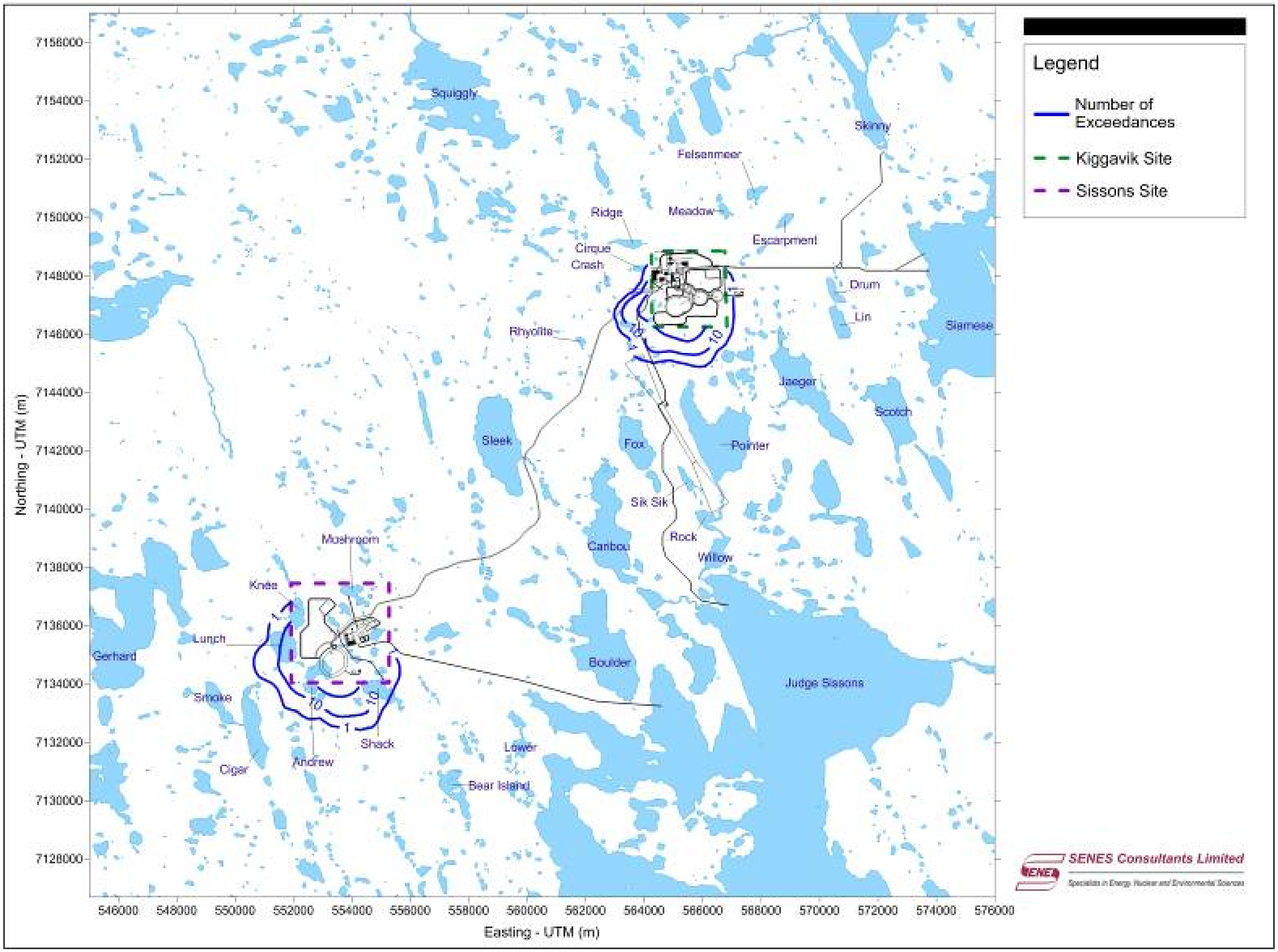


Figure 37 **Maximum Operation Assessment 1-hour NO_2 Exceedances**

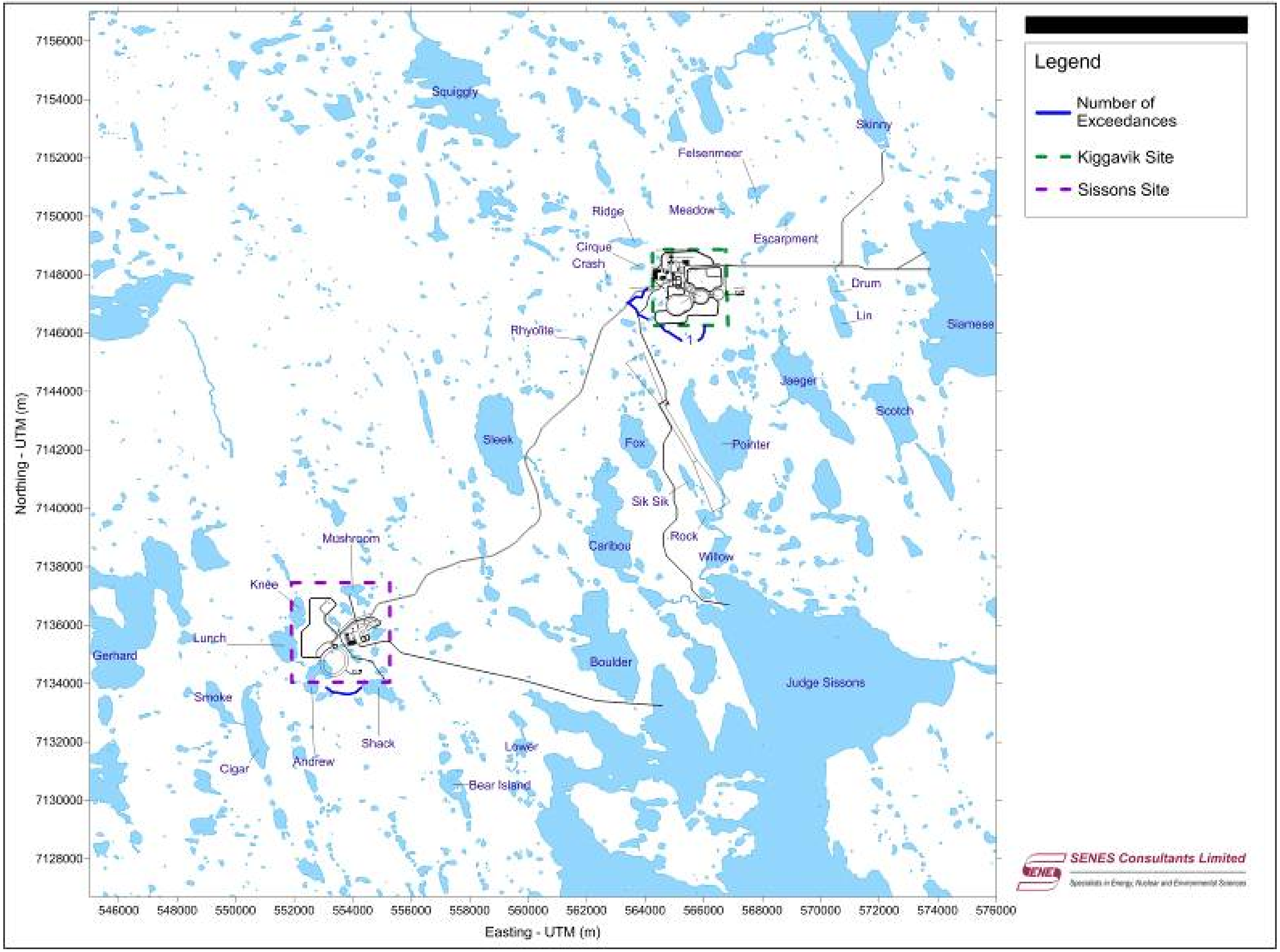


Figure 38 **Maximum Operation Assessment 24-hour NO_2 Exceedances**

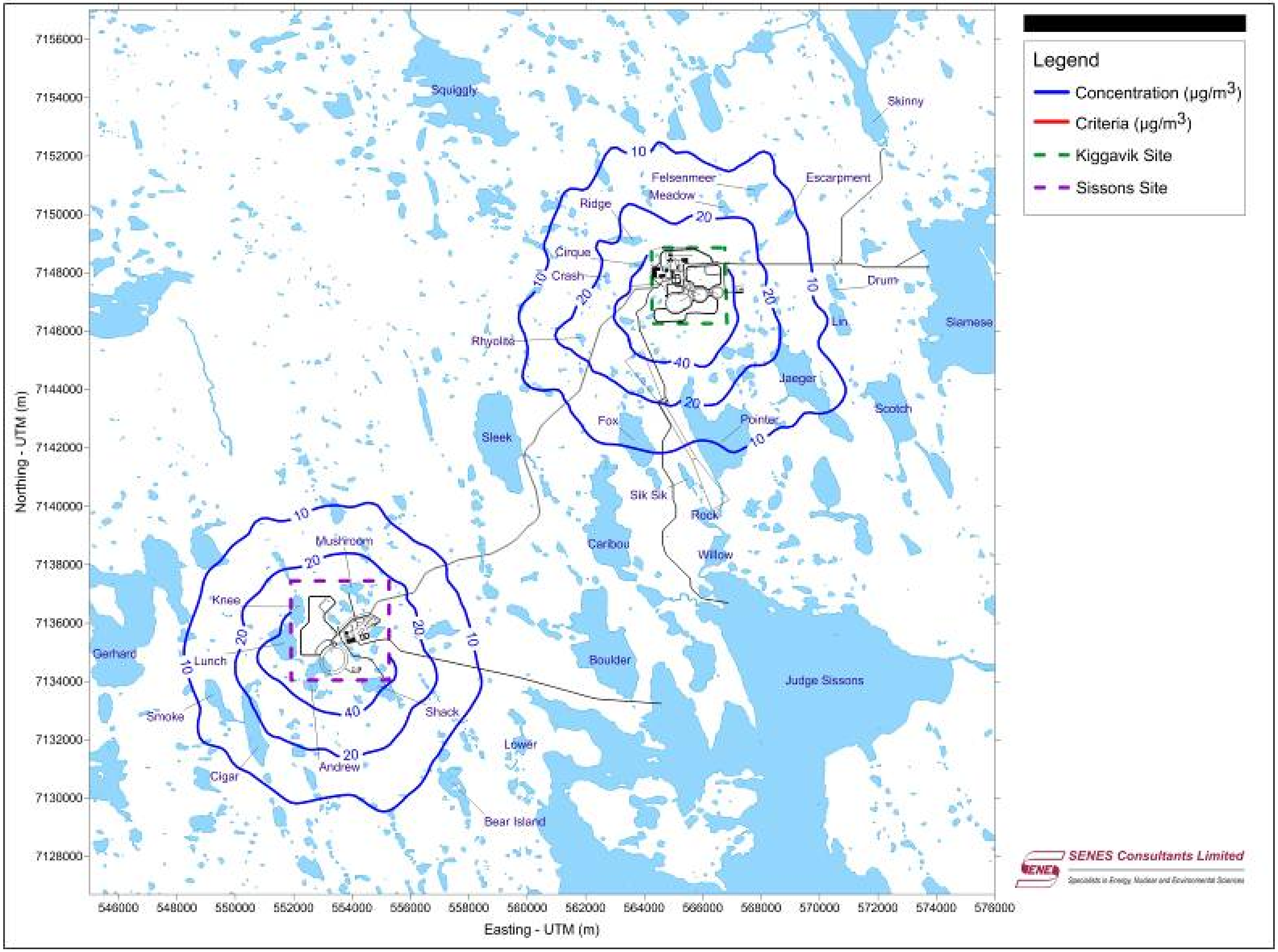


Figure 39 **Maximum Operation Assessment Incremental Maximum 1-hour SO_2 Concentration**

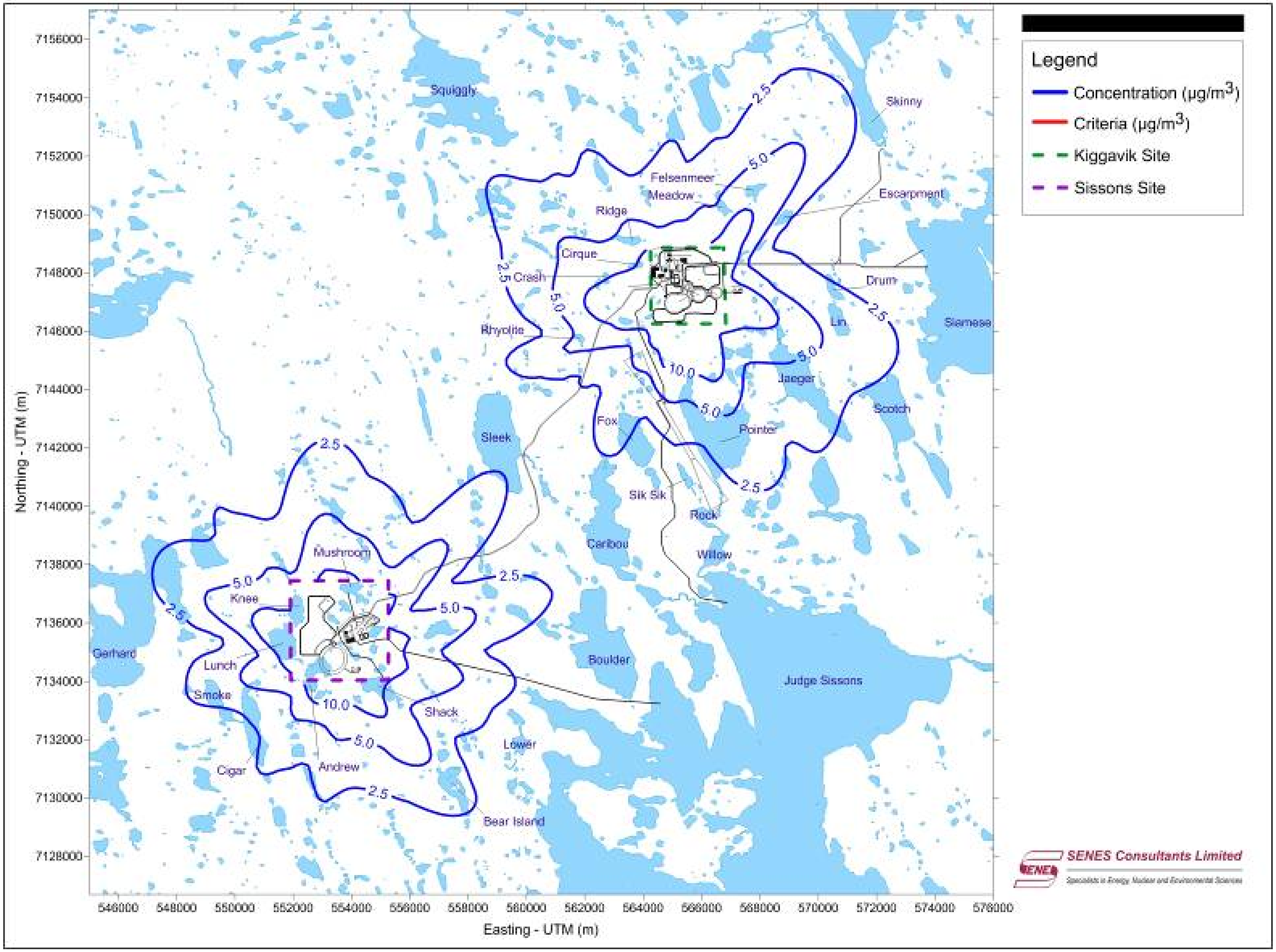


Figure 40 Maximum Operation Assessment Incremental Maximum 24-hour SO_2 Concentration

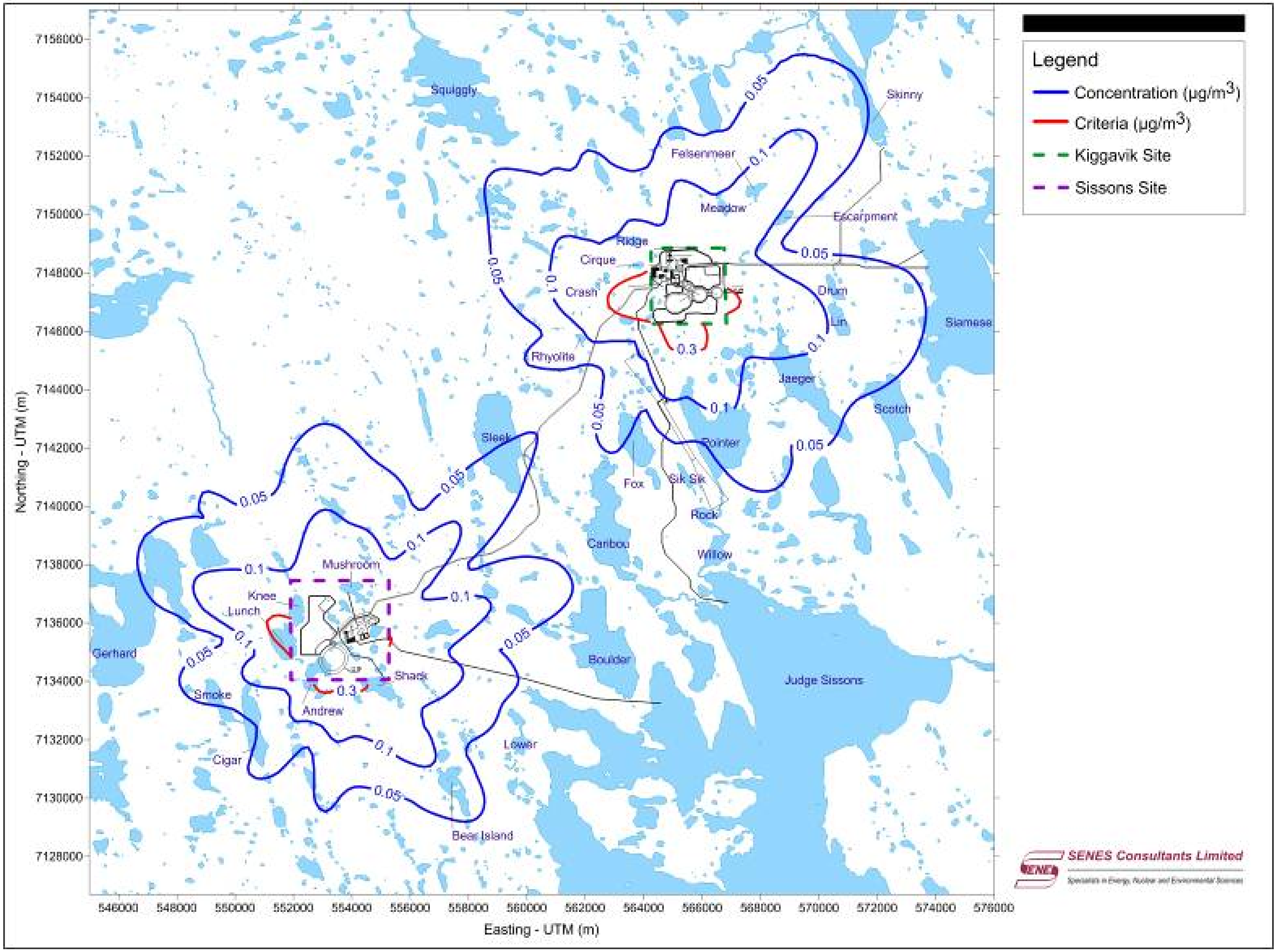


Figure 41 Maximum Operation Assessment Incremental Maximum 24-hour Uranium Concentration

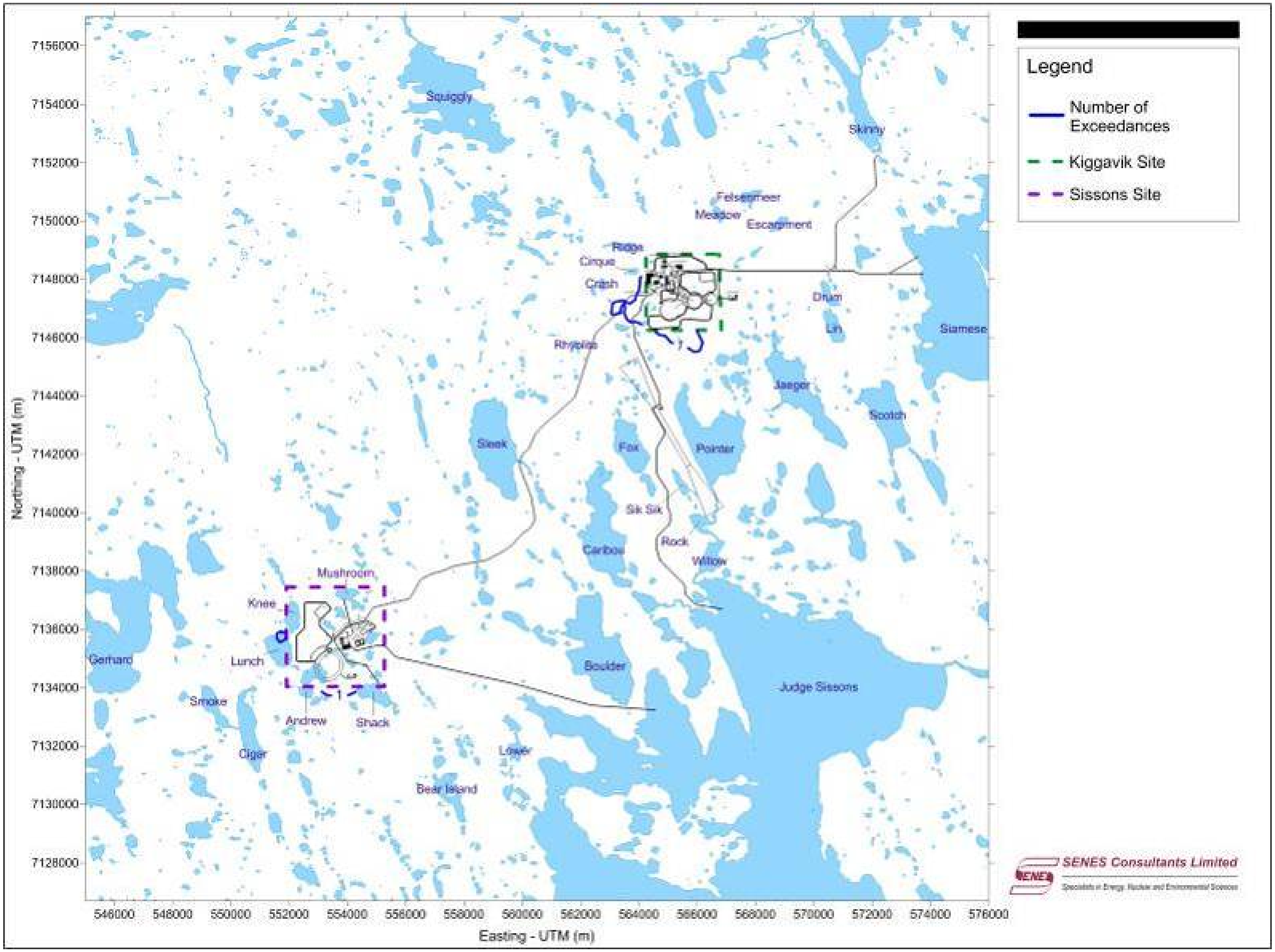


Figure 42 **Maximum Operation Assessment 24-hour Uranium Exceedances**

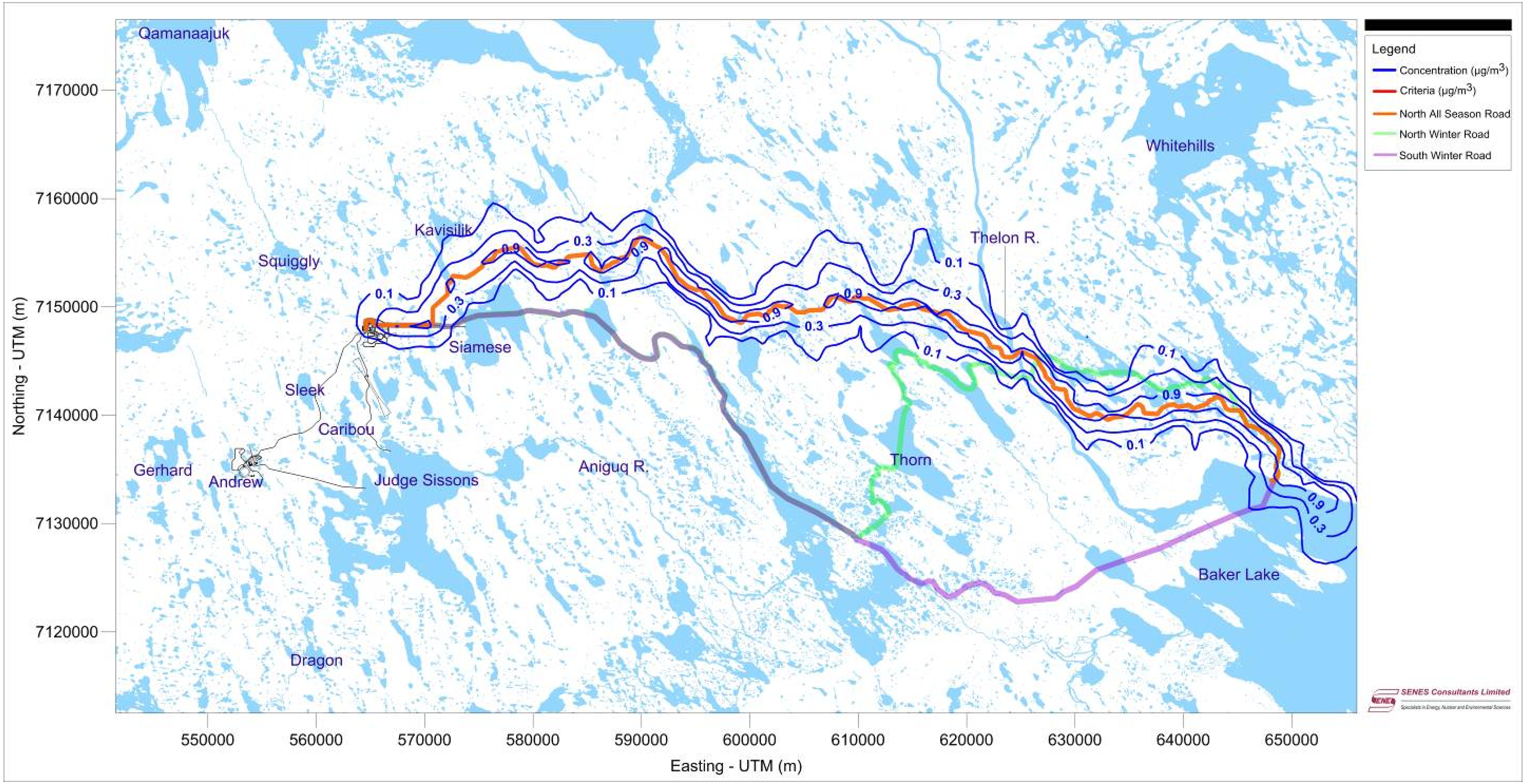


Figure 43 **Incremental Annual TSP Concentration for the All Season Access Road Option**

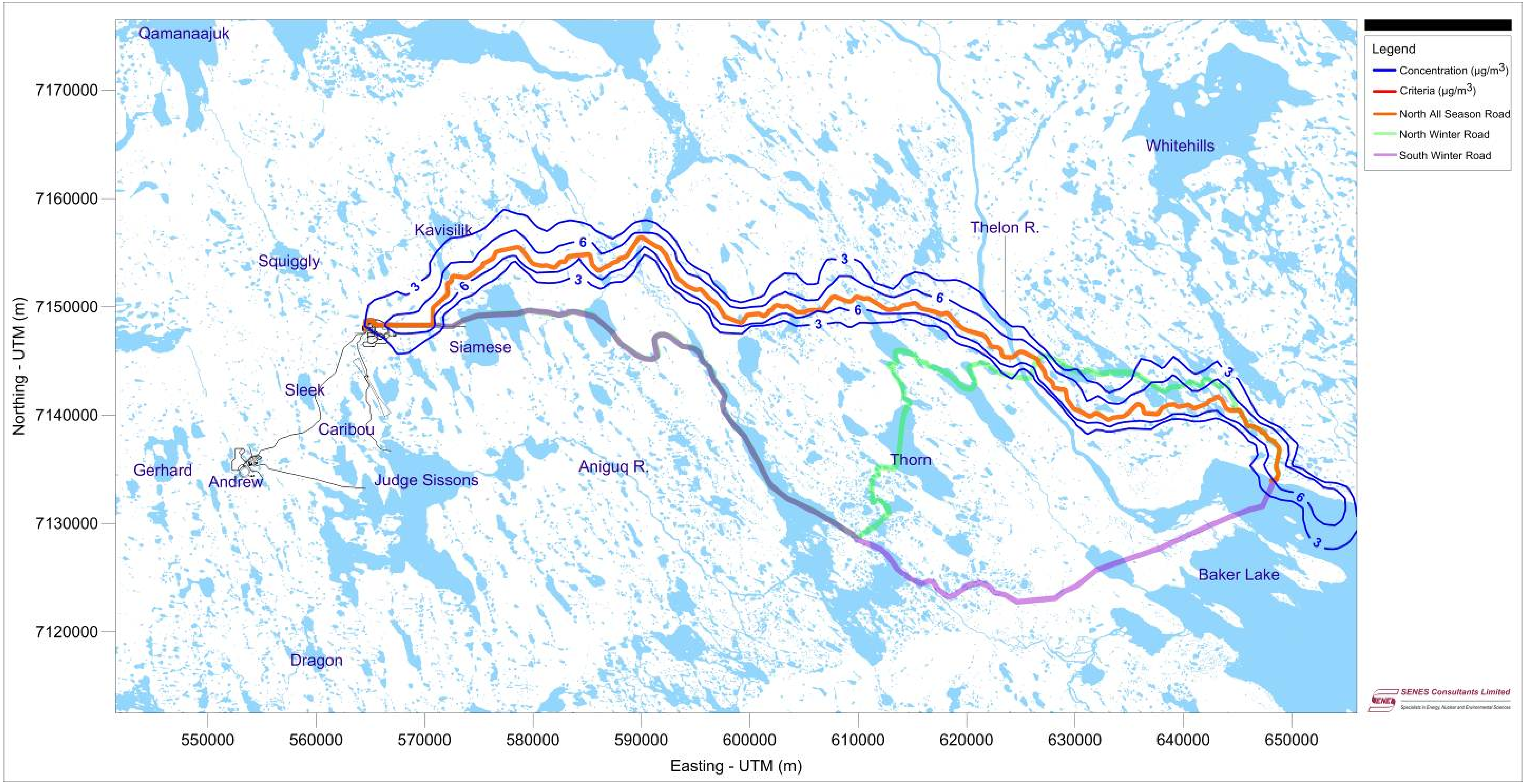


Figure 44 **Incremental 24-hr TSP Concentration for the All Season Access Road Option**

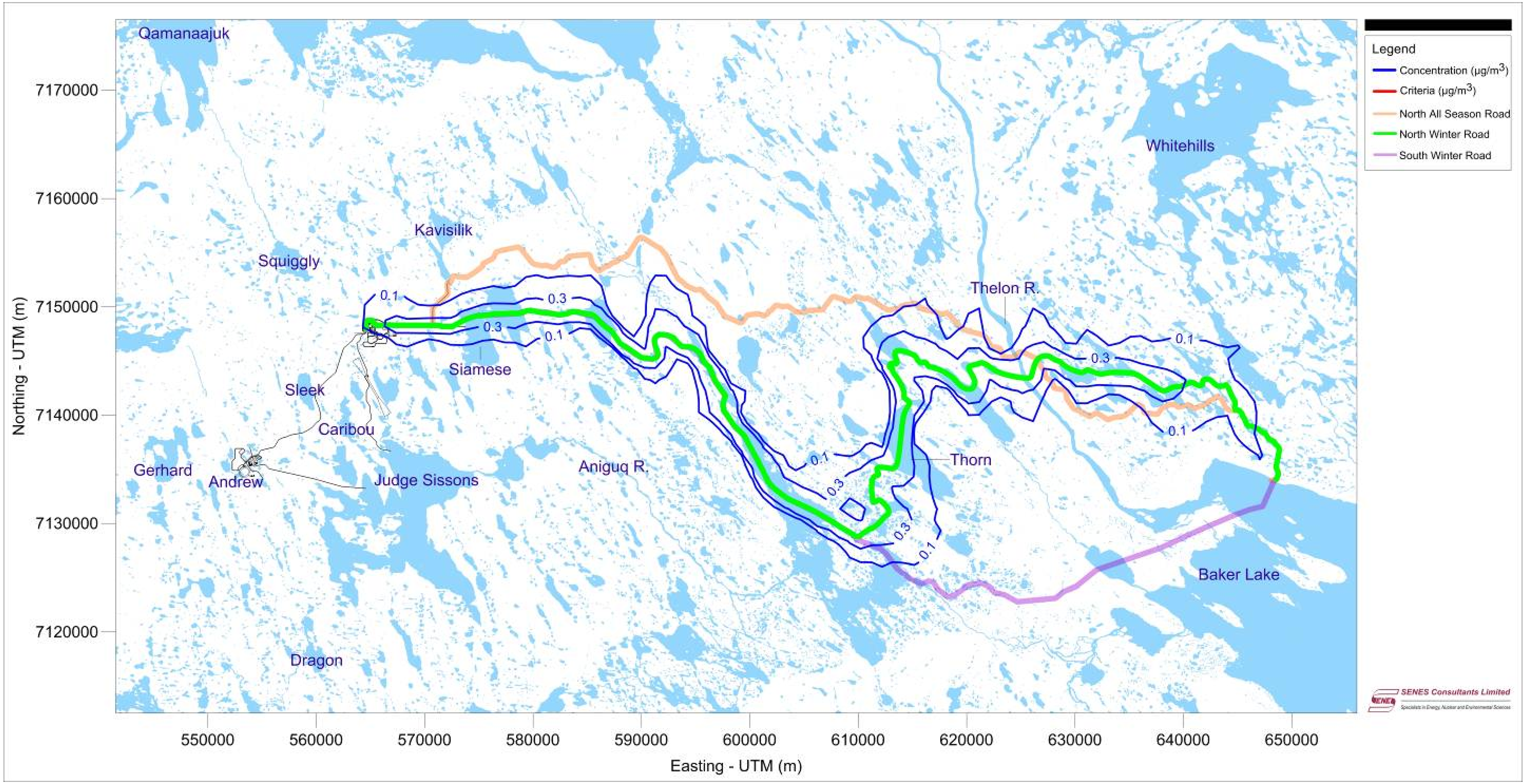


Figure 45 Incremental Annual TSP Concentration for the North Winter Road Option

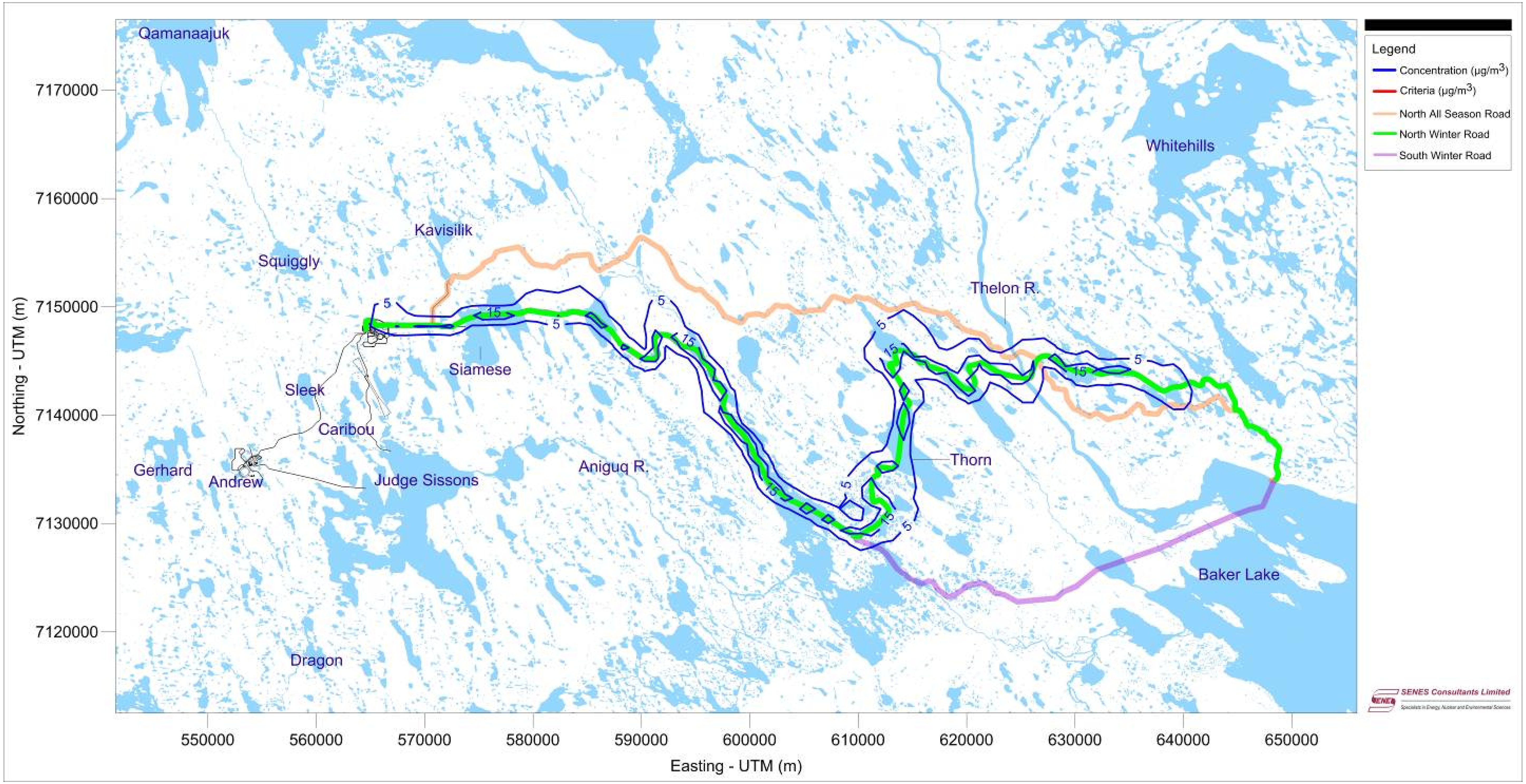


Figure 46 **Incremental 24-hr TSP Concentration for the North Winter Access Road Option**

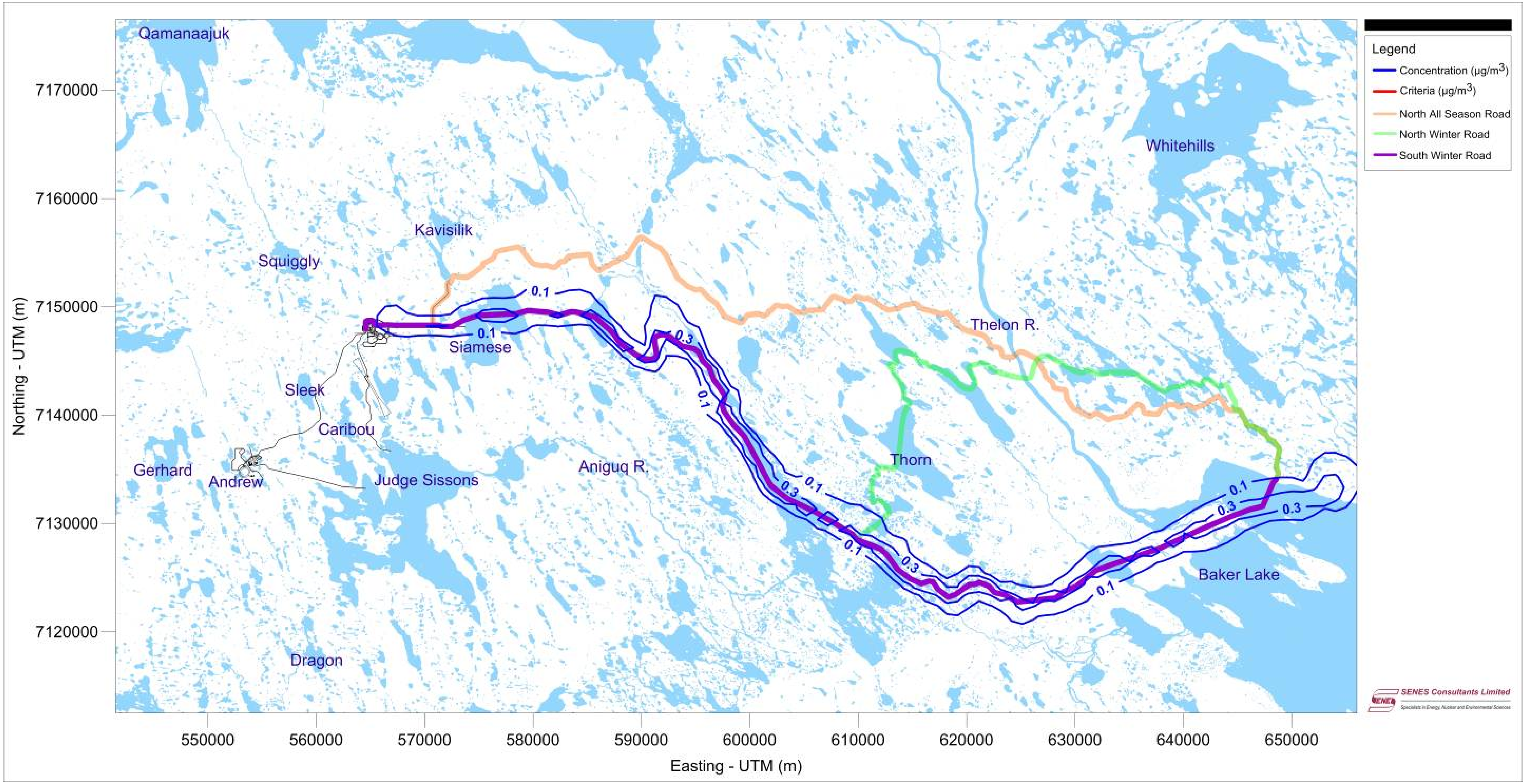


Figure 47 **Incremental Annual TSP Concentration for the South Winter Access Road Option**

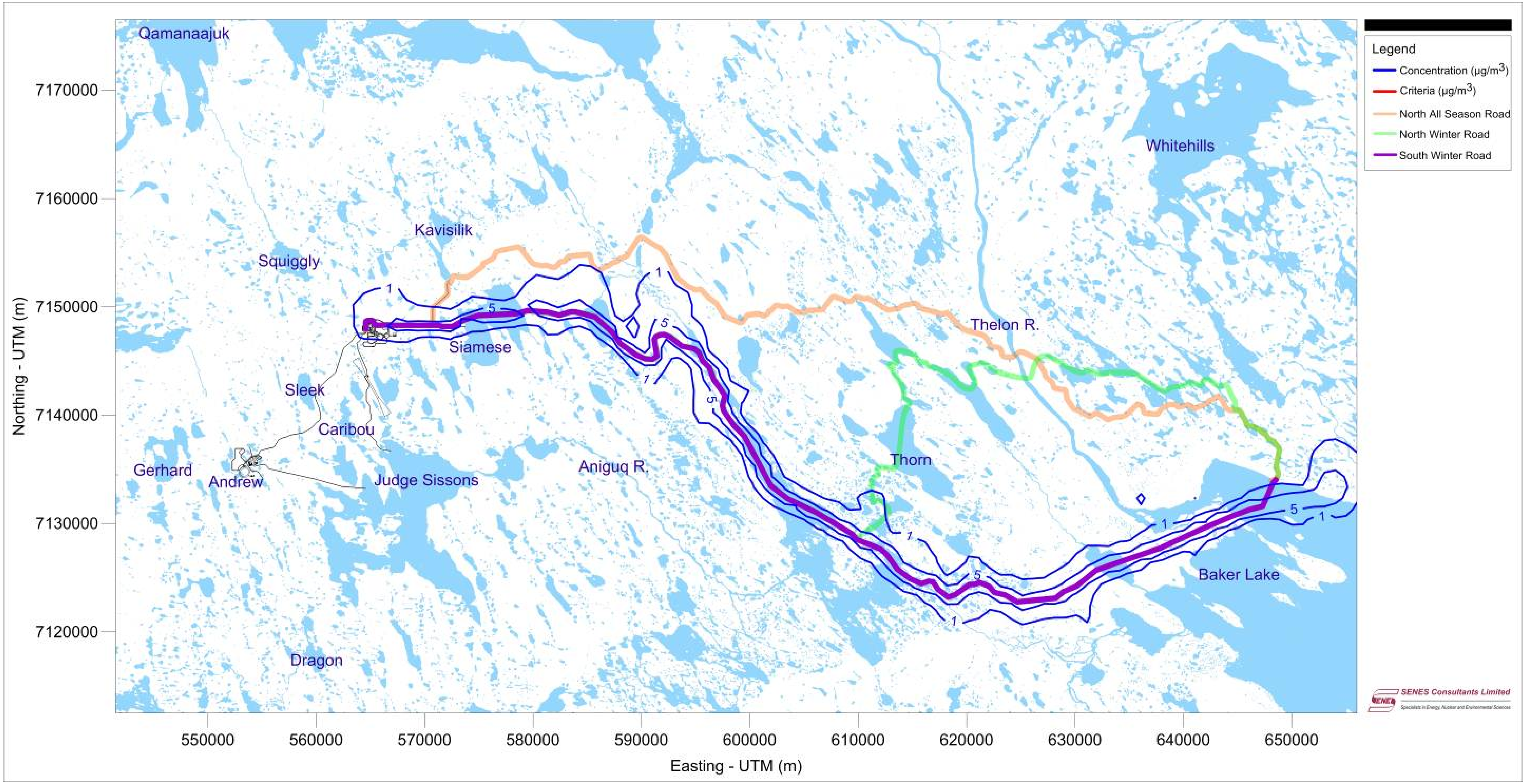


Figure 48 **Incremental 24-hr TSP Concentration for the South Winter Access Road Option**

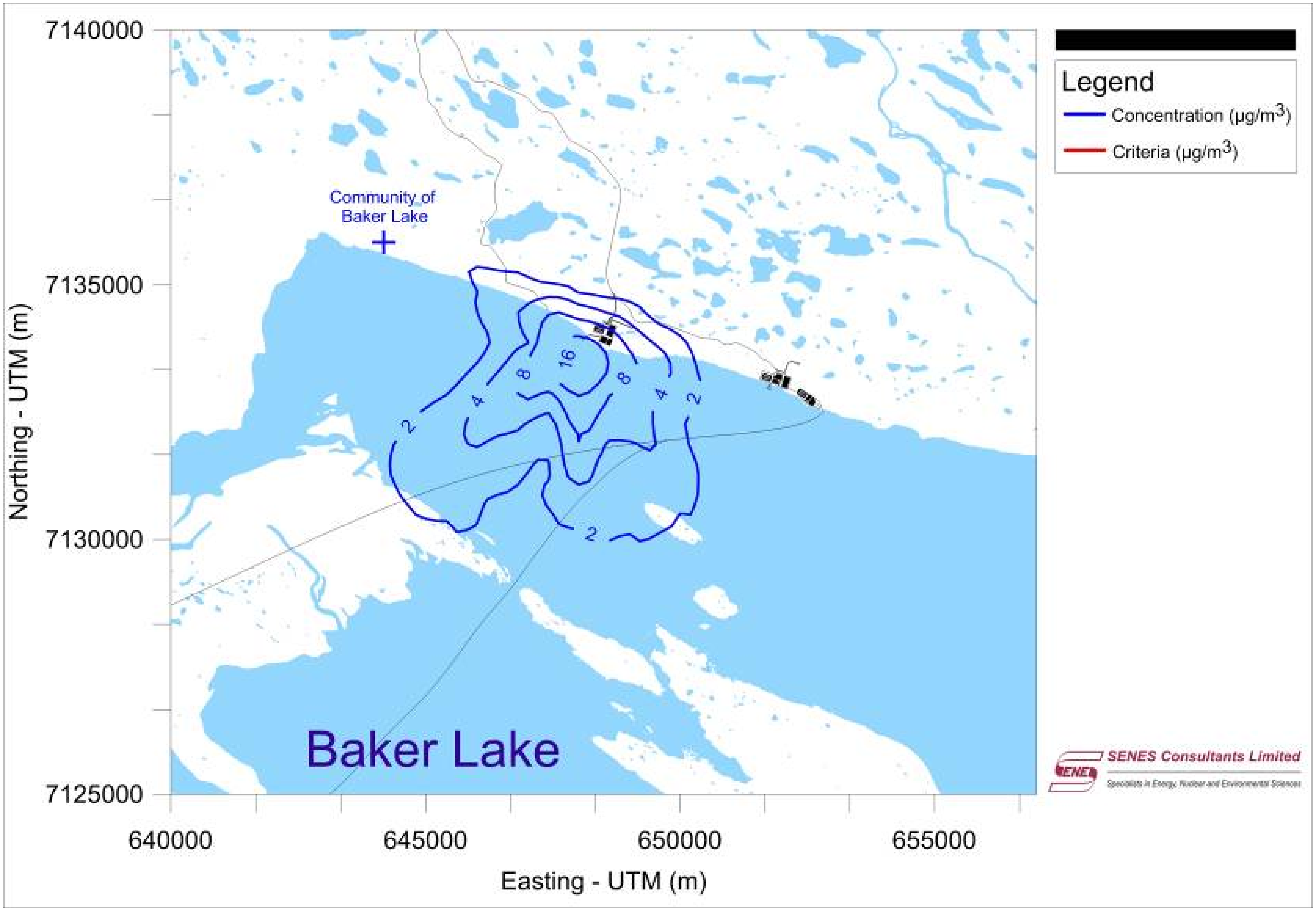


Figure 49 **Baker Lake Dock and Storage Facility Assessment Incremental Maximum 24-hour TSP Concentration**

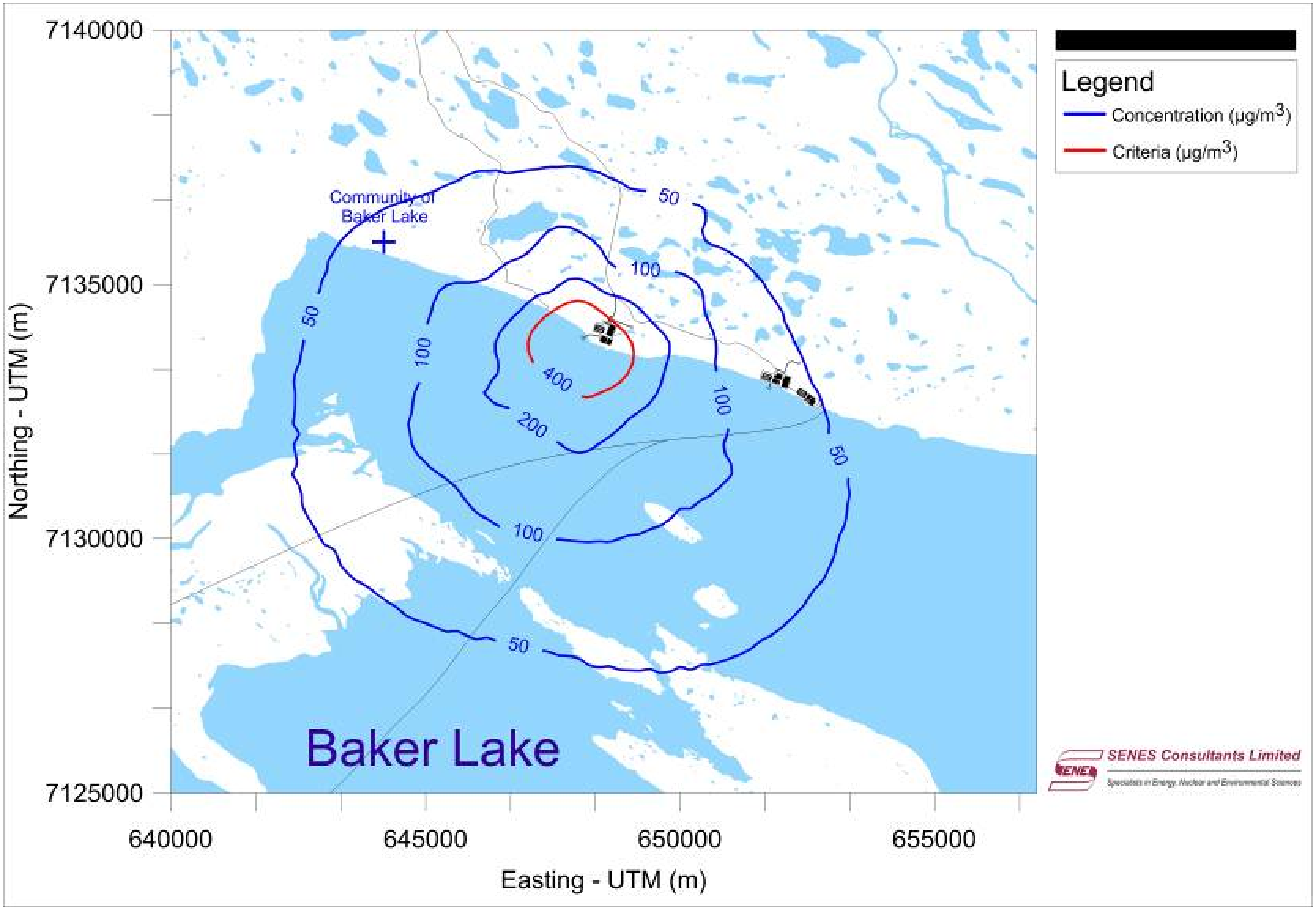


Figure 50 **Baker Lake Dock and Storage Facility Assessment Incremental Maximum 1-hour NO_2 Concentration**

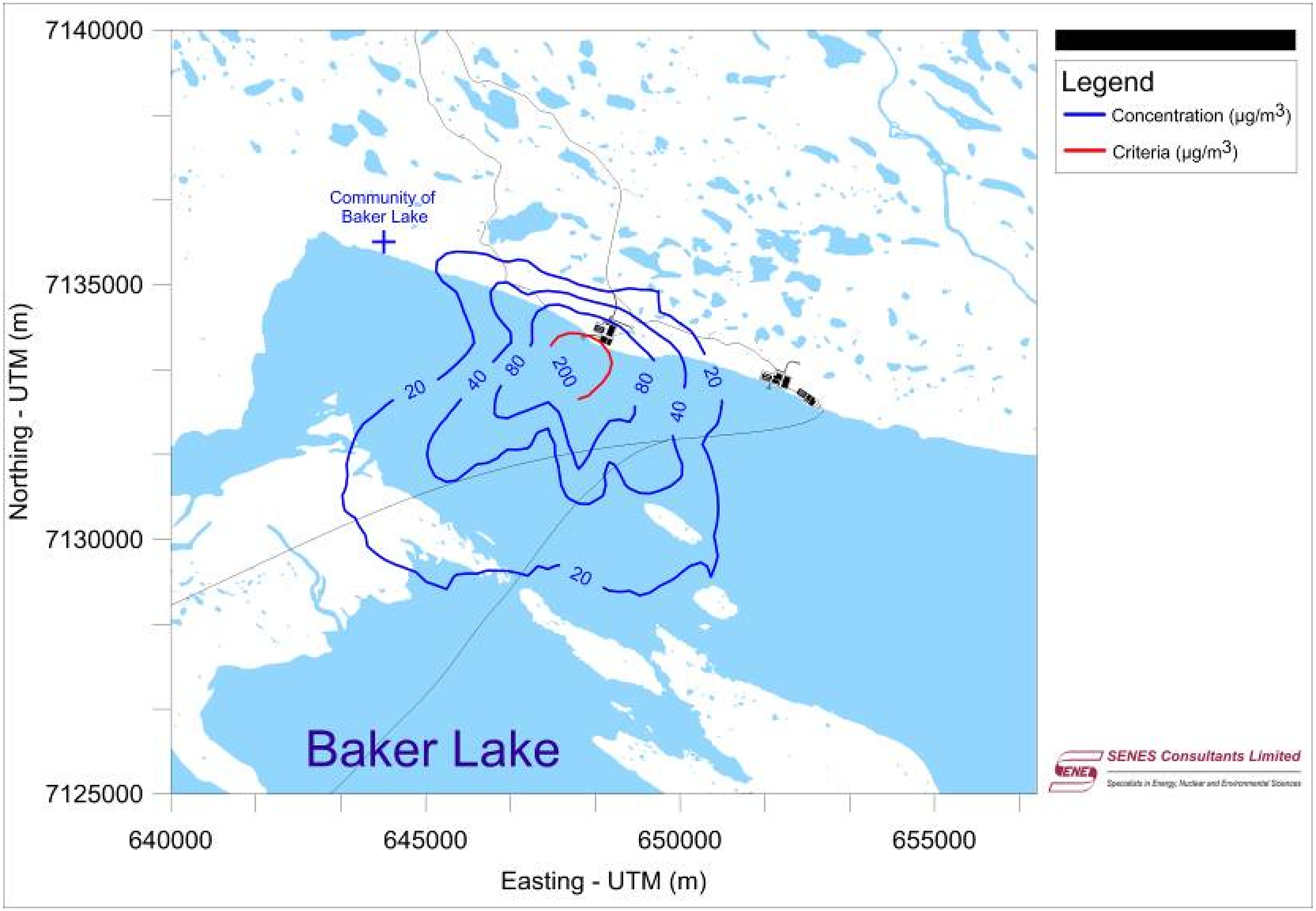


Figure 51 **Baker Lake Dock and Storage Facility Assessment Incremental Maximum 24-hour NO_2 Concentration**

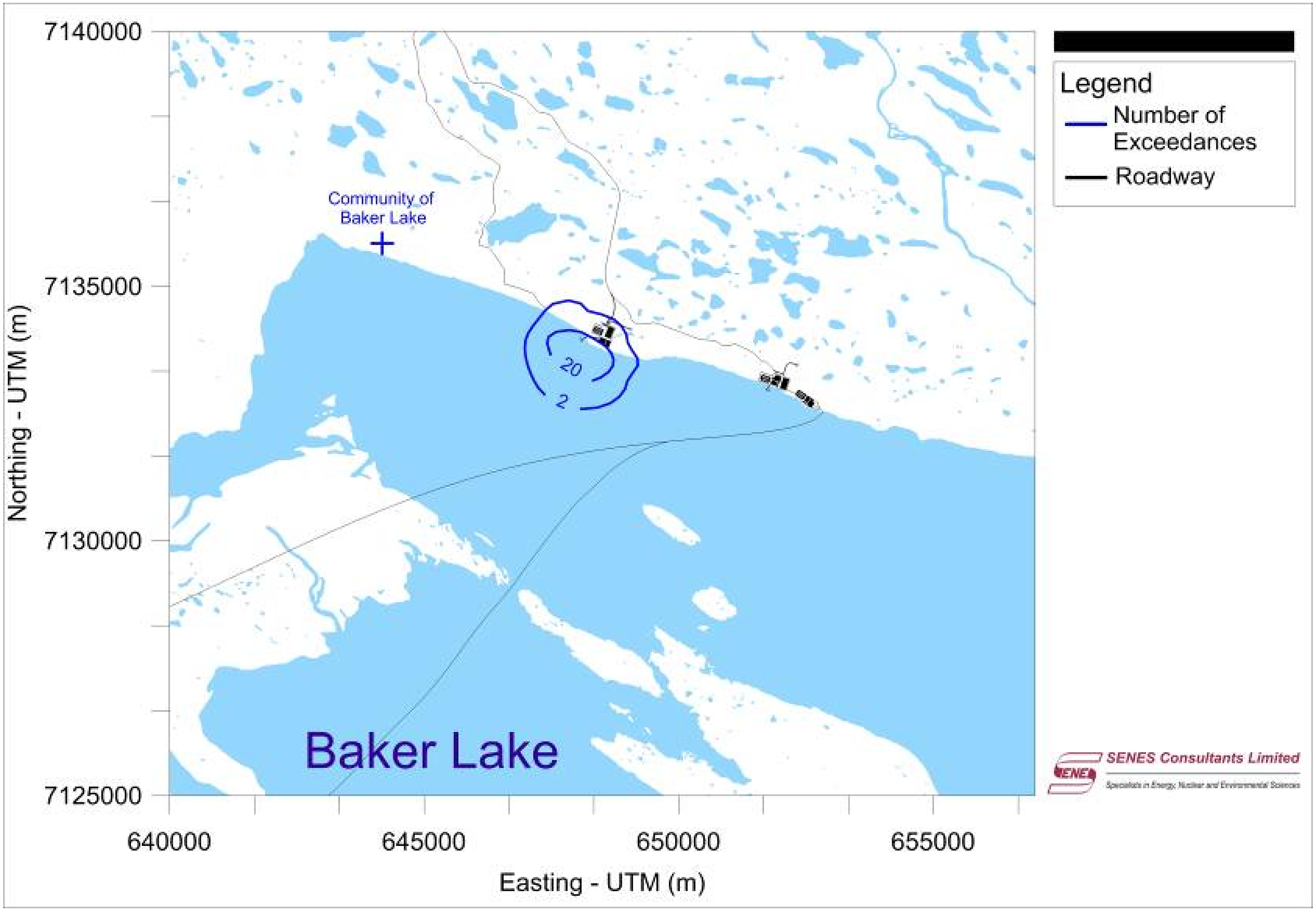


Figure 52 **Baker Lake Dock and Storage Facility Assessment 1-hour Exceedances**

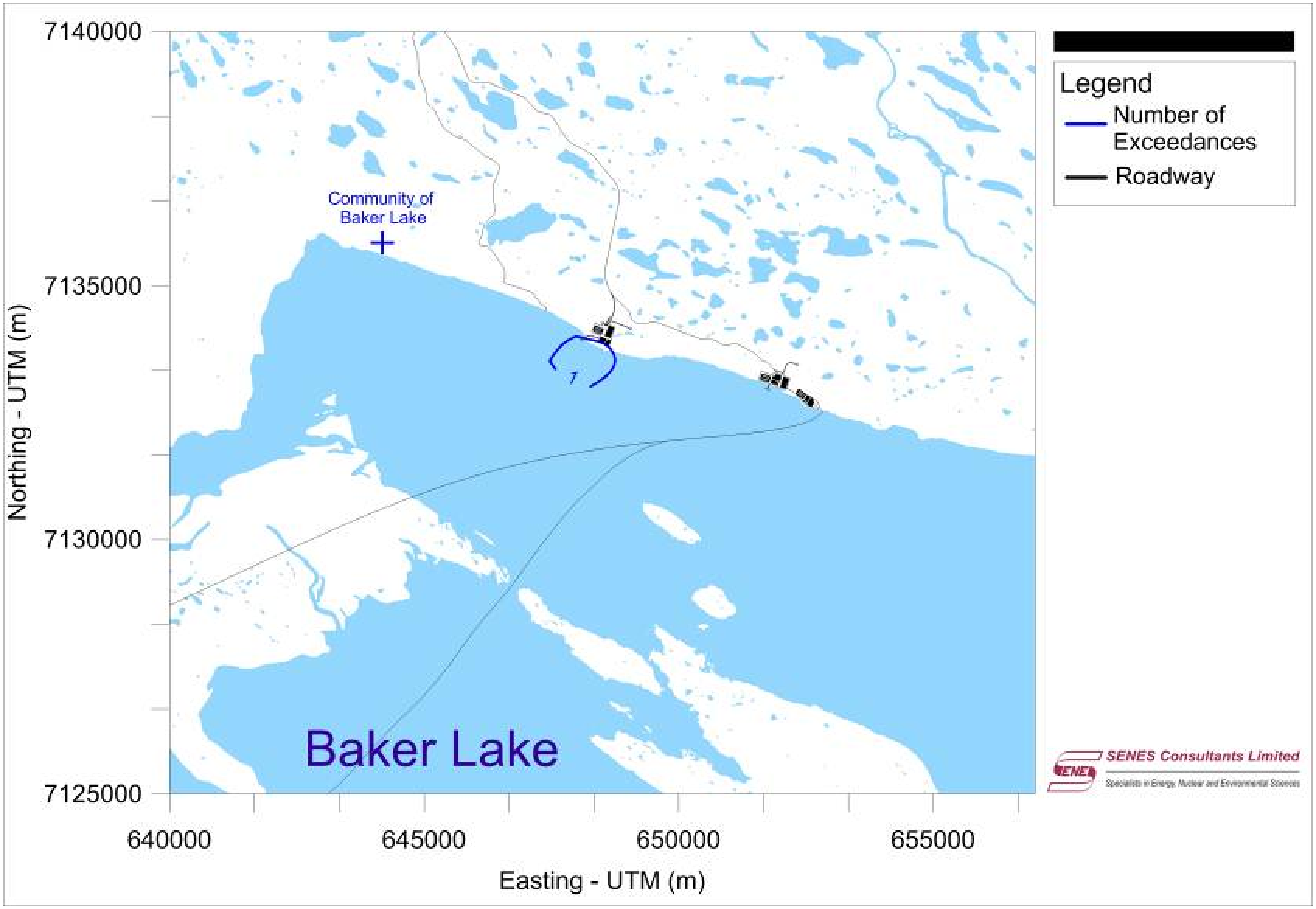


Figure 53 **Baker Lake Dock and Storage Facility Assessment 24-hour NO_2 Exceedances**

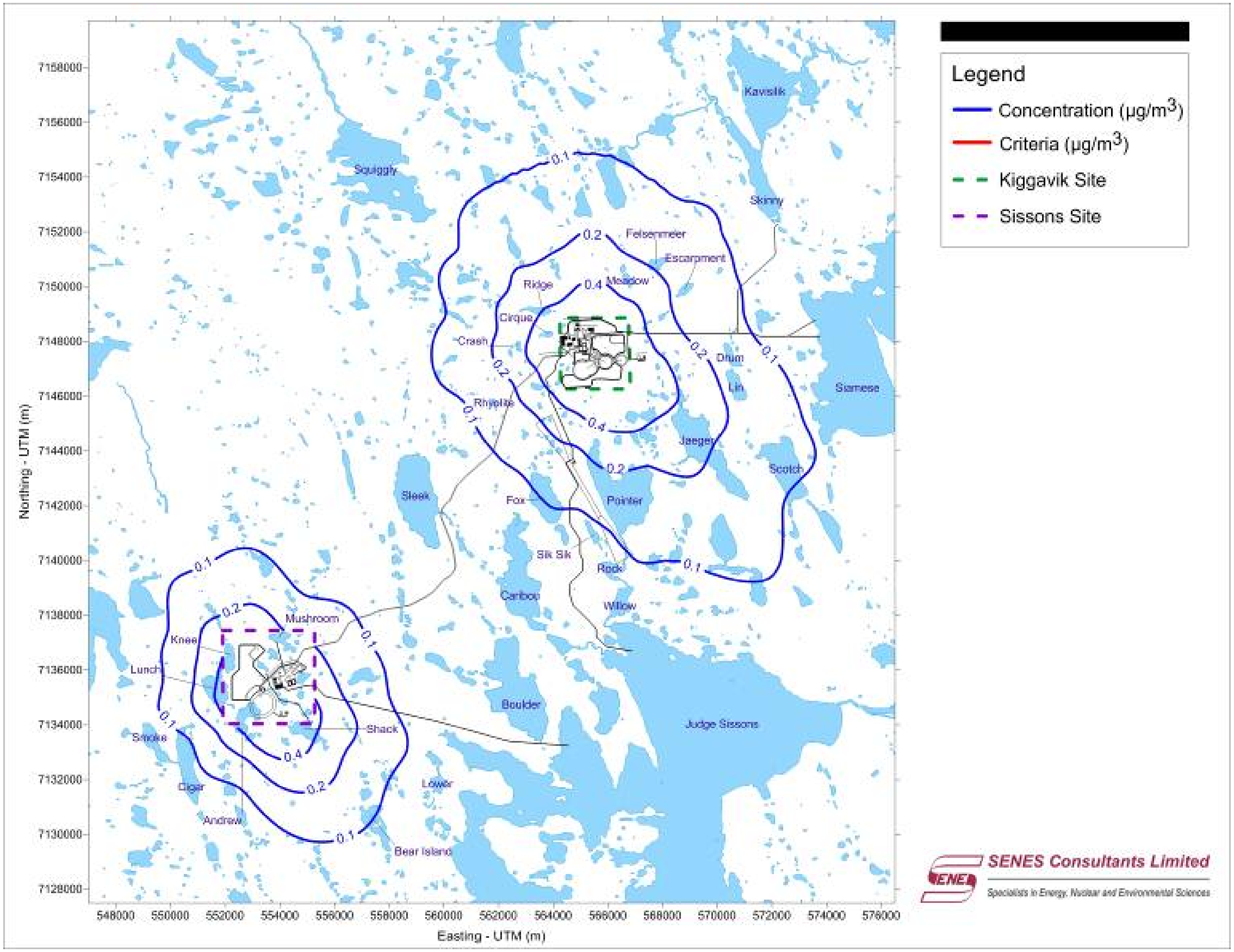


Figure 54 Final Closure Assessment Incremental Annual TSP Concentration

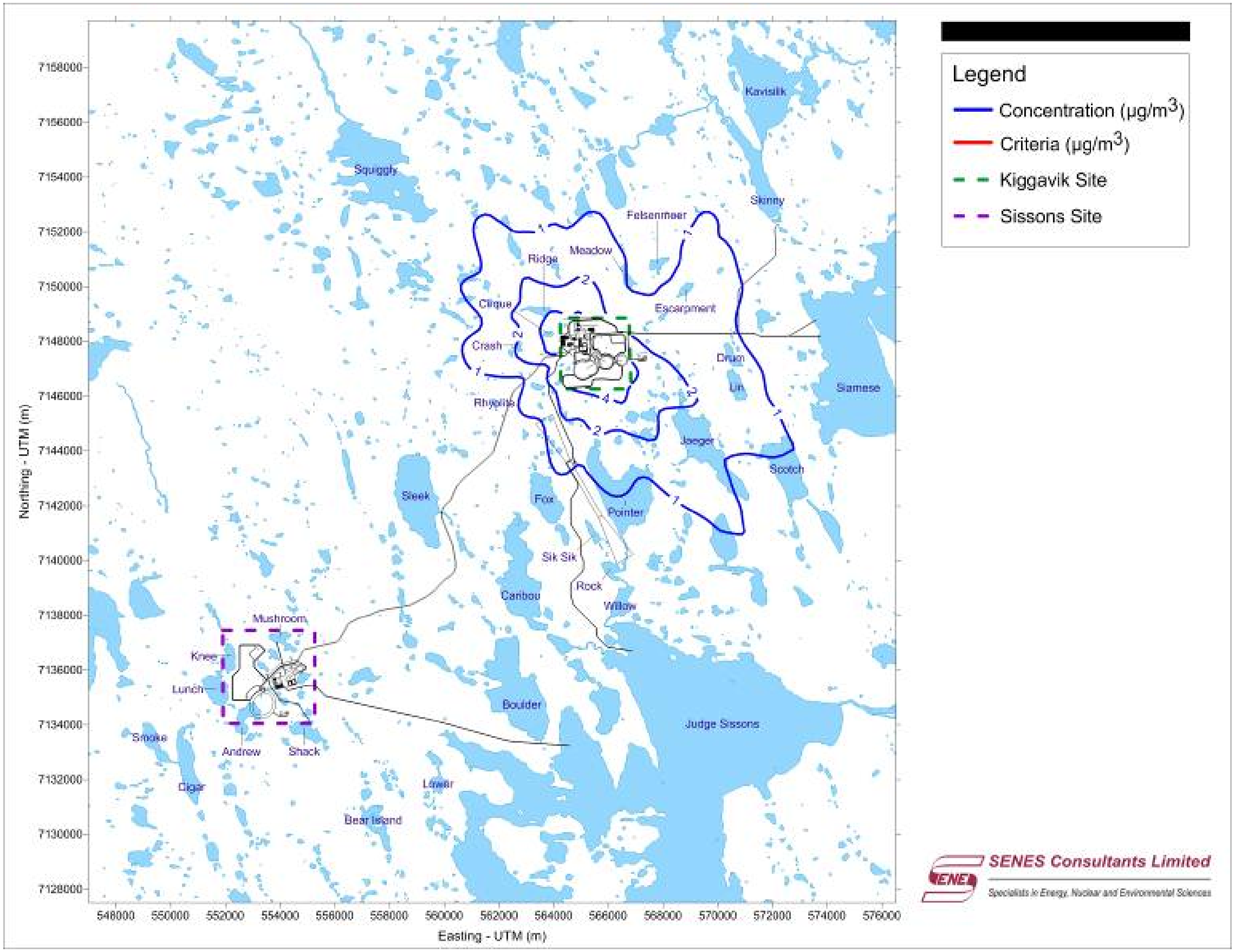


Figure 55 **Final Closure Assessment Incremental Annual NO_2 Concentration**

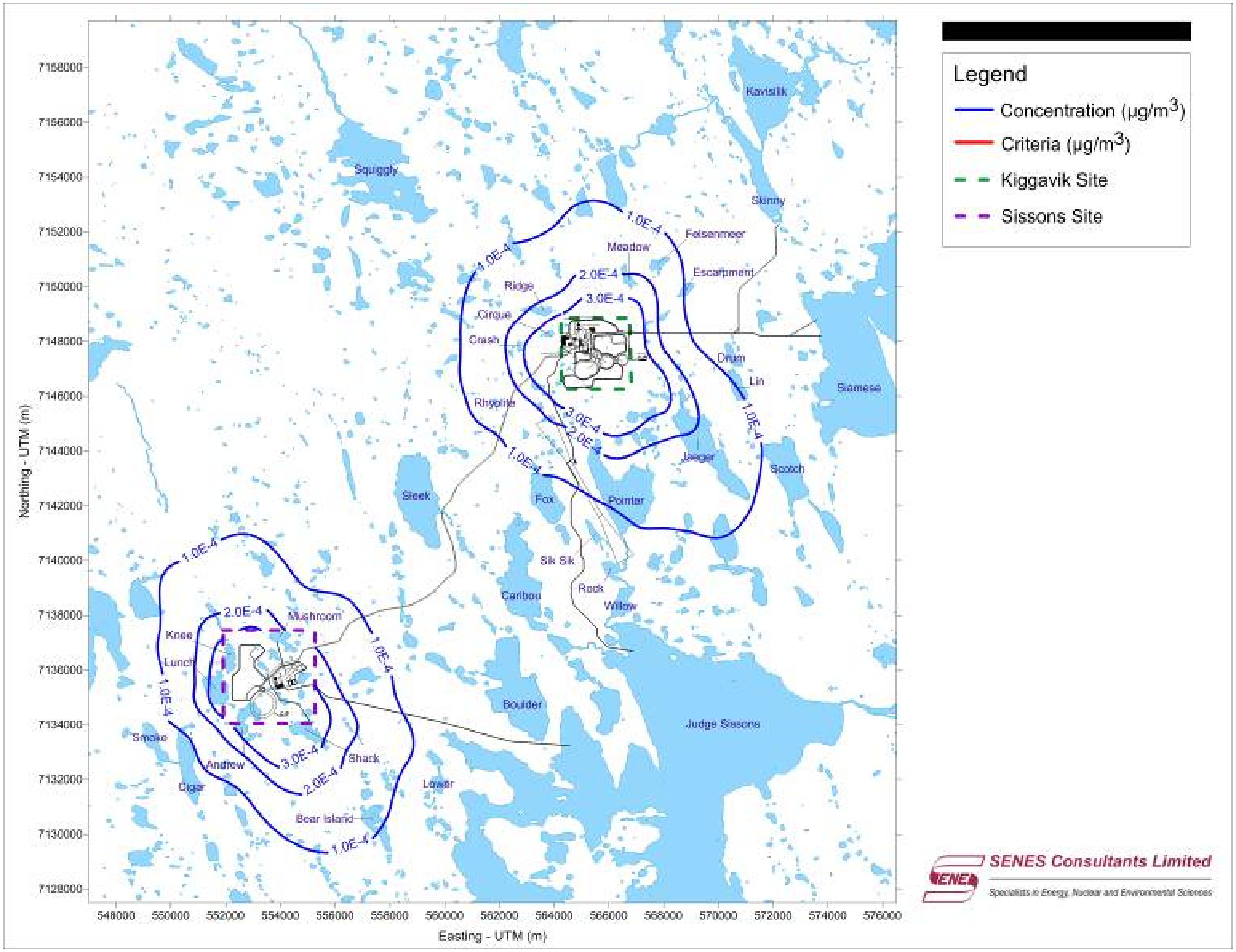


Figure 56 **Final Closure Assessment Incremental Annual Uranium Concentration**

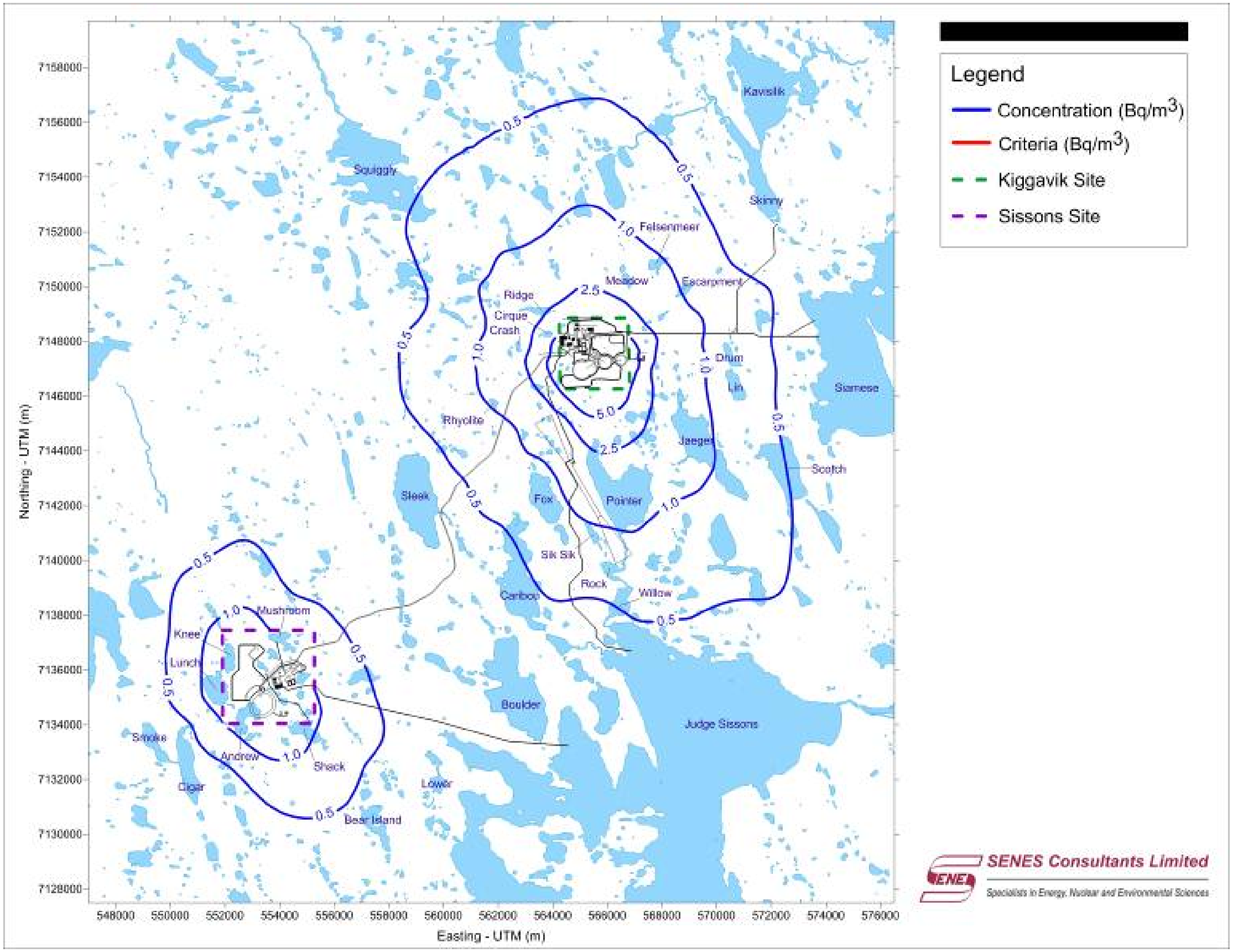


Figure 57 **Final Closure Assessment Incremental Annual Radon Concentration**

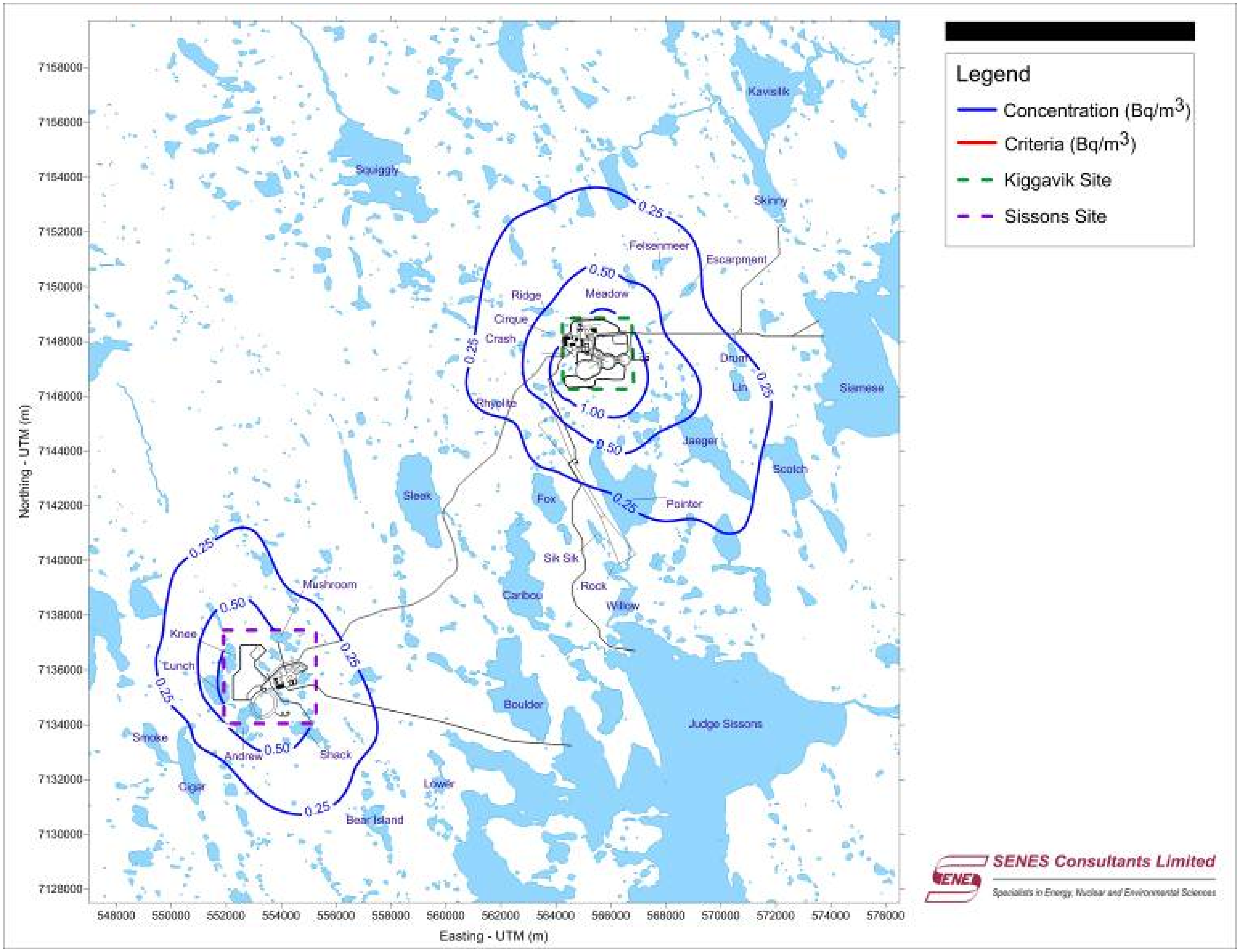


Figure 58 Post-Closure Assessment Incremental Annual Radon Concentration

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ATTACHMENT A	**AIR EMISSIONS CALCULATION METHODS**
ATTACHMENT A.1	**ON-SITE OPERATIONS**
ATTACHMENT A.2	**DECOMMISSIONING AND POST-DECOMMISSIONING**
ATTACHMENT A.3	**ACCESS ROADS**
ATTACHMENT A.4	**BAKER LAKE FACILITY**
ATTACHMENT A.5	**CONSTRUCTION**
ATTACHMENT A.6	**POTENTIAL ACID INPUT**

A.1 Air Emissions Calculation Methods: On-Site Operations

The following sections discuss the methods used to calculate air emissions from on-site operations of the Kiggavik Project and highlight the variables and assumptions that went into each of the emissions calculations. On-site operations refers to all mining, milling and supporting activities taking place at the Kiggavik site, the Sissons site and along the haul road connecting the two mine sites. At the end of this section, excerpts from the calculation spreadsheets for each of the on-site operations scenarios are provided. For each scenario, all variables and assumptions are provided, however, only the individual calculation spreadsheets for the maximum bounding scenario are provided as examples for each type of air emissions calculation.

Drilling

Emissions of dust from drilling were estimated using the US EPA AP-42 emission factor for Western Surface Coal Mining (US EPA 1998):

TSP = 0.59 kg per hole

For this assessment, it was assumed that an average of 150 holes will be drilled per day in each actively mined open pit. This value was estimated based on the amount of ANFO used per week in each open pit (see Blasting section below) and the maximum charge weight per hole as outlined in the report by Golder Associates (2011). Personal communications with AREVA staff (AREVA 2011) indicated that 60 to 70 holes will be drilled per day in the underground mine. T total of 70 was used as a conservative measure.

Blasting

For this assessment, it was assumed that ammonium nitrate-fuel oil (ANFO) would be the preferred explosive type, having a powder factor of 0.25 kg ANFO per tonne of rock for the open pit mines and a powder factor of 2.5 kg ANFO per tonne of rock for the underground mine. US EPA AP-42 emission factors for explosives detonation were used to estimate emissions of SO_2 and CO from blasting (US EPA 1980). For NO_x, often a significant constituent from blasting, a more up-to-date emission factor was used. The National Institute for Occupational Health and Safety (NIOSH) also has a published emission factor which is considered suitable for maintaining a healthy level of exposure of NO_x to workers (NIOSH 1997). It was assumed that the Kiggavik Project will take the necessary steps to limit the exposure of its workers to NO_x and the NIOSH emission factor was considered appropriate as a result.

To estimate emissions of particulate from blasting, the emission factor published by the Colorado Department of Health (Tistinic 1981) was used. This factor has been used in many other mining assessments and is considered conservative as it does not consider the amount of material being blasted, but only the number of blasts per day.

According to the Project Description (Volume 2), a 200,000 to 300,000 tonne blast will occur on average 2 to 3 times per week in the open pit mines. For this assessment, the higher end of both ranges was used and was applied to each active pit. Using the open pit powder factor from above, the total amount of ANFO required per blast is 75 tonnes.

To estimate the blast size and frequency for the underground mine, information from both the Project Description (AREVA 2011) and the Drilling and Blasting Design Report (Golder 2011) was used. Each blast was estimated to be 200 m^3 in size.

As mentioned in Section 4.1.1.1 of the main report, blasting emissions, in general, only last about 15 minutes. Since monthly variable emissions were applied to each model run, blasting could not be scaled in a way that captured this short-term release of emissions (only one type of variable emissions can be applied to each modelled source). As a result, a separate model run was completed to estimate the impact from blasting over shorter averaging periods (i.e., 1 and 24-hour). For this model run it was assumed that 1) blasting occurs independently of all other open pit mining activities and 2) blasting occurs once per day between noon and 1 pm. All other open pit activities (e.g., material loading) were turned off, but supporting activities such as power generation were included. Instead of re-modelling blasting using the entire meteorological dataset, the day with the highest predicted 24-hour NO_x concentration from the maximum bounding scenario model run was used.

Material Handling

Material handling includes activities such as loading haul trucks with ore and mine rock and unloading these materials to designated ore and mine rock stockpiles. The US EPA AP-42 emission factor for Aggregate Handling was used to the estimate emissions of dust from such activities (US EPA 2006a). Material handling depends on the average wind speed as well as the moisture content of the material being handled. For the purpose of this assessment, an estimate of 5% was used for the silt content and the average wind speed was varied on a monthly basis . A typical indoor wind speed of 1 m/s was used in the case of underground mining.

Dozing and Grading

For this assessment, it was assumed that bulldozers will be used for maintenance of the mine rock stockpiles and the US EPA emission factor was used to estimate dust emissions from this activity (US EPA 1998). Dust emissions from bulldozing depend on the silt and moisture content of the material. For this assessment it was assumed that the silt content of the mine rock is 5% and the moisture content 3%. These values are similar to what has been used in other northern mining assessments.

To maintain the on-site roads between the open pit mines, the ore and mine rock stockpiles, and the haul road, graders were assumed to be used during the summer months. The US EPA AP-42 emission factor was used to estimate dust emissions from this activity (US EPA 1998). Dust emissions from grading depend on the speed of the vehicle. For this assessment it was assumed that the graders would travel at an average speed of 8 km/hr.

Diesel Engines

Emissions from non-road mining equipment exhaust were estimated based on horsepower ratings and US EPA steady-state emission factors for non-road diesel engines (US EPA 2010). The emission factors were established to account for the effect of federal emission standards on non-road engines. For this assessment, it was assumed that all mining equipment would meet Tier 4 standards. To estimate emissions of SO_2, the 2010 Canada-Wide sulphur standard for diesel fuel of 15 ppm was used.

Equipment considered in this assessment is outlined in Table A-1.

For on-road vehicles such as supply trucks travelling along the haul roads and access road, vehicle tailpipe emissions were estimated using MOBILE6C model emission factors for heavy duty vehicles for the year 2010 (the 'C' denotes the adjustment for the average Canadian fleet by Environment Canada).

Unpaved Road Dust

Unpaved road dust was estimated using the US EPA AP-42 emission factor equation for unpaved industrial roads (US EPA 2006). The silt content of all unpaved roads was assumed to be 5%. For each in-pit ramp or haul route (including the haul road between Kiggavik and Sissons), the weighted average of the vehicle fleet was determined and the total number of vehicle kilometres travelled was calculated using daily production rates and the ore haul truck capacity (90 tonnes) and/or waste truck capacity (140 tonnes).

The generation of dust from unpaved roads can be controlled through operational practices such as watering, applying chemical dust suppressants or driving at lower speeds. For this assessment it was assumed that vehicle speeds along the open pit ramps and along the on-site haul routes will be kept below 25 km/h. This controls dust emissions by about 44% as suggested by the WRAP Fugitive Dust Handbook (WRAP 2006). An additional 50% control was applied during the winter (October to May) to account for dust suppression because of snow covered or frozen surfaces. During the summer months (June to September), it was assumed that watering will take place on an as needed basis on all haul routes, including in-pit ramps, so that dust emissions are controlled by an additional 75% at all times.

Wind Erosion

Wind erosion emissions were estimated using the emission factor equation for storage pile wind erosion published by the Air and Waste Management Association (AWMA 1992). This equation depends on both the silt content and the frequency or percentage of time that wind speeds exceed 5.4 m/s. According to the AMWA, below 5.4 m/s, wind erosion emissions are negligible. For each operational scenario assessed, the average frequency was varied by month.

There is a finite amount of erodible material within a stockpile. If left undisturbed, eventually all of the fines will get blown away. In reality, all of the fine particulate is likely to be removed by wind erosion within less than a year of a pile being undisturbed; however, as a conservative measure, mine rock stockpiles were considered to be a negligible source of emissions only if the pile was considered to be undisturbed for at least three years.

Emissions of dust from wind erosion inherently depend on the total area exposed to the wind. For this assessment, it was assumed that a typical daily working area within an open pit is 100 m by 100 m (1 ha). For large temporary or permanent stockpiles, it was assumed that 10% of the surface area is exposed to the wind at any given time. From experience with other assessments, this is a reasonable assumption. However, to be conservative, if 10% of the stockpile surface area worked out to be less than 1 ha, an active area of 1 ha was used.

Mill Operations

As described previously, ore crushing and grinding, calcining or drying, and yellowcake packaging are the main sources of dust and uranium emissions from the mill. Dust and uranium emissions arising from these activities were scaled based on 2008 stack monitoring data for AREVA's McClean Lake Operation. Emissions from crushing and grinding were scaled on the basis of proposed mill feed rates at Kiggavik relative to McCLean, whereas emissions from calcining or drying and yellowcake packaging were scaled based on yellowcake production.

Emissions of SO_2 from the acid plant were estimated using an emission factor of 75 g SO_2 per tonne of acid produced (AREVA 2011). However, NO_x and CO emissions were estimated using stack test data from McClean Lake which operates an acid plant similar to that proposed for the Kiggavik Project. Emissions were scaled based on the production of sulphuric acid relative to that at the McClean Lake Operation at the time of stack testing.

Power Generation

Power plant emissions of NO_x and CO were estimated according to manufacturer's specifications and the power output of each generator set. For this assessment, it was assumed that four (4) 4,186 kW Caterpillar 12CM32 diesel generator sets were used at the Kiggavik site. At the Sissons site, it was assumed that only one (1) 4,186 kW 12CM32 generator was used. The emission rate of particulate provided in the manufacturer's brochure was dependent on the flow rate, which could not be estimated due to limited availability of data. Instead, the AP-42 TSP emission factor for Large Stationary Diesel Engines was used (US EPA 1996).

Since the emission rate of SO_2 is highly dependent on fuel sulphur content, a mass balance calculation approach was used to estimate SO_2 emissions using anticipated power requirements supplied by AREVA. At the Kiggavik site, peak power generation is estimated to be 155 GWh per year and at the Sissons site, 23 GWh per year. It was also assumed that the diesel fuel used by the generator sets will meet the 2010 Canada-Wide sulphur standard for diesel fuel of 15 ppm.

Waste Incineration

An incinerator will be used at both the Kiggavik and Sissons sites; however, it was assumed that the Sissons incinerator will have a capacity that is 50% of the Kiggavik incinerator. For present purposes, a model similar to Eco Waste Solutions Model No. ECO 1.75TN MS 60L was used. Emissions from the incinerators were estimated using manufacturer's specifications and engineering estimates for the exhaust flow rate.

Underground Mining Exhaust

The preferred mining method for End Grid mine is the underhand drift-and-fill method. This involves removing ore in horizontal slices using a top down approach and replacing it with backfill. Sources of emissions from the underground mining are similar to open pit mining and include drilling, blasting, handling ore and mine rock, diesel engine emissions, etc. All emissions generated below the surface exhaust through one mine ventilation exhaust having a flow rate of 285 m^3/s, a diameter of 5 m and an exit temperature of 2 degrees Celsius. The portal will be used as a fresh air intake.

End Grid Backfill Plant

Cemented rock fill is proposed as the End Grid mine backfill material. Crushed mine rock (primarily from the Kiggavik site) will be mixed with cement to produce the backfill in a concrete batching plant located near the underground mine. Emissions of dust were estimated using AP-42 emission factors for Concrete Batching (US EPA 2006c). Backfill aggregate and cement quantities required for each production year were given in the proposed schedule provided to SENES by AREVA. The maximum hourly production rate of 60 tonnes of backfill per hour was used as per discussions with AREVA staff (AREVA 2011).

Uranium and Metals in Dust

Uranium and metal emission rates were calculated based on the composition of the parent material from which TSP is emitted (i.e., metal (%) x TSP (g/s)). The uranium grade and metal content of ore and mine rock for the Kiggavik Project were derived using either data supplied by AREVA or sampling data from EcoMetrix (EcoMetrix Inc. 2010, memorandum). The compositions of the ore and mine rock are provided below.

Uranium Grade and Metal Content of Ore

The expected grade of uranium (U%) for each ore deposit was provided by AREVA in the most recently proposed production schedule. To be conservative, a weighted average of U% for each ore deposit was calculated for each of the phased operational scenarios using those years having relatively high uranium grades. The selected year(s) for each of the periods assessed is shown in the Table A-2. Similarly, a weighted average of mill feed U% was calculated for each period based on information provided in AREVA's proposed production schedule. The overall maximum U% out of all production years was used for the maximum bounding scenario. The resulting weighted averages of ore and mill feed U% used in this assessment are provided in Table A-3.

The metal content for each of the ore deposits were provided to SENES by AREVA and are presented in Table A-4. For the mill ore feed, a weighted average of each metal grade was calculated assuming a combination of ores depending upon the period being assessed. For example, for Period 1 it was assumed that mill feed would be made up of ores from Centre Zone and East Zone open pits.

Table A-5 shows the calculated mill feed uranium grade for each scenario assessed.

Uranium Grade and Metal Content of Mine rock

There are three types of mine rock as defined in the Project Description (AREVA 2011):

- Type I Mine Rock: U% ≤ 40 ppm
- Type II or Clean Mine Rock: 40 ppm ≥ U% ≤ 250 ppm
- Type III or Special Mine Rock: 250 ppm ≥ U% ≤ 900 ppm (open pit) or 2100 ppm (End Grid)

As a conservative measure, the cut-off uranium concentrations were used for Type III mine rock (900 or 2100 ppm); however, the uranium concentrations for Type I and Type II mine rock were developed using EcoMetrix sampling data (EcoMetrix Inc. 2010, memorandum). The geometric standard deviation of U% was calculated for each mine area as well as for all samples combined. The final uranium concentrations used in this assessment are summarized in Table A-6.

The metal content of the different types of mine rock were obtained from AREVA (AREVA 2011) which was developed from the EcoMetrix data . This table is reproduced below simply as a reference (Table A-7).

Table A-8 outlines how the uranium and metal content of the various types of mine rock were applied to on-site sources of dust including mine rock stockpiles and on-site roads. For instance, it was assumed that all open pit ramps consist of Type II (clean rock) and that all on-site roads have been constructed with Type I rock.

Table A-1 Equipment List for Open Pit and Underground Mining

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)
Open Pit Mining				
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	4	630
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	3	2032
10 m^3 Ore Backhoe	Hitachi	EX1900	1	1025
Ore Haul Truck	Caterpillar	777 (777F)	2	1016
Waste Haul Truck	Caterpillar	785C	11	1450
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	2	580
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	1	410
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	2	149
22 m^3 Wheel Loader 992HL	Caterpillar	992K	2	801
Grader 16H	Caterpillar	16H	1	299
Underground Mining				
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	4	630
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	3	2032
10 m^3 Ore Backhoe	Hitachi	EX1900	1	1025
Ore Haul Truck	Caterpillar	777 (777F)	0	1016
Waste Haul Truck	Caterpillar	785C	0	1450
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	0	580
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	0	410
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	0	149
22 m^3 Wheel Loader 992HL	Caterpillar	992K	0	801
Grader 16H	Caterpillar	16H	0	299
Production loader (6 m^3)	n/a	n/a	2	705
Development loader (6 m^3)	n/a	n/a	1	353
Rammer-Jammer CRF loader (6 m^3)	n/a	n/a	1	353
Production haulage truck (45 tonne)	n/a	n/a	2	1173
Development haulage truck (45 tonne)	n/a	n/a	1	586
Backfill truck (45 tonne)	n/a	n/a	1	586
Production Drill Jumbo (2-boom)	n/a	n/a	2	294
Development Drill Jumbo (2-boom)	n/a	n/a	1	148
Blasters truck	n/a	n/a	1	148
Production bolter	n/a	n/a	2	294
Development bolter	n/a	n/a	1	148
Grader	n/a	n/a	1	165
Shotcrete carrier	n/a	n/a	2	294
Scissorlifts	n/a	n/a	3	231
Fuel truck	n/a	n/a	1	148
Boom truck	n/a	n/a	1	50
Jeeps	n/a	n/a	8	359
Surveyor jeep (with scissorlift)	n/a	n/a	1	90
Mechanics truck	n/a	n/a	1	148
Electrician truck	n/a	n/a	1	148
Personnel carrier	n/a	n/a	1	148

Table A-2 Uranium Ore Grade over the Project Lifetime and Selected Years for Assessment

Period	Year	East Zone Ore		Centre Zone Ore		Main Zone Ore		Andrew Lake Ore		End Grid Ore		Mill Ore Feed	
		Kt	U%	Kt	U%	Kt	U%	Kt	U%	Kt	U%	Kt	U%
1	0	-	-	-	-	-	-	-	-	-	-	-	-
	1	84	***0.258%***	824	***0.476%***	5	-	-	-	-	-	69	***0.460%***
2	2	-	-	0	-	388	***0.512%***	-	-	-	-	752	***0.454%***
	3	-	-	0	-	405	***0.681%***	0	-	-	-	668	***0.524%***
	4	-	-	-	-	1122	0.350%	0	-	0	-	906	0.367%
	5	-	-	-	-	830	0.346%	0	-	170	***0.345%***	946	0.358%
3	6	-	-	-	-	0	-	134	***0.511%***	308	0.309%	920	0.346%
	7	-	-	-	-	0	-	616	***0.632%***	328	0.303%	738	***0.514%***
	8	-	-	-	-	0	-	506	***0.536%***	326	0.288%	842	***0.442%***
	9	-	-	-	-	0	-	567	***0.546%***	336	0.320%	823	***0.448%***
	10	-	-	-	-	-	-	741	***0.516%***	317	0.335%	741	***0.498%***
	11	-	-	-	-	-	-	534	0.332%	223	***0.416%***	957	0.358%
	12	-	-	-	-	-	-	570	0.436%	50	***0.501%***	937	0.374%
4	13	-	-	-	-	-	-	0	-	0	-	81	***0.667%***

Notes:

Years selected to calculate the weighted average of U% for each of the periods are in ***bold italics.***

Table A-3 Calculated Weighted Average of U% by Scenario

Ore Source	Ore Uranium Grade (%)				
	Maximum	Period 1	Period 2	Period 3	Period 4
Main Zone East Open Pit	-	-	0.598	-	-
Main Zone West Open Pit	0.681	-	0.598	-	-
Centre Zone Open Pit	-	0.476	-	-	-
East Zone Open Pit	-	0.258	-	-	-
Purpose Built Open Pit	-	-	-	-	-
Andrew Lake Open Pit	0.682	-	-	0.554	-
End Grid Underground Mine	0.501	-	0.345	0.432	-
Mill Feed	0.667	0.460	0.487	0.474	0.667

Table A-4 Metal Content of Ore Deposits

Mine	Arsenic (%)	Cobalt (%)	Copper (%)	Lead (%)	Molybdenum (%)	Nickel (%)	Selenium (%)	Zinc (%)	Cadmium (%)	Chromium (%)
Main Zone East Open Pit	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
Main Zone West Open Pit	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
Centre Zone Open Pit	2.52E-03	1.87E-03	7.32E-03	2.83E-02	3.10E-03	7.81E-03	2.00E-05	9.78E-03	1.40E-04	1.78E-02
East Zone Open Pit	2.52E-03	1.87E-03	7.32E-03	2.83E-02	3.10E-03	7.81E-03	2.00E-05	9.78E-03	1.40E-04	1.78E-02
Purpose Built Open Pit	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
Andrew Lake Open Pit	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
End Grid Underground Mine	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02

Source: Data provided to SENES by AREVA on July 20, 2010. See file: 340680-001 Client Supplied Materials\KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls

Table A-5 Metal Content of Mill Ore Feed by Scenario

Scenario	Sources of Ore	Arsenic (%)	Cobalt (%)	Copper (%)	Lead (%)	Molybdenum (%)	Nickel (%)	Selenium (%)	Zinc (%)	Cadmium (%)	Chromium (%)
Maximum	n/a	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
Period 1	EZ + CZ + MZEST	2.51E-03	1.87E-03	7.30E-03	2.84E-02	3.23E-03	7.80E-03	2.09E-05	9.75E-03	1.40E-04	1.78E-02
Period 2	MZWEST + End Grid	8.57E-04	1.72E-03	3.19E-03	4.86E-02	2.74E-02	6.60E-03	2.20E-04	3.91E-03	1.20E-04	1.52E-02
Period 3	AL+ End Grid	2.96E-03	1.25E-03	4.92E-03	3.05E-02	5.87E-03	8.54E-03	2.20E-04	3.63E-03	1.13E-04	6.73E-02
Period 4	Remaining ore	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02

Notes:
n/a – not applicable
EZ = East Zone Open Pit
CZ = Centre Zone Open Pit
MZEST = Main Zone East Open Pit
MZWEST = Main Zone West Open Pit
AL = Andrew Lake Open Pit

Table A-6 Uranium Grades of Type I, Type II and Type III Mine rock

Parameter	Type I Mine rock	Andrew Lake		End Grid		Main Zone		Centre Zone		East Zone	
		Type II	Type III	Type II	Type III	Type II	Type III	Type II	Type III	Type II	Type III
# of Samples	114	7	5	0	1	10	5	2	1	0	0
Uranium (ppm)	10	200	900	250	2100	200	900	60	900	250	900

Notes:
Type II Mine rock: where no samples were available, the cut-off of 250 ppm was assumed.
Type III Mine rock: the cut-off for ore was used (900 ppm for open pits and 2100 ppm for the underground mine).

Table A-7 Metal Content of Type I, Type II and Type III Mine rock

Metal	Units	Type I Mine Rock		Type II Mine Rock		Type III Mine Rock	
		Kiggavik	Andrew Lake	Kiggavik	Andrew Lake	Kiggavik	Andrew Lake
As	ppm	0.80	3.69	0.92	3.28	0.73	1.92
Co	ppm	11.17	3.76	9.63	3.73	10.86	2.63
Cu	ppm	13.52	7.40	11.96	6.72	45.09	5.64
Pb	ppm	10.06	7.63	12.41	8.70	30.17	14.12
Mo	ppm	1.90	0.67	1.91	0.69	14.65	0.84
Ni	ppm	26.97	27.05	26.16	28.04	22.19	27.90
Se	ppm	1.13	1.33	1.14	1.28	1.43	1.10
Zn	ppm	35.50	13.57	30.14	13.43	35.24	9.95
Cd	ppm	0.05	0.08	0.04	0.09	0.05	0.11
Cr	ppm	46.28	86.59	45.77	84.50	42.14	77.05

Source: (AREVA 2011)

Table A-8 Uranium Grade and Metal Content of Stockpiled Material and Roads

Source	Uranium (%)	Arsenic (%)	Cobalt (%)	Copper (%)	Lead (%)	Molybdenum (%)	Nickel (%)	Selenium (%)	Zinc (%)	Cadmium (%)	Chromium (%)
Main Zone Open Pit Ramp	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
East Zone Open Pit Ramp	2.50E-01	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
Centre Zone Open Pit Ramp	6.00E-03	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
Andrew Lake Open Pit Ramp	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
Kiggavik Special Waste Pile	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03
Kiggavik Clean Rock Pile - North	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
Kiggavik Clean Rock Pile - South	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
Kiggavik Overburden Pile	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03
Andrew Lake Ore Pile	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
Sissons Special Waste Pile	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03
Sissons Clean Rock Pile	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
Sissons Overburden Pile	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03
End Grid Special Waste Pile	2.10E-01	1.00E-04	1.30E-03	2.00E-04	3.80E-03	1.00E-04	3.70E-03	9.00E-05	3.80E-03	1.00E-04	1.00E-02
End Grid Clean Waste Pile	2.50E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
End Grid Ore Pile	5.01E-01	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02
Kiggavik On-site Roads	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
Sissons On-site Roads	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
Haul Road between Kiggavik and Sissons	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
Road to Baker Lake (1 km)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Road to Airstrip	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03

Notes:

Pit ramps: assumed to be Type II mine rock (i.e., Clean Waste).
- Uranium values were calculated using EcoMetrix data (EcoMetrix 2010, memorandum)
- Values for metals were obtained from , AREVA, 2011). Kiggavik samples were applied to Main Zone, Centre Zone and East Zone.

Clean waste piles: U% developed using EcoMetrix data (EcoMetrix 2010, memorandum). Value varied by pit. Where no data existed, the cut-off for clean waste (250 ppm) was used. For metals, values were obtained from AREVA. Values differ between Kiggavik and Andrew Lake.

End Grid clean waste pile: data unavailable for Type II waste, therefore, used the same values as the Andrew Lake clean waste pile.

Special waste piles: For U%, used the cut-off value for open pits (900 ppm) and for the underground mine (2100 ppm). Values differ between Kiggavik and Andrew Lake.

Overburden piles: assumed to be the same as Type I Rock.
- U developed using EcoMetrix data (EcoMetrix 2010, memorandum). U% calculated to be approximately 10 ppm using all Type I samples.
- Values for Type I metals were obtained from AREVA. Values differ between Kiggavik and Andrew Lake.

On-site roads, haul road and road to airstrip: assumed to be constructed with Type I Rock.
- U and metals developed using EcoMetrix data (EcoMetrix 2010, memorandum). U% calculated to be approximately 10 ppm. It is unknown where the material will go, so the geometric mean was calculated using all Type I samples from Andrew Lake, Main Zone and Centre Zone.

Access road to Baker Lake is assumed to not contain any uranium or metals as the road will be constructed with borrowed materials.

Radon Emissions

Sources of Radon Gas

Radon gas (radon-222 or Rn-222) is created when its precursor or parent, radium-226 (Ra-226), decays. This decay process is continuous, resulting in the ongoing release of radon into the pores and fissures of the radium bearing material. For this assessment, it was assumed that radium-226 is present in equilibrium with its parent, uranium-238 (U-238); that is, for each Becquerel (Bq) of U-238 there is one Bq of Ra-226.

Potential sources of radon from the open pit mines, the underground mine and ore and mine rock stockpiles include:

- **Exposed surfaces of rock containing U-238.** Rn-222 is continuously released from exposed surfaces of U-238 (and subsequently Ra-226) bearing materials and is a function of the uranium grade and size of the exposed surface area. Sources in this assessment include open pit mines (walls and floors), exposed surfaces in the underground mine and surfaces of ore and mine rock stockpiles. Rn-222 is emitted from the surface of the pit or stockpile and from the underground mine ventilation exhaust.

- **Rock breaking.** Rn-222 released when a mass of ore or mine rock is broken and removed from an open pit or underground mine. The emission rate is a function of the uranium grade and the amount of ore and mine rock that is mined and/or removed per day.

- **Rock handling after storage.** Similar to rock breaking, if a material containing U-238/Ra-226 is stored in a pile for more than a few days it will have a “fresh” inventory or build-up of radon gas that is available for release upon handling the material once again.

- **Water inflow into open pits and underground mine.** Rn-222 is somewhat soluble in water under pressure, but when water enters into a mine which is depressurized it is released upon contact with air. In general terms, as groundwater migrates through rock, some radon will be transferred from the mineralized rock matrix to the groundwater. As a result, water flowing out of the pore spaces of ore and mine rock containing U-238 is also a source of radon gas in this assessment. It is assumed that the mine water flows through rock slowly enough to reach a near equilibrium state, therefore, radon released from mine water must be considered where there is inflow. Water inflow occurs in both the underground mine and to a lesser extent in Main Zone and Andrew Lake open pits during later production years.

Similarly, sources of radon from milling operations include:

- **Ore handling after storage.** If the ore is stockpiled for more than a few days before it is loaded into the mill it will have a “fresh” inventory of radon gas that is emitted upon re-handling the material. This term is only considered once during entry into the mill circuit although there are three possible points of release: 1) picking up the ore; 2) dropping the ore into the crusher; and 3) crushing the ore. Insufficient time is available for in-growth between each of these steps, therefore, only a single release of radon was considered.

- **Ore processing.** As the ore is processed through the remainder of the mill, additional radon gas will form through the decay of Ra-226 during agitated storage of the crushed ore slurry. Depending on the exact milling process, this is typically considered a continuous source of emission with radon being released from agitation as it is produced through decay. Radon gas emitted from all storage tanks in the mill is collected and vented directly to the atmosphere outside of the mill building.

- **Tailings management.** Tailings produced by the mill will be treated and discharged below water to a tailings management facility (TMF). Experience with similar mining projects has shown that Rn-222 emissions from similar types of TMFs are negligible. However, for conservatism, emissions were considered in this assessment. Emissions of radon gas depend on the concentration of Ra-226 in the TMF (i.e., Bq/L), the depth of the mixing layer in contact with air, and finally, the surface area of the TMF.

Radon Gas Calculations

The base assumption of most radon calculations is that every gram of uranium in ore or mine rock will generate an equivalent equilibrium radon activity level of 1.22×10^4 Bq. This will be used in almost all of the subsequent calculations; however, some facilities report uranium as U (or U-natural) and others as U_3O_8 which is about 85% U-natural.

Useful Conversion Factors

- U-natural to Ra-226 = 1.22×10^4 Bq Ra-226/g U-natural
- Radon Generation Rate = 2.1×10^{-6} Bq/s Rn-222 per Bq Ra-226

Radon Emissions from Exposed Surfaces

An Australian report for mine rock and a Nuclear Regulatory Commission guide for tailings provide a radon emission rate of 0.5 $Bq/m^2 \cdot s$ per Bq/g Ra-226. Alternatively a nominal (generic) value of 1 $Bq/m^2 \cdot s$ per Bq/g Ra-226 can be referenced as a universal and somewhat conservative value. A value of 0.5 $Bq/m^2 \cdot s/g$ Ra-226 was used in this assessment. The complete equation used to estimate radon emissions from exposed surfaces is:

Rn-222 (Bq/s) = 0.5 $Bq/m^2 \cdot s/g$ Ra-226 x area m^2 x 1.22×10^4 Bq Ra-226/g U x U % ÷ 100

The exposed surface area in each open pit was calculated using general geometry (i.e., the surface area of a cone) and information obtained from the site drawings and project description provided by AREVA. Since there will be exposed surfaces of both ore and mine rock, it was assumed that the exposed surface areas will be a function of the daily amount of material removed from the pit and the uranium grade of each rock type.

In order to calculate radon emissions from End Grid underground mine, SENES required information on the extent of exposed ore surfaces in the mine. AREVA requested this information from Golder Associates, which was provided in a memorandum to SENES dated

January 31, 2011. The memorandum outlined that each drift will be approximately 5 m x 5 m and 100 m in length in ore, with an estimated 6 drifts in production at any given time. It was further assumed that three (3) sides of each drift will be exposed to ore and one (1) side of each drift will be exposed to a combination (50% each) of Type II (clean) and Type III (special) mine rock. This was used to calculate the total expected exposed surface area of 9,000 m^2 of ore and 3,000 m^2 of mine rock.

An example calculation for surface emissions of radon from Andrew Lake open pit is provided below. It assumes that Andrew Lake is completely developed (i.e., the maximum surface area is exposed).

Sample Calculation – Andrew Lake

Ore U-238 = 0.63%
Mine rock U-238 = 0.09%
Clean Rock U-238 = 0.02%
Exposed Surface Area = 615,000 m^2 (3% ore, 1% mine rock, 96% clean rock)
Weighted Average U-238 = 0.63 x 0.03 + 0.09 x 0.01 + 0.02 x 0.96 = 0.039%

Therefore,

$E_{Rn\text{-}222}$ = 0.5 Bq/$m^2 \cdot$s per Bq/g Ra-226 x 615,000 m^2 x 1.22 x 10^4 Bq Ra-226/g U x 0.039% ÷ 100
= 1.47 x 10^6 Bq/s

Radon Emissions from Rock Breaking and Handling

To calculate the amount of radon gas emitted from rock breaking or handling activities, the total mass of rock handled and uranium content must be known. Note that radon from handling is only considered if the rock has been stockpiled/stored for more than a week after breaking, as all of the radon was assumed to have exited the exposed pores upon breaking, with insufficient time for new in-growth if handled within one week. The equation used to estimate radon emissions from rock breaking or handling is:

Rn-222 (Bq/s) = g rock per day x 1.22 x 10^4 Bq Ra-226/g U x U% ÷ 100 x Emanation Factor

The Emanation Factor represents the fraction of generated radon that escapes from the pore spaces of the rock and is discussed in more detail below. Typically a value of 0.02 was used. A sample calculation for Andrew Lake Pit is provided below.

Sample calculation – Andrew Lake

Ore U-238 = 0.63%
Mine rock U-238 = 0.09%
Clean Rock U-238 = 0.02%

Handling rate = 1,030 t ore + 403 t special waste + 33,091 t clean waste = 34,524 t

Average U-238 = (0.63 x 1,030 + 0.09 x 403 + 0.02 x 33,091) ÷ 34,524 = 0.039%

Therefore,

Rn-222 = 34,254 t/day x 10^6 g/t x 1.22 x10^4 Bq Ra-226/g U x 0.039% ÷ 100 x Emanation Factor (0.02)
= 3.3 x 10^9 Bq/day ÷ 24 hr/day ÷ 3600 s/hr
= 3.8 x 10^4 Bq/s

Radon Emissions from Mine Water Inflow

In order to calculate the amount of radon released from water that flows into open pits or mines, the water inflow rate must be known as well as the uranium content of the rock. In addition, the density and porosity of the rock must be known or assumed. The equation used to estimate radon emissions from water inflow is:

Rn-222 (Bq/s) = W x U x D x Rn / P x F x Emanation Factor

Where,
W = water inflow rate in m^3 per day
U = uranium concentration = U% ÷ 100 x 10^6 g/tonne
D = in situ rock density in tonnes per m^3
P = porosity in m^3 water per m^3 of rock
Rn = radon generation rate = 1.22 x 10^4 Bq Ra-226/g U

Conservative estimates of the mine water inflow rates were used to calculate emissions for the Main Zone open pit, Andrew Lake open pit and End Grid underground mine. The maximum water inflow rates that were used in this assessment are:

- Main Zone Open Pit: 1.4 m^3 per day, applicable to Period 2 and the Maximum Bounding Scenario
- Andrew Lake Open Pit: 100 m^3 per day, applicable to Period 3 and the Maximum Bounding Scenario
- End Grid Underground Mine: 200 m^3 per day, applicable to Period 3 and the Maximum Bounding Scenario

The porosity of the rock is another important factor in determining the amount of radon in mine water. An effective porosity of 1% was assumed for this assessment. A sample calculation for Andrew Lake mine water inflow is provided below.

Sample Calculation – Andrew Lake

Average Daily Water Inflow Rate = 100 m^3/day

Ore U-238 = 0.63%
Mine rock U-238 = 0.09%

Clean Rock U-238 = 0.02%

Density of ore = 2.35 tonnes/m^3
Density of mine rock = 2.7 tonnes/m^3

Handling rate = 1,030 t ore + 403 t special waste + 33,091 t clean waste = 34,524 t
Average U-238 = (0.63 x 1,030 + 0.09 x 403 + 0.02 x 33,091) ÷ 34,524 = 0.039%
Average in-situ density = (2.35 x 1,030 +2.7 x 403 t + 2.7 x 33,091 t) ÷ 34,524 = 2.8 tonnes/m^3

Rn-222 (Bq/s) = 100 m^3 water/day x 0.039% ÷ 100 x 10^6 g/t x 1.22x10^4 Bq Ra-226/g U x 2.8 t/m^3 rock x 1 m^3 rock/ 0.1 m^3 water x Emanation Factor (0.02)
= 2.7 x 10^8 Bq/day ÷ 24 hr/day ÷ 3600 s/hr
= 7.6 x 10^6 Bq/s

Radon Emanation Factor

The Radon Emanation Factor, which represents the fraction of radon that escapes from the rock matrix into the pore spaces of ore and mine rock, is an important factor which is affected by both the rock type as well as frozen and unfrozen conditions. Based on measurements of emanation factors for ore and mine rock from several northern Saskatchewan mines, which are primarily comprised of sandstone deposits, an emanation factor of 0.2 is a reasonably conservative value. However, it is understood that the ore deposits at the Kiggavik Project site are more similar to ores that were mined in Elliot Lake Ontario. Data provided in the *US Bureau of Mines Report 8264* (Austin and Droullard 1978) suggests that the emanation of radon from Elliot Lake ores (a dense quartz-pebble conglomerate) are relatively low; about 1% of the emanation rate for US sandstone ores. This is consistent with direct in-situ measurements of radon emanation in Elliot Lake mines as reported by Thompkins and Chen (1969), for example.

While there is no direct comparison for the emanation factor for Kiggavik, based on the differences between the rock characteristics at Kiggavik and other mines it is reasonable to assume that the emanation fraction would, on average, be substantially lower than emanation factors reported for northern Saskatchewan ores. As a result, for present purposes, a 10-fold reduction in emanation to 0.02 for both ore and mine rock was assumed. This may still be somewhat conservative, but given natural variability and limited data specific to the Kiggavik Project, it is considered a reasonable assumption.

With respect to radon emanation during frozen conditions, a further 10-fold reduction in the "effective" emanation of radon for a frozen core relative to unfrozen core was assumed. This assumption was based on measurements of radon emanation performed on frozen Cigar Lake cores (SENES and CEA 1987).

In summary, the following emanation factors were applied in this assessment:

- an emanation factor of 0.002 for mining in fully frozen areas; and
- an emanation fraction of 0.02 otherwise.

The frozen condition emanation factor was applied to rock extracted from open pits at depths located within the permafrost and during the early operational years at End Grid mine. The unfrozen emanation factor was applied to rock extracted from depths below the permafrost and to all ore and mine rock handled outside of the mines.

Radon Emissions from Tailings Management Facilities

To calculate the emissions of radon gas from active tailings management facilities, the concentration on radon in the TMF (i.e., Bq/L) and the depth of the mixing layer in contact with air have to be known or assumed. The equation used to estimate the radon generation rate from active TMFs is:

Rn-222 (Bq/s) = TMF surface area (m^2) x Bq Ra-226/L x mixing depth (m) x 1000 L/m^3 x 2.1 x 10^{-6} Bq/s Rn-222 per Bq Ra-226

From experience with similar mining projects, the concentration of radon in the TMF water is in the range of 1 to 3 Bq/L and the mixing layer is between 0.1 and 1 metre. As a conservative measure, 3 Bq/L and 1 metre were used.

Once a TMF is full to capacity, the tailings are consolidated and subsequently covered with a layer of mine rock and overburden/soil. Main Zone TMF will first be covered with a layer of special waste, followed by clean waste, whereas East Zone and Centre Zone TMFs will be covered with clean waste. Once covered, only surface area emissions of radon gas are considered as described above. If a layer of soil is added, radon emissions are damped according to the US EPA Office of Radiation Programs (US EPA 1983). For the purpose of this assessment, if a layer of mine rock is covered by soil, it was assumed that radon emissions penetrate through 50% of the soil cover. The most conservative option, a 1 m sandy soil cover was assumed.

Excerpts from Calculation Spreadsheets

Period 1 (Year 0 -1) Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			340680 Kiggavik
Month	December	Note: enter full name of month	
"Daily" or "Annual" Multiplier Used?	Daily		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Day - bcm - Scenario 1			from "AnnualSched_Apr2011" tab
East Zone - Total	2,686,000	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	350,000	bcm per year	
Centre Zone - Total	6,854,000	bcm per year	
Main Zone - Total	2,064,000	bcm per year	
Andrew Lake - Total	0	bcm per year	
End Grid - Total	0	bcm per year	
East Zone - Ore	90	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	900	kt per year	
Main Zone - Ore	5	kt per year	
Andrew Lake - Ore	0	kt per year	
End Grid - Ore	0	kt per year	
East Zone - WR Type III	59,000	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	121,000	bcm per year	
Main Zone - WR Type III	300	bcm per year	
Andrew Lake - WR Type III	0	bcm per year	
End Grid - WR Type III	0	kt per year	
East Zone - WR Type II	2,010,000	bcm per year	Clean waste
PB Pit - WR Type II	350,000	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	4,570,000	bcm per year	
Main Zone - WR Type II	0	bcm per year	
Andrew Lake - WR Type II	0	bcm per year	
End Grid - WR Type II	0	kt per year	
East Zone - OV	593,000	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	1,820,000	bcm per year	
Main Zone - OV	2,070,000	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Scenario 1			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	22,000	tonnes/day	
PB Pit - Total	3,100	tonnes/day	
Centre Zone - Total	54,000	tonnes/day	
Main Zone - Total	11,000	tonnes/day	
Andrew Lake - Total	0	tonnes/day	
End Grid - Total	0	tonnes/day	
East Zone - Ore	294	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	2,941	tonnes/day	
Main Zone - Ore	16	tonnes/day	
Andrew Lake - Ore	0	tonnes/day	
End Grid - Ore	0	tonnes/day	
East Zone - WR Type III	521	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	1,068	tonnes/day	
Main Zone - WR Type III	3	tonnes/day	
Andrew Lake - WR Type III	0	tonnes/day	
End Grid - WR Type III	0	tonnes/day	
East Zone - WR Type II	17,735	tonnes/day	Clean waste
PB Pit - WR Type II	3,088	tonnes/day	
Centre Zone - WR Type II	40,324	tonnes/day	
Main Zone - WR Type II	0	tonnes/day	
Andrew Lake - WR Type II	0	tonnes/day	
End Grid - WR Type II	0	tonnes/day	
East Zone - OV	3,198	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	9,814	tonnes/day	
Main Zone - OV	11,162	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	3	trips per day	
Special Waste	4	trips per day	
Clean Waste	127	trips per day	
Overburden	23	trips per day	
Centre Zone			
Ore	33	trips per day	
Special Waste	8	trips per day	
Clean Waste	288	trips per day	
Overburden	70	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	22	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	80	trips per day	
Andrew Lake			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	

Period 1 (Year 0 -1) Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road

Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	0	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	0	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe — Calculation Method: Mobile 6C

Variable	Assumed Value	Units	Comments
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions — Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling — Calculation Method: AP-42 Table 11.9-4, October 1998

Variable	Assumed Value	Units	Comments
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per Day - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Volume of blasted material - End Grid	100	m^3 per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's — Calculation Method: AP-42 Table 13.3-1, February 1980

Variable	Assumed Value	Units	Comments
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	3	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg rock/tonne ANFO	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - End Grid	255	tonnes per blast	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	110	tonnes per blast	Calculated
Average number of blasts per day	0	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions — Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing — Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998

Variable	Assumed Value	Units	Comments
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption

Wind Erosion — Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Total Air Requirement/Exhaust Flow Rate	285	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator — Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996

Variable	Assumed Value	Units	Comments
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Backfill Aggregate Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	0	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	0	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	0	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding — Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses

Variable	Assumed Value	Units	Comments
			Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Mill feed	70	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	0.460%	%	from "AnnualSched_Apr2011" tab
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	230	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	900	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	320	T U per year	from "AnnualSched_Apr2011" tab
Max theoretical U production	4,000	T U per year	Calculated based on plant availability and operating 24 hours per day
Hourly Uranium Production	43	kg U/hour	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day

Power Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Period 2 (Year 2 - 5) Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			340680 Kiggavik
Month	December	Note: enter full name of month	
"Daily" or "Annual" Multiplier Used?	Daily		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Year - Scenario 2			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	8,894,000	bcm per year	
Andrew Lake - Total	6,474,000	bcm per year	
End Grid - Total	144,000	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	2,000	kt per year	
Andrew Lake - Ore	0	kt per year	
End Grid - Ore	200	kt per year	
East Zone - WR Type III	0	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	0	bcm per year	
Main Zone - WR Type III	143,000	bcm per year	
Andrew Lake - WR Type III	0	bcm per year	
End Grid - WR Type III	10	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	0	bcm per year	
Main Zone - WR Type II	8,266,000	bcm per year	
Andrew Lake - WR Type II	6,474,000	bcm per year	
End Grid - WR Type II	200	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	0	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Scenario 2			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	0	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	0	tonnes/day	
Main Zone - Total	80,733	tonnes/day	
Andrew Lake - Total	57,124	tonnes/day	
End Grid - Total	1,339	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	6,536	tonnes/day	
Andrew Lake - Ore	0	tonnes/day	
End Grid - Ore	654	tonnes/day	
East Zone - WR Type III	0	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	0	tonnes/day	
Main Zone - WR Type III	1,262	tonnes/day	
Andrew Lake - WR Type III	0	tonnes/day	
End Grid - WR Type III	31	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	0	tonnes/day	
Main Zone - WR Type II	72,935	tonnes/day	
Andrew Lake - WR Type II	57,124	tonnes/day	
End Grid - WR Type II	654	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	0	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North Saskatchewan.
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic)
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic)
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	73	trips per day	
Special Waste	9	trips per day	
Clean Waste	521	trips per day	
Overburden	0	trips per day	
Andrew Lake			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	408	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	7	trips per day	
Special Waste	0	trips per day	
Clean Waste	5	trips per day	
Overburden	0	trips per day	

Period 2 (Year 2 - 5) Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road

Variable	Assumed Value	Units	Comments
Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	0	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	5	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe
Calculation Method: Mobile 6C

Variable	Assumed Value	Units	Comments
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions
Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red Dog EIS was 4.61%; average for Mid West EIS was 5%
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25 mph which equals 40 kph
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling
Calculation Method: AP-42 Table 11.9-4, October 1998

Variable	Assumed Value	Units	Comments
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per day - End Grid	200	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's
Calculation Method: AP-42 Table 13.3-1, February 1980

Variable	Assumed Value	Units	Comments
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	3	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	1	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.5	tonnes per blast	Calculated
Average number of blasts per day	0	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions
Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Emission Factors	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition,EPA420-P-04-009, July 2010
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing
Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998

Variable	Assumed Value	Units	Comments
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern Saskatchewan
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red Dog EIS was 4.61%; average for Mid West EIS was 5%
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption

Wind Erosion
Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine
Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Total Air Requirement/Exhaust Flow Rate	285	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator
Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996

Variable	Assumed Value	Units	Comments
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant
Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Backfill Aggregate Quantity	122,000	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	399	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	3	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per Section 6.4.6 of the IFS, April 2011
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	4,300	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	14	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding
Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses

Variable	Assumed Value	Units	Comments
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant
Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill
Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Mill feed	1,000	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	48.734%	%	from "AnnualSched_Apr2011" tab
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	3223	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	500	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	3,400	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	457	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Max theoretical U production	4,000	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day

Power Plant
Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Period 3 (Year 6 - 13) Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			**340680 Kiggavik**
Month	**December**	**Note:** enter full name of month	
"Daily" or "Annual" Multiplier Used?	**Daily**		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Year - Scenario 3			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	0	bcm per year	
Andrew Lake - Total	10,212,000	bcm per year	
End Grid - Total	164,000	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	0	kt per year	
Andrew Lake - Ore	200	kt per year	
End Grid - Ore	400	kt per year	
East Zone - WR Type III	0	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	0	bcm per year	
Main Zone - WR Type III	0	bcm per year	
Andrew Lake - WR Type III	28,200	bcm per year	
End Grid - WR Type III	20	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	0	bcm per year	
Main Zone - WR Type II	0	bcm per year	
Andrew Lake - WR Type II	10,126,000	bcm per year	
End Grid - WR Type II	40	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	0	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Scenario 3			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	0	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	0	tonnes/day	
Main Zone - Total	0	tonnes/day	
Andrew Lake - Total	90,249	tonnes/day	
End Grid - Total	1,503	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	0	tonnes/day	
Andrew Lake - Ore	654	tonnes/day	
End Grid - Ore	1,307	tonnes/day	
East Zone - WR Type III	0	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	0	tonnes/day	
Main Zone - WR Type III	0	tonnes/day	
Andrew Lake - WR Type III	249	tonnes/day	
End Grid - WR Type III	65	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	0	tonnes/day	
Main Zone - WR Type II	0	tonnes/day	
Andrew Lake - WR Type II	89,347	tonnes/day	
End Grid - WR Type II	131	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	0	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Andrew Lake			
Ore	7	trips per day	
Special Waste	2	trips per day	
Clean Waste	638	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	15	trips per day	
Special Waste	0	trips per day	
Clean Waste	1	trips per day	
Overburden	0	trips per day	

Period 3 (Year 6 - 13) Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road			
Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	5	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	9	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers
On-Road Vehicles Tailpipe	Calculation Method: Mobile 6C		
Variable	**Assumed Value**	**Units**	**Comments**
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used
Unpaved Road Emissions	Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95		
Variable	**Assumed Value**	**Units**	**Comments**
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake
Drilling	Calculation Method: AP-42 Table 11.9-4, October 1998		
Variable	**Assumed Value**	**Units**	**Comments**
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per day - End Grid	200	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)
Rock Blasting Volume Calc's	Calculation Method: AP-42 Table 13.3-1, February 1980		
Variable	**Assumed Value**	**Units**	**Comments**
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	3	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	1,503	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.5	tonnes per blast	Calculated
Average number of blasts per day	8	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition
NonRoad Equipment Tailpipe Emissions	Calculation Method: US EPA Nonroad (Excavators & Loaders)		
Variable	**Assumed Value**	**Units**	**Comments**
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Grading and Dozing	Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998		
Variable	**Assumed Value**	**Units**	**Comments**
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption
Wind Erosion	Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137		
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
End grid Underground Mine	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Total Air Requirement/Exhaust Flow Rate	285	m³/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011
Incinerator	Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996		
Variable	**Assumed Value**	**Units**	**Comments**
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	
Backfill Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Backfill Aggregate Quantity	241,000	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	788	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	6	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	8,500	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	28	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011
Ore Crushing and Grinding	Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses		
Variable	**Assumed Value**	**Units**	**Comments**
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U
Acid Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.
Mill	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Mill feed	900	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	0.474%	%	from "AnnualSched_Apr2011" tab
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	2901	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	600	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	3,800	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	510	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Max theoretical U production	4,000	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Power Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Period 4 (Year 14) Variables and Assumptions Spreadsheet

Variable	Assumed Value	Units	Comments
Summary of Variables Used for Emission Estimates on Worksheets			**340680 Kiggavik**
Month	**December**		**Note:** enter full name of month
"Daily" or "Annual" Multiplier Used?	**Daily**		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Year - Scenario 4			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	0	bcm per year	
Andrew Lake - Total	0	bcm per year	
End Grid - Total	0	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	0	kt per year	
Andrew Lake - Ore	0	kt per year	
End Grid - Ore	0	kt per year	
East Zone - WR Type III	0	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	0	bcm per year	
Main Zone - WR Type III	0	bcm per year	
Andrew Lake - WR Type III	0	bcm per year	
End Grid - WR Type III	0	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	0	bcm per year	
Main Zone - WR Type II	0	bcm per year	
Andrew Lake - WR Type II	0	bcm per year	
End Grid - WR Type II	0	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	0	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Scenario 4			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	0	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	0	tonnes/day	
Main Zone - Total	0	tonnes/day	
Andrew Lake - Total	0	tonnes/day	
End Grid - Total	0	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	0	tonnes/day	
Andrew Lake - Ore	0	tonnes/day	
End Grid - Ore	0	tonnes/day	
East Zone - WR Type III	0	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	0	tonnes/day	
Main Zone - WR Type III	0	tonnes/day	
Andrew Lake - WR Type III	0	tonnes/day	
End Grid - WR Type III	0	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	0	tonnes/day	
Main Zone - WR Type II	0	tonnes/day	
Andrew Lake - WR Type II	0	tonnes/day	
End Grid - WR Type II	0	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	0	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Andrew Lake			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	

Period 4 (Year 14) Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road			
Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	0	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	0	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe	Calculation Method: Mobile 6C		
Variable	**Assumed Value**	**Units**	**Comments**
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions	Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95		
Variable	**Assumed Value**	**Units**	**Comments**
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling	Calculation Method: AP-42 Table 11.9-4, October 1998		
Variable	**Assumed Value**	**Units**	**Comments**
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per day - End Grid	200	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's	Calculation Method: AP-42 Table 13.3-1, February 1980		
Variable	**Assumed Value**	**Units**	**Comments**
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	3	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	0	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.5	tonnes per blast	Calculated
Average number of blasts per day	0	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions	Calculation Method: US EPA Nonroad (Excavators & Loaders)		
Variable	**Assumed Value**	**Units**	**Comments**
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing	Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998		
Variable	**Assumed Value**	**Units**	**Comments**
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption

Wind Erosion	Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137		
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Total Air Requirement/Exhaust Flow Rate	285	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator	Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996		
Variable	**Assumed Value**	**Units**	**Comments**
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Backfill Aggregate Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	0	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	0	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	0	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding	Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses		
Variable	**Assumed Value**	**Units**	**Comments**
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Mill feed	90	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	0.667%	%	from "AnnualSched_Apr2011" tab
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	290	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	90	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	550	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	74	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Max theoretical U production	4,000	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day

Power Plant	Calculation Method: Engineering Calculations		
Variable	**Assumed Value**	**Units**	**Comments**
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Maximum Bounding Emissions Scenario Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			340680 Kiggavik
Month	December	Note: enter full name of month	
"Daily" or "Annual" Multiplier Used?	Daily		

Material Handling — Calculation Method: Drop Equation AP-42 13.2.4, November 2006

Variable	Assumed Value	Units	Comments
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3

Variable	Assumed Value	Units	Comments
Maximum Excavated per Year - Worst-Case			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	9,066,125	bcm per year	
Andrew Lake - Total	10,211,045	bcm per year	
End Grid - Total	165,949	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	1,122	kt per year	
Andrew Lake - Ore	741	kt per year	
End Grid - Ore	336	kt per year	
East Zone - WR Type III	0	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	0	bcm per year	
Main Zone - WR Type III	142,417	bcm per year	
Andrew Lake - WR Type III	123,383	bcm per year	
End Grid - WR Type III	33	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	0	bcm per year	
Main Zone - WR Type II	8,265,521	bcm per year	
Andrew Lake - WR Type II	10,125,844	bcm per year	
End Grid - WR Type II	184	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	3,124,334	bcm per year	
Andrew Lake - OV	1,989,514	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Worst-Case			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	0	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	0	tonnes/day	
Main Zone - Total	94,900	tonnes/day	
Andrew Lake - Total	103,800	tonnes/day	
End Grid - Total	2,000	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	3,700	tonnes/day	
Andrew Lake - Ore	2,500	tonnes/day	
End Grid - Ore	1,100	tonnes/day	
East Zone - WR Type III	0	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	0	tonnes/day	
Main Zone - WR Type III	1,300	tonnes/day	
Andrew Lake - WR Type III	1,100	tonnes/day	
End Grid - WR Type III	200	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	0	tonnes/day	
Main Zone - WR Type II	73,000	tonnes/day	
Andrew Lake - WR Type II	89,400	tonnes/day	
End Grid - WR Type II	700	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	16,900	tonnes/day	
Andrew Lake - OV	10,800	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material

On-site Truck Characteristics

Variable	Assumed Value	Units	Comments
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day

In-pit truck trips per day (one way)

East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	41	trips per day	
Special Waste	9	trips per day	
Clean Waste	521	trips per day	
Overburden	121	trips per day	
Andrew Lake			
Ore	28	trips per day	
Special Waste	8	trips per day	
Clean Waste	639	trips per day	
Overburden	77	trips per day	
End Grid			
Ore	12	trips per day	
Special Waste	1	trips per day	
Clean Waste	5	trips per day	
Overburden	0	trips per day	

Maximum Bounding Emissions Scenario Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road

Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	18	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	8	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe — Calculation Method: Mobile 6C

Variable	Assumed Value	Units	Comments
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions — Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling — Calculation Method: AP-42 Table 11.9-4, October 1998

Variable	Assumed Value	Units	Comments
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per blast - End Grid	200	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's — Calculation Method: AP-42 Table 13.3-1, February 1980

Variable	Assumed Value	Units	Comments
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Day	1	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	1,808	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.5	tonnes per blast	Calculated
Average number of blasts per day	9	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions — Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing — Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998

Variable	Assumed Value	Units	Comments
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern Saskatchewan
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red Dog EIS was 4.61%; average for Mid West EIS was 5%
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption

Wind Erosion — Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Total Air Requirement/Exhaust Flow Rate	285	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator — Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996

Variable	Assumed Value	Units	Comments
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Backfill Aggregate Quantity	241,000	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	788	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	6	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	8,500	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	28	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding — Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses

Variable	Assumed Value	Units	Comments
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Ore Stockpile	900	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	4,000	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day @ 85% availability
Max theoretical U production	4,000	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day @ 85% availability
Average U Grade	0.4%	%	AREVA e-mail dated May 20, 2011
Recovery rate	96%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed	1,042	kt ore per year	Calculated based on recovery rate and % U
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	3358	tonnes ore per day	Calculated based on plant availability and operating 365 days per year

Power Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Maximum Bounding Emissions Scenario Material Handling Calculation Spreadsheet

Source ID	Source Description	Material Handling Activity	k			M (%)	U (m/s)	Emission Factor in kg/tonne			Maximum Tonnes Handled per Hour	Uncontrolled (g/s)			Assumed Control Efficiency (%)	Metal Fraction (%)											Controlled (g/s)													
			SPM	PM_{10}	$PM_{2.5}$			SPM	PM_{10}	$PM_{2.5}$		SPM	PM_{10}	$PM_{2.5}$		Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
MZWEST	Main Zone East Pit - Ore	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	154	8.57E-02	4.05E-02	6.14E-03	0%	6.81E-01	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02	8.57E-02	4.05E-02	6.14E-03	5.84E-04	4.89E-07	1.46E-06	2.66E-06	4.31E-05	2.46E-05	5.66E-06	1.71E-07	3.34E-06	1.03E-07	1.32E-05
MZWEST	Main Zone East Pit - SW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	54	3.01E-02	1.42E-02	2.16E-03	0%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03	3.01E-02	1.42E-02	2.16E-03	2.71E-05	2.20E-08	3.27E-07	1.36E-06	9.09E-07	4.41E-07	6.68E-07	4.31E-08	1.06E-06	1.51E-09	1.27E-06
MZWEST	Main Zone East Pit - CW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	3042	1.69E+00	8.00E-01	1.21E-01	0%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	1.69E+00	8.00E-01	1.21E-01	3.38E-04	1.56E-06	1.63E-05	2.02E-05	2.10E-05	3.23E-06	4.42E-05	1.93E-06	5.10E-05	6.76E-08	7.74E-05
MZWEST	Main Zone East Pit - OVB	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	704	3.92E-01	1.85E-01	2.80E-02	0%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03	3.92E-01	1.85E-01	2.80E-02	3.92E-06	3.13E-07	4.37E-06	5.29E-06	3.94E-06	7.44E-07	1.06E-05	4.42E-07	1.39E-05	1.96E-08	1.81E-05
MZEST	Main Zone West Pit - Ore	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	0.00E+00	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	Main Zone West Pit - SW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	Main Zone West Pit - CW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	Main Zone West Pit - OVB	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	Centre Zone Pit - Ore	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	0.00E+00	2.52E-03	1.87E-03	7.32E-03	2.83E-02	3.10E-03	7.81E-03	2.00E-05	9.78E-03	1.40E-04	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	Centre Zone Pit - SW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	Centre Zone Pit - CW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	6.00E-03	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	Centre Zone Pit - OVB	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EZ	East Zone Pit - Ore	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	0.00E+00	2.52E-03	1.87E-03	7.32E-03	2.83E-02	3.10E-03	7.81E-03	2.00E-05	9.78E-03	1.40E-04	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EZ	East Zone Pit - SW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EZ	East Zone Pit - CW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	2.50E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EZ	East Zone Pit - OVB	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	Purpose built Pit	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL	Andrew Lake Pit - Ore	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	104	5.79E-02	2.74E-02	4.15E-03	0%	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02	5.79E-02	2.74E-02	4.15E-03	3.66E-04	9.61E-07	4.81E-07	2.92E-06	2.06E-05	3.23E-06	5.53E-06	2.90E-08	1.98E-06	6.37E-08	5.57E-05
AL	Andrew Lake Pit - SW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	46	2.55E-02	1.21E-02	1.83E-03	0%	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03	2.55E-02	1.21E-02	1.83E-03	2.29E-05	4.89E-08	6.70E-08	1.44E-07	3.60E-07	2.14E-08	7.11E-07	2.80E-08	2.54E-07	2.80E-09	1.96E-06
AL	Andrew Lake Pit - CW	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	3725	2.07E+00	9.80E-01	1.48E-01	0%	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03	2.07E+00	9.80E-01	1.48E-01	4.14E-04	6.79E-06	7.73E-06	1.39E-05	1.80E-05	1.43E-06	5.81E-05	2.65E-06	2.78E-05	1.86E-07	1.75E-04
AL	Andrew Lake Pit - OVB	Drop to Mine Trucks (Dumping)	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	450	2.50E-01	1.18E-01	1.79E-02	0%	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03	2.50E-01	1.18E-01	1.79E-02	2.50E-06	9.23E-07	9.41E-07	1.85E-06	1.91E-06	1.68E-07	6.77E-06	3.33E-07	3.40E-06	2.00E-08	2.17E-05
OREK	Kiggavik Ore Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	304	1.69E-01	8.00E-02	1.21E-02	0%	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02	1.69E-01	8.00E-02	1.21E-02	1.13E-03	2.86E-06	2.48E-06	6.76E-06	6.90E-05	2.96E-05	1.28E-05	3.43E-07	6.36E-06	1.97E-07	7.09E-05
OREK	Kiggavik Ore Pile	Front end loader	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	140	7.78E-02	3.68E-02	5.57E-03	0%	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02	7.78E-02	3.68E-02	5.57E-03	5.19E-04	1.31E-06	1.14E-06	3.11E-06	3.17E-05	1.36E-05	5.90E-06	1.58E-07	2.92E-06	9.07E-08	3.26E-05
SWK	Kiggavik Special Waste Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	54	3.01E-02	1.42E-02	2.16E-03	0%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03	3.01E-02	1.42E-02	2.16E-03	2.71E-05	2.20E-08	3.27E-07	1.36E-06	9.09E-07	4.41E-07	6.68E-07	4.31E-08	1.06E-06	1.51E-09	1.27E-06
CWNK	Kiggavik Clean Rock Pile - North	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	0	0.00E+00	0.00E+00	0.00E+00	0%	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWK	Kiggavik Clean Rock Pile - South	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	3042	1.69E+00	8.00E-01	1.21E-01	0%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03	1.69E+00	8.00E-01	1.21E-01	3.38E-04	1.56E-06	1.63E-05	2.02E-05	2.10E-05	3.23E-06	4.42E-05	1.93E-06	5.10E-05	6.76E-08	7.74E-05
KOVB	Kiggavik Overburden Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	704	3.92E-01	1.85E-01	2.80E-02	0%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03	3.92E-01	1.85E-01	2.80E-02	3.92E-06	3.13E-07	4.37E-06	5.29E-06	3.94E-06	7.44E-07	1.06E-05	4.42E-07	1.39E-05	1.96E-08	1.81E-05
ORES	Andrew Lake Ore Pad	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	104	5.79E-02	2.74E-02	4.15E-03	0%	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02	5.79E-02	2.74E-02	4.15E-03	3.66E-04	9.61E-07	4.81E-07	2.92E-06	2.06E-05	3.23E-06	5.53E-06	2.90E-08	1.98E-06	6.37E-08	5.57E-05
SWS	Andrew Lake Special Waste Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	46	2.55E-02	1.21E-02	1.83E-03	0%	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03	2.55E-02	1.21E-02	1.83E-03	2.29E-05	4.89E-08	6.70E-08	1.44E-07	3.60E-07	2.14E-08	7.11E-07	2.80E-08	2.54E-07	2.80E-09	1.96E-06
CWS	Andrew Lake Clean Rock Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	3725	2.07E+00	9.80E-01	1.48E-01	0%	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03	2.07E+00	9.80E-01	1.48E-01	4.14E-04	6.79E-06	7.73E-06	1.39E-05	1.80E-05	1.43E-06	5.81E-05	2.65E-06	2.78E-05	1.86E-07	1.75E-04
SOVB	Andrew Lake Overburden Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	450	2.50E-01	1.18E-01	1.79E-02	0%	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03	2.50E-01	1.18E-01	1.79E-02	2.50E-06	9.23E-07	9.41E-07	1.85E-06	1.91E-06	1.68E-07	6.77E-06	3.33E-07	3.40E-06	2.00E-08	2.17E-05
CWEG	End Grid (Backfill) Clean Waste	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	29	1.62E-02	7.67E-03	1.16E-03	0%	2.50E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03	1.62E-02	7.67E-03	1.16E-03	4.05E-06	5.32E-08	6.05E-08	1.09E-07	1.41E-07	1.12E-08	4.55E-07	2.08E-08	2.18E-07	1.46E-09	1.37E-06
SWEG	End Grid Special Waste Pile	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	8	4.63E-03	2.19E-03	3.32E-04	0%	2.10E-01	1.00E-04	1.30E-03	2.00E-04	3.80E-03	1.00E-04	3.70E-03	9.00E-05	3.80E-03	1.00E-04	1.00E-02	4.63E-03	2.19E-03	3.32E-04	9.73E-06	4.63E-09	6.02E-08	9.27E-09	1.76E-07	4.63E-09	1.71E-07	4.17E-09	1.76E-07	4.63E-09	4.63E-07
EGORE	End Grid Ore Pad	Truck Unloading to Pile	0.74	0.35	0.053	3%	5.10	0.00200	0.00095	0.00014	46	2.55E-02	1.21E-02	1.83E-03	0%	5.01E-01	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02	2.55E-02	1.21E-02	1.83E-03	1.28E-04	1.40E-06	5.30E-07	1.19E-06	5.29E-06	1.65E-06	1.68E-06	1.40E-07	1.03E-06	3.06E-08	2.88E-06
	End Grid	Handling of Ore	0.74	0.35	0.053	3%	1.00	0.00024	0.00011	0.00002	46	3.07E-03	1.45E-03	2.20E-04	0%	5.01E-01	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02	3.07E-03	1.45E-03	2.20E-04	1.54E-05	1.68E-07	6.38E-08	1.43E-07	6.37E-07	1.98E-07	2.02E-07	1.69E-08	1.24E-07	3.68E-09	3.46E-07
		Handling of SW	0.74	0.35	0.053	3%	1.00	0.00024	0.00011	0.00002	8	5.57E-04	2.64E-04	3.99E-05	0%	2.10E-01	1.00E-04	1.30E-03	2.00E-04	3.80E-03	1.00E-04	3.70E-03	9.00E-05	3.80E-03	1.00E-04	1.00E-02	5.57E-04	2.64E-04	3.99E-05	1.17E-06	5.57E-10	7.25E-09	1.11E-09	2.12E-08	5.57E-10	2.06E-08	5.02E-10	2.12E-08	5.57E-10	5.57E-08
		Handling of CW	0.74	0.35	0.053	3%	1.00	0.00024	0.00011	0.00002	29	1.95E-03	9.23E-04	1.40E-04	0%	2.50E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03	1.95E-03	9.23E-04	1.40E-04	4.88E-07	6.40E-09	7.28E-09	1.31E-08	1.70E-08	1.35E-09	5.47E-08	2.50E-09	2.62E-08	1.76E-10	1.65E-07
	Total																										5.57E-03	2.64E-03	3.99E-04	1.70E-05	1.75E-07	7.83E-08	1.57E-07	6.75E-07	2.00E-07	2.78E-07	1.99E-08	1.72E-07	4.41E-09	5.67E-07

[1] According to AREVA schedule (Aug 11, 2010), no clean waste or special waste from End Grid are brought up to surface.

Emission Factor Equation	Reference
$E = k \times (0.0016) \times (U/2.2)^{1.3} / (M/2)^{1.4}$	AP-42 13.2.4 November 2006

Parameter	SPM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

E = emission factor in kg/megagram
k = particle size multiplier for particulate size range and units of interest
U = mean wind speed (m/s)
M = material moisture content (%)

Maximum Bounding Emissions Scenario Pit Ramps and Unpaved Road Inputs Spreadsheet

Source ID	Pit Ramps and Unpaved Roads	s (%)	One-way Trips per Day - OR	One-way Trips per Day - SW	One-way Trips per Day - CW	One-way Trips per Day - OVB	One-way Trips per Day - Other	One-way Trips per Day - Water Truck	Total # of One-way Trips per day	Average Weight - Ore Truck (tonnes)	Average Weight - Waste Trucks (tonnes)	Average Weight - Water Trucks (tonnes)	Average Weight - Other (tonnes)	Weighted Average W (tonnes)	Road length[1] (km)	Vehicle Speed (km/h)	Control Efficiency - Summer (%) (Watering)	Control Efficiency - Winter (%) (Frozen Surface)	Control Efficiency for Speed <40 km/h	Notes
EZ	East Zone Pit ramp	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.50	7.5	75%	50%	44%	
EZ	East Zone Pit floor	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.05	7.5	75%	50%	44%	Length travelled on pit floor assumed to be 50 m
PB	Purpose Built Pit ramp	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.3	7.5	75%	50%	44%	
PB	Purpose Built Pit floor	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.02	7.5	75%	50%	44%	Length travelled on pit floor assumed to be 20 m
CZ	Centre Zone Pit ramp	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.85	7.5	75%	50%	44%	
CZ	Centre Zone Pit floor	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.05	7.5	75%	50%	44%	Length travelled on pit floor assumed to be 50 m
MZEST	Main Zone East Pit ramp	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.40	7.5	75%	50%	44%	
MZEST	Main Zone East Pit floor	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.10	7.5	75%	50%	44%	Length travelled on pit floor approx. 70 m (Frederic Guerin e-mail dated May 27, 2011). Assumed 100 to be conservative.
MZWEST	Main Zone West Pit ramp	5.0	41	9	521	121	0	0	693	115	170	24	0	167	1.75	7.5	75%	50%	44%	
MZWEST	Main Zone West Pit floor	5.0	41	9	521	121	0	0	693	115	170	24	0	167	0.10	7.5	75%	50%	44%	Length travelled on pit floor approx. 70 m (Frederic Guerin e-mail dated May 27, 2011). Assumed 100 to be conservative.
AL	Andrew Lake Pit ramp	5.0	28	8	639	77	0	0	751	115	170	24	0	168	2.60	7.5	75%	50%	44%	
AL	Andrew Lake Pit floor	5.0	28	8	639	77	0	0	751	115	170	24	0	168	0.10	7.5	75%	50%	44%	Length travelled on pit floor approx. 70 m (Frederic Guerin e-mail dated May 27, 2011). Assumed 100 to be conservative.
R1	segment off of main zone west ramp	5.0	41	9	0	121	0	0	171	115	170	24	0	157	0.078	20	75%	50%	44%	OR, SW & OVB from WZWEST
R2	segment off of main zone west ramp to main zone east ramp	5.0	41	0	0	121	0	0	162	115	170	24	0	156	0.436	20	75%	50%	44%	OR & OVB from MZWEST
R3	segment off of main zone east ramp	5.0	41	0	0	121	0	0	162	115	170	24	0	156	0.152	20	75%	50%	44%	OR & OVB from MZWEST + OR SW, CW & OVB from MZEST
R4	segment off of main zone west ramp to CW pile (south)	5.0	0	0	521	0	0	0	521	115	170	24	0	170	0.431	20	75%	50%	44%	CW from MZWEST
R5	segment off of main zone west ramp to west of SW pile	5.0	0	9	0	0	0	0	9	115	170	24	0	170	0.244	20	75%	50%	44%	SW from MZWEST
R6	road north from main zone east to east of SW pile	5.0	41	0	0	0	0	0	41	115	170	24	0	115	0.211	20	75%	50%	44%	OR from MZWEST + OR & SW from MZEST
R7	road north from east of SW pile to scanner	5.0	41	0	0	0	0	0	41	115	170	24	0	115	0.309	20	75%	50%	44%	OR from MZWEST + OR from MZEST + SW from CZ + SW from EZ
R8	road from main zone east ramp to CW pile (south)	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.229	20	75%	50%	44%	OVB from MZWEST + CW & OVB from MZEST
R9	road from main zone east ramp to CW pile (south)	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.139	20	75%	50%	44%	CW from MZEST
R10	overburden from main zone to CW pile (north)	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.499	20	75%	50%	44%	OVB from MZWEST + OVB from MZEST
R11	road from east zone pit to CW pile (north)	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.209	20	75%	50%	44%	OR, SW, CW & OVB from EZ
R12	road from east zone pit to Centre Zone	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.253	20	75%	50%	44%	OR & SW from EZ + CW & OVB from CZ + CW from PB + OVB from MZEST + OVB from MZWEST
R13	road from east zone pit to Centre Zone ramp	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.112	20	75%	50%	44%	OR & SW from EZ + OR & SW from CZ + CW from PB + OVB from MZEST + OVB from MZWEST
R14	road from Centre Zone to R15	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.118	20	75%	50%	44%	OR & SW from EZ + OR & SW from CZ + CW from PB + OVB from MZEST + OVB from MZWEST
R15	road from Centre Zone pit to Purpose Built	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.251	20	75%	50%	44%	CW from PB + OR & SW from EZ + OR & SW from CZ
R16	road from Purpose Built to scanner	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.242	20	75%	50%	44%	OR & SW from EZ + OR & SW from CZ
R17	road from scanner to ore pile	5.0	41	0	0	0	0	0	41	115	170	24	0	115	0.111	20	75%	50%	44%	OR from EZ, CZ, MZEST & MZWEST
R18	road off of purpose built	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.349	20	75%	50%	44%	CW from PB
R19	site entrance road from Baker Lake (links to R31)	5.0	0	0	0	0	11	0	11	115	170	24	40	40	1.671	20	75%	50%	44%	Supply and fuel trucks
R20	road off of Andrew Lake to Sissons scanner	5.0	28	8	639	77	0	0	751	115	170	24	0	168	0.387	20	75%	50%	44%	OR, SW, CW & OVB from AL
R21	road from Sissons scanner to SW pile	5.0	0	8	0	0	0	0	8	115	170	24	0	170	0.261	20	75%	50%	44%	SW from AL
R22	road from Sissons scanner to ore pile	5.0	28	0	639	77	0	0	743	115	170	24	0	168	0.092	20	75%	50%	44%	OR, CW & OVB from AL
R23	road past Sissons scanner to CW pile	5.0	0	0	639	77	18	0	734	115	170	24	180	170	0.123	20	75%	50%	44%	CW & OVB from AL + Ore trailers to Kiggavik (from AL)
R24	road past Sissons scanner to End Grid road	5.0	0	0	0	0	18	0	18	115	170	24	180	180	0.328	20	75%	50%	44%	Ore trailers to Kiggavik (from AL)
R25	road past Sissons scanner to Haul Road	5.0	0	0	0	0	26	0	26	115	170	24	180	180	0.787	20	75%	50%	44%	Ore trailers to Kiggavik (from AL and End Grid)
R26	road from decline to End Grid CW pile	5.0	12	1	5	0	0	0	19	115	170	24	0	134	0.241	20	75%	50%	44%	OR, SW & CW from End Grid
R27	road from decline to End Grid SW pile	5.0	12	1	0	0	0	0	14	115	170	24	0	121	0.326	20	75%	50%	44%	OR & SW from End Grid
R28	road from decline to End Grid ore pile	5.0	12	0	0	0	0	0	12	115	170	24	0	115	0.125	20	75%	50%	44%	OR from End Grid
R29	road from End Grid ore pile to R25	5.0	0	0	0	0	8	0	8	115	170	24	180	180	0.673	20	75%	50%	44%	Ore trailers to Kiggavik (from End Grid) + Ore trailers carrying aggregate
R30	Haul road b/n Kiggavik and Sissons	5.0	0	0	0	0	31	0	31	115	170	24	180	180	19.6	60	75%	50%	0%	Ore trailers to Kiggavik (from AL and End Grid) + Ore trailers carrying aggregate
R31	Road to Baker Lake (1 km segment modelled)	5.0	0	0	0	0	11	0	11	115	170	24	40	40	1.0	70	75%	50%	0%	Supply and fuel trucks
R32	Road to Airstrip	5.0	0	0	0	0	1	0	1	115	170	24	60	60	4.1	60	75%	50%	0%	Yellowcake transport to airstrip
CWNK	Clean waste pile north - Kiggavik (CW trucks only)	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.300	7.5	0%	50%	44%	Length taken as 1/2 width of the pile. Obtained from digitizing Site_Layout_revB
CWNK	Clean waste pile north - Kiggavik (OVB trucks only)	5.0	0	0	0	121	0	0	121	115	170	24	0	170	1.545	7.5	0%	50%	44%	Length obtained from digitizing a route to the OVB pile using Site_Layout_RevB
CWK	Clean waste pile south - Kiggavik	5.0	0	0	521	0	0	0	521	115	170	24	0	170	0.528	7.5	0%	50%	44%	Length taken as 1/2 width of the pile
KOVB	Overburden pile - Kiggavik	5.0	0	0	0	121	0	0	121	115	170	24	0	170	0.415	7.5	0%	50%	44%	Length taken as 1/2 width of the pile
SWK	Special waste pile - Kiggavik	5.0	0	9	0	0	0	0	9	115	170	24	0	170	0.264	7.5	0%	50%	44%	Length taken as 1/2 width of the pile
OREK	Ore pile - Kiggavik	5.0	0	0	0	0	0	0	0	115	170	24	0	0	0.264	7.5	0%	50%	44%	Length taken as 1/2 width of the pile
CWS	Clean waste pile - Sissons (CW trucks only)	5.0	0	0	639	0	0	0	639	115	170	24	0	170	0.572	7.5	0%	50%	44%	Length taken as 1/2 width of the pile. Obtained from digitizing Site_Layout_revB
CWS	Clean waste pile - Sissons (OVB trucks only)	5.0	0	0	0	77	0	0	77	115	170	24	0	170	1.193	7.5	0%	50%	44%	Length obtained from digitizing a route to the OVB pile using Site_Layout_RevB
SWS	Special waste pile - Sissons	5.0	0	8	0	0	0	0	8	115	170	24	0	170	0.099	7.5	0%	50%	44%	Length taken as 1/2 width of the pile
SOVB	Overburden pile - Sissons	5.0	0	0	0	77	0	0	77	115	170	24	0	170	0.341	7.5	0%	50%	44%	Length taken as 1/2 width of the pile

Always zero. Do not change.

Notes:

[1] Road lengths can be found in the following Excel file: ..\..\340680-1 IFS Revised site layout April2011\340680-1 Road Links_Site roads_RevB 31May2011.xlsx

Water trucks assumed to pass over any road or pit ramp/floor during the summer months only. Water trucks will not pass over piles or pit floors.

Ore at Sissons is assumed to be first dumped to piles and then hauled to Kiggavik in ore tractor trailers.

Maximum Bounding Emissions Scenario On-Road Tailpipe Calculation Spreadsheet

Source ID	Unpaved Road	One-way road length (km)	One-way Trips per day	Vehicle Speed (km/h)	SPM (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	Uranium (g/s)	As (g/s)	Co (g/s)	Cu (g/s)	Pb (g/s)	Mo (g/s)	Ni (g/s)	Se (g/s)	Zn (g/s)	Cd (g/s)	Cr (g/s)	NOx (g/s)	SO_2 (g/s)	CO (g/s)
R19	site entrance road from Baker Lake (links to R31)	1.7	11	20	5.05E-05	5.05E-05	4.09E-05	0	0	0	0	0	0	0	0	0	0	0	1.57E-03	8.58E-05	4.82E-04
R23	road past Sissons scanner to CW pile	0.1	18	20	6.03E-06	6.03E-06	4.88E-06	0	0	0	0	0	0	0	0	0	0	0	1.88E-04	1.02E-05	5.75E-05
R24	road past Sissons scanner to End Grid road	0.3	18	20	1.61E-05	1.61E-05	1.30E-05	0	0	0	0	0	0	0	0	0	0	0	5.01E-04	2.73E-05	1.54E-04
R25	road past Sissons scanner to Haul Road	0.8	26	20	5.56E-05	5.56E-05	4.50E-05	0	0	0	0	0	0	0	0	0	0	0	1.73E-03	9.45E-05	5.31E-04
R29	road from End Grid ore pile to R25	0.7	8	20	1.45E-05	1.45E-05	1.18E-05	0	0	0	0	0	0	0	0	0	0	0	4.52E-04	2.47E-05	1.39E-04
R30	Haul road b/n Kiggavik and Sissons	19.6	31	60	1.69E-03	1.69E-03	1.37E-03	0	0	0	0	0	0	0	0	0	0	0	5.05E-02	2.87E-03	1.10E-02
R31	Road to Baker Lake (1 km segment modelled)	1.0	11	70	3.03E-05	3.03E-05	2.45E-05	0	0	0	0	0	0	0	0	0	0	0	9.57E-04	5.14E-05	1.79E-04
R32	Road to Airstrip	4.1	1	60	1.14E-05	1.14E-05	9.23E-06	0	0	0	0	0	0	0	0	0	0	0	3.41E-04	1.94E-05	7.40E-05

Note:

Cells highlighed gray indicates that emissions of a contaminant are zero.

Mobile 6C Emission Factors - Year 2009 - Units g/VKT						
Vehicle Type	SPM	PM_{10}	$PM_{2.5}$	NO_x	SO_2*	CO
HD Diesel 40 km/hr	0.119	0.119	0.096	3.699	0.202	1.133
HD Diesel 50 km/hr	0.119	0.119	0.096	3.530	0.202	0.902
HD Diesel 60 km/hr	0.119	0.119	0.096	3.551	0.202	0.771
HD Diesel 70 km/hr	0.119	0.119	0.096	3.757	0.202	0.705
HD Diesel 80 km/hr	0.119	0.119	0.096	4.176	0.202	0.689

Notes:

Emission Factors obtained from the Mobile6C model for the Toronto Metropolitan area, for calendar year 2009, except for SO_2* which are for 2006.

..\Supplemental Info for Calcs\Mobile6C EF Results from Markham Bypass.xls

Maximum Bounding Emissions Scenario Unpaved Roads (winter) Calculation Spreadsheet

Source ID	Unpaved Road	s (%)	S - mean vehicle speed (kph)	W (tonnes)	Annual EF SPM	Emission Factor in g/VKT SPM	Emission Factor in g/VKT PM_{10}	Emission Factor in g/VKT $PM_{2.5}$	Total # of One-way Trips per day	One way length (km)	Roundtrip VKT per day
EZ	East Zone Pit ramp	5.0	8	0	0	0	0	0	0	0.50	0
EZ	East Zone Pit floor	5.0	8	0	0	0	0	0	0	0.05	0
PB	Purpose Built Pit ramp	5.0	8	0	0	0	0	0	0	0.30	0
PB	Purpose Built Pit floor	5.0	8	0	0	0	0	0	0	0.02	0
CZ	Centre Zone Pit ramp	5.0	8	0	0	0	0	0	0	0.85	0
CZ	Centre Zone Pit floor	5.0	8	0	0	0	0	0	0	0.05	0
MZEST	Main Zone East Pit ramp	5.0	8	0	0	0	0	0	0	0.40	0
MZEST	Main Zone East Pit floor	5.0	8	0	0	0	0	0	0	0.10	0
MZWEST	Main Zone West Pit ramp	5.0	8	167	3319	4769	1225	123	693	1.75	2424
MZWEST	Main Zone West Pit floor	5.0	8	167	3319	4769	1225	123	693	0.10	139
AL	Andrew Lake Pit ramp	5.0	8	168	3330	4785	1229	123	751	2.60	3907
AL	Andrew Lake Pit floor	5.0	8	168	3330	4785	1229	123	751	0.10	150
R1	segment off of main zone west ramp	5.0	20	157	3228	4639	1192	119	171	0.08	27
R2	segment off of main zone west ramp to main zone east ramp	5.0	20	156	3221	4629	1189	119	162	0.44	141
R3	segment off of main zone east ramp	5.0	20	156	3221	4629	1189	119	162	0.15	49
R4	segment off of main zone west ramp to CW pile (south)	5.0	20	170	3348	4811	1236	124	521	0.43	450
R5	segment off of main zone west ramp to west of SW pile	5.0	20	170	3348	4811	1236	124	9	0.24	5
R6	road north from main zone east to east of SW pile	5.0	20	115	2808	4035	1037	104	41	0.21	17
R7	road north from east of SW pile to scanner	5.0	20	115	2808	4035	1037	104	41	0.31	25
R8	road from main zone east ramp to CW pile (south)	5.0	20	170	3348	4811	1236	124	121	0.23	55
R9	road from main zone east ramp to CW pile (south)	5.0	20	0	0	0	0	0	0	0.14	0
R10	overburden from main zone to CW pile (north)	5.0	20	170	3348	4811	1236	124	121	0.50	120
R11	road from east zone pit to CW pile (north)	5.0	20	0	0	0	0	0	0	0.21	0
R12	road from east zone pit to Centre Zone	5.0	20	170	3348	4811	1236	124	121	0.25	61
R13	road from east zone pit to Centre Zone ramp	5.0	20	170	3348	4811	1236	124	121	0.11	27
R14	road from Centre Zone to R15	5.0	20	170	3348	4811	1236	124	121	0.12	28
R15	road from Centre Zone pit to Purpose Built	5.0	20	0	0	0	0	0	0	0.25	0
R16	road from Purpose Built to scanner	5.0	20	0	0	0	0	0	0	0.24	0
R17	road from scanner to ore pile	5.0	20	115	2808	4035	1037	104	41	0.11	9
R18	road off of purpose built	5.0	20	0	0	0	0	0	0	0.35	0
R19	site entrance road from Baker Lake (links to R31)	5.0	20	40	1746	2509	645	64	11	1.67	37
R20	road off of Andrew Lake to Sissons scanner	5.0	20	168	3330	4785	1229	123	751	0.39	582
R21	road from Sissons scanner to SW pile	5.0	20	170	3348	4811	1236	124	8	0.26	4
R22	road from Sissons scanner to ore pile	5.0	20	168	3330	4785	1229	123	743	0.09	137
R23	road past Sissons scanner to CW pile	5.0	20	170	3350	4814	1237	124	734	0.12	180
R24	road past Sissons scanner to End Grid road	5.0	20	180	3435	4936	1268	127	18	0.33	12
R25	road past Sissons scanner to Haul Road	5.0	20	180	3435	4936	1268	127	26	0.79	40
R26	road from decline to End Grid CW pile	5.0	20	134	3007	4322	1110	111	19	0.24	9
R27	road from decline to End Grid SW pile	5.0	20	121	2870	4125	1060	106	14	0.33	9
R28	road from decline to End Grid ore pile	5.0	20	115	2808	4035	1037	104	12	0.12	3
R29	road from End Grid ore pile to R25	5.0	20	180	3435	4936	1268	127	8	0.67	11
R30	Haul road b/n Kiggavik and Sissons	5.0	60	180	3435	4936	1268	127	31	19.6	1229
R31	Road to Baker Lake (1 km segment modelled)	5.0	70	40	1746	2509	645	64	11	1.00	22
R32	Road to Airstrip	5.0	60	60	2095	3011	774	77	1	4.15	8
CWNK	Clean waste pile north - Kiggavik (CW trucks only)	5.0	8	0	0	0	0	0	0	0.30	0
CWNK	Clean waste pile north - Kiggavik (OVB trucks only)	5.0	8	170	3348	4811	1236	124	121	1.55	373
CWK	Clean waste pile south - Kiggavik	5.0	8	170	3348	4811	1236	124	521	0.53	551
KOVB	Overburden pile - Kiggavik	5.0	8	170	3348	4811	1236	124	121	0.42	100
SWK	Special waste pile - Kiggavik	5.0	8	170	3348	4811	1236	124	9	0.26	5
OREK	Ore pile - Kiggavik	5.0	8	0	0	0	0	0	0	0.26	0
CWS	Clean waste pile - Sissons (CW trucks only)	5.0	8	170	3348	4811	1236	124	639	0.57	731
CWS	Clean waste pile - Sissons (OVB trucks only)	5.0	8	170	3348	4811	1236	124	77	1.19	184
SWS	Special waste pile - Sissons	5.0	8	170	3348	4811	1236	124	8	0.10	2
SOVB	Overburden pile - Sissons	5.0	8	170	3348	4811	1236	124	77	0.34	53

Source ID	Uncontrolled Emissions (g/s) Annual SPM	SPM	PM_{10}	$PM_{2.5}$	Control Efficiency (%)	Control Efficiency (%) (Speed Limit)	Metal Fraction (%) Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	2.50E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	2.50E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	6.00E-03	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	0.00E+00	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
MZWEST	9.31E+01	1.34E+02	3.44E+01	3.44E+00	50%	44%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
MZWEST	5.32E+00	7.65E+00	1.96E+00	1.96E-01	50%	44%	6.81E-01	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
AL	1.51E+02	2.16E+02	5.56E+01	5.56E+00	50%	44%	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
AL	5.79E+00	8.32E+00	2.14E+00	2.14E-01	50%	44%	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
R1	1.00E+00	1.44E+00	3.70E-01	3.70E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R2	5.26E+00	7.57E+00	1.94E+00	1.94E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R3	1.83E+00	2.63E+00	6.76E-01	6.76E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R4	1.74E+01	2.51E+01	6.44E+00	6.44E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R5	1.76E-01	2.52E-01	6.49E-02	6.49E-03	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R6	5.64E-01	8.11E-01	2.08E-01	2.08E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R7	8.27E-01	1.19E+00	3.05E-01	3.05E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R8	2.14E+00	3.08E+00	7.91E-01	7.91E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R10	4.67E+00	6.71E+00	1.72E+00	1.72E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R12	2.37E+00	3.41E+00	8.75E-01	8.75E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R13	1.04E+00	1.50E+00	3.86E-01	3.86E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R14	1.10E+00	1.59E+00	4.07E-01	4.07E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R17	2.97E-01	4.27E-01	1.10E-01	1.10E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R19	7.43E-01	1.07E+00	2.74E-01	2.74E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R20	2.24E+01	3.22E+01	8.28E+00	8.28E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R21	1.59E-01	2.28E-01	5.86E-02	5.86E-03	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R22	5.29E+00	7.60E+00	1.95E+00	1.95E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R23	6.99E+00	1.00E+01	2.58E+00	2.58E-01	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R24	4.66E-01	6.69E-01	1.72E-01	1.72E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R25	1.61E+00	2.31E+00	5.94E-01	5.94E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R26	3.13E-01	4.50E-01	1.16E-01	1.16E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R27	2.96E-01	4.25E-01	1.09E-01	1.09E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R28	9.90E-02	1.42E-01	3.66E-02	3.66E-03	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R29	4.20E-01	6.04E-01	1.55E-01	1.55E-02	50%	44%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R30	4.88E+01	7.02E+01	1.80E+01	1.80E+00	50%	0%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R31	4.45E-01	6.39E-01	1.64E-01	1.64E-02	50%	0%	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R32	2.01E-01	2.89E-01	7.43E-02	7.43E-03	50%	0%	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
CWNK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWNK	1.45E+01	2.08E+01	5.34E+00	5.34E-01	50%	44%	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWK	2.13E+01	3.07E+01	7.88E+00	7.88E-01	50%	44%	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
KOVB	3.88E+00	5.58E+00	1.43E+00	1.43E-01	50%	44%	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03
SWK	1.90E-01	2.73E-01	7.02E-02	7.02E-03	50%	44%	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03
OREK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	50%	44%	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
CWS	2.83E+01	4.07E+01	1.05E+01	1.05E+00	50%	44%	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
CWS	7.13E+00	1.03E+01	2.63E+00	2.63E-01	50%	44%	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SWS	6.05E-02	8.70E-02	2.24E-02	2.24E-03	50%	44%	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03
SOVB	2.04E+00	2.93E+00	7.53E-01	7.53E-02	50%	44%	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03

Source ID	Controlled Emissions (g/s) Annual SPM	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
MZWEST	2.61E+01	3.75E+01	9.63E+00	9.63E-01	7.49E-03	3.45E-05	3.61E-04	4.48E-04	4.65E-04	7.16E-05	9.80E-04	4.27E-05	1.13E-03	1.50E-06	1.71E-03
MZWEST	1.49E+00	2.14E+00	5.50E-01	5.50E-02	1.46E-02	1.22E-05	3.64E-05	6.64E-05	1.08E-03	6.14E-04	1.41E-04	4.28E-06	8.35E-05	2.57E-06	3.30E-04
AL	4.22E+01	6.06E+01	1.56E+01	1.56E+00	1.21E-02	1.99E-04	2.26E-04	4.07E-04	5.27E-04	4.18E-05	1.70E-03	7.75E-05	8.14E-04	5.45E-06	5.12E-03
AL	1.62E+00	2.33E+00	5.99E-01	5.99E-02	1.47E-02	3.87E-05	1.93E-05	1.18E-04	8.27E-04	1.30E-04	2.22E-04	1.17E-06	7.95E-05	2.56E-06	2.24E-03
R1	2.81E-01	4.04E-01	1.04E-01	1.04E-02	4.04E-06	8.07E-07	3.23E-06	1.01E-05	6.46E-06	3.23E-06	1.01E-05	8.07E-07	8.48E-06	4.04E-08	2.42E-05
R2	1.47E+00	2.12E+00	5.44E-01	5.44E-02	2.12E-05	4.24E-06	1.69E-05	5.30E-05	3.39E-05	1.69E-05	5.30E-05	4.24E-06	4.45E-05	2.12E-07	1.27E-04
R3	5.13E-01	7.37E-01	1.89E-01	1.89E-02	7.37E-06	1.47E-06	5.89E-06	1.84E-05	1.18E-05	5.89E-06	1.84E-05	1.47E-06	1.55E-05	7.37E-08	4.42E-05
R4	4.88E+00	7.02E+00	1.80E+00	1.80E-01	7.02E-05	1.40E-05	5.61E-05	1.75E-04	1.12E-04	5.61E-05	1.75E-04	1.40E-05	1.47E-04	7.02E-07	4.21E-04
R5	4.92E-02	7.07E-02	1.82E-02	1.82E-03	7.07E-07	1.41E-07	5.65E-07	1.77E-06	1.13E-06	5.65E-07	1.77E-06	1.41E-07	1.48E-06	7.07E-09	4.24E-06
R6	1.58E-01	2.27E-01	5.83E-02	5.83E-03	2.27E-06	4.54E-07	1.82E-06	5.67E-06	3.63E-06	1.82E-06	5.67E-06	4.54E-07	4.77E-06	2.27E-08	1.36E-05
R7	2.32E-01	3.33E-01	8.55E-02	8.55E-03	3.33E-06	6.65E-07	2.66E-06	8.32E-06	5.32E-06	2.66E-06	8.32E-06	6.65E-07	6.99E-06	3.33E-08	2.00E-05
R8	5.99E-01	8.61E-01	2.21E-01	2.21E-02	8.61E-06	1.72E-06	6.89E-06	2.15E-05	1.38E-05	6.89E-06	2.15E-05	1.72E-06	1.81E-05	8.61E-08	5.17E-05
R9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R10	1.31E+00	1.88E+00	4.83E-01	4.83E-02	1.88E-05	3.76E-06	1.50E-05	4.70E-05	3.01E-05	1.50E-05	4.70E-05	3.76E-06	3.94E-05	1.88E-07	1.13E-04
R11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R12	6.64E-01	9.54E-01	2.45E-01	2.45E-02	9.54E-06	1.91E-06	7.63E-06	2.38E-05	1.53E-05	7.63E-06	2.38E-05	1.91E-06	2.00E-05	9.54E-08	5.72E-05
R13	2.93E-01	4.20E-01	1.08E-01	1.08E-02	4.20E-06	8.41E-07	3.36E-06	1.05E-05	6.73E-06	3.36E-06	1.05E-05	8.41E-07	8.83E-06	4.20E-08	2.52E-05
R14	3.09E-01	4.44E-01	1.14E-01	1.14E-02	4.44E-06	8.88E-07	3.55E-06	1.11E-05	7.10E-06	3.55E-06	1.11E-05	8.88E-07	9.32E-06	4.44E-08	2.66E-05
R15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R17	8.32E-02	1.19E-01	3.07E-02	3.07E-03	1.19E-06	2.39E-07	9.56E-07	2.99E-06	1.91E-06	9.56E-07	2.99E-06	2.39E-07	2.51E-06	1.19E-08	7.17E-06
R18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R19	2.08E-01	2.99E-01	7.68E-02	7.68E-03	2.99E-06	5.98E-07	2.39E-06	7.47E-06	4.78E-06	2.39E-06	7.47E-06	5.98E-07	6.27E-06	2.99E-08	1.79E-05
R20	6.28E+00	9.02E+00	2.32E+00	2.32E-01	9.02E-05	1.80E-05	7.21E-05	2.25E-04	1.44E-04	7.21E-05	2.25E-04	1.80E-05	1.89E-04	9.02E-07	5.41E-04
R21	4.44E-02	6.39E-02	1.64E-02	1.64E-03	6.39E-07	1.28E-07	5.11E-07	1.60E-06	1.02E-06	5.11E-07	1.60E-06	1.28E-07	1.34E-06	6.39E-09	3.83E-06
R22	1.48E+00	2.13E+00	5.47E-01	5.47E-02	2.13E-05	4.26E-06	1.70E-05	5.32E-05	3.40E-05	1.70E-05	5.32E-05	4.26E-06	4.47E-05	2.13E-07	1.28E-04
R23	1.96E+00	2.81E+00	7.22E-01	7.22E-02	2.81E-05	5.62E-06	2.25E-05	7.03E-05	4.50E-05	2.25E-05	7.03E-05	5.62E-06	5.90E-05	2.81E-07	1.69E-04
R24	1.30E-01	1.87E-01	4.81E-02	4.81E-03	1.87E-06	3.75E-07	1.50E-06	4.68E-06	3.00E-06	1.50E-06	4.68E-06	3.75E-07	3.93E-06	1.87E-08	1.12E-05
R25	4.50E-01	6.47E-01	1.66E-01	1.66E-02	6.47E-06	1.29E-06	5.18E-06	1.62E-05	1.04E-05	5.18E-06	1.62E-05	1.29E-06	1.36E-05	6.47E-08	3.88E-05
R26	8.76E-02	1.26E-01	3.24E-02	3.24E-03	1.26E-06	2.52E-07	1.01E-06	3.15E-06	2.01E-06	1.01E-06	3.15E-06	2.52E-07	2.64E-06	1.26E-08	7.56E-06
R27	8.28E-02	1.19E-01	3.06E-02	3.06E-03	1.19E-06	2.38E-07	9.52E-07	2.98E-06	1.90E-06	9.52E-07	2.98E-06	2.38E-07	2.50E-06	1.19E-08	7.14E-06
R28	2.77E-02	3.98E-02	1.02E-02	1.02E-03	3.98E-07	7.97E-08	3.19E-07	9.96E-07	6.37E-07	3.19E-07	9.96E-07	7.97E-08	8.37E-07	3.98E-09	2.39E-06
R29	1.18E-01	1.69E-01	4.34E-02	4.34E-03	1.69E-06	3.38E-07	1.35E-06	4.23E-06	2.70E-06	1.35E-06	4.23E-06	3.38E-07	3.55E-06	1.69E-08	1.01E-05
R30	2.44E+01	3.51E+01	9.02E+00	9.02E-01	3.51E-04	7.02E-05	2.81E-04	8.77E-04	5.61E-04	2.81E-04	8.77E-04	7.02E-05	7.37E-04	3.51E-06	2.11E-03
R31	2.22E-01	3.19E-01	8.21E-02	8.21E-03	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
R32	1.01E-01	1.45E-01	3.71E-02	3.71E-03	1.45E-06	2.89E-07	1.16E-06	3.61E-06	2.31E-06	1.16E-06	3.61E-06	2.89E-07	3.03E-06	1.45E-08	8.67E-06
CWNK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
CWNK	4.05E+00	5.82E+00	1.49E+00	1.49E-01	9.04E-04	5.35E-06	5.60E-05	6.96E-05	7.22E-05	1.11E-05	1.52E-04	6.63E-06	1.75E-04	2.33E-07	2.66E-04
CWK	5.98E+00	8.59E+00	2.21E+00	2.21E-01	1.72E-03	7.90E-06	8.27E-05	1.03E-04	1.07E-04	1.64E-05	2.25E-04	9.79E-06	2.59E-04	3.44E-07	3.93E-04
KOVB	1.09E+00	1.56E+00	4.01E-01	4.01E-02	1.56E-05	1.25E-06	1.74E-05	2.11E-05	1.57E-05	2.97E-06	4.21E-05	1.77E-06	5.55E-05	7.81E-08	7.23E-05
SWK	5.32E-02	7.65E-02	1.97E-02	1.97E-03	6.88E-05	5.58E-08	8.31E-07	3.45E-06	2.31E-06	1.12E-06	1.70E-06	1.09E-07	2.70E-06	3.82E-09	3.22E-06
OREK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######
CWS	7.93E+00	1.14E+01	2.93E+00	2.93E-01	2.28E-03	3.74E-05	4.25E-05	7.66E-05	9.91E-05	7.86E-06	3.19E-04	1.46E-05	1.53E-04	1.03E-06	9.63E-04
CWS	2.00E+00	2.87E+00	7.37E-01	7.37E-02	5.74E-04	9.41E-06	1.07E-05	1.93E-05	2.50E-05	1.98E-06	8.05E-05	3.67E-06	3.85E-05	2.58E-07	2.43E-04
SWS	1.70E-02	2.44E-02	6.26E-03	6.26E-04	2.19E-05	4.68E-08	6.41E-08	1.37E-07	3.44E-07	2.05E-08	6.80E-07	2.68E-08	2.42E-07	2.68E-09	1.88E-06
SOVB	5.71E-01	8.21E-01	2.11E-01	2.11E-02	8.21E-06	3.03E-06	3.09E-06	6.07E-06	6.26E-06	5.50E-07	2.22E-05	1.09E-06	1.11E-05	6.57E-08	7.11E-05

Emission Factor Equation	Reference
$E_{unpaved} = k \times (s/12)^a \times (W/3)^b$	AP-42 13.2.2-4, November 2006

E = size speific emission factor (lb/VMT)
s = surface materal silt content (%) - equation based on range from 1.8 - 25.2%
W = mean vehicle weight (tons) where 1 tonne = 1.1 tons
1 lb/VMT = 281.9 g/VKT

Constant	Industrial Roads SPM	PM_{10}	$PM_{2.5}$
k	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

SILT CONTENT (%)	Location	Low	High	Average
construction sites	scraper routes	0.6	23.0	8.5
sand and gravel processing	plant road	4.1	6.0	4.8
western surface coal mining	plant road	4.9	5.3	5.1
western surface coal mining	haul road to/from pit	2.8	18.0	8.4

Maximum Bounding Emissions Scenario Non-Road Mining Equipment Calculation Spreadsheet - Mines

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)	Steady-State Emission Factor (g/hp-hr): PM EF_{ss}	NOx EF_{ss}	CO EF_{ss}	HC EF_{ss}	Transient Adjustment Factor (TAF): PM TAF	NOx TAF	CO TAF	HC TAF	BSFC	PM Adj g/hp.hr	% of Maximum Operating Capacity[1]	% Daily Operation [1]
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	4	630	0.0092	2.50	0.1330	0.1314	1	1	1	1	0.367	1.1484	80%	100%
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	3	2032	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	55%	100%
10 m^3 Ore Backhoe	Hitachi	EX1900	1	1025	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	57%	100%
Ore Haul Truck	Caterpillar	777 (777F)	0	1016	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
Waste Haul Truck	Caterpillar	785C	0	1450	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	0	580	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	0	410	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	0	149	0.0092	2.5	0.087	0.1314	1	1	1	1	0.367	1.1484	59%	100%
22 m^3 Wheel Loader 992HL	Caterpillar	992K	0	801	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	59%	100%
Grader 16H	Caterpillar	16H	0	299	0.0092	2.5	0.075	0.1314	1	1	1	1	0.367	1.1484	61%	25%
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	4	630	0.0092	2.50	0.1330	0.1314	1	1	1	1	0.367	1.1484	80%	100%
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	3	2032	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	55%	100%
10 m^3 Ore Backhoe	Hitachi	EX1900	1	1025	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	57%	100%
Ore Haul Truck	Caterpillar	777 (777F)	0	1016	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
Waste Haul Truck	Caterpillar	785C	0	1450	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	0	580	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	0	410	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	0	149	0.0092	2.5	0.087	0.1314	1	1	1	1	0.367	1.1484	59%	100%
22 m^3 Wheel Loader 992HL	Caterpillar	992K	0	801	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	59%	100%
Grader 16H	Caterpillar	16H	0	299	0.0092	2.5	0.075	0.1314	1	1	1	1	0.367	1.1484	61%	25%
Production loader (6 m^3)	n/a	n/a	2	705	0.0092	2.5	0.133	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Development loader (6 m^3)	n/a	n/a	1	353	0.0092	2.5	0.084	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Rammer-Jammer CRF loader (6 m^3)	n/a	n/a	1	353	0.0092	2.5	0.084	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Production haulage truck (45 tonne)	n/a	n/a	2	1173	0.0690	2.3920	0.764	0.2815	1	1	1	1	0.3670	1.1484	85%	85%
Development haulage truck (45 tonne)	n/a	n/a	1	586	0.0092	2.50	0.084	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Backfill truck (45 tonne)	n/a	n/a	1	586	0.0092	2.50	0.084	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Production Drill Jumbo (2-boom)	n/a	n/a	2	294	0.0092	2.5	0.075	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Development Drill Jumbo (2-boom)	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Blasters truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Production bolter	n/a	n/a	2	294	0.0092	2.5	0.075	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Development bolter	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Grader	n/a	n/a	1	165	0.0092	2.5	0.087	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Shotcrete carrier	n/a	n/a	2	294	0.0092	2.5	0.075	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Scissorlifts	n/a	n/a	3	231	0.0092	2.5	0.075	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Fuel truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Boom truck	n/a	n/a	1	50	0.2	3	2.366	0.1836	1	1	1	1	0.4080	1.2767	85%	85%
Jeeps	n/a	n/a	8	359	0.0092	2.50	0.084	0.1314	1	1	1	1	0.3670	1.1484	85%	85%
Surveyor jeep (w scissorlift)	n/a	n/a	1	90	0.0092	3	0.2370	0.1314	1	1	1	1	0.4080	1.2767	85%	85%
Mehcanics truck	n/a	n/a	1	148	0.0092	2.5	0.09	0.13	1	1	1	1	0.3670	1.1484	85%	85%
Electrician truck	n/a	n/a	1	148	0.0092	2.5	0.09	0.13	1	1	1	1	0.3670	1.1484	85%	85%
Personnel carrier	n/a	n/a	1	148	0.0092	2.5	0.09	0.13	1	1	1	1	0.3670	1.1484	85%	85%
Underground total																

Equipment	Uncontrolled (g/s): TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_2	CO
Blasthole Drill Rig -D80SP-150MM	0.0052	0.0052	0.0050	0	0	0	0	0	0	0	0	0	0	0	1.4000	0.003	0.0745
Waste 18 m^3 Hydraulic Shovel	0.0643	0.0643	0.0623	0	0	0	0	0	0	0	0	0	0	0	2.2277	0.003	0.7117
10 m^3 Ore Backhoe	0.0112	0.0112	0.0109	0	0	0	0	0	0	0	0	0	0	0	0.3882	0.003	0.1240
Ore Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Waste Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
18.5 m^3 Large Dozer - D10	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
13.5 m^3 Medium Dozer - D9	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
12 m^3 930G Wheel Loader w/ Forks	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
22 m^3 Wheel Loader 992HL	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Grader 16H	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Blasthole Drill Rig -D80SP-150MM	0.0052	0.0052	0.0050	0	0	0	0	0	0	0	0	0	0	0	1.4000	0.003	0.0745
Waste 18 m^3 Hydraulic Shovel	0.0643	0.0643	0.0623	0	0	0	0	0	0	0	0	0	0	0	2.2277	0.003	0.7117
10 m^3 Ore Backhoe	0.0112	0.0112	0.0109	0	0	0	0	0	0	0	0	0	0	0	0.3882	0.003	0.1240
Ore Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Waste Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
18.5 m^3 Large Dozer - D10	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
13.5 m^3 Medium Dozer - D9	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
12 m^3 930G Wheel Loader w/ Forks	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
22 m^3 Wheel Loader 992HL	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Grader 16H	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000
Production loader (6 m^3)	0.0026	0.0026	0.0025	0	0	0	0	0	0	0	0	0	0	0	0.7078	0.003	0.0377
Development loader (6 m^3)	0.0007	0.0007	0.0006	0	0	0	0	0	0	0	0	0	0	0	0.1770	0.003	0.0059
Rammer-Jammer CRF loader (6 m^3)	0.0007	0.0007	0.0006	0	0	0	0	0	0	0	0	0	0	0	0.1770	0.003	0.0059
Production haulage truck (45 tonne)	0.0325	0.0325	0.0315	0	0	0	0	0	0	0	0	0	0	0	1.1266	0.003	0.3599
Development haulage truck (45 tonne)	0.0011	0.0011	0.0010	0	0	0	0	0	0	0	0	0	0	0	0.2940	0.003	0.0099
Backfill truck (45 tonne)	0.0011	0.0011	0.0010	0	0	0	0	0	0	0	0	0	0	0	0.2940	0.003	0.0099
Production Drill Jumbo (2-boom)	0.0011	0.0011	0.0011	0	0	0	0	0	0	0	0	0	0	0	0.2947	0.003	0.0088
Development Drill Jumbo (2-boom)	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Blasters truck	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Production bolter	0.0011	0.0011	0.0011	0	0	0	0	0	0	0	0	0	0	0	0.2947	0.003	0.0088
Development bolter	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Grader	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0828	0.003	0.0029
Shotcrete carrier	0.0011	0.0011	0.0011	0	0	0	0	0	0	0	0	0	0	0	0.2947	0.003	0.0088
Scissorlifts	0.0013	0.0013	0.0012	0	0	0	0	0	0	0	0	0	0	0	0.3472	0.003	0.0104
Fuel truck	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Boom truck	0.0020	0.0020	0.0019	0	0	0	0	0	0	0	0	0	0	0	0.0299	0.004	0.0236
Jeeps	0.0053	0.0053	0.0051	0	0	0	0	0	0	0	0	0	0	0	1.4425	0.003	0.0485
Surveyor jeep (w scissorlift)	0.0002	0.0002	0.0002	0	0	0	0	0	0	0	0	0	0	0	0.0541	0.004	0.0043
Mehcanics truck	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Electrician truck	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Personnel carrier	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0740	0.003	0.0026
Underground total	5.28E-02	5.28E-02	5.12E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E+00	7.41E-02	5.63E-01

Notes:

Cells highlighed gray indicates that emissions of a contaminant are zero.

Emission factors were obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.

- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2 = (BSFC \times 453.6 \times (1\text{-}soxcnv) - HC) \times 0.01 \times soxdsl \times 2$$

where:

soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)

soxdsl is the episodic weight % of sulphur in nonroad diesel fuel

[1] % of maximum operating capacity for open ptis based on manufacturer's brochure or assumption from URBEMIS2007 Model Appendix G for each piece of Equipment (equipment not listed in Appendix G assumed to be "Other General Industrial Equipment").

% daily operation in open pits based on the same document or assumed 100%.

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

Allocation of Emissions to Active Pits

Source	BCM Excavated per Year - Total	% of Toal Excavated per Year	BCM Excavated per Year - Waste	% of Toal Excavated per Year	kt Excavated per Year - Ore	% of Toal Excavated per Year	Uncontrolled (g/s): TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_2	CO
East Zone Pit	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000
Purpose Built Pit	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000
Centre Zone Pit	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000
Main Zone West Pit	9,066,125	100%	11,532,273	100%	1,122	100%	0.0806	0.0806	0.0782	0	0	0	0	0	0	0	0	0	0	0	4.0160	0.0349	0.9102
Main Zone East Pit	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000
Andrew Lake Pit	10,211,045	100%	12,238,741	100%	741	100%	0.0806	0.0806	0.0782	0	0	0	0	0	0	0	0	0	0	0	4.0160	0.0349	0.9102

Notes:

Cells highlighed gray indicates that emissions of a contaminant are zero.

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Maximum Bounding Emissions Scenario Non-Road Mining Equipment Calculation Spreadsheet - Stockpiles

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)	Steady-State Emission Factor (g/hp-hr): PM EF_{ss}	NOx EF_{ss}	CO EF_{ss}	HC EF_{ss}	Transient Adjustment Factor (TAF): PM TAF	NOx TAF	CO TAF	HC TAF	BSFC	PM Adj g/hp.hr	% of Maximum Operating Capacity[1]	% Daily Operation[1]
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	0	630	0.0092	2.50	0.1330	0.1314	1	1	1	1	0.367	1.1484	80%	100%
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	0	2032	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	55%	100%
10 m^3 Ore Backhoe	Hitachi	EX1900	0	1025	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	57%	100%
Ore Haul Truck	Caterpillar	777 (777F)	0	1016	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
Waste Haul Truck	Caterpillar	785C	0	1450	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	2	580	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	1	410	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	2	149	0.0092	2.5	0.087	0.1314	1	1	1	1	0.367	1.1484	59%	100%
22 m^3 Wheel Loader 992HL	Caterpillar	992K	2	801	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	59%	100%
Grader 16H	Caterpillar	16H	0	299	0.0092	2.5	0.075	0.1314	1	1	1	1	0.367	1.1484	61%	25%
Blasthole Drill Rig -D80SP-150MM	Sandvik	D245S	0	630	0.0092	2.50	0.1330	0.1314	1	1	1	1	0.367	1.1484	80%	100%
Waste 18 m^3 Hydraulic Shovel	Terex / O&K	RH 170	0	2032	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	55%	100%
10 m^3 Ore Backhoe	Hitachi	EX1900	0	1025	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	57%	100%
Ore Haul Truck	Caterpillar	777 (777F)	0	1016	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
Waste Haul Truck	Caterpillar	785C	0	1450	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	50%	100%
18.5 m^3 Large Dozer - D10	Caterpillar	D10T	2	580	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
13.5 m^3 Medium Dozer - D9	Caterpillar	D9T	1	410	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	40%	83%
12 m^3 930G Wheel Loader w/ Forks	Caterpillar	930H	2	149	0.0092	2.5	0.087	0.1314	1	1	1	1	0.367	1.1484	59%	100%
22 m^3 Wheel Loader 992HL	Caterpillar	992K	2	801	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	59%	100%
Grader 16H	Caterpillar	16H	0	299	0.0092	2.5	0.075	0.1314	1	1	1	1	0.367	1.1484	61%	25%

Equipment	Uncontrolled (g/s): TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_2	CO	CO_2	CH_4
Blasthole Drill Rig -D80SP-150MM	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Waste 18 m^3 Hydraulic Shovel	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
10 m^3 Ore Backhoe	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Ore Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Waste Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
18.5 m^3 Large Dozer - D10	0.0010	0.0010	0.0010	0	0	0	0	0	0	0	0	0	0	0	0.2685	0.003	0.0090	0	0
13.5 m^3 Medium Dozer - D9	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0949	0.003	0.0032	0	0
12 m^3 930G Wheel Loader w/ Forks	0.0004	0.0004	0.0004	0	0	0	0	0	0	0	0	0	0	0	0.1221	0.003	0.0042	0	0
22 m^3 Wheel Loader 992HL	0.0181	0.0181	0.0176	0	0	0	0	0	0	0	0	0	0	0	0.6280	0.003	0.2006	0	0
Grader 16H	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Blasthole Drill Rig -D80SP-150MM	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Waste 18 m^3 Hydraulic Shovel	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
10 m^3 Ore Backhoe	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Ore Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
Waste Haul Truck	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0
18.5 m^3 Large Dozer - D10	0.0010	0.0010	0.0010	0	0	0	0	0	0	0	0	0	0	0	0.2685	0.003	0.0090	0	0
13.5 m^3 Medium Dozer - D9	0.0003	0.0003	0.0003	0	0	0	0	0	0	0	0	0	0	0	0.0949	0.003	0.0032	0	0
12 m^3 930G Wheel Loader w/ Forks	0.0004	0.0004	0.0004	0	0	0	0	0	0	0	0	0	0	0	0.1221	0.003	0.0042	0	0
22 m^3 Wheel Loader 992HL	0.0181	0.0181	0.0176	0	0	0	0	0	0	0	0	0	0	0	0.6280	0.003	0.2006	0	0
Grader 16H	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.003	0.0000	0	0

Notes:

Emission factors were obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.

Cells highlighed gray indicates that emissions of a contaminant are zero.

- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2=(BSFC \times 453.6 \times (1\text{-}soxcnv)\text{-}HC) \times 0.01 \times soxdsl \times 2$$

where:

soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)

soxdsl is the episodic weight % of sulphur in nonroad diesel fuel

[1] % of maximum operating capacity for open ptis based on manufacturer's brochure or assumption from URBEMIS2007 Model Appendix G for each piece of Equipment (equipment not listed in Appendix G assumed to be "Other General Industrial Equipment").

% daily operation in open pits based on the same document or assumed 100%.

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

Allocation of Emissions to Active Piles

Source	BCM Material per Year - Total	% of Total Material per Year	BCM Material per Year - Waste	% of Toal Material per Year	BCM Material per Year - Ore	% of Toal Material per Year	Uncontrolled (g/s): TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_2	CO	CO_2	CH_4
Kiggavik Ore Pile	470,729	4%	0	0%	470,729	100%	0.0007	0.0007	0.0007	0	0	0	0	0	0	0	0	0	0	0	0.0294	0.0075	0.0080	0.0000	0.0000
Kiggavik Waste Rock Pile	142,417	1%	142,417	1%	0	0%	0.0002	0.0002	0.0002	0	0	0	0	0	0	0	0	0	0	0	0.0134	0.0003	0.0026	0.0000	0.0000
Kiggavik Clean Rock Pile North	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000
Kiggavik Clean Rock Pile South	8,265,521	69%	8,265,521	72%	0	0%	0.0137	0.0137	0.0133	0	0	0	0	0	0	0	0	0	0	0	0.7770	0.0196	0.1498	0.0000	0.0000
Kiggavik Overburden Pile	3,124,334	26%	3,124,334	27%	0	0%	0.0052	0.0052	0.0050	0	0	0	0	0	0	0	0	0	0	0	0.2937	0.0074	0.0566	0.0000	0.0000
Andrew Lake Ore Pad	0	0%	0	0%	0	0%	0.0000	0.0000	0.0000	0	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000	0.0000	0.0000
Andrew Lake Waste Rock Pile	123,383	1%	123,383	1%	0	0%	0.0002	0.0002	0.0002	0	0	0	0	0	0	0	0	0	0	0	0.0112	0.0003	0.0022	0.0000	0.0000
Andrew Lake Clean Rock Pile	10,125,844	83%	10,125,844	83%	0	0%	0.0165	0.0165	0.0160	0	0	0	0	0	0	0	0	0	0	0	0.9213	0.0231	0.1796	0.0000	0.0000
Andrew Lake Overburden Pile	1,989,514	16%	1,989,514	16%	0	0%	0.0032	0.0032	0.0031	0	0	0	0	0	0	0	0	0	0	0	0.1810	0.0045	0.0353	0.0000	0.0000

Note: Since End Grid Piles and ORES are small and temporary, equipment will primarily be used on larger piles, therefore, they were not included.

Cells highlighed gray indicates that emissions of a contaminant are zero.

Maximum Bounding Emissions Scenario Non-Road Mining Equipment Calculation Spreadsheet – Mine Roads

Equipment	Manufacturer	Model	Steady-State Emission Factor (g/hp-hr)				Transient Adjustment Factor (TAF)				BSFC	PM Adj g/hp.hr	Emission Factor per Unit in g/hp-hr							
			PM EF_{ss}	NOx EF_{ss}	CO EF_{ss}	HC EF_{ss}	PM TAF	NOx TAF	CO TAF	HC TAF			SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO	CO_2	CH_4
Ore Haul Truck	Caterpillar	777 (777F)	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	0.069	0.069	0.067	2.392	0.003	0.764	0	0
Waste Haul Truck	Caterpillar	785C	0.0690	2.3920	0.7642	0.2815	1	1	1	1	0.367	1.1484	0.069	0.069	0.067	2.392	0.003	0.764	0	0
Water Truck	Peterbilt	348	0.0092	2.50	0.084	0.1314	1	1	1	1	0.367	1.1484	0.009	0.009	0.009	2.500	0.003	0.084	0	0
Grader 16H	Caterpillar	16H	0.0092	2.50	0.075	0.1314	1	1	1	1	0.367	1.1484	0.009	0.009	0.009	2.500	0.003	0.075	0	0

Notes:

Emission factors were obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.

- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2 = (BSFC \times 453.6 \times (1 - soxcnv) - \mathrm{HC}) \times 0.01 \times \mathrm{soxdsl} \times 2$$

where:

soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)

soxdsl is the episodic weight % of sulphur in nonroad diesel fuel

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

Equipment	Manufacturer	Model	Power Rating (hp)	Average Speed (km/hr)	Emission Factor per Unit in g/VKT							
					SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO	CO_2	CH_4*
Ore Truck	Caterpillar	777 (777F)	1016	20	3.51	3.51	3.40	121.51	0.18	38.82	0.00	0.00
Waste Haul Truck	Caterpillar	785C	1450	20	5.00	5.00	4.85	173.42	0.25	55.40	0.00	0.00
Water Truck	Peterbilt	348	330	20	0.15	0.15	0.15	41.25	0.06	1.39	0.00	0.00
Grader 16H	Caterpillar	16H	299	8	0.34	0.34	0.33	93.44	0.13	2.80	0.00	0.00

On-Site Roads Tailpipe

Summer — Note: Enter **Summer** for June, July, August September, otherwise, enter **Winter**

Unpaved Road	One way length (km)	One-way Trips per Day - Ore	One-way Trips per Day - Waste	One-way Trips per Day - Water Truck	One-way Trips per Day - Grader	VKT per day - Ore	VKT per day - Waste	VKT per day - Water	VKT per day - Grader	Uncontrolled Emissions (g/s)								Control Efficiency (%)
										SPM	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO	CO_2	CH_4*	
East Zone Pit ramp	0.50	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
East Zone Pit floor	0.05	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Purpose Built Pit ramp	0.30	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Purpose Built Pit floor	0.02	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Centre Zone Pit ramp	0.85	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Centre Zone Pit floor	0.05	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Main Zone East Pit ramp	0.40	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Main Zone East Pit floor	0.10	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Main Zone West Pit ramp	1.75	41	651	0	1	143.89	2280.00	0.00	3.50	1.38E-01	1.38E-01	1.34E-01	4.78E+00	6.97E-03	1.53E+00	0.00E+00	0.00E+00	0%
Main Zone West Pit floor	0.10	41	651	0	1	8.22	130.29	0.00	0.20	7.88E-03	7.88E-03	7.64E-03	2.73E-01	3.98E-04	8.72E-02	0.00E+00	0.00E+00	0%
Andrew Lake Pit ramp	2.60	28	724	0	1	144.44	3762.57	0.00	5.20	2.24E-01	2.24E-01	2.17E-01	7.76E+00	1.13E-02	2.48E+00	0.00E+00	0.00E+00	0%
Andrew Lake Pit floor	0.10	28	724	0	1	5.56	144.71	0.00	0.20	8.61E-03	8.61E-03	8.35E-03	2.98E-01	4.35E-04	9.53E-02	0.00E+00	0.00E+00	0%
segment off of main zone west ramp	0.08	41	130	0	1	6.45	20.40	0.00	0.16	1.44E-03	1.44E-03	1.40E-03	5.02E-02	7.32E-05	1.60E-02	0.00E+00	0.00E+00	0%
segment off of main zone west ramp to main zone east ramp	0.44	41	121	0	1	35.88	105.35	0.00	0.87	7.56E-03	7.56E-03	7.33E-03	2.63E-01	3.83E-04	8.37E-02	0.00E+00	0.00E+00	0%
segment off of main zone east ramp	0.15	41	121	0	1	12.47	36.63	0.00	0.30	2.63E-03	2.63E-03	2.55E-03	9.14E-02	1.33E-04	2.91E-02	0.00E+00	0.00E+00	0%
segment off of main zone west ramp to CW pile (south)	0.43	0	521	0	1	0.00	449.96	0.00	0.86	2.61E-02	2.61E-02	2.53E-02	9.04E-01	1.32E-03	2.89E-01	0.00E+00	0.00E+00	0%
segment off of main zone west ramp to west of SW pile	0.24	0	9	0	1	0.00	4.53	0.00	0.49	2.64E-04	2.64E-04	2.56E-04	9.63E-03	1.40E-05	2.92E-03	0.00E+00	0.00E+00	0%
road north from main zone east to east of SW pile	0.21	41	0	0	1	17.36	0.00	0.00	0.42	7.06E-04	7.06E-04	6.85E-04	2.49E-02	3.62E-05	7.81E-03	0.00E+00	0.00E+00	0%
road north from east of SW pile to scanner	0.31	41	0	0	1	25.45	0.00	0.00	0.62	1.03E-03	1.03E-03	1.00E-03	3.65E-02	5.31E-05	1.15E-02	0.00E+00	0.00E+00	0%
road from main zone east ramp to CW pile (south)	0.23	0	121	0	1	0.00	55.25	0.00	0.46	3.20E-03	3.20E-03	3.10E-03	1.11E-01	1.62E-04	3.54E-02	0.00E+00	0.00E+00	0%
road from main zone east ramp to CW pile (south)	0.14	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
overburden from main zone to CW pile (north)	0.50	0	121	0	1	0.00	120.47	0.00	1.00	6.98E-03	6.98E-03	6.77E-03	2.43E-01	3.54E-04	7.73E-02	0.00E+00	0.00E+00	0%
road from east zone pit to CW pile (north)	0.21	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road from east zone pit to Centre Zone	0.25	0	121	0	1	0.00	61.18	0.00	0.51	3.54E-03	3.54E-03	3.44E-03	1.23E-01	1.80E-04	3.92E-02	0.00E+00	0.00E+00	0%
road from east zone pit to Centre Zone ramp	0.11	0	121	0	1	0.00	26.97	0.00	0.22	1.56E-03	1.56E-03	1.52E-03	5.44E-02	7.93E-05	1.73E-02	0.00E+00	0.00E+00	0%
road from Centre Zone to R15	0.12	0	121	0	1	0.00	28.47	0.00	0.24	1.65E-03	1.65E-03	1.60E-03	5.74E-02	8.37E-05	1.83E-02	0.00E+00	0.00E+00	0%
road from Centre Zone pit to Purpose Built	0.25	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road from Purpose Built to scanner	0.24	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road from scanner to ore pile	0.11	41	0	0	1	9.14	0.00	0.00	0.22	3.72E-04	3.72E-04	3.60E-04	1.31E-02	1.91E-05	4.11E-03	0.00E+00	0.00E+00	0%
road off of purpose built	0.35	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
site entrance road from Baker Lake (links to R31)	1.67	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road off of Andrew Lake to Sissons scanner	0.39	28	724	0	1	21.50	560.10	0.00	0.77	3.33E-02	3.33E-02	3.23E-02	1.16E+00	1.68E-03	3.69E-01	0.00E+00	0.00E+00	0%
road from Sissons scanner to SW pile	0.26	0	8	0	1	0.00	4.10	0.00	0.52	2.39E-04	2.39E-04	2.32E-04	8.78E-03	1.28E-05	2.64E-03	0.00E+00	0.00E+00	0%
road from Sissons scanner to ore pile	0.09	28	716	0	1	5.13	132.12	0.00	0.18	7.86E-03	7.86E-03	7.62E-03	2.73E-01	3.97E-04	8.70E-02	0.00E+00	0.00E+00	0%
road past Sissons scanner to CW pile	0.12	0	716	0	1	0.00	175.80	0.00	0.25	1.02E-02	1.02E-02	9.87E-03	3.53E-01	5.15E-04	1.13E-01	0.00E+00	0.00E+00	0%
road past Sissons scanner to End Grid road	0.33	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road past Sissons scanner to Haul Road	0.79	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
road from decline to End Grid CW pile	0.24	12	6	0	1	5.89	3.10	0.00	0.48	4.20E-04	4.20E-04	4.08E-04	1.50E-02	2.19E-05	4.65E-03	0.00E+00	0.00E+00	0%
road from decline to End Grid SW pile	0.33	12	1	0	1	7.97	0.93	0.00	0.65	3.80E-04	3.80E-04	3.69E-04	1.38E-02	2.01E-05	4.20E-03	0.00E+00	0.00E+00	0%
road from decline to End Grid ore pile	0.12	12	0	0	1	3.05	0.00	0.00	0.25	1.25E-04	1.25E-04	1.21E-04	4.55E-03	6.62E-06	1.38E-03	0.00E+00	0.00E+00	0%
road from End Grid ore pile to R25	0.67	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Haul road b/n Kiggavik and Sissons	19.60	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Road to Baker Lake (1 km segment modelled)	1.00	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Road to Airstrip	4.15	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Clean waste pile north - Kiggavik (CW trucks only)	0.30	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Clean waste pile north - Kiggavik (OVB trucks only)	1.55	0	121	0	0	0.00	373.03	0.00	0.00	2.16E-02	2.16E-02	2.10E-02	7.49E-01	1.09E-03	2.39E-01	0.00E+00	0.00E+00	0%
Clean waste pile south - Kiggavik	0.53	0	521	0	0	0.00	550.95	0.00	0.00	3.19E-02	3.19E-02	3.09E-02	1.11E+00	1.61E-03	3.53E-01	0.00E+00	0.00E+00	0%
Overburden pile - Kiggavik	0.42	0	121	0	0	0.00	100.19	0.00	0.00	5.80E-03	5.80E-03	5.63E-03	2.01E-01	2.93E-04	6.42E-02	0.00E+00	0.00E+00	0%
Special waste pile - Kiggavik	0.26	0	9	0	0	0.00	4.91	0.00	0.00	2.84E-04	2.84E-04	2.76E-04	9.85E-03	1.44E-05	3.15E-03	0.00E+00	0.00E+00	0%
Ore pile - Kiggavik	0.26	0	0	0	0	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%
Clean waste pile - Sissons (CW trucks only)	0.57	0	639	0	0	0.00	730.81	0.00	0.00	4.23E-02	4.23E-02	4.10E-02	1.47E+00	2.14E-03	4.69E-01	0.00E+00	0.00E+00	0%
Clean waste pile - Sissons (OVB trucks only)	1.19	0	77	0	0	0.00	184.09	0.00	0.00	1.07E-02	1.07E-02	1.03E-02	3.69E-01	5.39E-04	1.18E-01	0.00E+00	0.00E+00	0%
Special waste pile - Sissons	0.10	0	8	0	0	0.00	1.56	0.00	0.00	9.05E-05	9.05E-05	8.77E-05	3.14E-03	4.57E-06	1.00E-03	0.00E+00	0.00E+00	0%
Overburden pile - Sissons	0.34	0	77	0	0	0.00	52.64	0.00	0.00	3.05E-03	3.05E-03	2.96E-03	1.06E-01	1.54E-04	3.38E-02	0.00E+00	0.00E+00	0%

Unpaved Road	Controlled Emissions (g/s)																		
	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_2	CO	CO_2	CH_4*
East Zone Pit ramp	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
East Zone Pit floor	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Purpose Built Pit ramp	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Purpose Built Pit floor	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Centre Zone Pit ramp	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Centre Zone Pit floor	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Main Zone East Pit ramp	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Main Zone East Pit floor	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Main Zone West Pit ramp	1.38E-01	1.38E-01	1.34E-01	0	0	0	0	0	0	0	0	0	0	0	4.78E+00	6.97E-03	1.53E+00	0.00E+00	0.00E+00
Main Zone West Pit floor	7.88E-03	7.88E-03	7.64E-03	0	0	0	0	0	0	0	0	0	0	0	2.73E-01	3.98E-04	8.72E-02	0.00E+00	0.00E+00
Andrew Lake Pit ramp	2.24E-01	2.24E-01	2.17E-01	0	0	0	0	0	0	0	0	0	0	0	7.76E+00	1.13E-02	2.48E+00	0.00E+00	0.00E+00
Andrew Lake Pit floor	8.61E-03	8.61E-03	8.35E-03	0	0	0	0	0	0	0	0	0	0	0	2.98E-01	4.35E-04	9.53E-02	0.00E+00	0.00E+00
segment off of main zone west ramp	1.44E-03	1.44E-03	1.40E-03	0	0	0	0	0	0	0	0	0	0	0	5.02E-02	7.32E-05	1.60E-02	0.00E+00	0.00E+00
segment off of main zone west ramp to main zone east ramp	7.56E-03	7.56E-03	7.33E-03	0	0	0	0	0	0	0	0	0	0	0	2.63E-01	3.83E-04	8.37E-02	0.00E+00	0.00E+00
segment off of main zone east ramp	2.63E-03	2.63E-03	2.55E-03	0	0	0	0	0	0	0	0	0	0	0	9.14E-02	1.33E-04	2.91E-02	0.00E+00	0.00E+00
segment off of main zone west ramp to CW pile (south)	2.61E-02	2.61E-02	2.53E-02	0	0	0	0	0	0	0	0	0	0	0	9.04E-01	1.32E-03	2.89E-01	0.00E+00	0.00E+00
segment off of main zone west ramp to west of SW pile	2.64E-04	2.64E-04	2.56E-04	0	0	0	0	0	0	0	0	0	0	0	9.63E-03	1.40E-05	2.92E-03	0.00E+00	0.00E+00
road north from main zone east to east of SW pile	7.06E-04	7.06E-04	6.85E-04	0	0	0	0	0	0	0	0	0	0	0	2.49E-02	3.62E-05	7.81E-03	0.00E+00	0.00E+00
road north from east of SW pile to scanner	1.03E-03	1.03E-03	1.00E-03	0	0	0	0	0	0	0	0	0	0	0	3.65E-02	5.31E-05	1.15E-02	0.00E+00	0.00E+00
road from main zone east ramp to CW pile (south)	3.20E-03	3.20E-03	3.10E-03	0	0	0	0	0	0	0	0	0	0	0	1.11E-01	1.62E-04	3.54E-02	0.00E+00	0.00E+00
road from main zone east ramp to CW pile (south)	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
overburden from main zone to CW pile (north)	6.98E-03	6.98E-03	6.77E-03	0	0	0	0	0	0	0	0	0	0	0	2.43E-01	3.54E-04	7.73E-02	0.00E+00	0.00E+00
road from east zone pit to CW pile (north)	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road from east zone pit to Centre Zone	3.54E-03	3.54E-03	3.44E-03	0	0	0	0	0	0	0	0	0	0	0	1.23E-01	1.80E-04	3.92E-02	0.00E+00	0.00E+00
road from east zone pit to Centre Zone ramp	1.56E-03	1.56E-03	1.52E-03	0	0	0	0	0	0	0	0	0	0	0	5.44E-02	7.93E-05	1.73E-02	0.00E+00	0.00E+00
road from Centre Zone to R15	1.65E-03	1.65E-03	1.60E-03	0	0	0	0	0	0	0	0	0	0	0	5.74E-02	8.37E-05	1.83E-02	0.00E+00	0.00E+00
road from Centre Zone pit to Purpose Built	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road from Purpose Built to scanner	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road from scanner to ore pile	3.72E-04	3.72E-04	3.60E-04	0	0	0	0	0	0	0	0	0	0	0	1.31E-02	1.91E-05	4.11E-03	0.00E+00	0.00E+00
road off of purpose built	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
site entrance road from Baker Lake (links to R31)	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road off of Andrew Lake to Sissons scanner	3.33E-02	3.33E-02	3.23E-02	0	0	0	0	0	0	0	0	0	0	0	1.16E+00	1.68E-03	3.69E-01	0.00E+00	0.00E+00
road from Sissons scanner to SW pile	2.39E-04	2.39E-04	2.32E-04	0	0	0	0	0	0	0	0	0	0	0	8.78E-03	1.28E-05	2.64E-03	0.00E+00	0.00E+00
road from Sissons scanner to ore pile	7.86E-03	7.86E-03	7.62E-03	0	0	0	0	0	0	0	0	0	0	0	2.73E-01	3.97E-04	8.70E-02	0.00E+00	0.00E+00
road past Sissons scanner to CW pile	1.02E-02	1.02E-02	9.87E-03	0	0	0	0	0	0	0	0	0	0	0	3.53E-01	5.15E-04	1.13E-01	0.00E+00	0.00E+00
road past Sissons scanner to End Grid road	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road past Sissons scanner to Haul Road	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
road from decline to End Grid CW pile	4.20E-04	4.20E-04	4.08E-04	0	0	0	0	0	0	0	0	0	0	0	1.50E-02	2.19E-05	4.65E-03	0.00E+00	0.00E+00
road from decline to End Grid SW pile	3.80E-04	3.80E-04	3.69E-04	0	0	0	0	0	0	0	0	0	0	0	1.38E-02	2.01E-05	4.20E-03	0.00E+00	0.00E+00
road from decline to End Grid ore pile	1.25E-04	1.25E-04	1.21E-04	0	0	0	0	0	0	0	0	0	0	0	4.55E-03	6.62E-06	1.38E-03	0.00E+00	0.00E+00
road from End Grid ore pile to R25	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Haul road b/n Kiggavik and Sissons	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Road to Baker Lake (1 km segment modelled)	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Road to Airstrip	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clean waste pile north - Kiggavik (CW trucks only)	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clean waste pile north - Kiggavik (OVB trucks only)	2.16E-02	2.16E-02	2.10E-02	0	0	0	0	0	0	0	0	0	0	0	7.49E-01	1.09E-03	2.39E-01	0.00E+00	0.00E+00
Clean waste pile south - Kiggavik	3.19E-02	3.19E-02	3.09E-02	0	0	0	0	0	0	0	0	0	0	0	1.11E+00	1.61E-03	3.53E-01	0.00E+00	0.00E+00
Overburden pile - Kiggavik	5.80E-03	5.80E-03	5.63E-03	0	0	0	0	0	0	0	0	0	0	0	2.01E-01	2.93E-04	6.42E-02	0.00E+00	0.00E+00
Special waste pile - Kiggavik	2.84E-04	2.84E-04	2.76E-04	0	0	0	0	0	0	0	0	0	0	0	9.85E-03	1.44E-05	3.15E-03	0.00E+00	0.00E+00
Ore pile - Kiggavik	0.00E+00	0.00E+00	0.00E+00	0	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Clean waste pile - Sissons (CW trucks only)	4.23E-02	4.23E-02	4.10E-02	0	0	0	0	0	0	0	0	0	0	0	1.47E+00	2.14E-03	4.69E-01	0.00E+00	0.00E+00
Clean waste pile - Sissons (OVB trucks only)	1.07E-02	1.07E-02	1.03E-02	0	0	0	0	0	0	0	0	0	0	0	3.69E-01	5.39E-04	1.18E-01	0.00E+00	0.00E+00
Special waste pile - Sissons	9.05E-05	9.05E-05	8.77E-05	0	0	0	0	0	0	0	0	0	0	0	3.14E-03	4.57E-06	1.00E-03	0.00E+00	0.00E+00
Overburden pile - Sissons	3.05E-03	3.05E-03	2.96E-03	0	0	0	0	0	0	0	0	0	0	0	1.06E-01	1.54E-04	3.38E-02	0.00E+00	0.00E+00

Notes:

Assuming pits, stockpiles and ore pads are not graded.

Assume roads are not graded during the winter months.

Assume grader or water truck only passes over roads with traffic

Cells highlighed gray indicates that emissions of a contaminant are zero.

Do not change these cells.

Maximum Bounding Emissions Scenario Grading Calculation Spreadsheet

Source ID	Unpaved Road	Description	Mean Vehicle Speed (kph)	Emission Factor in kg/VKT SPM	Emission Factor in kg/VKT PM_{10}	Emission Factor in kg/VKT $PM_{2.5}$	One-way Length (km)	One-wayTrips per Day	Uncontrolled Emission Rate (g/s) SPM	Uncontrolled Emission Rate (g/s) PM_{10}	Uncontrolled Emission Rate (g/s) $PM_{2.5}$	Control (%)
EZ	East Zone Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.50	0	0.0000	0.0000	0.0000	0%
EZ	East Zone Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.05	0	0.0000	0.0000	0.0000	0%
PB	Purpose Built Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.30	0	0.0000	0.0000	0.0000	0%
PB	Purpose Built Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.02	0	0.0000	0.0000	0.0000	0%
CZ	Centre Zone Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.85	0	0.0000	0.0000	0.0000	0%
CZ	Centre Zone Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.05	0	0.0000	0.0000	0.0000	0%
MZEST	Main Zone East Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.40	0	0.0000	0.0000	0.0000	0%
MZEST	Main Zone East Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.10	0	0.0000	0.0000	0.0000	0%
MZWEST	Main Zone West Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	1.75	1	0.0249	0.0087	0.0008	0%
MZWEST	Main Zone West Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.10	1	0.0014	0.0005	0.0000	0%
AL	Andrew Lake Pit ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	2.60	1	0.0370	0.0129	0.0011	0%
AL	Andrew Lake Pit floor	Grading CAT 16H	8.0	0.615	0.215	0.019	0.10	1	0.0014	0.0005	0.0000	0%
R1	segment off of main zone west ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.08	1	0.0011	0.0004	0.0000	0%
R2	segment off of main zone west ramp to main zone east ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.44	1	0.0062	0.0022	0.0002	0%
R3	segment off of main zone east ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.15	1	0.0022	0.0008	0.0001	0%
R4	segment off of main zone west ramp to CW pile (south)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.43	1	0.0061	0.0021	0.0002	0%
R5	segment off of main zone west ramp to west of SW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.24	1	0.0035	0.0012	0.0001	0%
R6	road north from main zone east to east of SW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.21	1	0.0030	0.0011	0.0001	0%
R7	road north from east of SW pile to scanner	Grading CAT 16H	8.0	0.615	0.215	0.019	0.31	1	0.0044	0.0015	0.0001	0%
R8	road from main zone east ramp to CW pile (south)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.23	1	0.0033	0.0011	0.0001	0%
R9	road from main zone east ramp to CW pile (south)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.14	0	0.0000	0.0000	0.0000	0%
R10	overburden from main zone to CW pile (north)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.50	1	0.0071	0.0025	0.0002	0%
R11	road from east zone pit to CW pile (north)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.21	0	0.0000	0.0000	0.0000	0%
R12	road from east zone pit to Centre Zone	Grading CAT 16H	8.0	0.615	0.215	0.019	0.25	1	0.0036	0.0013	0.0001	0%
R13	road from east zone pit to Centre Zone ramp	Grading CAT 16H	8.0	0.615	0.215	0.019	0.11	1	0.0016	0.0006	0.0000	0%
R14	road from Centre Zone to R15	Grading CAT 16H	8.0	0.615	0.215	0.019	0.12	1	0.0017	0.0006	0.0001	0%
R15	road from Centre Zone pit to Purpose Built	Grading CAT 16H	8.0	0.615	0.215	0.019	0.25	0	0.0000	0.0000	0.0000	0%
R16	road from Purpose Built to scanner	Grading CAT 16H	8.0	0.615	0.215	0.019	0.24	0	0.0000	0.0000	0.0000	0%
R17	road from scanner to ore pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.11	1	0.0016	0.0006	0.0000	0%
R18	road off of purpose built	Grading CAT 16H	8.0	0.615	0.215	0.019	0.35	0	0.0000	0.0000	0.0000	0%
R19	site entrance road from Baker Lake (links to R31)	Grading CAT 16H	8.0	0.615	0.215	0.019	1.67	0	0.0000	0.0000	0.0000	0%
R20	road off of Andrew Lake to Sissons scanner	Grading CAT 16H	8.0	0.615	0.215	0.019	0.39	1	0.0055	0.0019	0.0002	0%
R21	road from Sissons scanner to SW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.26	1	0.0037	0.0013	0.0001	0%
R22	road from Sissons scanner to ore pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.09	1	0.0013	0.0005	0.0000	0%
R23	road past Sissons scanner to CW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.12	1	0.0017	0.0006	0.0001	0%
R24	road past Sissons scanner to End Grid road	Grading CAT 16H	8.0	0.615	0.215	0.019	0.33	0	0.0000	0.0000	0.0000	0%
R25	road past Sissons scanner to Haul Road	Grading CAT 16H	8.0	0.615	0.215	0.019	0.79	0	0.0000	0.0000	0.0000	0%
R26	road from decline to End Grid CW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.24	1	0.0034	0.0012	0.0001	0%
R27	road from decline to End Grid SW pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.33	1	0.0046	0.0016	0.0001	0%
R28	road from decline to End Grid ore pile	Grading CAT 16H	8.0	0.615	0.215	0.019	0.12	1	0.0018	0.0006	0.0001	0%
R29	road from End Grid ore pile to R25	Grading CAT 16H	8.0	0.615	0.215	0.019	0.67	0	0.0000	0.0000	0.0000	0%
R30	Haul road b/n Kiggavik and Sissons	Grading CAT 16H	8.0	0.615	0.215	0.019	19.60	0	0.0000	0.0000	0.0000	0%
R31	Road to Baker Lake (1 km segment modelled)	Grading CAT 16H	8.0	0.615	0.215	0.019	1.00	0	0.0000	0.0000	0.0000	0%
R32	Road to Airstrip	Grading CAT 16H	8.0	0.615	0.215	0.019	4.15	0	0.0000	0.0000	0.0000	0%
CWNK	Clean waste pile north - Kiggavik (CW trucks only)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.30	0	0.0000	0.0000	0.0000	0%
CWNK	Clean waste pile north - Kiggavik (OVB trucks only)	Grading CAT 16H	8.0	0.615	0.215	0.019	1.55	0	0.0000	0.0000	0.0000	0%
CWK	Clean waste pile south - Kiggavik	Grading CAT 16H	8.0	0.615	0.215	0.019	0.53	0	0.0000	0.0000	0.0000	0%
KOVB	Overburden pile - Kiggavik	Grading CAT 16H	8.0	0.615	0.215	0.019	0.42	0	0.0000	0.0000	0.0000	0%
SWK	Special waste pile - Kiggavik	Grading CAT 16H	8.0	0.615	0.215	0.019	0.26	0	0.0000	0.0000	0.0000	0%
OREK	Ore pile - Kiggavik	Grading CAT 16H	8.0	0.615	0.215	0.019	0.26	0	0.0000	0.0000	0.0000	0%
CWS	Clean waste pile - Sissons (CW trucks only)	Grading CAT 16H	8.0	0.615	0.215	0.019	0.57	0	0.0000	0.0000	0.0000	0%
CWS	Clean waste pile - Sissons (OVB trucks only)	Grading CAT 16H	8.0	0.615	0.215	0.019	1.19	0	0.0000	0.0000	0.0000	0%
SWS	Special waste pile - Sissons	Grading CAT 16H	8.0	0.615	0.215	0.019	0.10	0	0.0000	0.0000	0.0000	0%
SOVB	Overburden pile - Sissons	Grading CAT 16H	8.0	0.615	0.215	0.019	0.34	0	0.0000	0.0000	0.0000	0%

Source ID	Metal Fraction (%) Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	2.50E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	2.50E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
PB	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
CZ	6.00E-03	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
MZEST	0.00E+00	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
MZWEST	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
MZWEST	6.81E-01	5.70E-04	1.70E-03	3.10E-03	5.03E-02	2.87E-02	6.60E-03	2.00E-04	3.90E-03	1.20E-04	1.54E-02
AL	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
AL	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
R1	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R2	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R3	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R4	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R5	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R6	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R7	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R8	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R9	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R10	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R11	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R12	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R13	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R14	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R15	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R16	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R17	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R18	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R19	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R20	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R21	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R22	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R23	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R24	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R25	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R26	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R27	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R28	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R29	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R30	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
R31	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R32	1.00E-03	2.00E-04	8.00E-04	2.50E-03	1.60E-03	8.00E-04	2.50E-03	2.00E-04	2.10E-03	1.00E-05	6.00E-03
CWNK	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWNK	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWK	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
KOVB	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03
SWK	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03
OREK	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
CWS	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
CWS	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SWS	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03
SOVB	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03

Source ID	Controlled Emission Rate (g/s) SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZWEST	2.49E-02	8.71E-03	7.73E-04	4.99E-06	2.29E-08	2.40E-07	2.98E-07	3.09E-07	4.76E-08	6.52E-07	2.84E-08	7.51E-07	9.97E-10	1.14E-06
MZWEST	1.42E-03	4.98E-04	4.42E-05	9.70E-06	8.12E-09	2.42E-08	4.42E-08	7.17E-07	4.09E-07	9.40E-08	2.85E-09	5.56E-08	1.71E-09	2.19E-07
AL	3.70E-02	1.29E-02	1.15E-03	7.41E-06	1.21E-07	1.38E-07	2.49E-07	3.22E-07	2.56E-08	1.04E-06	4.74E-08	4.97E-07	3.33E-09	3.13E-06
AL	1.42E-03	4.98E-04	4.42E-05	9.00E-06	2.36E-08	1.18E-08	7.19E-08	5.06E-07	7.94E-08	1.36E-07	7.12E-10	4.86E-08	1.57E-09	1.37E-06
R1	1.12E-03	3.91E-04	3.46E-05	1.12E-08	2.24E-09	8.94E-09	2.79E-08	1.79E-08	8.94E-09	2.79E-08	2.24E-09	2.35E-08	1.12E-10	6.71E-08
R2	6.22E-03	2.17E-03	1.93E-04	6.22E-08	1.24E-08	4.97E-08	1.55E-07	9.95E-08	4.97E-08	1.55E-07	1.24E-08	1.31E-07	6.22E-10	3.73E-07
R3	2.16E-03	7.55E-04	6.70E-05	2.16E-08	4.32E-09	1.73E-08	5.40E-08	3.46E-08	1.73E-08	5.40E-08	4.32E-09	4.54E-08	2.16E-10	1.30E-07
R4	6.15E-03	2.15E-03	1.91E-04	6.15E-08	1.23E-08	4.92E-08	1.54E-07	9.84E-08	4.92E-08	1.54E-07	1.23E-08	1.29E-07	6.15E-10	3.69E-07
R5	3.48E-03	1.22E-03	1.08E-04	3.48E-08	6.96E-09	2.78E-08	8.69E-08	5.56E-08	2.78E-08	8.69E-08	6.96E-09	7.30E-08	3.48E-10	2.09E-07
R6	3.01E-03	1.05E-03	9.32E-05	3.01E-08	6.01E-09	2.41E-08	7.52E-08	4.81E-08	2.41E-08	7.52E-08	6.01E-09	6.32E-08	3.01E-10	1.80E-07
R7	4.41E-03	1.54E-03	1.37E-04	4.41E-08	8.82E-09	3.53E-08	1.10E-07	7.05E-08	3.53E-08	1.10E-07	8.82E-09	9.26E-08	4.41E-10	2.65E-07
R8	3.26E-03	1.14E-03	1.01E-04	3.26E-08	6.52E-09	2.61E-08	8.15E-08	5.22E-08	2.61E-08	8.15E-08	6.52E-09	6.85E-08	3.26E-10	1.96E-07
R9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R10	7.11E-03	2.48E-03	2.20E-04	7.11E-08	1.42E-08	5.69E-08	1.78E-07	1.14E-07	5.69E-08	1.78E-07	1.42E-08	1.49E-07	7.11E-10	4.27E-07
R11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R12	3.61E-03	1.26E-03	1.12E-04	3.61E-08	7.22E-09	2.89E-08	9.03E-08	5.78E-08	2.89E-08	9.03E-08	7.22E-09	7.58E-08	3.61E-10	2.17E-07
R13	1.59E-03	5.56E-04	4.93E-05	1.59E-08	3.18E-09	1.27E-08	3.98E-08	2.55E-08	1.27E-08	3.98E-08	3.18E-09	3.34E-08	1.59E-10	9.55E-08
R14	1.68E-03	5.87E-04	5.21E-05	1.68E-08	3.36E-09	1.34E-08	4.20E-08	2.69E-08	1.34E-08	4.20E-08	3.36E-09	3.53E-08	1.68E-10	1.01E-07
R15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R17	1.58E-03	5.53E-04	4.91E-05	1.58E-08	3.17E-09	1.27E-08	3.96E-08	2.53E-08	1.27E-08	3.96E-08	3.17E-09	3.33E-08	1.58E-10	9.50E-08
R18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R20	5.51E-03	1.93E-03	1.71E-04	5.51E-08	1.10E-08	4.41E-08	1.38E-07	8.82E-08	4.41E-08	1.38E-07	1.10E-08	1.16E-07	5.51E-10	3.31E-07
R21	3.71E-03	1.30E-03	1.15E-04	3.71E-08	7.43E-09	2.97E-08	9.28E-08	5.94E-08	2.97E-08	9.28E-08	7.43E-09	7.80E-08	3.71E-10	2.23E-07
R22	1.31E-03	4.59E-04	4.08E-05	1.31E-08	2.63E-09	1.05E-08	3.29E-08	2.10E-08	1.05E-08	3.29E-08	2.63E-09	2.76E-08	1.31E-10	7.89E-08
R23	1.75E-03	6.11E-04	5.42E-05	1.75E-08	3.50E-09	1.40E-08	4.37E-08	2.80E-08	1.40E-08	4.37E-08	3.50E-09	3.67E-08	1.75E-10	1.05E-07
R24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R25	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R26	3.43E-03	1.20E-03	1.06E-04	3.43E-08	6.87E-09	2.75E-08	8.59E-08	5.49E-08	2.75E-08	8.59E-08	6.87E-09	7.21E-08	3.43E-10	2.06E-07
R27	4.65E-03	1.62E-03	1.44E-04	4.65E-08	9.29E-09	3.72E-08	1.16E-07	7.44E-08	3.72E-08	1.16E-07	9.29E-09	9.76E-08	4.65E-10	2.79E-07
R28	1.78E-03	6.20E-04	5.50E-05	1.78E-08	3.55E-09	1.42E-08	4.44E-08	2.84E-08	1.42E-08	4.44E-08	3.55E-09	3.73E-08	1.78E-10	1.07E-07
R29	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R30	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R31	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KOVB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OREK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SOVB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	0.1323													

Notes:
Assume stockpiles and pit floors are not graded.
Assume roads are not graded during the winter months.

Size Fraction	Emission Factor Equation	Reference
SPM <30 μm	$E = 0.0034 \times (S)^{2.5}$	AP-42 Table 11.9-2, October 1998
PM <10 μm	$E = 0.60 \times 0.0056 \times (S)^{2.0}$	AP-42 Table 11.9-2, October 1998
PM <2.5 μm	$E = 0.031 \times 0.0034 \times (S)^{2.5}$	AP-42 Table 11.9-2, October 1998

E = emission factor in kg/VKT
S = mean vehicle speed (kph)

Maximum Bounding Emissions Scenario Bulldozing Calculation Spreadsheet

Source ID	Source Location	Silt (%)	Moisture (%)	Emission Factor in kg/hr			Operating Hours per Day	Operating Frequency	Uncontrolled Emission Rate (g/s)			Control Based on Watering (%)
				SPM	PM_{10}	$PM_{2.5}$			SPM	PM_{10}	$PM_{2.5}$	
OREK	Kiggavik Ore Pile	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%
SWK	Kiggavik Special Waste Pile	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
CWNK	Kiggavik Clean Rock Pile North	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%
CWK	Kiggavik Clean Rock Pile South	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
KOVB	Kiggavik Overburden Pile	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
ORES	Andrew Lake Ore Pile	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%
SWS	Andrew Lake Special Waste Pile	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
CWS	Andrew Lake Clean Rock Pile	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
SOVB	Andrew Lake Overburden Pile	5.0	3.0	4.300	0.811	0.452	20	40%	0.3982	0.0750	0.0418	0%
CWEG	End Grid Clean Waste Pile	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%
SWEG	End Grid Special Waste Pile	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%
EGORE	End Grid Ore Pile	5.0	3.0	4.300	0.811	0.452	0	40%	0.0000	0.0000	0.0000	0%

Source ID	Metal %										
	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
OREK	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
SWK	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03
CWNK	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWK	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
KOVB	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03
ORES	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
SWS	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03
CWS	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SOVB	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03
CWEG	2.50E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SWEG	2.10E-01	1.00E-04	1.30E-03	2.00E-04	3.80E-03	1.00E-04	3.70E-03	9.00E-05	3.80E-03	1.00E-04	1.00E-02
EGORE	5.01E-01	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02

Source ID	Controlled Emission Rate (g/s)													
	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
OREK	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00
SWK	3.98E-01	7.50E-02	4.18E-02	3.58E-04	2.91E-07	4.32E-06	1.80E-05	1.20E-05	5.83E-06	8.84E-06	5.69E-07	1.40E-05	1.99E-08	1.68E-05
CWNK	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00
CWK	3.98E-01	7.50E-02	4.18E-02	7.96E-05	3.66E-07	3.83E-06	4.76E-06	4.94E-06	7.60E-07	1.04E-05	4.54E-07	1.20E-05	1.59E-08	1.82E-05
KOVB	3.98E-01	7.50E-02	4.18E-02	3.98E-06	3.19E-07	4.45E-06	5.38E-06	4.01E-06	7.57E-07	1.07E-05	4.50E-07	1.41E-05	1.99E-08	1.84E-05
ORES	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00
SWS	3.98E-01	7.50E-02	4.18E-02	3.58E-04	7.64E-07	1.05E-06	2.25E-06	5.62E-06	3.34E-07	1.11E-05	4.38E-07	3.96E-06	4.38E-08	3.07E-05
CWS	3.98E-01	7.50E-02	4.18E-02	7.96E-05	1.31E-06	1.49E-06	2.68E-06	3.46E-06	2.75E-07	1.12E-05	5.10E-07	5.35E-06	3.58E-08	3.36E-05
SOVB	3.98E-01	7.50E-02	4.18E-02	3.98E-06	1.47E-06	1.50E-06	2.95E-06	3.04E-06	2.67E-07	1.08E-05	5.30E-07	5.40E-06	3.19E-08	3.45E-05
CWEG	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00
SWEG	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00
EGORE	0.00E+00	#######	#######	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00

Notes:
As per the IFS, bulldozers will primarily be used for maintenance of stockpiles. Secondary functions include maintenance of road berms and assisting with loading ore and waste in pits. For simplicity, it was assumed that bulldozers will only be used on stockpiles.
Since End Grid Piles and ORES are small and temporary, equipment will primarily be used on larger piles, therefore, they were not included.

Size Fraction	Emission Factor Equation	Reference
SPM <30 µm	$E = 2.6 \times (s)^{1.2} \times (M)^{-1.3}$	AP-42 Table 11.9-2, October 1998
PM <10 µm	$E = 0.75 \times 0.45 \times (s)^{1.5} \times (M)^{-1.4}$	AP-42 Table 11.9-2, October 1998
PM <2.5 µm	$E = 0.105 \times 2.6 \times (s)^{1.2} \times (M)^{-1.3}$	AP-42 Table 11.9-2, October 1998

E = emission factor in kg/hour
s = silt content (%)
M = material moisture content (%)

Maximum Bounding Emissions Scenario Drilling Calculation Spreadsheet

Source ID	Source Location	Description	Emission Factor in kg/hole			Number of Holes Drilled per Day	Uncontrolled Emission Rate (g/s)			Control Based on Watering (%)
			SPM	PM_{10}	$PM_{2.5}$		SPM	PM_{10}	$PM_{2.5}$	
EZ	East Zone Pit	Drilling	0.590	0.301	0.089	0	0.0000	0.0000	0.0000	0%
PB	Purpose Built Pit	Drilling	0.590	0.301	0.089	0	0.0000	0.0000	0.0000	0%
CZ	Centre Zone Pit	Drilling	0.590	0.301	0.089	0	0.0000	0.0000	0.0000	0%
MZWEST	Main Zone East Pit	Drilling	0.590	0.301	0.089	150	1.0209	0.5207	0.1531	0%
MZEST	Main Zone West Pit	Drilling	1.590	0.811	0.239	0	0.0000	0.0000	0.0000	0%
AL	Andrew Lake Pit	Drilling	0.590	0.301	0.089	150	1.0209	0.5207	0.1531	0%
	End Grid Underground Mine	Drilling	0.590	0.301	0.089	633	4.3211	2.2038	0.6482	0%

Source ID	Metal %										
	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######
PB	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######
MZWEST	5.59E-02	1.17E-04	1.00E-03	1.35E-03	3.85E-03	1.71E-03	2.82E-03	1.19E-04	3.07E-03	1.01E-05	5.14E-03
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######
AL	3.91E-02	3.66E-04	3.85E-04	8.01E-04	1.91E-03	2.33E-04	3.00E-03	1.25E-04	1.40E-03	1.20E-05	1.11E-02
	3.25E-01	3.45E-03	1.47E-03	3.08E-03	1.31E-02	3.96E-03	5.17E-03	3.82E-04	3.14E-03	8.19E-05	1.03E-02

Source ID	Controlled Emission Rate (g/s)													
	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	#######	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.00E+00
PB	0.00E+00	#######	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.00E+00
CZ	0.00E+00	#######	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.00E+00
MZWEST	1.02E+00	5.21E-01	1.53E-01	5.71E-04	1.19E-06	1.02E-05	1.38E-05	3.93E-05	1.75E-05	2.88E-05	1.21E-06	3.13E-05	1.03E-07	5.25E-05
MZEST	0.00E+00	#######	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.00E+00
AL	1.02E+00	5.21E-01	1.53E-01	3.99E-04	3.74E-06	3.93E-06	8.18E-06	1.95E-05	2.38E-06	3.07E-05	1.28E-06	1.43E-05	1.23E-07	1.13E-04
	4.32E+00	#######	6.48E-01	1.41E-02	1.49E-04	6.34E-05	1.33E-04	5.68E-04	1.71E-04	2.23E-04	1.65E-05	1.35E-04	3.54E-06	4.44E-04
	6.36E+00													

Size Fraction	Emission Factor Equatio	Reference
SPM <30 µm	E = 0.59 kg/hole	AP-42 Table 11.9-4, October 1998
PM <10 µm	E = 51% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995
PM <2.5 µm	E = 15% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995

Maximum Bounding Emissions Scenario Blasting Calculation Spreadsheet

Source ID	Source Location	Description	Emission Factor						Number of Blasts per Day	ANFO Required per Blast (tonnes)	Uncontrolled Emission Rate (g/s)						Control Based on Watering (%)
			SPM (kg/blast)	PM_{10} (kg/blast)	$PM_{2.5}$ (kg/blast)	NOx (kg/Mg)	SO_2 (kg/Mg)	CO (kg/Mg)			SPM	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	
EZ	East Zone Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0%
PB	Purpose Built Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0%
CZ	Centre Zone Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0%
MZWEST	Main Zone West Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	1	75	0.4479	0.2284	0.0672	4.3404	0.8681	29.5139	0%
MZEST	Main Zone East Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	0	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0%
AL	Andrew Lake Pit	Explosive Blasting	38.7	19.737	5.805	5	1	34	1	75	0.4479	0.2284	0.0672	4.3404	0.8681	29.5139	0%
	End Grid Underground Mine	Explosive Blasting	38.7	19.737	5.805	5	1	34	9	0.5	2.0246	1.0325	0.3037	0.2616	0.0523	1.7787	0%

Source ID	Source Location	Metal %										
		Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	East Zone Pit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	Purpose Built Pit	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
CZ	Centre Zone Pit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZWEST	Main Zone West Pit	5.59E-02	1.17E-04	1.00E-03	1.35E-03	3.85E-03	1.71E-03	2.82E-03	1.19E-04	3.07E-03	1.01E-05	5.14E-03
MZEST	Main Zone East Pit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL	Andrew Lake Pit	3.91E-02	3.66E-04	3.85E-04	8.01E-04	1.91E-03	2.33E-04	3.00E-03	1.25E-04	1.40E-03	1.20E-05	1.11E-02
	End Grid Underground Mine	3.25E-01	3.45E-03	1.47E-03	3.08E-03	1.31E-02	3.96E-03	5.17E-03	3.82E-04	3.14E-03	8.19E-05	1.03E-02

Source ID	Source Location	Controlled Emission Rate (g/s)																
		SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO
EZ	East Zone Pit	0.0000	0.0000	0.0000	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.0000	0.0000	0.0000
PB	Purpose Built Pit	0.0000	0.0000	0.0000	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.0000	0.0000	0.0000
CZ	Centre Zone Pit	0.0000	0.0000	0.0000	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.0000	0.0000	0.0000
MZWEST	Main Zone West Pit	0.4479	0.2284	0.0672	2.51E-04	5.23E-07	4.50E-06	6.04E-06	1.73E-05	7.67E-06	1.26E-05	5.33E-07	1.37E-05	4.54E-08	2.30E-05	4.3404	0.8681	29.5139
MZEST	Main Zone East Pit	0.0000	0.0000	0.0000	0.00E+00	#######	#######	#######	#######	#######	#######	#######	#######	#######	0.00E+00	0.0000	0.0000	0.0000
AL	Andrew Lake Pit	0.4479	0.2284	0.0672	1.75E-04	1.64E-06	1.73E-06	3.59E-06	8.55E-06	1.04E-06	1.35E-05	5.62E-07	6.27E-06	5.39E-08	4.95E-05	4.3404	0.8681	29.5139
	End Grid Underground Mine	2.0246	1.0325	0.3037	6.59E-03	6.99E-05	2.97E-05	6.23E-05	2.66E-04	8.01E-05	1.05E-04	7.74E-06	6.35E-05	1.66E-06	2.08E-04	0.2616	0.0523	1.7787

Notes:

Emission factors for PM are taken from Colorado Department of Health (1981).

Emission factors for SO_2 and CO are taken from AP-42 Table 13.3-1 for detonation of ANFO. Kiggavik uses 100% emulsion or emulsion + ANFO. However at present time no emission factor for the detonation of emulsion is available.

Emission factor for NO_x is 10 lb/ton ANFO used, taken from NIOSH publication TIC-2 No. 20025380, A Technique for Measuring Toxic Gases Produced by Blasting Agents, January 1997.

Size Fraction	Emission Factor Equatio	Reference
SPM <30 μm	E = 38.7 kg/blast	CDOH 1981
PM <10 μm	E = 51% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995
PM <2.5 μm	E = 15% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995

Maximum Bounding Emissions Scenario Wind Erosion Calculation Spreadsheet

Source ID	Wind Erosion Source	Active or Inactive?	s %	Base Length (m)	Base Width (m)	Height of Pile (m)	Occupied Area (ha)	Surface Area (ha)	Active Surface Area (ha)[1]	E (kg/ha/day) TSP	E (kg/ha/day) PM_{10}	E (kg/ha/day) $PM_{2.5}$	Uncontrolled (g/s) TSP	Uncontrolled (g/s) PM_{10}	Uncontrolled (g/s) $PM_{2.5}$	Assumed Control Efficiency (%)
EZ	East Zone Pit Active Area	Inactive	5	N/A	N/A	N/A	6.6	6.6	0.0	19.749	9.875	3.950	0.00000	0.00000	0.00000	0%
PB	Purpose Built Pit Active Area	Inactive	5	N/A	N/A	N/A	2.8	2.8	0.0	19.749	9.875	3.950	0.00000	0.00000	0.00000	0%
CZ	Centre Zone Pit Active Area	Inactive	5	N/A	N/A	N/A	14.3	14.3	0.0	19.749	9.875	3.950	0.00000	0.00000	0.00000	0%
MZEST	Main Zone East Pit Active Area	Inactive	5	N/A	N/A	N/A	16.2	16.2	0.0	19.749	9.875	3.950	0.00000	0.00000	0.00000	0%
MZWEST	Main Zone West Pit Active Area	Active	5	N/A	N/A	N/A	25.9	25.9	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
AL	Andrew Lake Pit Active Area	Active	5	N/A	N/A	N/A	46.9	46.9	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
OREK	Kiggavik Ore Pile - large	Active	5	255	145	7	5.2	4.2	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
OREK	Kiggavik Ore Pile - small	Active	5	135	95	7	n/a	1.6	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
SWK	Kiggavik Special Waste Pile	Active	5	520	237	10	12.3	13.8	1.4	19.749	9.875	3.950	0.31588	0.15794	0.06318	0%
CWNK	Kiggavik Clean Rock Pile North	Active	5	1150	478	50	54.9	71.2	7.1	19.749	9.875	3.950	1.62782	0.81391	0.32556	0%
CWK	Kiggavik Clean Rock Pile South	Active	5	2060	377	50	77.6	102.0	10.2	19.749	9.875	3.950	2.33089	1.16545	0.46618	0%
KOVB	Kiggavik Overburden Pile	Active	5	500	300	50	14.0	23.0	2.3	19.749	9.875	3.950	0.52573	0.26286	0.10515	0%
ORES	Andrew Lake Ore Pad	Active	5	95	95	10	0.9	1.3	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
SWS	Andrew Lake Special Waste Pile	Active	5	600	200	10	12.0	13.6	1.4	19.749	9.875	3.950	0.31102	0.15551	0.06220	0%
CWS	Andrew Lake Clean Rock Pile	Active	5	2000	683	50	136.7	163.5	16.4	19.749	9.875	3.950	3.73788	1.86894	0.74758	0%
SOVB	Andrew Lake Overburden Pile	Active	5	500	280	50	14.7	21.8	2.2	19.749	9.875	3.950	0.49830	0.24915	0.09966	0%
CWEG	End Grid (Backfill) Clean Waste Pile	Active	5	150	100	10	1.5	2.0	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
SWEG	End Grid Special Waste Pile	Active	5	150	100	10	1.5	2.0	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%
EGORE	End Grid Ore Pile	Active	5	50	50	10	0.2	0.5	1.0	19.749	9.875	3.950	0.22858	0.11429	0.04572	0%

Source ID	Metal % Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	2.50E-02	8.00E-05	9.50E-04	9.40E-04	2.58E-03	1.20E-03	2.11E-03	2.00E-05	2.73E-03	5.00E-06	5.60E-03
CZ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZWEST	5.59E-02	1.17E-04	1.00E-03	1.35E-03	3.85E-03	1.71E-03	2.82E-03	1.19E-04	3.07E-03	1.01E-05	5.14E-03
AL	3.91E-02	3.66E-04	3.85E-04	8.01E-04	1.91E-03	2.33E-04	3.00E-03	1.25E-04	1.40E-03	1.20E-05	1.11E-02
OREK	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
OREK	6.67E-01	1.69E-03	1.47E-03	4.00E-03	4.08E-02	1.75E-02	7.59E-03	2.03E-04	3.76E-03	1.17E-04	4.20E-02
SWK	9.00E-02	7.30E-05	1.09E-03	4.51E-03	3.02E-03	1.47E-03	2.22E-03	1.43E-04	3.52E-03	5.00E-06	4.21E-03
CWNK	1.55E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
CWK	2.00E-02	9.20E-05	9.63E-04	1.20E-03	1.24E-03	1.91E-04	2.62E-03	1.14E-04	3.01E-03	4.00E-06	4.58E-03
KOVB	1.00E-03	8.00E-05	1.12E-03	1.35E-03	1.01E-03	1.90E-04	2.70E-03	1.13E-04	3.55E-03	5.00E-06	4.63E-03
ORES	6.32E-01	1.66E-03	8.30E-04	5.05E-03	3.55E-02	5.57E-03	9.54E-03	5.00E-05	3.41E-03	1.10E-04	9.61E-02
SWS	9.00E-02	1.92E-04	2.63E-04	5.64E-04	1.41E-03	8.40E-05	2.79E-03	1.10E-04	9.95E-04	1.10E-05	7.71E-03
CWS	2.00E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SOVB	1.00E-03	3.69E-04	3.76E-04	7.40E-04	7.63E-04	6.70E-05	2.71E-03	1.33E-04	1.36E-03	8.00E-06	8.66E-03
CWEG	2.50E-02	3.28E-04	3.73E-04	6.72E-04	8.70E-04	6.90E-05	2.80E-03	1.28E-04	1.34E-03	9.00E-06	8.45E-03
SWEG	2.10E-01	1.00E-04	1.30E-03	2.00E-04	3.80E-03	1.00E-04	3.70E-03	9.00E-05	3.80E-03	1.00E-04	1.00E-02
EGORE	5.01E-01	5.49E-03	2.08E-03	4.67E-03	2.08E-02	6.46E-03	6.60E-03	5.50E-04	4.05E-03	1.20E-04	1.13E-02

Source ID	Controlled Emission Rate (g/s) TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
EZ	0.00000	0.00000	0.00000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB	0.00000	0.00000	0.00000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CZ	0.00000	0.00000	0.00000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZEST	0.00000	0.00000	0.00000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MZWEST	0.22858	0.11429	0.04572	1.28E-04	2.67E-07	2.29E-06	3.08E-06	8.81E-06	3.92E-06	6.44E-06	2.72E-07	7.01E-06	2.31E-08	1.18E-05
AL	0.22858	0.11429	0.04572	8.93E-05	8.37E-07	8.81E-07	1.83E-06	4.36E-06	5.33E-07	6.87E-06	2.87E-07	3.20E-06	2.75E-08	2.53E-05
OREK	0.22858	0.11429	0.04572	1.52E-03	3.86E-06	3.35E-06	9.14E-06	9.33E-05	4.00E-05	1.73E-05	4.64E-07	8.59E-06	2.67E-07	9.59E-05
OREK	0.22858	0.11429	0.04572	1.52E-03	3.86E-06	3.35E-06	9.14E-06	9.33E-05	4.00E-05	1.73E-05	4.64E-07	8.59E-06	2.67E-07	9.59E-05
SWK	0.31588	0.15794	0.06318	2.84E-04	2.31E-07	3.43E-06	1.42E-05	9.53E-06	4.63E-06	7.01E-06	4.52E-07	1.11E-05	1.58E-08	1.33E-05
CWNK	1.62782	0.81391	0.32556	2.53E-04	1.50E-06	1.57E-05	1.95E-05	2.02E-05	3.11E-06	4.26E-05	1.86E-06	4.91E-05	6.51E-08	7.45E-05
CWK	2.33089	1.16545	0.46618	4.66E-04	2.14E-06	2.24E-05	2.79E-05	2.89E-05	4.45E-06	6.10E-05	2.66E-06	7.03E-05	9.32E-08	1.07E-04
KOVB	0.52573	0.26286	0.10515	5.26E-06	4.21E-07	5.87E-06	7.11E-06	5.29E-06	9.99E-07	1.42E-05	5.94E-07	1.87E-05	2.63E-08	2.43E-05
ORES	0.22858	0.11429	0.04572	1.44E-03	3.79E-06	1.90E-06	1.15E-05	8.11E-05	1.27E-05	2.18E-05	1.14E-07	7.79E-06	2.51E-07	2.20E-04
SWS	0.31102	0.15551	0.06220	2.80E-04	5.97E-07	8.18E-07	1.75E-06	4.39E-06	2.61E-07	8.68E-06	3.42E-07	3.09E-06	3.42E-08	2.40E-05
CWS	3.73788	1.86894	0.74758	7.48E-04	1.23E-05	1.39E-05	2.51E-05	3.25E-05	2.58E-06	1.05E-04	4.78E-06	5.02E-05	3.36E-07	3.16E-04
SOVB	0.49830	0.24915	0.09966	4.98E-06	1.84E-06	1.87E-06	3.69E-06	3.80E-06	3.34E-07	1.35E-05	6.63E-07	6.76E-06	3.99E-08	4.31E-05
CWEG	0.22858	0.11429	0.04572	5.71E-05	7.50E-07	8.53E-07	1.54E-06	1.99E-06	1.58E-07	6.41E-06	2.93E-07	3.07E-06	2.06E-08	1.93E-05
SWEG	0.22858	0.11429	0.04572	4.80E-04	2.29E-07	2.97E-06	4.57E-07	8.69E-06	2.29E-07	8.46E-06	2.06E-07	8.69E-06	2.29E-07	2.29E-05
EGORE	0.22858	0.11429	0.04572	1.14E-03	1.25E-05	4.75E-06	1.07E-05	4.75E-05	1.48E-05	1.51E-05	1.26E-06	9.26E-06	2.74E-07	2.58E-05

[1] Active area for pits was assumed to be 100 metres by 100 meters. Active area for stock piles was assumed to be 10% of total area or 100 metres by 100 metres, whichever is larger.

Equation	Reference
E = k*1.9 *(s/1.5) * f/15	AWMA - Air Pollution Engineering Manual, 1992, page 137

E = emission factor (kg/ha/day)
k = particle size multilier for particulate size range of interest
s = Silt Content in %
f = % of time that the unobstructed wind speed exceeds 5.4 m/s at mean pile height

Parameter	TSP	PM_{10}	$PM_{2.5}$	Reference
k	1.0	0.5	0.2	AWMA - Air Pollution Engineering Manual, 1992, page 137
f	see wind frequency table below - Updated from CALMET runs May 2011.			

Stockpile surface area sample calculation:

Conservatively assume stockpiles acting as a rectangular prism, then
SA = B + Ph = (lw) + 2(l+w)(h)

Where,
B = Base area
P = Perimeter
h = Height of pile

Month	f
January	39
February	20
March	33
April	31
May	22
June	13
July	8
August	21
September	35
October	21
November	34
December	47

Maximum Bounding Emissions Scenario Mill Calculation Spreadsheet

McClean Stack Testing Results

Source	Stack Test Data					Calculated				
	Particulate (kg/h)	Uranium (kg/h)	NO_x (kg/h)	SO_2 (kg/h)	CO (kg/h)	Particulate (g/s)	Uranium (g/s)	NO_x (g/s)	SO_2 (g/s)	CO (g/s)
Crushing & Grinding Stack	0.01	0.0	0.0	0.0	0.0	3.61E-03	-	0.00	0.00	0.00
Yellowcake Calciner Stack	6.0	6.90E-03	0.76	0.02	0.39	1.67	1.92E-03	0.21	0.01	0.11
Yellowcake Packaging Area Stack	0.1	2.60E-03	0.0	0.0	0.0	0.03	7.22E-04	0.00	0.00	0.00
Total for Calcining and Packaging	6.1	0.0	0.8	0.0	0.4	1.69	2.64E-03	0.21	0.01	0.11

Note: stack test report for yellowcake packaging area includes NOx, SO_2 and CO; however, it is likely that these are a result of heating equipment that shares a stack with the packaging area.

McClean Mill Production:

Ore Feed	t/day	677
Prod'n during Calcining test	kg U/h	832
Prod'n during Packaging test	kg U/h	2255
Grade	%U (2008)	0.81%

Note: Grade U% from McClean Report 34918 "McCLEAN LAKE OPERATONS ATMOSPHERIC AND WATERSHED DISPERSION MODELLING", May 2009, page 12.

Kiggavik

Ore Feed	t/day	3358
Yellowcake Prod'n	kg U/h	537
Grade	%U	0.400%

Source ID	Description	Emission Rate (g/s)																
		TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO
MILL	Crushing & Grinding	1.79E-02	9.13E-03	2.69E-03	1.19E-04	3.03E-07	2.62E-07	7.16E-07	7.31E-06	3.14E-06	1.36E-06	3.64E-08	6.73E-07	2.09E-08	7.51E-06	0.00E+00	0.00E+00	0.00E+00
MILL	Calcining	1.08E+00	5.49E-01	1.61E-01	1.24E-03	0	0	0	0	0	0	0	0	0	0	1.36E-01	3.59E-03	6.99E-02
MILL	Packaging	5.96E-03	3.04E-03	8.93E-04	1.72E-04	0	0	0	0	0	0	0	0	0	0	0.00E+00	0.00E+00	0.00E+00
		1.10E+00																

Size Fraction	Emission Factor	Reference
PM <10 µm	E = 51% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995
PM <2.5 µm	E = 15% of TSP	AP-42 Table B.2.2, Category 3 - Aggregate, Unprocessed Ores, January 1995

Notes:

Cells highlighed gray indicate that emissions of a contaminant are insignificant. Assumed that most metals/minerals have been removed during the milling process.

Maximum Bounding Emissions Scenario Underground Mine Calculation Spreadsheet

Source ID	Source	TSP Emission Rate (g/s)	PM_{10} Emission Rate (g/s)	$PM_{2.5}$ Emission Rate (g/s)	Uranium Emission Rate (g/s)	As Emission Rate (g/s)	Co Emission Rate (g/s)	Cu Emission Rate (g/s)	Pb Emission Rate (g/s)	Mo Emission Rate (g/s)	Ni Emission Rate (g/s)	Se Emission Rate (g/s)	Zn Emission Rate (g/s)	Cd Emission Rate (g/s)	Cr Emission Rate (g/s)	NO_X Emission Rate (g/s)	SO_2 Emission Rate (g/s)	CO Emission Rate (g/s)
End Grid	NonRoad Equipment Tailpipe Emissions	0.0528	0.0528	0.0512	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	6.1350	0.0741	0.5634
	Material Handling Emissions	0.0056	0.0026	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	-	-
	Drilling Emissions	4.3211	2.2038	0.6482	0.0141	0.0001	0.0001	0.0001	0.0006	0.0002	0.0002	0.0000	0.0001	0.0000	0.0004	-	-	-
	Blasting Emissions	2.0246	1.0325	0.3037	0.0066	0.0001	0.0000	0.0001	0.0003	0.0001	0.0001	0.0000	0.0001	0.0000	0.0002	0.2616	0.0523	1.7787
EXHAUST	Total Emissions from Underground Mine	**6.404**	**3.292**	**1.003**	**0.021**	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**6.397**	**0.126**	**2.342**

Maximum Bounding Emissions Scenario Power Generation Calculation Spreadsheet

Diesel Generator Sets

CAT model 12CM32 diesel generator set was selected (AREVA memo dated January 3, 2011).

Number of generators operating - Kiggavik	4		
Number of generators operating - Sissons	1		
Full Load Power	4186	eKW	(Caterpillar Engine Performance Report January 17, 2011)
	5611	hp	
	5760	bKW	

$$hp = \frac{kw}{0.746 \times Efficiency}$$

ENGINE POWER	4186	eKW
	5611	hp
Contaminant	EF[1]	ER (g/s)
PM (lb/hp-hr)	7.0E-04	0.49
NOx (g/KWh)	13.60	15.81
CO (g/KWh)	0.06	0.07

Notes:

1. EF for PM from AP-42 Ch. 3.4 - Large Stationary Diesel and all Stationary Dual-fuel Engines, Table 3.4-1

EF for Nox and CO obtained from CATERPILLAR Engine Performance Report Model 9CM32 C provided January 17, 2011

Sulphur Dioxide emissions calculations

Sulphur fuel content		0.0015	%
Power generation at Kiggavik		155,000,000	kWh/year
Power generation at Kiggavik		23,000,000	kWh/year
Heating value		19,676	Btu/lb
Convert kWh to Btu		3412.142	Btu/kWh
Convert lb to g		453.5924	g/lb
Operating hours per year		8760	hours
SO2 @ Kiggavik	total	0.0058	g/s
SO2 @ Sissons	total	0.0009	g/s

Kiggavik

Source ID	Emission Rate (g/s)															
	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_x	CO
STK	1.98E+00	1.90E+00	1.78E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	63.3	0.0058	0.3

Size Fraction	Emission Factor Equation	Reference
PM <10 µm	E = 96% of TSP	AP-42 Table B.2.2, Category 1 - Gasoline and Diesel Fueled Stationary IC Engines, January 1995
PM <2.5 µm	E = 90% of TSP	AP-42 Table B.2.2, Category 1 - Gasoline and Diesel Fueled Stationary IC Engines, January 1996

Sissons

7Jan11: Assumed 1 generator set at Sissons.

Power requirement for Sissons is significantly less than Kiggavik, at 23,000,000 kWh in comparison to 155,000,000 kWh at Kiggavik. The ratio is approximately 15%, which is equivalent to 1 out of 6 generator running.

Therefore, it was assumed the power plant at Sissons consists of 1 CAT 3616 4.4 MW generator.

Source ID	Emission Rate (g/s)															
	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NOx	SO_x	CO
SPPL	4.95E-01	4.75E-01	4.45E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	15.81	0.0009	0.07

Maximum Bounding Emissions Scenario Incineration Calculation Spreadsheet

Tested Emission Rate (mg/m^3)

Source ID	Source Description	Exhaust Gas Flow Rate (m^3/s)	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CO_2	CH_4	Hg	HCl	CDD/CDF
KINC	Multi-chamber Incinerator at Kiggavik	7.2	3.112	2.458	1.400	0	0	0	0	0	0	0	0	0	0	0	14.64	7.78	1.09	0	0	0	0	1.24E-11
SINC	Multi-chamber Incinerator at Sissons	3.6	3.112	2.458	1.400	0	0	0	0	0	0	0	0	0	0	0	14.64	7.78	1.09	0	0	0	0	1.24E-11

Uncontrolled Emission Rate (g/s)

Source ID	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CO_2	CH_4	Hg	HCl	CDD/CDF
KINC	2.23E-02	1.76E-02	1.00E-02	0	0	0	0	0	0	0	0	0	0	0	1.05E-01	5.58E-02	7.81E-03	0	0	0	0	8.93E-14
SINC	1.12E-02	8.81E-03	5.02E-03	0	0	0	0	0	0	0	0	0	0	0	5.25E-02	2.79E-02	3.91E-03	0	0	0	0	4.46E-14

Notes:
Emission factor data from Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.

0.033

Cells highlighed gray indicate that emissions of a contaminant are zero.

Emission Factor (mg/m^3)	Tested Emission Rate (mg/m^3) TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CO_2	CH_4	Hg	HCl	CDD/CDF
@ 25 C, 11% O2	20	-	-	0	0	0	0	0	0	0	0	0	0	0	94	50	7	0	0	0	0	8.00E-11
@ 1000 C, 6% O2	3.1	-	-	0	0	0	0	0	0	0	0	0	0	0	14.6	7.8	1.1	0	0	0	0	1.24E-11

Source: Emission data in Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.

Calculating Exhaust Gas Volumetric Flow Rate Based on Mass Flow Rate:

Flue Gas Temperature (°C)	1000	from Eco Waste Solutions Technical Specification sheet
Flue Gas Flow Rate (kg/s) (max)	1.996	from Eco Waste Solutions Technical Specification sheet
Density of air at STP	1.189	Assumed flue gas has similar composition to air
Actual Flue Gas Volumetric Flow Rate (m^3/s)	7.2	at 1000 C and 6% O2

Maximum Bounding Emissions Scenario Backfill Plant Calculation Spreadsheet

Controlled Emission Factor (kg/Mg)

Source ID	Source Description	Process Rate (t/day) or (t/hr)	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CO2	CH4	Hg	HCl	CDD/CDF
BATCH PLANT	Cement Unloading (to Silo)	28	0.0005	1.70E-04	1.70E-04	0	8.38E-07	0	0	3.68E-07	0	8.83E-06	0	0	1.17E-07	1.26E-07	0	0	0	0	0	0	0	0
BATCH PLANT	Uncontrolled Aggregate Transfer	788	0.0035	1.70E-03	0.000257	5.44E-07	3.22E-09	3.37E-08	4.19E-08	4.34E-08	6.69E-09	9.16E-08	3.99E-09	1.05E-07	1.40E-10	1.60E-07	0	0	0	0	0	0	0	0
BATCH PLANT	Unloading to continuous CRF mixer	60	0.0092	2.80E-03	0.000646	0	4.19E-06	0	0	1.91E-07	0	1.64E-06	0	0	5.29E-09	7.11E-07	0	0	0	0	0	0	0	0

Controlled Emission Rate (g/s)

Source ID	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CO2	CH4	Hg	HCl	CDD/CDF
BATCH PLANT	1.61E-04	5.47E-05	5.47E-05	0.0	2.69E-07	0.0	0.0	1.18E-07	0.0	2.84E-06	0.0	0.0	3.76E-08	4.05E-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BATCH PLANT	3.19E-02	1.55E-02	2.35E-03	4.96E-06	2.94E-08	3.07E-07	3.82E-07	3.96E-07	6.09E-08	8.35E-07	3.64E-08	9.62E-07	1.28E-09	1.46E-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BATCH PLANT	1.53E-01	4.67E-02	1.08E-02	0.0	6.98E-05	0.0	0.0	3.18E-06	0.0	2.73E-05	0.0	0.0	8.82E-08	1.19E-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Notes:
Road dust emissions due to the transfer of aggregate have been considered in the haul road emissions calculation Unpaved Road Dust
According to the IFS, Section 6.4.3, cemented rock fill typically has enough strength to support adjacent mining 7-10 days after placement. Therefore, it is unlikely that the batch plant will operate simultaneously with underground mining.
Emission factor source: AP-42 Chapter 11.12 Concrete Batching, June 2006. Assumed $PM_{2.5}$ size fraction for Central Mix is 23% of PM_{10} (based on constants used in Equation 11.12-1 - see table below).

Constant	AP-42 Table 11.12-4 Central Mix SPM	PM_{10}	$PM_{2.5}$
k	0.19	0.13	0.03
a	0.95	0.45	0.45
b	0.9	0.9	0.9
c	0.001	0.001	0.0002

Maximum Bounding Emissions Scenario Acid Plant Calculation Spreadsheet

Emissions scaled based on McClean emissions (stack test for Acid Plant)

	Acid Plant	Stack Emission Rate			Calculated Emission Rate		
		SO_2 (kg/h)	NO_X (kg/h)	CO (kg/h)	SO_2 (g/s)	NO_X (g/s)	CO (g/s)
McClean		5.52	0.05	0.08	1.53	0.0139	0.02

Source: Source Testing of AREVA Resources Canada Inc. McClean Lake, Yellowcake Calciner, Yellowcake Packaging Area, Grinding, Crystallizer and Acid Plant Stacks, SRC Publication No. 10448-29C08, June 2008.
Note: SO_2 emission rate not used. Emission from IFS used instead.

Production of H_2SO_4			
McClean	100.1	tonnes/day	1323.477
Kiggavik	350	tonnes/day	
SO_2 EF	75	g/tonne H_2SO_4	

Source ID	Emission Rate (g/s)															
	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO
ACID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.86E-02	3.04E-01	7.77E-02

Notes:
Cells highlighed gray indicates that emissions of a contaminant are zero.

A.2 Air Emissions Calculation Methods: Decommissioning and Post-Decommissioning

Decommissioning

For the purpose of this assessment, decommissioning activities assessed included backfilling all special waste at Kiggavik and Sissons into the Main Zone TMF and mined-out Andrew Lake pit, respectively. It was conservatively assumed that all material will be a backfilled over a two year period. Therefore, the average amount of special waste moved over a one year period is about 603,500 tonnes at Kiggavik and about 764,400 tonnes at Sissons.

Activities for charging or covering Centre Zone pit with a layer of Type II mine rock were also considered in this assessment. It is anticipated that by the time decommissioning gets underway, Centre Zone TMF will have begun to be charged. For present purposes, it was assumed that half of Centre Zone TMF had already been charged and that the remainder was completed concurrently with backfilling of special waste. The mine rock cover was assumed to originate from the north Type II mine rock pile.

Sources of dust emissions from backfilling special waste and charging Centre Zone TMF include:

- material handling at the stockpiles and at Main Zone TMF, Centre Zone TMF and Andrew Lake open pit;
- unpaved road dust;
- diesel-powered engines;
- dozing within Main Zone TMF, Centre Zone TMF and Andrew Lake; and
- wind erosion of the special waste stockpiles and active working areas within Main Zone, Centre Zone and Andrew Lake.

Emissions from each of the listed activities were calculated used the same methods outlined in Attachment A.1 – On-Site Operations. To backfill special waste into Andrew Lake pit, it was assumed that haul trucks travelled all the way to the bottom of the pit to dump its load rather than dumping it over the edge of the pit.

Radon emissions were also considered during this assessment. Radon was considered to be generated from the following sources:

- handling of Type II and Type II mine rock;
- surface area emissions from permanent clean rock stockpiles;
- surface area emissions from charged TMFs (East Zone and part of Centre Zone); and
- surface area emissions from backfilled Type III mine rock in Main Zone TMF and Andrew Lake pit.

Again, the same methods as outlined in Attachment A.1 were used to calculate radon emissions.

Post-Decommissioning

During the post-decommissioning period, air emissions are assumed to consist of only radon gas released from the surfaces of the Type II (clean) mine rock stockpiles and decommissioned TMFs which are covered with a layer of clean rock and soil. Since the piles will be well compacted, remain largely undisturbed, and the TMFs re-vegetated, dust emissions were not considered. The size of the clean rock piles were reduced to reflect that material had been taken away to cover decommissioned TMFs.

Surface area emissions of radon from the permanent Type II mine rock piles and the decommissioned TMFs were estimated using the methods outlined in Attachment A.1.

Decommissioning Scenario Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			340680 Kiggavik
Month	December		Note: enter full name of month
"Daily" or "Annual" Multiplier Used?	Daily		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	365	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Year - Decomm.			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	0	bcm per year	
Andrew Lake - Total	0	bcm per year	
End Grid - Total	0	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	0	kt per year	
Andrew Lake - Ore	0	kt per year	
End Grid - Ore	0	kt per year	
East Zone - WR Type III	29,500	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	60,500	bcm per year	
Main Zone - WR Type III	133,500	bcm per year	
Andrew Lake - WR Type III	255,500	bcm per year	
End Grid - WR Type III	75	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	264,500	bcm per year	
Main Zone - WR Type II	0	bcm per year	
Andrew Lake - WR Type II	0	bcm per year	
End Grid - WR Type II	0	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	0	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Decomm.			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	218	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	2,404	tonnes/day	
Main Zone - Total	988	tonnes/day	
Andrew Lake - Total	1,890	tonnes/day	
End Grid - Total	204	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	0	tonnes/day	
Andrew Lake - Ore	0	tonnes/day	
End Grid - Ore	0	tonnes/day	
East Zone - WR Type III	218	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	448	tonnes/day	
Main Zone - WR Type III	988	tonnes/day	
Andrew Lake - WR Type III	1,890	tonnes/day	
End Grid - WR Type III	204	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	1,957	tonnes/day	
Main Zone - WR Type II	0	tonnes/day	
Andrew Lake - WR Type II	0	tonnes/day	
End Grid - WR Type II	0	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	0	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	2	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	3	trips per day	
Clean Waste	14	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	0	trips per day	
Special Waste	7	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Andrew Lake			
Ore	0	trips per day	
Special Waste	14	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	0	trips per day	
Special Waste	1	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	

Decommissioning Scenario Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road

Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	1	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	70	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	25	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	10	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	43	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	1	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	11	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	19.6	km	IFS Section 6.6, April 2011
Vehicle speed	60	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	0	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	0	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe — Calculation Method: Mobile 6C

Variable	Assumed Value	Units	Comments
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions — Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling — Calculation Method: AP-42 Table 11.9-4, October 1998

Variable	Assumed Value	Units	Comments
Est. Number of Holes per Day - Open Pits	150	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	70	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per day - End Grid	200	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's — Calculation Method: AP-42 Table 13.3-1, February 1980

Variable	Assumed Value	Units	Comments
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	15	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	3	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	215	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	300,000	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	75	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	0	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.5	tonnes per blast	Calculated
Average number of blasts per day	0.0000	#	Calculated
Control - End Grid	50%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions — Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing — Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998

Variable	Assumed Value	Units	Comments
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	1	trips per day	Assumption

Wind Erosion — Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Total Air Requirement/Exhaust Flow Rate	285	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	5	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	14.5	m/s	Calculated
Air Exhaust Exit Temperature	2.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator — Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996

Variable	Assumed Value	Units	Comments
Quantity incinerated	109	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	50%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Backfill Aggregate Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	0	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	0	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	0	tonnes per day	Calculated
Max plant capacity	60	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding — Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses

Variable	Assumed Value	Units	Comments
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Maximum Daily Production	350	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Mill feed	0	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	0.000%	%	from "AnnualSched_Apr2011" tab
Plant availability	85%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	0	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	0	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	0	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	0	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Max theoretical U production	4,000	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	537	kg U/hour	Calculated based on plant availability and operating 24 hours per day

Power Plant — Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Kiggavik			
Max number of generators operating simultaneously	4	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	1	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

Post-Decommissioning Scenario Variables and Assumptions Spreadsheet

Summary of Variables Used for Emission Estimates on Worksheets			**340680 Kiggavik**
Month	**December**	**Note:** enter full name of month	
"Daily" or "Annual" Multiplier Used?	**Daily**		
Material Handling	Calculation Method: Drop Equation AP-42 13.2.4, November 2006		
Variable	**Assumed Value**	**Units**	**Comments**
Operation days per month - January to March	12	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per month - April to December	30	days per month	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Operation days per year	306	days per year	Calculated
Operation hours per day	24	hours per day	Assumption
Conversion factor bcm to tonnes - waste rock	2.7	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - overburden	1.65	tonnes/bcm	Midpoint of dry bulk density as outlined in the IFS rounded to 1.65
Conversion factor bcm to tonnes - ore - East Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Centre Zone	2.36	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Main Zone	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - Andrew Lake	2.35	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Conversion factor bcm to tonnes - ore - End Grid	2.40	tonnes/bcm	KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, SenesRequest3
Variable	**Assumed Value**	**Units**	**Comments**
Maximum Excavated per Year - Post-Decomm.			from "AnnualSched_Apr2011" tab
East Zone - Total	0	bcm per year	Note: rock types will not add up to total due to rounding
PB Pit - Total	0	bcm per year	
Centre Zone - Total	0	bcm per year	
Main Zone - Total	0	bcm per year	
Andrew Lake - Total	0	bcm per year	
End Grid - Total	0	bcm per year	
East Zone - Ore	0	kt per year	
PB Pit - Ore	0	kt per year	
Centre Zone - Ore	0	kt per year	
Main Zone - Ore	0	kt per year	
Andrew Lake - Ore	0	kt per year	
End Grid - Ore	0	kt per year	
East Zone - WR Type III	0	bcm per year	Special waste
PB Pit - WR Type III	0	bcm per year	
Centre Zone - WR Type III	0	bcm per year	
Main Zone - WR Type III	0	bcm per year	
Andrew Lake - WR Type III	0	bcm per year	
End Grid - WR Type III	0	kt per year	
East Zone - WR Type II	0	bcm per year	Clean waste
PB Pit - WR Type II	0	bcm per year	Assume all of PB is clean
Centre Zone - WR Type II	0	bcm per year	
Main Zone - WR Type II	0	bcm per year	
Andrew Lake - WR Type II	0	bcm per year	
End Grid - WR Type II	0	kt per year	
East Zone - OV	0	bcm per year	Overburden
PB Pit - OV	0	bcm per year	
Centre Zone - OV	0	bcm per year	
Main Zone - OV	0	bcm per year	
Andrew Lake - OV	0	bcm per year	
End Grid - OV	0	kt per year	
Maximum Excavated per Day - tonnes - Post-Decomm.			Note: values have been rounded up to either nearest 10, 100 or 1000 as applicable
East Zone - Total	0	tonnes/day	
PB Pit - Total	0	tonnes/day	
Centre Zone - Total	0	tonnes/day	
Main Zone - Total	0	tonnes/day	
Andrew Lake - Total	0	tonnes/day	
End Grid - Total	0	tonnes/day	
East Zone - Ore	0	tonnes/day	
PB Pit - Ore	0	tonnes/day	
Centre Zone - Ore	0	tonnes/day	
Main Zone - Ore	0	tonnes/day	
Andrew Lake - Ore	0	tonnes/day	
End Grid - Ore	0	tonnes/day	
East Zone - WR Type III	0	tonnes/day	Special waste
PB Pit - WR Type III	0	tonnes/day	
Centre Zone - WR Type III	0	tonnes/day	
Main Zone - WR Type III	0	tonnes/day	
Andrew Lake - WR Type III	0	tonnes/day	
End Grid - WR Type III	0	tonnes/day	
East Zone - WR Type II	0	tonnes/day	Clean waste
PB Pit - WR Type II	0	tonnes/day	
Centre Zone - WR Type II	0	tonnes/day	
Main Zone - WR Type II	0	tonnes/day	
Andrew Lake - WR Type II	0	tonnes/day	
End Grid - WR Type II	0	tonnes/day	
East Zone - OV	0	tonnes/day	Overburden
PB Pit - OV	0	tonnes/day	
Centre Zone - OV	0	tonnes/day	
Main Zone - OV	0	tonnes/day	
Andrew Lake - OV	0	tonnes/day	
End Grid - OV	0	tonnes/day	
Moisture Content of extracted material	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid-west in North
Moisture Content of clean fill	-	%	
Wind Speed		m/s	Average wind speeds at the Kiggavik site from CALMET
January	4.94	m/s	
February	3.45	m/s	
March	4.43	m/s	
April	4.23	m/s	
May	4.14	m/s	
June	3.50	m/s	
July	3.37	m/s	
August	3.44	m/s	
September	4.85	m/s	
October	3.99	m/s	
November	4.24	m/s	
December	5.10	m/s	
Control Efficiency	0%	%	Assumed no control for dumping of excavated material
On-site Truck Characteristics			
Variable	**Assumed Value**	**Units**	**Comments**
Waste Truck Capacity	140	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Truck Capacity	90	tonnes	IFS, Section 6.2.1.2, Figure 6.2-3 April 2011
Ore Trailer Capacity	140	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Empty average waste truck vehicle weight	100	tonnes	CAT785C (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of waste truck	240	tonnes	Calculated
Loaded / Empty average waste truck vehicle weight on haul road	170	tonnes	Based on 100 tonnes empty and 250 tonnes when loaded (100+250)/2=175
Empty average ore truck vehicle weight	70	tonnes	CAT777F (equipment provided in KiggavikProject_HLDC_June30_ToSenes_RevAug11.xls, Basic
Loaded weight of ore truck	160	tonnes	Calculated
Loaded / Empty average ore truck vehicle weight on haul road	115	tonnes	Average of loaded and empty weight
Ore-trailers used between Kiggavik and Sissons			
Empty average vehicle weight	110	tonnes	Calculated
Loaded weight of vehicle	250	tonnes	IFS Section 6.6, April 2011. Based on CAT 785C type trucks.
Loaded / Empty average vehicle weight on haul road	180	tonnes	Average of loaded and empty weight
Standard tractor-trailers used on access road (from Baker Lake to Kiggavik)			
Empty average vehicle weight	20	tonnes	From Kiggavik Screening Level Assessment (SENES 2008)
Loaded weight of vehicle	60	tonnes	Information provided by AREVA October 21, 2010
Loaded / Empty average vehicle weight	40	tonnes	Average of loaded and empty weight
Underground Trucks Hauling Ore from End Grid			
Underground Trucks Capacity	45	tonnes	CAT AD45B (45-tonne underground truck)
Empty average vehicle weight	40	tonnes	CAT AD45B (45-tonne underground truck)
Loaded weight of vehicle	85	tonnes	CAT AD45B (45-tonne underground truck)
Loaded / Empty average vehicle weight on haul road	63	tonnes	Average of loaded and empty weight
Explosive trucks			
Empty average vehicle weight	13	tonnes	Peterbilt 367 (equipment provided in AREVA memo October 21, 2010)
Loaded weight of vehicle	26	tonnes	Assumed
Loaded / Empty average vehicle weight	20	tonnes	Average of loaded and empty weight
Number of trips for explosives	6	trips per day	Calculated
Yellowcake transport trucks			Aassumed same as tractor-trailers from Baker Lake to Kiggavik
Loaded / Empty average vehicle weight	60	tonnes	Information provided by AREVA October 21, 2010
Number of trips	1	trip per day	Assumed: according to 34680-2, the total annual trips required for yellowcake are 96 trips per year; also AREVA memo dated October 21, 2010 stated frequency of yellowcake transportation flights of 336 flights/year; therefore 1 trip/day should be conservative.
Vehicle Speed	70	kph	Assumed same as tractor-trailers from Baker Lake to Kiggavik
Water truck			
Loaded / Empty average vehicle weight	24	tonnes	Assumed: based on GVW 35,000 lbs for Peterbilt 348, http://www.peterbilt.com/voc348.1.aspx
Number of trips	1	trip per day	Assumed - 1 water truck; 1 trip per day
In-pit truck trips per day (one way)			
East Zone			Calculated based on quantities excavated and truck capacities above
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Centre Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Purpose-built Pit			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Main Zone			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
Andrew Lake			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	
End Grid			
Ore	0	trips per day	
Special Waste	0	trips per day	
Clean Waste	0	trips per day	
Overburden	0	trips per day	

Post-Decommissioning Scenario Variables and Assumptions Spreadsheet, continued

Access Road and Haul Road

Access Road from Baker Lake to Kiggavik			
Length of road to be included in modelling	0	km	Only 1km stretch is included in the assessment of impact of access road on Kiggavik site.
Vehicle speed - All Weather Road	0	km/h	IFS Section 12.5.3.1, April 2011
Vehicle speed - Winter Road	0	km/h	IFS Section 12.5.2.6, April 2011
Traffic volume - All Weather Road	0	trips/day	IFS Section 12.5.3.1, April 2011 - All weather road must be capable of handling 3625 vehicles (plue return trips) per year
Traffic volume - Winter Road	0	trips/day	Project Description (AREVA 2008)
Access Road Modelled Scenario			
Length of road	0	km	Only modelling 1 km stretch for Scenarios and worst case.
Traffic volume	0	trips per day	IFS Section 12.5.2.6, April 2011 - the total annual trips are 3920 per year which equals an average of 11 trips per day, including fuel and dry goods, etc.
Worst Case Scenario - Vehicle speed	70	km/h	Assume the same speed as the All Weather Road
Haul Road between Kiggavik and Sissons			
Length of road	0.0	km	IFS Section 6.6, April 2011
Vehicle speed	0	km/h	IFS Section 6.6, April 2011
Traffic volume from AL ore	0	trips per day	Calculated based on total quantities of ore from Andrew Lake and capacity of ore trailers
Traffic volume from EG ore	0	trips per day	Calculated based on total quantities of ore from End Grid and capacity of ore trailers

On-Road Vehicles Tailpipe

Calculation Method: Mobile 6C

Variable	Assumed Value	Units	Comments
Trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks - HDDV8b Emission factors were used

Unpaved Road Emissions

Calculation Method: Unpaved Road Emissions, AP-42 5th Edition, 13.2.2, 1/95

Variable	Assumed Value	Units	Comments
On-site haul trucks (gravel roads) - Silt %	5	(%)	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
On-site haul trucks - vehicle speed	20	kph	Assumption
Control Efficiency for On-site Vehicles with Speed < 40 kph	44%	(%)	WRAP Fugitive Dust Handbook, September 2006, control efficiency due to speed limit of 25
On-site haul trucks - Control Efficiency - Summer	75%	(%)	Assumed 75% control for watering road in summer when necessary
On-site haul trucks - Control Efficiency - Winter	50%	(%)	Assumed 50% control in winter due to frozen surface
number of days in a year with at least 0.254 mm of precipitation	111	(days)	From: Canadian Climate Normals Mean number of days with 0.254 mm (0.01 inch) or more of precipitation in Baker Lake

Drilling

Calculation Method: AP-42 Table 11.9-4, October 1998

Variable	Assumed Value	Units	Comments
Est. Number of Holes per Day - Open Pits	0	holes per day	Calculated based on amt. of ANFO used per week ÷ max charge weight per hole
Max Number of Holes per blast - End Grid	0	holes per blast	IFS, Section 6.4.8 Drilling and Blasting, April 2011
Amount of blasted material per day - End Grid	0	tonnes per blast	Based on 5 m by 5 m blast face with holes about 4 m deep and Golder drilling and blasting report (Golder Associates 2011)

Rock Blasting Volume Calc's

Calculation Method: AP-42 Table 13.3-1, February 1980

Variable	Assumed Value	Units	Comments
Blasting Material	Emulsion/ANFO	-	Will use either a 70/30 Emulsion/ANFO blend or 100% ANFO. No emission factors available for ANFO.
Duration of Emissions	0	minutes	Assumed contaminants from explosives detonation are emitted to atmosphere over 15 min
Open Pits			
Max Number of Blasts per Week	0	#	IFS, Section 6.2.1.4, April 2011
Max charge weight per hole	0	kg	Table 15 of Golder drilling and blasting report (Golder Associates 2011)
ANFO Explosives Powder Factor - Open Pits	0.25	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Max amount of rock to be blasted - Open Pits	0	tonnes per blast	IFS, Section 6.2.1.4, April 2011
Total Amount of ANFO required per blast - Open Pits	0	tonnes per blast	Calculated
End Grid Underground Mine			
ANFO Explosives Powder Factor - End Grid	2.5	kg ANFO/tonne of rock	IFS, Section 6.2.1.4, April 2011
Amount of rock to be blasted per day - End Grid	0	tonnes per day	Calculated. Used average denisty of waste rock and ore.
Total Amount of ANFO required per blast - End Grid	0.0	tonnes per blast	Calculated
Average number of blasts per day	0	#	Calculated
Control - End Grid	0%	%	Assumed that 50% of dust will be retained in the mine due to deposition

NonRoad Equipment Tailpipe Emissions

Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Equipment hp ratings	various	hp	Actual horsepower ratings from equipment brochures, etc.
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Crankcase Emission Factors for Nonroad Engine Modeling - Compression-
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated

Grading and Dozing

Calculation Method: Western Surface Coal Mining - Bulldozing AP-42 Table 11.9-2, October 1998

Variable	Assumed Value	Units	Comments
Material Moisture Content (%)	3%	%	Assumption: 2.5% was used for Red Dog in Alaska; 3% was used for Mid West in northern
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008); average for Red
Dozer Operating Hours per Day	20	hours per day	Assumption: Red Dog used 20 hours per day
Bulldozer Operating Frequency	40%	%	Assumption: same as Red Dog, % of time dozer operates for each operating hour
Control Efficiency based on watering	0%	%	Assumption: watering is unlikely
Mean vehicle speed for Graders	8.0	kph	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)
Number of trips per day - Graders	0	trips per day	Assumption

Wind Erosion

Calculation Method: AWMA Air Pollution Engineering Manual, 1992, page 137

Variable	Assumed Value	Units	Comments
Maximum Height of Permanent Clean Rock Stockpiles	50	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Maximum Height of Ore and Temporary Waste Rock Stockpiles	10	m	AREVA e-mail dated June 30, 2010. Based on total amount of material put into stockpiles.
Material Silt Content (%)	5%	%	Assumption: used in the Kiggavik Screening Level Assessment (SENES 2008)

End grid Underground Mine

Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Total Air Requirement/Exhaust Flow Rate	0	m^3/s	IFS, Section 6.4.10, April 2011
Air Exhaust Diameter	0	m	IFS, Section 6.4.10, April 2011
Air Exhaust Exit Velocity	0.0	m/s	Calculated
Air Exhaust Exit Temperature	0.0	degrees C	IFS, Section 6.4.10, April 2011

Incinerator

Calculation Method: Refuse Combustion - AP-42 Chapter 2.1, October 1996

Variable	Assumed Value	Units	Comments
Quantity incinerated	0	kg/h	Based on charge rate of 1750 kg/cycle and a total cycle time of 10-hour burn plus 6-hour cool down. (Eco Waste Solutions Incinerator Model No. ECO 1.75TN 1P MS 60L Technical Specification sheet, provided as part of AREVA memo dated October 21, 2010.)
Capacity of Incinerator at Sissons vs. Kiggavik	0%	%	Assumed: the Sissons incinerator will be significantly smaller than the Kiggavik incinerator (AREVA 2010, memorandum)
Type of control equipment	none	-	

Backfill Plant

Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Backfill Aggregate Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Aggregate Quantity	0	tonnes per day	Calculated
Backfill Aggregate Transfer - Number of Trips from Kiggavik	0	trips per day	Assuming aggregate is preferentially transferred from Kiggavik using ore trailer trucks as per
Backfill Aggregate Transfer - Number of Trips from End Grid	0	trips per day	According to IFS, Section 6.4.6, End Grid only provides a fraction of aggregate, therefore, it was assumed that main sources is Kiggavik clean rock.
Backfill Cement Quantity	0	tonnes per year	from "AnnualSched_Apr2011" tab
Backfill Cement Quantity	0	tonnes per day	Calculated
Max plant capacity	0	tonnes per hour	IFS, Section 6.4.6, April 2011

Ore Crushing and Grinding

Calculation Method: MOE Procedure Document Table C-2, Approximating Particulate Emissions from Baghouses

Variable	Assumed Value	Units	Comments
	-		Assumed a similar design to McClean - use stack testing to scale emissions based on U

Acid Plant

Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Maximum Daily Production	0	tonnes H_2SO_4 per day	IFS, Section 8.4.11.1, April 2011. Peak daily production capacity is 310t/day, but used 350 t per day to be conservative.
SO_2 Emission Factor	75	g per tonne of H_2SO_4	IFS, Section 8.4.11.1, April 2011. Based on acid plant design.

Mill

Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Mill feed	0	kt ore per year	from "AnnualSched_Apr2011" tab
U Grade	0%	%	from "AnnualSched_Apr2011" tab
Plant availability	0%	%	from KiggavikProject_HLDC_June30_ToSENES_RevAug11.xls
Mill feed per day	0	tonnes ore per day	Calculated based on plant availability and operating 365 days per year
Ore Stockpile	0	Kt ore	from "AnnualSched_Apr2011" tab
Tonnes U produced	0	T U per year	from "AnnualSched_Apr2011" tab
Hourly Uranium Production	0	kg U/hour	Calculated based on plant availability and operating 24 hours per day
Max theoretical U production	0	T U per year	AREVA e-mail dated May 20, 2011
Max Hourly Uranium Production	0	kg U/hour	Calculated based on plant availability and operating 24 hours per day

Power Plant

Calculation Method: Engineering Calculations

Variable	Assumed Value	Units	Comments
Kiggavik			
Max number of generators operating simultaneously	0	#	IFS, Section 11.1.1, Table 11.1-1, April 2011
Unit Capacity	4190	kW	IFS, Section 11.1.1, Table 11.1-1, April 2011
Annual power consumption	155,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Sissons			
Max number of generators operating simultaneously	0	#	According to the IFS Section 11.1.1, there will be 3 small 1450 kW units at Sissons; however, one large 4190 kW unit was considered to simplify modelling.
Unit Capacity	4190	kW	
Annual Power consumption at Sissons	23,000,000	kWh/year	SupplementalData_Kissavik&SissonsLayouts_ToSenes_Nov3.pdf page 3
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Assume using same diesel fuel for power plant as vehicles. Canada-wide diesel fuel sulphur content as of 2010
Episodic (local) Diesel Fuel Sulphur Content	0.0015	%	Calculated
Diesel High Heating Value	19,300	Btu/lb	AP-42 Chapter 3.3 - Gasoline and Diesel Industrial Engines (10/96), Table 3.3-1

RADON

Variable	Assumed Value	Units	Comments
Unfrozen emanation factor	0.02	-	SENES memoradum to AREVA dated July 15, 2011
Frozen conditions emanation factor	0.002	-	SENES memoradum to AREVA dated July 15, 2011
Radon penetration of soil cover	50%	%	Figure 8-2 of the document: US EPA, 1983. Final Impact Statement for Standards for the Control of Byproduct Materials from Uranium Ore Processing (40 CFR 192). Volume 1. Office of Radiation Programs, Washington DC. Assumes a min. soil thickness of 1 m and type A soil to be conservative.

A.3 Air Emissions Calculation Methods: Access Roads

Like the mine site roads and haul road between Kiggavik and Sissons, air emissions from the Access Roads include vehicle exhaust (i.e., NO_x, SO_2 and CO) and re-suspended road dust; however, road dust is only generated from sections of roadway constructed with quarried granular fill. As a result, dust emissions were only calculated for the All-Season Access Road and the portions of the winter road options that were constructed with fill. For this assessment, it was assumed that 50% of the winter road over-land crossings were constructed with granular fill. A 50% reduction for frozen conditions during the winter months was also applied.

Since the Access Roads are not travelled often, there is sufficient time between the passing of vehicles to allow wind erosion to occur. For a roadway with higher traffic volumes, such as the mine site roads, emissions are predominately generated by the vehicles themselves. Since this is not the case for Access Roads, wind erosion emissions were considered in this assessment. Again, wind erosion is only applicable to road sections constructed with granular fill. It was also assumed that frozen conditions would prevent any wind erosion during the winter months (October to May).

Additional parameters and assumptions used for assessing the Access Road Options are provided below. Excerpts from the emissions calculation spreadsheets are also provided at the end of this section. Note that total emissions were averaged over the entire length of the roadway.

Preferred Option: Winter Road

As inferred by the name, the Winter Road Option would be used to transport fuel and other supplies during the winter months when frozen water bodies and ice pads can be utilized. The operating window for the Kiggavik Project is 110 days; however, 90 days was used as a conservative measure (i.e. use of a shorter operating window results in higher daily traffic volumes and higher daily emission rates). Other parameters used for the winter road options are presented in Table A-9 below. Information was obtained from the Project Description (Volume 2) and refined for the specific options with information from AREVA (AREVA 2011).

Table A-9 Winter Access Road Parameters

Parameter	Units	North Winter Route	South Winter Route
Length of road	km	216	100
Over-land crossing[(a)]	km	131	50
Speed	km/h	25	25
Operating window	days	90	90
Loads (one-way)	loads per year	3,920	3,920
Traffic (one-way)	vehicles per day	43	43
Daily operation	hours	24	24

Notes:

Assumes that 50% of over-land crossings are constructed using granular fill

All-Season Access Road

As an alternative to the Winter Road Option, an All-Season Road Option presented by AREVA was also assessed. This road will be constructed using granular fill excavated from bedrock quarries located along the route. Table A-10 summarizes the parameters and/or assumptions used in assessing the All-Season Road Option.

Table A-10 All-Season Access Road Parameters

Parameter	Units	All-Season Road
Length of road	km	114
Speed	km/h	80
Operating window	days	310
Loads (one-way)	load per year	3,625
Traffic (one-way)	vehicles per day	11
Daily operation	hours	24

Access Roads Assessment Inputs Spreadsheet

Source ID	Pit Ramps and Unpaved Roads	s (%)	One-way Trips per Day - OR	One-way Trips per Day - SW	One-way Trips per Day - CW	One-way Trips per Day - OVB	One-way Trips per Day - Other	One-way Trips per Day - Water Truck	Total # of One-way Trips per day	Average Weight - Ore Truck (tonnes)	Average Weight - Waste Trucks (tonnes)	Average Weight - Water Trucks (tonnes)	Average Weight - Other (tonnes)	Weighted Average W (tonnes)	Road length[1] (km)	Vehicle Speed (km/h)	Control Efficiency - Summer (%) (Watering)	Control Efficiency - Winter (%) (Frozen Surface)	Control Efficiency for Speed <40 km/h
NAS	North All Season Access Road - 100% granular fill	5.0	0	0	0	0	10	0	10	115	170	24	40	40	112.1	80	0%	50%	0%
SWR	South Winter Road Option - over land 50% fill	5.0	0	0	0	0	43	0	43	115	170	24	40	40	27.3	25	0%	50%	44%
SWR	South Winter Road Option - over land no fill	2.5	0	0	0	0	43	0	43	115	170	24	40	40	27.3	25	0%	50%	44%
SWR	South Winter Road Option - over ice	0.0	0	0	0	0	43	0	43	115	170	24	40	40	50.1	25	0%	0%	44%
NWR	North Winter Road Option - over land 50% fill	5.0	0	0	0	0	43	0	43	115	170	24	40	40	65.7	25	0%	50%	44%
NWR	North Winter Road Option - over land no fill	2.5	0	0	0	0	43	0	43	115	170	24	40	40	65.7	25	0%	50%	44%
NWR	North Winter Road Option - over ice	0.0	0	0	0	0	43	0	43	115	170	24	40	40	84.4	25	0%	0%	44%

Always zero. Do not change.

Notes:

[1] Road lengths can be found in the following Excel file: ..\..\340680-1 IFS Revised site layout April2011\340680-1 Road Links_Site roads_RevB 31May2011.xlsx

Water trucks assumed to pass over any road or pit ramp/floor during the summer months only. Water trucks will not pass over piles or pit floors.

Access Roads Assessment On-Road Tailpipe Calculation Spreadsheet

Source ID	Unpaved Road	One-way road length (km)	One-way Trips per day	Vehicle Speed (km/h)	SPM (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	Uranium (g/s)	As (g/s)	Co (g/s)	Cu (g/s)	Pb (g/s)	Mo (g/s)	Ni (g/s)	Se (g/s)	Zn (g/s)	Cd (g/s)	Cr (g/s)	NOx (g/s)	SO_2 (g/s)	CO (g/s)
NAS	North All Season Access Road - 100% granular fill	112.1	10	80	3.08E-03	3.08E-03	2.50E-03	0	0	0	0	0	0	0	0	0	0	0	1.08E-01	5.23E-03	1.79E-02
SWR	South Winter Road Option - over land 50% fill	27.3	43	25	3.23E-03	3.23E-03	2.62E-03	0	0	0	0	0	0	0	0	0	0	0	1.01E-01	5.49E-03	3.08E-02
SWR	South Winter Road Option - over land no fill	27.3	43	25	3.23E-03	3.23E-03	2.62E-03	0	0	0	0	0	0	0	0	0	0	0	1.01E-01	5.49E-03	3.08E-02
SWR	South Winter Road Option - over ice	50.1	43	25	5.93E-03	5.93E-03	4.80E-03	0	0	0	0	0	0	0	0	0	0	0	1.85E-01	1.01E-02	5.65E-02
NWR	North Winter Road Option - over land 50% fill	65.7	43	25	7.77E-03	7.77E-03	6.29E-03	0	0	0	0	0	0	0	0	0	0	0	2.42E-01	1.32E-02	7.41E-02
NWR	North Winter Road Option - over land no fill	65.7	43	25	7.77E-03	7.77E-03	6.29E-03	0	0	0	0	0	0	0	0	0	0	0	2.42E-01	1.32E-02	7.41E-02
NWR	North Winter Road Option - over ice	84.4	43	25	9.98E-03	9.98E-03	8.08E-03	0	0	0	0	0	0	0	0	0	0	0	3.11E-01	1.69E-02	9.51E-02
Note:					4.10E-02																

Cells highlighed gray indicates that emissions of a contaminant are zero.

Mobile 6C Emission Factors - Year 2009 - Units g/VKT						
Vehicle Type	SPM	PM_{10}	$PM_{2.5}$	NO_x	SO_2*	CO
HD Diesel 40 km/hr	0.119	0.119	0.096	3.699	0.202	1.133
HD Diesel 50 km/hr	0.119	0.119	0.096	3.530	0.202	0.902
HD Diesel 60 km/hr	0.119	0.119	0.096	3.551	0.202	0.771
HD Diesel 70 km/hr	0.119	0.119	0.096	3.757	0.202	0.705
HD Diesel 80 km/hr	0.119	0.119	0.096	4.176	0.202	0.689

Notes:

Emission Factors obtained from the Mobile6C model for the Toronto Metropolitan area, for calendar year 2009, except for SO_2* which are for 2006.

..\Supplemental Info for Calcs\Mobile6C EF Results from Markham Bypass.xls

Access Roads Assessment Unpaved Road Dust (winter) Calculation Spreadsheet

Source ID	Unpaved Road	s (%)	S - mean vehicle speed (kph)	W (tonnes)	Annual EF	Emission Factor in g/VKT			Total # of One-way Trips per day	One way length (km)	Roundtrip VKT per day	Uncontrolled Emissions (g/s)				Control Efficiency (%)	Control Efficiency (%) (Speed Limit)
					SPM	SPM	PM_{10}	$PM_{2.5}$				Annual SPM	SPM	PM_{10}	$PM_{2.5}$		
NAS	North All Season Access Road - 100% granular fill	5.0	80	40	1746	2509	645	64	10	112.12	2242	4.53E+01	6.51E+01	1.67E+01	1.67E+00	50%	0%
SWR	fill	5.0	25	40	1746	2509	645	64	43	27.34	2351	4.75E+01	6.83E+01	1.75E+01	1.75E+00	50%	44%
SWR	South Winter Road Option - over land no fill	2.5	25	40	1075	1544	345	35	43	27.34	2351	2.92E+01	4.20E+01	9.40E+00	9.40E-01	50%	44%
SWR	South Winter Road Option - over ice	0.0	25	40	0	0	0	0	43	50.11	4310	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%	44%
NWR	North Winter Road Option - over land 50%	5.0	25	40	1746	2509	645	64	43	65.71	5651	1.14E+02	1.64E+02	4.22E+01	4.22E+00	50%	44%
NWR	North Winter Road Option - over land no fill	2.5	25	40	1075	1544	345	35	43	65.71	5651	7.03E+01	1.01E+02	2.26E+01	2.26E+00	50%	44%
NWR	North Winter Road Option - over ice	0.0	25	40	0	0	0	0	43	84.35	7254	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0%	44%

Source ID	Unpaved Road	Metal Fraction (%)										
		Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
NAS	North All Season Access Road - 100% granular fill	8.40E-05	1.32E-04	5.79E-04	1.22E-03	9.36E-04	3.60E-05	1.04E-03	1.51E-04	3.02E-03	4.00E-06	#######
SWR	fill	8.40E-05	1.32E-04	5.79E-04	1.22E-03	9.36E-04	3.60E-05	1.04E-03	1.51E-04	3.02E-03	4.00E-06	#######
SWR	South Winter Road Option - over land no fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
SWR	South Winter Road Option - over ice	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
NWR	North Winter Road Option - over land 50%	8.40E-05	1.32E-04	5.79E-04	1.22E-03	9.36E-04	3.60E-05	1.04E-03	1.51E-04	3.02E-03	4.00E-06	#######
NWR	North Winter Road Option - over land no fill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######
NWR	North Winter Road Option - over ice	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	#######	#######	#######	#######	#######	#######

Source ID	Unpaved Road	Controlled Emissions (g/s)														
		Annual SPM	SPM	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
NAS	North All Season Access Road - 100% granular fill	2.27E+01	3.26E+01	8.36E+00	8.36E-01	2.73E-05	4.30E-05	1.88E-04	3.97E-04	3.05E-04	1.17E-05	3.39E-04	4.92E-05	9.83E-04	1.30E-06	####
SWR	fill	1.33E+01	1.91E+01	4.91E+00	4.91E-01	1.61E-05	2.52E-05	1.11E-04	2.33E-04	1.79E-04	6.88E-06	1.99E-04	2.89E-05	5.77E-04	7.65E-07	####
SWR	South Winter Road Option - over land no fill	8.19E+00	1.18E+01	2.63E+00	2.63E-01	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	####
SWR	South Winter Road Option - over ice	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	####
NWR	North Winter Road Option - over land 50%	3.20E+01	4.59E+01	1.18E+01	1.18E+00	3.86E-05	6.06E-05	2.66E-04	5.61E-04	4.30E-04	1.65E-05	4.78E-04	6.94E-05	1.39E-03	1.84E-06	####
NWR	North Winter Road Option - over land no fill	1.97E+01	2.83E+01	6.33E+00	6.33E-01	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	####
NWR	North Winter Road Option - over ice	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	#######	0.00E+00	#######	#######	#######	#######	#######	#######	####

1.38E+02

Emission Factor Equation	Reference
$E_{unpaved} = k \times (s/12)^a \times (W/3)^b$	AP-42 13.2.2-4, November 2006

E = size speific emission factor (lb/VMT)
s = surface materal silt content (%) - equation based on range from 1.8 - 25.2%
W = mean vehicle weight (tons) where 1 tonne = 1.1 tons
1 lb/VMT = 281.9 g/VKT

Constant	Industrial Roads		
	SPM	PM_{10}	$PM_{2.5}$
k	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

SILT CONTENT (%)	Location	Low	High	Average
construction sites	scraper routes	0.6	23.0	8.5
sand and gravel processing	plant road	4.1	6.0	4.8
western surface coal mining	plant road	4.9	5.3	5.1
western surface coal mining	haul road to/from pit	2.8	18.0	8.4

Access Roads Assessment Wind Erosion (winter) Calculation Spreadsheet

Source ID	Wind Erosion Source	Active or Inactive?	s %	Base Length (m)	Base Width (m)	Height of Pile (m)	Occupied Area (ha)	Surface Area (ha)	Active Surface Area (ha)[1]	E (kg/ha/day)			Uncontrolled (g/s)			Assumed Control Efficiency (%)[2]
										TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	
NAS	North All Season Access Road	Active	5	n/a	n/a	n/a	112	112	112	19.749	9.875	3.950	25.63	12.81	5.13	100%

Source ID	Metal %										
	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
NAS	8.40E-05	1.32E-04	5.79E-04	1.22E-03	9.36E-04	3.60E-05	1.04E-03	1.51E-04	3.02E-03	4.00E-06	0.00E+00

Source ID	Controlled Emission Rate (g/s)													
	TSP	PM_{10}	$PM_{2.5}$	Uranium	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr
NAS	0.00000	0.00000	0.00000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] Active area for pits was assumed to be 100 metres by 100 meters. Active area for stock piles was assumed to be 10% of total area or 100 metres by 100 metres, whichever is larger.
[2] Assume wind erosion only occurs from All Season Road during the summer months (JJAS)

Equation	Reference
$E = k*1.9 *(s/1.5) * f/15$	AWMA - Air Pollution Engineering Manual, 1992, page 137

E = emission factor (kg/ha/day)
k = particle size multilier for particulate size range of interest
s = Silt Content in %
f = % of time that the unobstructed wind speed exceeds 5.4 m/s at mean pile height

Parameter	TSP	PM_{10}	$PM_{2.5}$	Reference
k	1.0	0.5	0.2	AWMA - Air Pollution Engineering Manual, 1992, page 137
f	see wind frequency table below - Updated from CALMET runs May 2011.			

Stockpile surface area sample calculation:

Conservatively assume stockpiles acting as a rectangular prism, then
SA = B + Ph = (lw) + 2(l+w)(h)

Where,
B = Base area
P = Perimeter
h = Height of pile

Month	f
January	39
February	20
March	33
April	31
May	22
June	13
July	8
August	21
September	35
October	21
November	34
December	47

A.4 Air Emissions Calculation Methods: Baker Lake Facility

Air emissions were calculated for typical operations at the Baker Lake Facility which consists primarily of unloading and transferring of sea-containers from barges to the shipping yard. Emissions from diesel-powered equipment at the Baker Lake Facility were considered and a list of equipment considered is provided in Table A-11 below.

Table A-11 Baker Lake Facility Equipment List

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)
Mobile Crane	Zoomlion	QUY200	1	343
Shunt / Rigging Truck	Kalmar	Ottawa 4x2	1	160
Container Handler	Kalmar	DCD200-250	1	264
Heavy Lift Truck	Kalmar	DC F280-330	1	260
Reach Stacker	Kamlar	DRF	1	422

Emissions from two (2) manoeuvring 4,500 horsepower tug-barges near the dock were also considered in this assessment. Emissions factors were obtained from the Environment Canada's National Emission Inventory Tool for the Commercial Marine Sector V2.5 which is a database that was used in the baseline assessments for the SENES study "*Canadian Arctic Marine Assessment 2002-2050*" (SENES 2010). The emission factors are summarized in Table A-12 below. Note that a load factor of 10% was applied as per the database tool to represent manoeuvring tug-barges. The sulphur fuel content of marine diesel was assumed to be 1% which is consistent with proposed regulations for 2015.

Table A-12 Tug-Barge Emission Factors

Engine	Fuel Type	Fuel Origin	NO_x	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$
M2	MDO	Dom	18.1	0.297	1.1	0.868	0.833	0.767
M4	MDO	Dom	13.9	0.297	1.1	0.868	0.833	0.767

Source: National Emission Inventory Tool for the Commercial Marine Sector V2.5, prepared for Environment Canada by Levelton Consultants Ltd., March 2008.

Notes:
M2 = propulsion 2-stroke engine
M4 = propulsion 4-stroke engine
MDO = marine diesel fuel
Dom = domestic fuel source

In general, it was conservatively assumed that all equipment including the tug-barges operate simultaneously over a 24 hour period. Excerpts from the emissions calculations spreadsheets are provided at the end of this section.

Baker Lake Facility Assessment Variables and Assumptions Spreadsheet

NonRoad Equipment Tailpipe Emissions	Calculation Method: US EPA Nonroad Equipment		
Variable	**Assumed Value**	**Units**	**Comments**
Equipment hp ratings			
Mobile Crane	343	hp	Zoomlion QUY200
Shunt / Rigging Truck	160	hp	Kalmar Ottawa 4x2
Container Handler	264	hp	Kalmar DCD200-250
Heavy Lift Truck	260	hp	Kalmar DC F280-330
Reach Stacker	422	hp	Kamlar DRF
Idling Tug-Barge	4500	hp	HP rating from IFS Section 12.3.3 - Tug-Barge Fleet
Episodic (local) Diesel Fuel Sulphur Content	15	ppm	Canada-wide off-road diesel fuel sulphur for content as of 2010
	0.0015	%	Calculated
Marine Vessel Diesel Fuel Sulphur Content	1000	ppm	Arctic Marine diesel fuel sulphur for content effective 2015 - personal communication with D. Hrebenyk
	0.1	%	

Baker Lake Facility Assessment Non-Road Equipment Emissions Calculation Spreadsheet

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)	Steady-State Emission Factor (g/hp-hr)				Load Factor % [1]	% Daily Operation [1]	Uncontrolled (g/s)					
					$PM\ EF_{ss}$	$NOx\ EF_{ss}$	$CO\ EF_{ss}$	$HC\ EF_{ss}$			TSP	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Mobile Crane	Zoomlion	QUY200	1	343	0.0092	2.50	0.084	0.1314	10%	100%	0.0001	0.0001	0.0001	0.0238	0.003	0.0008
Shunt / Rigging Truck	Kalmar	Ottawa 4x2	1	160	0.0092	2.50	0.087	0.1314	10%	100%	0.0000	0.0000	0.0000	0.0111	0.003	0.0004
Container Handler	Kalmar	DCD200-250	1	264	0.0092	2.50	0.075	0.1314	10%	100%	0.0001	0.0001	0.0001	0.0183	0.003	0.0006
Heavy Lift Truck	Kalmar	DC F280-330	1	260	0.0092	2.50	0.075	0.1314	10%	100%	0.0001	0.0001	0.0001	0.0181	0.003	0.0005
Reach Stacker	Kamlar	DRF	1	422	0.0092	2.50	0.075	0.1314	10%	100%	0.0001	0.0001	0.0001	0.0293	0.003	0.0009
Total											0.0004	0.0004	0.0004	0.1007	0.0175	0.0032

Notes:

[1] load factor assumed to be 80% and daily operating capacity conservatively assumed to be 100%

Emission factors for non road equipmentwere obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.

- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2 = (BSFC \times 453.6 \times (1 - soxcnv) - HC) \times 0.01 \times soxdsl \times 2$$

where:

soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)

soxdsl is the episodic weight % of sulphur in nonroad diesel fuel

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

Baker Lake Facility Assessment Marine Vessel Emissions Calculation Spreadsheet

Equipment	Number of Units	Power Rating (kW)	Emission Factor (g/kw-hr)						Load Factor % [1]	% Daily Operation[1]	Uncontrolled (g/s)					
			TSP	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2			TSP	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
Idling Tug-Barge	2	3356	0.87	0.83	0.77	18.1	1.1	0.297	10%	100%	0.16	0.16	0.14	3.37	0.21	0.06

Notes:

[1] load factor from Marine Tool Databse v2.5 for tugs at maneuvering speeds. Daily operating capacity conservatively assumed to be 100%

SO2 calculated using the following equation used in the *Canadian Arctic Marine Assessment 2002-2050* (SENES 2010)

$$SO2 = 0.4653(S) + 0.25$$

where:

S = sulphur content of fuel in %

A.5 Air Emissions Calculation Methods: Construction

On-Site Construction

Dust emissions from construction of the each of the mine sites, Kiggavik and Sissons, were estimated using the general US EPA AP-42 emission factor for heavy construction:

TSP = 2.69×10^6 g per ha per month

The total footprint of each of the mine sites was determined from project site drawings provided by AREVA. The total footprint of Kiggavik is about 680 ha and the total footprint of Sissons is about 1,160 ha. It was also assumed that it would take approximately two (2) years to complete construction such that the average monthly construction rate would be 28 ha for the Kiggavik site and 48 ha for the Sissons site.

Emissions from diesel-powered construction equipment were also estimated using US EPA emission factors for non-road equipment (US EPA 2010). A list of equipment considered is provided in

Table A-13. In general, it was assumed that all equipment operates simultaneously at a load of 80% over the entire construction shift. A typical construction shift will be 10 hours per day (AREVA 2011). Excerpts from the emissions calculations spreadsheets are provided at the end of this section.

Access Road Construction: Quarrying

The All-Season Road Option and sections of the Winter Road Option will be constructed with granular fill. Fill will be extracted from bedrock quarries located along the length of each of the options. Each quarry will be developed sequentially as construction progresses and equipment will be moved from one quarry to the next. Assuming similar production rates, emissions from each quarry will be the same; however, in order to capture the effect of terrain on resulting concentrations, three (3) quarries along the All-Season Road Option were selected for assessment: Q2, Q10 and Q18. Quarry Q18 is also the closest to the community of Baker Lake. The location of each of the quarries was provided in Figure 8 in the main report.

Details about quarrying activities were limited, therefore, typical sources of dust from AP-42 Chapter 11.19.2 *Crushed Stone Processing and Pulverized Mineral Processing* (US EPA 2004) were assumed including:

- truck loading of extracted aggregate material;
- unloading of aggregate to the primary crusher;
- primary crushing;
- screening;
- conveyor transfer to a secondary crusher; and
- secondary crushing.

The AP-42 material handling emission factor was used to estimate dust from loading/unloading and conveyor drops. A moisture content of 3% was assumed and the average annual wind speed of 4.1 m/s obtained from CALMET was used. Uncontrolled emission factors for crushing and screening were obtained from AP-42 Table 11.19.2-1 (US EPA 2004). A conservative production rate of 300 tonnes per hour was assumed to occur over a 10 hour working day.

As with all other diesel-powered equipment, exhaust emissions from quarrying machinery, including the crushing and screening plant, were estimated using US EPA non-road emission factors (US EPA 2010). The equipment considered in the quarrying assessment is provided in

Table A-14. Further calculation details are provided in spreadsheet excerpts at the end of this section.

Table A-13 Mine Site Construction Equipment List

Equipment Type	Number of Units	Power Rating[a] (hp)
1604 Crusher Jaw	1	300
1604 Cone Plant	1	300
1604 Screen Plant	1	110
1604 Power Tower	1	200
1604 Stacking Conveyor	1	48
Feeder and Bin wall Conveyor	1	48
Rock truck	6	1450
Art truck	2	1450
Loader 988	1	705
Loader 980	1	705
Loader 966	1	705
Skid Steer 262	1	149
Dozer D8R	2	580
Dozer D6R	1	580
Grader 14	1	299
Excavator 345	2	801
Crane 65t	1	330
Pick up F350 Ambulance	1	359
F350 Crew cab	6	359
Bus 48 passenger	2	359
winch truck	1	586
Scissor deck	1	231
Fuel trailer	1	148
Water truck	1	330
Lub fuel truck	1	148
Fuel truck	1	148
Flat deck truck F550	1	359
RO/RO Truck	1	148
Vac Truck	2	148
Mechanical truck	2	148
Weld Truck	2	148
Tire truck	1	148

Notes:
[a] Power ratings based on either similar equipment that will be used during mining operations or typical equipment used for other mining assessments

Table A-14 Quarry Equipment List

Equipment Type	Quantity	Model	Power Rating[a] (hp)
1604 Crusher Jaw	1	-	300
1604 Cone Plant	1	-	300
1604 Screen Plant	1	-	110
1604 Power Tower (Generator)	1	-	200
1604 Stacking Conveyor	1	-	48
Feeder and Bin wall Conveyor	1	-	48
Waste haul truck	1	Cat 785D	1348
Small wheel loader	2	Cat 992K	801
Excavator 345	1	Terex RH170	2000

Notes:
[a] Power ratings based on either similar equipment that will be used during mining operations or typical equipment used for other mining assessments

Mine Site Construction Assessment Dust Calculation Spreadsheet

Source ID	Unpaved Road	Emission Factor in Mg/ha/month of activity			Total Occupied Area (ha)	Working Area (ha per month)	Working Hours per day	Uncontrolled Emissions (g/s)			Control Efficiency (%)	Controlled Emissions (g/s)		
		SPM	PM_{10}	$PM_{2.5}$				SPM	PM_{10}	$PM_{2.5}$		SPM	PM_{10}	$PM_{2.5}$
Kiggavik	Construction Area of Kiggavik	2.69	2.69	2.69	680	28	10	1.23E+01	1.23E+01	1.23E+01	0%	1.23E+01	1.23E+01	1.23E+01
Sissons	Construction Area of Sissons	2.69	2.69	2.69	1160	48	10	2.09E+01	2.09E+01	2.09E+01	0%	2.09E+01	2.09E+01	2.09E+01

Notes:
Emissions only occur over a 10 hour working day

Emission Factor Equation	Reference
E = 2.69 Mg/ha/month	AP-42 13.2.3, January 1995

Mine Site Construction Assessment Non-Road Equipment Emissions Calculation Spreadsheet

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)	Steady-State Emission Factor (g/hp-hr)				% of Maximum Operating Capacity[1]	% Daily Operation [1]	Uncontrolled (g/s)					
					PM EF_{ss}	NOx EF_{ss}	CO EF_{ss}	HC EF_{ss}			TSP	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
1604 Crusher Jaw	n/a	n/a	1	300	0.0092	2.5	0.084	0.1314	100%	100%	7.67E-04	7.67E-04	7.44E-04	0.2083	0.003	0.0070
1604 Cone Plant	n/a	n/a	1	300	0.0092	2.5	0.084	0.1314	100%	100%	7.67E-04	7.67E-04	7.44E-04	0.2083	0.003	0.0070
1604 Screen Plant	n/a	n/a	1	110	0.0092	2.5	0.087	0.1314	100%	100%	2.81E-04	2.81E-04	2.73E-04	0.0764	0.003	0.0027
On-site																
1604 Power Tower	n/a	n/a	1	200	0.0092	2.5	0.075	0.1314	100%	100%	5.11E-04	5.11E-04	4.96E-04	0.1389	0.003	0.0042
1604 Stacking Conveyor	n/a	n/a	1	48	0.2	4.7279	1.5323	0.2789	100%	100%	2.67E-03	2.67E-03	2.59E-03	0.0630	0.004	0.0204
Feeder and Bin wall Conveyor	n/a	n/a	1	48	0.2	4.7279	1.5323	0.2789	100%	100%	2.67E-03	2.67E-03	2.59E-03	0.0630	0.004	0.0204
Rock truck	n/a	n/a	6	1450	0.0690	2.3920	0.7642	0.2815	100%	100%	1.67E-01	1.67E-01	1.62E-01	5.7807	0.003	1.8468
Art truck	n/a	n/a	2	1450	0.0690	2.3920	0.7642	0.2815	100%	100%	5.56E-02	5.56E-02	5.39E-02	1.9269	0.003	0.6156
Loader 988	n/a	n/a	1	705	0.0092	2.5	0.133	0.1314	100%	100%	1.80E-03	1.80E-03	1.75E-03	0.4898	0.003	0.0261
Loader 980	n/a	n/a	1	705	0.0092	2.5	0.133	0.1314	100%	100%	1.80E-03	1.80E-03	1.75E-03	0.4898	0.003	0.0261
Loader 966	n/a	n/a	1	705	0.0092	2.5	0.133	0.1314	100%	100%	1.80E-03	1.80E-03	1.75E-03	0.4898	0.003	0.0261
Skid Steer 262	n/a	n/a	1	149	0.0092	2.5	0.087	0.1314	100%	100%	3.81E-04	3.81E-04	3.69E-04	0.1035	0.003	0.0036
dozer D8R	n/a	n/a	2	580	0.0092	2.50	0.084	0.1314	100%	100%	2.96E-03	2.96E-03	2.88E-03	0.8056	0.003	0.0271
dozer D6R	n/a	n/a	1	580	0.0092	2.50	0.084	0.1314	100%	100%	1.48E-03	1.48E-03	1.44E-03	0.4028	0.003	0.0135
Grader 14	n/a	n/a	1	299	0.0092	2.5	0.075	0.1314	100%	100%	7.64E-04	7.64E-04	7.41E-04	0.2076	0.003	0.0062
Excavator 345	n/a	n/a	2	801	0.0690	2.3920	0.7642	0.2815	100%	100%	3.07E-02	3.07E-02	2.98E-02	1.0644	0.003	0.3401
Crane 65t	n/a	n/a	1	330	0.0092	2.50	0.084	0.1314	100%	100%	8.43E-04	8.43E-04	8.18E-04	0.2292	0.003	0.0077
Pick up F350 Ambulance	n/a	n/a	1	359	0.0092	2.5	0.084	0.1314	100%	100%	9.18E-04	9.18E-04	8.91E-04	0.2496	0.003	0.0084
F350 Crew cab	n/a	n/a	6	359	0.0092	2.5	0.084	0.1314	80%	42%	1.85E-03	1.85E-03	1.80E-03	0.5031	0.001	0.0169
Bus 48 passenger	n/a	n/a	2	359	0.0092	2.5	0.084	0.1314	80%	42%	6.17E-04	6.17E-04	5.99E-04	0.1677	0.001	0.0056
winch truck	n/a	n/a	1	586	0.0092	2.5	0.084	0.1314	80%	42%	5.03E-04	5.03E-04	4.88E-04	0.1367	0.001	0.0046
Scissor deck	n/a	n/a	1	231	0.0092	2.5	0.075	0.1314	80%	42%	1.98E-04	1.98E-04	1.92E-04	0.0538	0.001	0.0016
fuel trailer	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.001	0.0012
water truck	n/a	n/a	1	330	0.0092	2.50	0.084	0.1314	80%	42%	2.83E-04	2.83E-04	2.75E-04	0.0770	0.001	0.0026
lub fuel truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.001	0.0012
fuel truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.001	0.0012
Flat deck truck F550	n/a	n/a	1	359	0.0092	2.5	0.084	0.1314	80%	42%	3.09E-04	3.09E-04	2.99E-04	0.0839	0.001	0.0028
RO/RO Truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.001	0.0012
Vac Truck	n/a	n/a	2	148	0.0092	2.5	0.087	0.1314	80%	42%	2.53E-04	2.53E-04	2.46E-04	0.0688	0.001	0.0024
Mech truck	n/a	n/a	2	148	0.0092	2.5	0.087	0.1314	80%	42%	2.53E-04	2.53E-04	2.46E-04	0.0688	0.001	0.0024
Weld Truck	n/a	n/a	2	148	0.0092	2.5	0.087	0.1314	80%	42%	2.53E-04	2.53E-04	2.46E-04	0.0688	0.001	0.0024
Tire truck	n/a	n/a	1	148	0.0092	2.5	0.087	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.001	0.0012
										Total	0.279	0.279	0.270	1.44E+01	8.00E-02	3.06E+00
Baker Lake Dock																
Waste Hydraulic Excavator	Terex / O&K	RH 170	1	2032	0.0690	2.392	0.7642	0.2815	80%	42%	1.31E-02	1.31E-02	1.27E-02	0.4537	0.003	0.1449
Large Wheel Loader	Caterpillar	993K	1	801	0.0690	2.392	0.7642	0.2815	80%	42%	5.16E-03	5.16E-03	5.00E-03	0.1788	0.003	0.0571
Motor Grader	Caterpillar	16M	1	299	0.0092	2.50	0.0750	0.1314	80%	42%	2.57E-04	2.57E-04	2.49E-04	0.0698	0.003	0.0021
Large Dozer	Caterpillar	834H	1	580	0.0092	2.50	0.0840	0.1314	80%	42%	4.98E-04	4.98E-04	4.83E-04	0.1353	0.003	0.0045
Mech truck	2.0000	147.5100	1	148	0.0092	2.50	0.0870	0.1314	80%	42%	1.27E-04	1.27E-04	1.23E-04	0.0344	0.003	0.0012
										Total	0.019	0.019126	0.019	8.72E-01	1.75E-02	2.10E-01

Notes:

Cells highlighed gray indicates that emissions of a contaminant are zero.

Emission factors were obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.

- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2 = (BSFC \times 453.6 \times (1 - soxcnv) - HC) \times 0.01 \times soxdsl \times 2$$

where:

soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)

soxdsl is the episodic weight % of sulphur in nonroad diesel fuel

[1] % of maximum operating capacity for open ptis based on manufacturer's brochure or assumption from URBEMIS2007 Model Appendix G for each piece of Equipment (equipment not listed in Appendix G assumed to be "Other General Industrial Equipment").

% daily operation in open pits based on the same document or assumed 100%.

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

Quarry Assessment Material Handling Calculation Spreadsheet

Source ID	Source Description	Material Handling Activity	k SPM	k PM_{10}	k $PM_{2.5}$	M (%)	U (m/s)	Emission Factor in kg/tonne SPM	Emission Factor in kg/tonne PM_{10}	Emission Factor in kg/tonne $PM_{2.5}$	Maximum Tonnes Handled per Hour	Uncontrolled (g/s) SPM	Uncontrolled (g/s) PM_{10}	Uncontrolled (g/s) $PM_{2.5}$	Assumed Control Efficiency (%)	Controlled (g/s) SPM	Controlled (g/s) PM_{10}	Controlled (g/s) $PM_{2.5}$
Q2	Quarry 2	Truck loading	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q2	Quarry 2	Truck unloading to primary crushing plant	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q2	Quarry 2	Conveyor transfer point to screen plant	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	300	2.22E-01	1.05E-01	1.59E-02	0%	2.22E-01	1.05E-01	1.59E-02
Q2	Quarry 2	Conveyor transfer point to secondary crusher	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03
Q2	Quarry 2	Conveyor drop to product truck	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03
Q10	Quarry 10	Truck loading	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q10	Quarry 10	Truck unloading to primary crushing plant	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q10	Quarry 10	Conveyor transfer point to screen plant	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	300	2.22E-01	1.05E-01	1.59E-02	0%	2.22E-01	1.05E-01	1.59E-02
Q10	Quarry 10	Conveyor transfer point to secondary	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03
Q10	Quarry 10	Conveyor drop to product truck	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03
Q18	Quarry 18	Truck loading	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q18	Quarry 18	Truck unloading to primary crushing plant	0.74	0.35	0.053	3%	4.1	0.00151	0.00071	0.00011	300	1.26E-01	5.94E-02	9.00E-03	0%	1.26E-01	5.94E-02	9.00E-03
Q18	Quarry 18	Conveyor transfer point to screen plant	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	300	2.22E-01	1.05E-01	1.59E-02	0%	2.22E-01	1.05E-01	1.59E-02
Q18	Quarry 18	Conveyor transfer point to secondary	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03
Q18	Quarry 18	Conveyor drop to product truck	0.74	0.35	0.053	2%	4.1	0.00266	0.00126	0.00019	150	1.11E-01	5.24E-02	7.94E-03	0%	1.11E-01	5.24E-02	7.94E-03

Emission Factor Equation	Reference
$E = k \times (0.0016) \times (U/2.2)^{1.3} / (M/2)^{1.4}$	AP-42 13.2.4 November 2006

Parameter	SPM	PM_{10}	$PM_{2.5}$
k	0.74	0.35	0.053

E = emission factor in kg/megagram
k = particle size multiplier for particulate size range and units of interest
U = mean wind speed (m/s)
M = material moisture content (%)

Quarry Assessment Crushing and Screening Calculation Spreadsheet

Source ID	Source Type	Description	Emission Factor (kg/Mg)[1]			Processing Rate (tonnes/hr)[2]	Emission Rate (g/s)		
			PM	PM_{10}	$PM_{2.5}$*		PM	PM_{10}	$PM_{2.5}$*
Q2	Jaw Crusher	Primary Crushing (Uncontrolled)	0.0027	0.0012	0.0012	300	2.25E-01	1.00E-01	1.00E-01
Q2	Sceen Plant	Screening (Uncontrolled)	0.0125	0.0043	0.0043	300	1.04E+00	3.58E-01	3.58E-01
Q2	Cone Crusher	Secondary Crushing (Uncontrolled)	0.0195	0.0075	0.0075	150	8.13E-01	3.13E-01	3.13E-01
Q10	Jaw Crusher	Primary Crushing (Uncontrolled)	0.0027	0.0012	0.0012	300	2.25E-01	1.00E-01	1.00E-01
Q10	Sceen Plant	Screening (Uncontrolled)	0.0125	0.0043	0.0043	300	1.04E+00	3.58E-01	3.58E-01
Q10	Cone Crusher	Secondary Crushing (Uncontrolled)	0.0195	0.0075	0.0075	150	8.13E-01	3.13E-01	3.13E-01
Q18	Jaw Crusher	Primary Crushing (Uncontrolled)	0.0027	0.0012	0.0012	300	2.25E-01	1.00E-01	1.00E-01
Q18	Sceen Plant	Screening (Uncontrolled)	0.0125	0.0043	0.0043	300	1.04E+00	3.58E-01	3.58E-01
Q18	Cone Crusher	Secondary Crushing (Uncontrolled)	0.0195	0.0075	0.0075	150	8.13E-01	3.13E-01	3.13E-01

Notes:

[1] Primary and secondary crushing assumed to be the same as tertiary crushing

[2] Assumed that 50% of material needs to be crushed again in the cone crusher plant

*Where data is unavailable, $PM_{2.5}$ assumed to be equal to PM_{10}

Reference
AP-42 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing Table 11.19.2-1, August 2004

Quarry Assessment Wind Erosion Calculation Spreadsheet

Source ID	Wind Erosion Source	s %	f	E (kg/ha/day)			Active Surface Area (ha)[1]	Uncontrolled (g/s)			Assumed Control Efficiency (%)	Controlled Emission Rate (g/s)		
				TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$
Q2	East Zone Pit Active Area	5	27	11.396	5.698	2.279	0.25	0.03297	0.01649	0.00659	0%	0.03297	0.01649	0.00659
Q10	Purpose Built Pit Active Area	5	27	11.396	5.698	2.279	0.25	0.03297	0.01649	0.00659	0%	0.03297	0.01649	0.00659
Q18	Centre Zone Pit Active Area	5	27	11.396	5.698	2.279	0.25	0.03297	0.01649	0.00659	0%	0.03297	0.01649	0.00659

[1] Active area for pits was assumed to be 50 metres by 50 meters.

Equation	Reference
E = k*1.9 *(s/1.5) * f/15	AWMA - Air Pollution Engineering Manual, 1992, page 137

E = emission factor (kg/ha/day)
k = particle size multilier for particulate size range of interest
s = Silt Content in %
f = % of time that the unobstructed wind speed exceeds 5.4 m/s at mean pile height

Parameter	TSP	PM_{10}	$PM_{2.5}$	Reference
k	1.0	0.5	0.2	AWMA - Air Pollution Engineering Manual, 1992, page 137
f	average frequency obtained from CALMET data			

Quarry Assessment Wind Erosion Calculation Spreadsheet

Equipment	Manufacturer	Model	Number of Units	Power Rating (hp)	Steady-State Emission Factor (g/hp-hr)				% of Maximum Operating Capacity	% Daily Operation	Uncontrolled (g/s)					
					PM EF_{ss}	NOx EF_{ss}	CO EF_{ss}	HC EF_{ss}			TSP	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
1604 Crusher Jaw	n/a	n/a	1	300	0.0092	2.5	0.084	0.1314	80%	80%	4.91E-04	4.91E-04	4.76E-04	0.133	0.003	0.004
1604 Cone Plant	n/a	n/a	1	300	0.0092	2.5	0.084	0.1314	80%	80%	4.91E-04	4.91E-04	4.76E-04	0.133	0.003	0.004
1604 Screen Plant	n/a	n/a	1	110	0.0092	2.5	0.087	0.1314	80%	80%	1.80E-04	1.80E-04	1.75E-04	0.049	0.003	0.002
1604 Power Tower	n/a	n/a	1	200	0.0092	2.5	0.075	0.1314	80%	80%	3.27E-04	3.27E-04	3.17E-04	0.089	0.003	0.003
1604 Stacking Conveyor	n/a	n/a	1	48	0.2	4.7279	1.5323	0.2789	80%	80%	1.71E-03	1.71E-03	1.66E-03	0.040	0.004	0.013
Feeder and Bin wall Conveyor	n/a	n/a	1	48	0.2	4.7279	1.5323	0.2789	80%	80%	1.71E-03	1.71E-03	1.66E-03	0.040	0.004	0.013
Waste haul truck	Caterpillar	785D	1	1348	0.0690	2.3920	0.7642	0.2815	80%	80%	1.65E-02	1.65E-02	1.60E-02	0.573	0.003	0.183
Small wheel loader	Caterpillar	992K	2	801	0.0690	2.3920	0.7642	0.2815	80%	80%	1.97E-02	1.97E-02	1.91E-02	0.681	0.003	0.218
Excavator 345	Terex	RH170	1	2000	0.0690	2.3920	0.7642	0.2815	80%	80%	2.45E-02	2.45E-02	2.38E-02	0.850	0.003	0.272
										Total	0.066	0.066	0.064	2.59	0.03	0.71

Notes:
Cells highlighed gray indicates that emissions of a contaminant are zero.
Emission factors were obtained from the USEPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition* dated July 2010, EPA-420-R-10-018.
- see Table A4. *Zero Steady-State Emission Factors for Nonroad CI Engines*
- assumed Tier 4 (Tier 4A or just Tier 4), which are applicable to model years 2011 to 2014. No adjustments (i.e., TAF or sulphur content) needed to Tier 4 Efs.
- TAF is 1 for Tier 4 models. Also, PM not adjusted for sulphur content (resulted in a negative value)
- SO2 calculated using the following equation:

$$SO2=(BSFC\times 453.6\times (1\text{-}soxcnv)\text{-}HC)\times 0.01\times soxdsl\times 2$$

where:
soxcnv is the fraction of fuel sulphur converted to direct PM (0.3 for Tier 4)
soxdsl is the episodic weight % of sulphur in nonroad diesel fuel
% operating capacity and % daily operation assumed to be 80%

Size Fraction	% in Range	Reference
PM <30 µm	100%	EPA420-R-10-018, July 2010
PM <10 µm	100%	EPA420-R-10-018, July 2010
PM <2.5 µm	97%	EPA420-R-10-018, July 2010

A.6 Air Emissions Calculation Methods: Potential Acid Input

To calculate Potential Acid Input (PAI), two (2) main steps are required:

1. PAI resulting from sulphur species is calculated from annual sulphur deposition rates expressed in kg/ha/yr. These are subsequently converted to keq/ha/yr using the following equation:

$$\boldsymbol{PAI}_{\boldsymbol{sulphur}} = \frac{([SO_2]_{dep,wet} + [SO_2]_{dep,dry}) \times 2}{64} + \frac{([SO_4^{2-}]_{dep,wet} + [SO_4^{2-}]_{dep,dry}) \times 2}{96}$$

Where:

$[SO_2]_{dep,wet}$ = wet deposition of sulphur dioxide in kg/ha/yr

$[SO_2]_{dep,dry}$ = dry deposition of sulphur dioxide in kg/ha/yr

$[SO_4^{2-}]_{dep,wet}$ = wet deposition of sulphate in kg/ha/yr

$[SO_4^{2-}]_{dep,dry}$ = dry deposition of sulphate in kg/ha/yr

2. PAI resulting from nitrogen species is calculated from the annual nitrogen deposition rates expressed as kg/ha/yr. Since there is more than one chemical species considered, these fluxes are converted to kiloequivalents per hectare per year (keq/ha/yr) by dividing the predicted deposition rate by the molecular weight and multiplying by the hydrogen ion equivalents as follows:

$$\boldsymbol{PAI}_{\text{nitrogen}} = \frac{([NO]_{\boldsymbol{dep,wet}} + [NO]_{\boldsymbol{dep,dry}})}{30} + \frac{([NO_2]_{\boldsymbol{dep,wet}} + [NO_2]_{\boldsymbol{dep,dry}})}{46} + \frac{([HNO_3]_{\boldsymbol{dep,wet}} + [HNO_3]_{\boldsymbol{dep,dry}})}{63} + \frac{([NO_3^-]_{\boldsymbol{dep,wet}} + [NO_3^-]_{\boldsymbol{dep,dry}})}{62}$$

Where:

$[NO]_{dep,wet}$ = wet deposition of nitrogen oxide in kg/ha/yr

$[NO]_{dep,dry}$ = dry deposition of nitrogen oxide in kg/ha/yr

$[NO_2]_{dep,wet}$ = wet deposition of nitrogen dioxide in kg/ha/yr

$[NO_2]_{dep,dry}$ = dry deposition of nitrogen dioxide in kg/ha/yr

$[HNO_3]_{dep,wet}$ = wet deposition of nitric acid in kg/ha/yr

$[HNO_3]_{dep,dry}$ = dry deposition of nitric acid in kg/ha/yr

$[NO_3^-]_{dep,wet}$ = wet deposition of nitrate in kg/ha/yr

$[NO_3^-]_{dep,dry}$ = dry deposition of nitrate in kg/ha/yr

Here 'keq' refers to hydrogen ion equivalents (1 keq = 1 kmol H^+). The total PAI is calculated as the sum of the sulphur and nitrogen deposition rates from sources within the study area together with the background PAI for the region.

$$PAI = PAI_{sulphur} + PAI_{nitrogen} + PAI_{background}$$

In this equation, the PAI background accounts for background sulphur, nitrogen, Cl^-, NH_4^+ and base cations. Background PAI levels for the modelling domain were determined using the National Atmospheric Chemistry Precipitation Database (NAtChem) for Snare Rapids, NT

(NAtChem 2008). Snare Rapids is the only location in the NT for which NAtChem precipitation data is available and therefore it was used to determine the background PAI for the assessment. NAtChem data provides wet deposition values for sulphur, nitrogen, Cl^-, NH_4^+ and base cations. The NAtChem data is provided in Table A - 15.

The following equations demonstrate the background PAI calculation:

$$PAI_{background} = PAI_{acidifying\ substances} + PAI_{base\ cations}$$

The PAI from acidifying substances can be expressed as:

$$PAI_{acidifying\ substances} = \frac{\left([SO_4^{2-}]_{dep,wet} + [SO_4^{2-}]_{dep,dry}\right) \times 2}{96} + \frac{[NO_3^-]_{dep,wet} + [NO_3^-]_{dep,dry}}{62} + \frac{[NH_4^+]_{dep,wet}}{18} + \frac{[Cl^-]_{dep,wet}}{35.5}$$

Where:

$[SO_4^{2-}]_{dep,wet}$ = wet deposition of sulphate in keq/ha/yr

$[SO_4^{2-}]_{dep,dry}$ = dry deposition of sulphate in keq/ha/yr

$[NO_3^-]_{dep,wet}$ = wet deposition of nitrate in keq/ha/yr

$[NO_3^-]_{dep,dry}$ = dry deposition of nitrate in keq/ha/yr

$[NH_4^+]_{dep,wet}$ = wet deposition of ammoinium in keq/ha/yr

$[Cl^-]_{dep,wet}$ = wet deposition of chlorine in keq/ha/yr

NAtChem data only provides wet deposition values. In order to determine the background dry deposition values for the modelling domain, the average ratio of dry deposition to wet deposition for nitrogen and sulphur in predicted in the LAA was applied to NAtChem wet nitrogen and sulphur deposition values to determine the background dry nitrogen and sulphur deposition values for the modelling domain.

$$PAI_{base\ cation} = -\left(\frac{[Ca^{2+}]_{dep,back} \times 2}{40} + \frac{[Mg^{2+}]_{dep,back} \times 2}{24} + \frac{[K^+]_{dep,back}}{39} + \frac{[Na^+]_{dep,back}}{23}\right)$$

The base cations PAI are calculated according to the following equation:

Where:

$[Ca^{2+}]_{dep,back}$ = background deposition of calcium in keq/ha/yr

$[Mg^{2+}]_{dep,back}$ = background deposition of magnesium in keq/ha/yr

$[K^+]_{dep,back}$ = background deposition of potassium in keq/ha/yr

$[Na^+]_{dep,back}$ = background deposition of sodium in keq/ha/yr

An average annual background PAI value of 0.093 keq/ha/yr was calculated.

Table A - 15 NAtCHEM Database 2008 Annual Summary Statistics of Precipitation Chemistry Data for Snare Rapids, NT Monitoring Station

Constituent	Wet Deposition (kg/ha/yr)
SO_4=	0.988
NO_3^-	1.111
Cl^-	0.276
NH_4^+	0.899
Na^+	0.23
Ca^{++}	0.251
Mg^{++}	0.051
K^+	0.159

ATTACHMENT B **DETAILED AIR EMISSIONS SUMMARIES**

ATTACHMENT B.1 **AIR EMISSIONS: PHASED OPERATIONS**

ATTACHMENT B.2 **AIR EMISSIONS: MAXIMUM BOUNDING SCENARIO**

ATTACHMENT B.3 **AIR EMISSIONS: DECOMMISSIONING**

Attachment B.1 Air Emissions: Phased Operations

Table B-1 Period 1 (Year 0 and 1) Maximum Air Emissions Rate Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	3.0E+00	1.2E+00	2.9E-01	3.8E-04	9.8E-06	4.0E-05	7.1E-05	7.7E-04	4.3E-04	1.4E-04	4.7E-06	1.0E-04	1.9E-06	3.0E-04	2.7E+00	3.8E-01	1.3E+01	-	2.3E+05
	Main Zone West Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Centre Zone Pit	1.4E+01	4.3E+00	6.9E-01	4.5E-03	3.2E-05	1.4E-04	2.1E-04	3.8E-04	5.0E-05	4.0E-04	1.5E-05	4.7E-04	1.6E-06	7.3E-04	5.7E+00	4.0E-01	1.4E+01	-	4.2E+05
	East Zone Pit	4.6E+00	1.7E+00	3.6E-01	1.1E-02	1.1E-05	4.7E-05	7.4E-05	1.3E-04	1.7E-05	1.3E-04	5.0E-06	1.6E-04	5.6E-07	2.5E-04	3.1E+00	3.8E-01	1.3E+01	-	1.7E+06
	Purpose Built Pit	1.7E+00	8.3E-01	2.4E-01	4.3E-04	1.4E-06	1.6E-05	1.7E-05	4.2E-05	1.9E-05	3.8E-05	5.4E-07	4.8E-05	8.5E-08	9.5E-05	2.0E+00	3.7E-01	1.3E+01	-	3.1E+04
	Kiggavik Type II Mine Rock Pile - South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type II Mine Rock Pile - North	2.8E+01	7.7E+00	1.0E+00	4.3E-03	2.5E-05	2.7E-04	3.3E-04	3.4E-04	5.3E-05	7.2E-04	3.1E-05	8.3E-04	1.1E-06	1.3E-03	2.0E+00	1.0E-02	6.3E-01	-	7.0E+05
	Kiggavik Overburden Pile	5.7E+00	1.7E+00	2.8E-01	5.7E-05	4.6E-06	6.4E-05	7.7E-05	5.8E-05	1.1E-05	1.5E-04	6.5E-06	2.0E-04	2.9E-07	2.6E-04	5.7E-01	5.6E-03	1.7E-01	-	1.2E+04
	Kiggavik Ore Pile	5.4E-01	2.7E-01	9.8E-02	2.5E-03	1.3E-05	1.0E-05	3.9E-05	1.5E-04	1.7E-05	4.2E-05	1.1E-07	5.2E-05	7.5E-07	9.6E-05	2.6E-02	7.5E-03	7.2E-03	-	1.3E+06
	Kiggavik Type III Mine rock Pile	8.4E-01	2.7E-01	1.1E-01	7.6E-04	6.1E-07	9.1E-06	3.8E-05	2.5E-05	1.2E-05	1.9E-05	1.2E-06	3.0E-05	4.2E-08	3.5E-05	3.9E-01	1.4E-02	1.9E-02	-	7.1E+05
	Mill	8.8E-02	4.5E-02	1.3E-02	1.2E-04	3.1E-08	2.3E-08	9.0E-08	3.5E-07	4.0E-08	9.6E-08	2.6E-10	1.2E-07	1.7E-09	2.2E-07	1.1E-02	2.9E-04	5.6E-03	-	8.4E+04
	Acid Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.9E-03	2.4E-02	6.2E-03	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	-	-	-	-	-	-	-	-	-	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	-	-	-	-	-	-	-	-	-	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	9.5E+00	2.5E+00	2.8E-01	9.5E-05	1.9E-05	7.6E-05	2.4E-04	1.5E-04	7.6E-05	2.4E-04	1.9E-05	2.0E-04	9.5E-07	5.7E-04	1.2E+00	1.8E-03	3.7E-01	-	-
Sissons Site	Andrew Lake Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Type III Mine rock Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Ore Pad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Special Ore Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	3.6E-07	1.5E-06	4.6E-06	2.9E-06	1.5E-06	4.6E-06	3.6E-07	3.8E-06	1.8E-08	1.1E-05	1.4E-02	5.7E-05	5.5E-04	-	-

Table B-2 Period 2 (Year 2 – 5) Maximum Air Emissions Rate Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0E+00	3.0E+02
	Main Zone West Pit	3.8E+01	1.1E+01	1.4E+00	2.0E-02	4.4E-05	3.8E-04	4.9E-04	1.5E-03	6.6E-04	1.1E-03	4.4E-05	1.1E-03	3.9E-06	1.9E-03	8.6E+00	4.0E-01	1.5E+01	0.0E+00	1.4E+06
	Centre Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0E+00	9.0E+02
	East Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0E+00	4.2E+02
	Purpose Built Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0E+00	-
	Kiggavik Type II Mine Rock Pile - South	2.1E+01	6.1E+00	9.8E-01	4.2E-03	1.9E-05	2.0E-04	2.5E-04	2.6E-04	4.0E-05	5.5E-04	2.4E-05	6.3E-04	8.4E-07	9.6E-04	1.4E+00	7.3E-03	4.4E-01	0.0E+00	1.3E+06
	Kiggavik Type II Mine Rock Pile - North	1.6E+00	8.1E-01	3.3E-01	2.5E-04	1.5E-06	1.6E-05	1.9E-05	2.0E-05	3.1E-06	4.3E-05	1.9E-06	4.9E-05	6.5E-08	7.5E-05	-	-	-	0.0E+00	6.7E+05
	Kiggavik Overburden Pile	5.3E-01	2.6E-01	1.1E-01	5.3E-06	4.2E-07	5.9E-06	7.1E-06	5.3E-06	1.0E-06	1.4E-05	5.9E-07	1.9E-05	2.6E-08	2.4E-05	-	-	-	0.0E+00	1.4E+04
	Kiggavik Ore Pile	7.0E-01	3.5E-01	1.1E-01	3.4E-03	6.0E-06	1.2E-05	2.2E-05	3.4E-04	1.9E-04	4.6E-05	1.5E-06	2.7E-05	8.4E-07	1.1E-04	2.0E-01	1.1E-02	5.4E-02	0.0E+00	1.8E+06
	Kiggavik Type III Mine rock Pile	8.2E-01	2.7E-01	1.1E-01	7.4E-04	6.0E-07	8.9E-06	3.7E-05	2.5E-05	1.2E-05	1.8E-05	1.2E-06	2.9E-05	4.1E-08	3.4E-05	3.8E-01	1.4E-02	1.7E-02	0.0E+00	7.6E+05
	Mill	9.4E-01	4.8E-01	1.4E-01	1.3E-03	1.5E-07	3.0E-07	5.5E-07	8.4E-06	4.7E-06	1.1E-06	3.8E-08	6.7E-07	2.1E-08	2.6E-06	1.2E-01	3.0E-03	5.9E-02	0.0E+00	1.2E+06
	Acid Plant	-	-	-	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-02	2.6E-01	6.6E-02	0.0E+00	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E+01	5.8E-03	2.8E-01	0.0E+00	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	9.9E+00	2.6E+00	2.9E-01	9.9E-05	2.0E-05	7.9E-05	2.5E-04	1.6E-04	7.9E-05	2.5E-04	2.0E-05	2.1E-04	9.9E-07	5.9E-04	1.2E+00	1.8E-03	3.8E-01	0.0E+00	0.0E+00
Sissons Site	Andrew Lake Pit	9.2E+00	3.0E+00	5.4E-01	1.8E-03	3.0E-05	3.4E-05	6.1E-05	7.9E-05	6.3E-06	2.6E-04	1.2E-05	1.2E-04	8.2E-07	7.7E-04	4.2E+00	3.9E-01	1.3E+01	0.0E+00	5.9E+05
	Andrew Lake Type III Mine rock Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Special Waste Pile	6.3E-01	1.9E-01	8.8E-02	1.3E-03	6.3E-07	8.2E-06	1.3E-06	2.4E-05	6.3E-07	2.3E-05	5.6E-07	2.4E-05	6.3E-07	6.3E-05	-	-	-	0.0E+00	2.0E+05
	End Grid Clean Waste Pile	6.4E-01	2.0E-01	8.9E-02	1.6E-04	2.1E-06	2.4E-06	4.3E-06	5.6E-06	4.4E-07	1.8E-05	8.2E-07	8.6E-06	5.8E-08	5.4E-05	-	-	-	0.0E+00	3.1E+04
	Andrew Lake Ore Pad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	5.0E-01	2.5E-01	1.0E-01	5.0E-06	1.8E-06	1.9E-06	3.7E-06	3.8E-06	3.3E-07	1.3E-05	6.6E-07	6.8E-06	4.0E-08	4.3E-05	-	-		0.0E+00	1.3E+04
	Andrew Lake Clean Rock Pile	1.9E+01	5.7E+00	1.0E+00	3.7E-03	6.1E-05	7.0E-05	1.3E-04	1.6E-04	1.3E-05	5.3E-04	2.4E-05	2.5E-04	1.7E-06	1.6E-03	1.2E+00	5.8E-03	3.7E-01	0.0E+00	1.8E+06
	End Grid Special Ore Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E+01	8.6E-04	7.0E-02	0.0E+00	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.2E-02	2.8E-02	3.9E-03	4.5E-14	-
	Backfill Plant	1.7E-01	5.5E-02	1.2E-02	2.5E-06	7.0E-05	1.6E-07	1.9E-07	3.4E-06	3.1E-08	2.9E-05	1.8E-08	4.9E-07	1.1E-07	1.3E-05	-	-	-	0.0E+00	-
	End Grid Underground Mine Exhaust	2.0E+00	1.0E+00	3.4E-01	2.2E-03	3.3E-05	1.6E-05	3.4E-05	1.2E-04	3.5E-05	7.4E-05	4.6E-06	4.1E-05	7.8E-07	1.8E-04	6.2E+00	9.0E-02	1.1E+00	0.0E+00	1.4E+05
	On-Site Roads at Sissons	8.1E+00	2.1E+00	2.4E-01	8.1E-05	1.6E-05	6.5E-05	2.0E-04	1.3E-04	6.5E-05	2.0E-04	1.6E-05	1.7E-04	8.1E-07	4.9E-04	1.0E+00	1.5E-03	3.2E-01	0.0E+00	-
Roads	Haul road b/n Kiggavik and Sissons	4.9E+00	1.3E+00	1.3E-01	4.9E-05	9.8E-06	3.9E-05	1.2E-04	7.8E-05	3.9E-05	1.2E-04	9.8E-06	1.0E-04	4.9E-07	2.9E-04	6.8E-02	4.8E-04	3.4E-03	0.0E+00	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.2E-03	6.0E-05	2.9E-04	0.0E+00	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	3.6E-07	1.5E-06	4.6E-06	2.9E-06	1.5E-06	4.6E-06	3.6E-07	3.8E-06	1.8E-08	1.1E-05	1.4E-02	5.7E-05	5.5E-04	0.0E+00	-

Table B-3 Period 3 (Year 6 – 13) Maximum Air Emissions Rate Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6E+03
	Centre Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.0E+02
	East Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type II Mine Rock Pile - South	2.3E+00	1.2E+00	4.7E-01	4.7E-04	2.1E-06	2.2E-05	2.8E-05	2.9E-05	4.5E-06	6.1E-05	2.7E-06	7.0E-05	9.3E-08	1.1E-04	-	-	-	-	1.2E+06
	Kiggavik Type II Mine Rock Pile - North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4E+04
	Kiggavik Ore Pile	5.7E-01	2.8E-01	1.0E-01	2.7E-03	1.7E-05	7.1E-06	2.8E-05	1.7E-04	3.3E-05	4.9E-05	1.3E-06	2.1E-05	6.5E-07	3.8E-04	9.1E-03	7.3E-03	2.5E-03	-	1.7E+06
	Kiggavik Type III Mine rock Pile	3.2E-01	1.6E-01	6.3E-02	2.8E-04	2.3E-07	3.4E-06	1.4E-05	9.5E-06	4.6E-06	7.0E-06	4.5E-07	1.1E-05	1.6E-08	1.3E-05	-	-	-	-	7.6E+05
	Mill	1.0E+00	5.3E-01	1.6E-01	1.4E-03	4.6E-07	1.9E-07	7.6E-07	4.7E-06	9.1E-07	1.3E-06	3.4E-08	5.6E-07	1.8E-08	1.0E-05	1.3E-01	3.4E-03	6.6E-02	-	1.1E+06
	Acid Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.6E-02	2.9E-01	7.4E-02	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	-	-	-	-	-	-	-	-	-	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	-	-	-	-	-	-	-	-	-	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.0E-07	2.4E-06	7.5E-06	4.8E-06	2.4E-06	7.5E-06	6.0E-07	6.3E-06	3.0E-08	1.8E-05	6.9E-03	1.0E-04	6.9E-04	0.0E+00	-
Sissons Site	Andrew Lake Pit	5.8E+01	1.6E+01	2.0E+00	2.3E-02	2.2E-04	2.3E-04	4.8E-04	1.2E-03	1.6E-04	1.8E-03	7.2E-05	8.2E-04	7.4E-06	6.8E-03	1.1E+01	4.2E-01	1.5E+01	-	9.9E+05
	Andrew Lake Type III Mine rock Pile	7.2E-01	2.3E-01	1.1E-01	6.5E-04	1.4E-06	1.9E-06	4.1E-06	1.0E-05	6.0E-07	2.0E-05	7.9E-07	7.2E-06	7.9E-08	5.5E-05	2.3E-01	1.4E-02	8.2E-03	-	7.4E+05
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.8E-04	2.3E-07	3.0E-06	4.6E-07	8.7E-06	2.3E-07	8.5E-06	2.1E-07	8.7E-06	2.3E-07	2.3E-05	-	-	-	-	2.6E+05
	End Grid Clean Waste Pile	2.3E-01	1.2E-01	4.6E-02	5.8E-05	7.6E-07	8.6E-07	1.6E-06	2.0E-06	1.6E-07	6.5E-06	3.0E-07	3.1E-06	2.1E-08	2.0E-05	-	-	-	-	3.1E+04
	Andrew Lake Ore Pad	2.4E-01	1.2E-01	4.7E-02	1.4E-03	4.0E-06	2.0E-06	1.2E-05	8.7E-05	1.4E-05	2.3E-05	1.2E-07	8.3E-06	2.7E-07	2.3E-04	-	-	-	-	4.4E+05
	Andrew Lake Overburden Pile	5.0E-01	2.5E-01	1.0E-01	5.0E-06	1.8E-06	1.9E-06	3.7E-06	3.8E-06	3.3E-07	1.3E-05	6.6E-07	6.8E-06	4.0E-08	4.3E-05	-	-	-	-	1.3E+04
	Andrew Lake Clean Rock Pile	2.8E+01	8.3E+00	1.4E+00	5.6E-03	9.2E-05	1.0E-04	1.9E-04	2.4E-04	1.9E-05	7.8E-04	3.6E-05	3.7E-04	2.5E-06	2.4E-03	1.8E+00	1.6E-02	5.7E-01	-	2.0E+06
	End Grid Special Ore Pile	2.6E-01	1.3E-01	4.8E-02	1.1E-03	1.4E-05	5.4E-06	1.2E-05	5.4E-05	1.7E-05	1.7E-05	1.4E-06	1.0E-05	3.1E-07	2.9E-05	-	-	-	-	1.3E+05
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	-	-	-	-	-	-	-	-	-	-	1.6E+01	8.6E-04	7.0E-02	-	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	-	-	-	-	-	-	-	-	-	-	5.2E-02	2.8E-02	3.9E-03	4.5E-14	-
	Backfill Plant	1.9E-01	6.2E-02	1.3E-02	5.0E-06	7.0E-05	3.1E-07	3.8E-07	3.7E-06	6.1E-08	3.1E-05	3.6E-08	9.6E-07	1.3E-07	1.3E-05	-	-	-	-	-
	End Grid Underground Mine Exhaust	2.2E+00	1.1E+00	3.7E-01	7.9E-03	9.7E-05	3.9E-05	8.4E-05	3.7E-04	1.1E-04	1.3E-04	1.0E-05	7.9E-05	2.3E-06	2.3E-04	6.2E+00	9.2E-02	1.2E+00	-	3.5E+05
	On-Site Roads at Sissons	1.3E+01	3.4E+00	3.8E-01	1.3E-04	2.6E-05	1.1E-04	3.3E-04	2.1E-04	1.1E-04	3.3E-04	2.6E-05	2.8E-04	1.3E-06	7.9E-04	1.6E+00	2.8E-03	5.1E-01	0.0E+00	-
Roads	Haul road b/n Kiggavik and Sissons	1.3E+01	3.3E+00	3.3E-01	1.3E-04	2.5E-05	1.0E-04	3.2E-04	2.0E-04	1.0E-04	3.2E-04	2.5E-05	2.7E-04	1.3E-06	7.6E-04	7.8E-02	1.0E-03	5.5E-03	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	-	-	-	-	-	-	-	-	-	-	4.2E-03	6.0E-05	2.9E-04	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	3.6E-07	1.5E-06	4.6E-06	2.9E-06	1.5E-06	4.6E-06	3.6E-07	3.8E-06	1.8E-08	1.1E-05	1.4E-02	5.7E-05	5.5E-04	-	-

Table B-4 Period 4 (Year 14) Maximum Air Emissions Rate Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6E+03
	Centre Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.0E+02
	East Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type II Mine Rock Pile - South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2E+06
	Kiggavik Type II Mine Rock Pile - North	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4E+04
	Kiggavik Ore Pile	4.7E-01	2.4E-01	1.0E-01	3.1E-03	1.4E-05	5.8E-06	2.3E-05	1.4E-04	2.7E-05	4.0E-05	1.0E-06	1.7E-05	5.3E-07	3.1E-04	3.8E-01	2.1E-02	1.0E-01	-	2.1E+06
	Kiggavik Type III Mine rock Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.6E+05
	Mill	1.5E-01	7.7E-02	2.3E-02	2.0E-04	4.6E-08	1.9E-08	7.6E-08	4.7E-07	9.1E-08	1.3E-07	3.4E-09	5.6E-08	1.8E-09	1.0E-06	1.9E-02	4.9E-04	9.6E-03	-	1.5E+05
	Acid Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7E-03	4.2E-02	1.1E-02	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	-	-	-	-	-	-	-	-	-	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	-	-	-	-	-	-	-	-	-	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.0E-07	2.4E-06	7.5E-06	4.8E-06	2.4E-06	7.5E-06	6.0E-07	6.3E-06	3.0E-08	1.8E-05	6.9E-03	1.0E-04	6.9E-04	-	-
Sissons Site	Andrew Lake Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.5E+05
	Andrew Lake Type III Mine rock Pile	3.1E-01	1.5E-01	6.2E-02	2.8E-04	5.9E-07	8.1E-07	1.7E-06	4.4E-06	2.6E-07	8.6E-06	3.4E-07	3.1E-06	3.4E-08	2.4E-05	-	-	-	-	7.4E+05
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Ore Pad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3E+04
	Andrew Lake Clean Rock Pile	3.7E+00	1.9E+00	7.5E-01	7.5E-04	1.2E-05	1.4E-05	2.5E-05	3.3E-05	2.6E-06	1.0E-04	4.8E-06	5.0E-05	3.4E-07	3.2E-04	-	-	-	-	2.0E+06
	End Grid Special Ore Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	-	-	-	-	-	-	-	-	-	-	4.2E-03	6.0E-05	2.9E-04	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	3.6E-07	1.5E-06	4.6E-06	2.9E-06	1.5E-06	4.6E-06	3.6E-07	3.8E-06	1.8E-08	1.1E-05	1.4E-02	5.7E-05	5.5E-04	-	-

Attachment B.2 Air Emissions: Maximum Bounding Scenario

Table B-5 Maximum Bounding Scenario Maximum Air Emissions Rates Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0E+03
	Main Zone West Pit	4.4E+01	1.2E+01	1.7E+00	2.4E-02	5.1E-05	4.4E-04	5.7E-04	1.7E-03	7.4E-04	1.2E-03	5.2E-05	1.3E-03	4.4E-06	2.2E-03	1.3E+01	9.1E-01	3.2E+01	-	1.1E+06
	Centre Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.0E+02
	East Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2E+02
	Purpose Built Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type II Mine Rock Pile - South	2.1E+01	6.2E+00	9.9E-01	4.2E-03	1.9E-05	2.0E-04	2.5E-04	2.6E-04	4.0E-05	5.5E-04	2.4E-05	6.3E-04	8.4E-07	9.6E-04	1.9E+00	2.1E-02	5.0E-01	-	1.3E+06
	Kiggavik Type II Mine Rock Pile - North	1.3E+01	3.6E+00	5.7E-01	2.0E-03	1.2E-05	1.2E-04	1.5E-04	1.6E-04	2.5E-05	3.4E-04	1.5E-05	3.9E-04	5.2E-07	5.9E-04	7.5E-01	1.1E-03	2.4E-01	-	6.7E+05
	Kiggavik Overburden Pile	4.3E+00	1.3E+00	2.4E-01	4.3E-05	3.4E-06	4.8E-05	5.8E-05	4.3E-05	8.1E-06	1.2E-04	4.8E-06	1.5E-04	2.1E-07	2.0E-04	4.9E-01	7.7E-03	1.2E-01	-	1.5E+04
	Kiggavik Ore Pile	7.0E-01	3.5E-01	1.1E-01	4.7E-03	1.2E-05	1.0E-05	2.8E-05	2.9E-04	1.2E-04	5.3E-05	1.4E-06	2.6E-05	8.2E-07	3.0E-04	2.9E-02	7.5E-03	8.0E-03	-	2.5E+06
	Kiggavik Type III Mine rock Pile	8.2E-01	2.7E-01	1.1E-01	7.4E-04	6.0E-07	8.9E-06	3.7E-05	2.5E-05	1.2E-05	1.8E-05	1.2E-06	2.9E-05	4.1E-08	3.5E-05	2.3E-02	3.5E-04	5.7E-03	-	7.6E+05
	Mill	1.1E+00	5.6E-01	1.6E-01	1.5E-03	3.0E-07	2.6E-07	7.2E-07	7.3E-06	3.1E-06	1.4E-06	3.6E-08	6.7E-07	2.1E-08	7.5E-06	1.4E-01	3.6E-03	7.0E-02	-	1.8E+06
	Acid Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.9E-02	3.0E-01	7.8E-02	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	-	-	-	-	-	-	-	-	-	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	-	-	-	-	-	-	-	-	-	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	1.6E+01	4.1E+00	4.6E-01	1.6E-04	3.2E-05	1.3E-04	4.0E-04	2.5E-04	1.3E-04	4.0E-04	3.2E-05	3.3E-04	1.6E-06	9.5E-04	2.0E+00	3.0E-03	6.3E-01	-	-
Sissons Site	Andrew Lake Pit	6.7E+01	1.8E+01	2.4E+00	2.8E-02	2.5E-04	2.6E-04	5.6E-04	1.4E-03	1.8E-04	2.0E-03	8.4E-05	9.5E-04	8.5E-06	7.8E-03	1.6E+01	9.1E-01	3.3E+01	-	1.6E+06
	Andrew Lake Type III Mine rock Pile	7.6E-01	2.5E-01	1.1E-01	6.8E-04	1.5E-06	2.0E-06	4.3E-06	1.1E-05	6.4E-07	2.1E-05	8.3E-07	7.6E-06	8.3E-08	5.8E-05	1.4E-02	2.9E-04	3.2E-03	-	7.5E+05
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.9E-04	2.3E-07	3.0E-06	4.7E-07	8.9E-06	2.3E-07	8.6E-06	2.1E-07	8.9E-06	2.3E-07	2.3E-05	-	-	-	-	2.6E+05
	End Grid Clean Waste Pile	2.4E-01	1.2E-01	4.7E-02	6.1E-05	8.0E-07	9.1E-07	1.6E-06	2.1E-06	1.7E-07	6.9E-06	3.1E-07	3.3E-06	2.2E-08	2.1E-05	-	-	-	-	3.1E+04
	Andrew Lake Ore Pad	2.9E-01	1.4E-01	5.0E-02	1.8E-03	4.8E-06	2.4E-06	1.4E-05	1.0E-04	1.6E-05	2.7E-05	1.4E-07	9.8E-06	3.2E-07	2.8E-04	-	-	-	-	5.4E+05
	Andrew Lake Overburden Pile	2.7E+00	8.0E-01	1.9E-01	2.6E-05	9.8E-06	1.0E-05	2.0E-05	2.0E-05	1.8E-06	7.2E-05	3.5E-06	3.6E-05	2.1E-07	2.3E-04	2.9E-01	4.7E-03	6.9E-02	-	1.4E+04
	Andrew Lake Clean Rock Pile	3.4E+01	9.8E+00	1.5E+00	6.7E-03	1.1E-04	1.3E-04	2.3E-04	2.9E-04	2.3E-05	9.5E-04	4.3E-05	4.5E-04	3.0E-06	2.8E-03	2.8E+00	2.6E-02	7.7E-01	-	2.0E+06
	End Grid Special Ore Pile	2.5E-01	1.3E-01	4.8E-02	1.3E-03	1.4E-05	5.3E-06	1.2E-05	5.3E-05	1.6E-05	1.7E-05	1.4E-06	1.0E-05	3.0E-07	2.9E-05	-	-	-	-	1.5E+05
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	-	-	-	-	-	-	-	-	-	-	1.6E+01	8.6E-04	7.0E-02	-	-
	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	-	-	-	-	-	-	-	-	-	-	5.2E-02	2.8E-02	3.9E-03	4.5E-14	-
	Backfill Plant	1.9E-01	6.2E-02	1.3E-02	5.0E-06	7.0E-05	3.1E-07	3.8E-07	3.7E-06	6.1E-08	3.1E-05	3.6E-08	9.6E-07	1.3E-07	1.3E-05	-	-	-	-	-
	End Grid Underground Mine Exhaust	6.4E+00	3.3E+00	1.0E+00	2.1E-02	2.2E-04	9.3E-05	2.0E-04	8.3E-04	2.5E-04	3.3E-04	2.4E-05	2.0E-04	5.2E-06	6.5E-04	6.4E+00	1.3E-01	2.3E+00	-	2.8E+05
	On-Site Roads at Sissons	1.5E+01	4.0E+00	4.4E-01	1.5E-04	3.1E-05	1.2E-04	3.8E-04	2.4E-04	1.2E-04	3.8E-04	3.1E-05	3.2E-04	1.5E-06	9.2E-04	1.8E+00	2.8E-03	5.8E-01	-	-
Roads	Haul road b/n Kiggavik and Sissons	3.5E+01	9.0E+00	9.0E-01	3.5E-04	7.0E-05	2.8E-04	8.8E-04	5.6E-04	2.8E-04	8.8E-04	7.0E-05	7.4E-04	3.5E-06	2.1E-03	1.1E-01	3.0E-03	1.3E-02	-	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	-	-	-	-	-	-	-	-	-	-	4.1E-03	5.6E-05	2.8E-04	-	-
	Road to Airstrip	1.8E-01	5.2E-02	5.0E-03	1.8E-06	3.6E-07	1.5E-06	4.6E-06	2.9E-06	1.5E-06	4.6E-06	3.6E-07	3.8E-06	1.8E-08	1.1E-05	1.3E-02	3.7E-05	4.8E-04	-	-

Attachment B.3 Air Emissions: Decommissioning

Table B-6 Decommissioning Maximum Air Emissions Rates Summary

Location	Source	Emission Rate (g/s)																		
		TSP	PM_{10}	$PM_{2.5}$	U	As	Co	Cu	Pb	Mo	Ni	Se	Zn	Cd	Cr	NO_x	SO_2	CO	CDD/CDF	Radon (Bq/s)
Kiggavik Site	Main Zone East Pit	7.4E-01	2.2E-01	8.6E-02	6.7E-04	5.4E-07	8.1E-06	3.4E-05	2.2E-05	1.1E-05	1.6E-05	1.1E-06	2.6E-05	3.7E-08	3.1E-05	1.5E-01	2.0E-03	9.0E-03		1.4E+06
	Main Zone West Pit	8.3E-01	2.4E-01	9.4E-02	7.4E-04	6.0E-07	9.0E-06	3.7E-05	2.5E-05	1.2E-05	1.8E-05	1.2E-06	2.9E-05	4.1E-08	3.5E-05	1.5E-01	2.0E-03	9.0E-03		8.9E+05
	Centre Zone Pit	7.9E-01	2.3E-01	9.4E-02	1.4E-04	1.7E-06	5.2E-06	7.3E-06	8.3E-06	1.0E-06	2.1E-05	9.5E-07	1.7E-05	5.1E-08	5.1E-05	1.7E-01	2.4E-03	8.9E-03		6.8E+04
	East Zone Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.2E+04
	Purpose Built Pit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type II Mine Rock Pile - South	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2E+06
	Kiggavik Type II Mine Rock Pile - North	4.8E-01	1.8E-01	5.9E-02	7.4E-05	4.4E-07	4.6E-06	5.7E-06	5.9E-06	9.1E-07	1.2E-05	5.4E-07	1.4E-05	1.9E-08	2.2E-05	2.7E-01	2.4E-03	7.6E-02	-	6.6E+05
	Kiggavik Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Ore Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kiggavik Type III Mine rock Pile	3.6E-01	1.8E-01	7.1E-02	3.2E-04	2.6E-07	3.8E-06	1.6E-05	1.1E-05	5.2E-06	7.9E-06	5.1E-07	1.2E-05	1.8E-08	1.5E-05	2.2E-01	2.0E-03	5.9E-02	-	7.6E+05
	Mill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Acid Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	-	-	-	-	-	-	-	-	-	-	6.3E+01	5.8E-03	2.8E-01	-	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	-	-	-	-	-	-	-	-	-	-	1.0E-01	5.6E-02	7.8E-03	8.9E-14	-
	On-Site Roads at Kiggavik	2.8E-01	7.2E-02	8.1E-03	2.8E-06	5.6E-07	2.2E-06	6.9E-06	4.4E-06	2.2E-06	6.9E-06	5.6E-07	5.8E-06	2.8E-08	1.7E-05	3.6E-02	5.3E-05	1.1E-02	-	-
Sissons Site	Andrew Lake Pit	1.9E+00	5.4E-01	1.3E-01	8.9E-04	5.4E-06	6.4E-06	1.2E-05	2.1E-05	1.4E-06	5.4E-05	2.3E-06	2.3E-05	1.9E-07	1.6E-04	3.3E-01	2.8E-03	5.7E-02	-	1.8E+05
	Andrew Lake Type III Mine rock Pile	3.7E-01	1.9E-01	7.2E-02	3.2E-04	6.9E-07	9.5E-07	2.0E-06	5.1E-06	3.0E-07	1.0E-05	4.0E-07	3.6E-06	4.0E-08	2.8E-05	2.8E-01	2.6E-03	7.5E-02	-	7.5E+05
	End Grid Special Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Clean Waste Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Ore Pad	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0E+06
	End Grid Special Ore Pile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Power Plant at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Incinerator at Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	On-Site Roads at Sissons	3.0E-01	7.9E-02	8.9E-03	3.0E-06	6.0E-07	2.4E-06	7.6E-06	4.8E-06	2.4E-06	7.6E-06	6.0E-07	6.3E-06	3.0E-08	1.8E-05	4.0E-02	5.8E-05	1.2E-02	-	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Road to Airstrip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

ATTACHMENT C **AIR DISPERSION MODELLING**

ATTACHMENT C.1 **CALMET METEOROLOGY**

ATTACHMENT C.2 **MODEL SETUP**

Attachment C.1 CALMET Meteorology

Meteorological Stations

Data from several meteorological stations was used in this assessment. One of the meteorological stations is located within the Local Assessment Area near the proposed Pointer Lake Airstrip, about 3 km south of the Accommodation Complex. It was installed in August 2009 and since then it has been recording surface temperature, relative humidity, wind speed and direction and atmospheric pressure data. Hourly surface wind speed and direction data from this station was used to develop the one year meteorological data set for air dispersion modelling. The meteorological dataset used in this assessment is for the period August 15, 2009 to August 14, 2010.

The nearest Environment Canada (EC) surface station is located at the Baker Lake Airport, approximately 80 km east of the Kiggavik Project site. It records hourly data including air temperature, precipitation, atmospheric pressure, wind speed and direction, relative humidity, cloud ceiling and sky cover. Upon examining the Baker Lake Airport station data, it was found that about 1,730 hours had recorded wind speeds less 0.5 m/s in the one year period chosen for this assessment (i.e., 19.8% calms). As a result, another station was considered. EC also operates a climate station located in Baker Lake which records hourly observations of air temperature, wind speed and direction, atmospheric pressure and relative humidity. Approximately 40% of the wind data needed for the assessment period was missing from the climate station dataset beginning on March 23, 2010 up until August 14, 2010. Therefore, the final Baker Lake wind data set that was used for modelling was created by filling in the gaps of missing hourly wind observations at the Baker Lake climate station with data from the Baker Lake Airport station. The result is a dataset having a complete record of hourly wind data for the period considered in this assessment, with 8% calms.

CALMET Model

The CALMET meteorological model was used to simulate meteorological conditions in the assessment areas (LAA and RAA) for a one year period (August 15, 2009 to August 14, 2010). The CALMET simulation was initialized with gridded three dimensional wind field data from the Nonhydrostatic Mesoscale Model (NMM) analysis data obtained from the National Centre for Environmental Prediction (NCEP). The NMM initialization fields were available for a grid having a spatial resolution of 32 km and temporal resolution of 6 hours. The grid points that were selected from the NMM analysis are presented in Figure C-1. The red line represents the Regional Assessment Area and the blue line the Local Assessment Area. The use of mesoscale analysis facilitates the generation of three dimensional profiles for the proper simulation of the wind fields at upper levels in the atmosphere and allows for a better definition of the boundary layer heights (i.e., mixing heights) and thus an improved simulation of plume dispersion. The initial wind fields from the NMM analysis were modified with the surface observations from the Kiggavik meteorological station and the combined dataset from the Baker Lake stations in order to better represent the local characteristics within the local and regional assessment areas.

In order to model wet deposition (which was required for the assessment of PAI), CALMET also requires precipitation data. Daily total precipitation from the Baker Lake Airport station was used and divided evenly over the hours in each day when there was precipitation.

The CALMET model was run for a large modelling domain measuring 117 km in an east-west direction and 65 km in a north-south direction, with a grid spacing of 1 km. The CALMET model domain was defined to include the South Winter Road Option between Baker Lake and the mine site.

To properly simulate the transport and dispersion of COPCs in CALPUFF, it is important to be able to accurately simulate the typical log-linear vertical profile of wind speed, temperature, turbulence intensity, and wind direction within the atmospheric boundary layer (i.e., within about 2,000 m above the Earth's surface). In order to capture this vertical structure, a total of ten vertical layers were selected. Within CALMET, vertical layers are defined as the midpoint between two layer interfaces. (i.e., eleven interfaces = ten layers, with the lowest layer interface always being ground level or zero). The vertical interfaces used in this study are: 0, 20, 40, 80, 160, 300, and 600, 1000, 1500, 2200 and 3000 m.

CALMET requires geophysical data in order to prepare the wind fields and other meteorological parameters. The geophysical data include:

- terrain elevation data;
- land use data;
- surface roughness length;
- albedo;
- Bowen Ratio;
- soil heat flux parameter;
- vegetation leaf area index; and
- anthropogenic heat flux.

These parameters are discussed in more detail below.

Terrain Elevation Data

Gridded terrain elevations for the modelling domain were derived from 30 arc-second Digital Elevation Models (DEM) produced by the United States Geological Survey (USGS). The spacing of the elevations is approximately 1 km. The raw terrain data was processed in each gridded cell (1 km x 1 km) within the CALMET modelling domain and the resulting terrain elevations are presented in Figure C-2. This terrain field effectively resolves major land features within the modelled area.

Land Use Data

Land use and land cover (LULC) data were processed for each CALMET grid cell to produce a 1 km resolution field of fractional land use categories and weighted land use values of surface and vegetation properties. Surface properties, such as albedo, Bowen Ratio, roughness length, soil heat flux and leaf area index are computed proportionately to the fractional land use category within each grid cell. The CALMET default values for land use categories and the land use related parameters are listed in Table C-1. These are based on the US Geological Survey and Land Use Classification System as shown in Table C-2. The generated land use categories for each CALMET grid cell are shown in Figure C-3.

To better represent local climate conditions during the winter months (October through May), the land use dataset was revised to reflect a completely snow covered/frozen landscape. In short, land use category 90 – Perennial Snow or Ice was applied to each CALMET grid cell.

Stability Classes and Mixing Heights

Meteorological mechanisms govern the dispersion, transformation and eventual removal of COPCs from the atmosphere. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component and horizontal dispersion in the boundary layer as primarily a function of the wind field. The generation of mechanical turbulence is similarly a function of the wind speed, but in combination with the surface roughness. The variability in wind direction determines the general path pollutants will follow. To adequately characterize the dispersion meteorology, information is needed on the prevailing wind regime, mixing depth and atmospheric stability.

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner assignment scheme identifies six Stability Classes, “A” to “F”, to categorize the degree of atmospheric stability (Pasquill 1962; Turner 1969). These classes indicate the characteristics of the prevailing meteorological conditions.

The stability classes are summarized in the table below. Stability Class “A” represents highly unstable conditions that are typically found during summer, categorized by strong winds and convective conditions. Conversely, Stability Class “F” relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion. Classes “B” through to “E” represent conditions intermediate to these extremes.

Atmospheric Stability Class Category Description

Atmospheric Stability Class	Category	Description
A	Very unstable	Low wind, clear skies, hot daytime conditions
B	Unstable	Clear skies, daytime conditions
C	Moderately Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very Stable	Low winds, clear skies, cold night-time conditions

The frequency of occurrence for each stability class for the modelling period August 15, 2009 to August 14, 2010 as predicted by CALMET is presented in Figure C-4. The results indicate the most typical conditions are neutral stability class “D”. The second highest frequency is stability class “F” which is indicative of highly stable conditions, which is conducive to moderate to low dispersion due to a lack of mechanical mixing.

Diurnal variations in average mixing depths predicted by CALMET are illustrated Figure C-5. It can be seen that an increase in the mixing depth begins during the morning hours due to the onset of vertical mixing following sunrise and that maximum mixing heights occur in the mid to late afternoon due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.

Wind

A summary of the average annual wind behaviour simulated by CALMET for the period August 15, 2009 to August 14, 2010 is presented in Figure C-6 and compared to the on-site (Pointer Lake) meteorological observations. The figure was generated using CALMET wind data interpolated at the grid point closest to the Pointer Lake station so that modelled and observed data can be compared.

As can be seen in Figure C-6, on-site winds derived from CALMET are predominately from the northwest (11.5% frequency) to north-northwest (9.8% frequency) at an average speed of 5.0 m/s and 5.3 m/s, respectively. The overall average annual wind speed is 4.1 m/s. Calm wind conditions (i.e., wind speeds less than 0.5 m/s) were predicted to occur 1.7% of the time. Observations at the on-site or Pointer Lake station show that the wind blows predominately from the west-northwest (10.4% frequency) at an average speed of 5.3 m/s and from the northwest (10.0 % frequency) at an average speed of 6.0 m/s. The average annual wind speed at the Pointer Lake station is 4.7 m/s. The observation dataset indicates calm conditions at the site occur 5.7% of the time. In all, the CALMET interpolated wind data compares well with on-site observations, indicating that CALMET meteorological wind data is sufficiently representative for air dispersion modelling purposes.

Table C-1 Default CALMET Land Use Categories and Associated Geophysical Parameters

Land Use Type	Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m ^{2})	Leaf Area Index
10	Urban or Built-up Land	1	0.18	1.5	0.25	0	0.2
20	Agricultural Land – UnIrrigated	0.25	0.15	1	0.15	0	3
-20*	Agricultural Land – Irrigated	0.25	0.15	0.5	0.15	0	3
30	Rangeland	0.05	0.25	1	0.15	0	0.5
40	Forest Land	1	0.1	1	0.15	0	7
50	Water	0.001	0.1	0	1	0	0
54	Small Water Body	0.001	0.1	0	1	0	0
55	Large Water Body	0.001	0.1	0	1	0	0
60	Wetland	1	0.1	0.5	0.25	0	2
61	Forested Wetland	1	0.1	0.5	0.25	0	2
62	Nonforested Wetland	0.2	0.1	0.1	0.25	0	1
70	Barren Land	0.05	0.3	1	0.15	0	0.05
80	Tundra	0.2	0.3	0.5	0.15	0	0
90	Perennial Snow or Ice	0.05	0.7	0.5	0.15	0	0

Source: Scire et al 2000a

Notes:

Land use categories and geophysical parameters are based on the 14-cateorgy system of the US Geological Survey Land Use Classification System (Table C-2).

Table C-2 US Geological Survey Land Use and Land Cover Classification System

Level I		Level II	
10	Urban or Built-up Land	11	Residential
		12	Commercial and Services
		13	Industrial
		14	Transportation, Communications and Utilities
		15	Industrial and Commercial Complexes
		16	Mixed Urban or Built-up Land
		17	Other Urban or Built-up Land
20	Agricultural Land	21	Cropland
		22	Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
		23	Confined Feeding Operations
		24	Other Agricultural Land
30	Rangeland	31	Herbaceous Rangeland
		32	Shrub and Brush Rangeland
		33	Mixed Rangeland
40	Forest Land	41	Deciduous Forest Land
		42	Evergreen Forest Land
		43	Mixed Forest Land
50	Water	51	Streams and Canals
		52	Lakes
		53	Reservoirs
		54	Bays and Estuaries
		55	Oceans and Seas
60	Wetland	61	Forested Wetland
		62	Nonforested Wetland
70	Barren Land	71	Dry Salt Flats
		72	Beaches
		73	Sandy Areas Other than Beaches
		74	Bare Exposed Rock
		75	Strip Mines, Quarries, and Gravel Pits
		76	Transitional Areas
		77	Mixed Barren Land
80	Tundra	81	Shrub and Brush Tundra
		82	Herbaceous Tundra
		83	Bare Ground
		84	Wet Tundra
		85	Mixed Tundra
90	Perennial Snow/Ice	91	Perennial Snowfields
		92	Glaciers

Source: Scire et al 2000a

Figure C-1 NMM Grid Points within the Regional and Local Study Areas used to initialize the CALMET Model

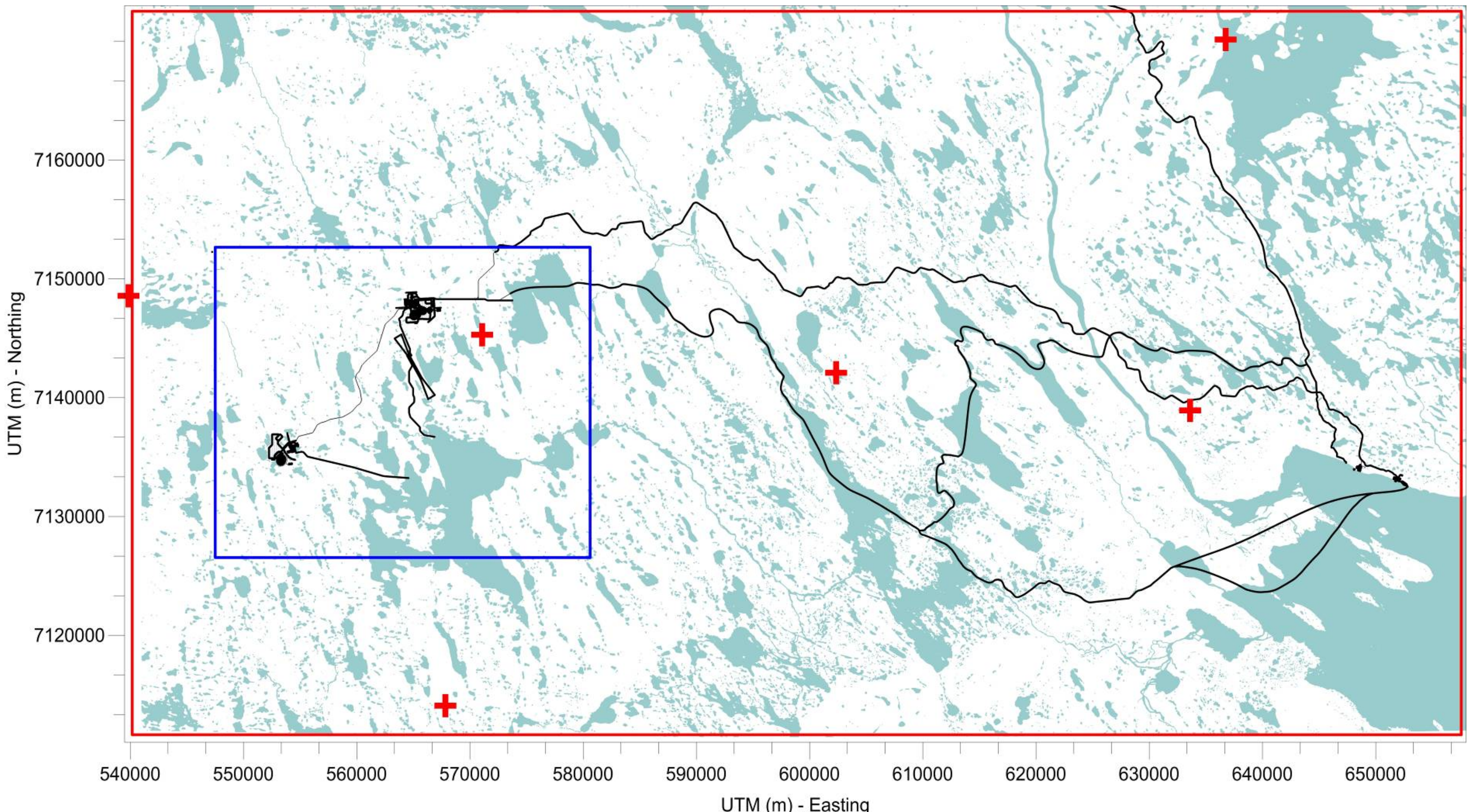


Figure C-2 CALMET Terrain Elevations

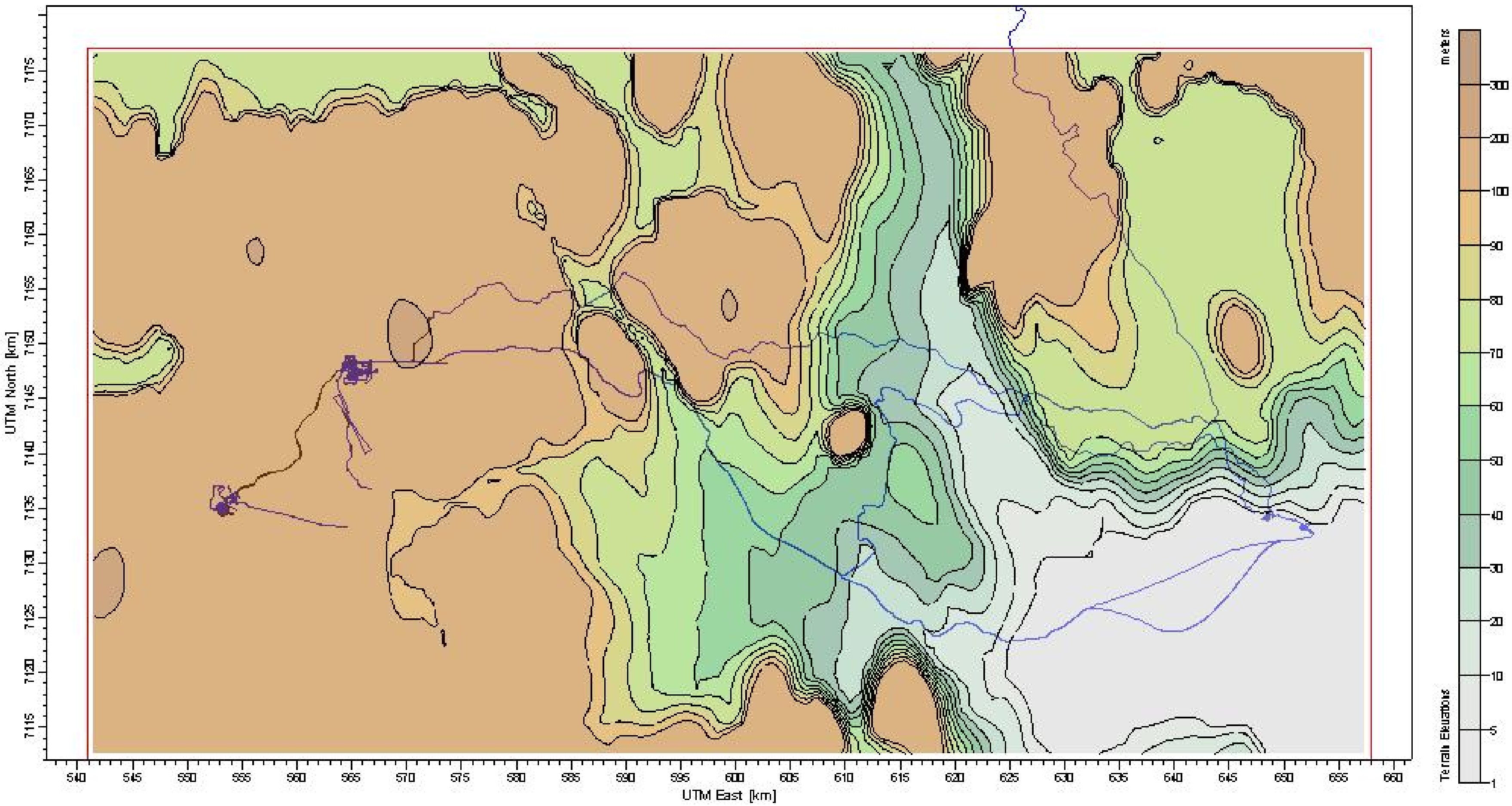


Figure C-3 CALMET Land Use Data

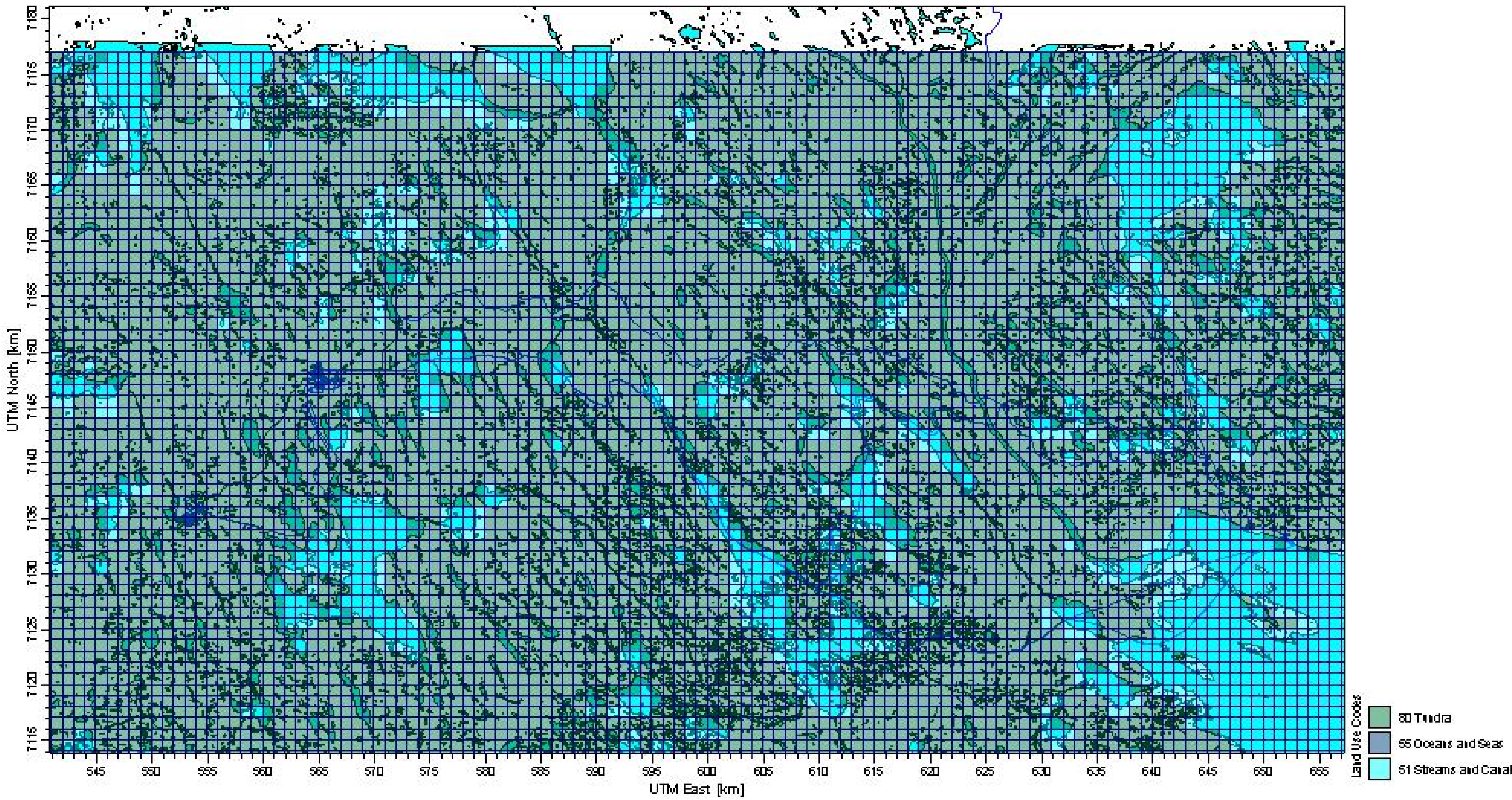


Figure C-4 CALMET Stability Class Frequency for the period August 15, 2009 to August 14, 2010

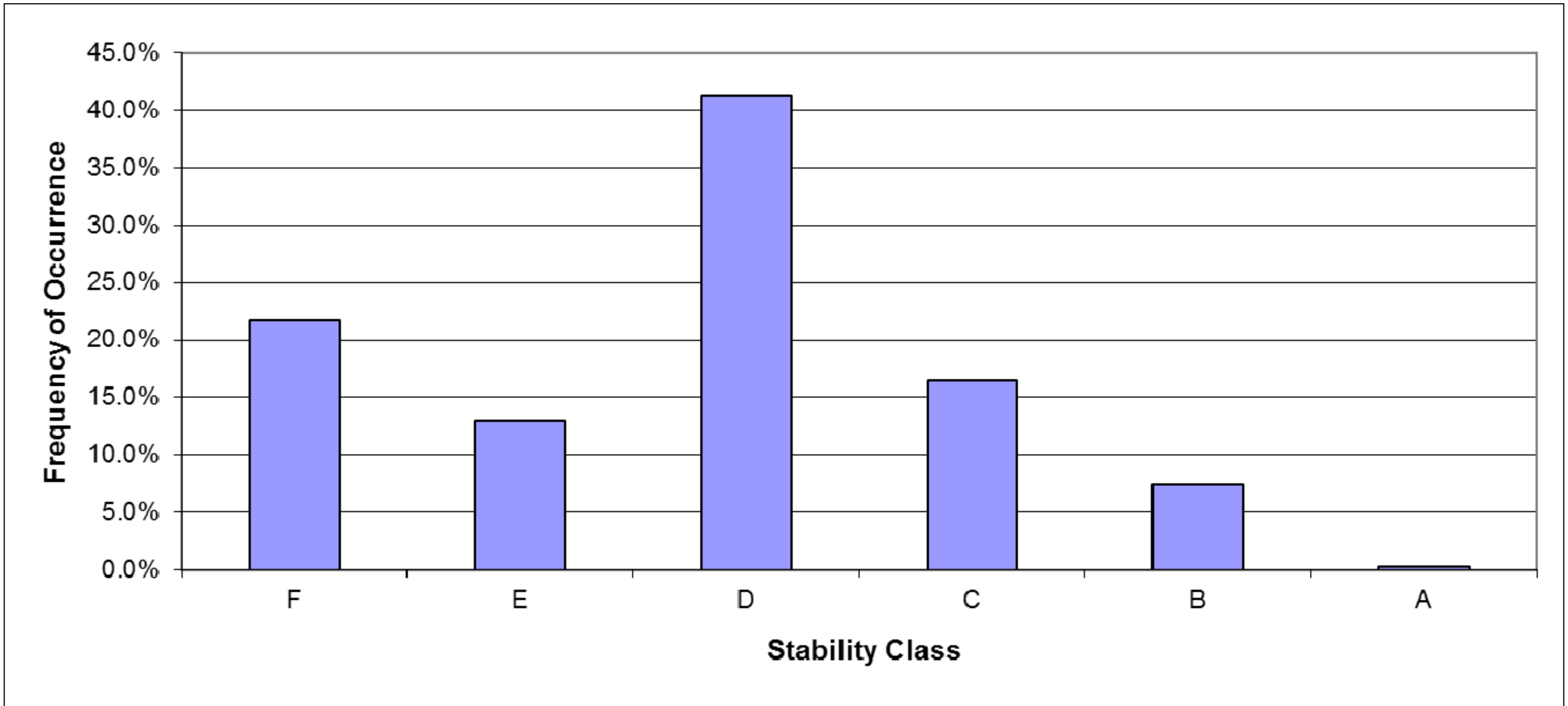


Figure C-5 Diurnal Variation in Average CALMET Mixing Heights for the period August 15, 2009 to August 14, 2010

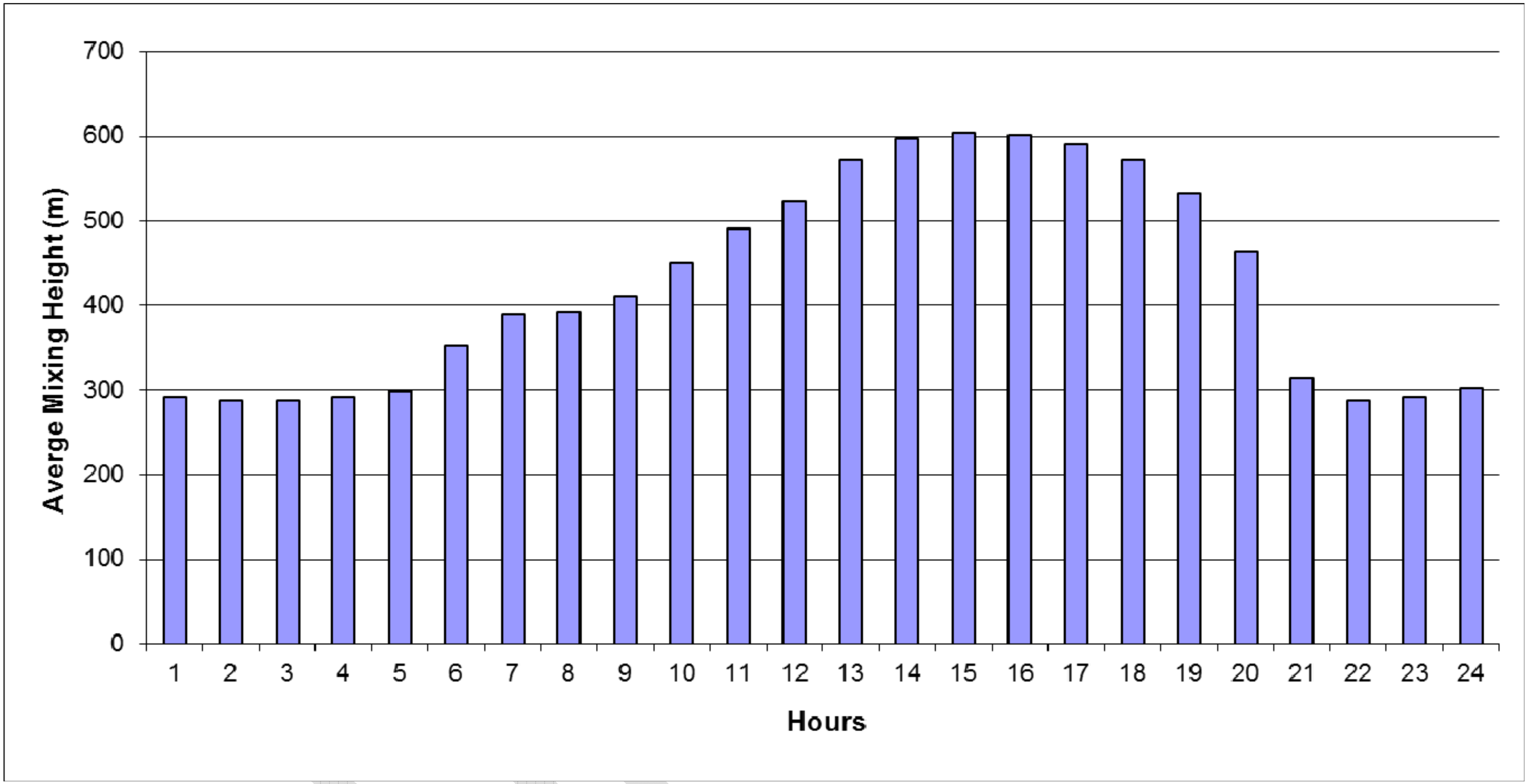
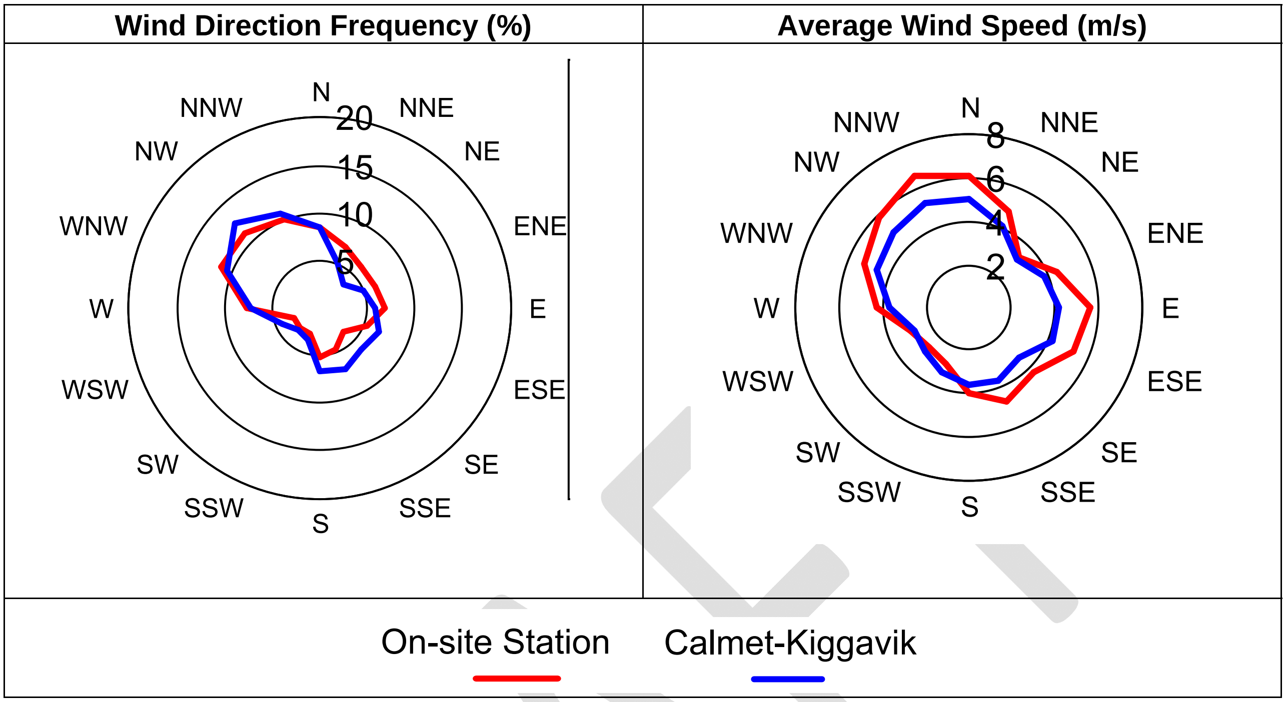


Figure C-6 Wind Rose Comparison of CALMET-Kiggavik Meteorological Dataset to On-Site Station Observations for the period August 15, 2009 to August 14, 2010



Notes:
Percentage of Calms for the On-site Station: 5.4%
Percentage of Calms for CALMET-Kiggavik: 1.7%

Attachment C.2 Model Setup

Table C-3 Kiggavik and Sissons Mine Sites Area Source Parameters

Emission Source	Source Type	UTM Coordinates (m)		Area (m^2)	Total Area (m^2)
		East	North		
Main Zone Pit	Area	565193	7147001	86,002	421,406
		565228	7147000	76,004	
		565000	7147003	41,296	
		565003	7146996	103,708	
		565004	7146998	70,299	
		564999	7147255	44,097	
Andrew Lake Pit	Area	553115	7135006	63,908	468,802
		552999	7134424	404,894	
Central Zone Pit	Area	565650	7147120	122,768	142,820
		566004	7147104	20,052	
East Zone Pit	Area	566346	7147234	65,894	65,894
Purpose Build Pit	Area	565416	7147477	28,007	28,007

Table C-4 Kiggavik and Sissons Mine Sites Volume Source Parameters

Emission Source	Source Type	Number of Volume Sources	Maximum Source Height (m)
Kiggavik Ore Pile	Volume	3	10
Kiggavik Type II Mine Rock Pile - North	Volume	6	50
Kiggavik Type II Mine Rock Pile - South	Volume	13	50
Kiggavik Type III Mine Rock Pile	Volume	2	10
Kiggavik Overburden Pile	Volume	2	10
Mill	Volume	3	22
Andrew Lake Type II Mine Rock Pile	Volume	6	50
Andrew Lake Type III Mine Rock Pile	Volume	6	10
Andrew Lake Ore Pile	Volume	1	10
Andrew Lake Overburden Pile	Volume	1	10
End Grid Clean Rock Pile	Volume	1	10
End Grid Special Waste Rock Pile	Volume	1	10
End Grid Ore Pile	Volume	1	10

Table C-5 Kiggavik and Sissons Mine Sites Point Source Parameters

Emission Source	Source Type	UTM Coordinates (m)		Stack Parameters			
		East	North	Height (m)	Diameter (m)	Exit Velocity (m/s)	Exit Temperature (Deg. C)
Kiggavik Power Plant	Point	564776	7147770	30	0.9	20	330
		564779	7147770	30	0.9	20	330
		564778	7147770	30	0.9	20	330
		564778	7147770	30	0.9	20	330
Sissons Power Plant	Point	554087	7135764	30	0.9	20	330
Kiggavik Incinerator	Point	565365	7147847	11.8	0.97	9.85	1000
Sissons Incinerator	Point	554094	7135826	11.8	0.97	9.85	1000
Acid Plant	Point	564854	7147754	30	1.2	8.5	82
Underground Mine Exhaust	Point	554724	7135969	1	5	14.5	2
Backfill Plant	Point	554238	7135635	15	0.5	15	5

ATTACHMENT D	**AIR DISPERSION MODELLING RESULTS**
ATTACHMENT D.1	**MODEL RESULTS: TABULAR**
ATTACHMENT D.2	**MODEL RESULTS: GRAPHICAL**

Attachment D.1 Model Results: Tabular

Table D - 1 Quarry Assessment – Maximum Predicted COPC Concentrations at 500 m Distance from Selected Quarries

Quarry	UTM Coordinates (m)		Maximum Incremental Concentration (µg/m³) at a distance of 500 m from the Quarry						
	Easting	Northing	TSP	PM_{10}	$PM_{2.5}$	NO_2		SO_2	
			24-hour Maximum	24-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum
Q2	573460	7152497	14.6	7.9	6.0	38.6	10.6	0.8	0.2
Q10	615476	7150167	9.5	5.6	4.3	37.2	7.5	0.7	0.1
Q18	642133	7138389	9.9	5.4	4.1	34.1	7.2	0.7	0.1
Air Quality Criteria (µg/m³)			**120**	**50**	**-**	**400**	**200**	**450**	**150**

Notes:
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} criterion adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
NO_2 criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table D - 2 Maximum Bounding Scenario – Maximum Increment 1- and 24-hr Concentrations of COPCs

Discrete Receptor	UTM Coordinates (m)		Maximum Incremental Concentration (µg/m³)								
	Easting	Northing	TSP	PM_{10}	$PM_{2.5}$		Uranium	NO_2		SO_2	
			24-hour	24-hour	24-hr 98th Percentile	24-hour	24-hour	1-hour	24-hour	1-hour	24-hour
Accommodation Complex	564900	7148433	283.20 (8 days)	115.20 (12 days)	14.13	22.50	0.31 (1 day)	380.70	171.90	41.00	15.40
Community of Baker Lake	644179	7135840	0.70	0.60	0.06	0.20	0.00	3.80	1.00	0.16	0.04
Judge Sissons Lake Cabin	566550	7137729	12.80	11.10	0.88	2.00	0.02	36.50	12.90	2.70	0.80
Air Quality Criteria (µg/m³)			**120**	**50**	**30***	-	**0.3**	**400**	**200**	**450**	**150**

Notes:
Red text indicates that a value is greater than the air quality criteria. Number of exceedances indicated in brackets.
Concentrations predicted as a result of all sources, including blasting.
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} criterion adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
* Canada-Wide Standard for $PM_{2.5}$ based on the average 98th percentile over 3 consecutive years. Note that modelling only occurred over 1 year.
NO_2 criterion adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.
Uranium criterion adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190

Table D - 3 Maximum Bounding Scenario – Maximum Incremental 24-hr Metal Concentrations

Receptor Name	UTM Coordinates (m)		24-hour Maximum Incremental Concentration (µg/m³)									
	Easting	Northing	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	8.10E-04	5.30E-05	2.60E-02	3.60E-03	6.10E-03	1.80E-02	7.60E-03	1.10E-02	4.90E-04	1.10E-02
Community of Baker Lake	644179	7135840	8.30E-06	2.70E-07	1.60E-04	1.50E-05	2.80E-05	5.60E-05	1.80E-05	6.00E-05	2.90E-06	4.60E-05
Judge Sissons Lake Cabin	566550	7137729	1.60E-04	5.70E-06	4.60E-03	2.40E-04	5.00E-04	9.70E-04	3.70E-04	1.30E-03	6.00E-05	7.10E-04
Air Quality Criteria (µg/m³)			**0.3**	**0.025**	**0.5**	**0.1**	**50**	**0.5**	**120**	**0.2***	**10**	**120**

Notes:
24-hour criteria provided in Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
*Nickel criterion adopted from the Ontario Ministry of Environment's new standard under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table D - 4 Annual Incremental COPC Concentrations for Phased Operations Period 1 to 4

Discrete Receptor	UTM Coordinates (m)		Operation Period	Annual Incremental Concentration (μg/m³)								
	Easting	Northing		TSP	PM_{10}	$PM_{2.5}$	Uranium	NO_2	SO_2	Radon (Bq/m³)	Pb-210 (Bq/m³)	Po-210 (Bq/m³)
Accommodation Complex	564900	7148433	Period 1 (Year 0-1)	19.58	8.68	1.97	0.01	13.65	1.31	7.72	1.50E-04	1.50E-04
			Period 2 (Year 2-5)	14.32	6.97	1.81	0.02	10.39	0.63	12.45	2.10E-04	2.10E-04
			Period 3 (Year 6-13)	4.82	2.99	1.12	0.01	6.22	0.36	10.88	1.30E-04	1.30E-04
			Period 4 (Year 14)	1.42	1.02	0.56	0.01	6.56	0.13	9.09	8.20E-05	8.20E-05
			Maximum	19.58	8.68	1.97	0.02	13.65	1.31	12.45	2.10E-04	2.10E-04
Community of Baker Lake	644179	7135840	Period 1 (Year 0-1)	0.01	0.01	0.00	0.00	0.03	0.00	0.01	1.40E-07	1.40E-07
			Period 2 (Year 2-5)	0.02	0.01	0.00	0.00	0.04	0.00	0.01	2.10E-07	2.10E-07
			Period 3 (Year 6-13)	0.01	0.01	0.00	0.00	0.04	0.00	0.01	2.00E-07	2.00E-07
			Period 4 (Year 14)	0.00	0.00	0.00	0.00	0.02	0.00	0.01	3.00E-08	3.00E-08
			Maximum	0.02	0.01	0.00	0.00	0.04	0.00	0.01	2.10E-07	2.10E-07
Judge Sissons Lake Cabin	566550	7137729	Period 1 (Year 0-1)	0.53	0.34	0.08	0.00	0.78	0.06	0.19	5.30E-06	5.30E-06
			Period 2 (Year 2-5)	0.77	0.47	0.11	0.00	0.80	0.03	0.29	7.80E-06	7.80E-06
			Period 3 (Year 6-13)	0.41	0.29	0.08	0.00	0.59	0.02	0.24	5.10E-06	5.10E-06
			Period 4 (Year 14)	0.05	0.04	0.03	0.00	0.40	0.00	0.20	1.00E-06	1.00E-06
			Maximum	0.77	0.47	0.11	0.00	0.80	0.06	0.29	7.80E-06	7.80E-06
Air Quality Criteria (μg/m³)				**60**	**-**	**-**	**0.03**	**60**	**30**	**60 (Bq/m³)**	**0.21 (Bq/m³)**	**0.028 (Bq/m³)**

Notes:
NO_2 concentrations predicted as a result of all sources, including blasting.
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} criterion adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
NO_2 AQ criteria from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.
Uranium criteria adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190

Table D - 5 Annual Incremental Metal Concentrations for Phased Operations Period 1 to 4

Discrete Receptor	UTM Coordinates (m)		Operation Period	Annual Concentration (µg/m³)									
	Easting	Northing		As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	Period 1 (Year 0-1)	8.30E-04	3.70E-06	1.50E-03	2.80E-04	4.80E-04	1.00E-03	3.20E-04	7.90E-04	3.10E-05	9.00E-04
			Period 2 (Year 2-5)	4.20E-04	3.10E-06	1.00E-03	1.80E-04	3.00E-04	1.20E-03	6.00E-04	5.30E-04	2.30E-05	5.30E-04
			Period 3 (Year 6-13)	6.10E-04	1.60E-06	9.80E-04	3.00E-05	9.90E-05	4.20E-04	8.50E-05	1.60E-04	5.60E-06	9.00E-05
			Period 4 (Year 14)	4.50E-04	1.00E-06	6.20E-04	1.20E-05	4.80E-05	2.80E-04	5.50E-05	8.20E-05	2.30E-06	3.60E-05
			Maximum	8.30E-04	3.70E-06	1.50E-03	2.80E-04	4.80E-04	1.20E-03	6.00E-04	7.90E-04	3.10E-05	9.00E-04
Community of Baker Lake	644179	7135840	Period 1 (Year 0-1)	1.50E-06	3.10E-09	1.50E-06	3.00E-07	4.60E-07	9.10E-07	3.00E-07	8.30E-07	3.40E-08	9.40E-07
			Period 2 (Year 2-5)	2.30E-06	4.50E-09	2.50E-06	3.40E-07	5.30E-07	1.10E-06	4.50E-07	1.20E-06	5.30E-08	1.00E-06
			Period 3 (Year 6-13)	3.80E-06	5.00E-09	3.40E-06	1.60E-07	3.70E-07	8.20E-07	1.60E-07	9.90E-07	4.60E-08	5.20E-07
			Period 4 (Year 14)	3.10E-07	4.70E-10	3.20E-07	9.80E-09	2.60E-08	1.00E-07	1.80E-08	6.80E-08	2.70E-09	3.20E-08
			Maximum	3.80E-06	5.00E-09	3.40E-06	3.40E-07	5.30E-07	1.10E-06	4.50E-07	1.20E-06	5.30E-08	1.00E-06
Judge Sissons Lake Cabin	566550	7137729	Period 1 (Year 0-1)	4.20E-05	1.20E-07	5.70E-05	1.10E-05	1.70E-05	3.60E-05	1.30E-05	3.00E-05	1.30E-06	3.40E-05
			Period 2 (Year 2-5)	3.90E-05	1.60E-07	8.80E-05	1.30E-05	2.00E-05	4.40E-05	1.80E-05	4.20E-05	1.90E-06	4.00E-05
			Period 3 (Year 6-13)	1.30E-04	1.30E-07	9.70E-05	4.80E-06	1.20E-05	2.30E-05	4.60E-06	2.80E-05	1.30E-06	1.50E-05
			Period 4 (Year 14)	7.60E-06	1.50E-08	9.60E-06	2.70E-07	8.10E-07	3.50E-06	6.70E-07	1.80E-06	6.70E-08	8.40E-07
			Maximum	1.30E-04	1.60E-07	9.70E-05	1.30E-05	2.00E-05	4.40E-05	1.80E-05	4.20E-05	1.90E-06	4.00E-05
			Air Quality Criteria (µg/m³)	0.06	0.005	0.3	0.02	9.6	0.1	23	0.4	1.9	23

Notes:
Annual Air Quality Criteria developed from in Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
*Nickel criterion adopted from the Ontario Ministry of Environment's new standard under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table D - 6 Incremental Annual Dust Deposition for Phased Operations Period 2 (Year 2-5)

Receptor Name	UTM Coordinates (m)		Dust Deposition	
	Easting	Northing	Average Annual (g/m²/30 days)	Total Annual (g/m²/year)
Camp	564900	7148433	5.20E-01	6.32E+00
Baker Lake	644179	7135840	1.78E-04	2.17E-03
Judge Sissons Lake	566550	7137729	3.21E-02	3.91E-01
		Air Quality Criteria	**4.6 g/m²/30 days**	**55 g/m²/year**

Table D - 7 Estimated Annual Potential Acid Input based on Phased Operations Period 2 NO_2 and SO_2 Emissions

Parameter	Background PAI (keq/ha/yr)	Total PAI (keq/ha/yr)		Mine Contribution to PAI (%)
		Kiggavik	Sissons	
Max. Annual Average Deposition	0.093	0.294	0.172	68%
Area above 0.17 keq/ha/yr (ha)	0	2200	0	100%
Area above 0.22 keq/ha/yr (ha)	0	730	0	100%
Area above 0.25 keq/ha/yr (ha)	0	225	0	100%
Area above 0.50 keq/ha/yr (ha)	0	0	0	n/a
Area above 1.00 keq/ha/yr (ha)	0	0	0	n/a

Notes:
Mine contribution refers to both mine sites, Kiggavik and Sissons.

Table D - 8 Overall Maximum Incremental TSP, NO_2 and SO_2 Concentrations predicted for each Kiggavik-Baker Lake Access Road Option

Access Road Option	Overall Maximum Incremental Concentration							
	TSP (µg/m^3)		NO_2 (µg/m^3)			SO_2 (µg/m^3)		
	24-hr Maximum	Annual	1-hr Maximum	24-hr Maximum	Annual	1-hr Maximum	24-hr Maximum	Annual
North All-Season Road	54.92	5.11	1.40E-01	7.00E-02	8.80E-03	1.00E-02	5.40E-03	6.70E-04
North Winter Road	52.76	3.25	8.40E-01	4.80E-01	2.80E-02	7.30E-02	4.10E-02	2.40E-03
South Winter Road	44.95	1.83	6.50E-01	4.30E-01	1.70E-02	5.60E-02	3.70E-02	1.40E-03
Air Quality Criteria (µg/m^3)	**120**	**60**	**400**	**200**	**100**	**450**	**150**	**30**

Notes:
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
NO_2 criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table D - 9 Dock and Storage Facility Incremental Dust and Gaseous Concentrations Predicted at the Community of Baker Lake

Receptor	UTM Coordinates (m)		Incremental Concentration									
			TSP (µg/m^3)		PM_{10} (µg/m^3)	PM2.5 (µg/m^3)	NO_2 (µg/m^3)			SO_2 (µg/m^3)		
	Easting	Northing	24-hour Maximum	Annual	24-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual
Community of Baker Lake	644179	7135840	8.8E-01	7.7E-05	8.7E-01	8.0E-01	59.86	11.70	0.19	5.51	1.11	0.02
Air Quality Criteria (µg/m^3)			**120**	**60**	**50**	**-**	**400**	**200**	**100**	**450**	**150**	**30**

Notes:
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} criterion adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
NO_2 criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.

Table D - 10 Incremental Annual COPC Concentrations during Final Closure

Receptor Name	UTM Coordinates (m)		Incremental Annual Concentration (µg/m³)								
	Easting	Northing	TSP	PM_{10}	$PM_{2.5}$	Uranium	NO_2	SO_2	Radon (Bq/m^3)	Pb-210 (Bq/m^3)	Po-210 (Bq/m^3)
Accommodation Complex	564900	7148433	1.10	0.69	0.42	0.00	6.40	0.03	6.40	8.2E-06	8.2E-06
Community of Baker Lake	644179	7135840	0.00	0.00	0.00	0.00	0.01	0.00	0.01	1.3E-08	1.3E-08
Judge Sissons Lake Cabin	566550	7137729	0.05	0.04	0.03	0.00	0.43	0.00	0.43	4.8E-07	4.8E-07
Air Quality Criteria (µg/m³)			**60**	**-**	**-**	**0.03**	**100**	**30**	**60 (Bq/m^3)**	**0.21 (Bq/m^3)**	**0.028 (Bq/m^3)**

Notes:
TSP and SO_2 criteria based on Nunavut Department of Sustainable Development Environmental Guideline for Air Quality - Sulphur Dioxide & Suspended Particulates, 2002.
PM_{10} criterion adopted from Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
NO_2 criteria adopted from the NWT Department of Environment and Natural Resources Guideline for Ambient Air Quality Standards in the Northwest Territories, January 2011.
Uranium criteria adopted from the Ontario Ministry of Environment's new AAQC under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190

Table D - 11 Predicted Incremental Annual Metal Concentrations during Final Closure

Receptor Name	UTM Coordinates (m)		Incremental Annual Concentration (µg/m³)									
	Easting	Northing	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	1.3E-06	6.1E-08	5.6E-05	1.1E-05	3.5E-05	2.5E-05	1.1E-05	2.7E-05	1.5E-06	3.5E-05
Community of Baker Lake	644179	7135840	3.6E-09	1.5E-10	1.3E-07	1.5E-08	4.0E-08	3.5E-08	1.1E-08	5.3E-08	2.7E-09	4.8E-08
Judge Sissons Lake Cabin	566550	7137729	1.3E-07	5.1E-09	4.5E-06	5.3E-07	1.6E-06	1.3E-06	4.5E-07	1.8E-06	9.6E-08	1.8E-06
Air Quality Criteria (µg/m³)			0.06	0.005	0.3	0.02	9.6	0.10	23	0.4	1.9	23

Notes:
Annual Air Quality criteria developed from in Ontario's Ambient Air Quality Criteria, Ontario Ministry of Environment Standards and Development Branch, 2008.
*Nickel AQ criteria adopted from the Ontario Ministry of Environment's new standard under Regulation 419/05 accepted June 22, 2011. EBR No. 010-7190.

Table D - 12 Predicted Incremental Annual Radon Concentrations during Post-Closure

Receptor Name	UTM Coordinates (m)		Radon (Bq/m^3)
	Easting	Northing	Annual Concentration
Accommodation Complex	564900	7148433	1.1E+00
Community of Baker Lake	644179	7135840	3.1E-03
Judge Sissons Lake Cabin	566550	7137729	8.4E-02
		Air Quality Criteria (Bq/m^3)	**60**

Figure D-1 Quarry Assessment - Incremental Maximum 24-hr TSP Concentration (µg/m³)

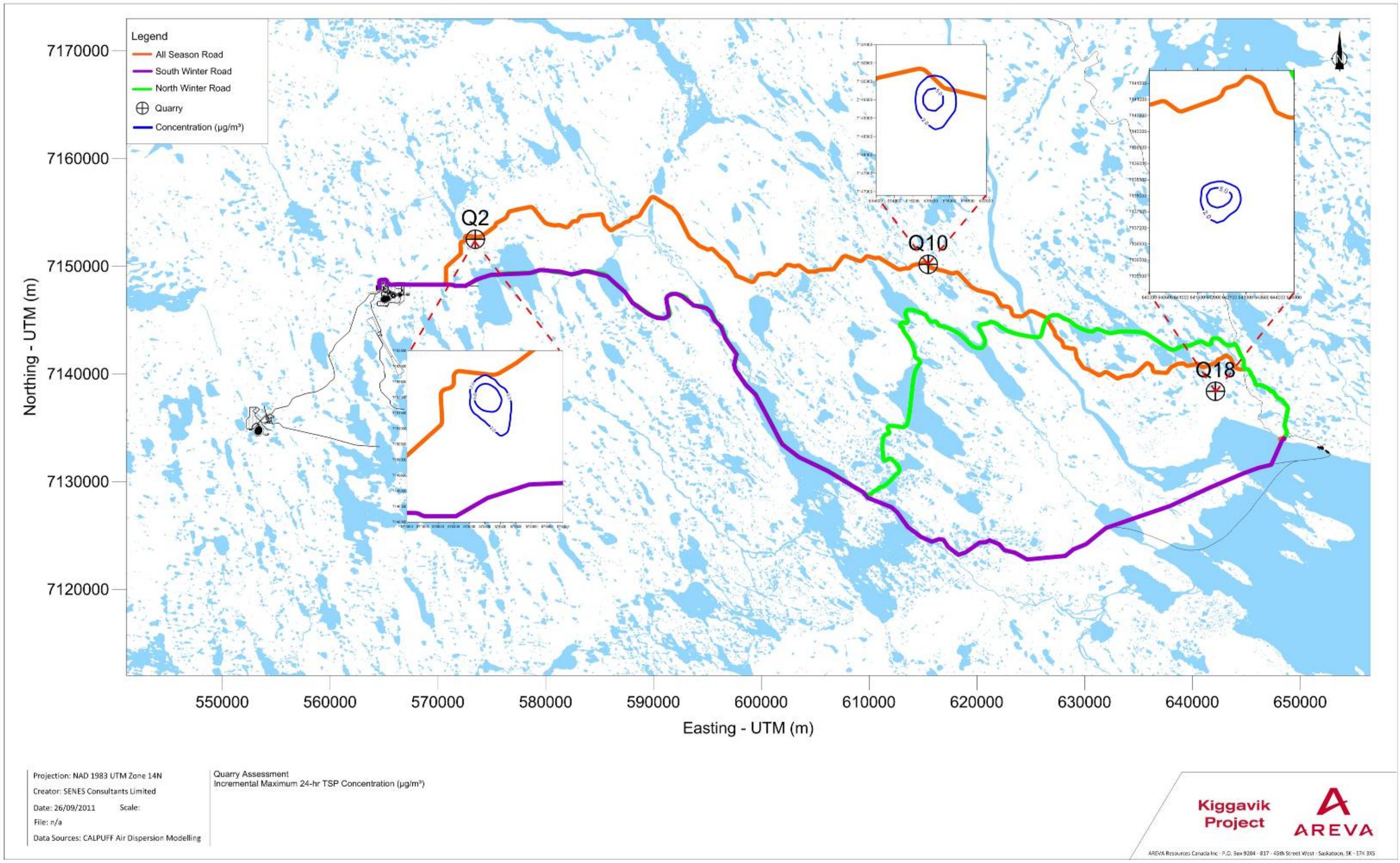


Figure D-2 Maximum Bounding Scenario - Incremental Maximum 24-hr TSP Concentration (µg/m³)

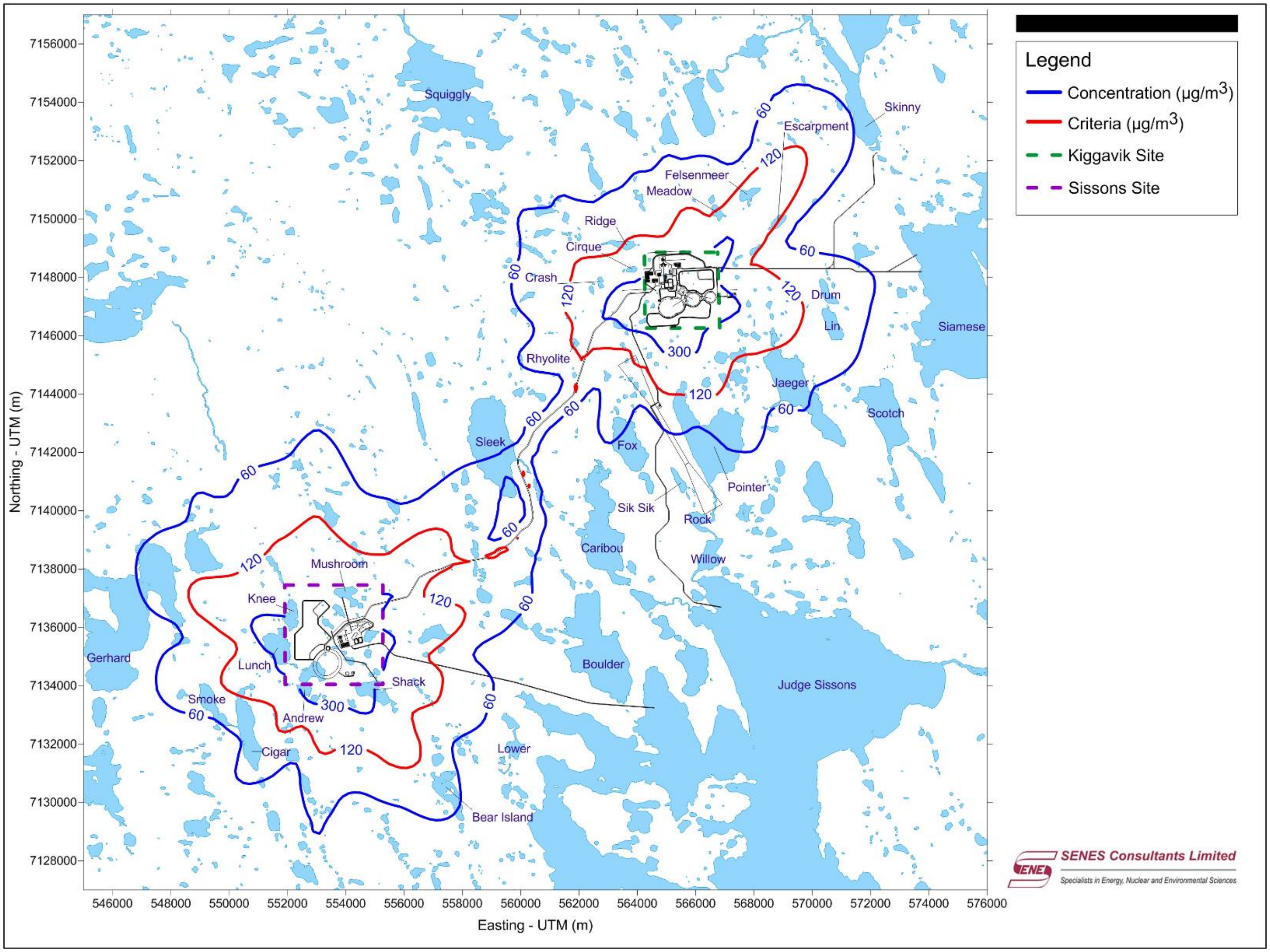


Figure D-3 Maximum Bounding Scenario - 24-hr TSP Exceedances (days)

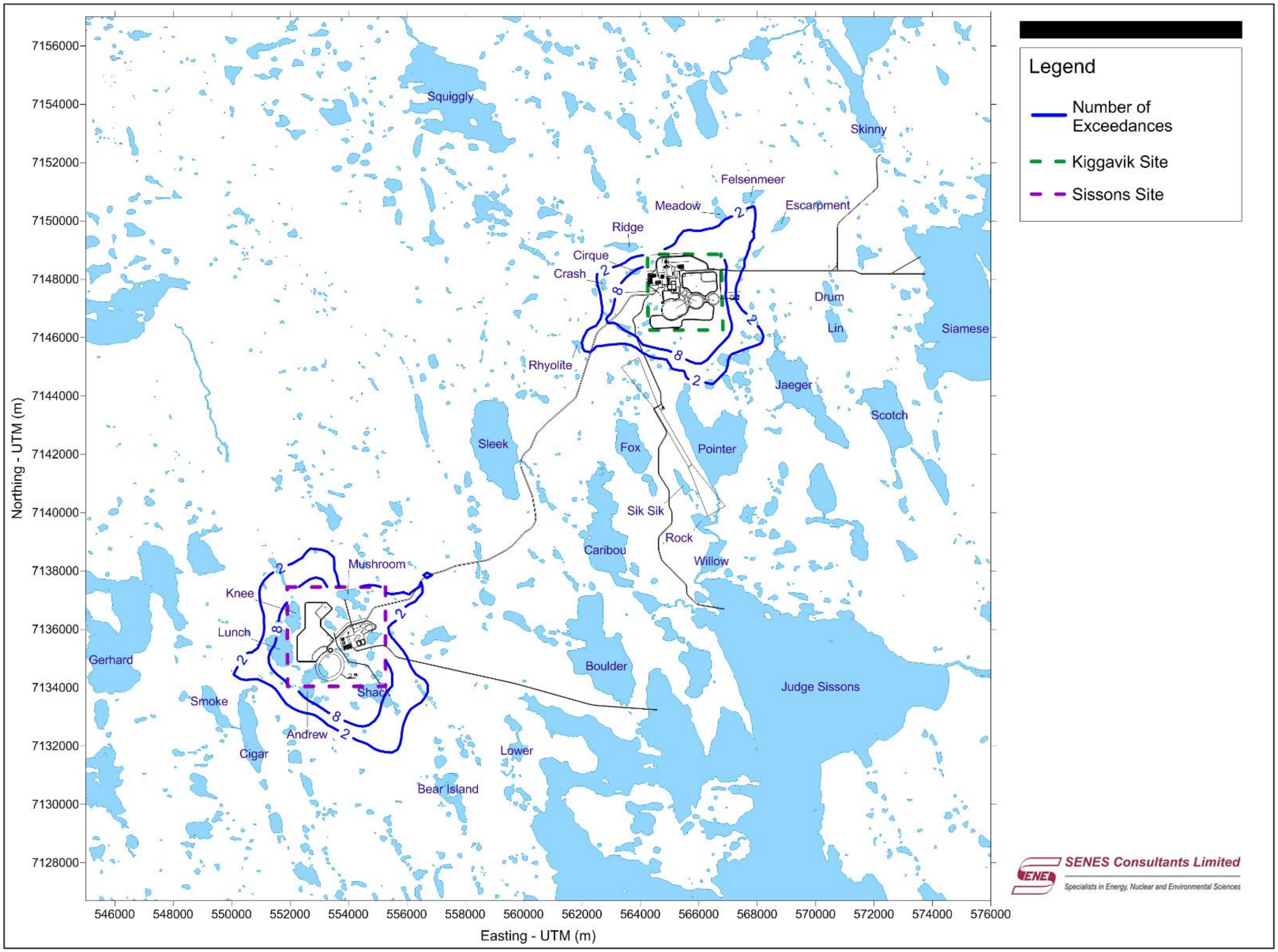


Figure D-4 Maximum Bounding Scenario - Incremental Maximum 24-hr PM_{10} Concentration (µg/m³)

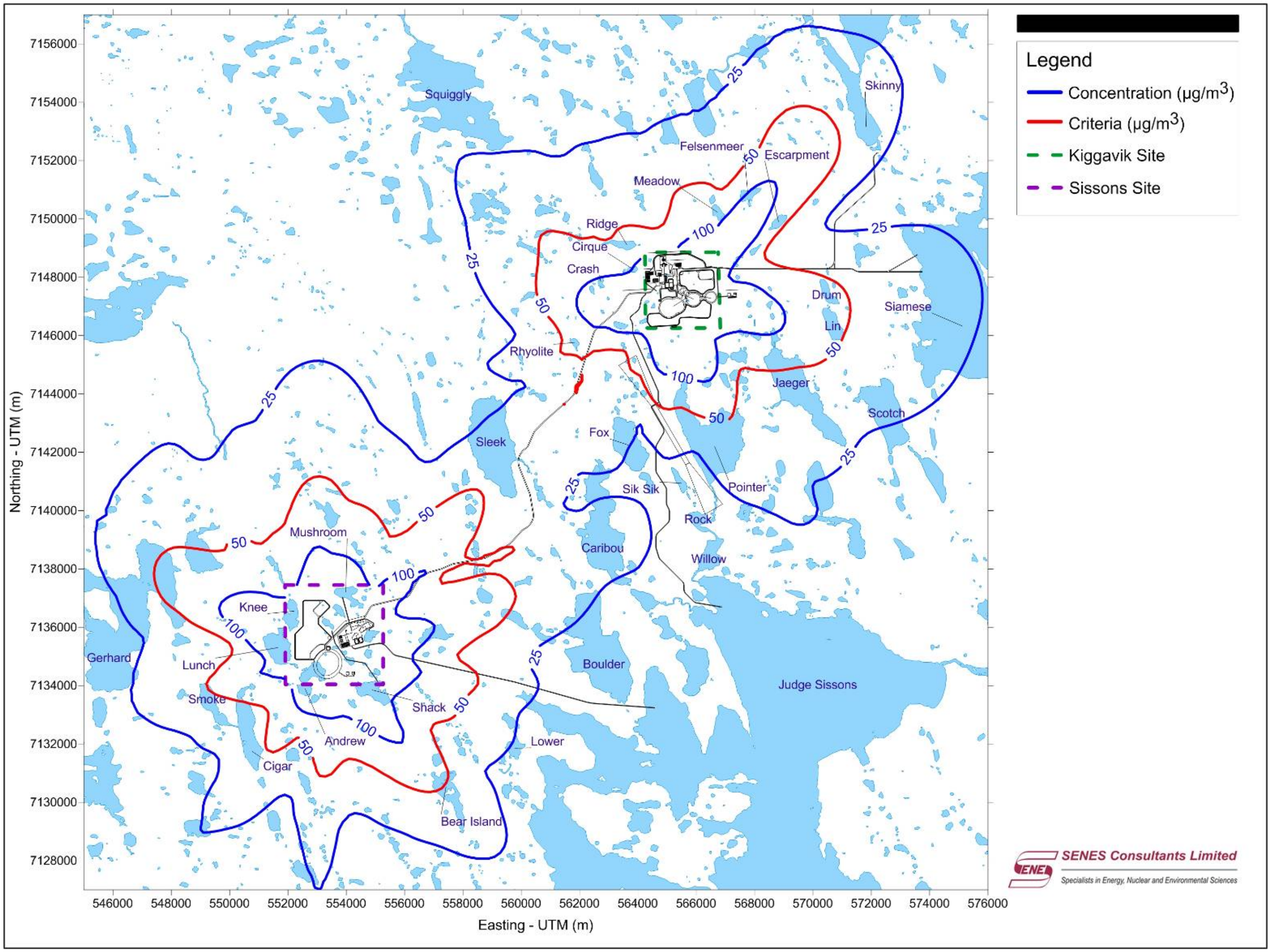


Figure D-5 Maximum Bounding Scenario - 24-hr PM_{10} Exceedances (days)

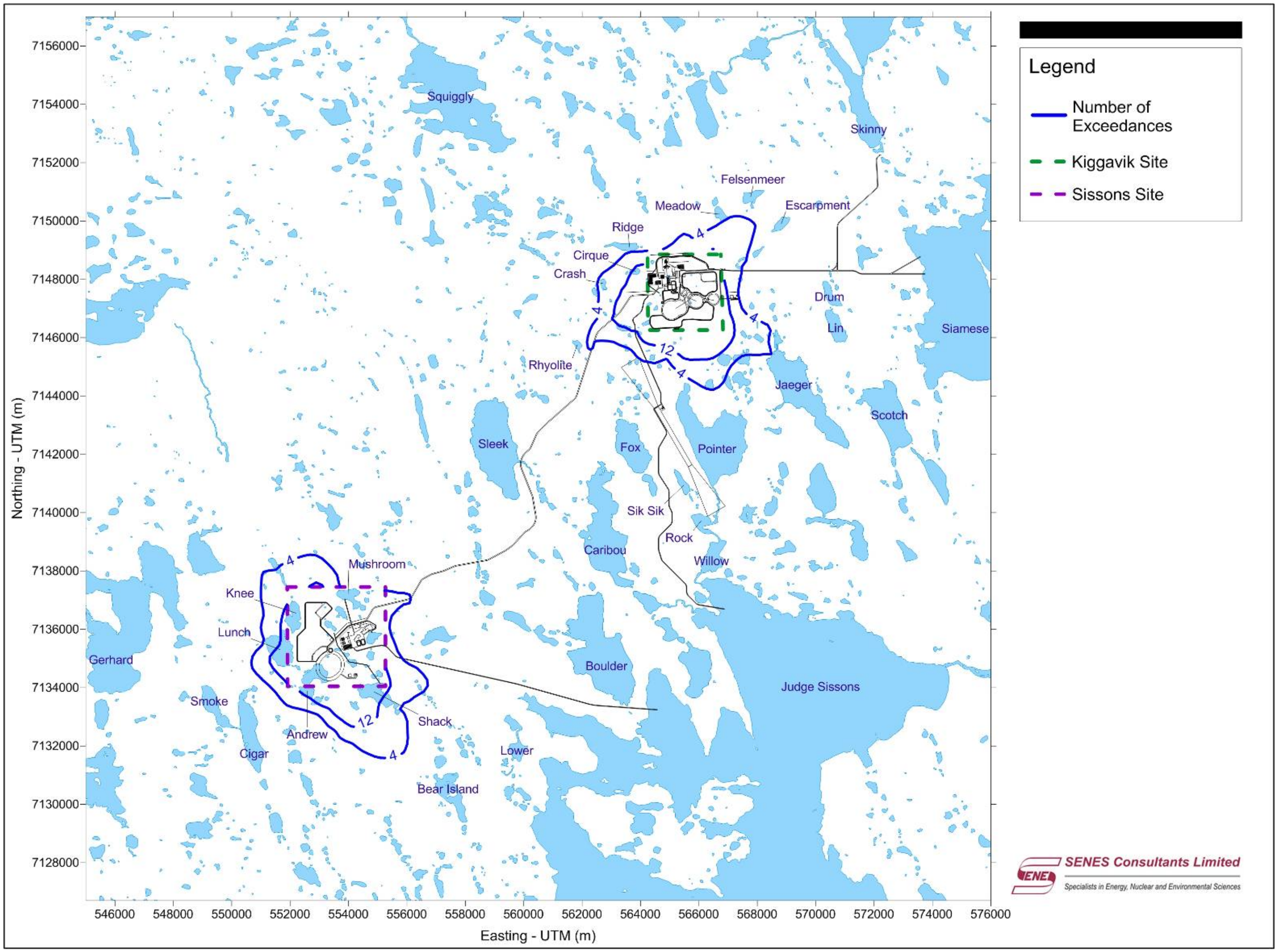


Figure D-6 Maximum Bounding Scenario - Incremental Maximum 24-hr $PM_{2.5}$ Concentration (µg/m³)

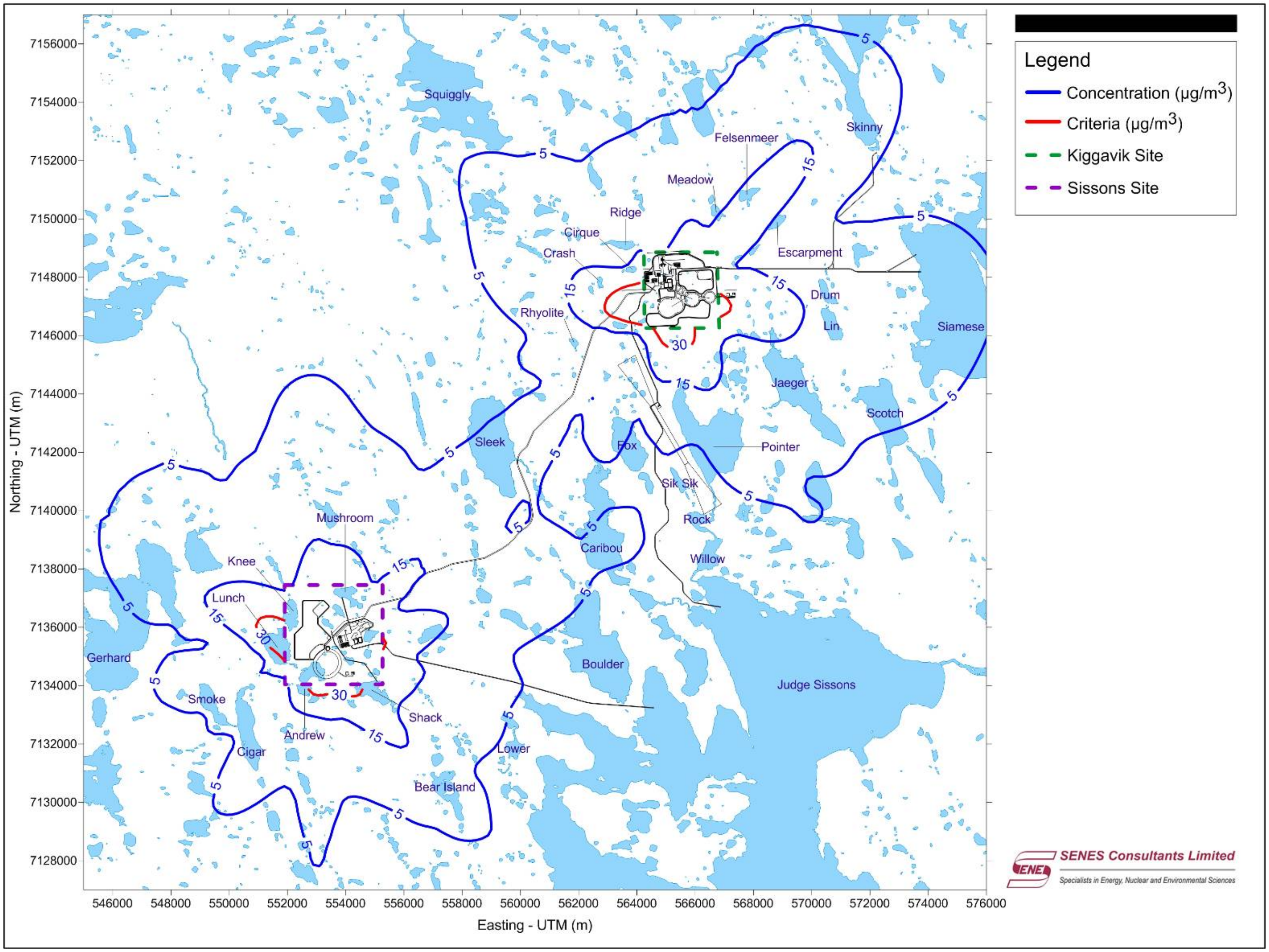


Figure D-7 Maximum Bounding Scenario - 24-hr $PM_{2.5}$ Exceedances (days)

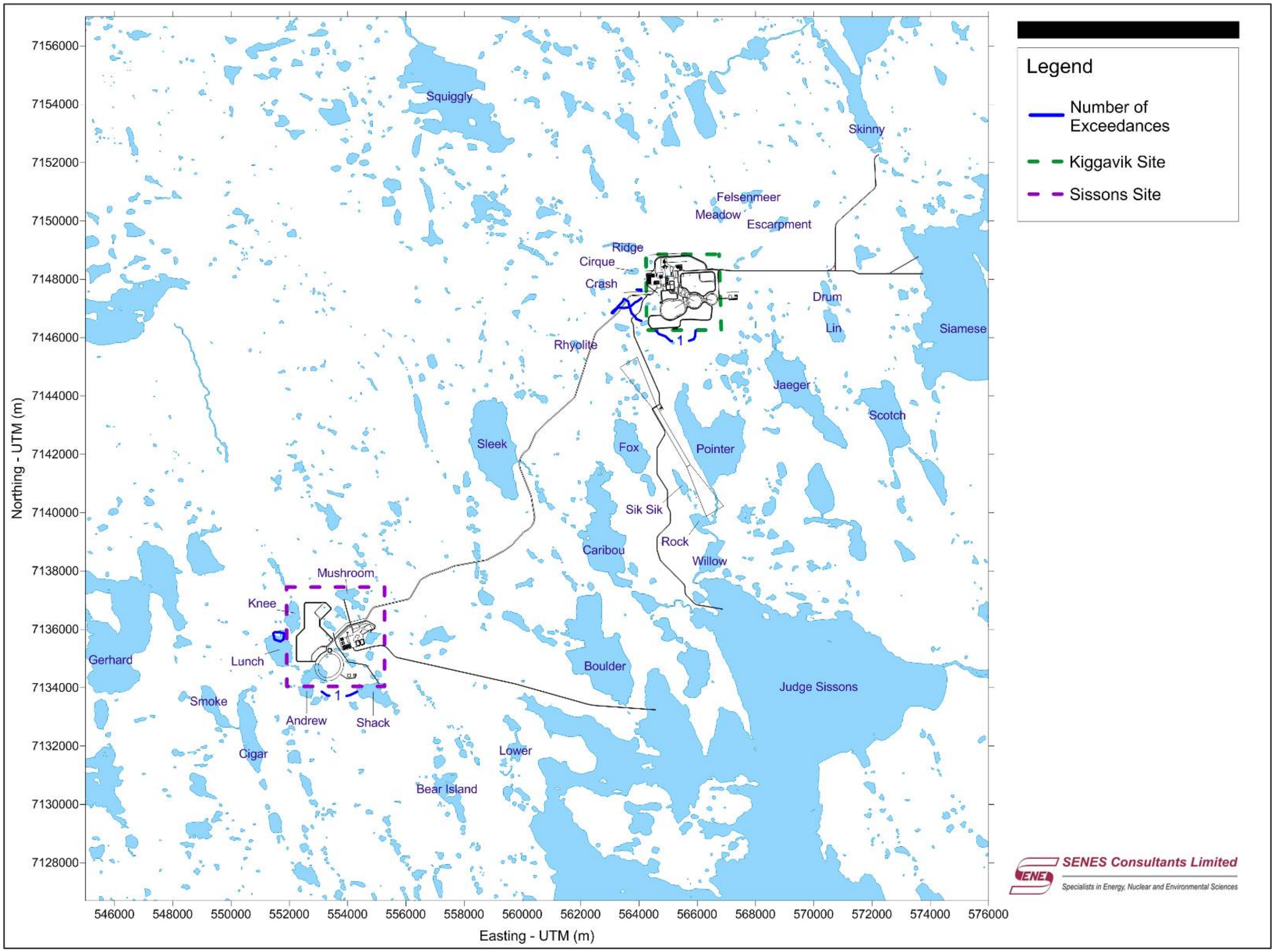


Figure D-8 Maximum Bounding Scenario - Incremental Maximum 24-hr Uranium Concentration (µg/m³)

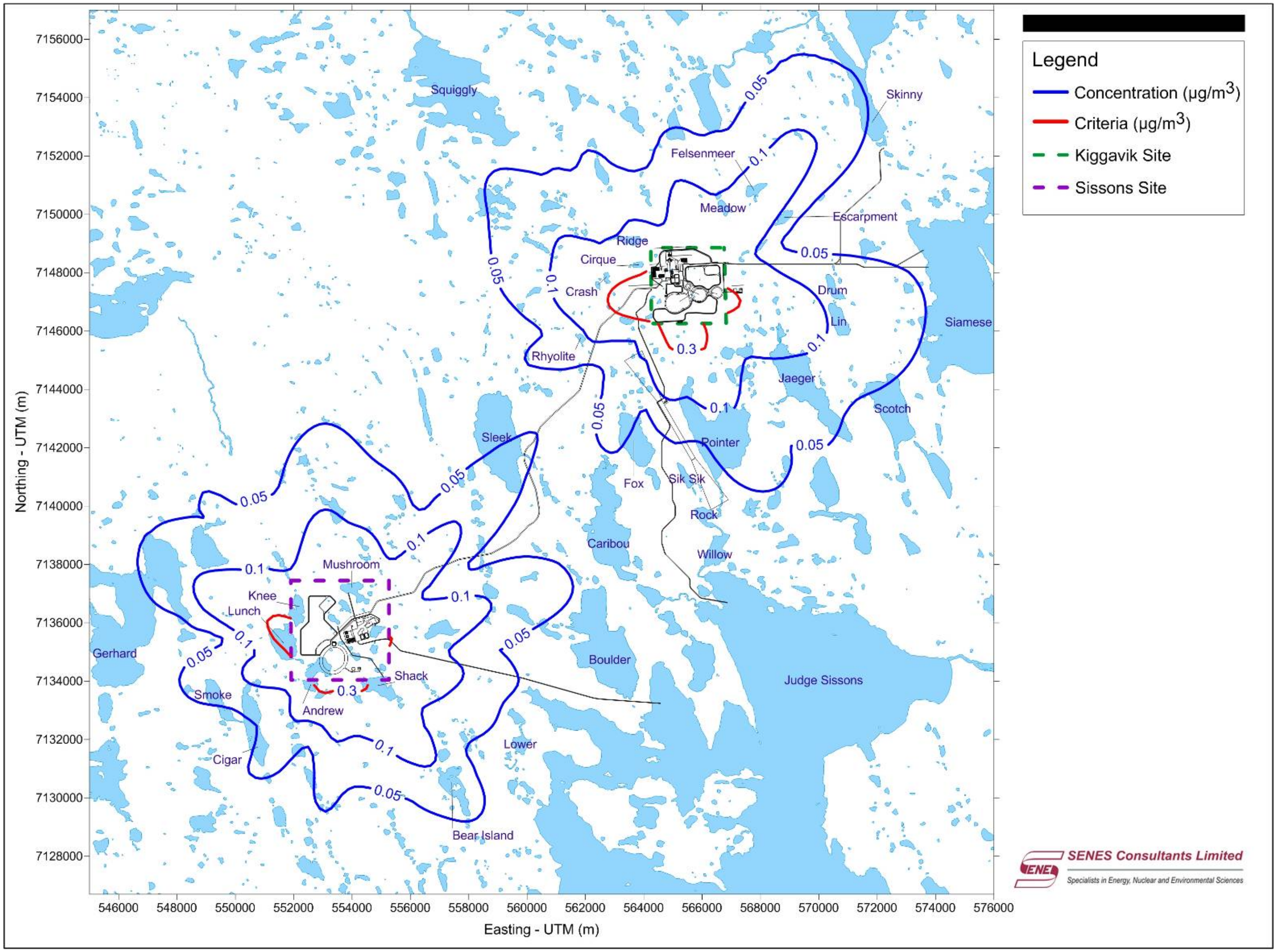


Figure D-9 Maximum Bounding Scenario - Incremental Maximum 24-hr Arsenic Concentration (µg/m³)

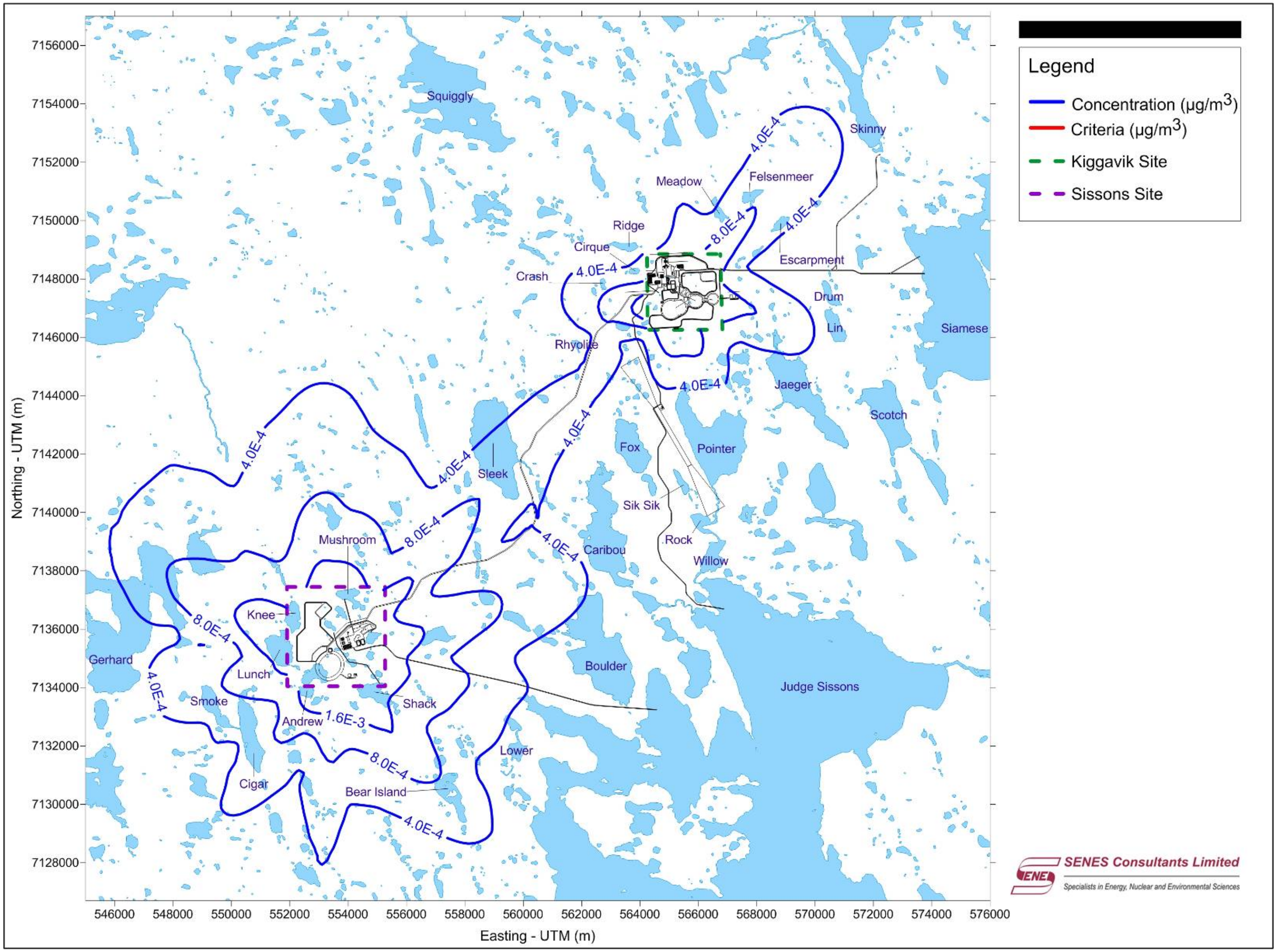


Figure D-10 Maximum Bounding Scenario - Incremental Maximum 24-hr Cobalt Concentration (µg/m³)

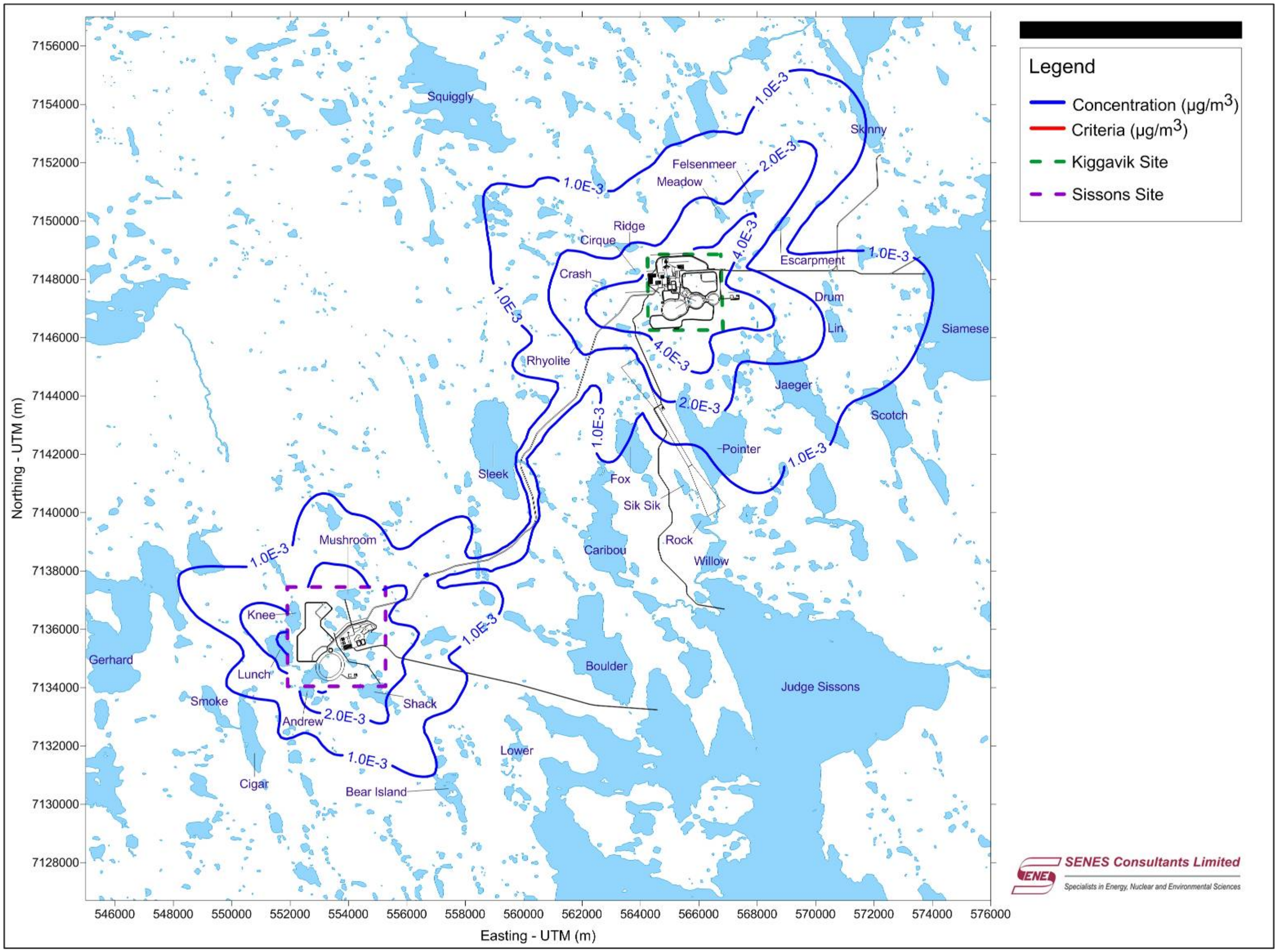


Figure D-11 Maximum Bounding Scenario - Incremental Maximum 24-hr Cadmium Concentration (µg/m³)

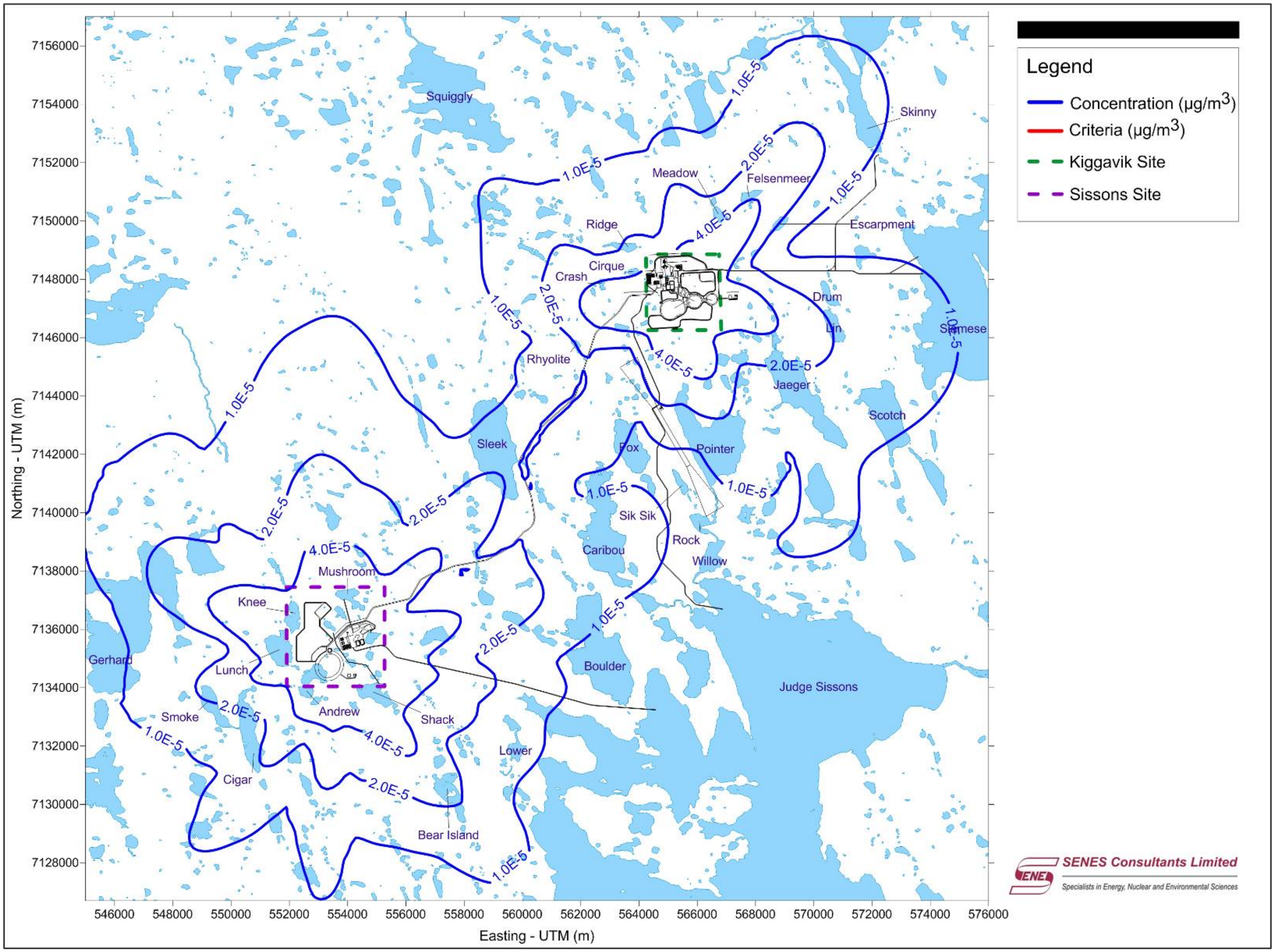


Figure D-12 Maximum Bounding Scenario - Incremental Maximum 24-hr Chromium Concentration (µg/m³)

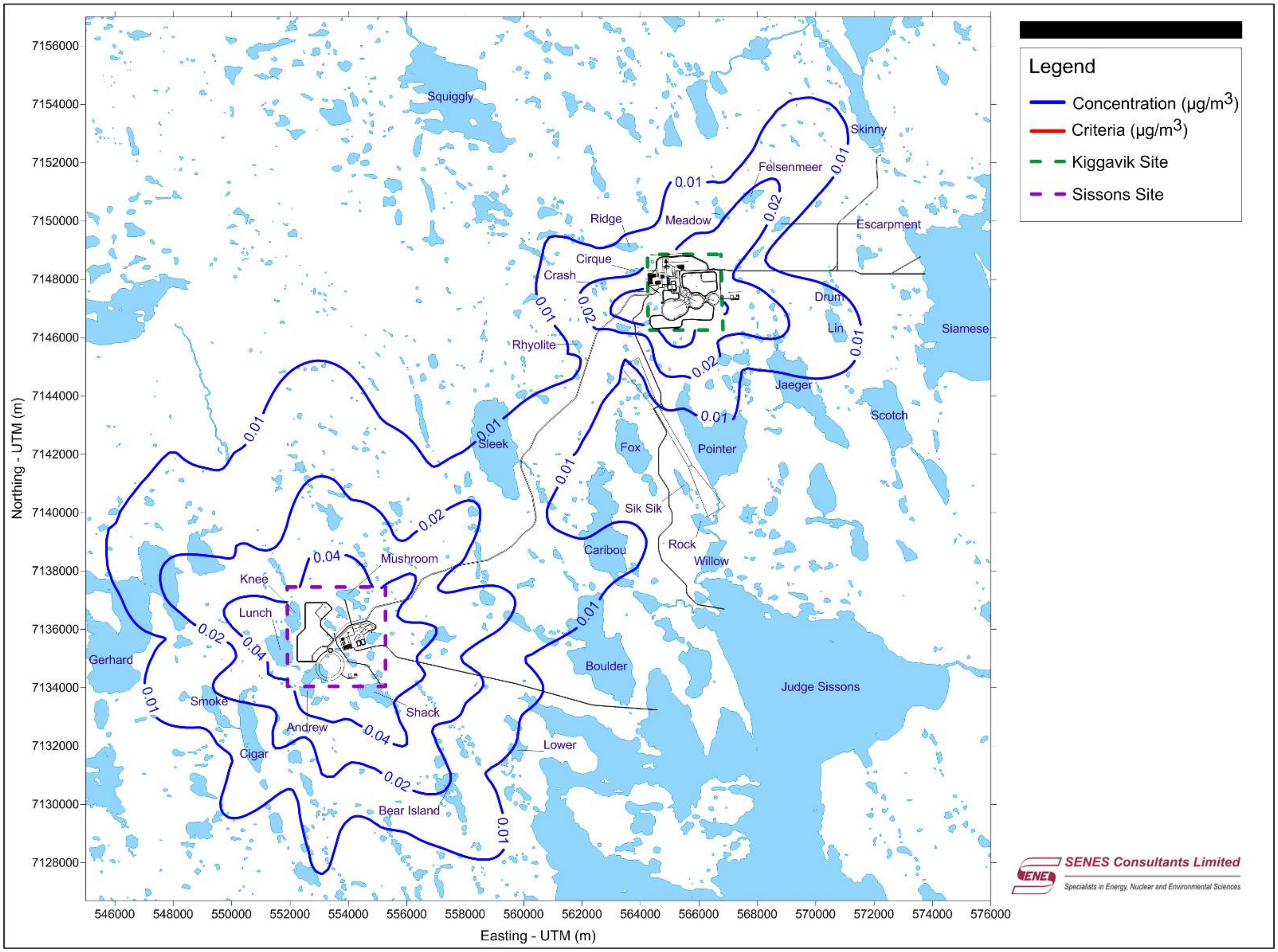


Figure D-13 Maximum Bounding Scenario - Incremental Maximum 24-hr Copper Concentration (μg/m³)

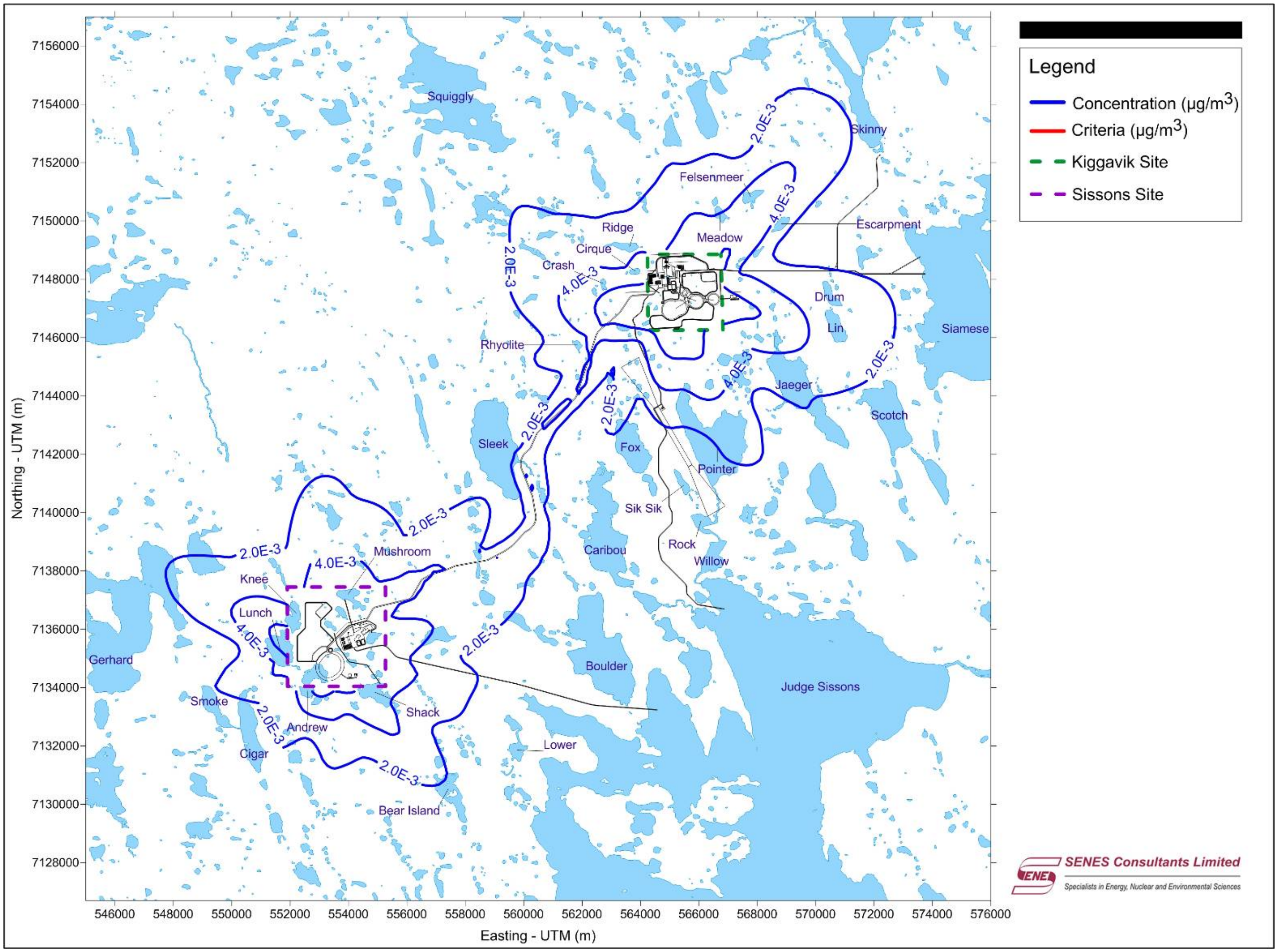


Figure D-14 Maximum Bounding Scenario - Incremental Maximum 24-hr Lead Concentration (µg/m³)

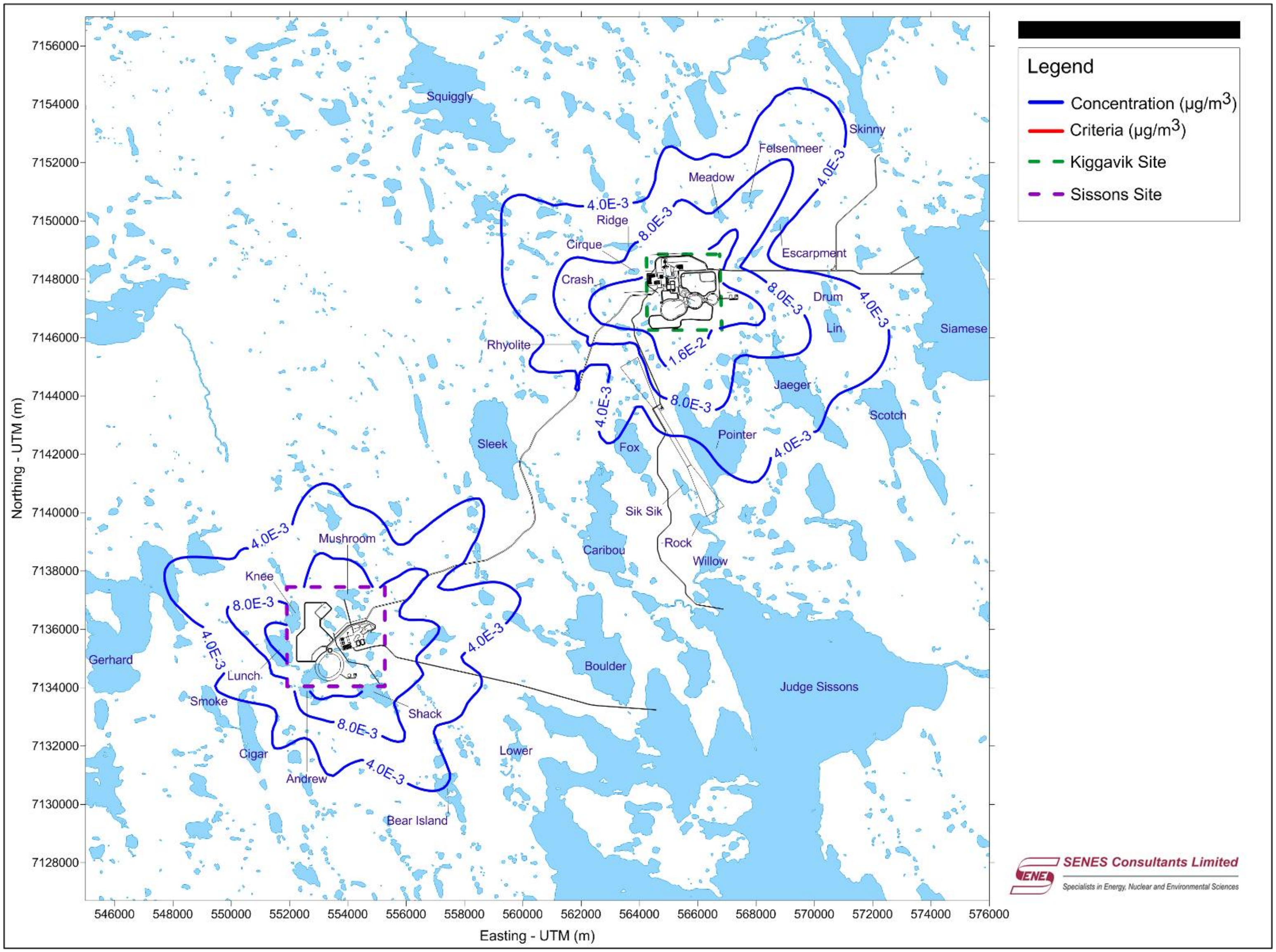


Figure D-15 Maximum Bounding Scenario - Incremental Maximum 24-hr Molybdenum Concentration (µg/m³)

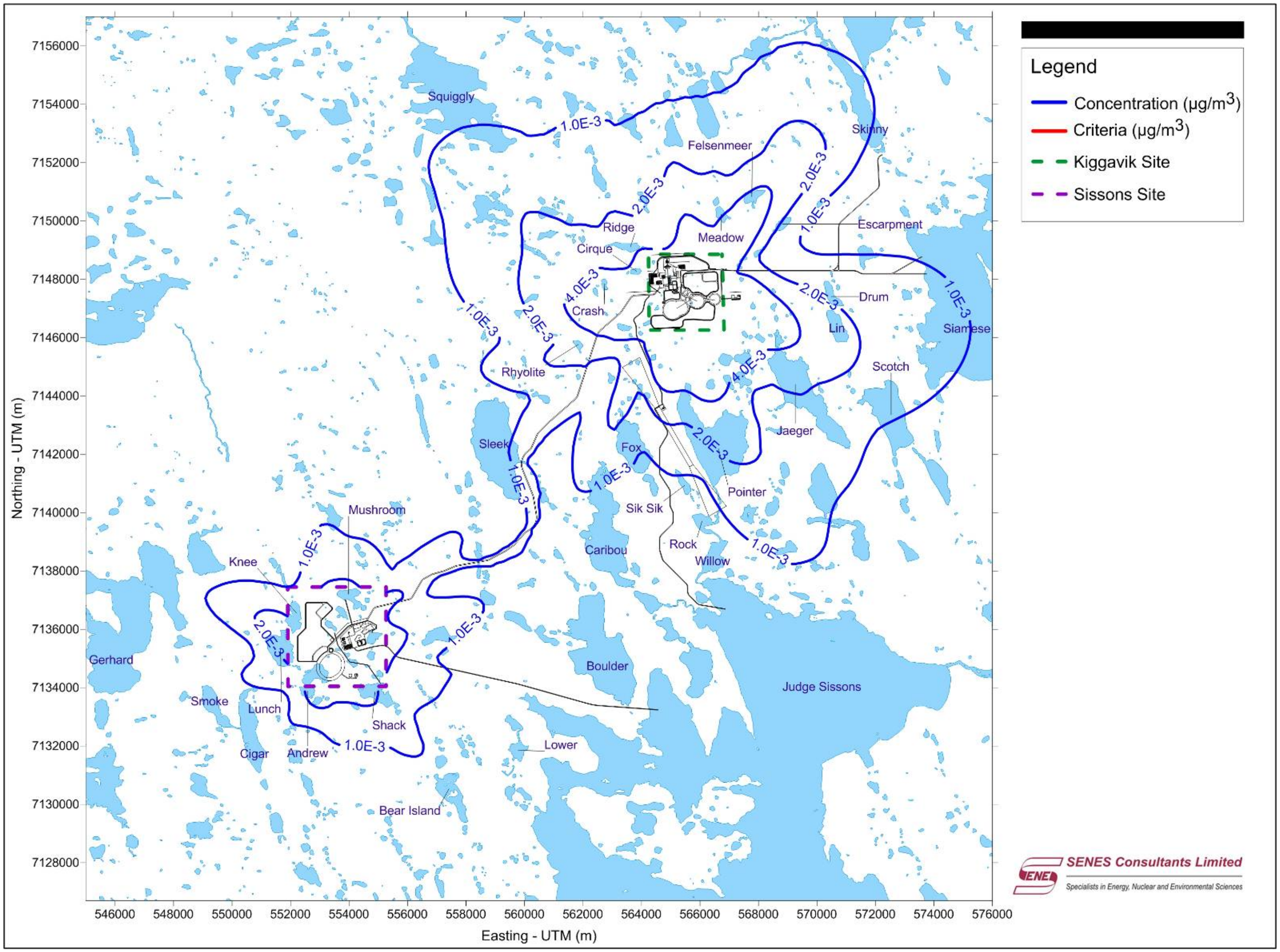


Figure D-16 Maximum Bounding Scenario - Incremental Maximum 24-hr Nickel Concentration (µg/m³)

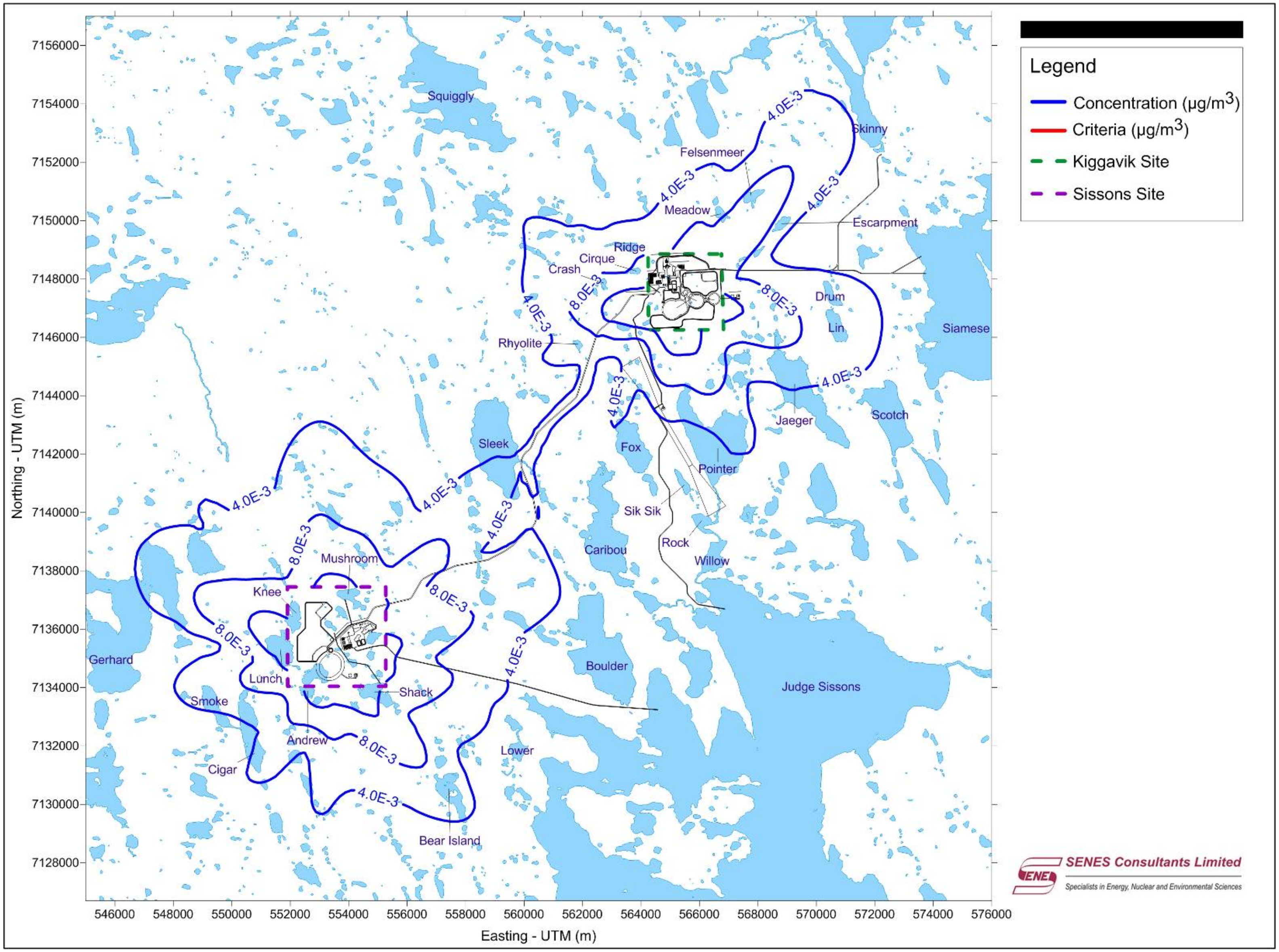


Figure D-17 Maximum Bounding Scenario - Incremental Maximum 24-hr Selenium Concentration (µg/m³)

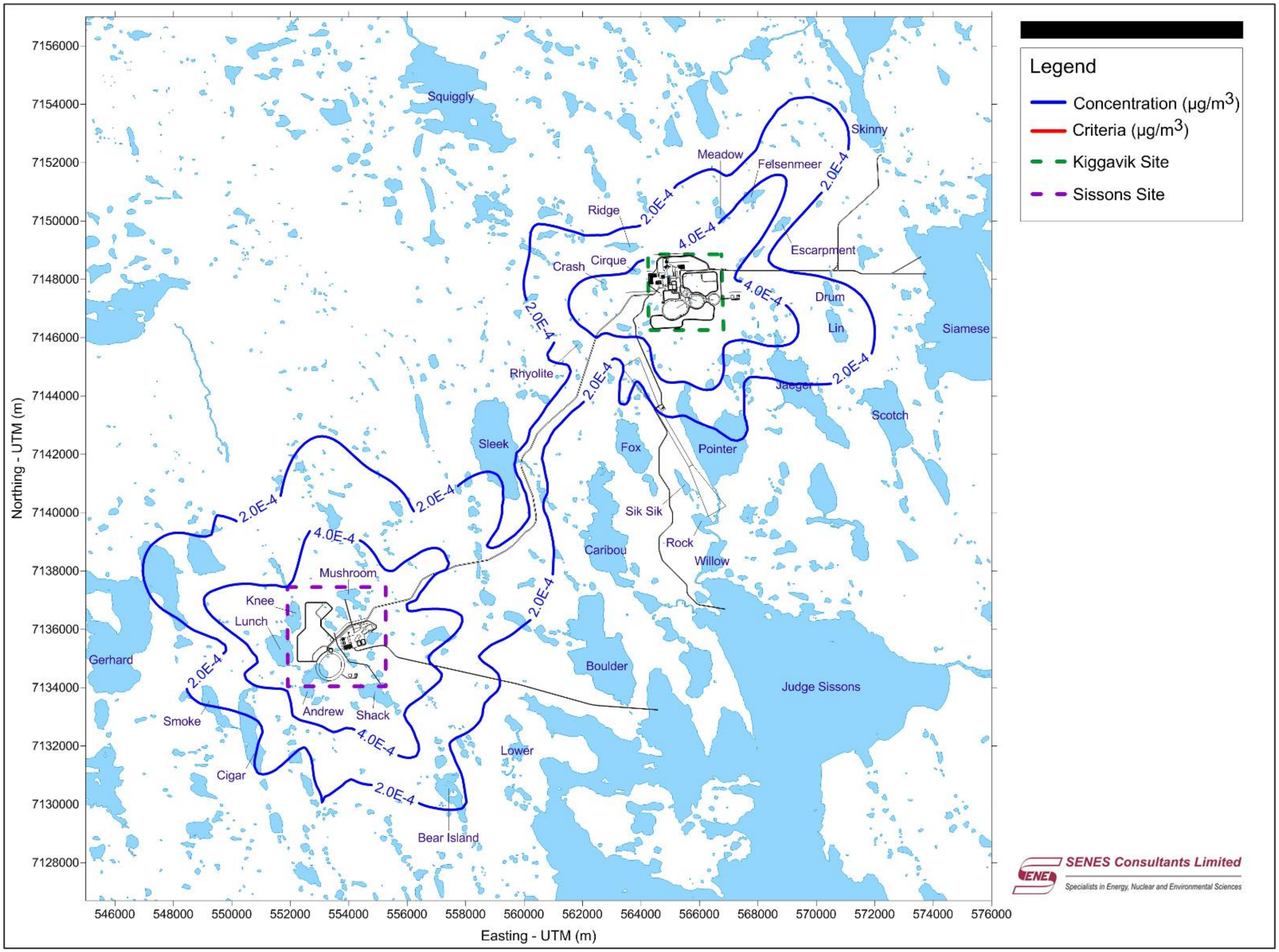


Figure D-18 Maximum Bounding Scenario - Incremental Maximum 24-hr Zinc Concentration (µg/m³)

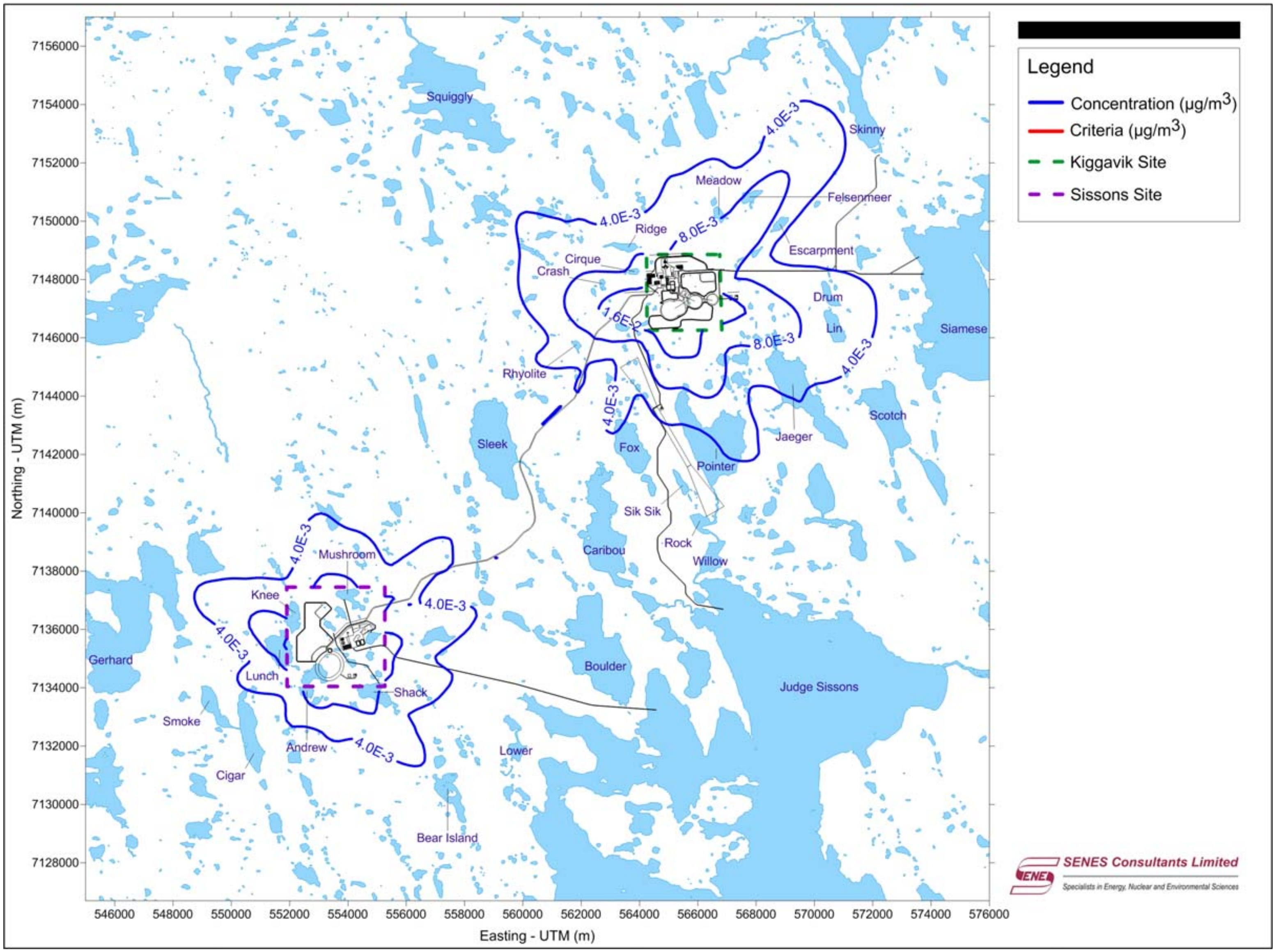


Figure D-19 Maximum Bounding Scenario - Incremental Maximum 1-hr NO_2 Concentration (µg/m³)

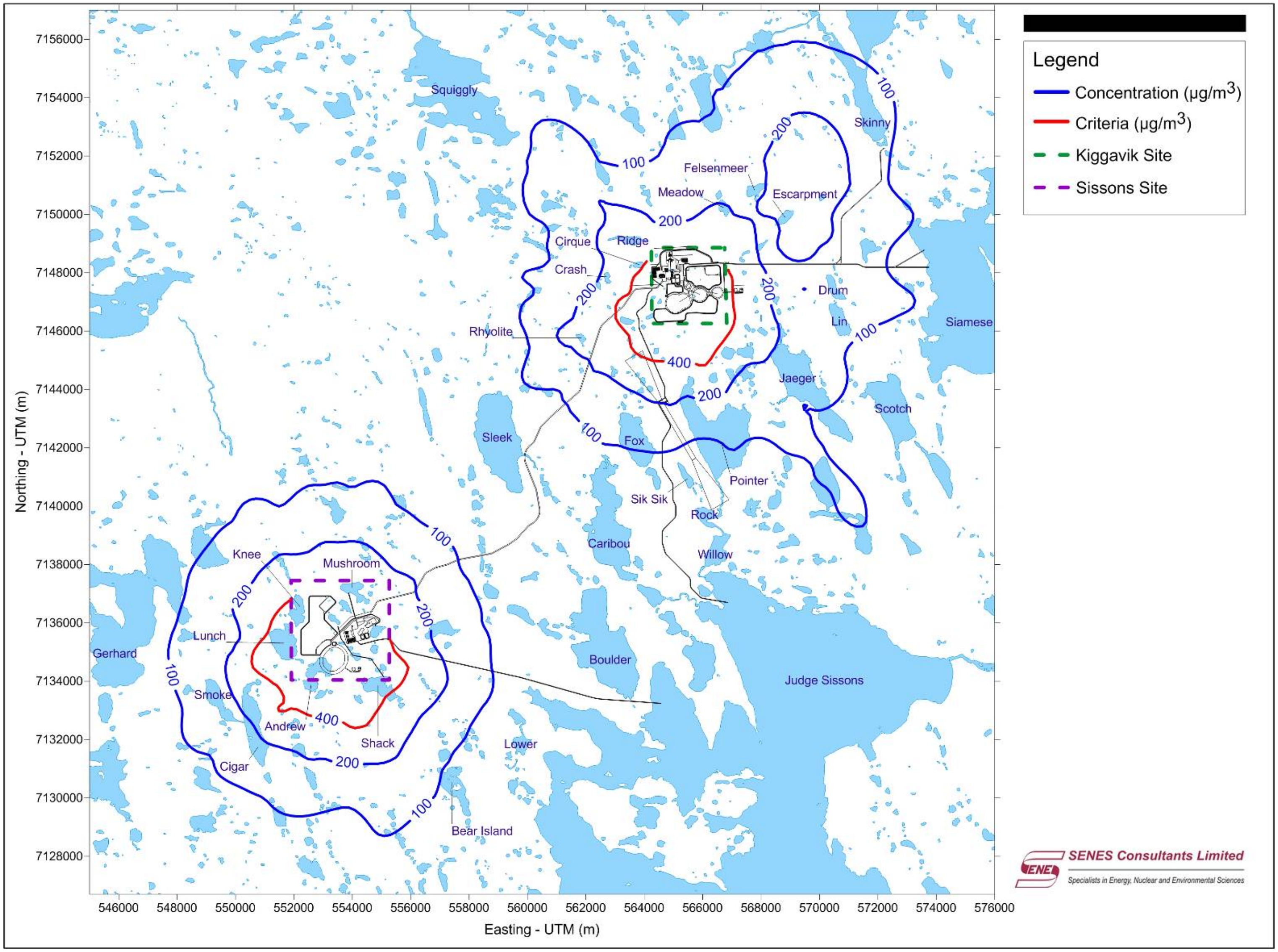


Figure D-20 Maximum Bounding Scenario - Incremental Maximum 24-hr NO_2 Concentration (µg/m³)

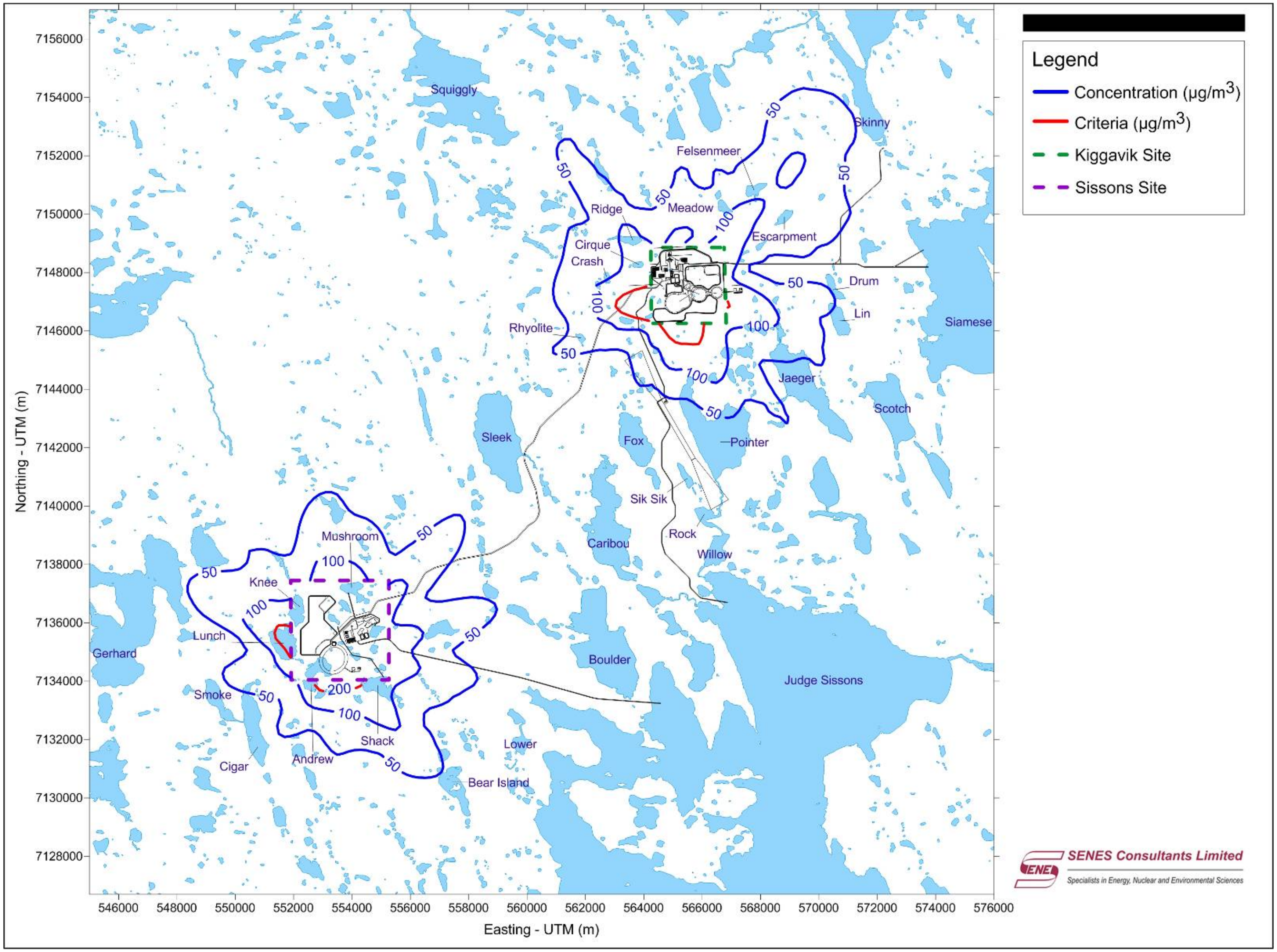


Figure D-21 Maximum Bounding Scenario - 1-hr NO_2 Exceedances (hours)

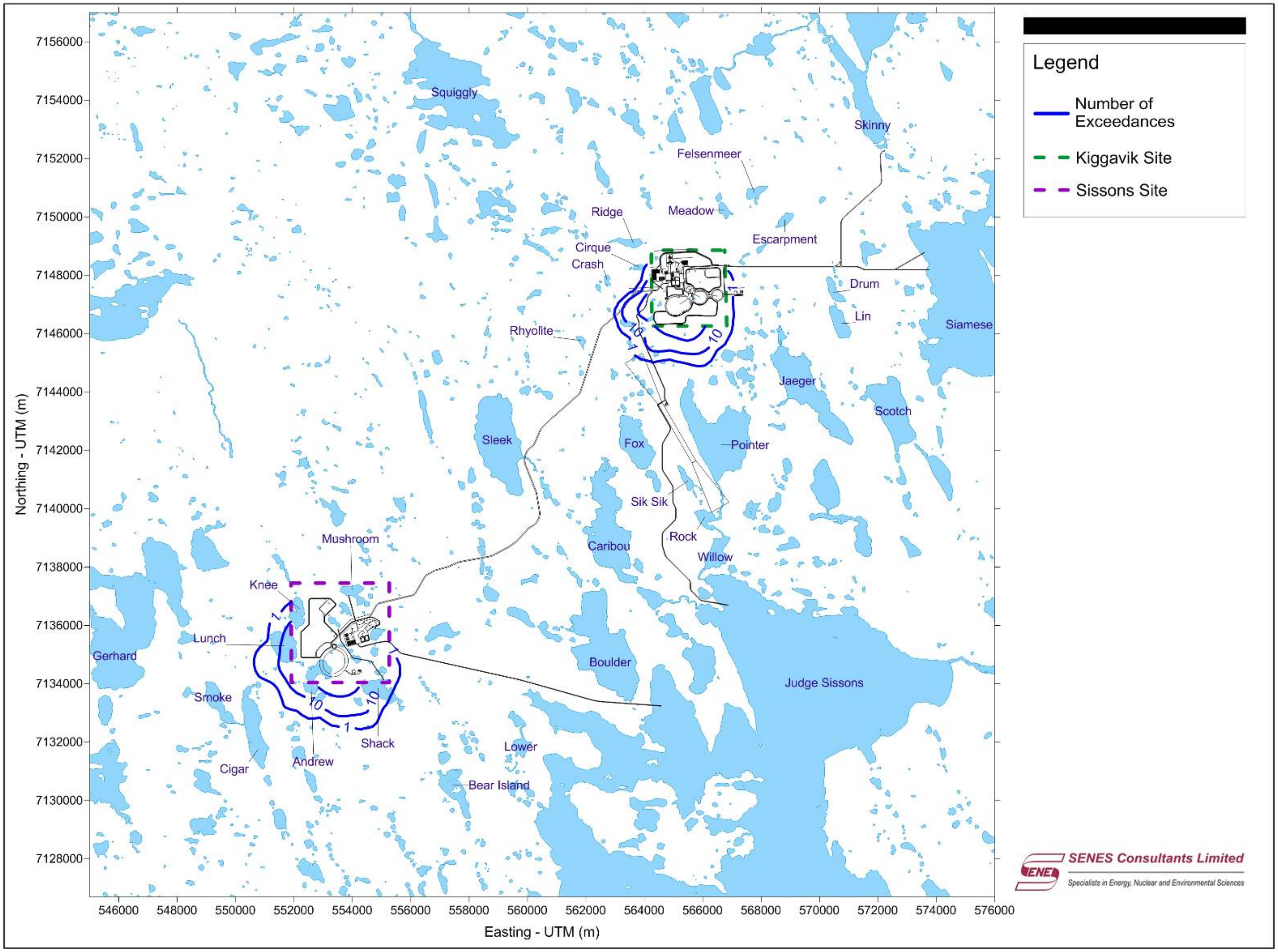


Figure D-22 Maximum Bounding Scenario - 24-hr NO_2 Exceedances (days)

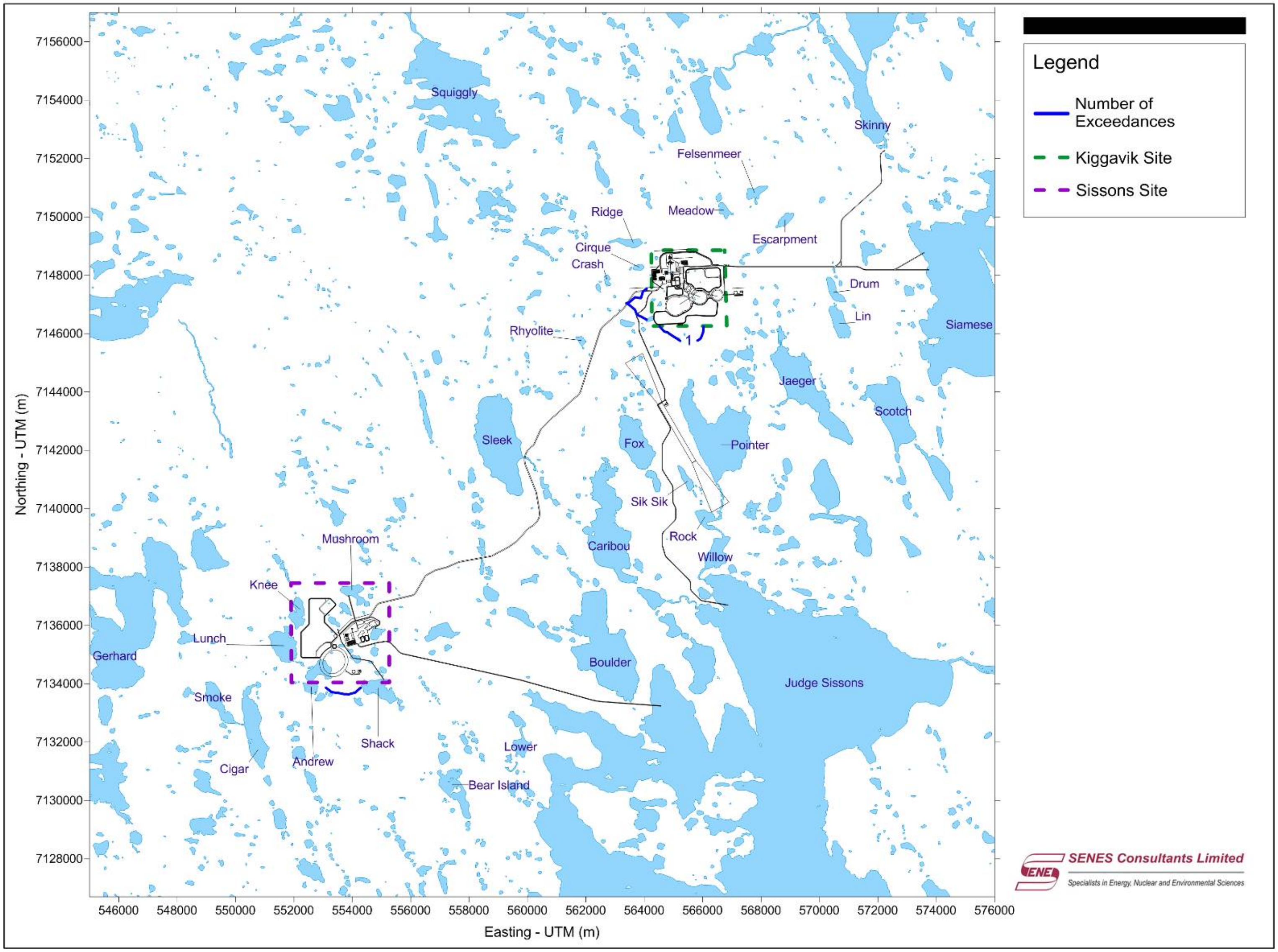


Figure D-23 Maximum Bounding Scenario - Incremental Maximum 1-hr SO_2 Concentration (µg/m³)

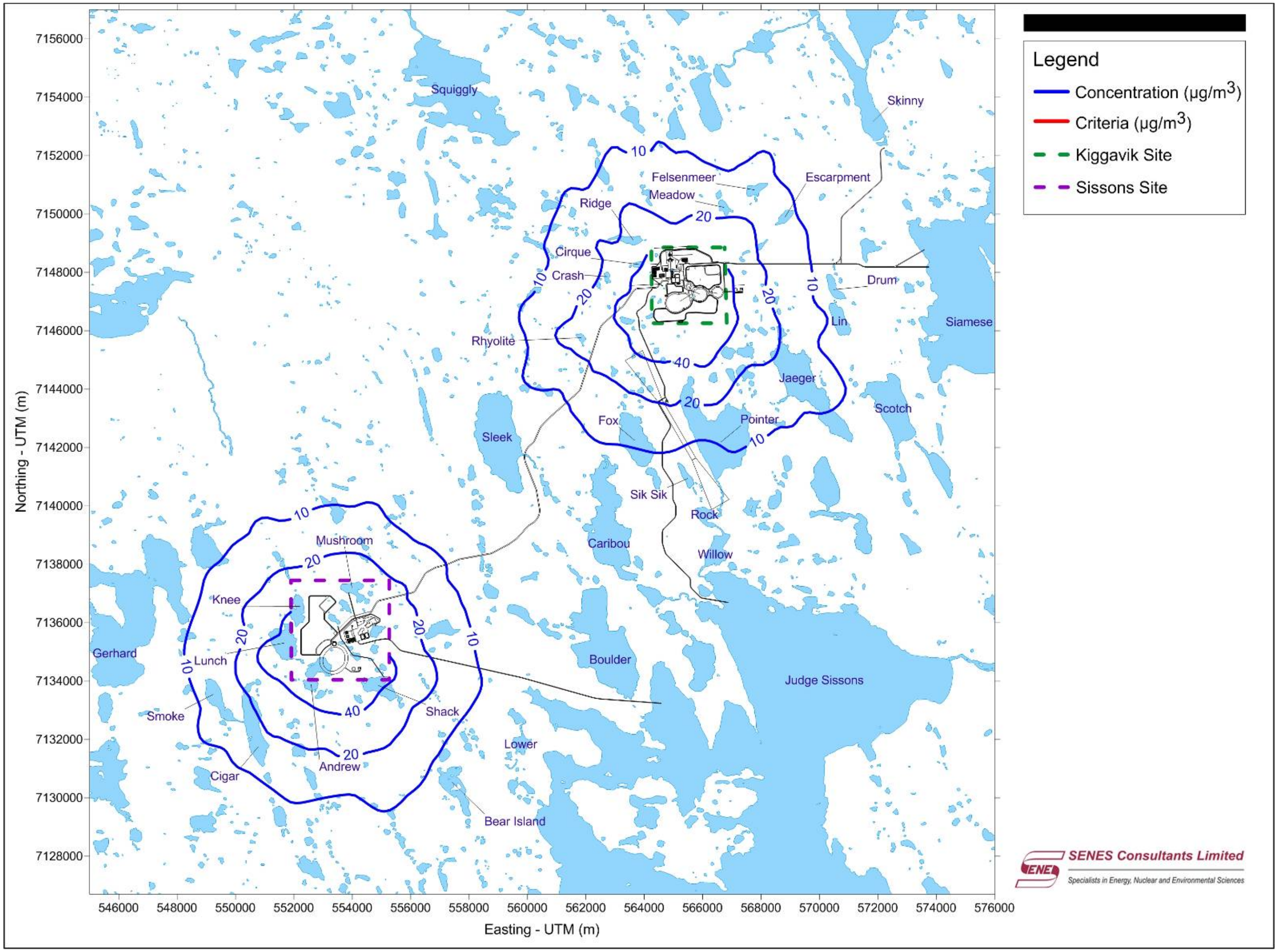


Figure D-24 Maximum Bounding Scenario - Incremental Maximum 24-hr SO_2 Concentration (µg/m³)

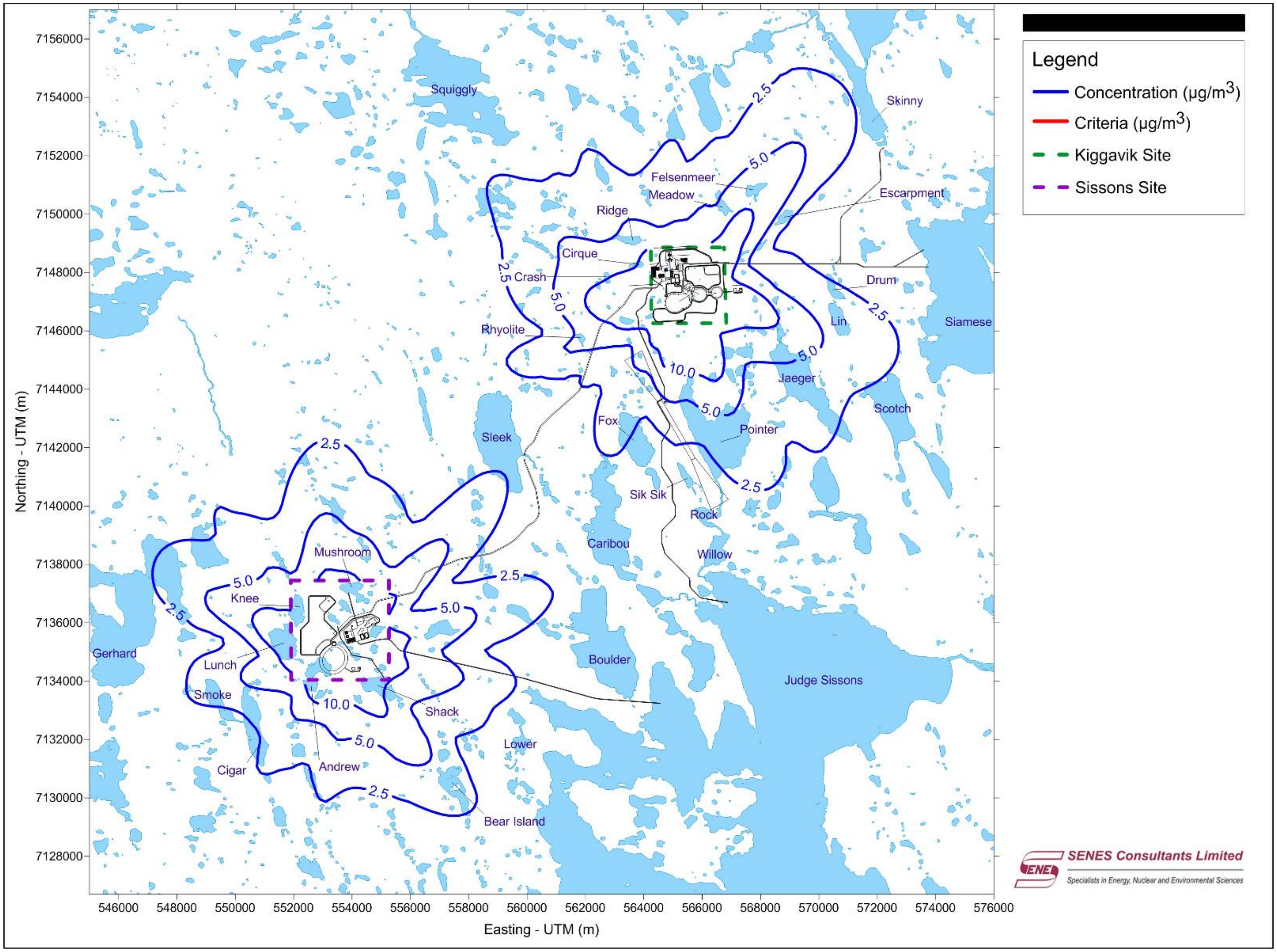


Figure D-25 Period 1 (Year 0 and 1) - Incremental Annual TSP Concentration (µg/m³)

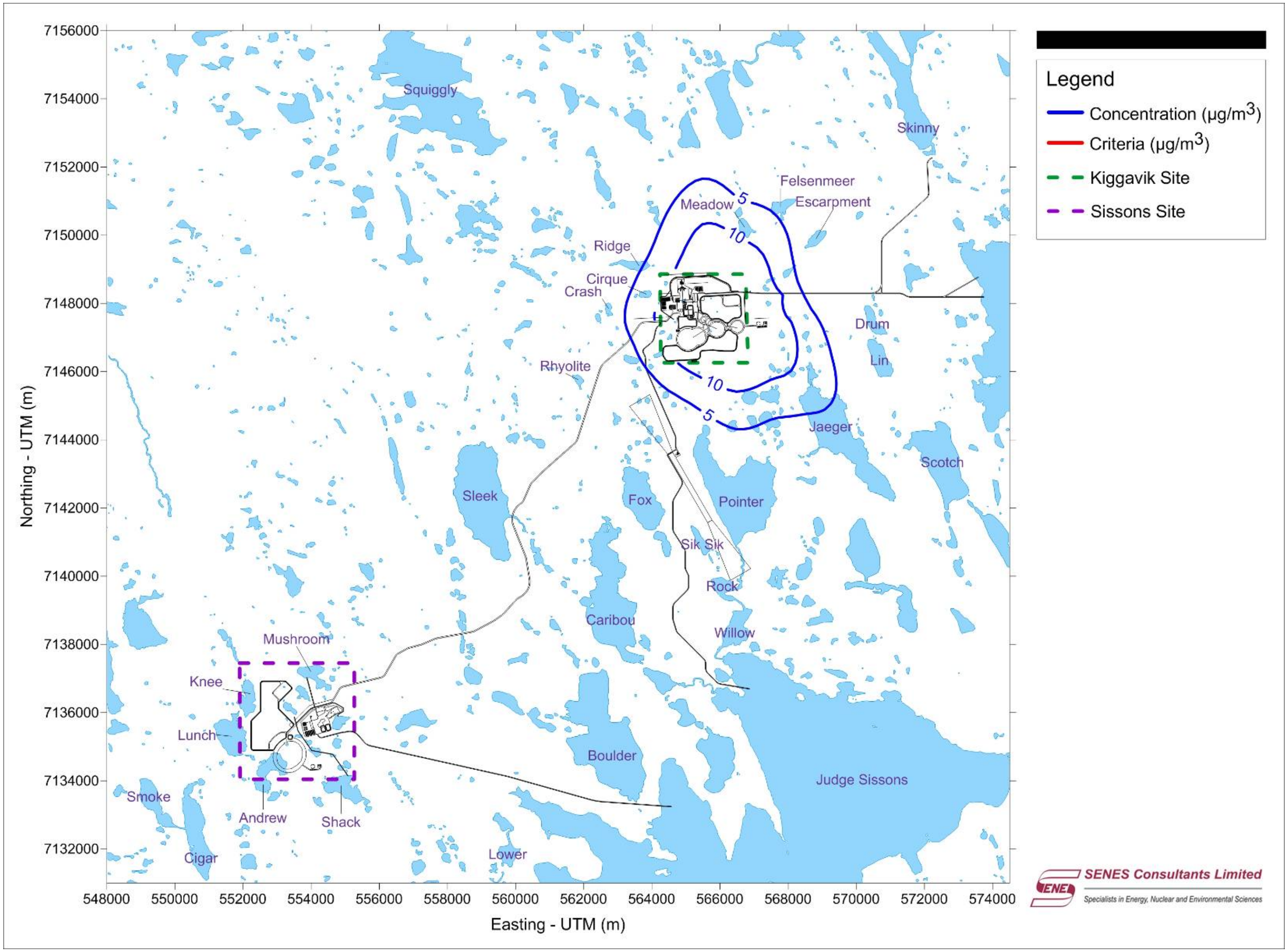


Figure D-26 Period 1 (Year 0 and 1) - Incremental Annual PM_{10} Concentration (µg/m³)

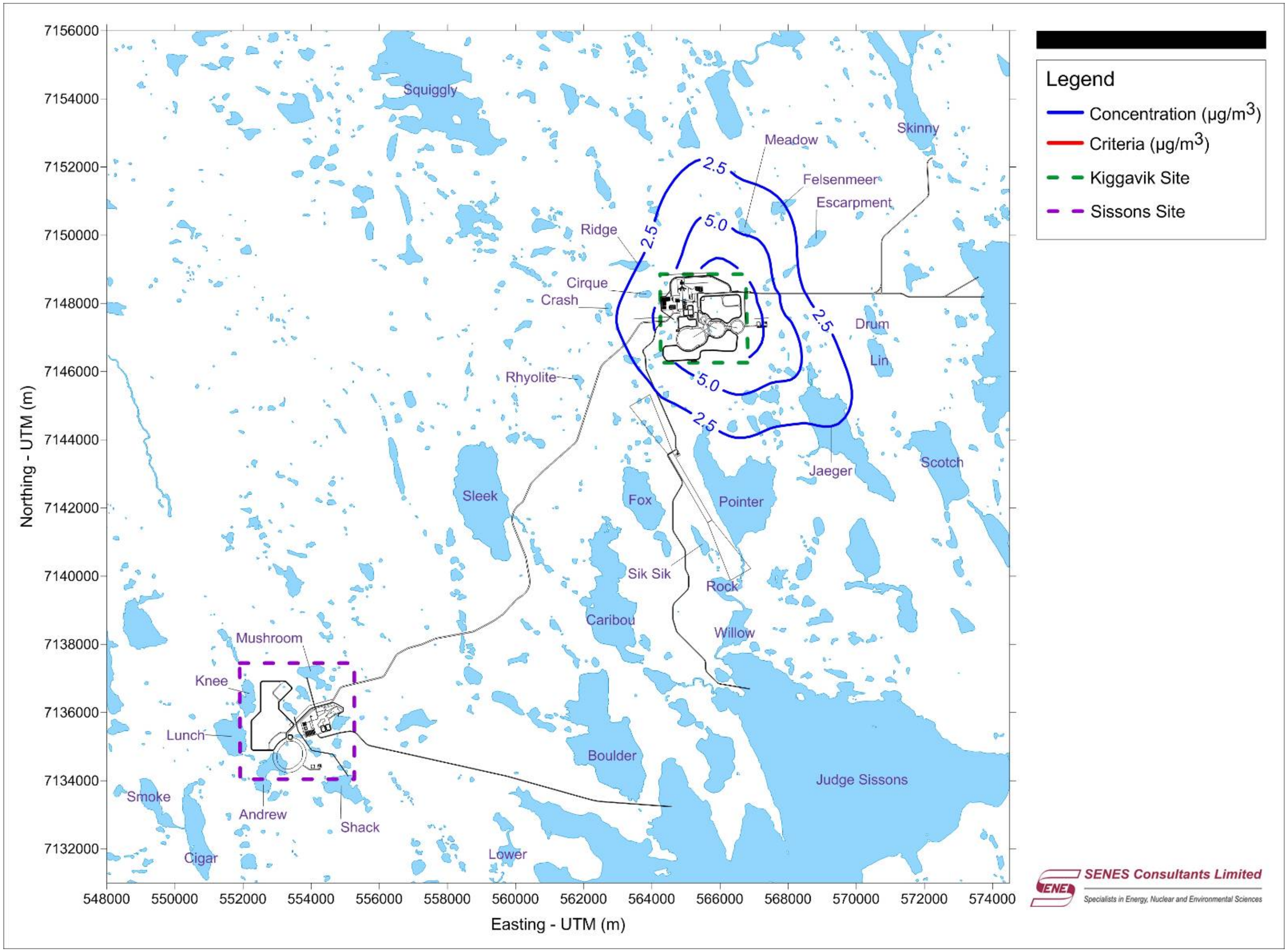


Figure D-27 Period 1 (Year 0 and 1) - Incremental Annual $PM_{2.5}$ Concentration (μg/m³)

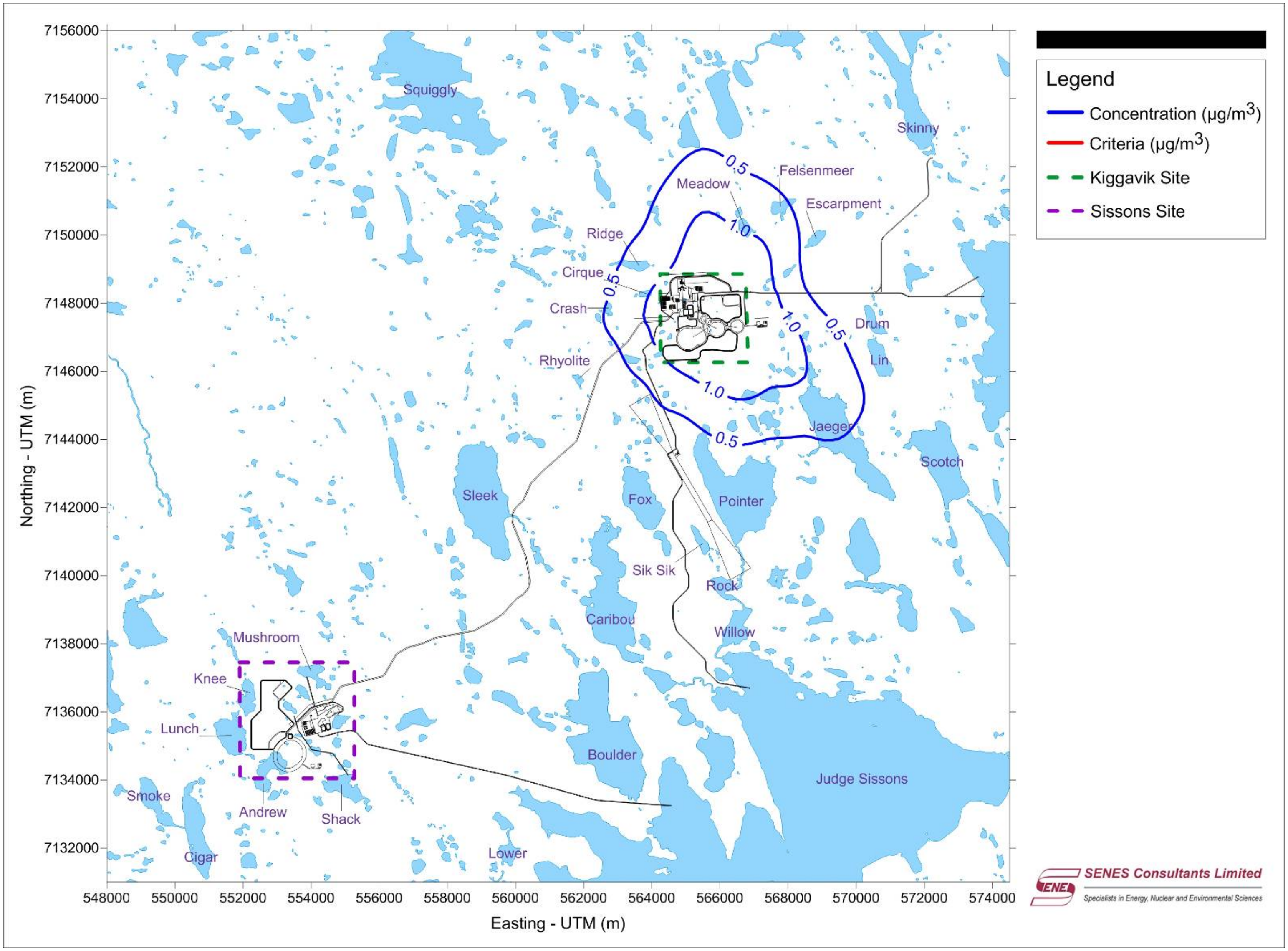


Figure D-28 Period 1 (Year 0 and 1) - Incremental Annual Uranium Concentration (µg/m³)

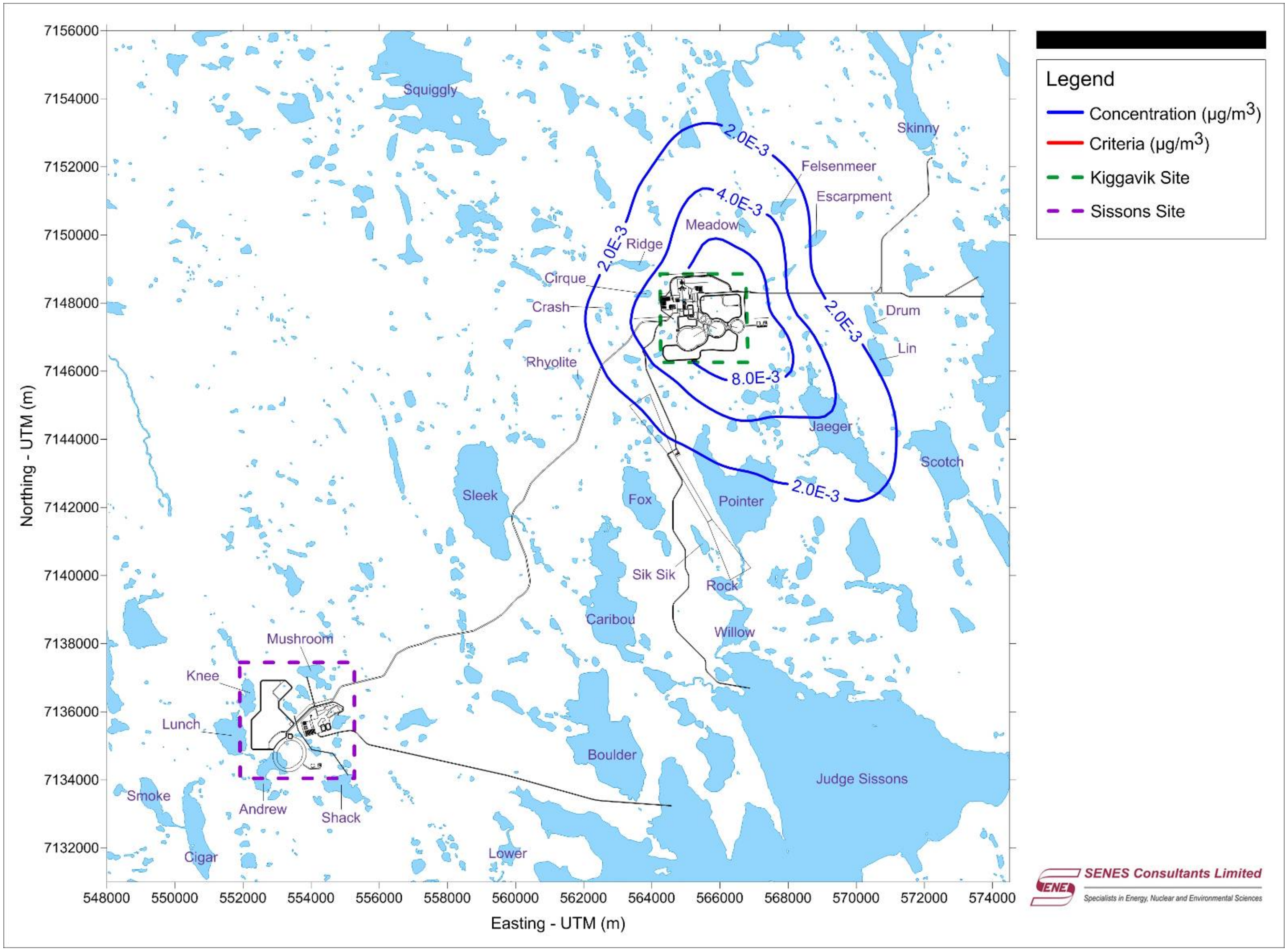


Figure D-29 Period 1 (Year 0 and 1) - Incremental Annual Arsenic Concentration (µg/m³)

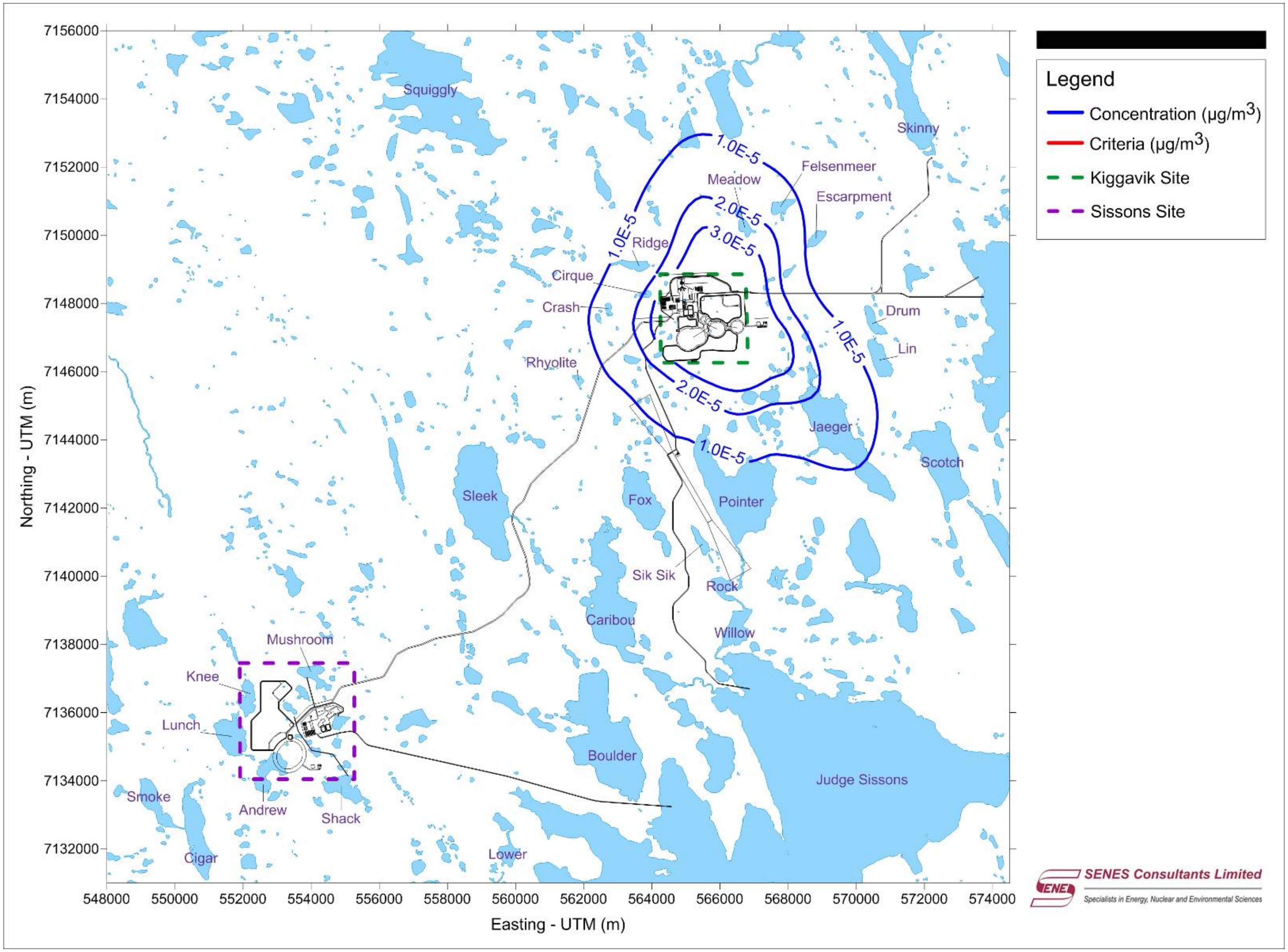


Figure D-30 Period 1 (Year 0 and 1) - Incremental Annual Cobalt Concentration (µg/m³)

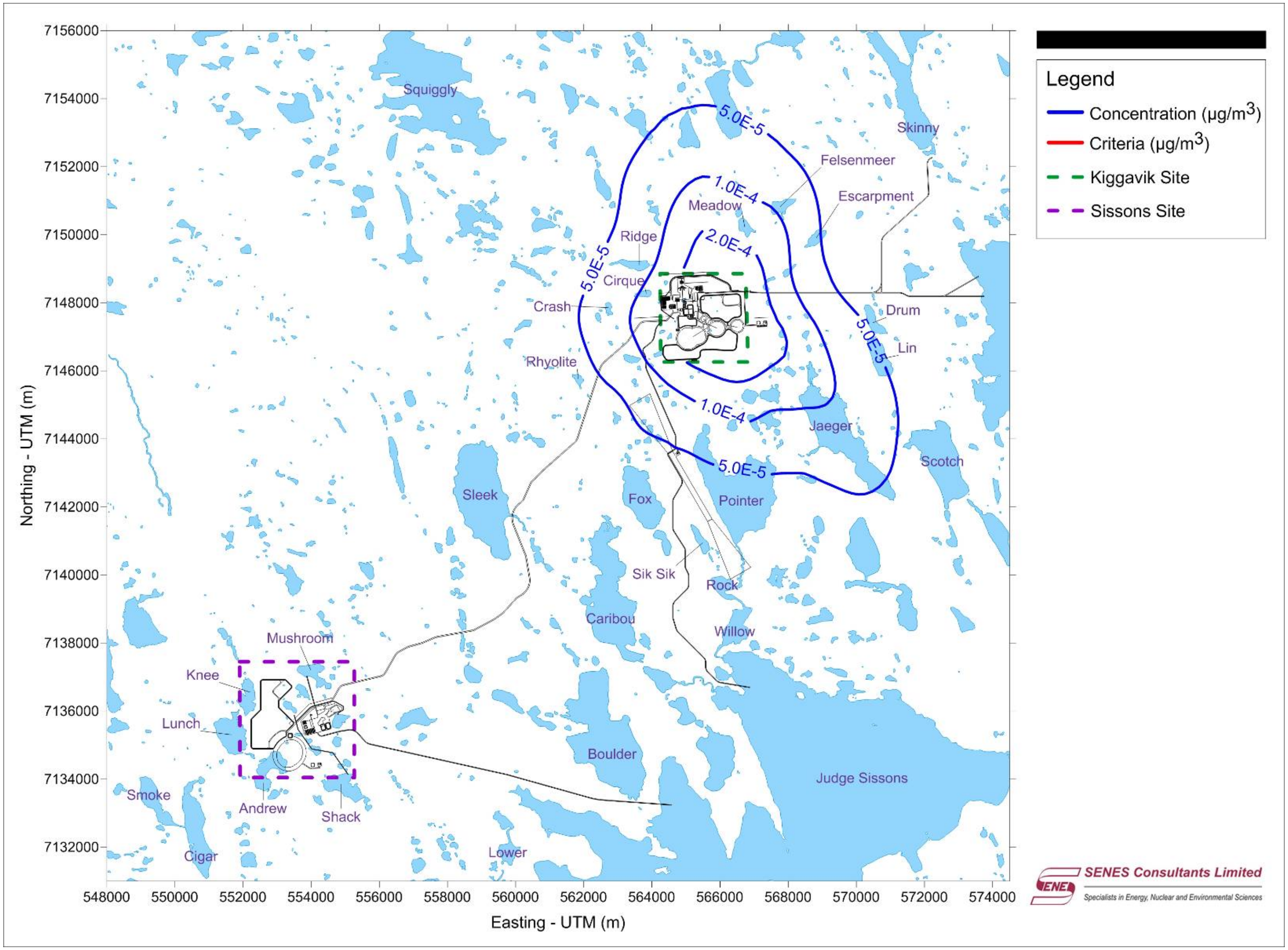


Figure D-31 Period 1 (Year 0 and 1) - Incremental Annual Cadmium Concentration (µg/m³)

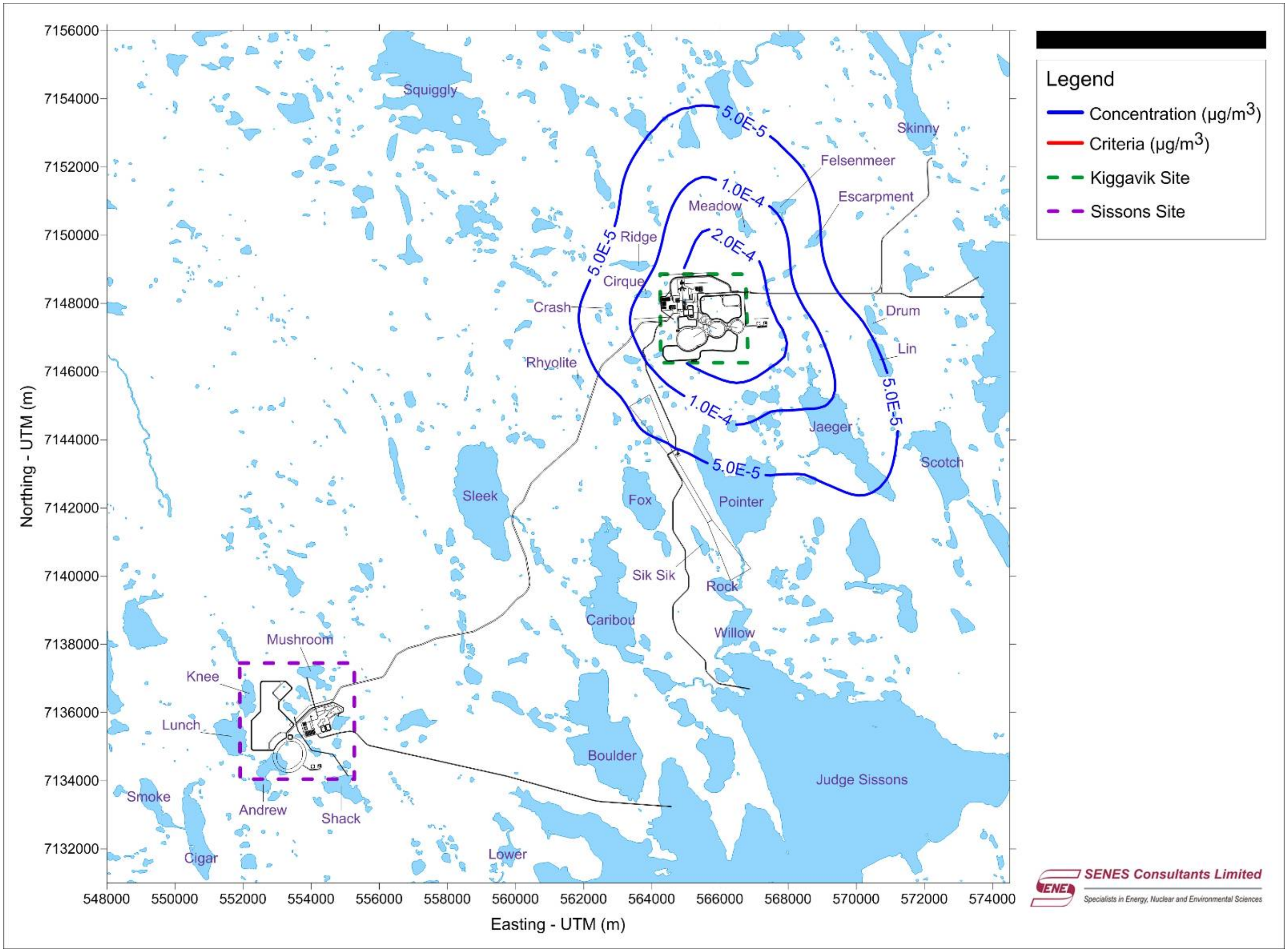


Figure D-32 Period 1 (Year 0 and 1) - Incremental Annual Chromium Concentration (µg/m³)

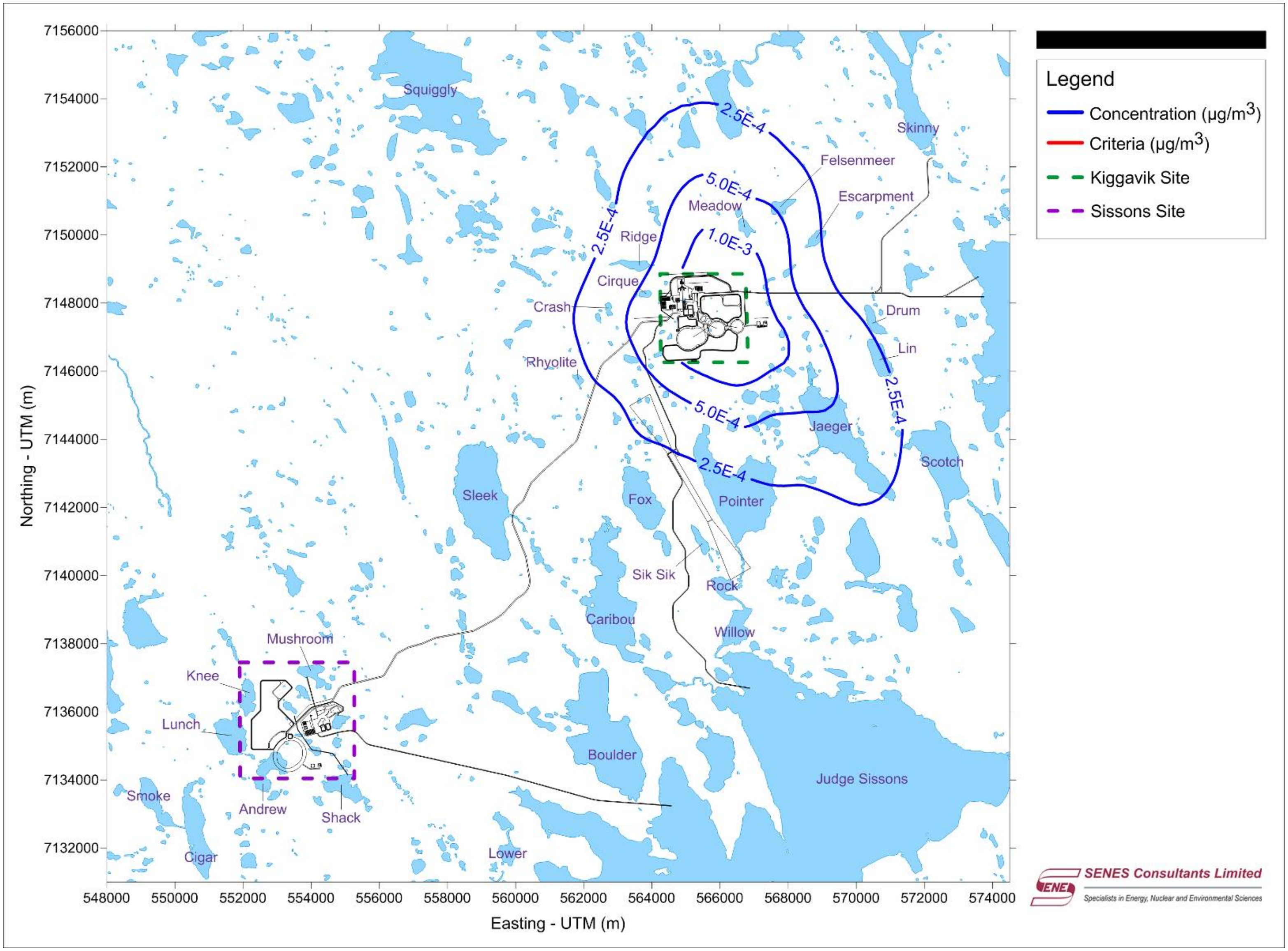


Figure D-33 Period 1 (Year 0 and 1) - Incremental Annual Copper Concentration (µg/m³)

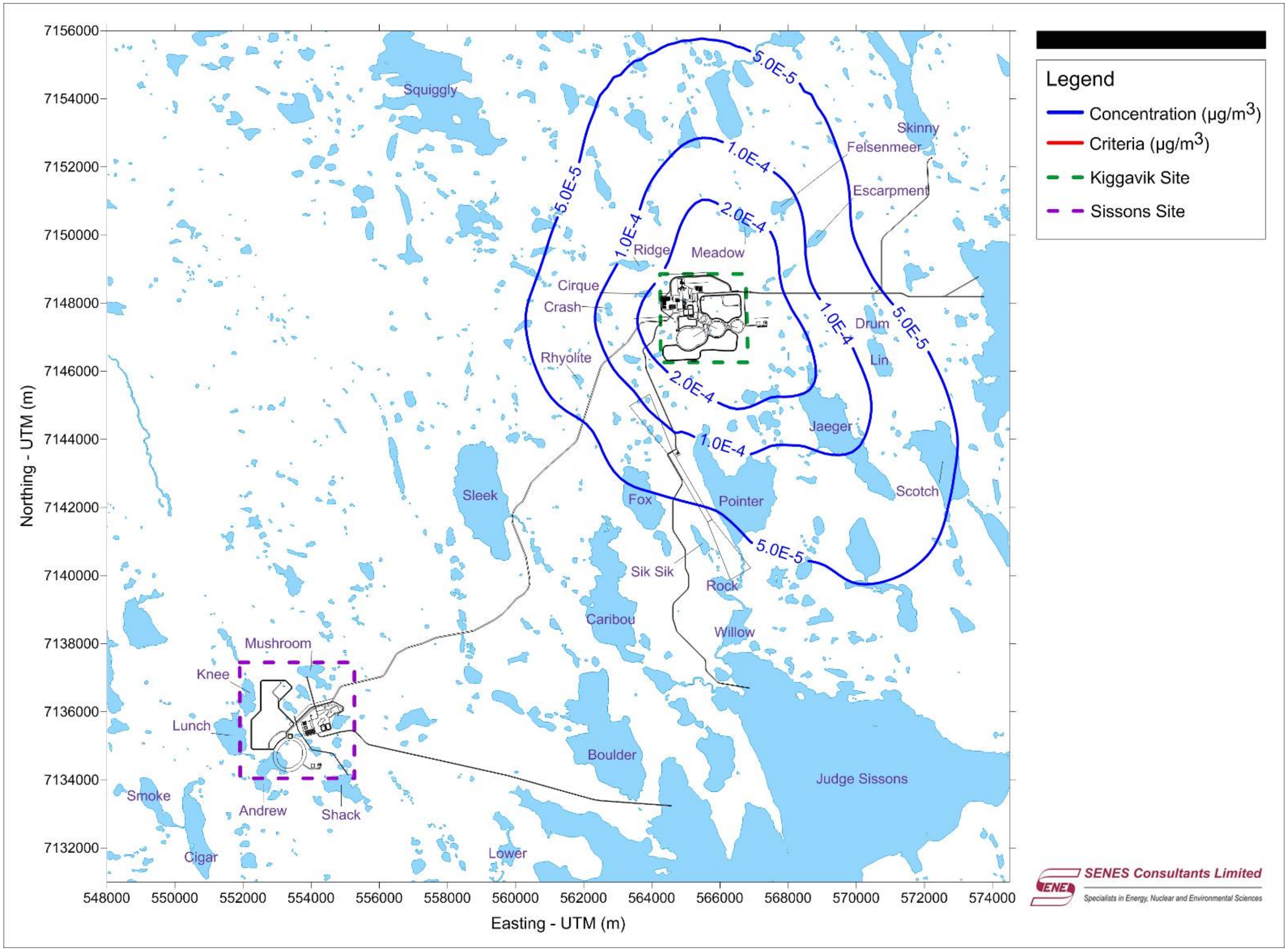


Figure D-34 Period 1 (Year 0 and 1) - Incremental Annual Lead Concentration (µg/m³)

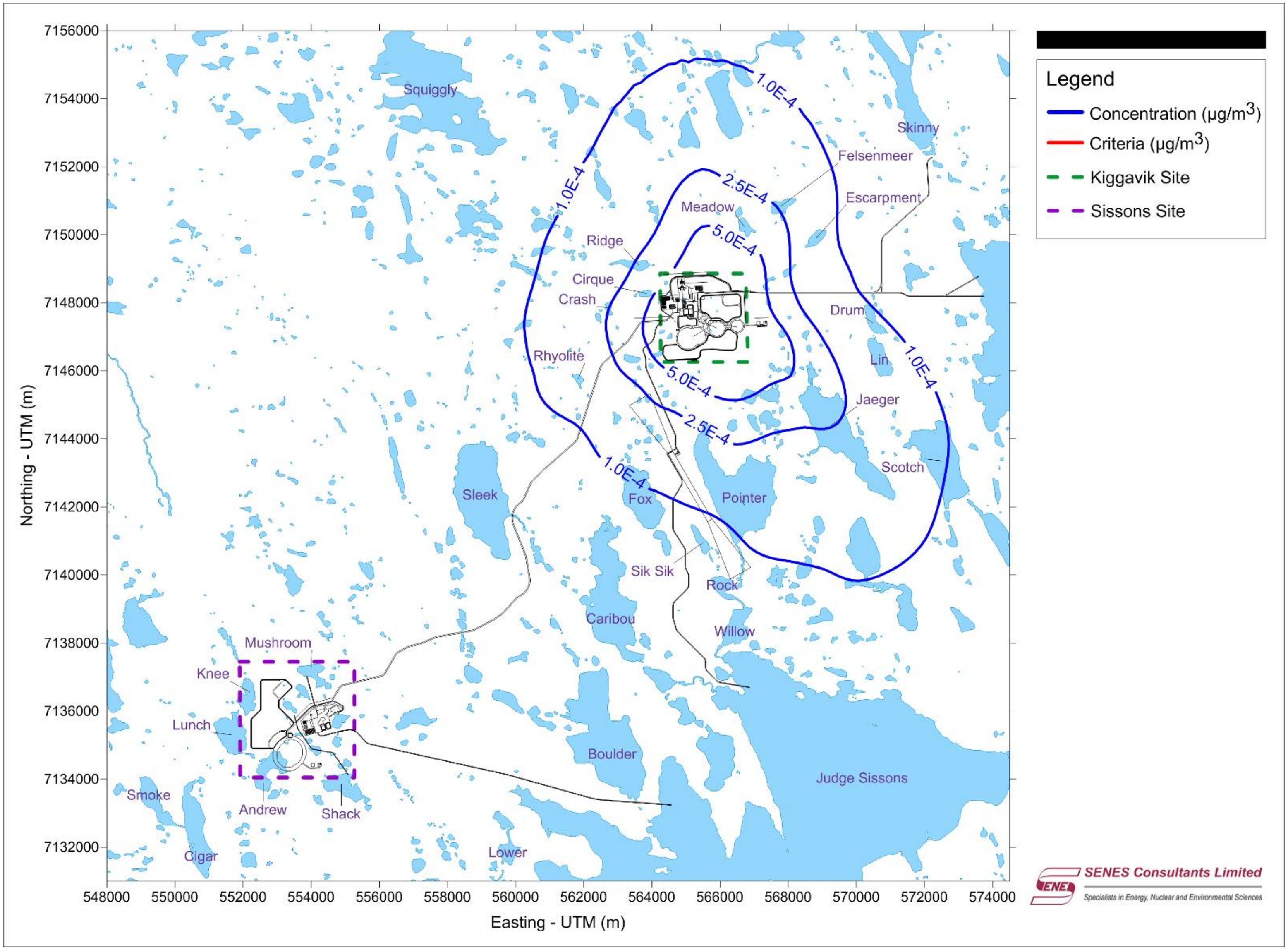


Figure D-35 Period 1 (Year 0 and 1) - Incremental Annual Molybdenum Concentration (µg/m³)

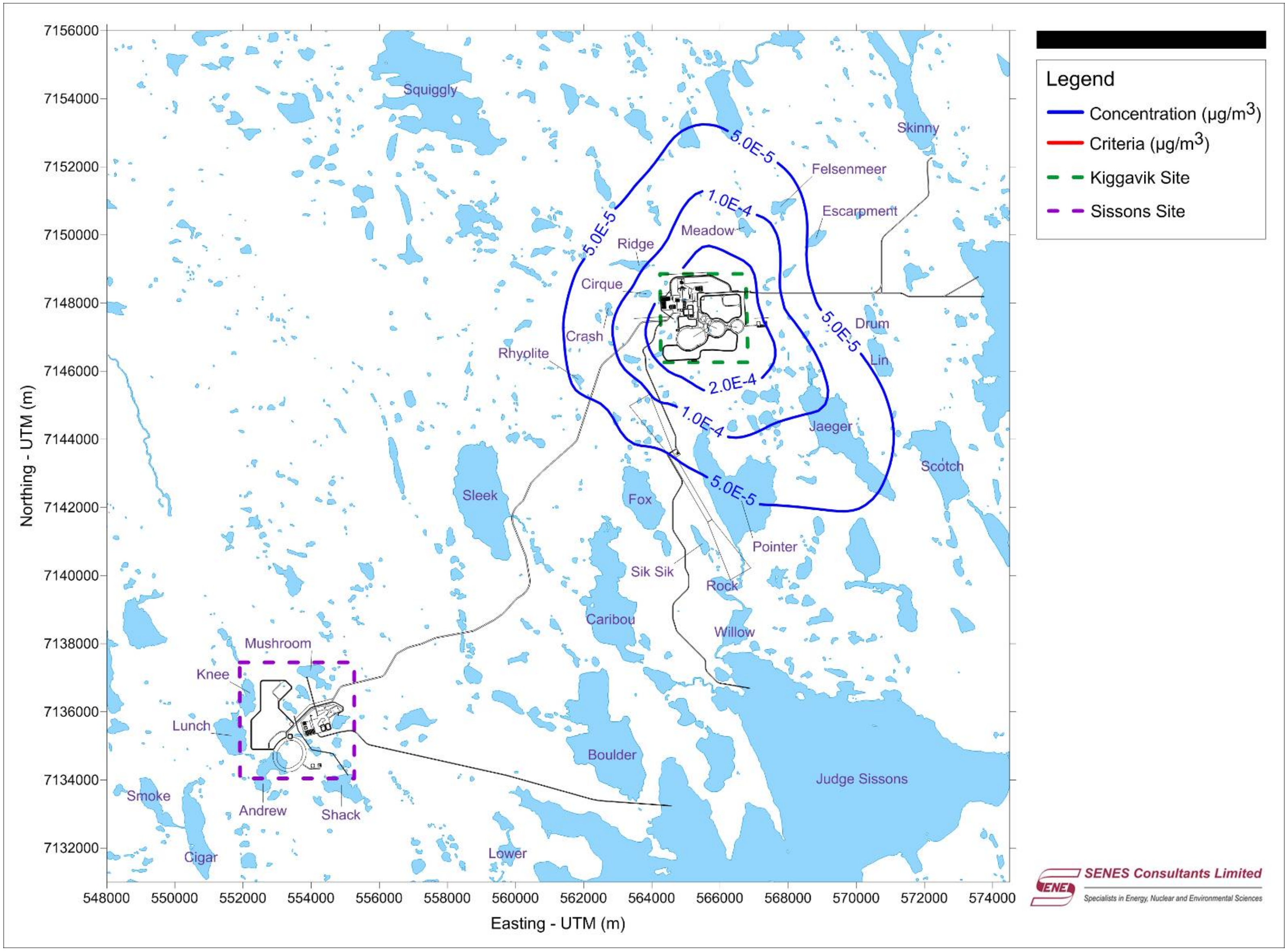


Figure D-36 Period 1 (Year 0 and 1) - Incremental Annual Nickel Concentration (µg/m³)

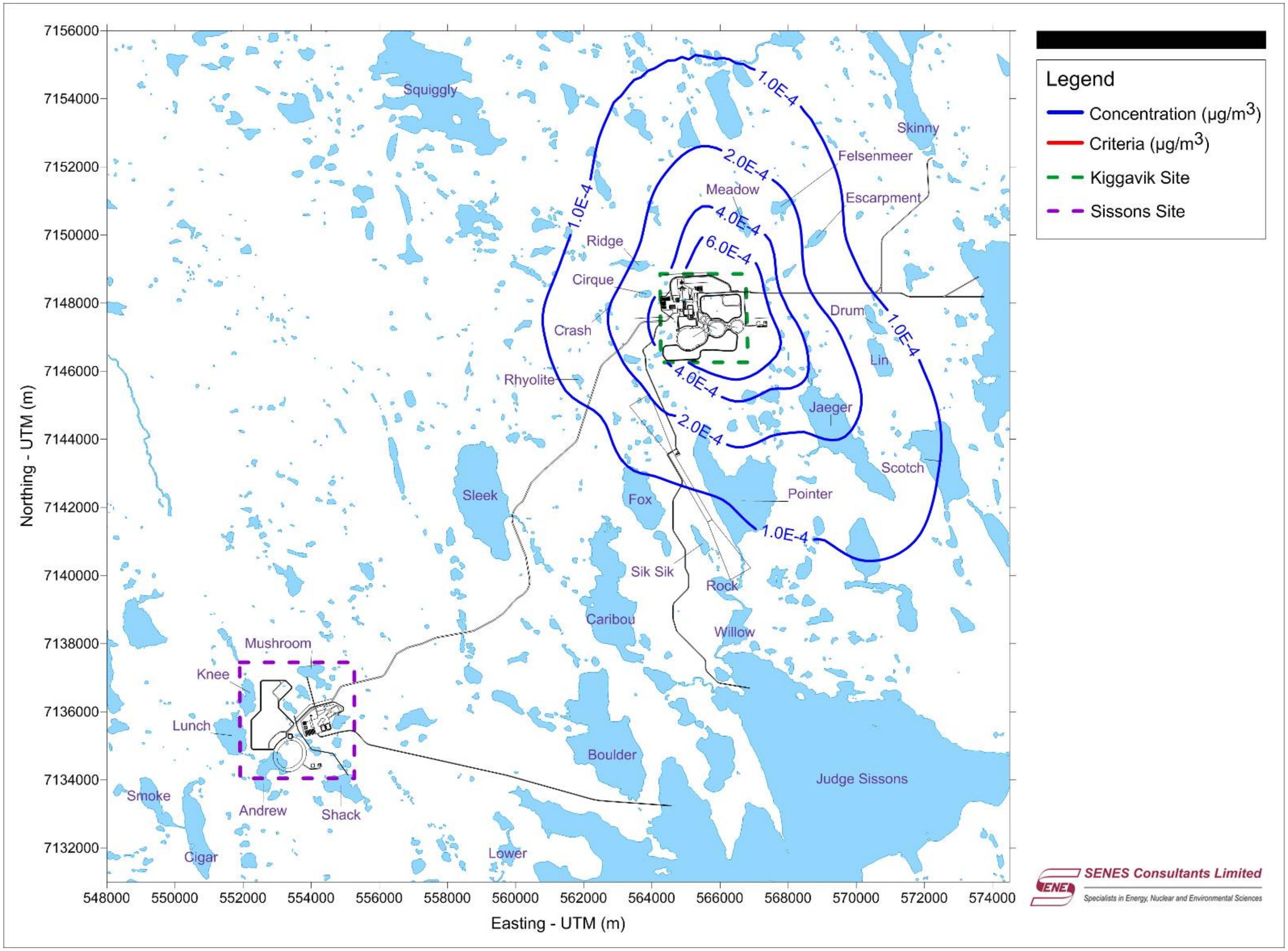


Figure D-37 Period 1 (Year 0 and 1) - Incremental Annual Selenium Concentration (µg/m³)

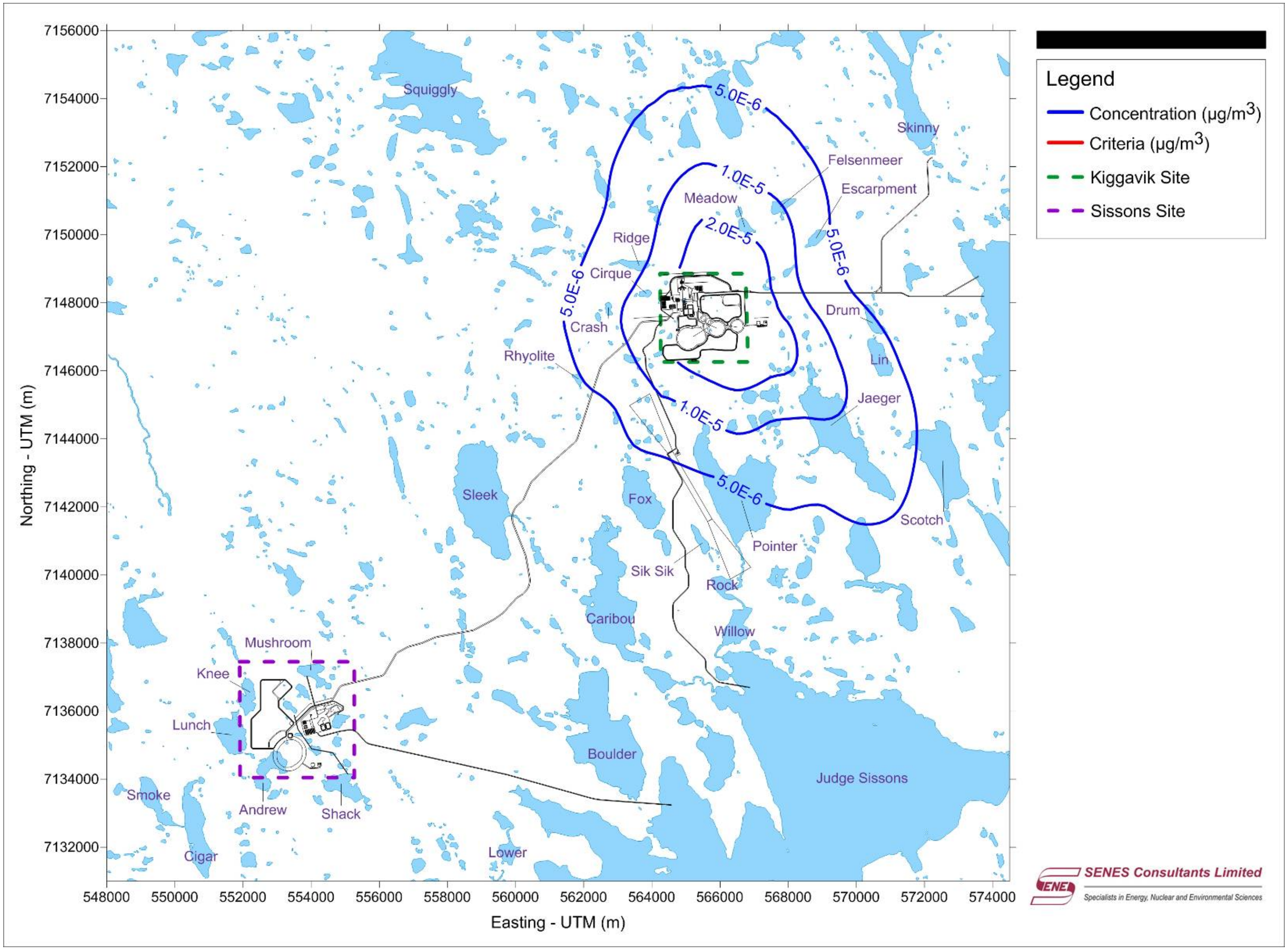


Figure D-38 Period 1 (Year 0 and 1) - Incremental Annual Zinc Concentration (µg/m³)

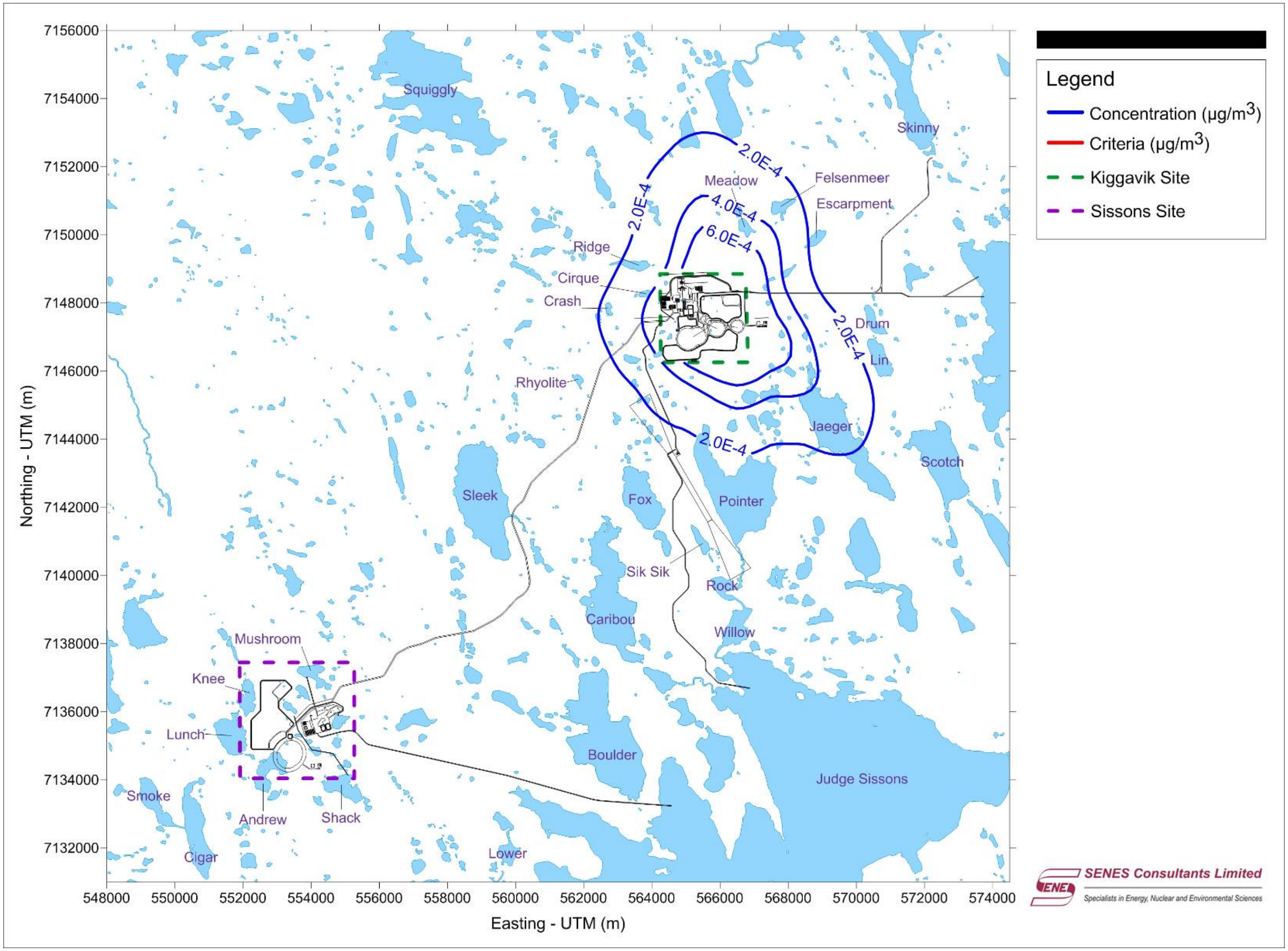


Figure D-39 Period 1 (Year 0 and 1) - Incremental Annual NO_2 Concentration (µg/m³)

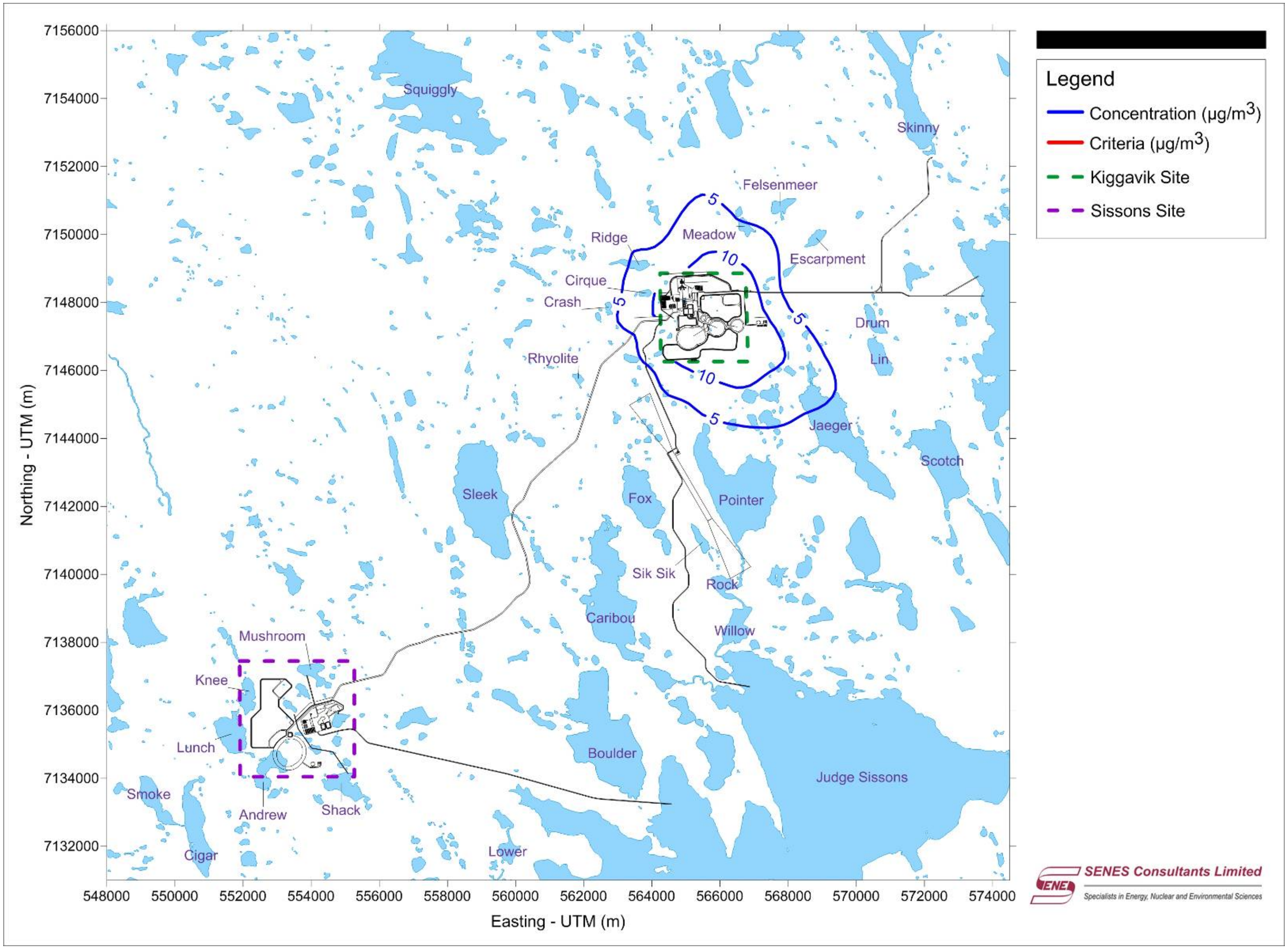


Figure D-40 Period 1 (Year 0 and 1) - Incremental Annual SO_2 Concentration (µg/m³)

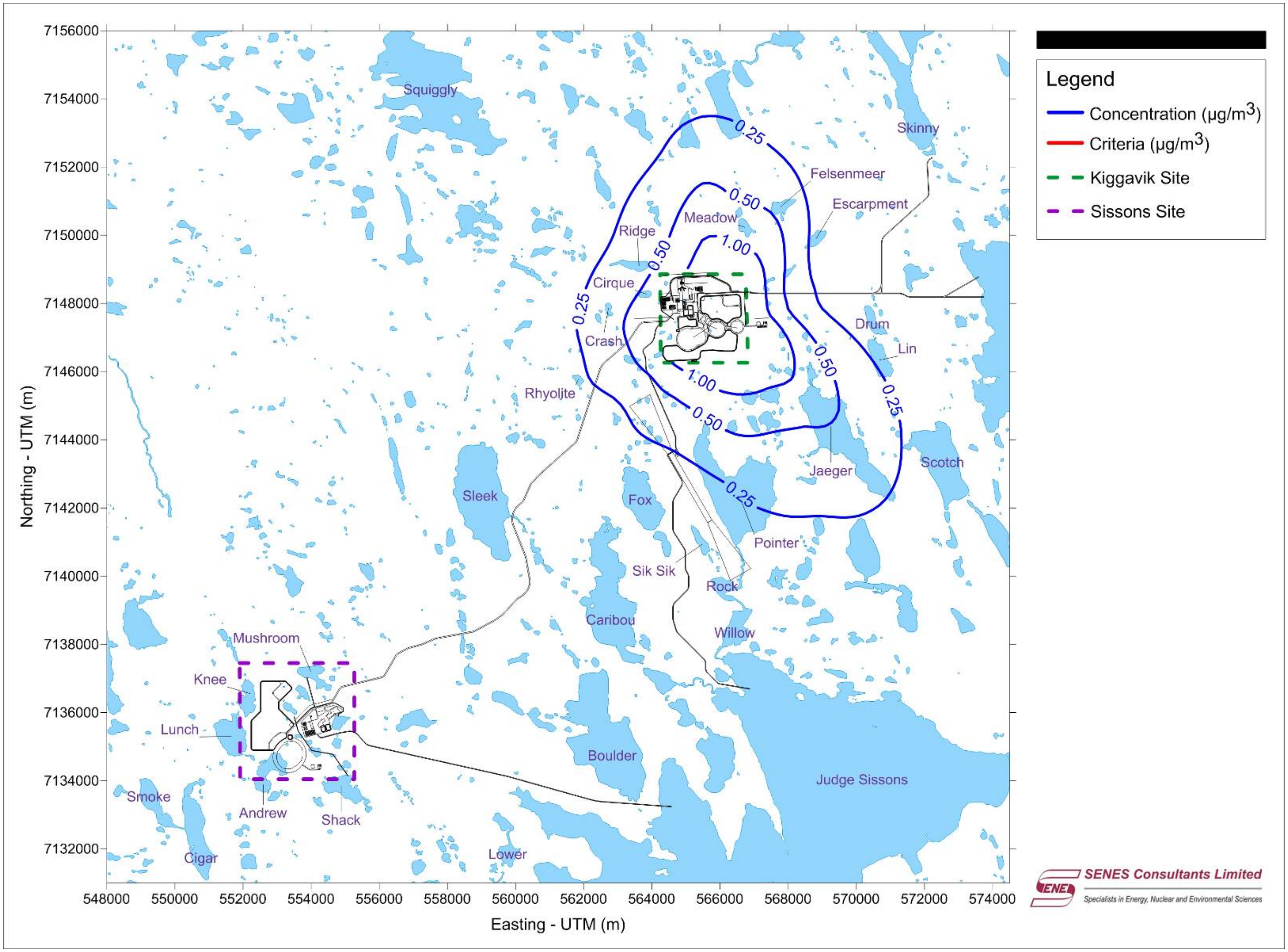


Figure D-41 Period 1 (Year 0 and 1) - Incremental Annual Radon Concentration (Bq/m³)

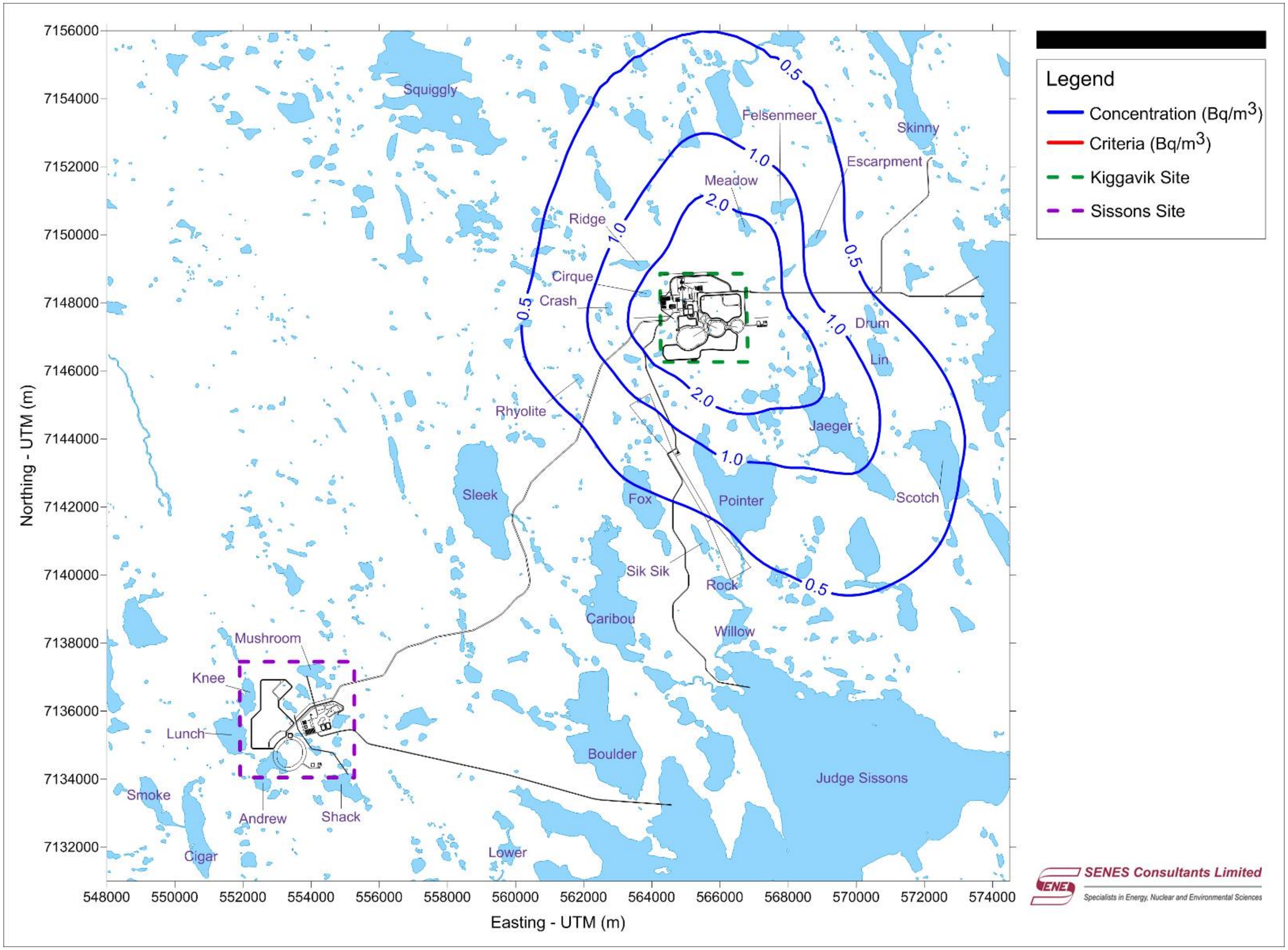


Figure D-42 Period 1 (Year 0 and 1) - Incremental Annual Lead-210 or Polonium-210 Concentration (Bq/m³)

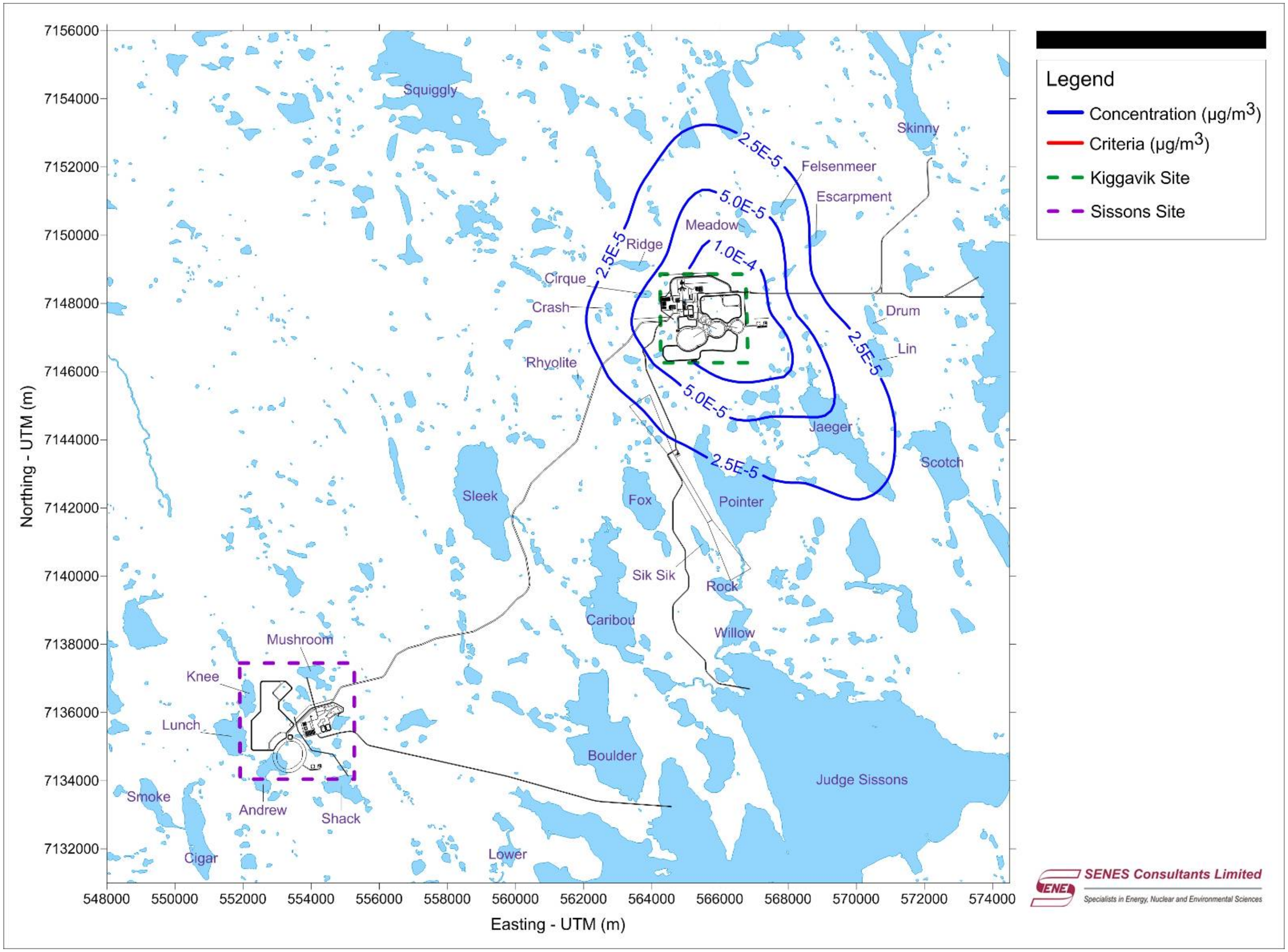


Figure D-43 Period 2 (Year 2-5) - Incremental Annual TSP Concentration (µg/m³)

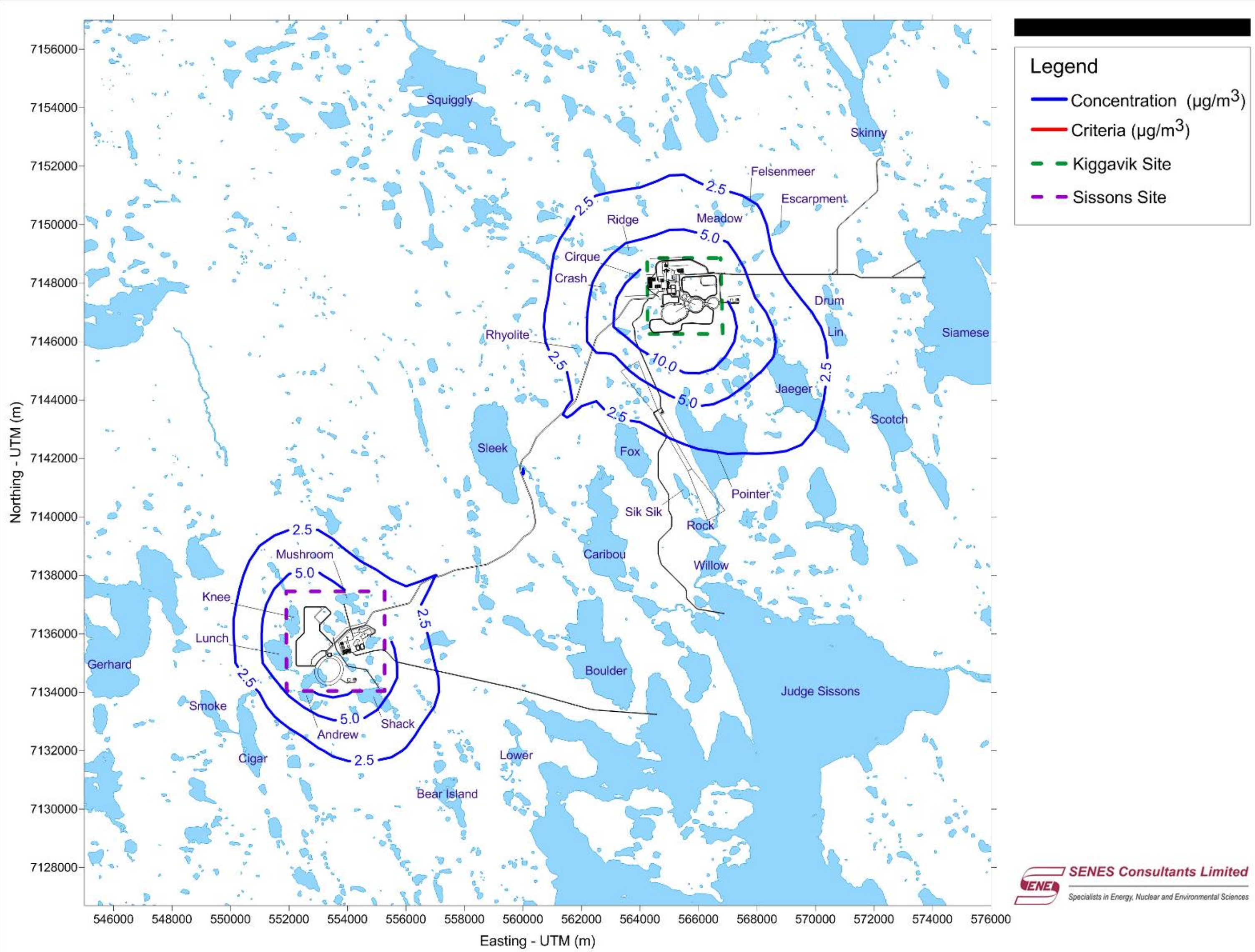


Figure D-44 Period 2 (Year 2-5) - Total Annual Dust Deposition (g/m²/year)

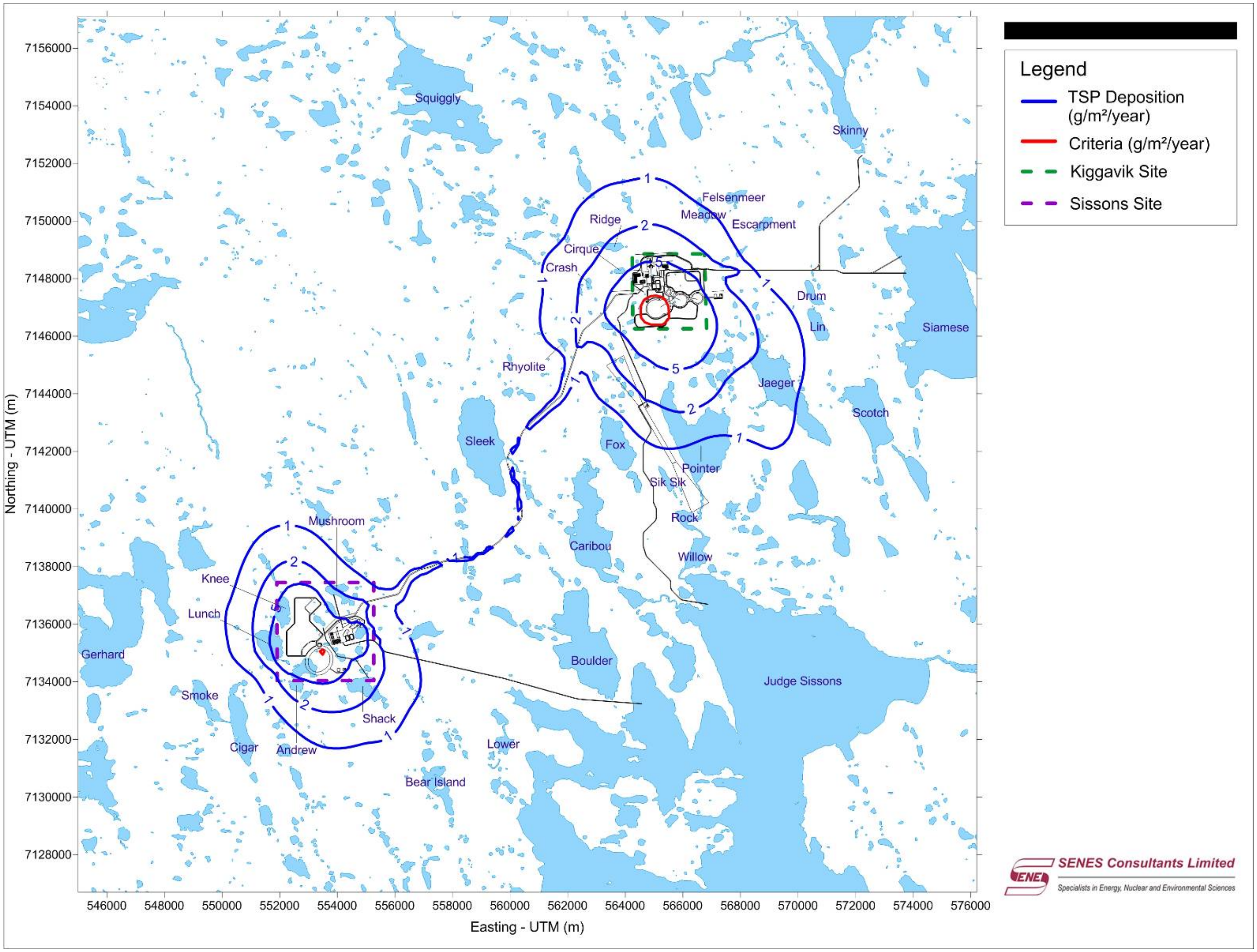


Figure D-45 Period 2 (Year 2-5) - Incremental Annual PM_{10} Concentration (µg/m³)

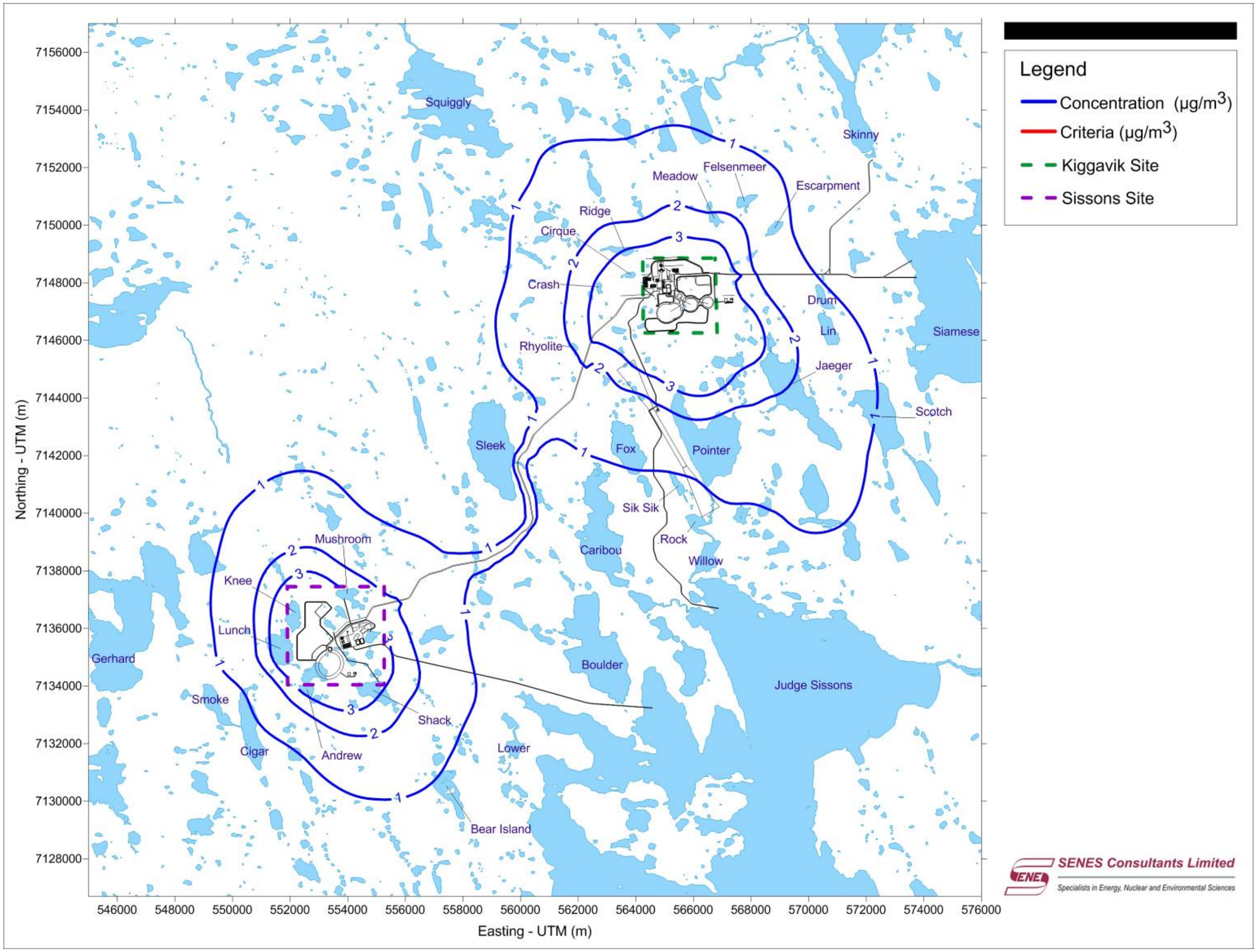


Figure D-46 Period 2 (Year 2-5) - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

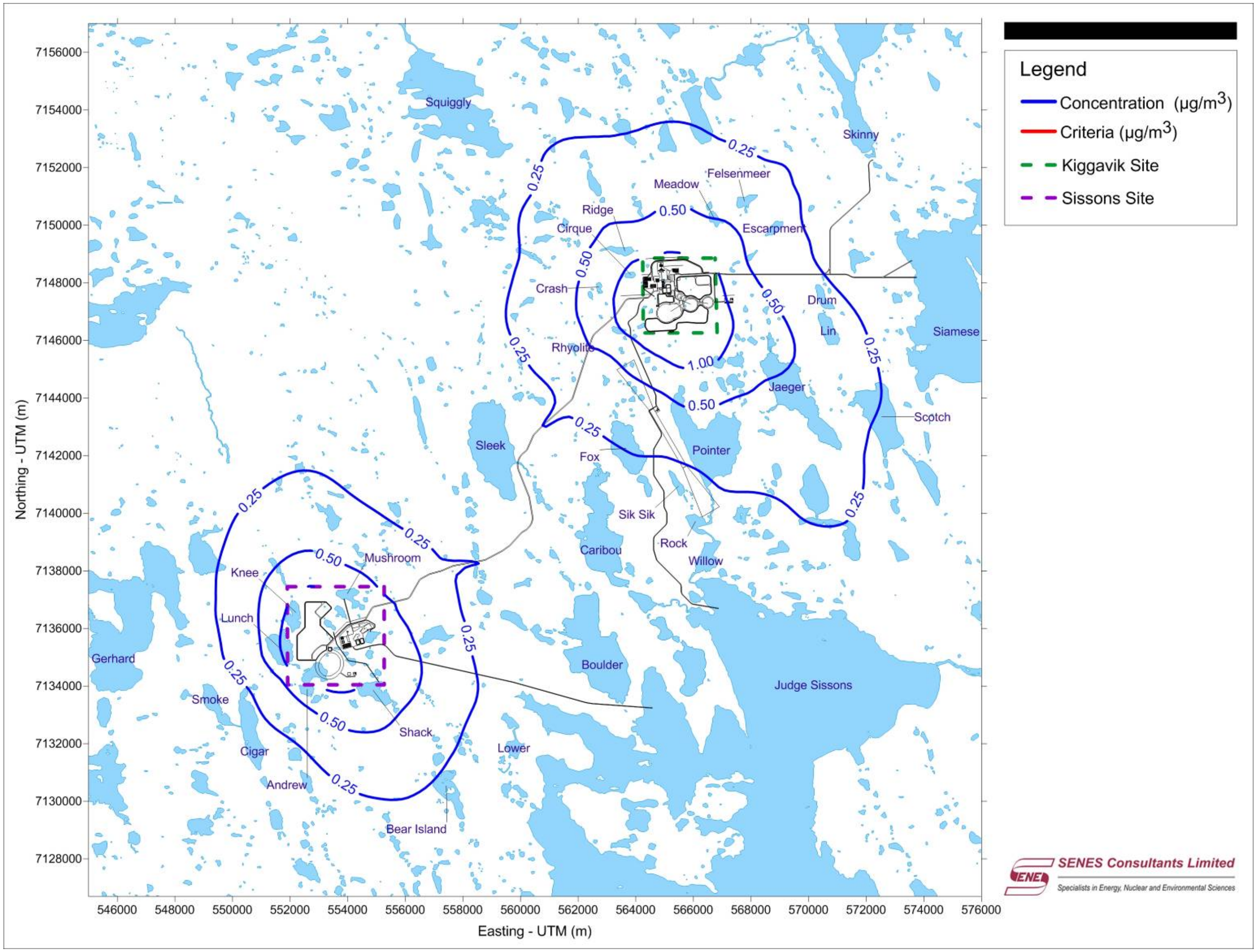


Figure D-47 Period 2 (Year 2-5) - Incremental Annual Uranium Concentration (µg/m³)

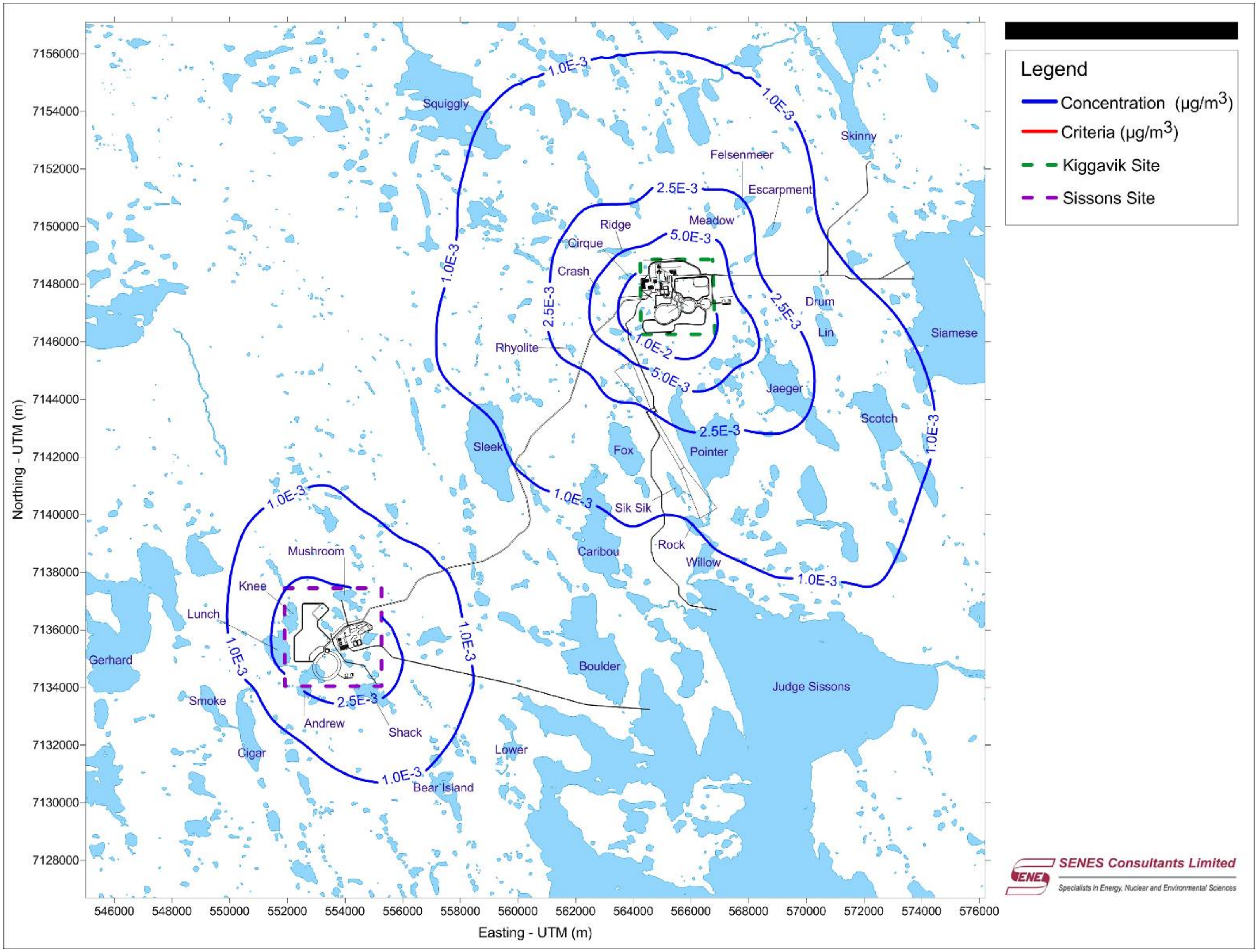


Figure D-48 Period 2 (Year 2-5) - Incremental Annual Arsenic Concentration (μg/m³)

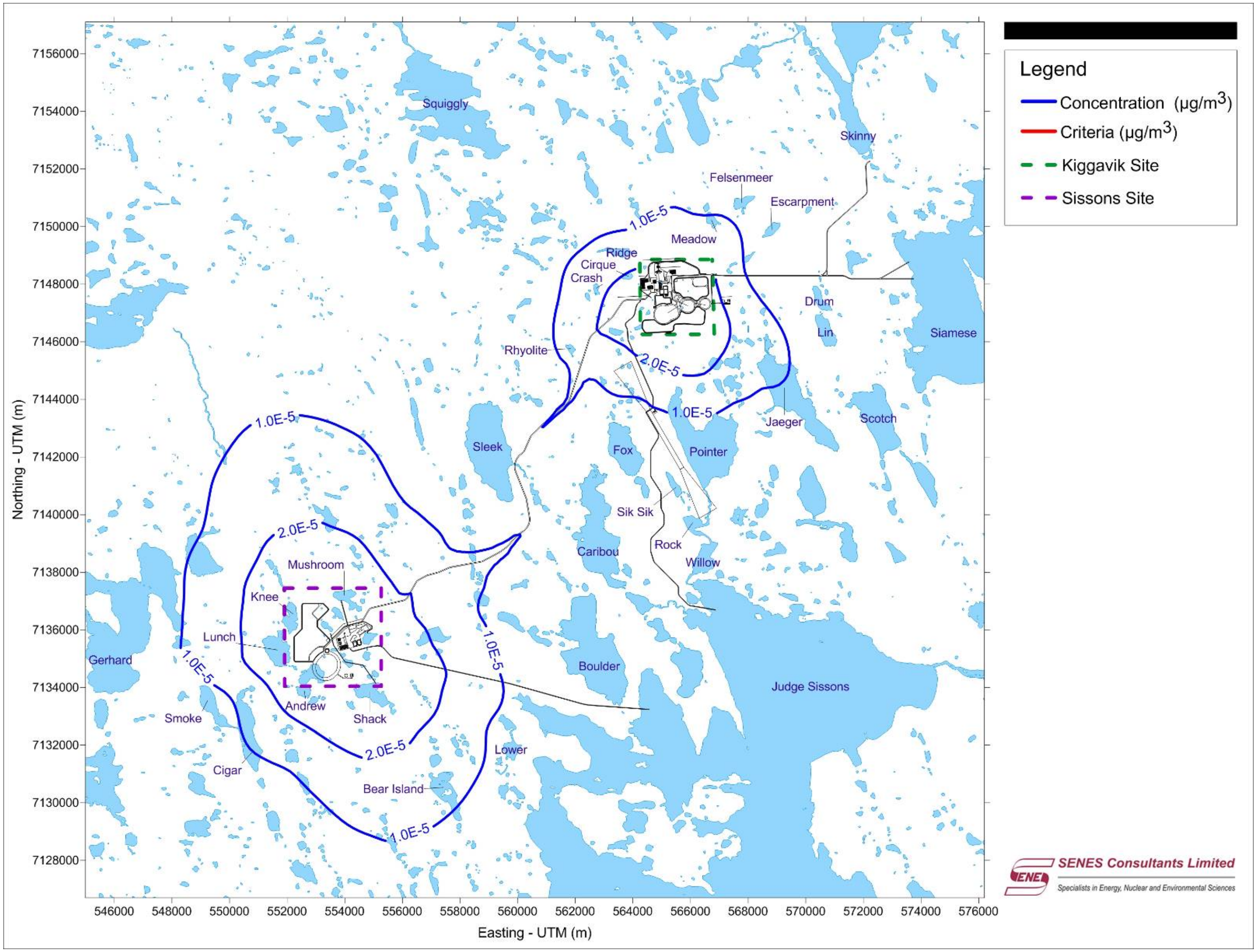


Figure D-49   Period 2 (Year 2-5) - Incremental Annual Cobalt Concentration (µg/m³)

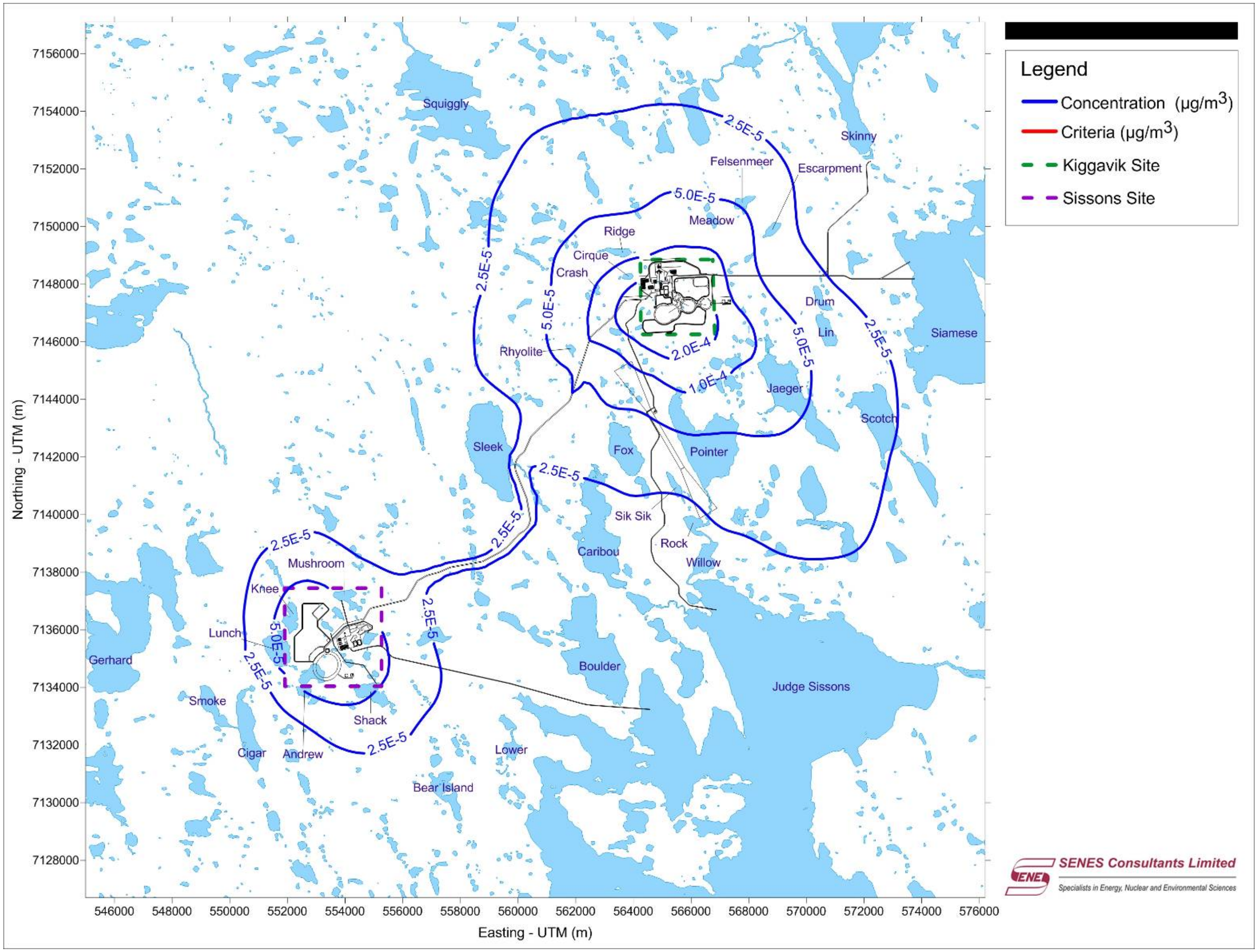


Figure D-50 Period 2 (Year 2-5) - Incremental Annual Cadmium Concentration (µg/m³)

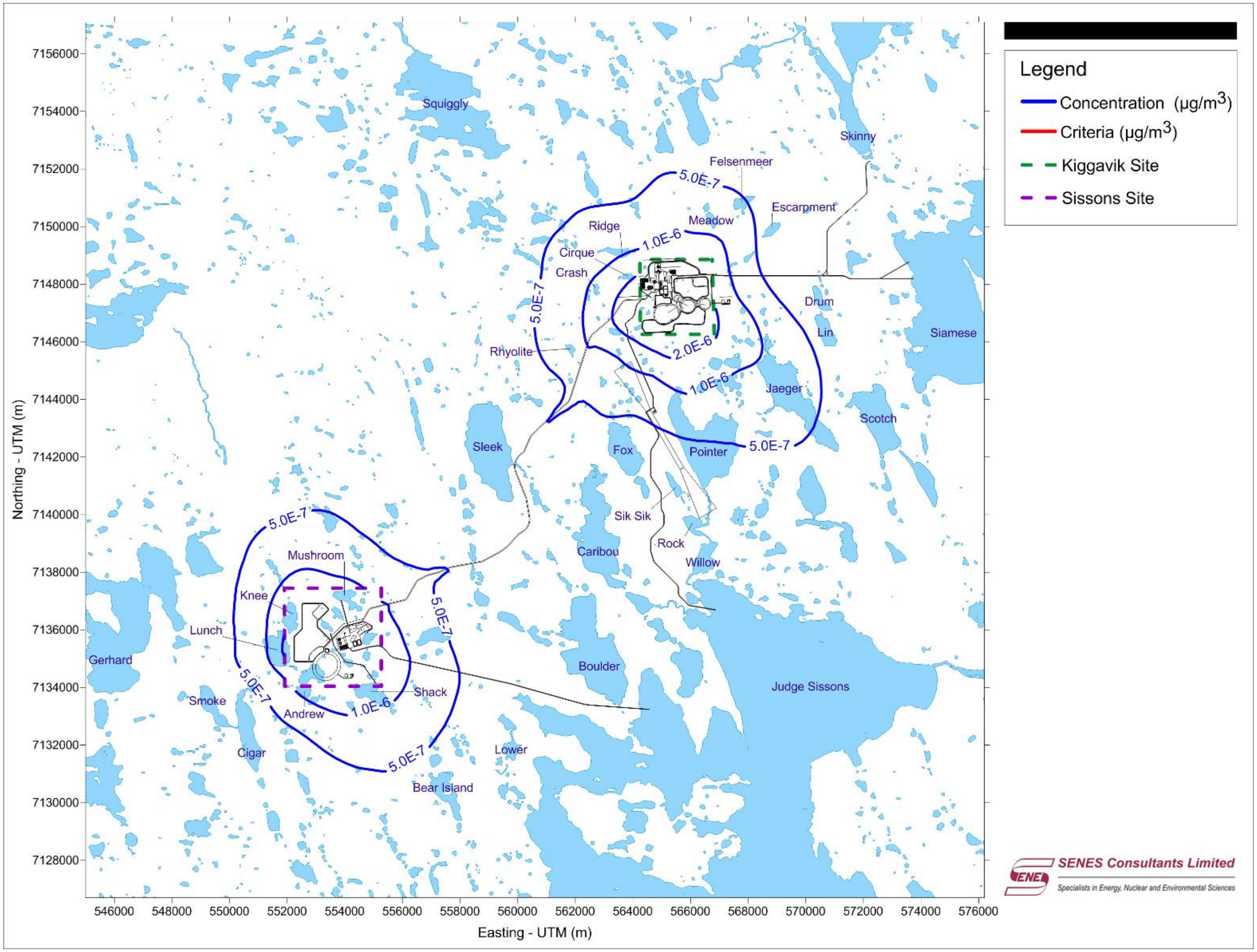


Figure D-51 Period 2 (Year 2-5) - Incremental Annual Chromium Concentration (µg/m³)

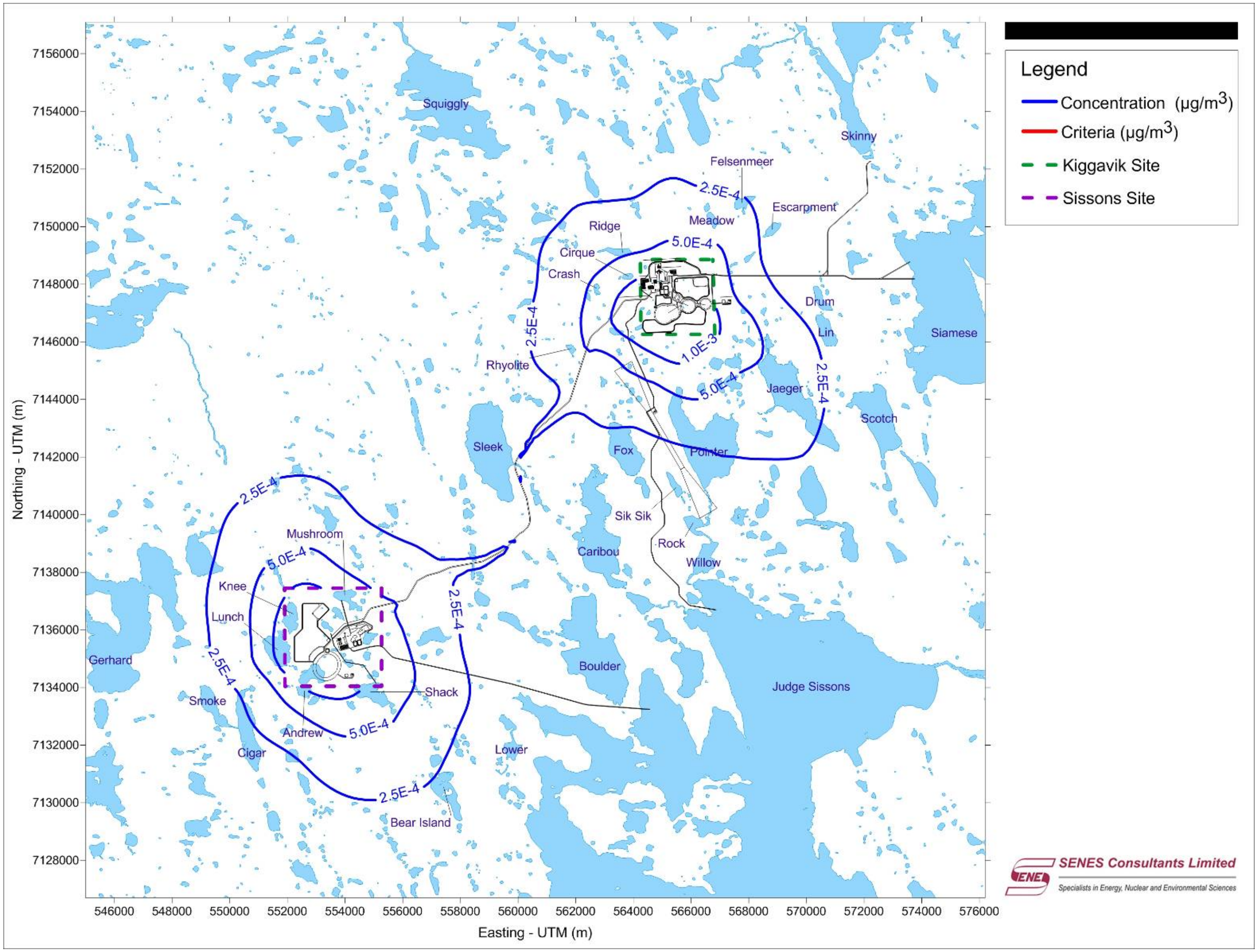


Figure D-52 Period 2 (Year 2-5) - Incremental Annual Copper Concentration (µg/m³)

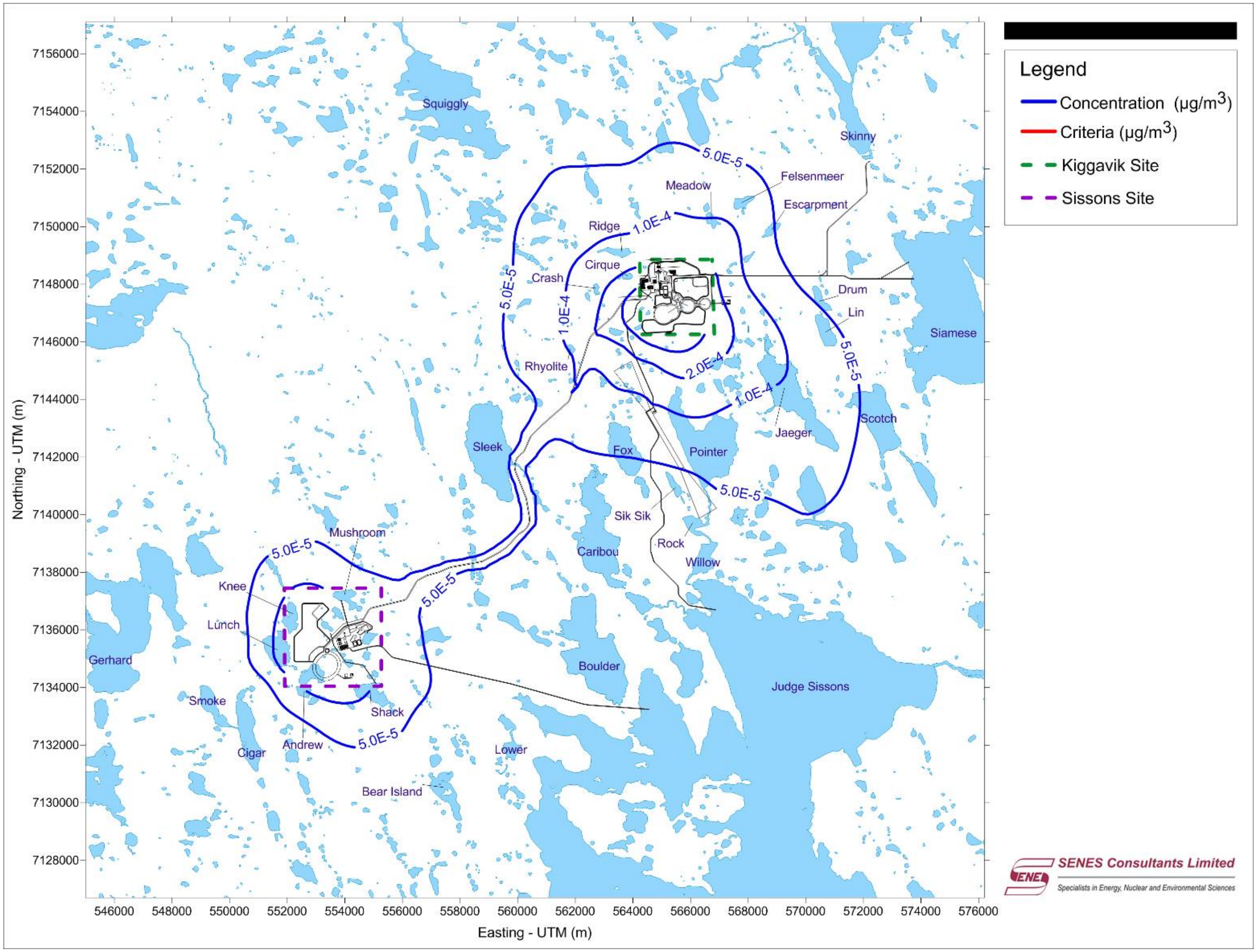


Figure D-53 Period 2 (Year 2-5) - Incremental Annual Lead Concentration (µg/m³)

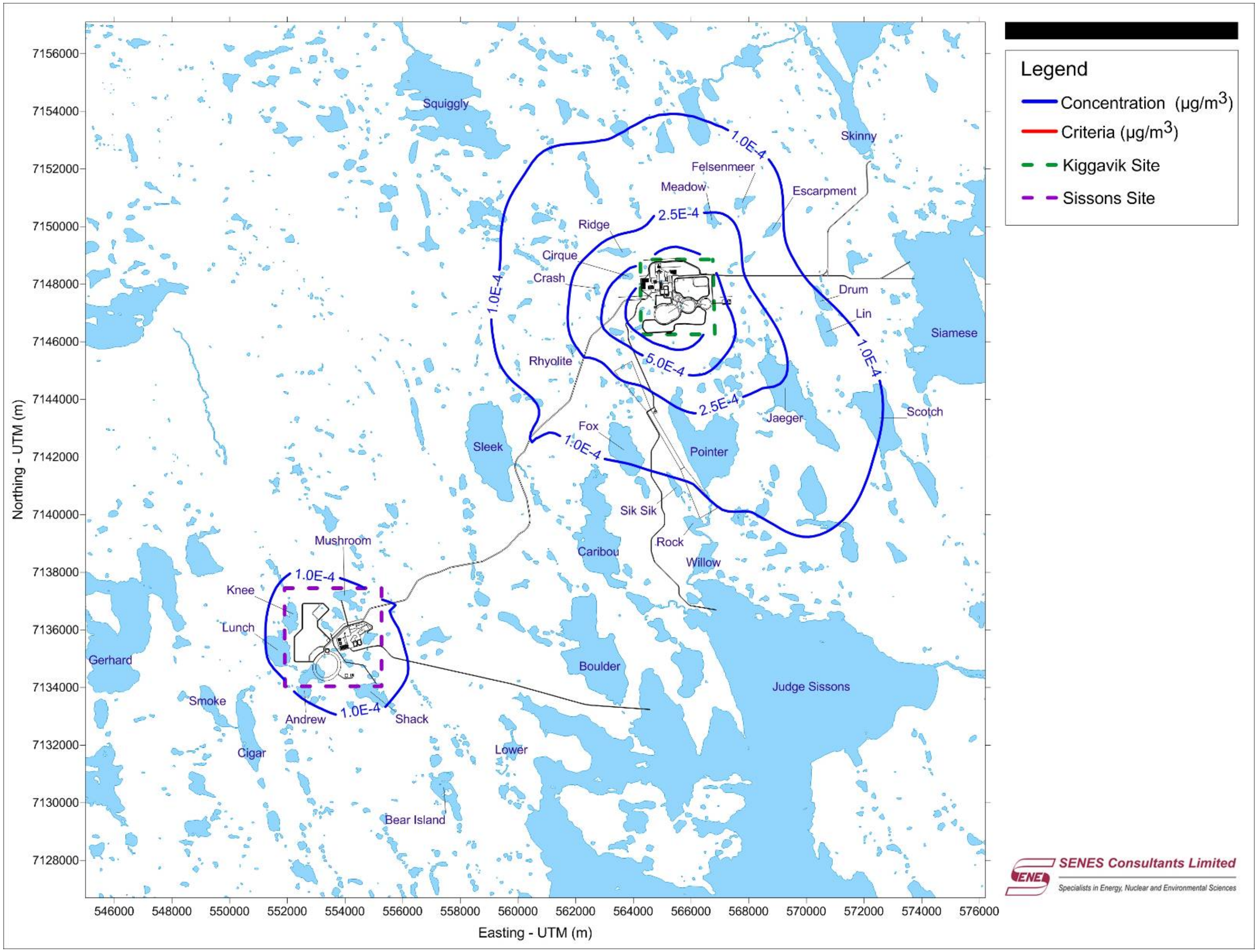


Figure D-54 Period 2 (Year 2-5) - Incremental Annual Molybdenum Concentration (µg/m³)

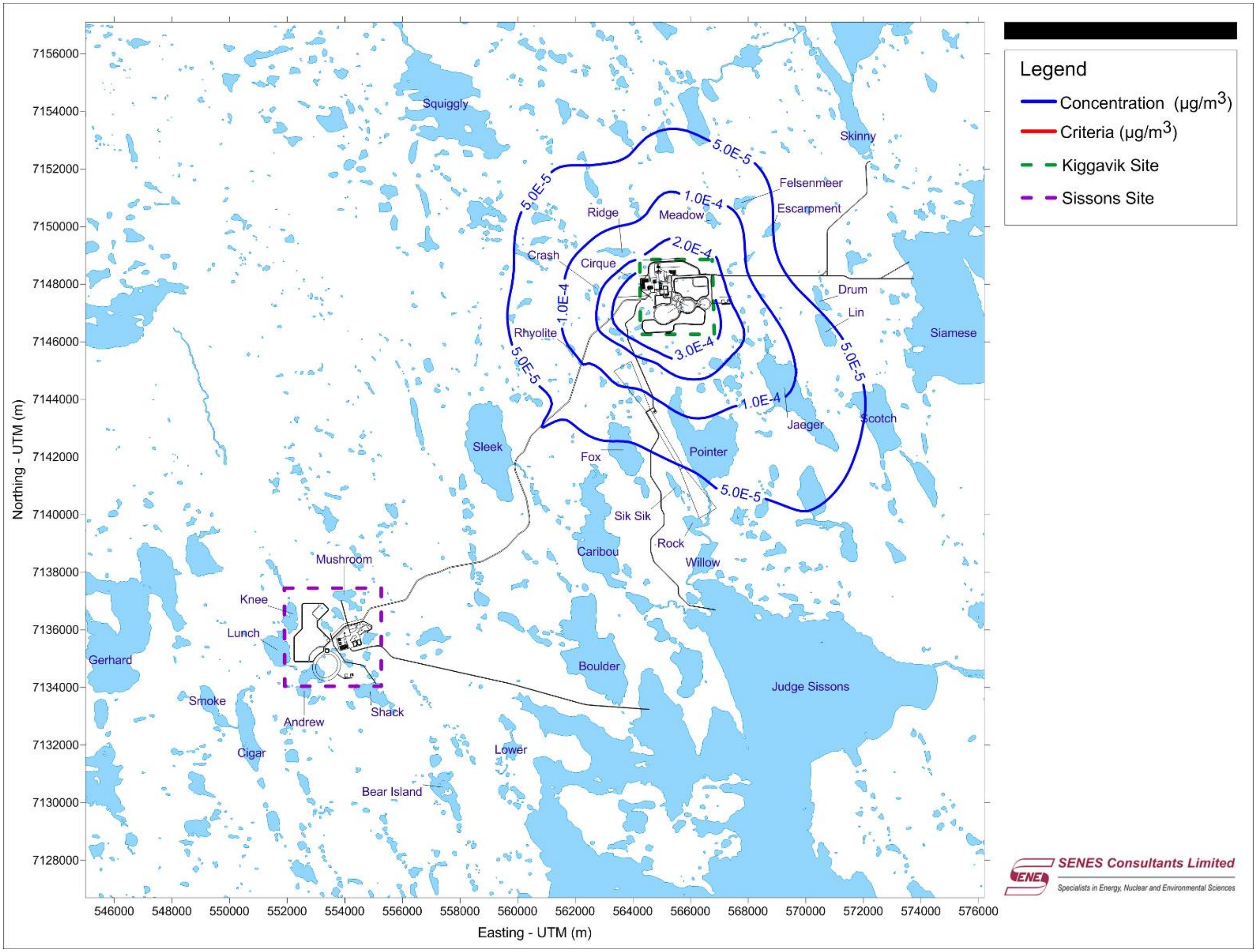


Figure D-55 Period 2 (Year 2-5) - Incremental Annual Nickel Concentration (µg/m³)

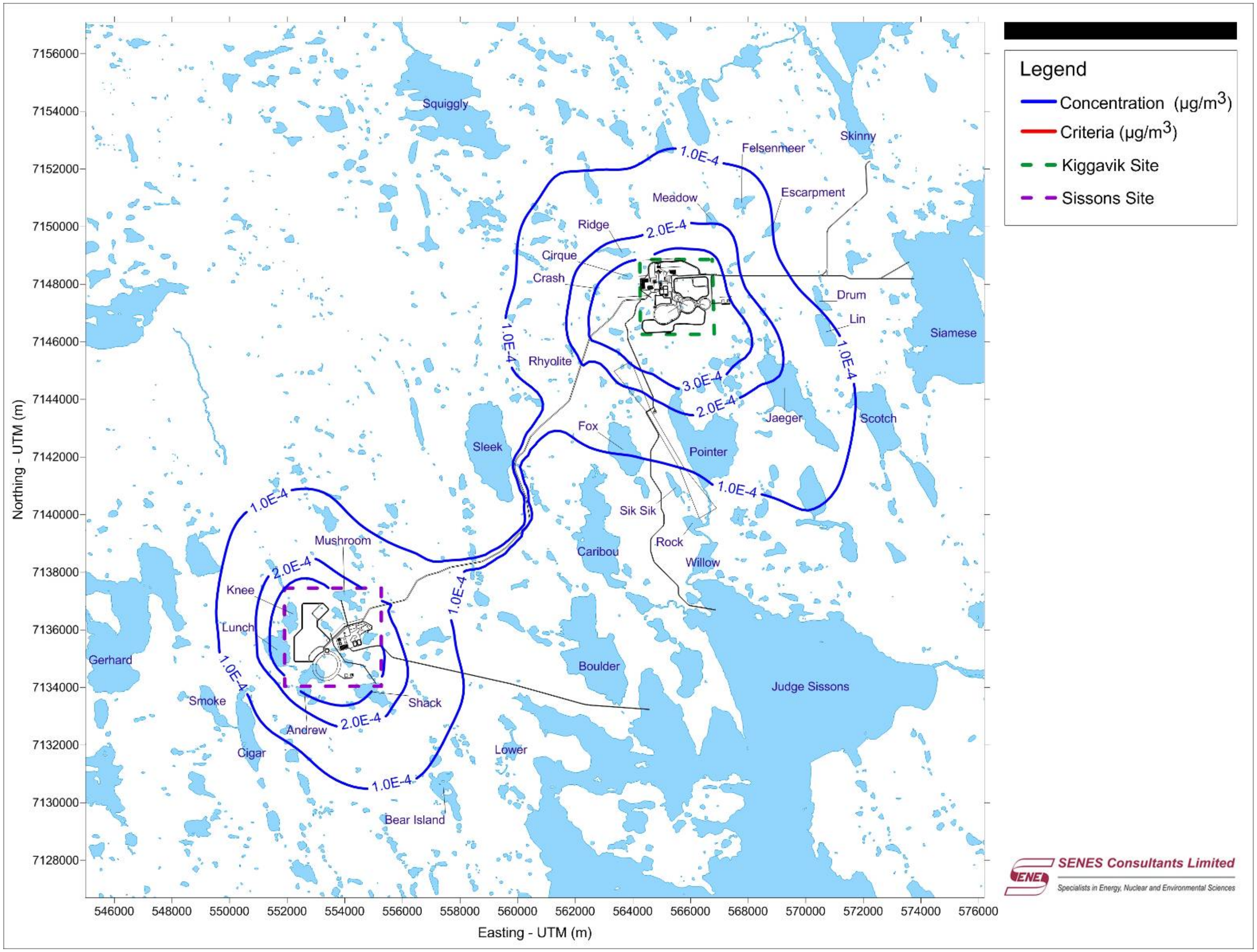


Figure D-56 Period 2 (Year 2-5) - Incremental Annual Selenium Concentration (µg/m³)

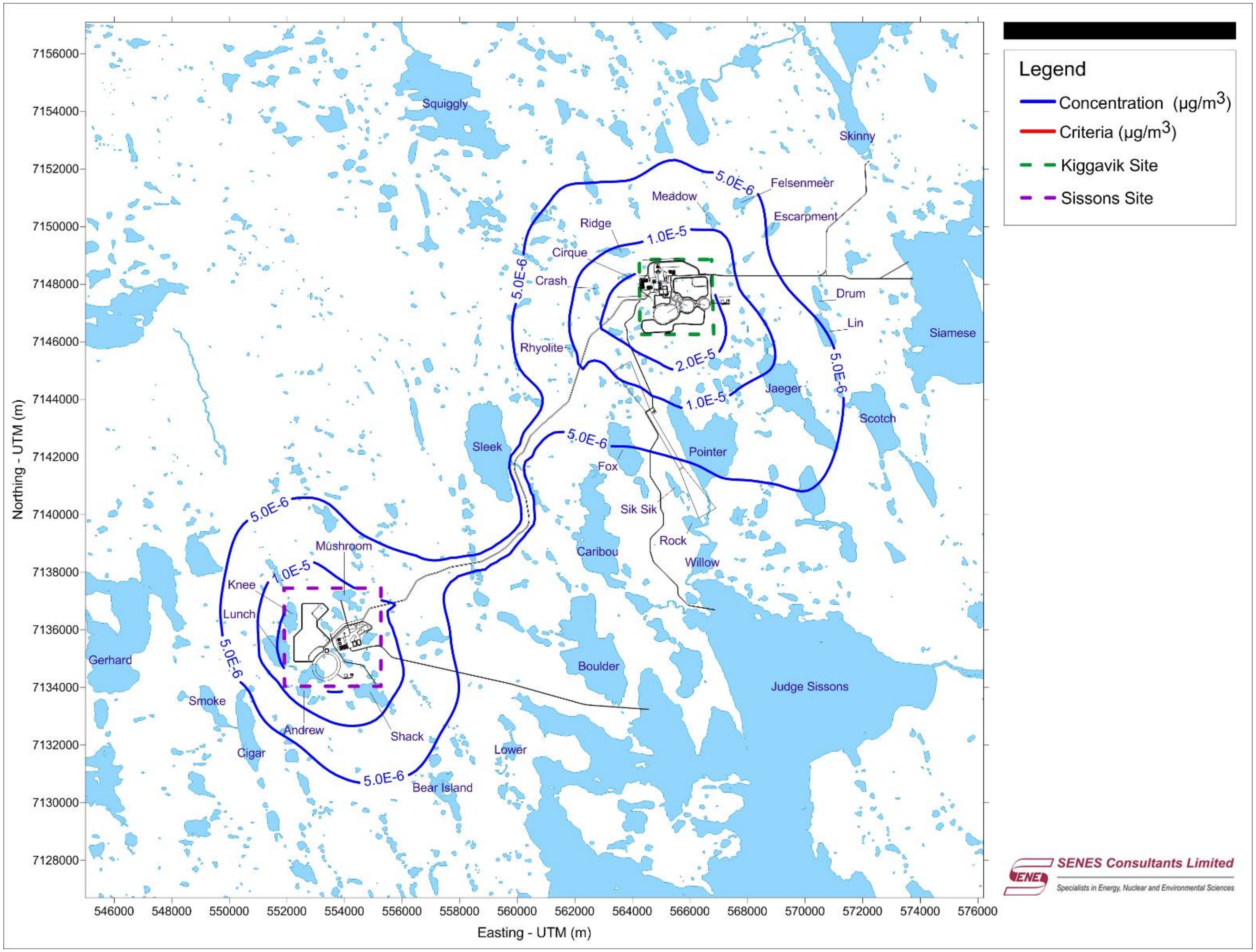


Figure D-57 Period 2 (Year 2-5) - Incremental Annual Zinc Concentration (µg/m³)

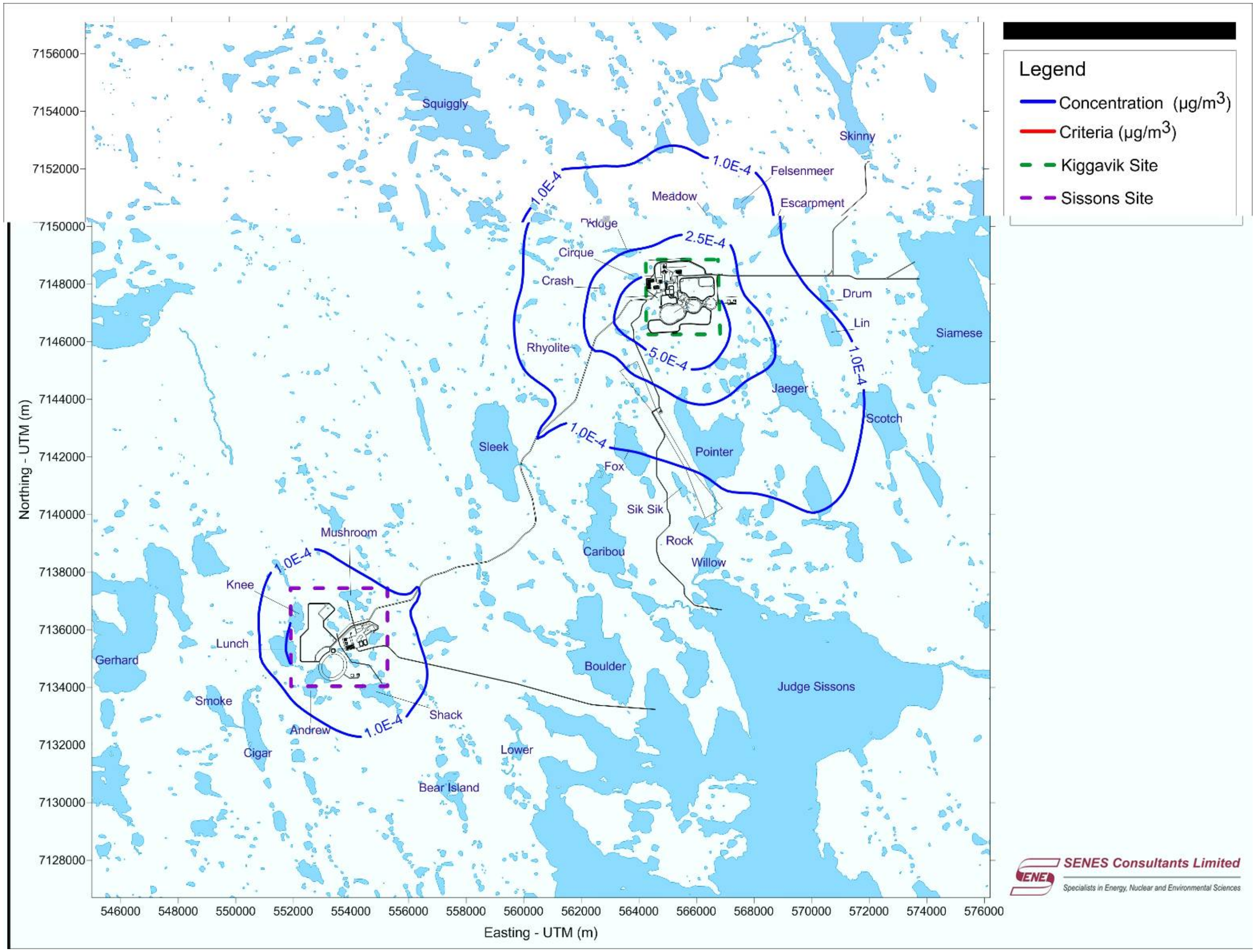


Figure D-58 Period 2 (Year 2-5) - Incremental Annual NO_2 Concentration (µg/m³)

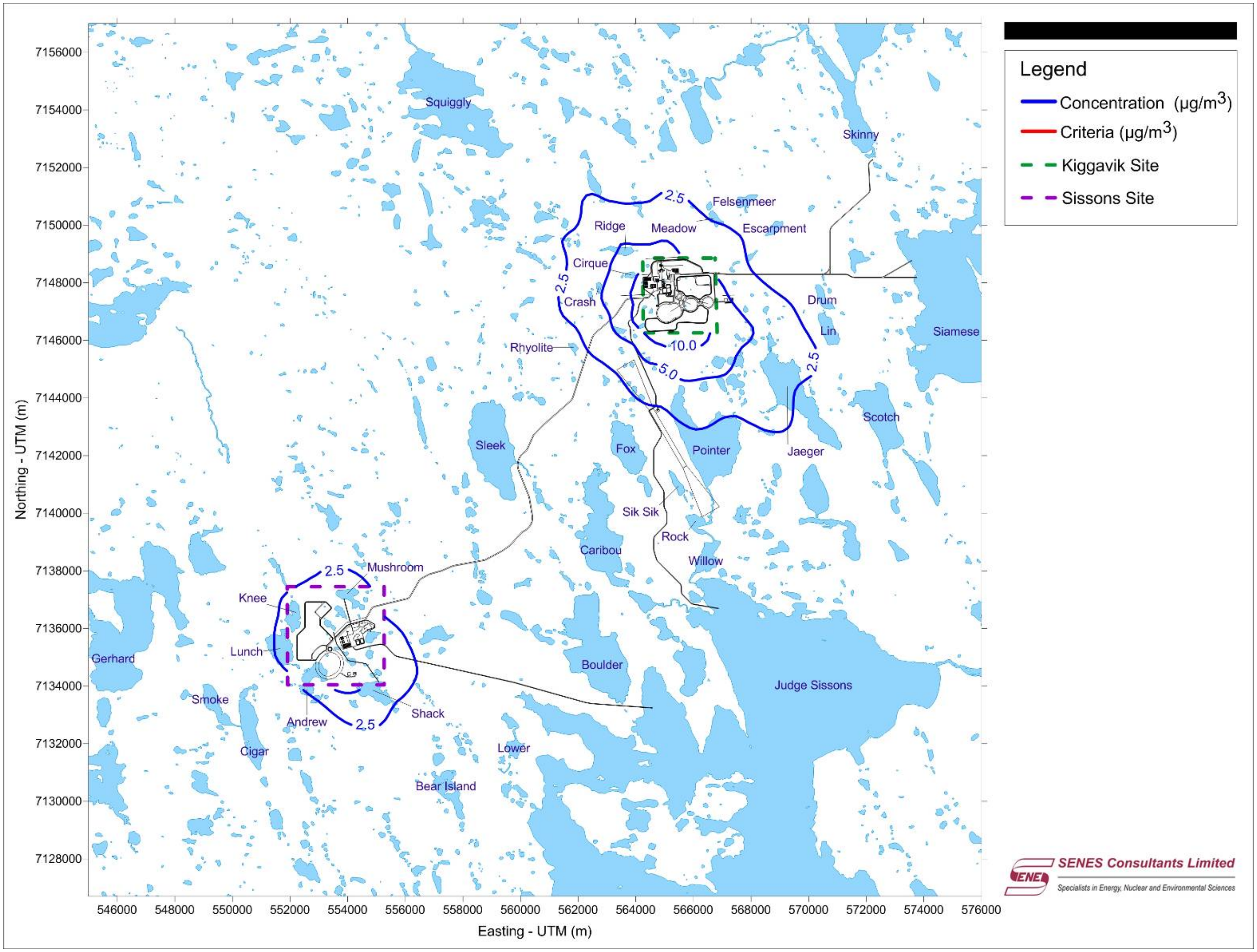


Figure D-59 Period 2 (Year 2-5) - Incremental Annual SO_2 Concentration (µg/m³)

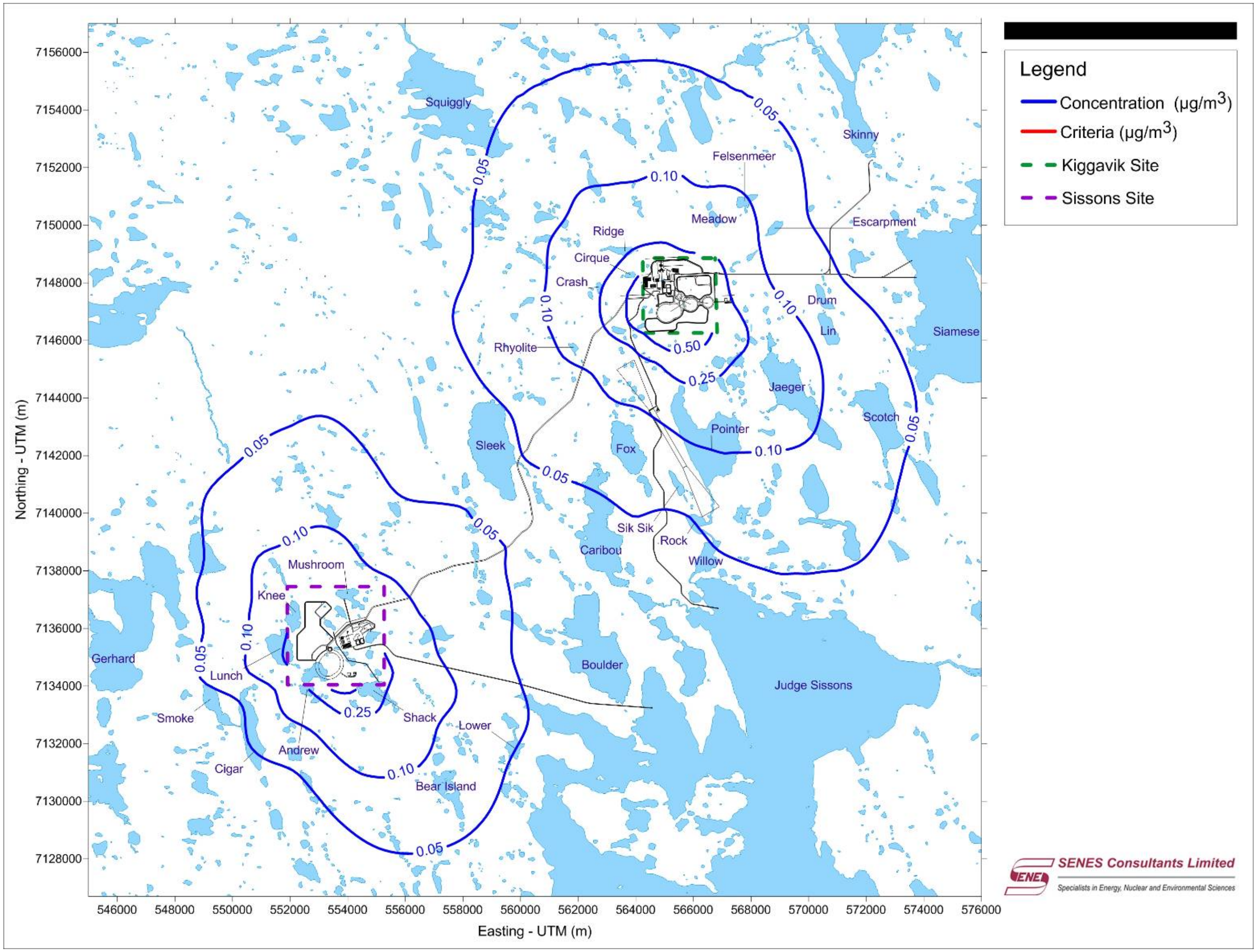


Figure D-60 Period 2 (Year 2-5) - Total Annual Potential Acid Input (Including Background) (µg/m³)

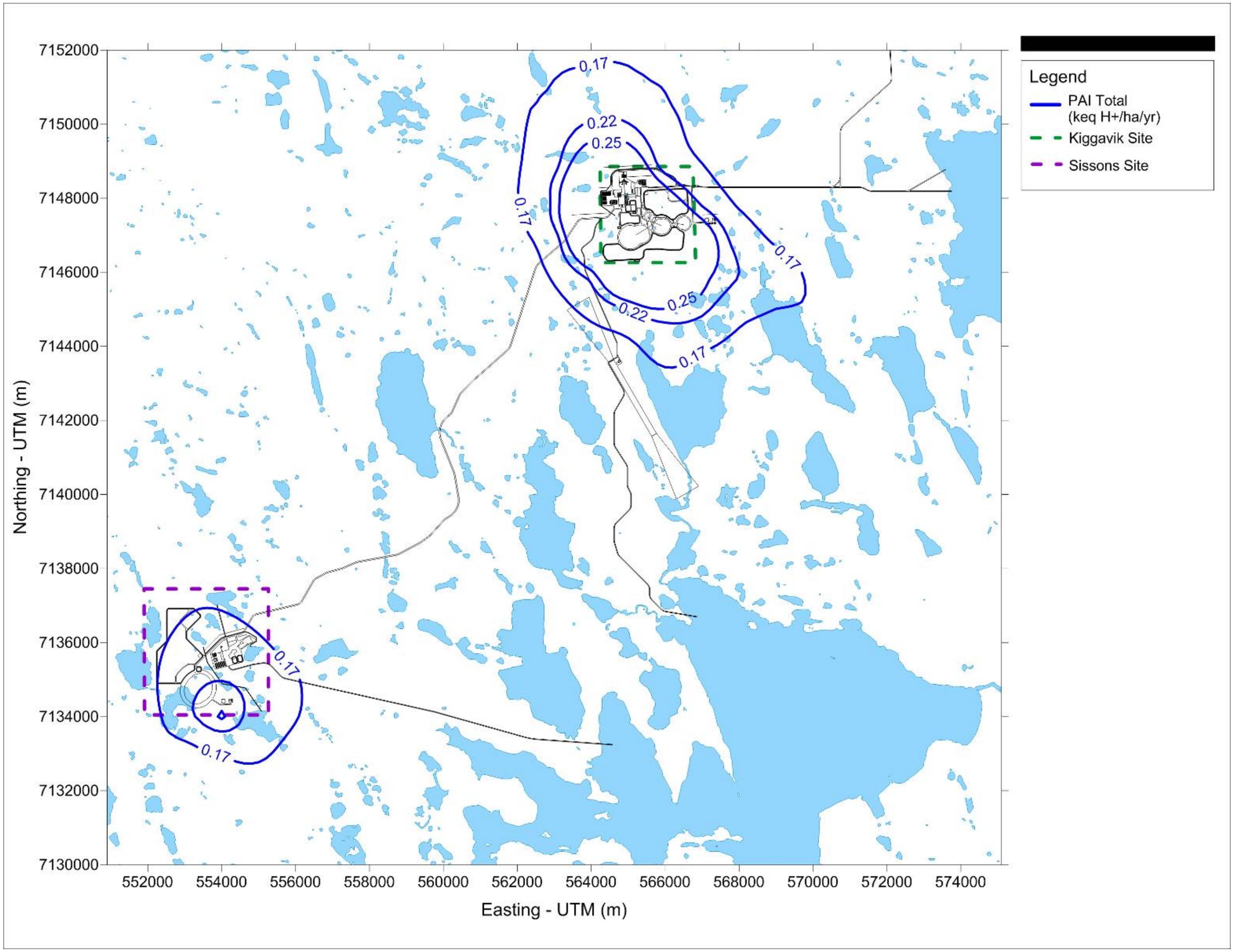


Figure D-61 Period 2 (Year 2-5) - Incremental Annual Radon Concentration (Bq/m³)

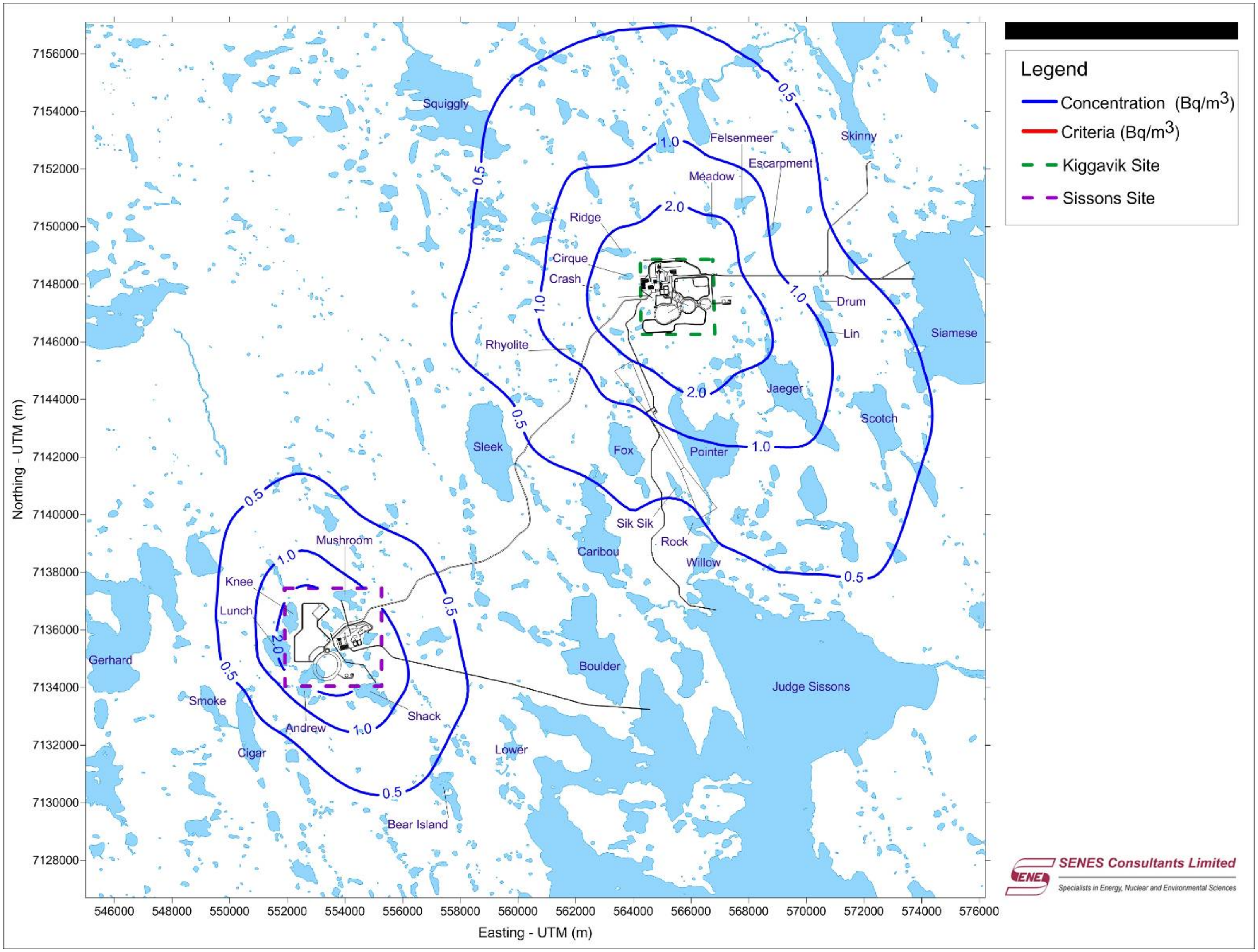


Figure D-62 Period 2 (Year 2-5) - Incremental Annual Lead-210 or Polonium-210 Concentration (Bq/m³)

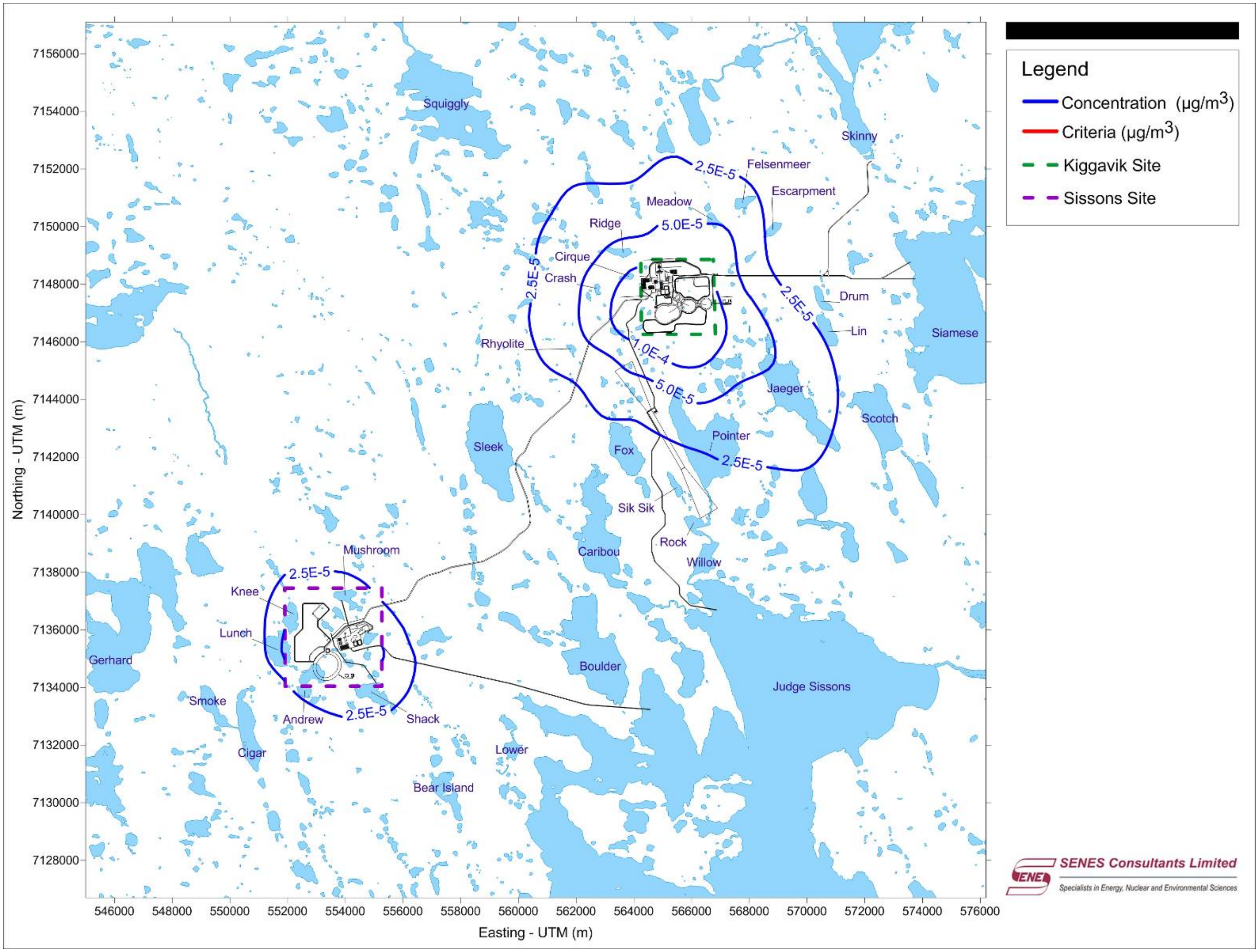


Figure D-63 Period 3 (Year 6-13) - Incremental Annual TSP Concentration (µg/m³)

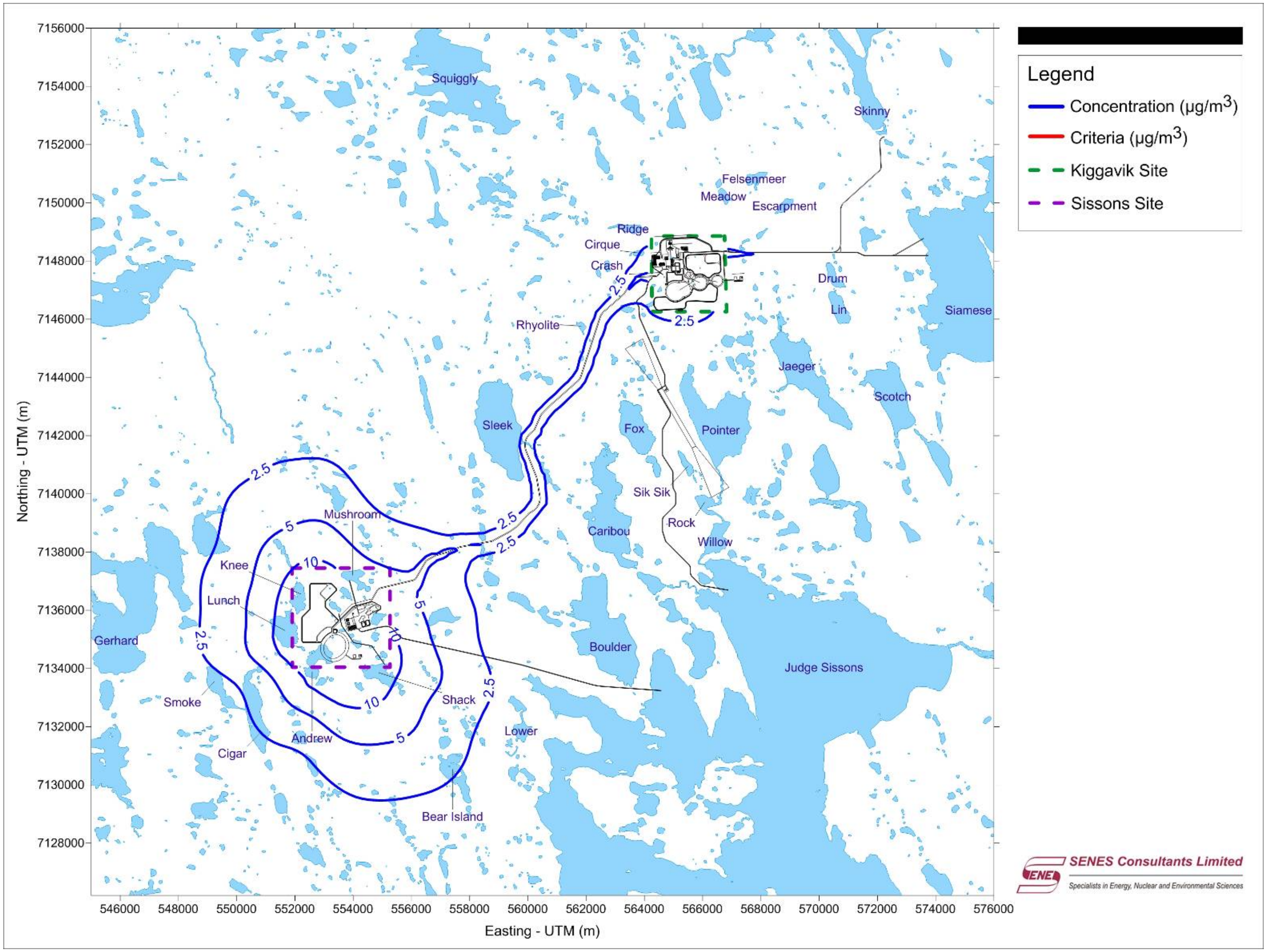


Figure D-64 Period 3 (Year 6-13) - Incremental Annual PM_{10} Concentration (µg/m³)

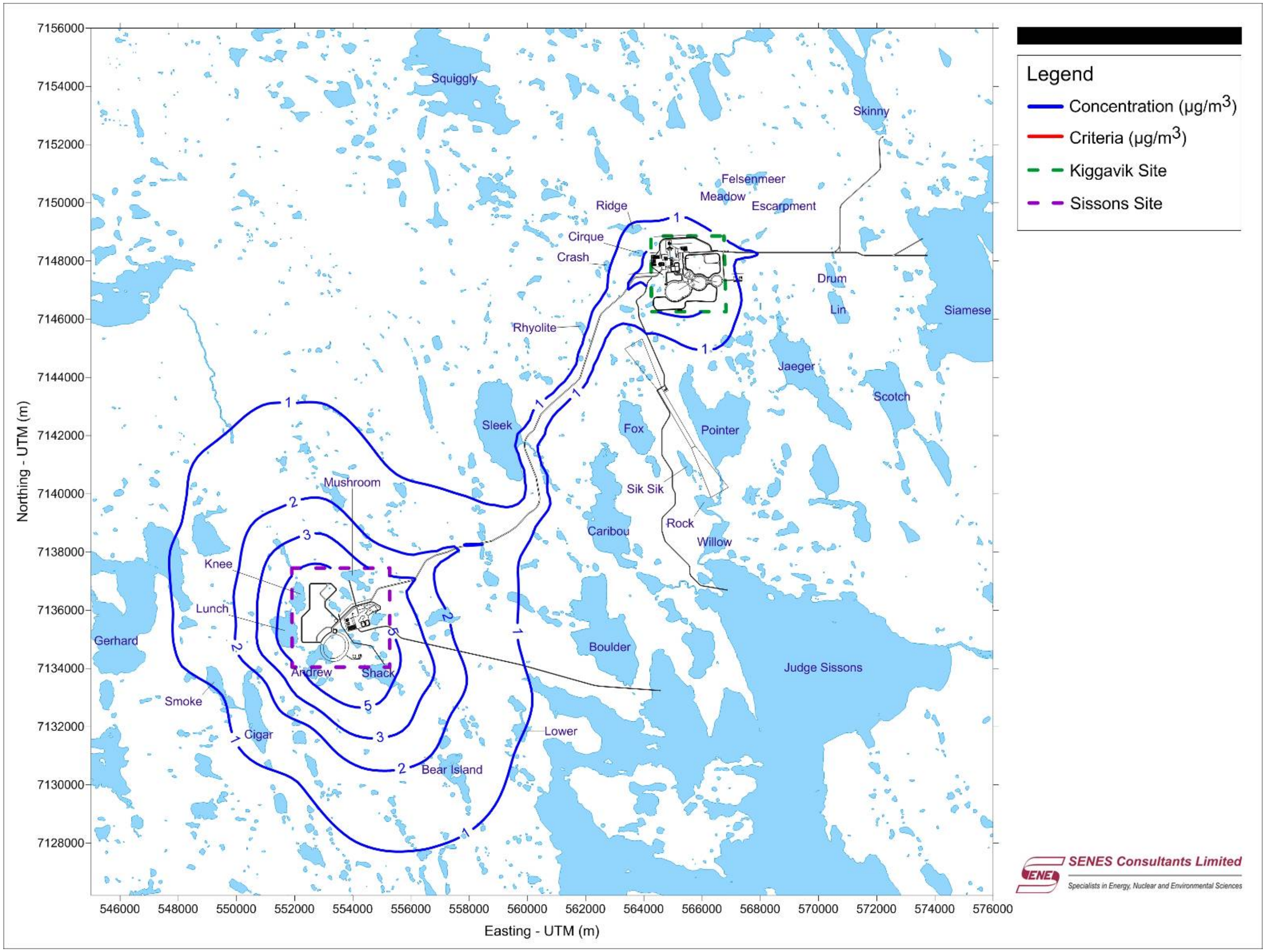


Figure D-65 Period 3 (Year 6-13) - Incremental Annual $PM_{2.5}$ Concentration ($\mu g/m^3$)

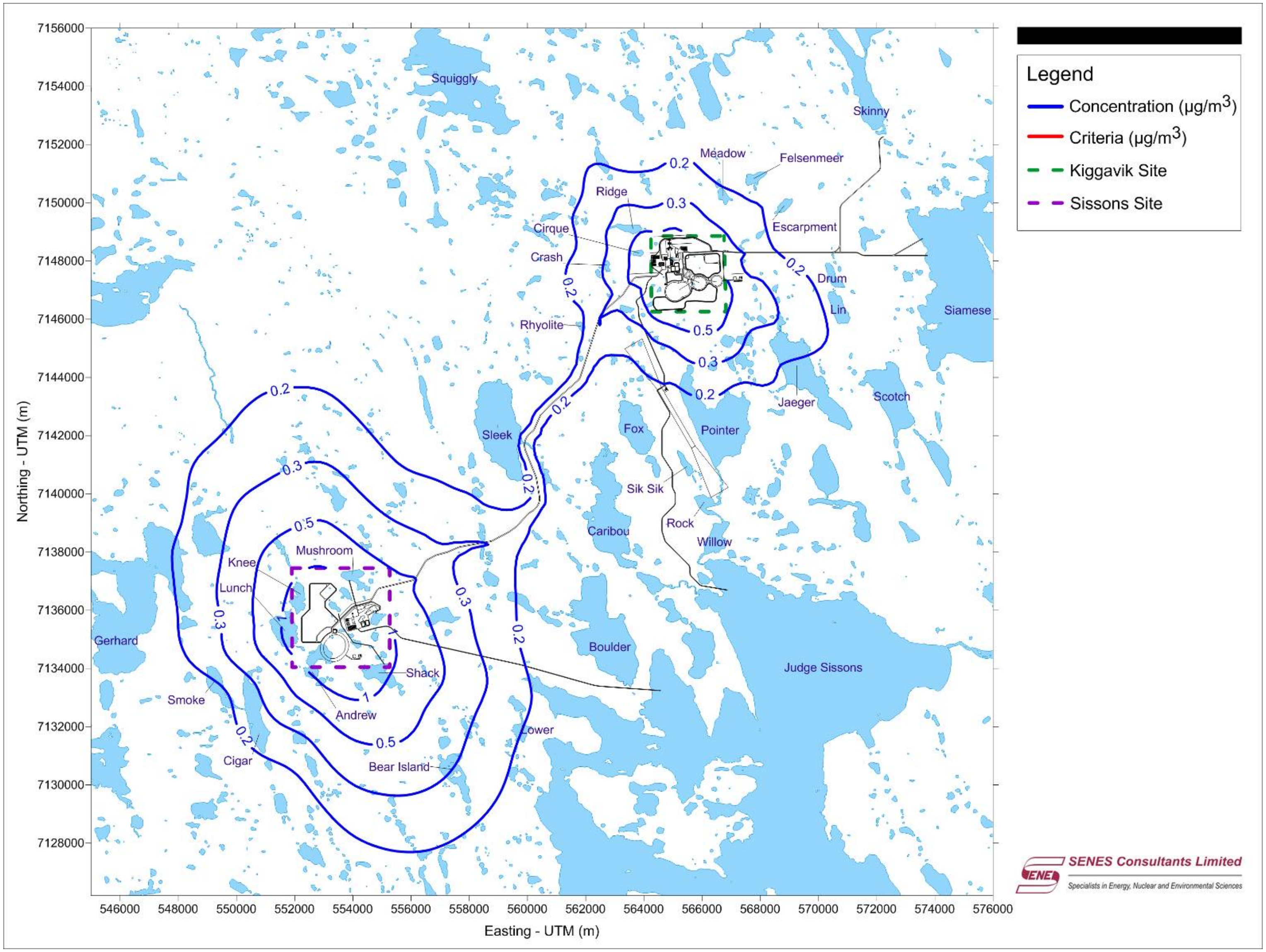


Figure D-66 Period 3 (Year 6-13) - Incremental Annual Uranium Concentration (µg/m³)

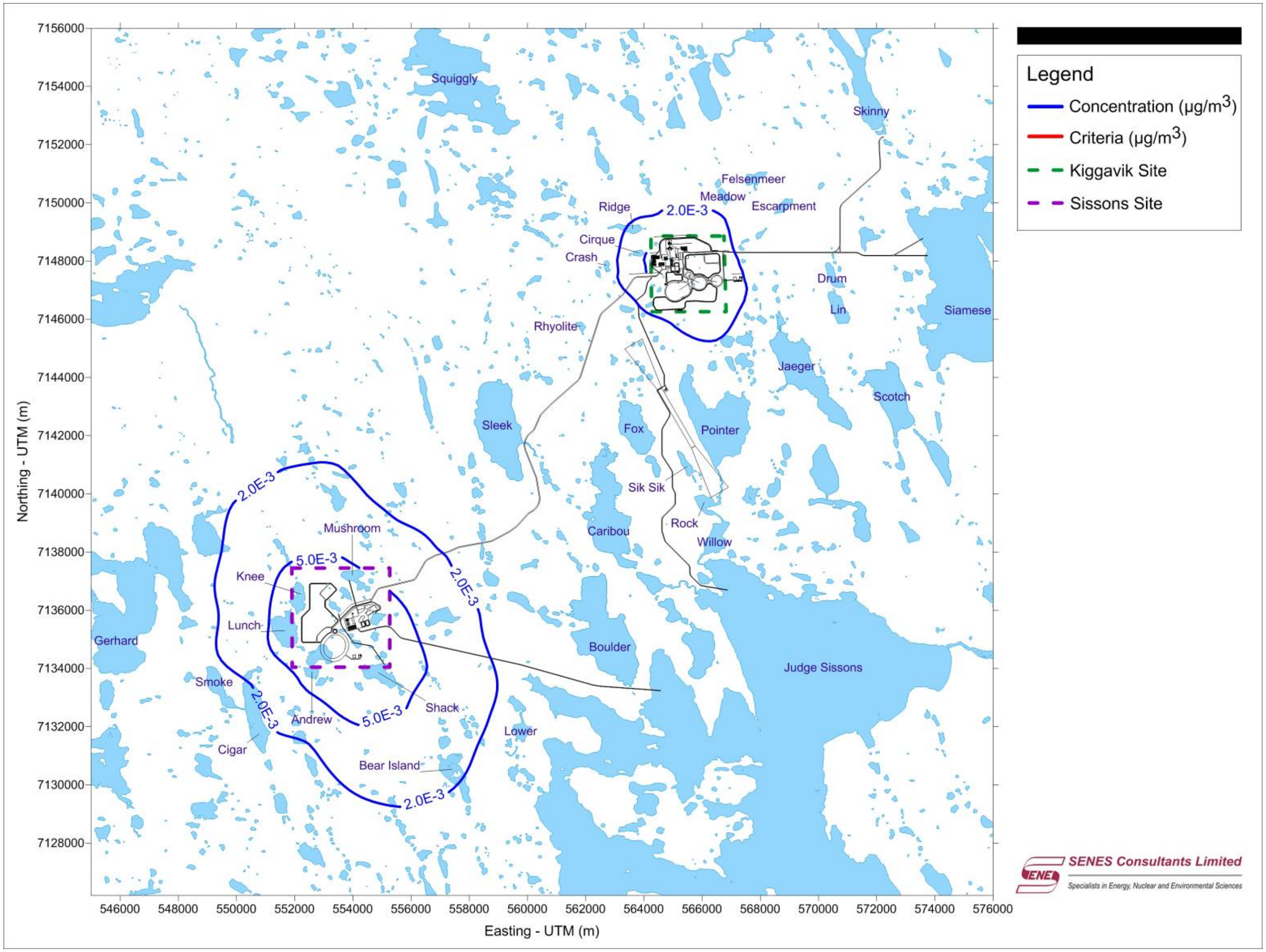


Figure D-67 Period 3 (Year 6-13) - Incremental Annual Arsenic Concentration (µg/m³)

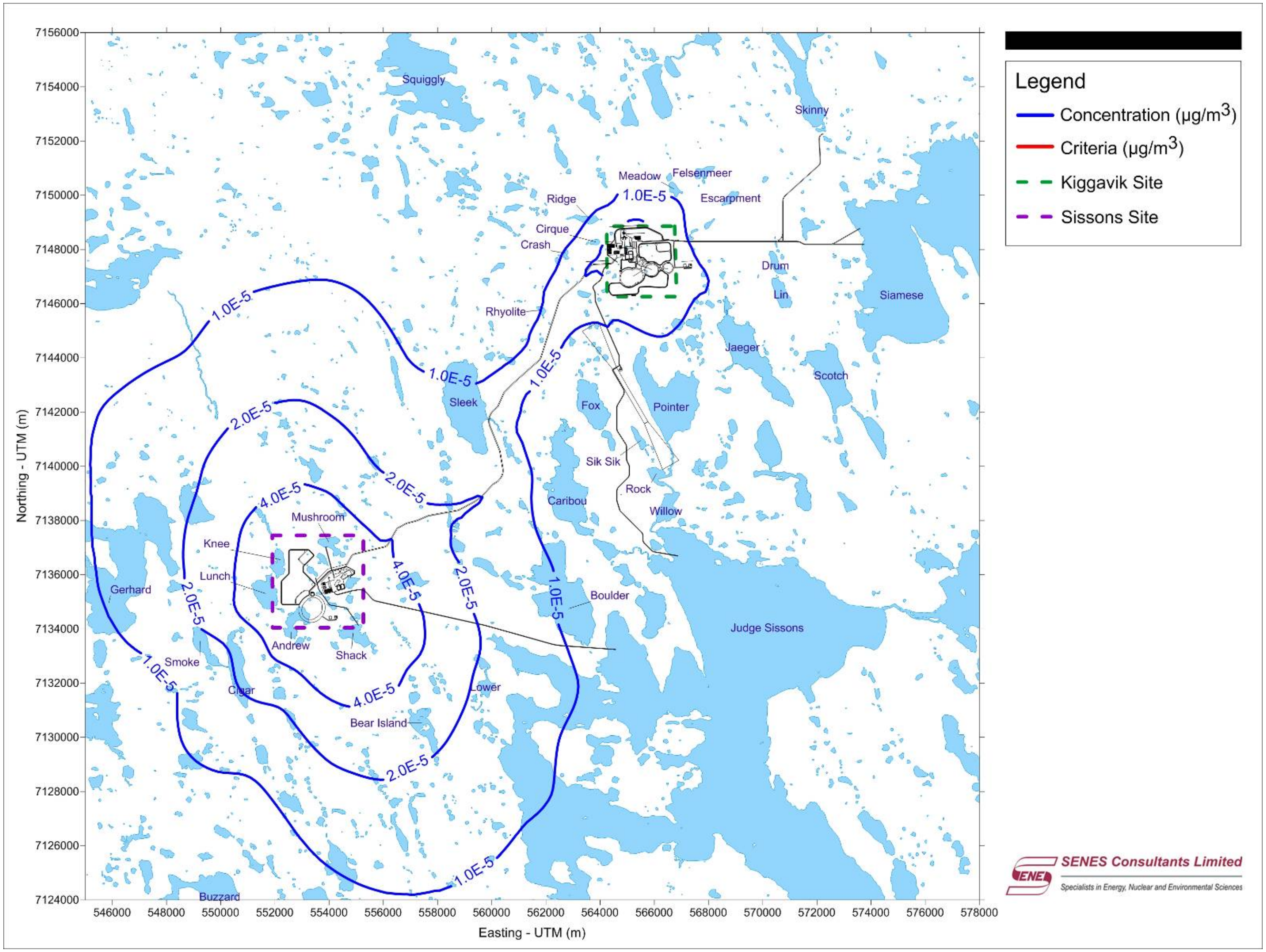


Figure D-68 Period 3 (Year 6-13) - Incremental Annual Cobalt Concentration (µg/m³)

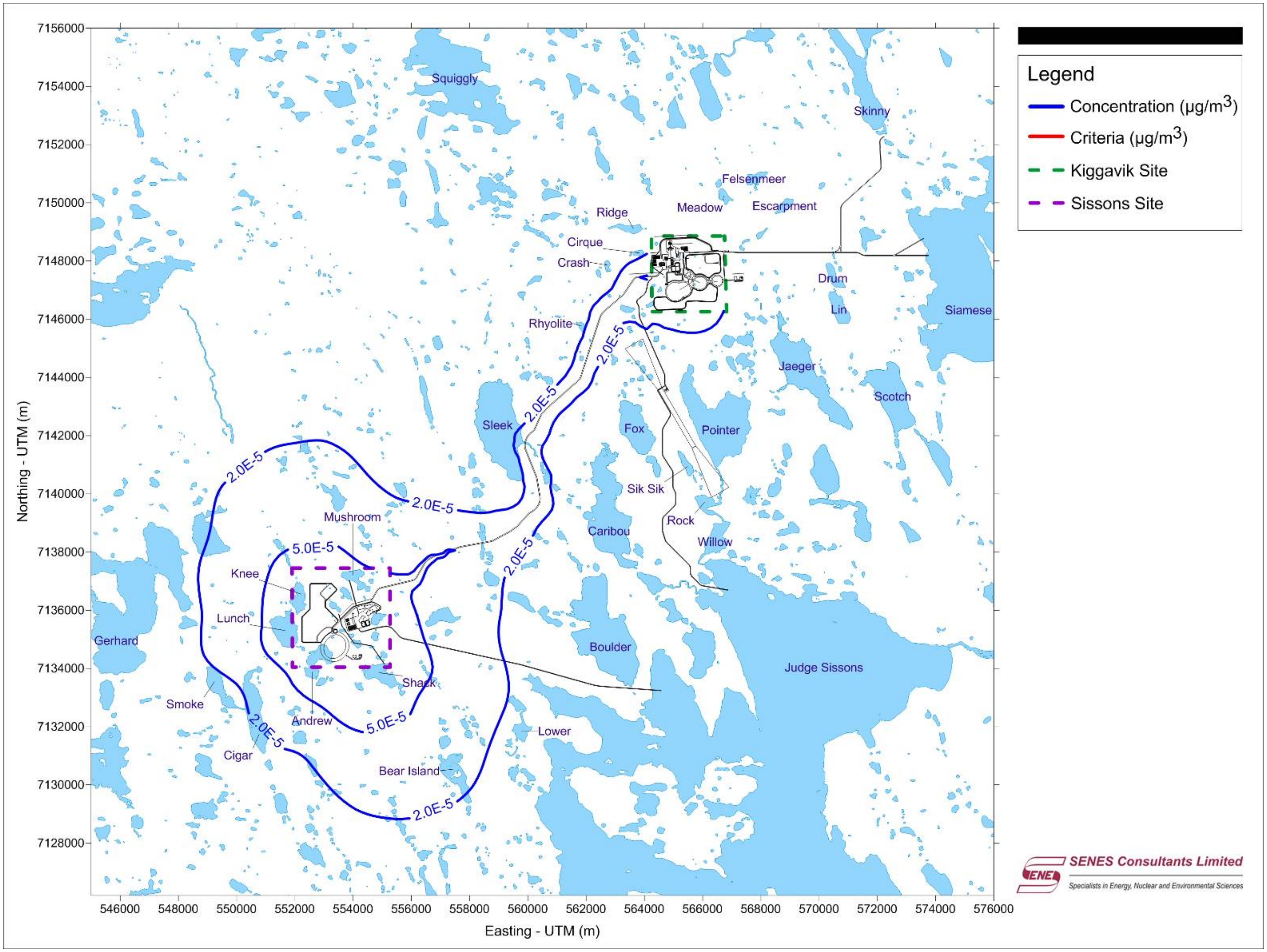


Figure D-69 Period 3 (Year 6-13) - Incremental Annual Cadmium Concentration (µg/m³)

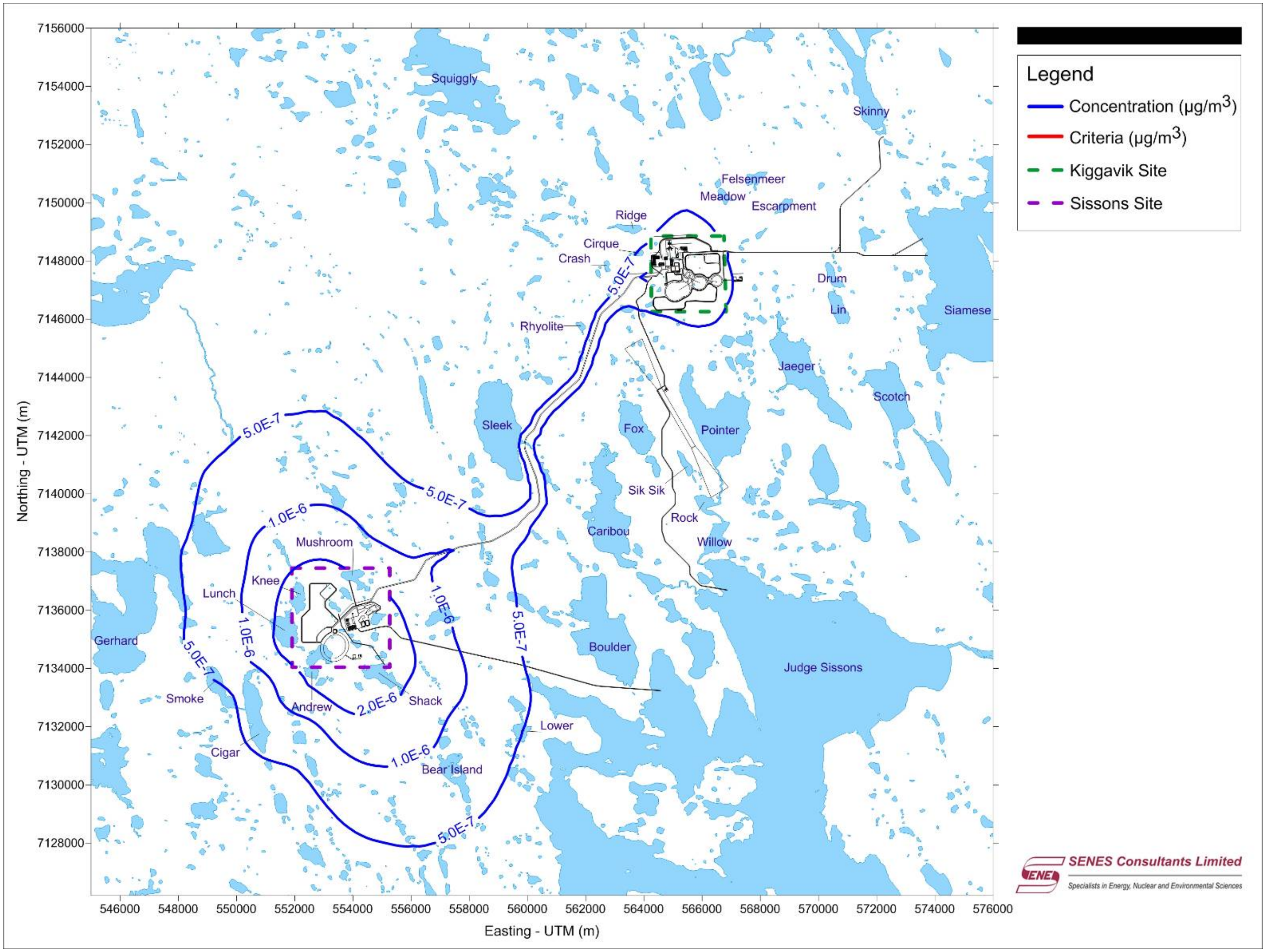


Figure D-70 Period 3 (Year 6-13) - Incremental Annual Chromium Concentration (µg/m³)

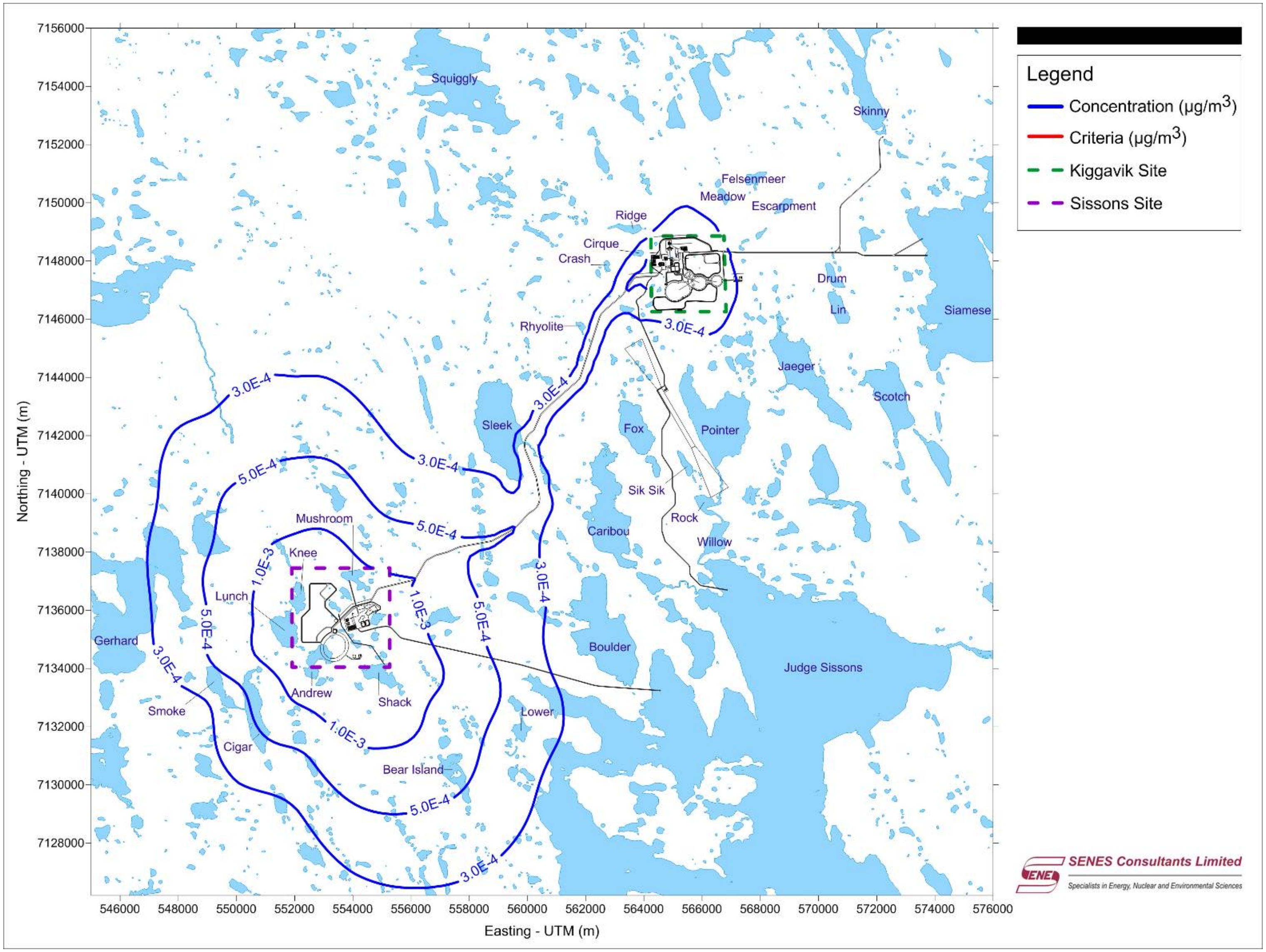


Figure D-71 Period 3 (Year 6-13) - Incremental Annual Copper Concentration (µg/m³)

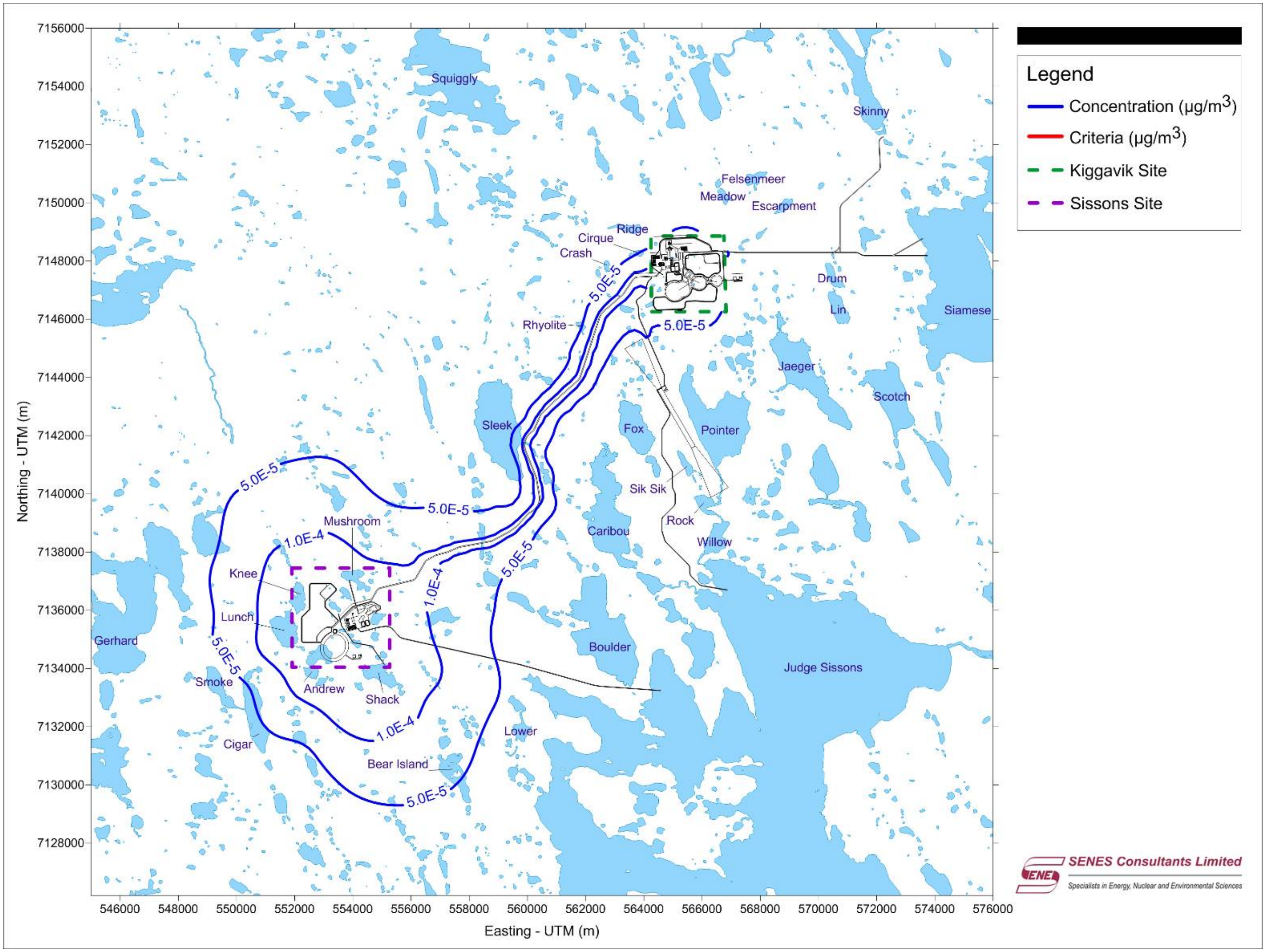


Figure D-72 Period 3 (Year 6-13) - Incremental Annual Lead Concentration (µg/m³)

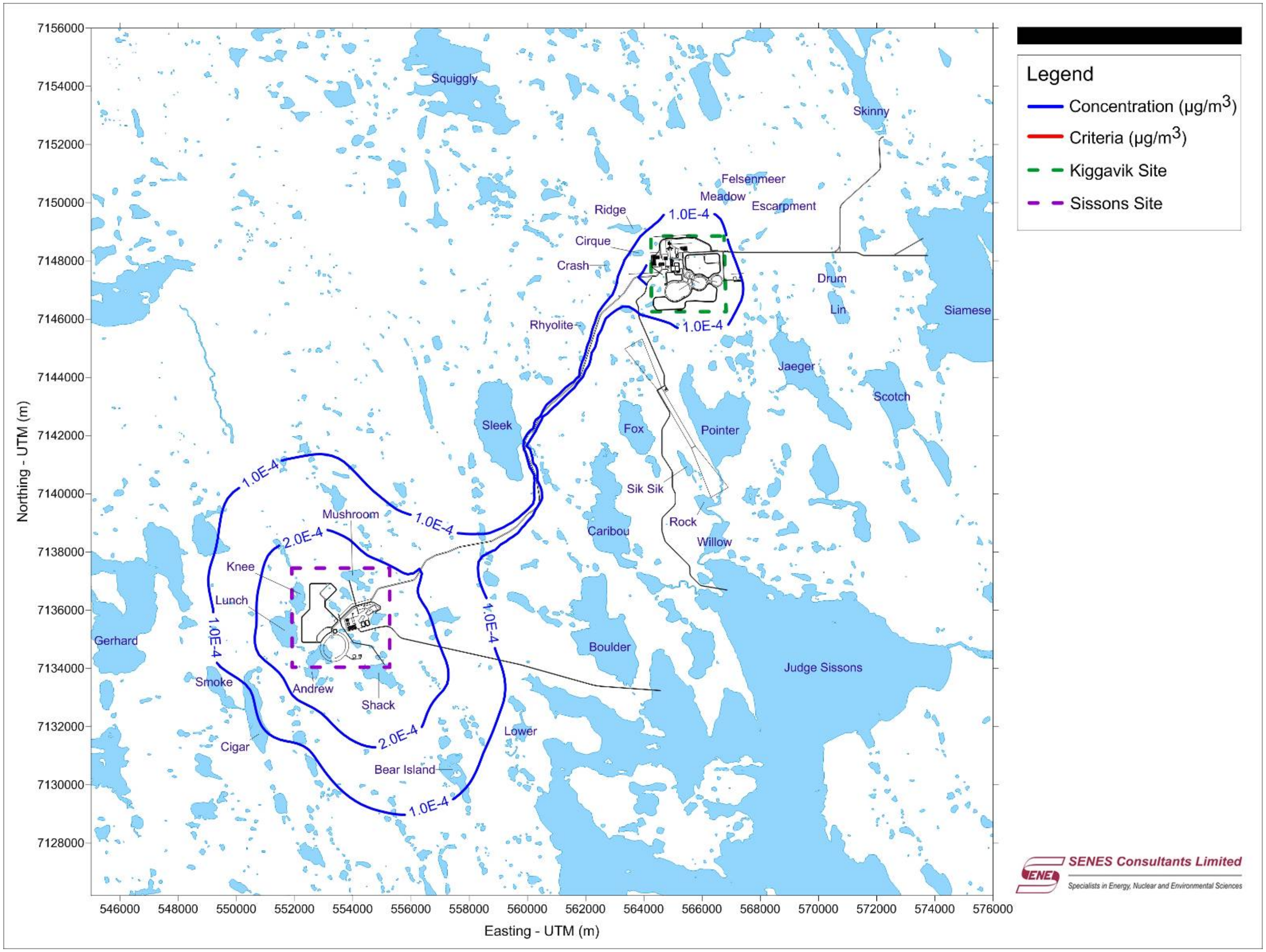


Figure D-73 Period 3 (Year 6-13) - Incremental Annual Molybdenum Concentration (µg/m³)

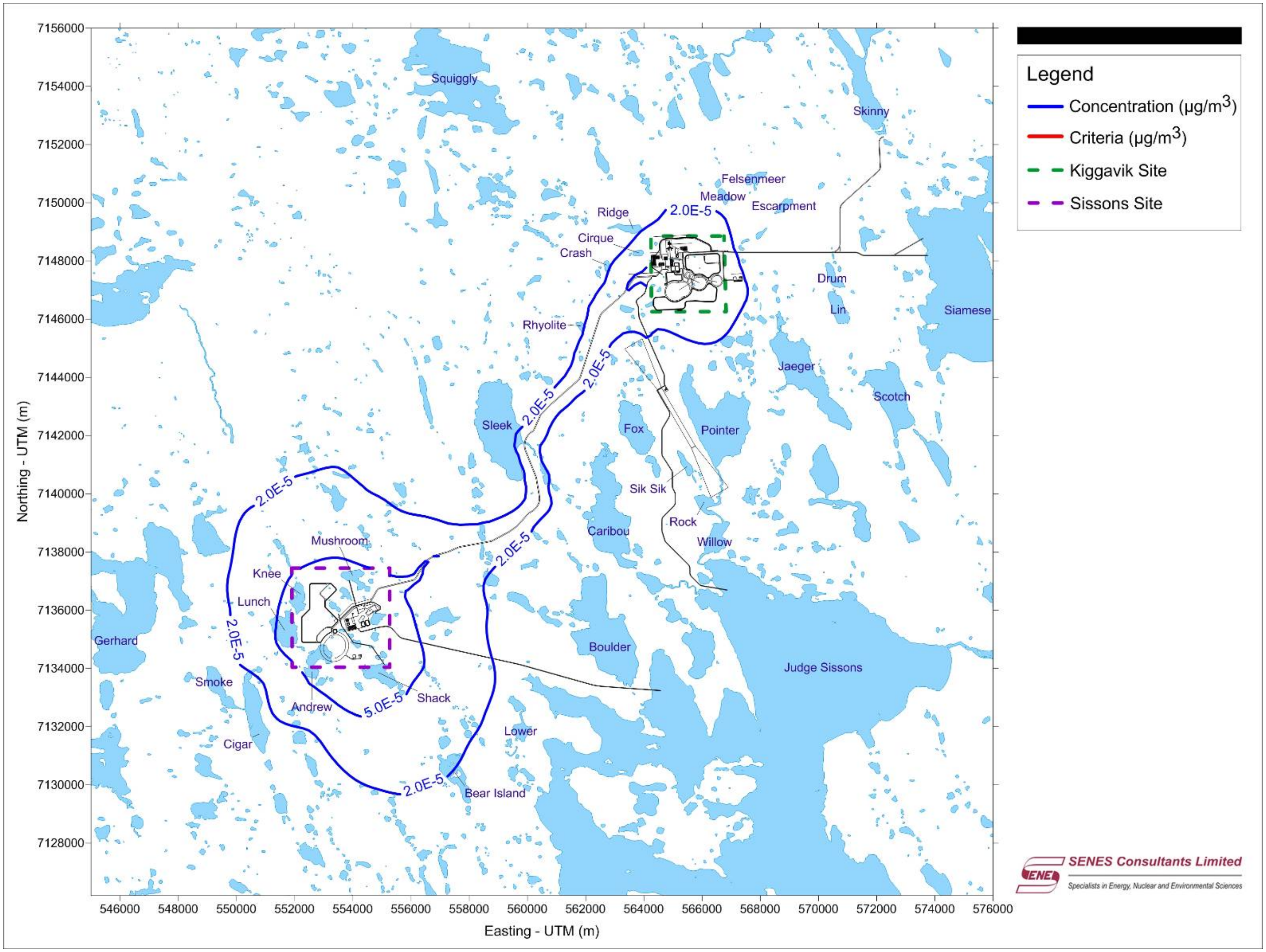


Figure D-74 Period 3 (Year 6-13) - Incremental Annual Nickel Concentration (µg/m³)

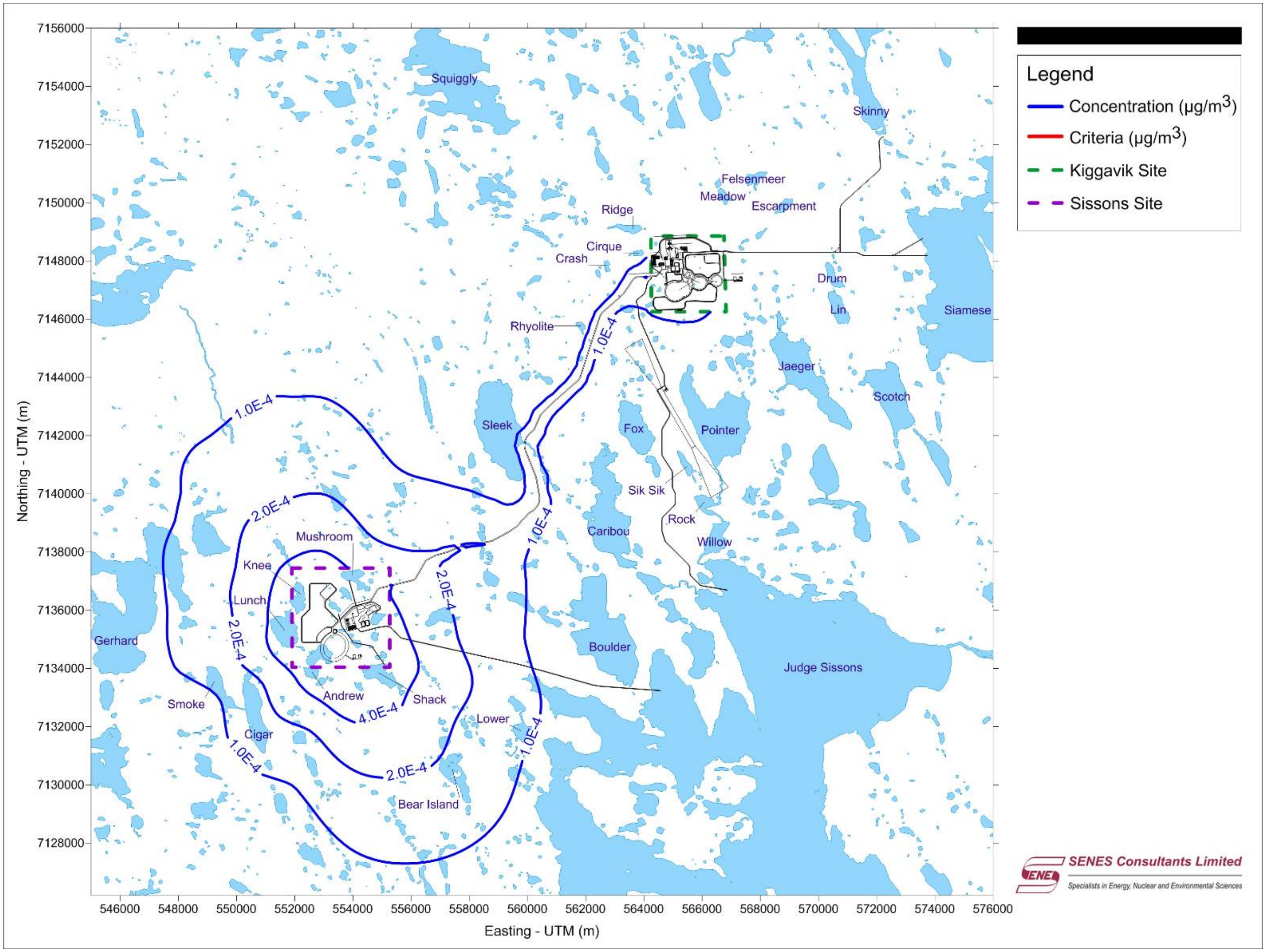


Figure D-75 Period 3 (Year 6-13) - Incremental Annual Selenium Concentration (µg/m³)

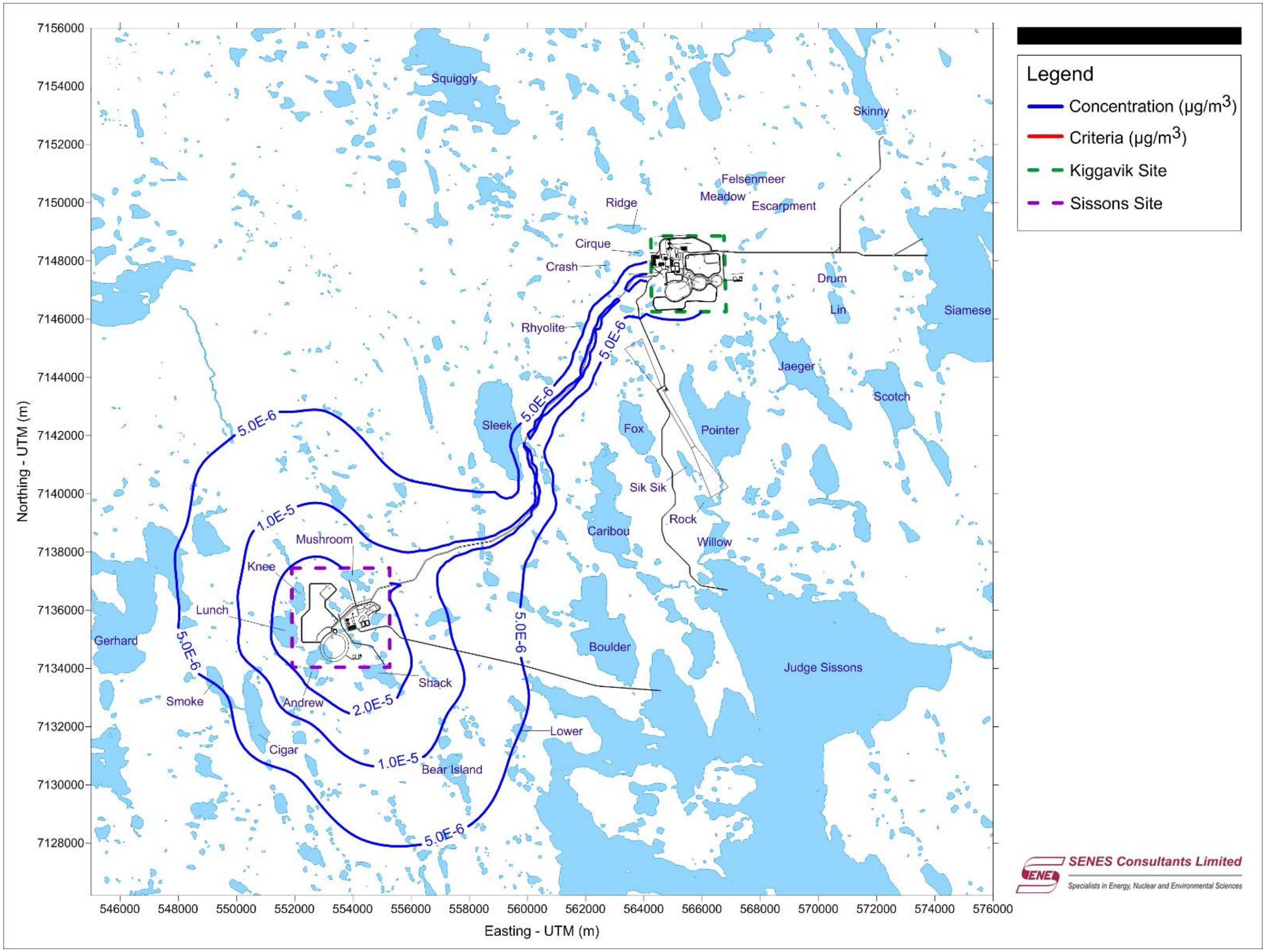


Figure D-76 Period 3 (Year 6-13) - Incremental Annual Zinc Concentration (µg/m³)

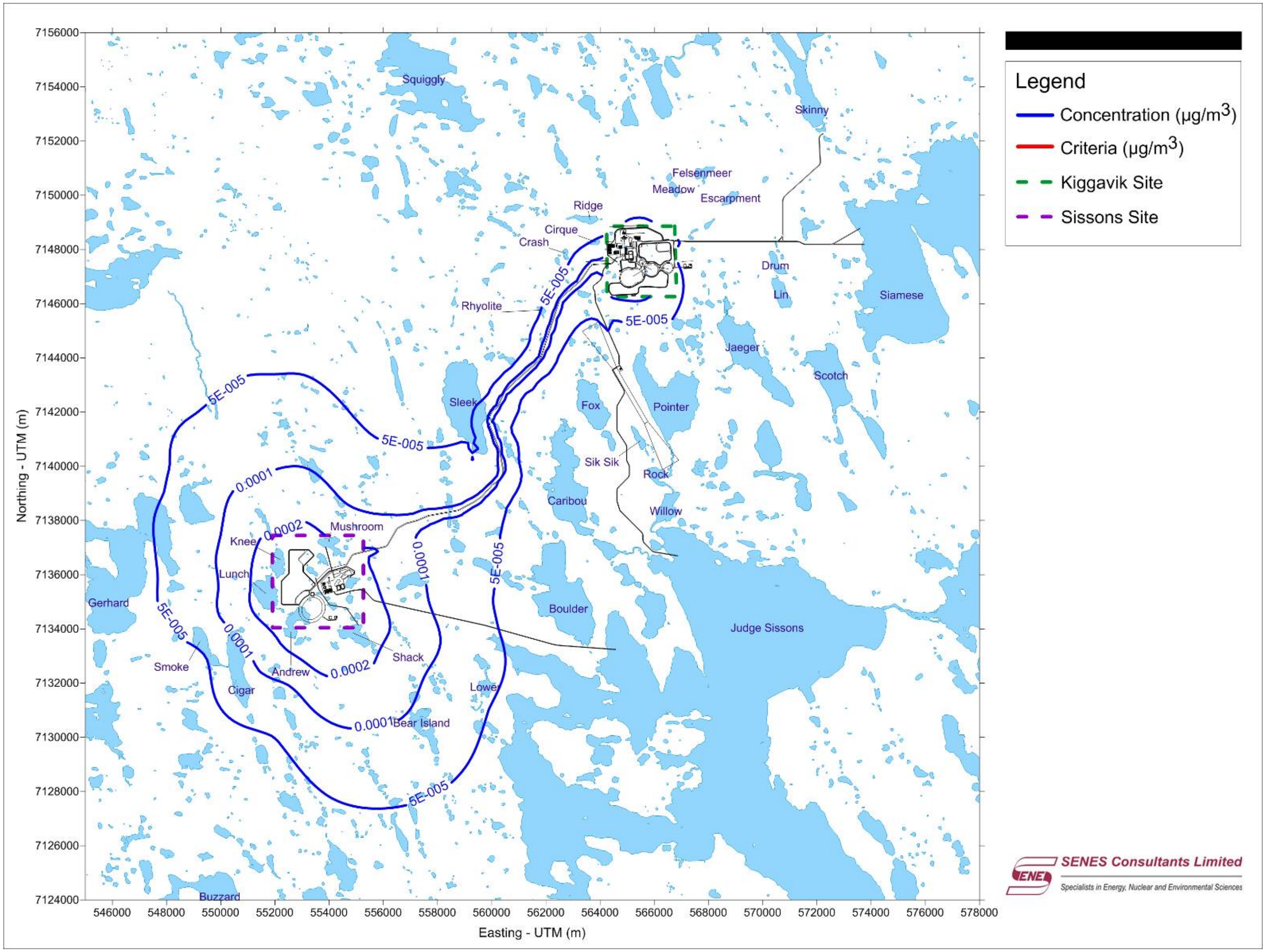


Figure D-77 Period 3 (Year 6-13) - Incremental Annual NO_2 Concentration (µg/m³)

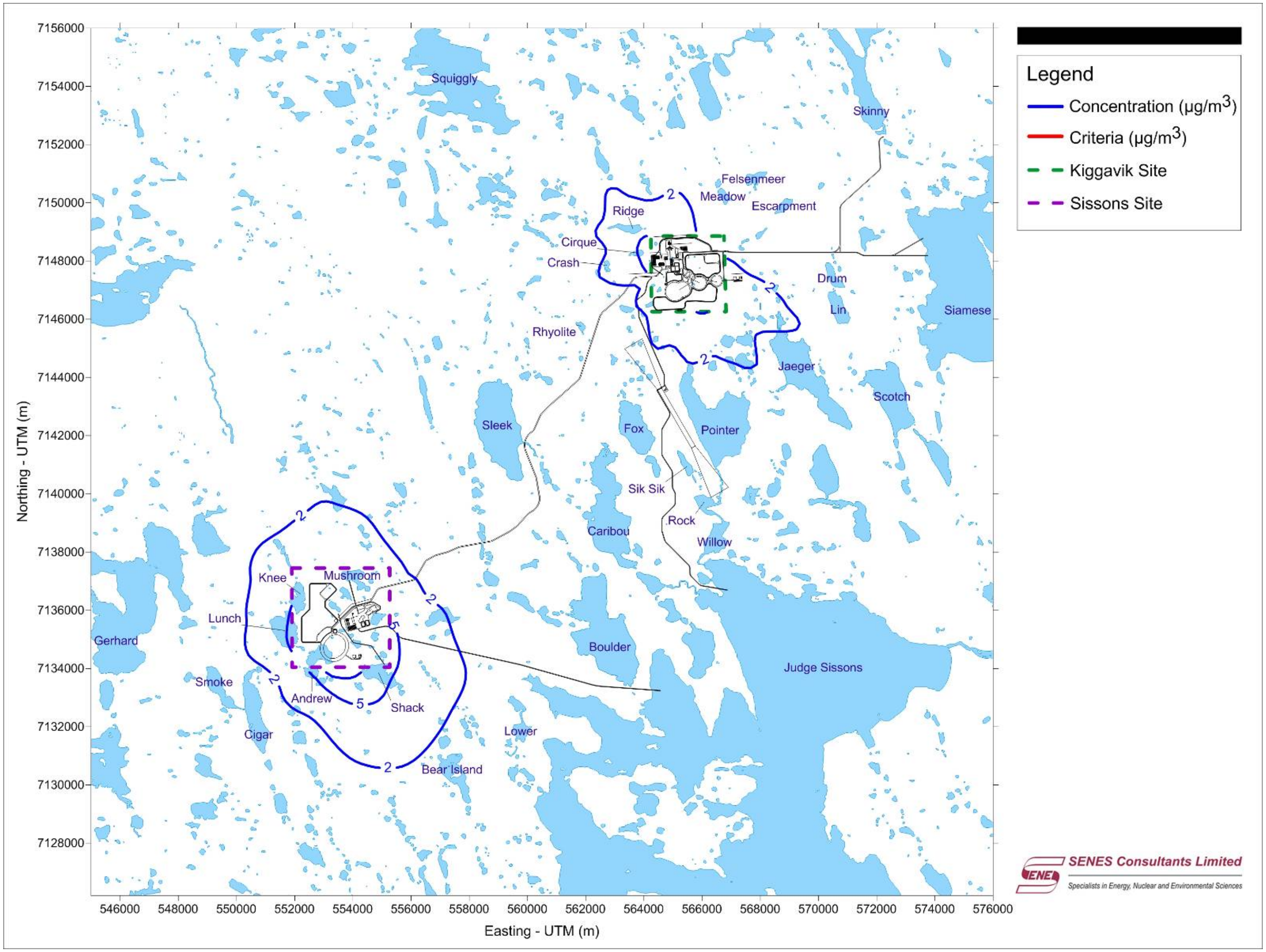


Figure D-78 Period 3 (Year 6-13) - Incremental Annual SO_2 Concentration (µg/m³)

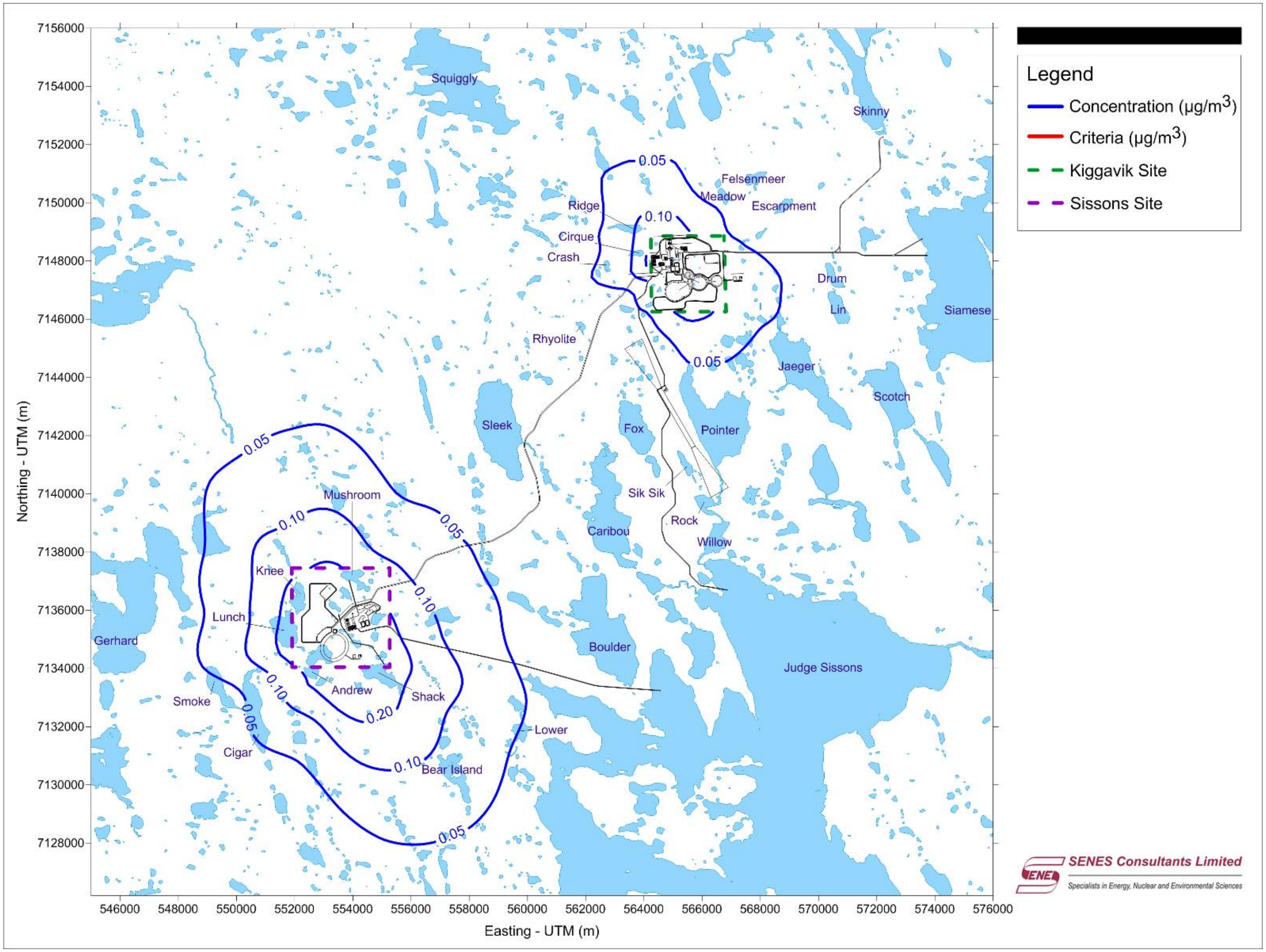


Figure D-79 Period 3 (Year 6-13) - Incremental Annual Radon Concentration (Bq/m³)

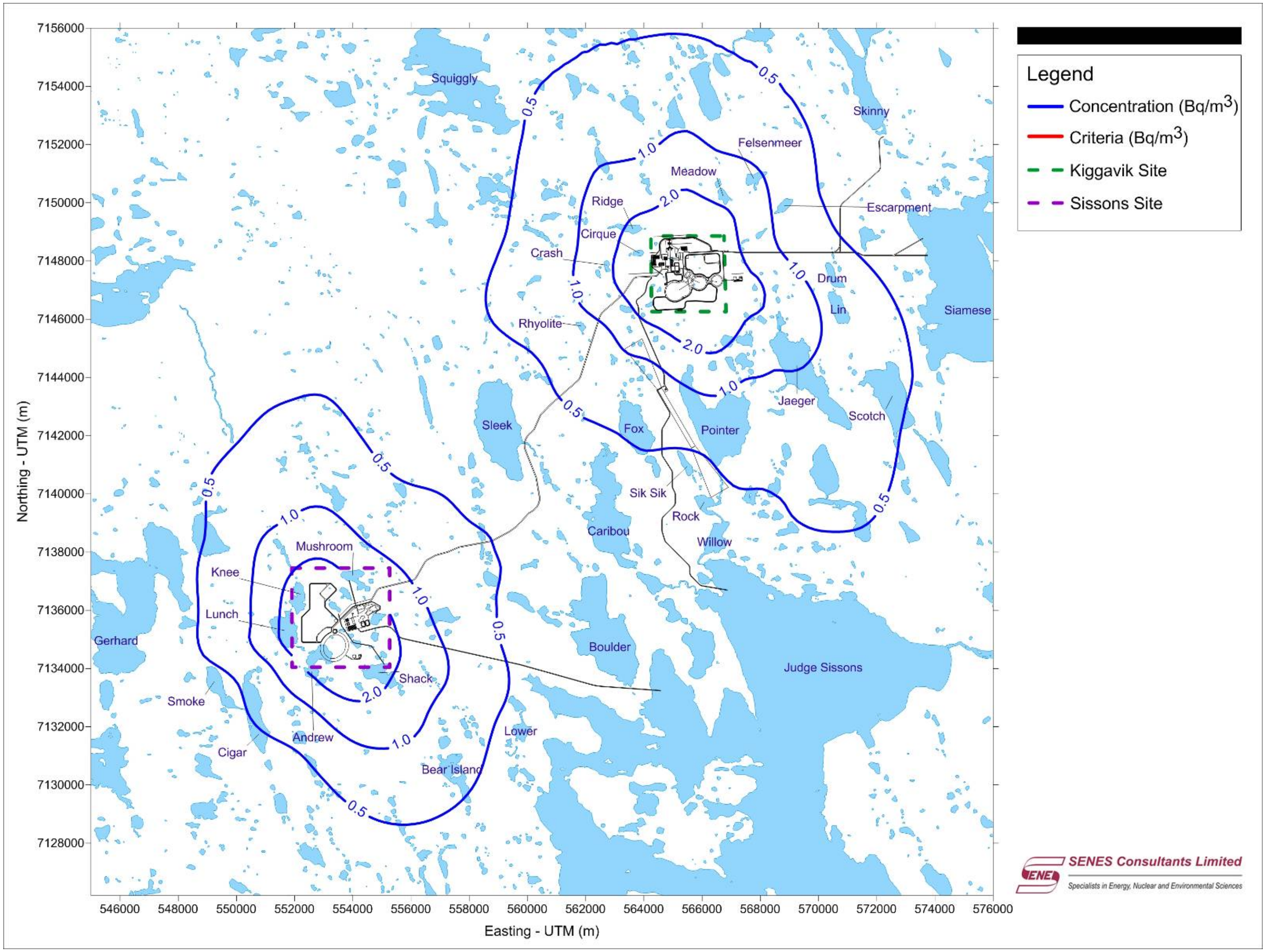


Figure D-80 Period 3 (Year 6-13) - Incremental Annual Lead-210 or Polonium-210 Concentration (Bq/m³)

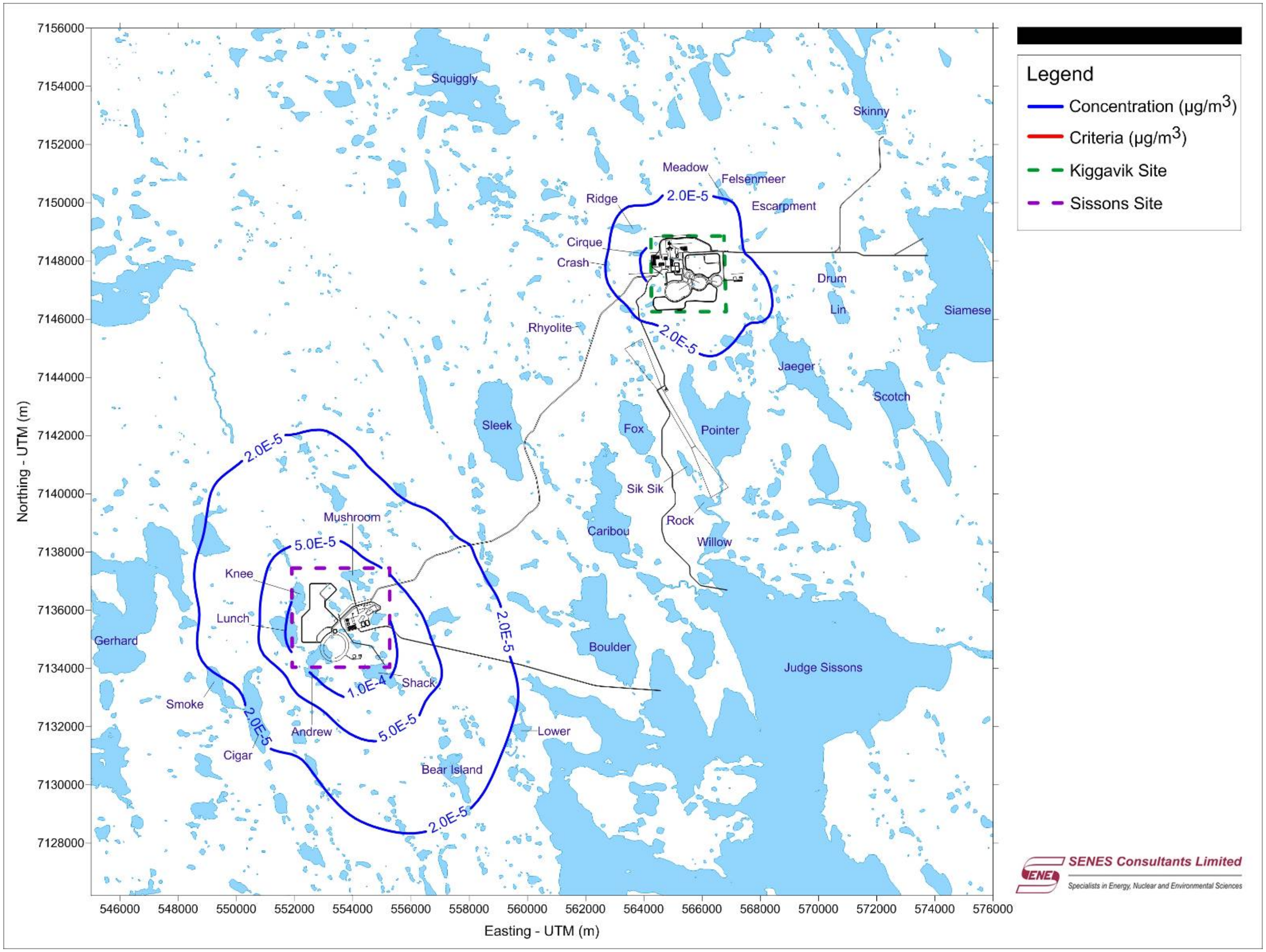


Figure D-81   Period 4 (Year 14) - Incremental Annual TSP Concentration (µg/m³)

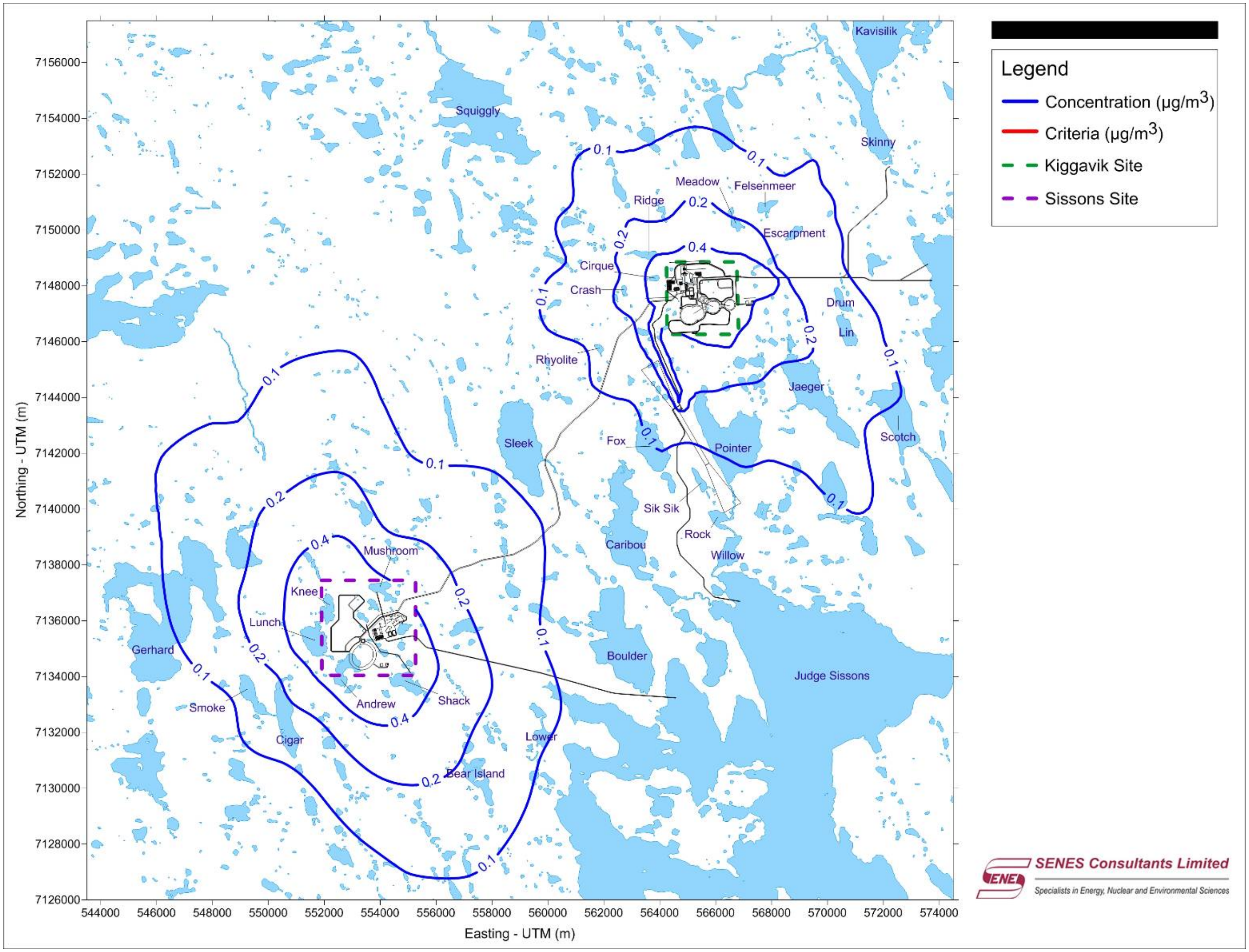


Figure D-82 Period 4 (Year 14) - Incremental Annual PM_{10} Concentration (µg/m³)

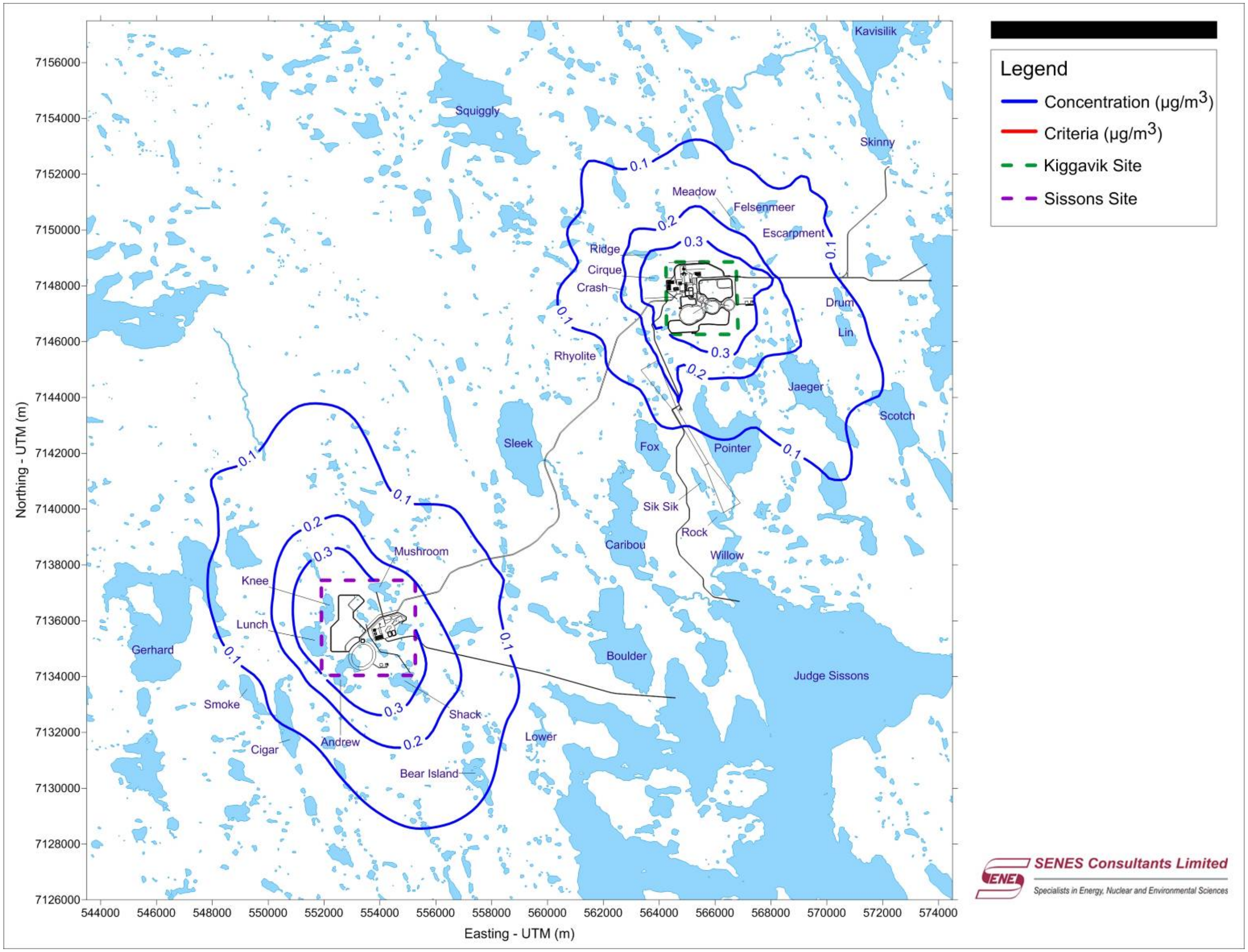


Figure D-83 Period 4 (Year 14) - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

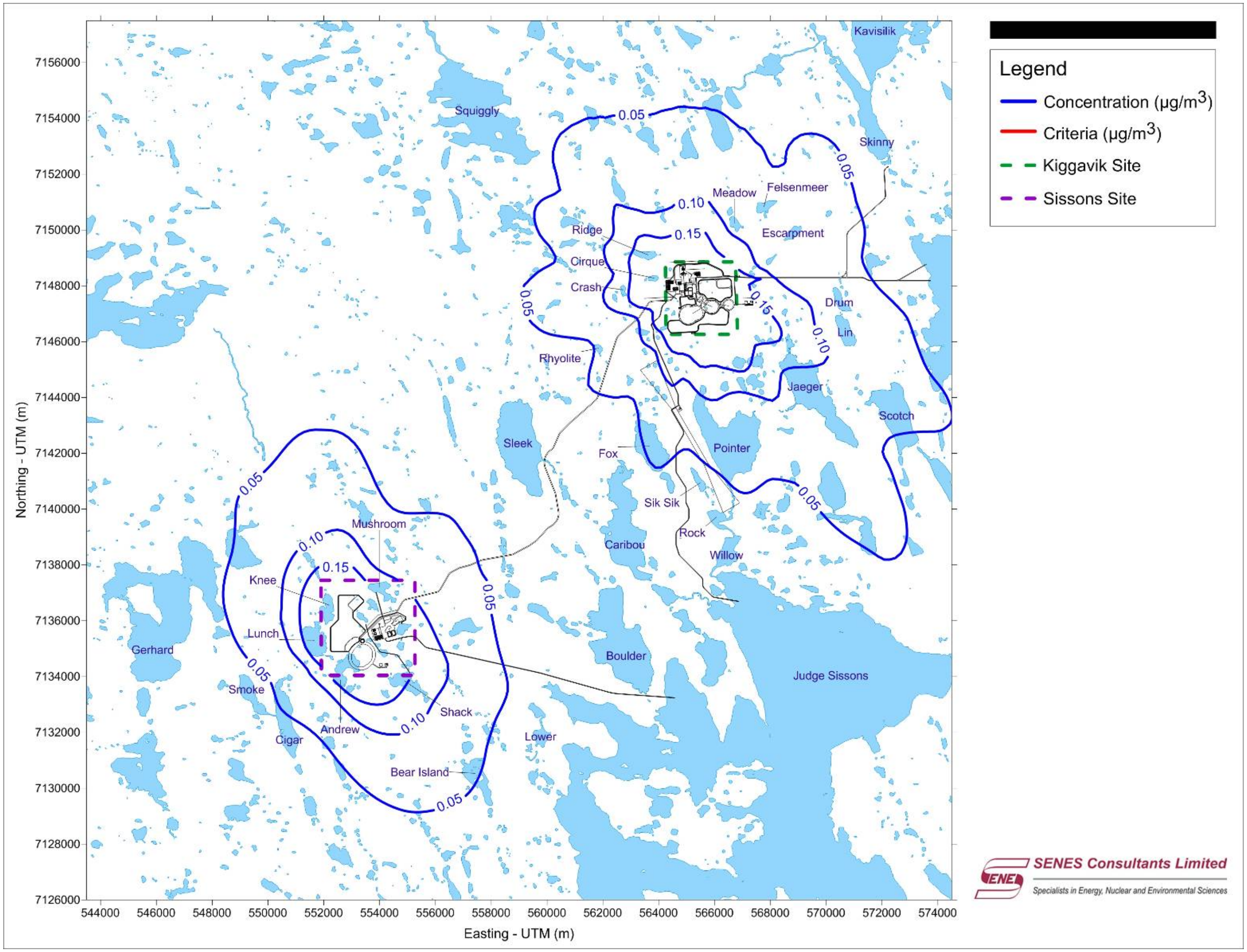


Figure D-84 Period 4 (Year 14) - Incremental Annual Uranium Concentration (µg/m³)

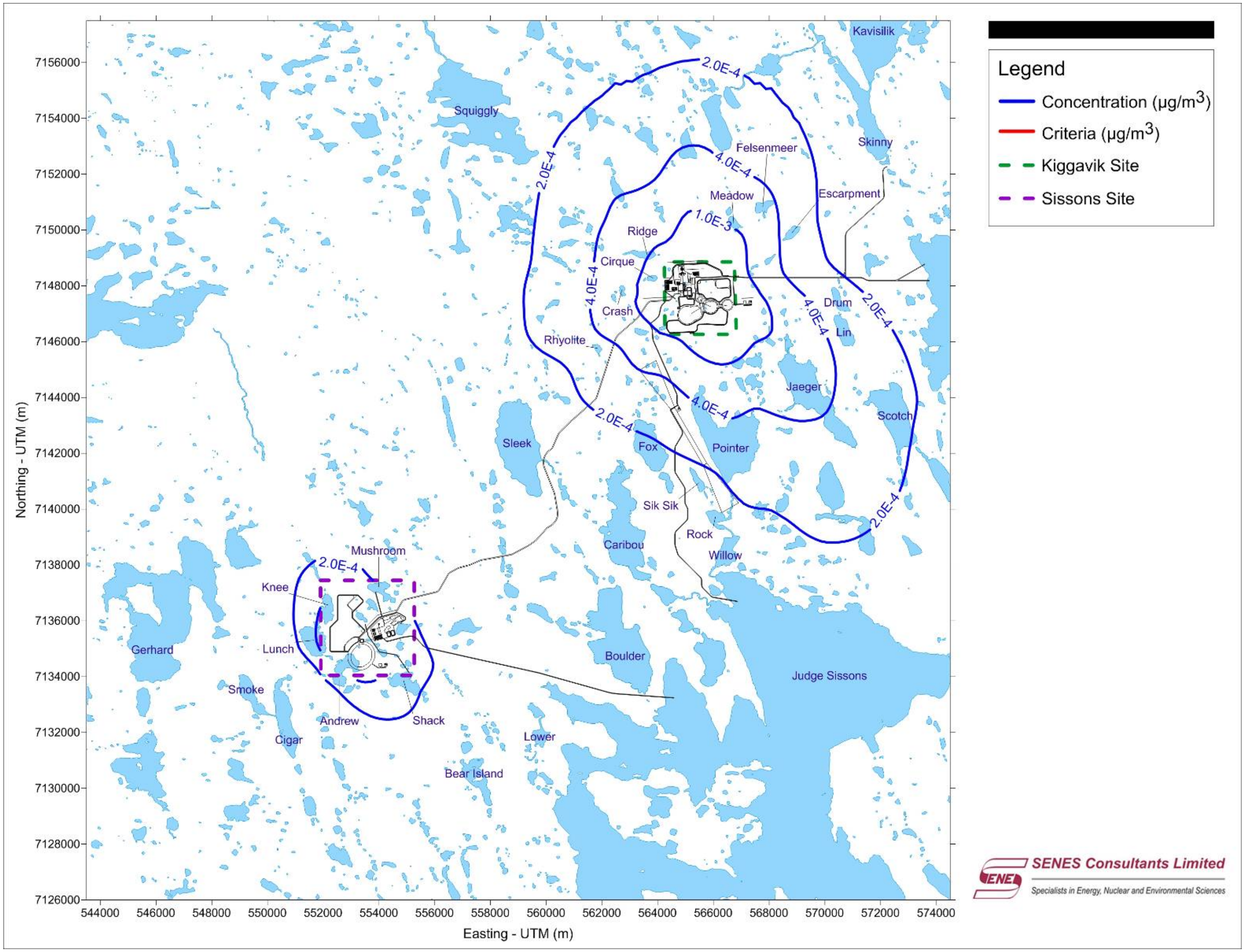


Figure D-85 Period 4 (Year 14) - Incremental Annual Arsenic Concentration (µg/m³)

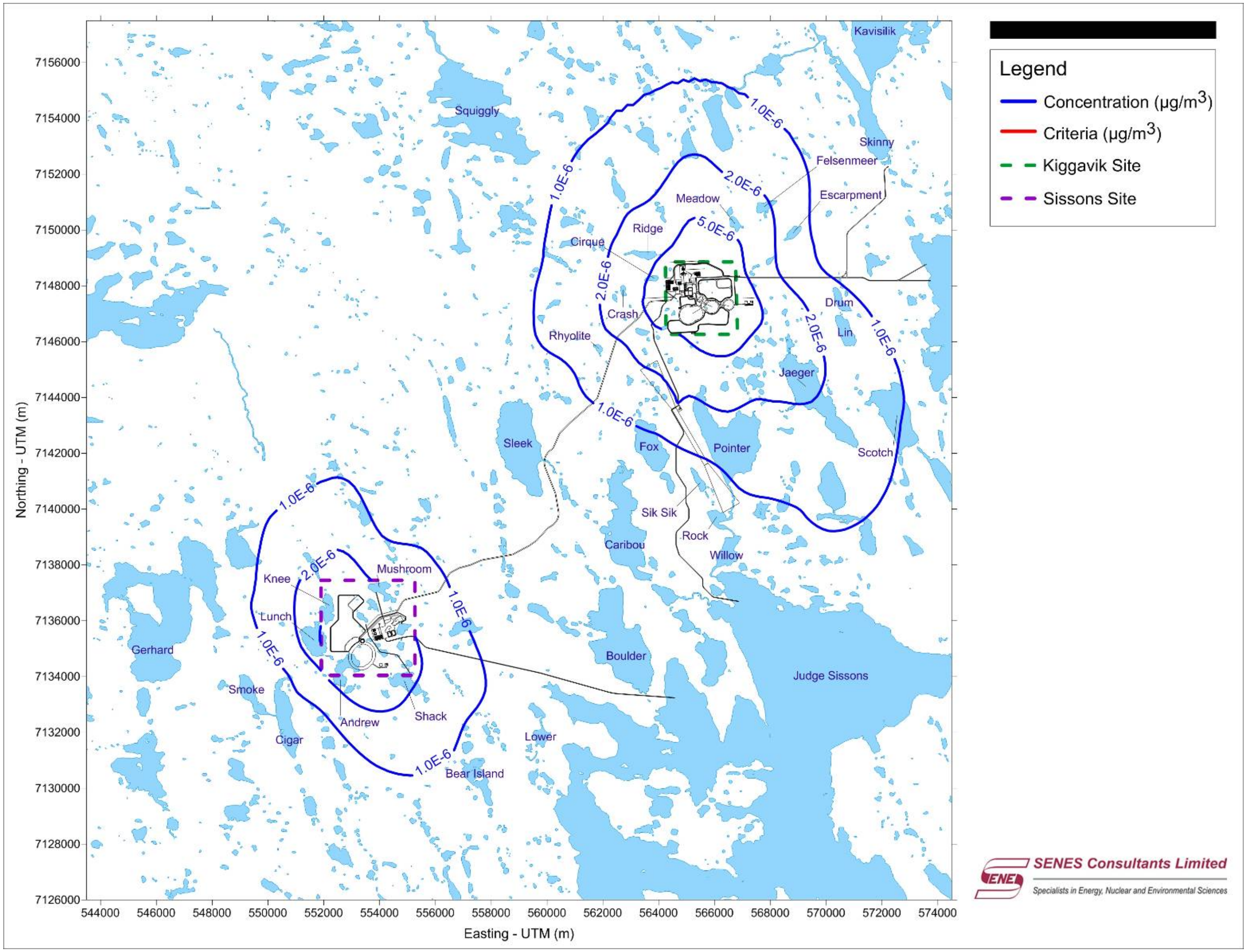


Figure D-86 Period 4 (Year 14) - Incremental Annual Cobalt Concentration (µg/m³)

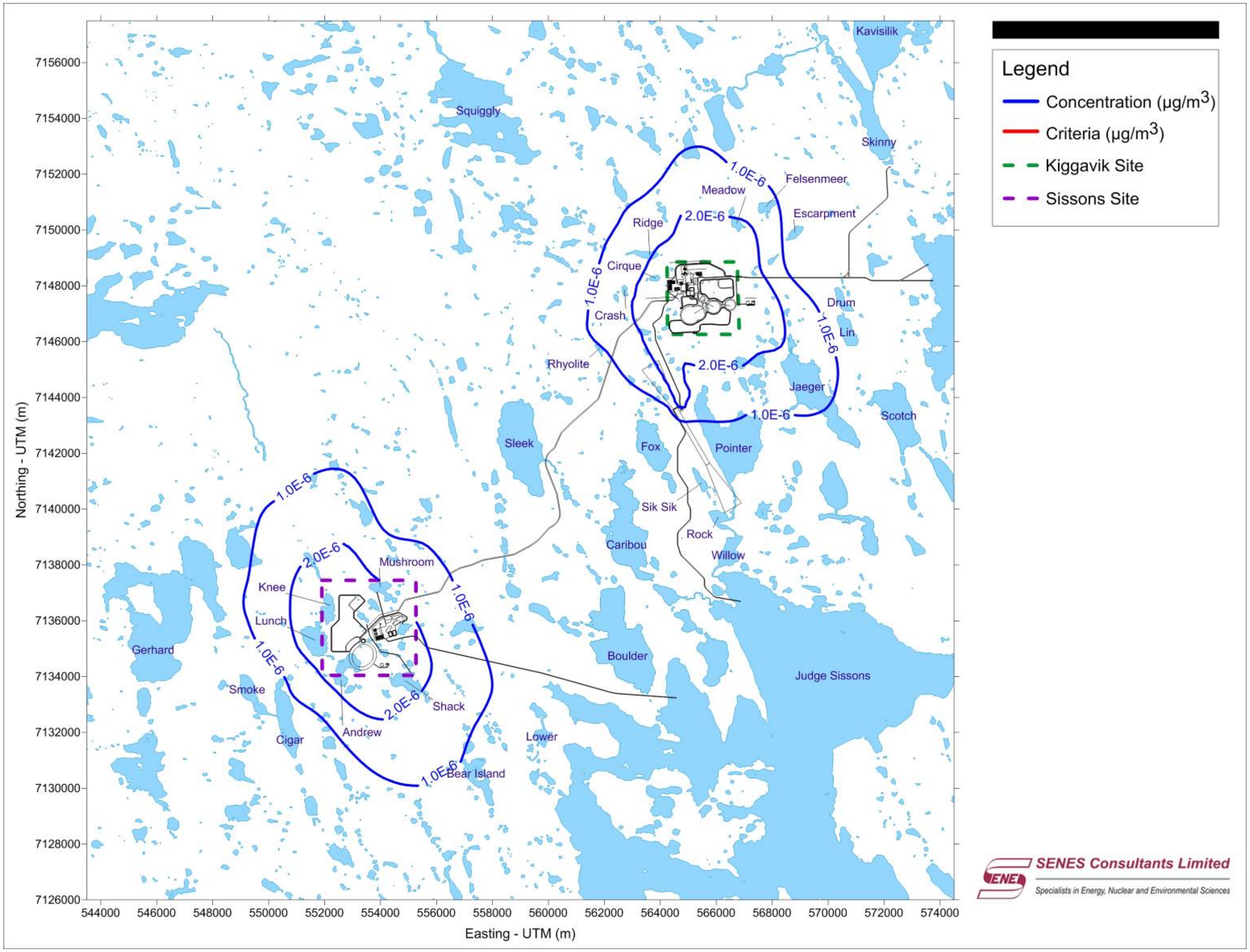


Figure D-87 Period 4 (Year 14) - Incremental Annual Cadmium Concentration (µg/m³)

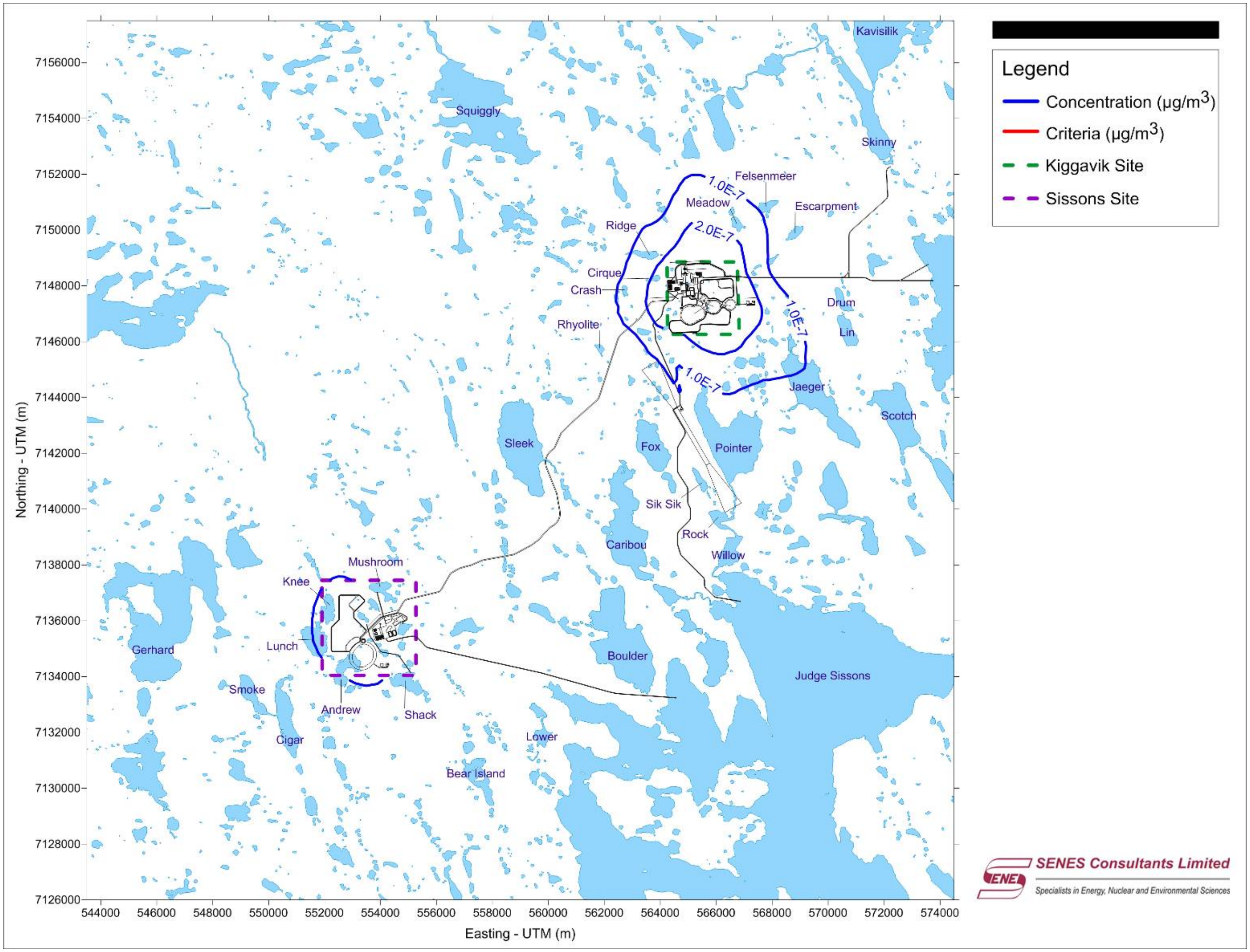


Figure D-88   Period 4 (Year 14) - Incremental Annual Chromium Concentration ($\mu g/m^3$)

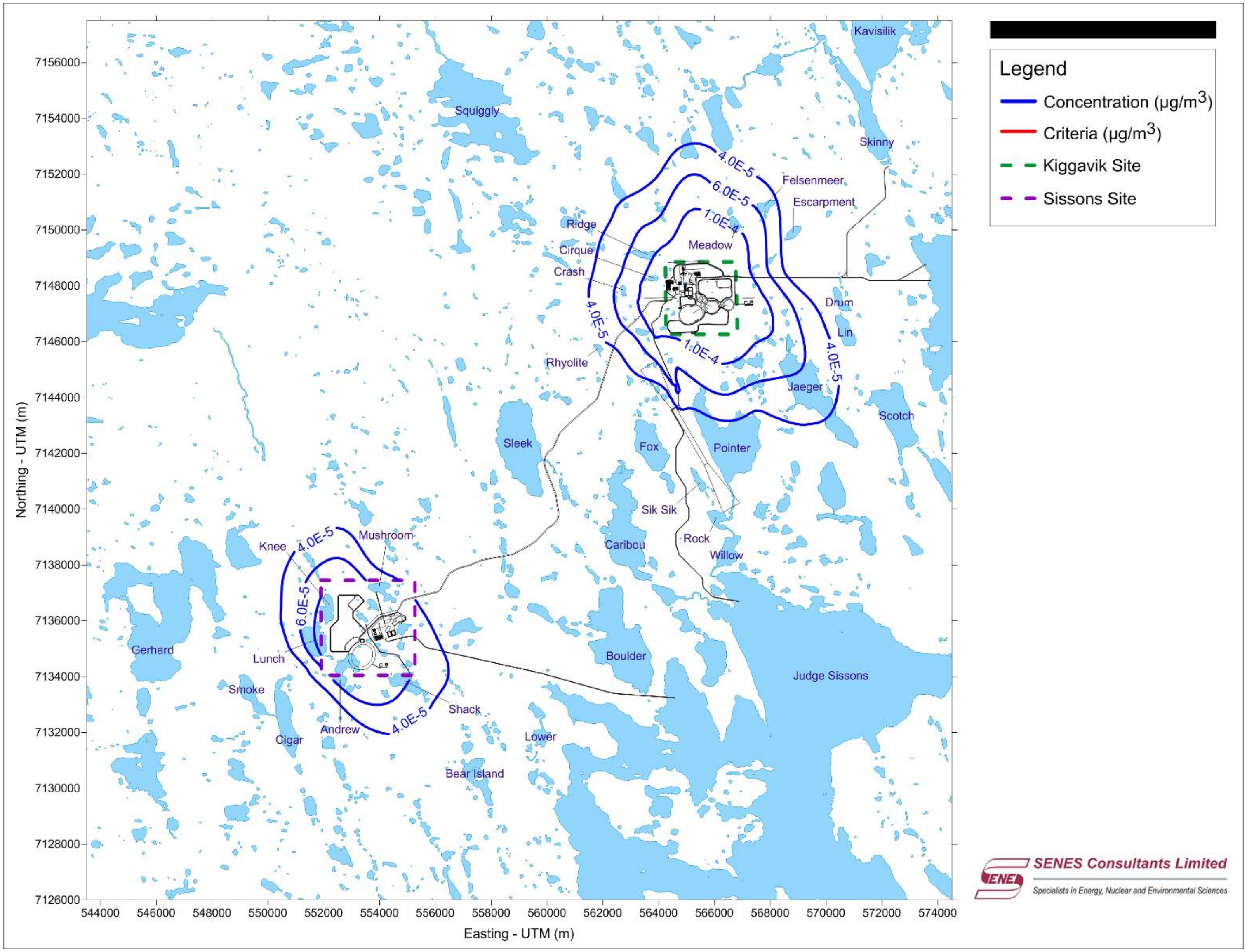


Figure D-89 Period 4 (Year 14) - Incremental Annual Copper Concentration (µg/m³)

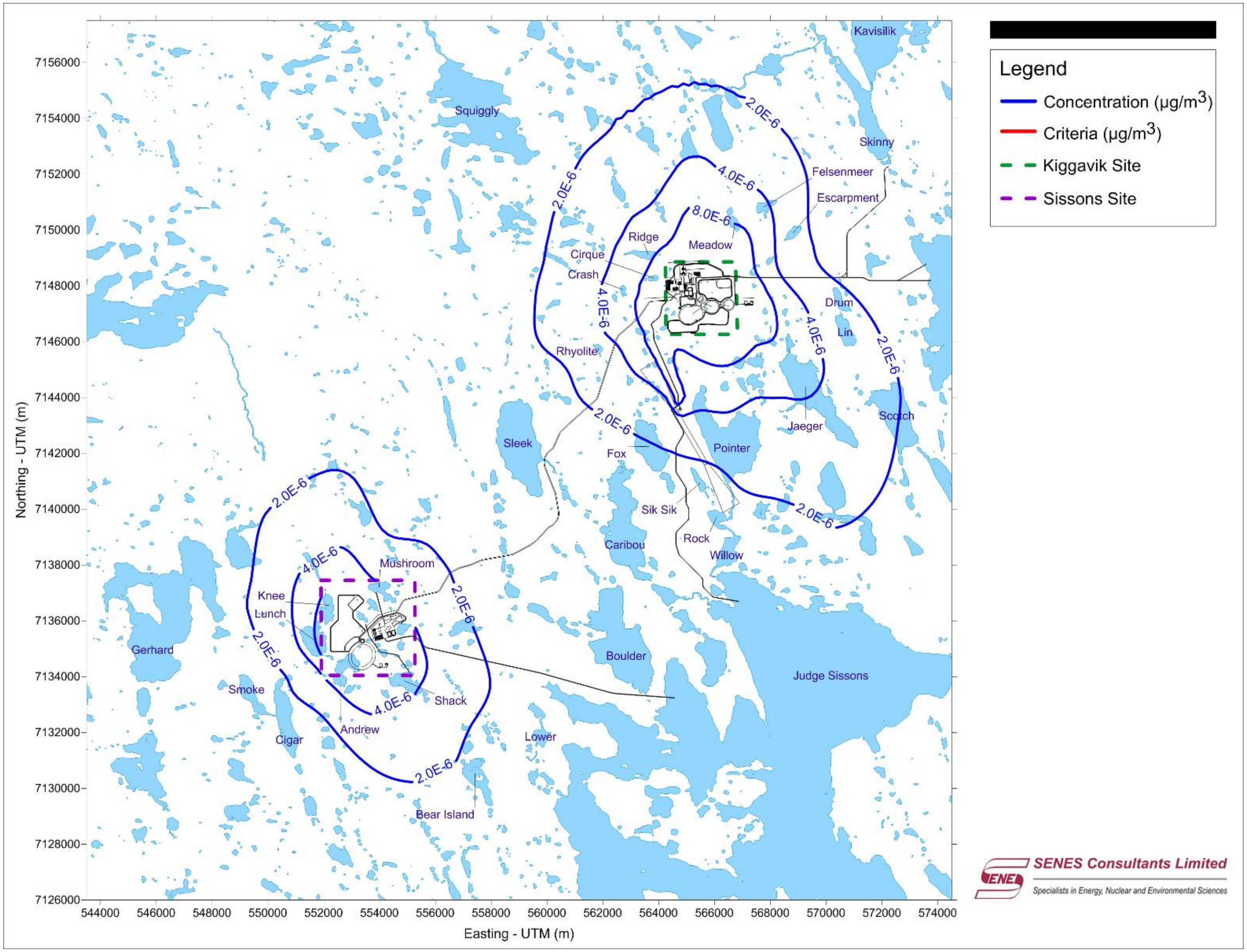


Figure D-90 Period 4 (Year 14) - Incremental Annual Lead Concentration (µg/m³)

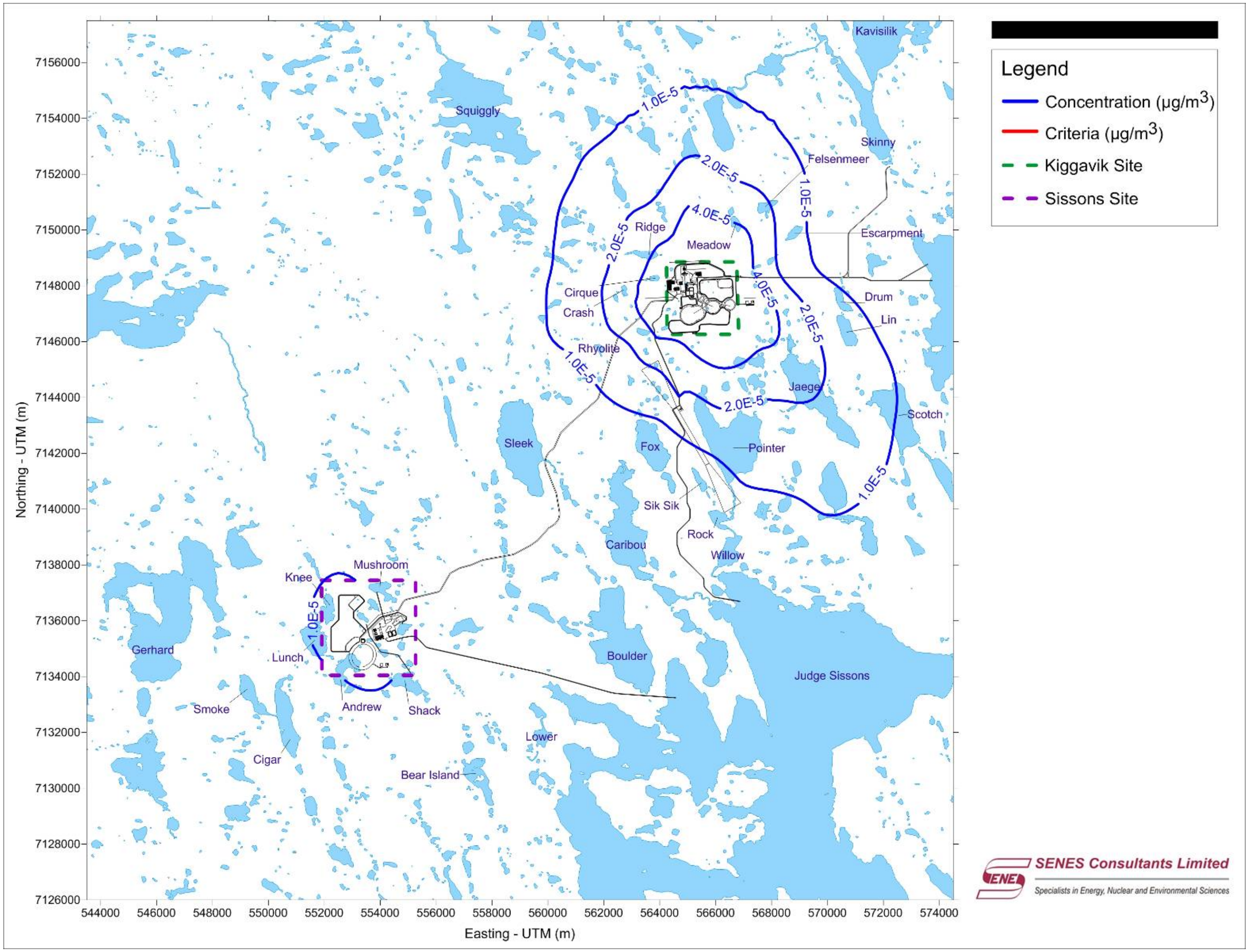


Figure D-91 Period 4 (Year 14) - Incremental Annual Molybdenum Concentration (µg/m³)

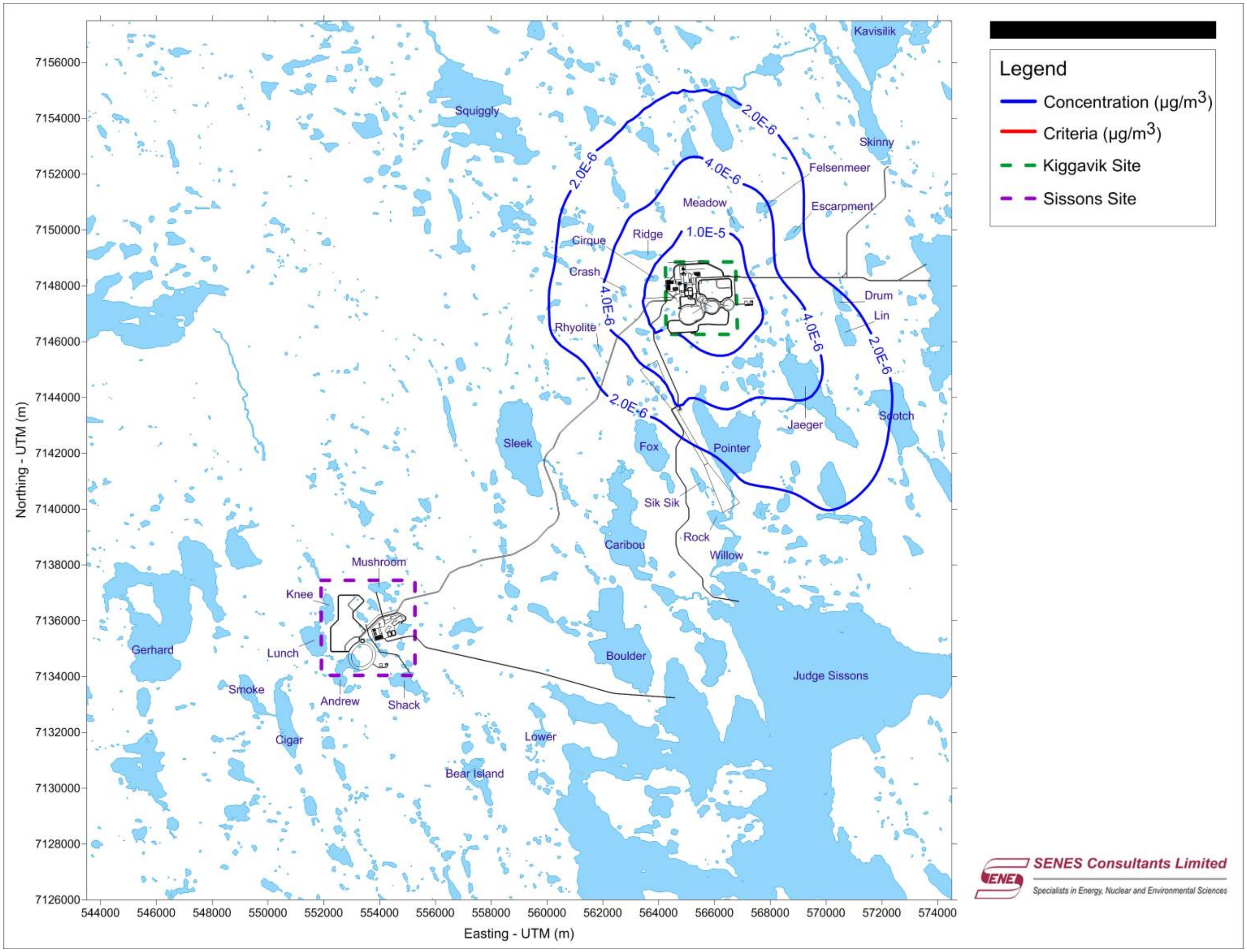


Figure D-92 Period 4 (Year 14) - Incremental Annual Nickel Concentration (µg/m³)

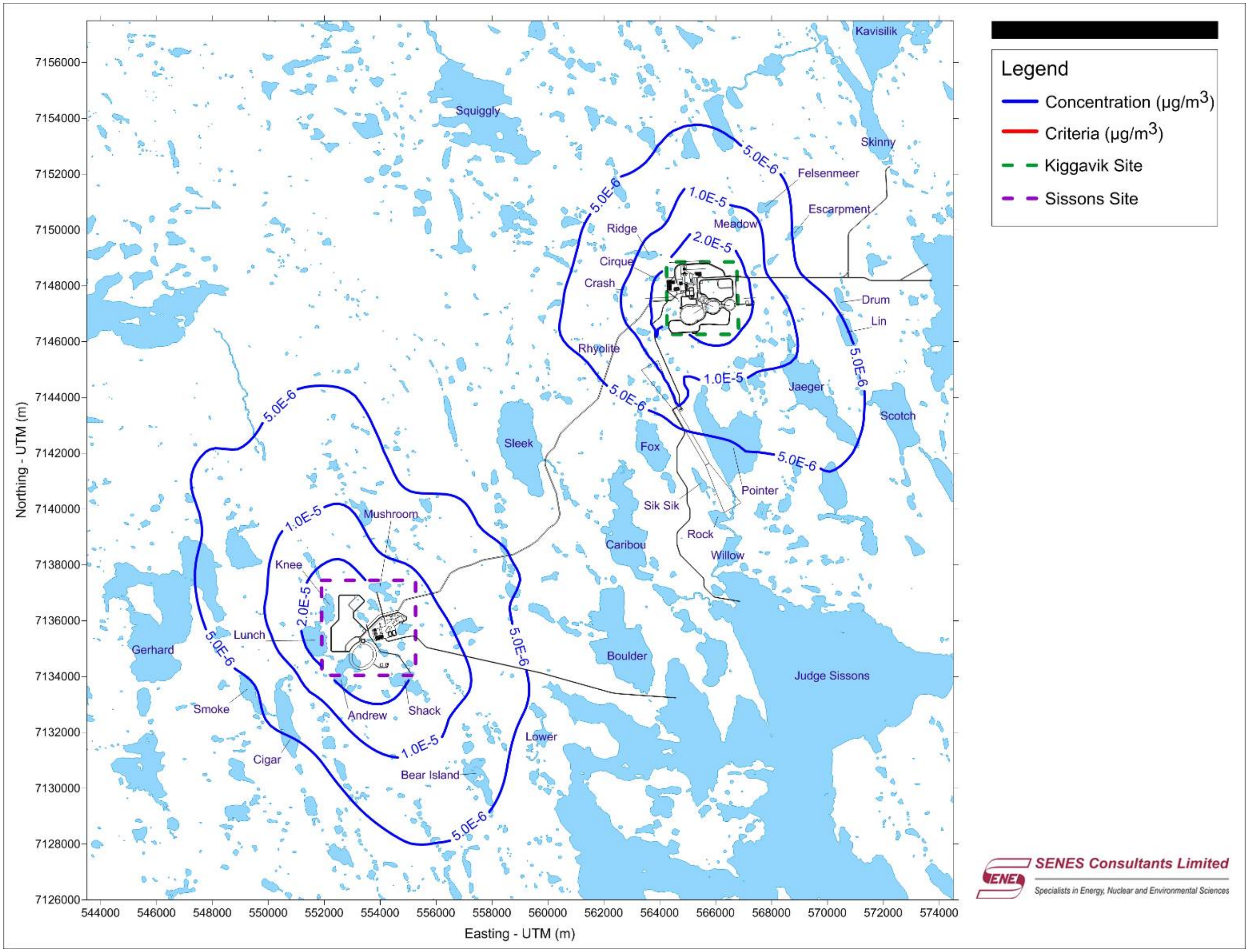


Figure D-93 Period 4 (Year 14) - Incremental Annual Selenium Concentration (µg/m³)

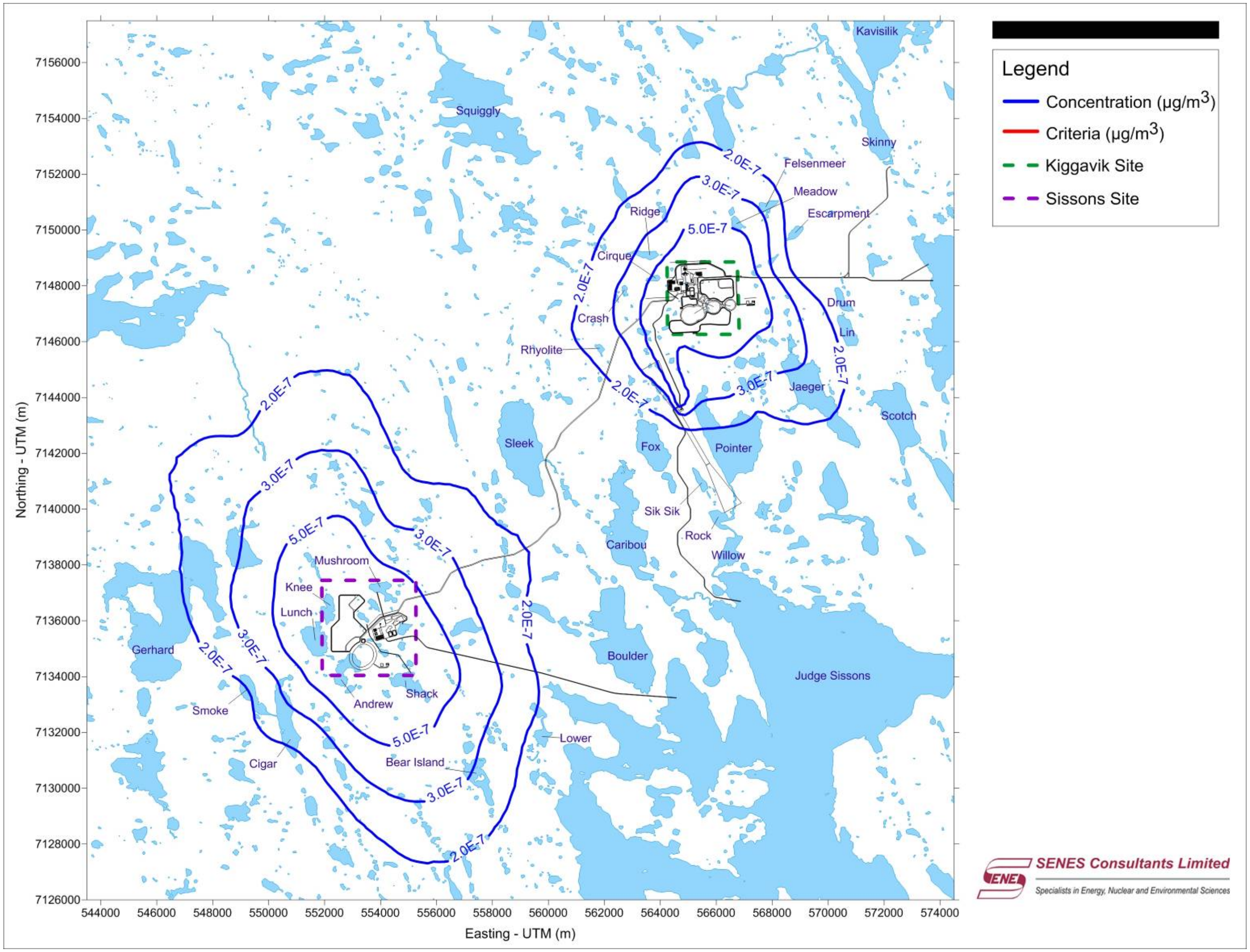


Figure D-94   Period 4 (Year 14) - Incremental Annual Zinc Concentration (µg/m³)

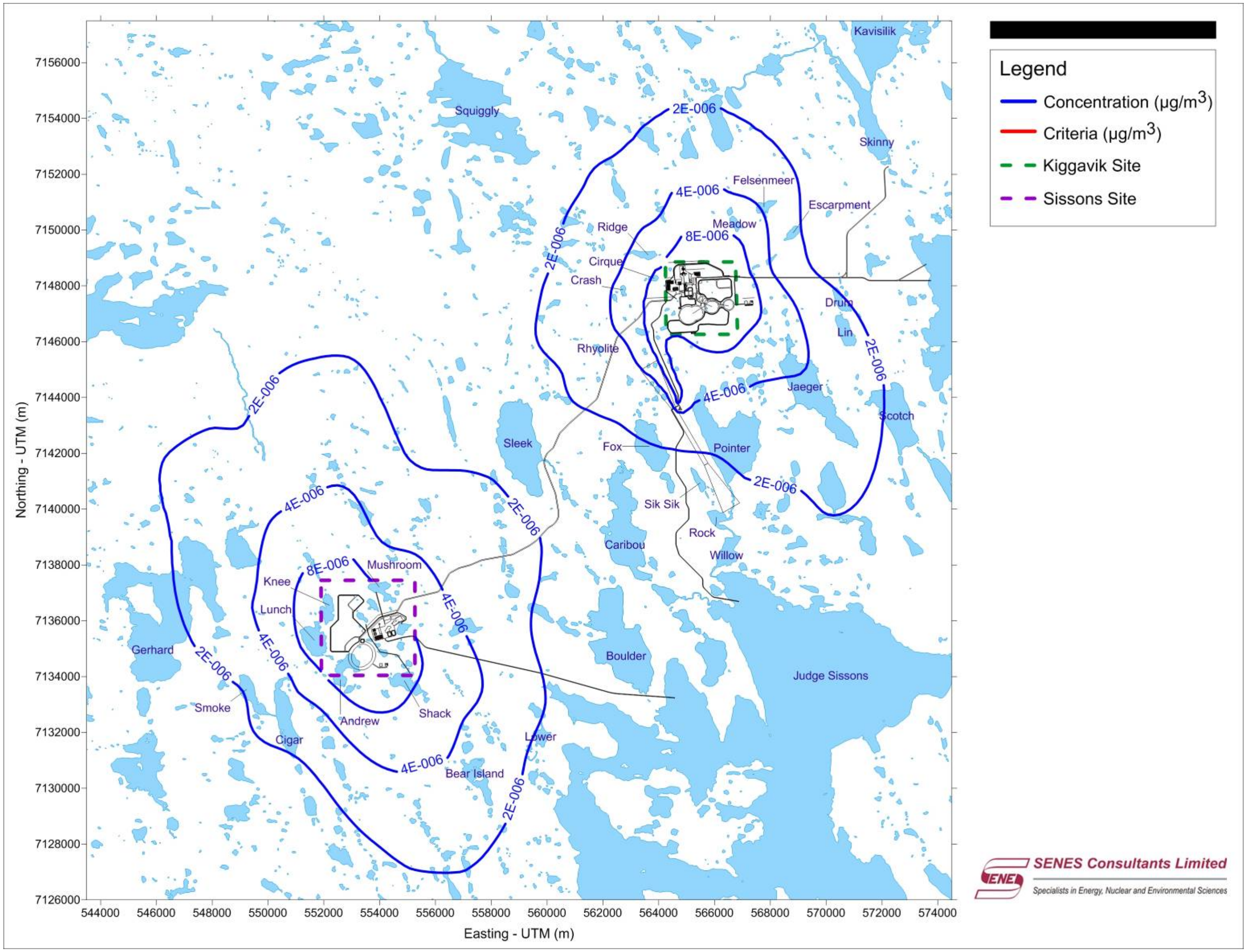


Figure D-95 Period 4 (Year 14) - Incremental Annual NO_2 Concentration (μg/m³)

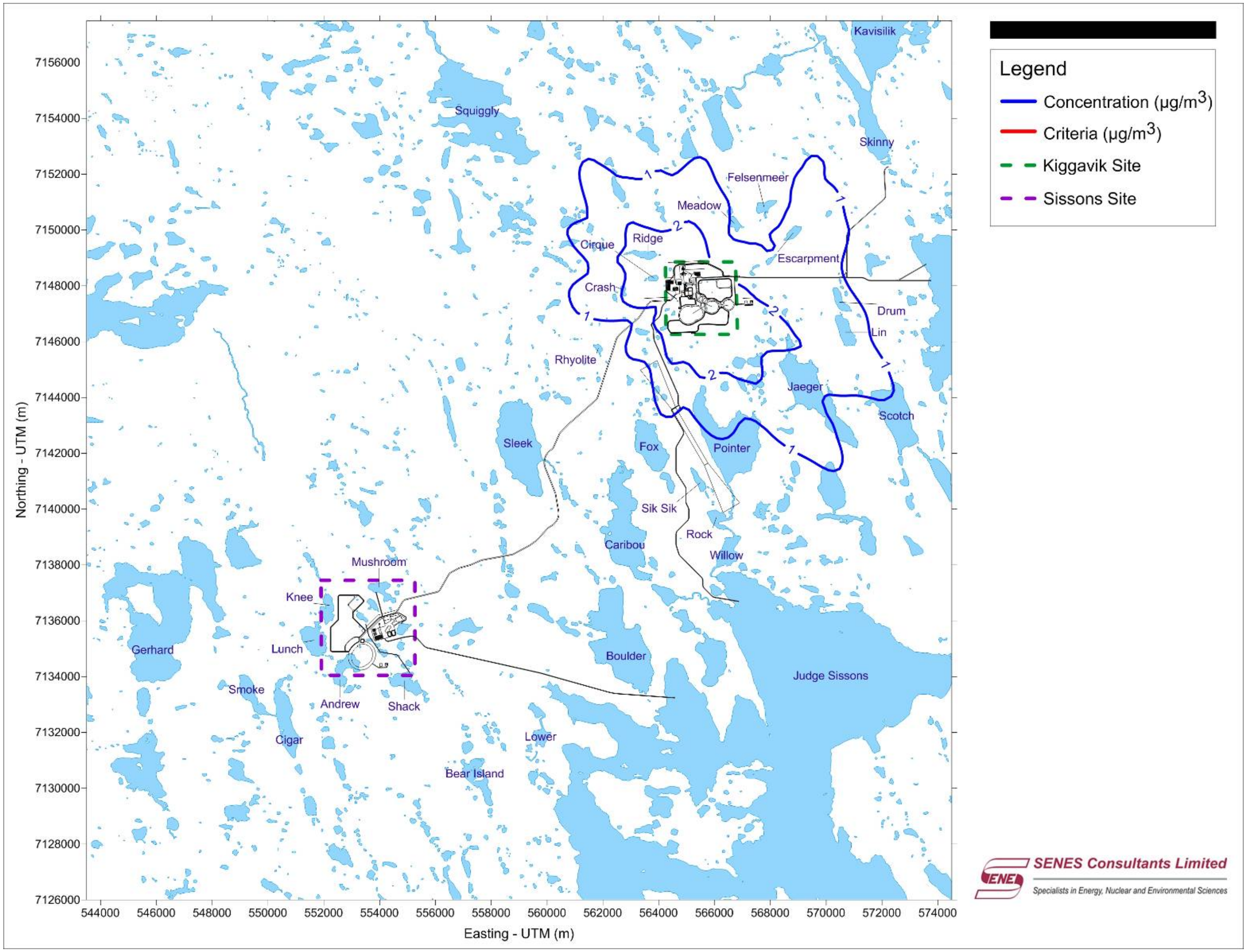


Figure D-96 Period 4 (Year 14) - Incremental Annual SO_2 Concentration (µg/m³)

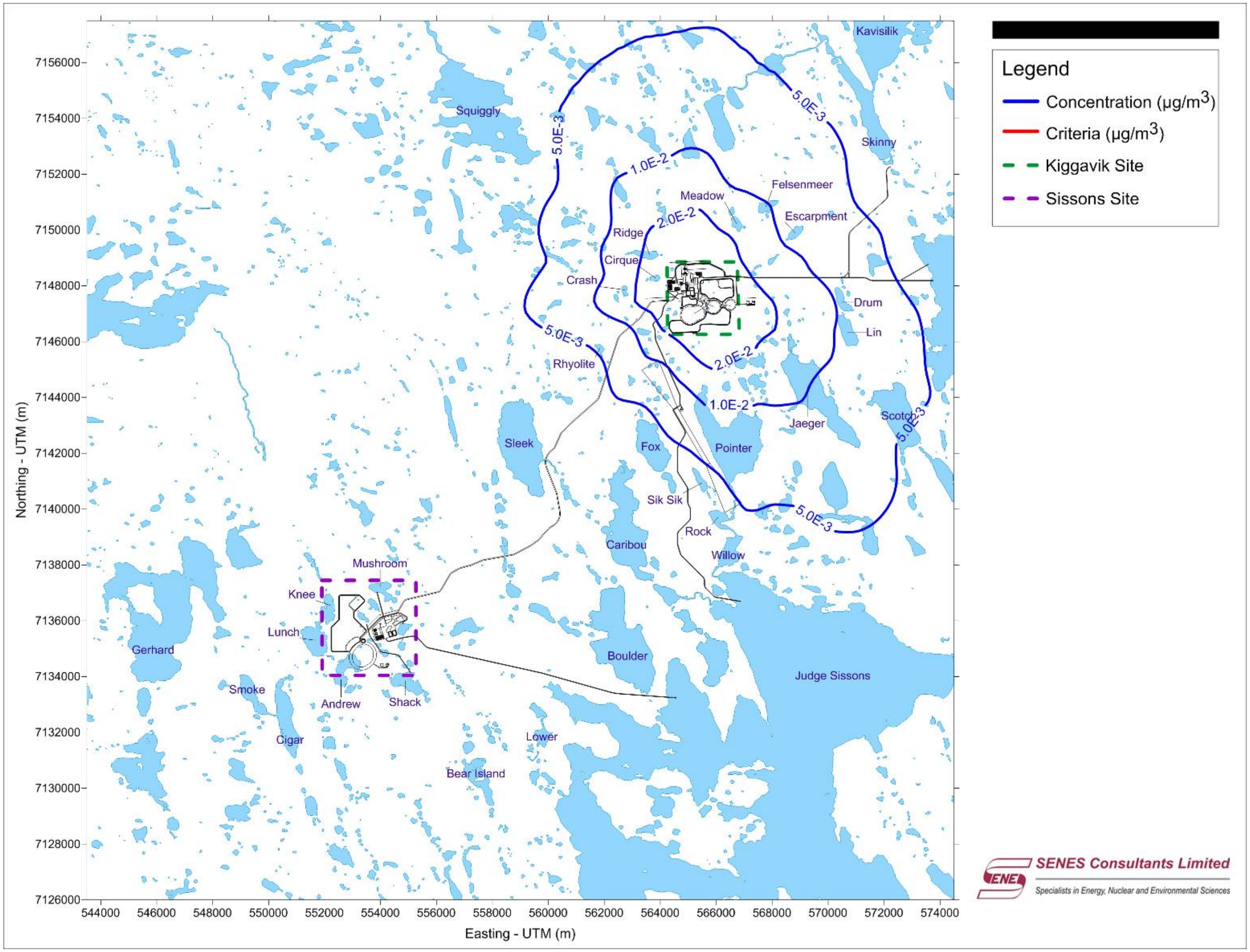


Figure D-97 Period 4 (Year 14) - Incremental Annual Radon Concentration (Bq/m³)

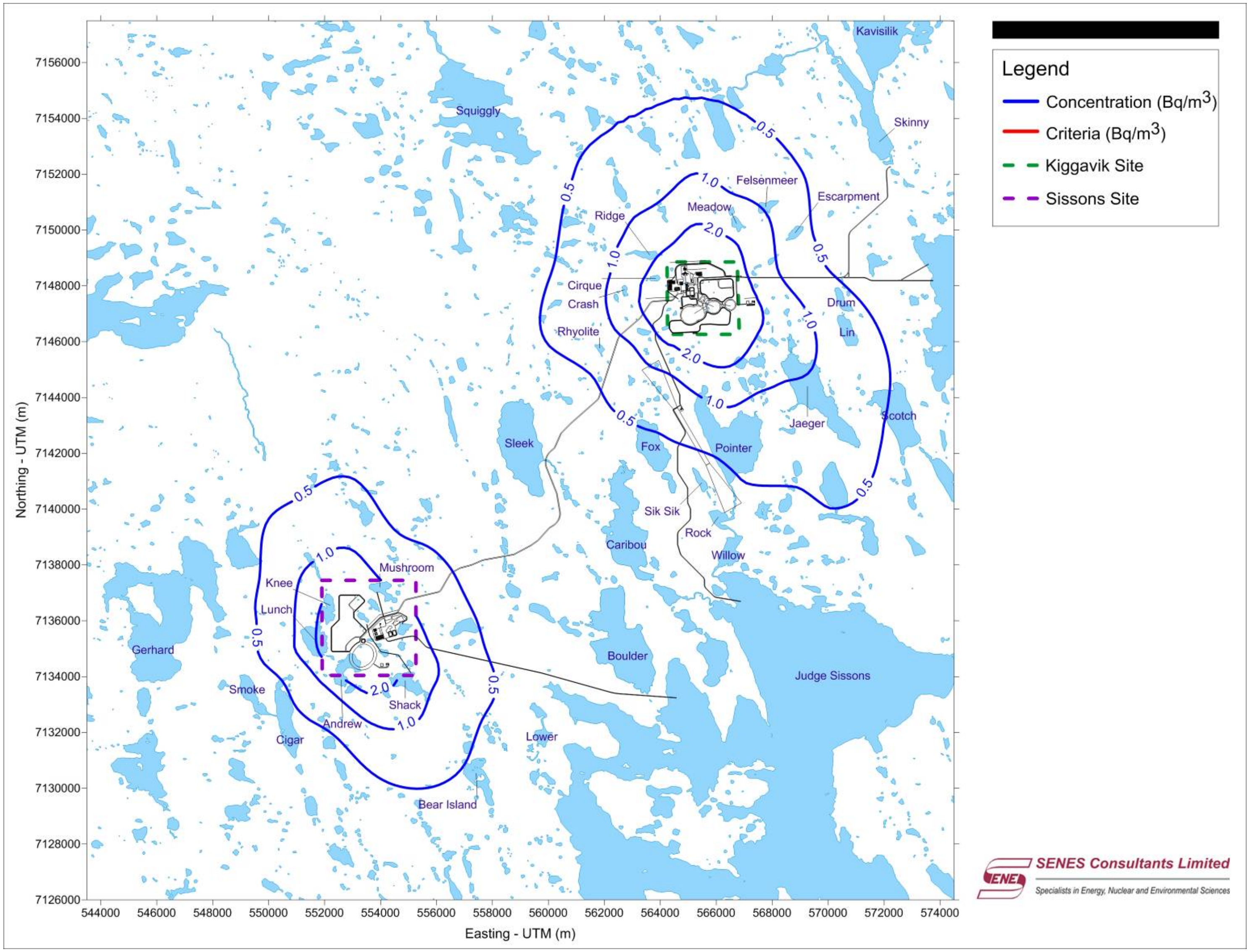


Figure D-98 Period 4 (Year 14) - Incremental Annual Lead-210 or Polonium-210 Concentration (Bq/m³)

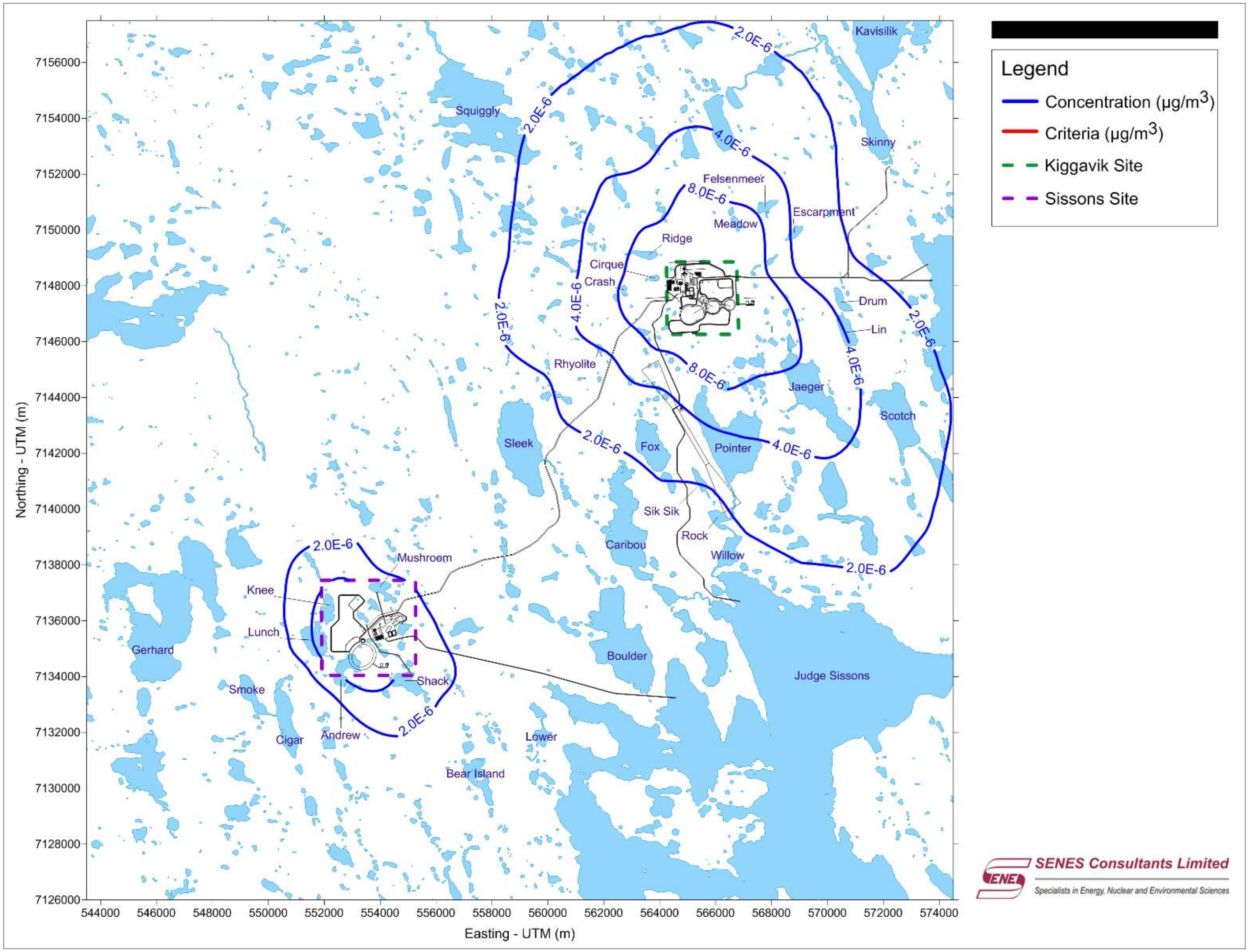


Figure D-99 Final Closure - Incremental Annual TSP Concentration (µg/m³)

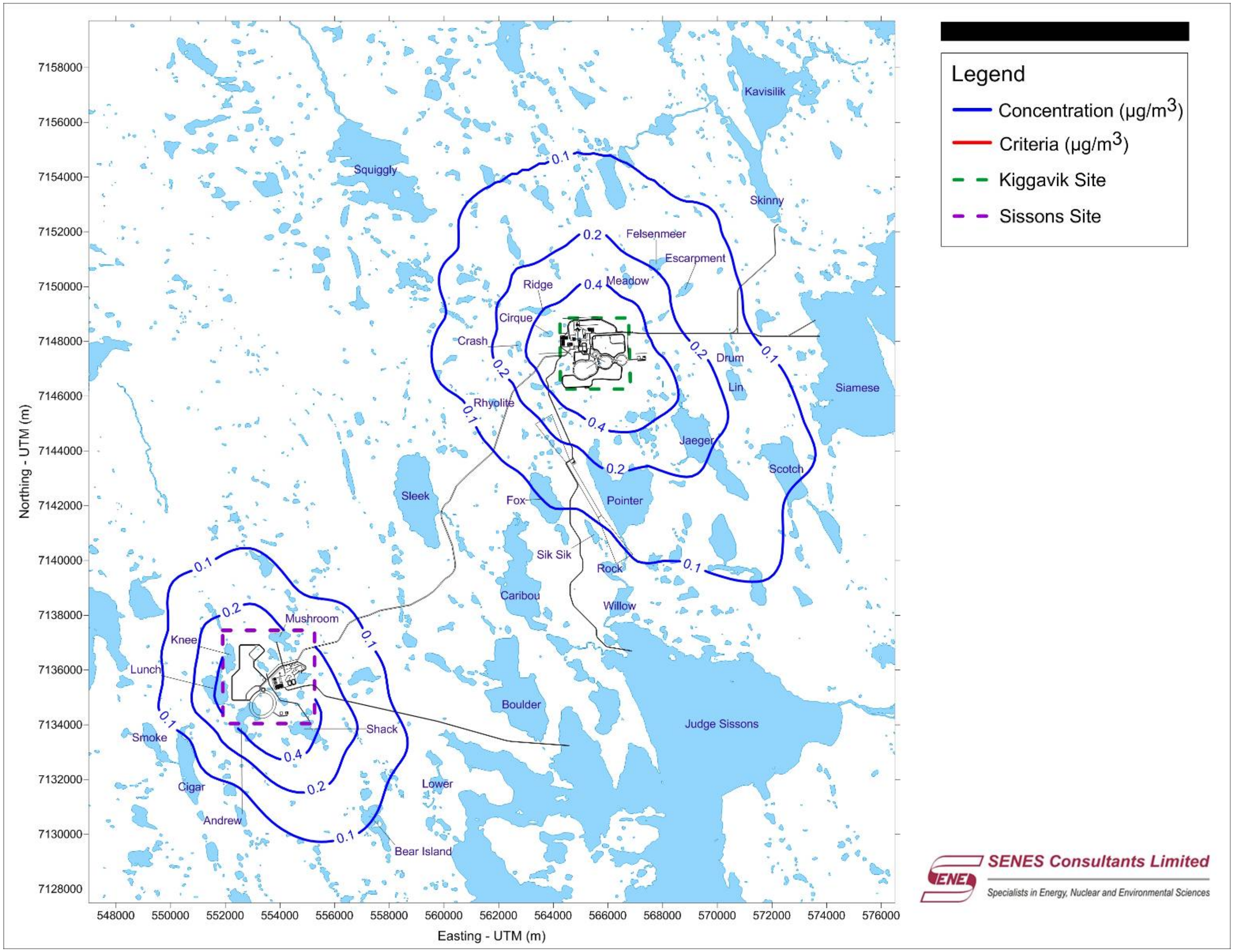


Figure D-100 Final Closure - Incremental Annual PM_{10} Concentration (µg/m³)

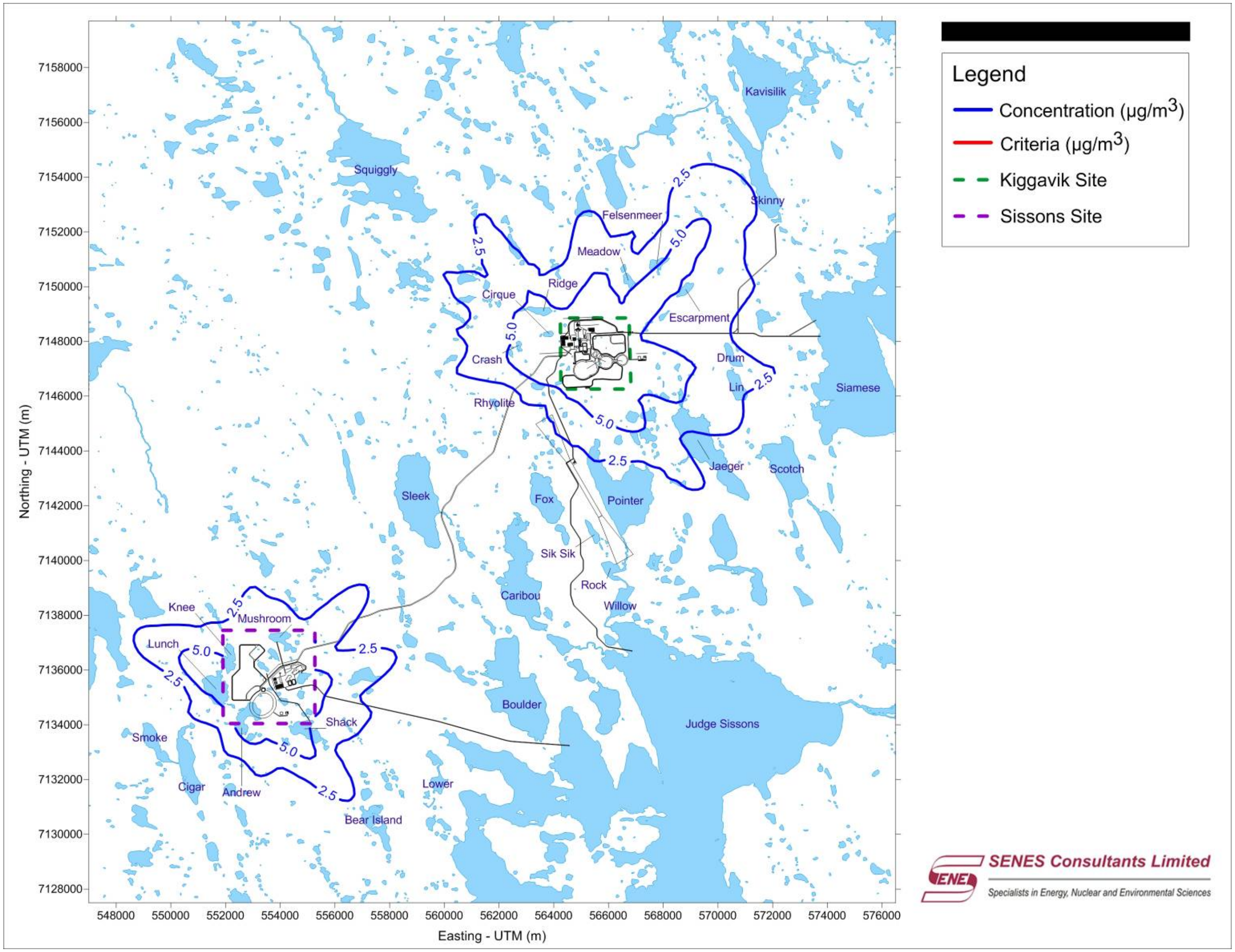


Figure D-101 Final Closure - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

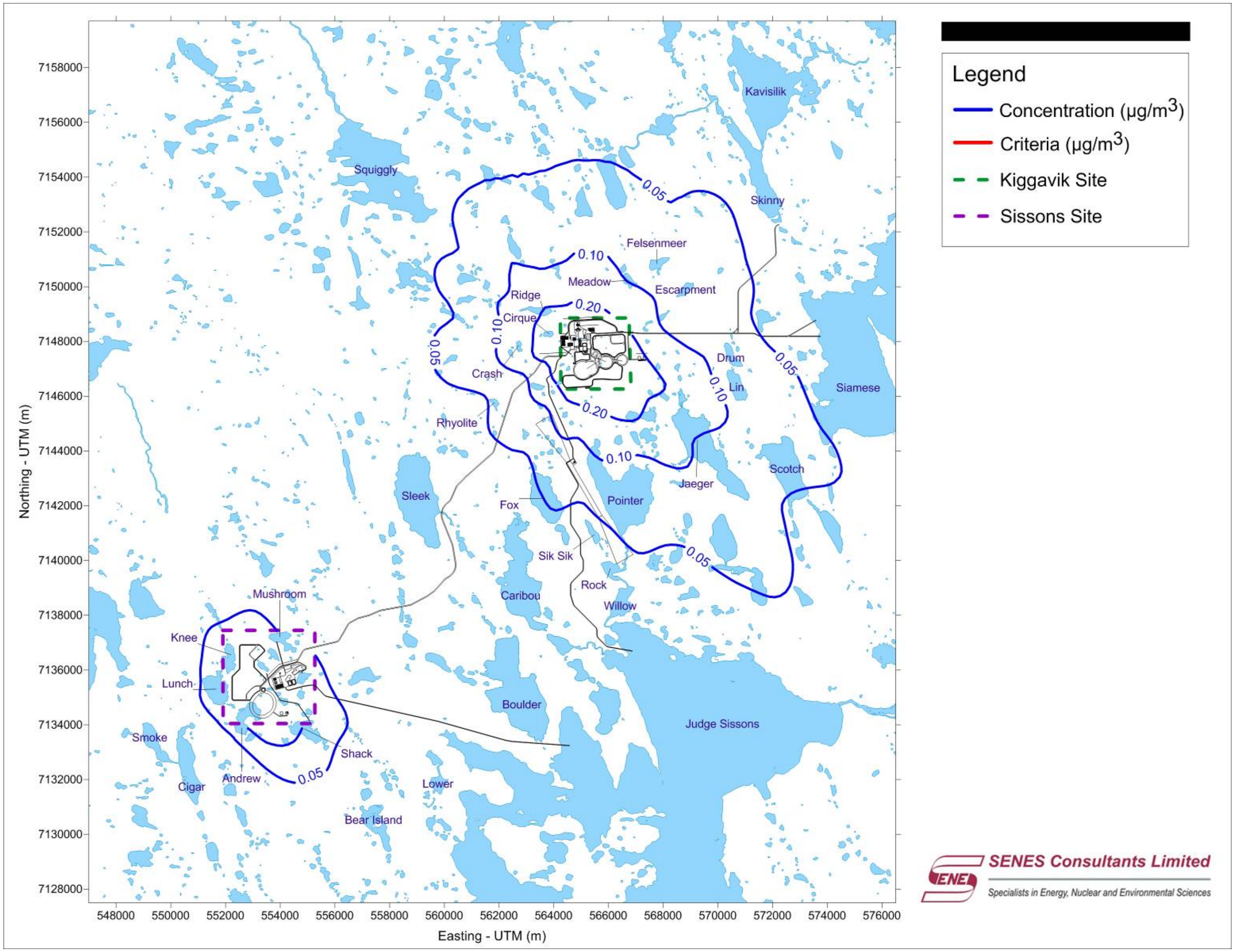


Figure D-102 Final Closure - Incremental Annual Uranium Concentration (µg/m³)

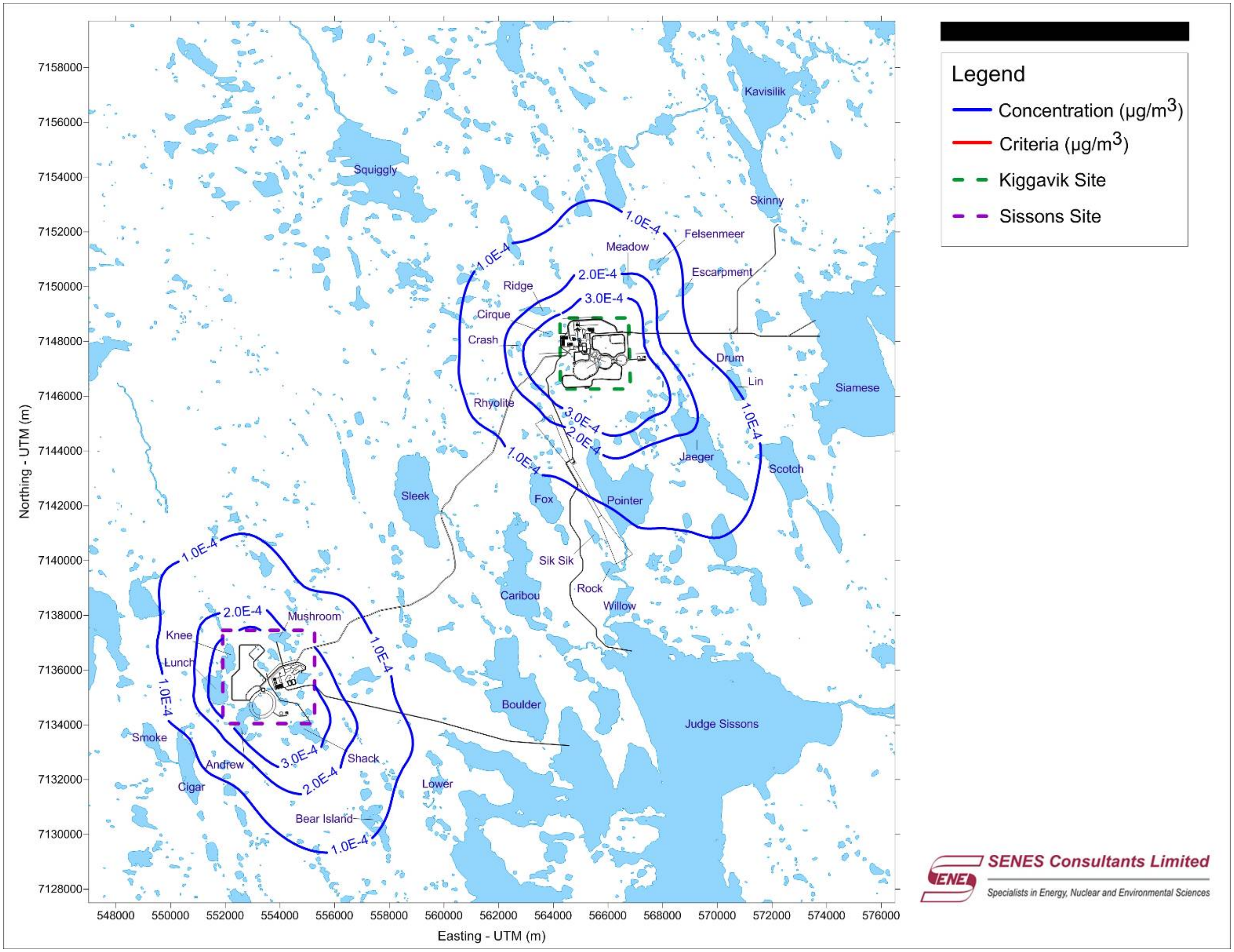


Figure D-103 Final Closure - Incremental Annual Arsenic Concentration (µg/m³)

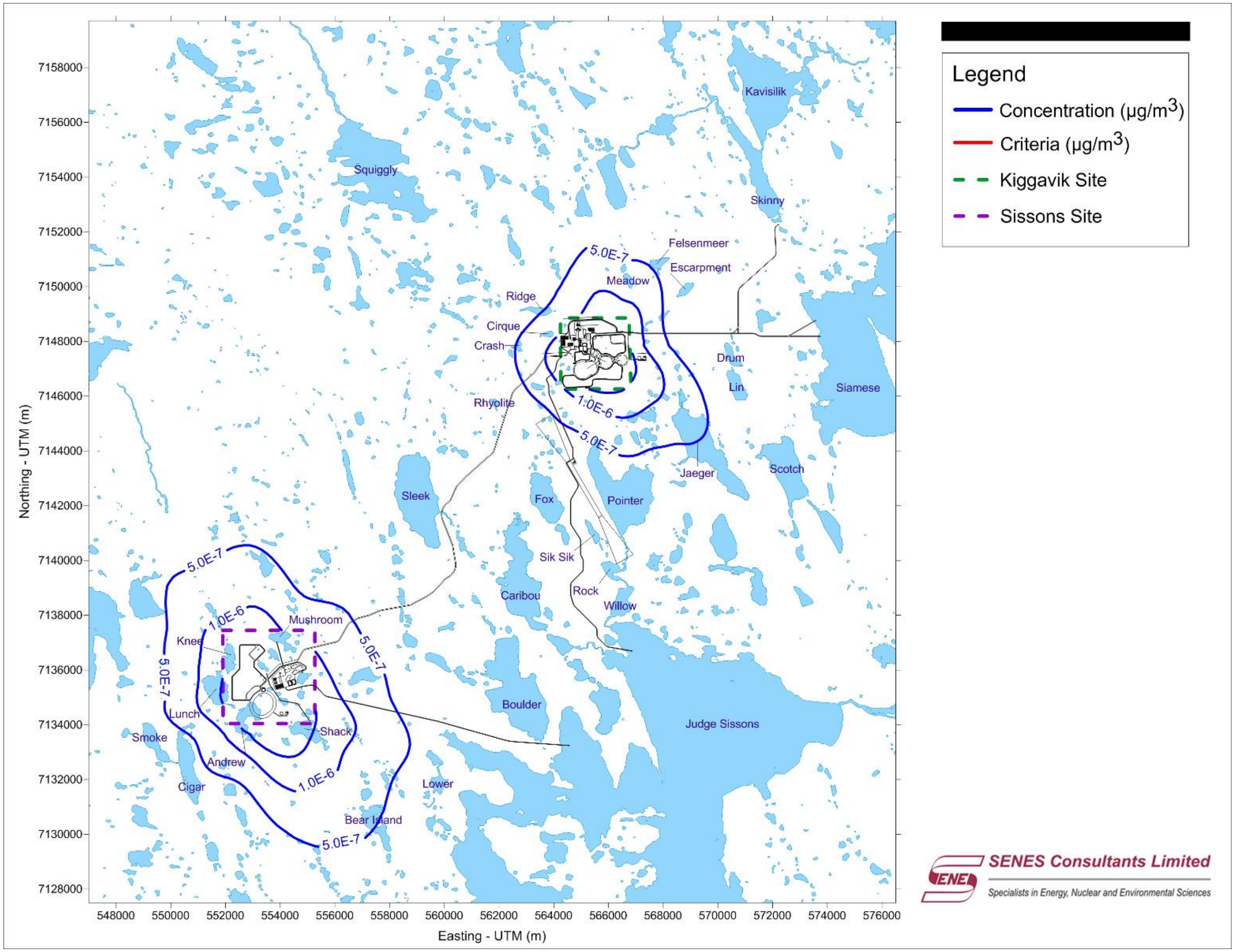


Figure D-104 Final Closure - Incremental Annual Cobalt Concentration (µg/m³)

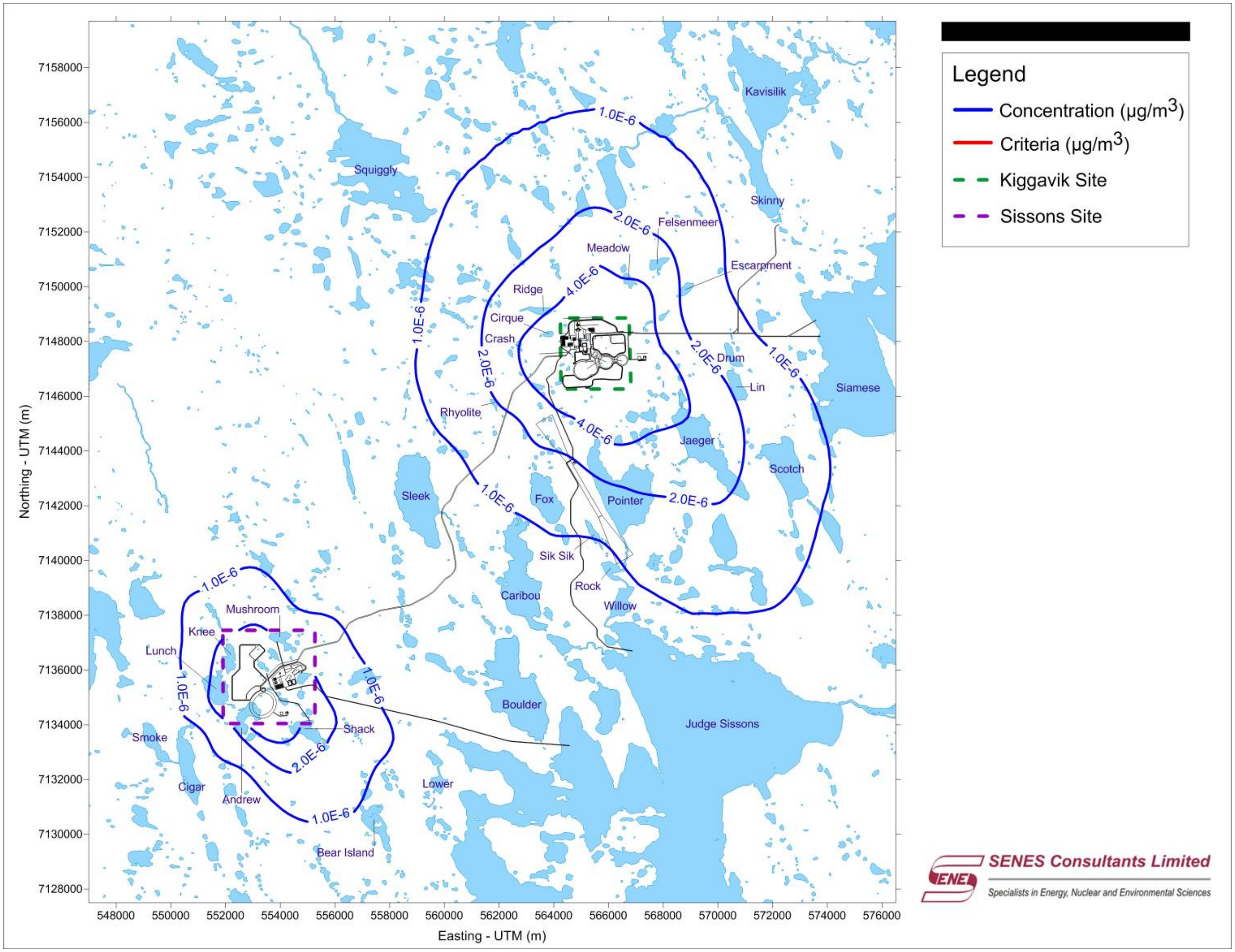


Figure D-105 Final Closure - Incremental Annual Cadmium Concentration (µg/m³)

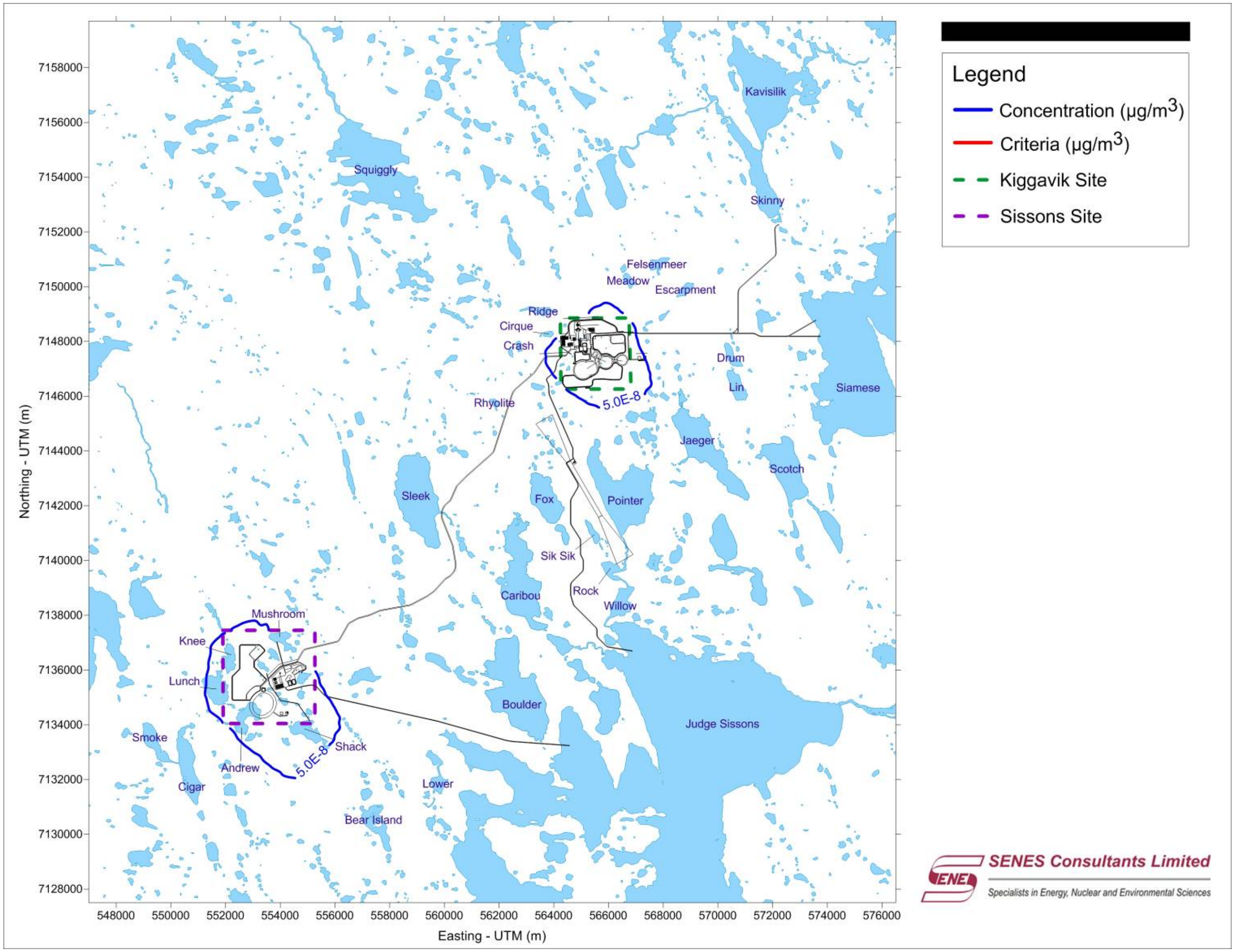


Figure D-106 Final Closure - Incremental Annual Chromium Concentration (µg/m³)

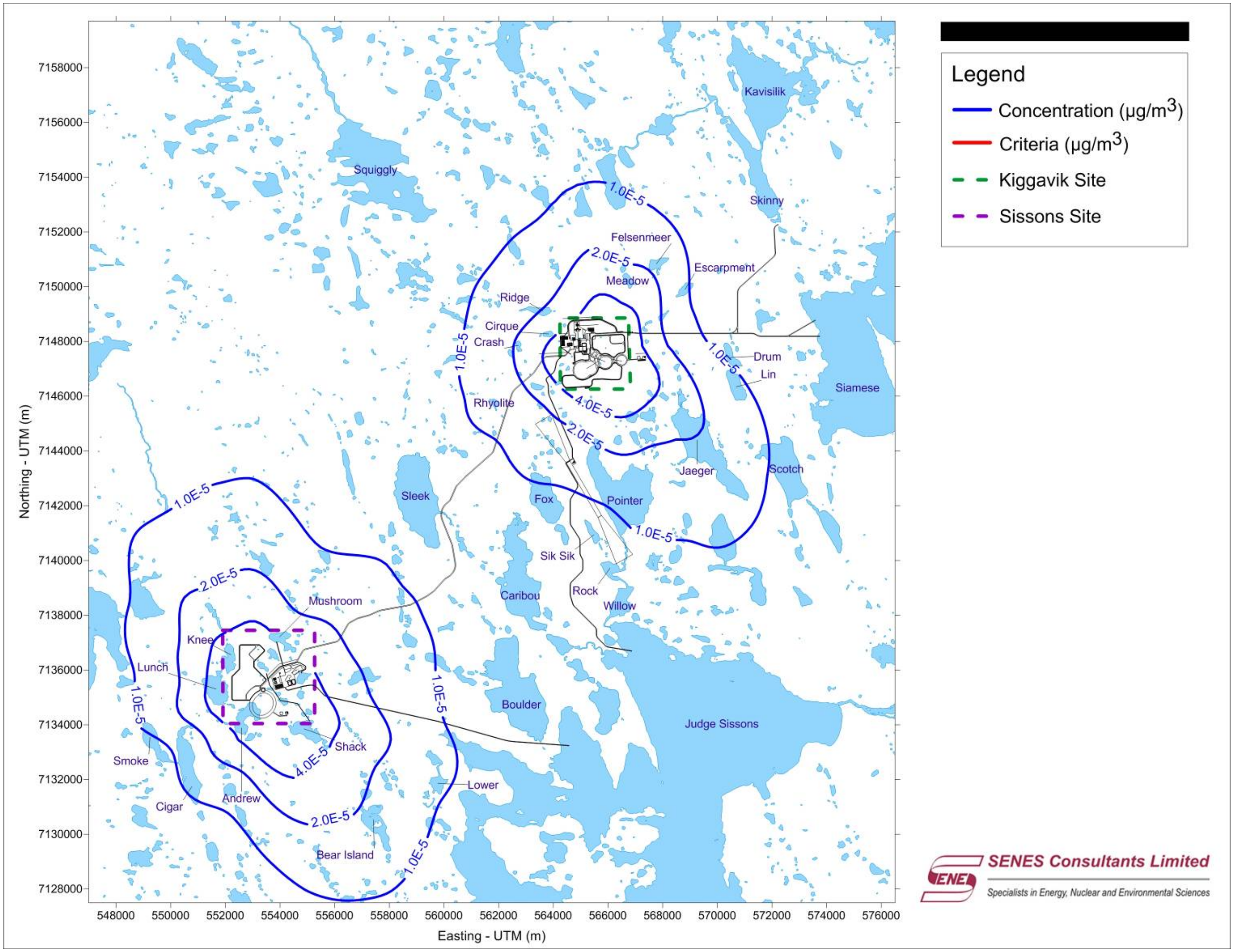


Figure D-107 Final Closure - Incremental Annual Copper Concentration (µg/m³)

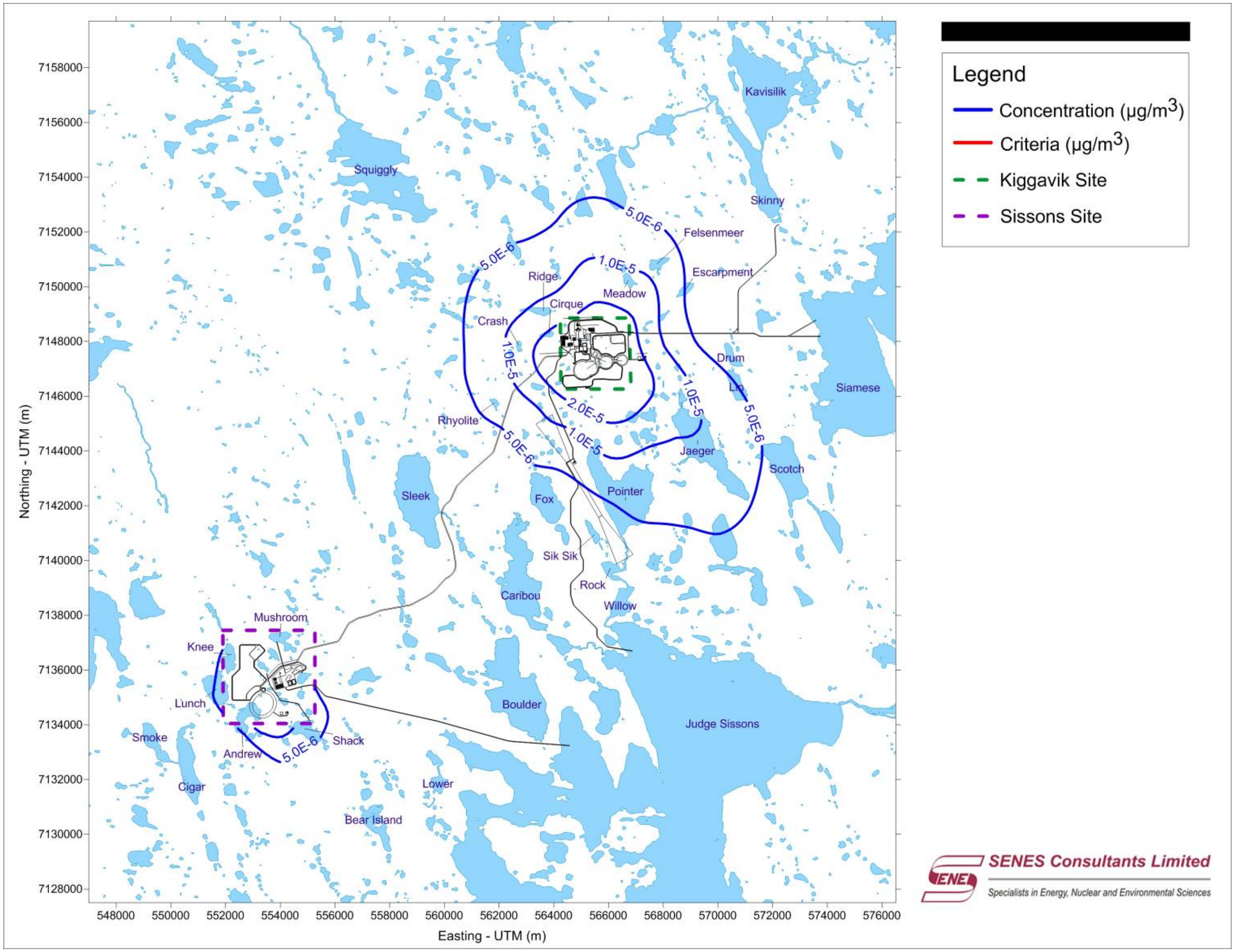


Figure D-108 Final Closure - Incremental Annual Lead Concentration (µg/m³)

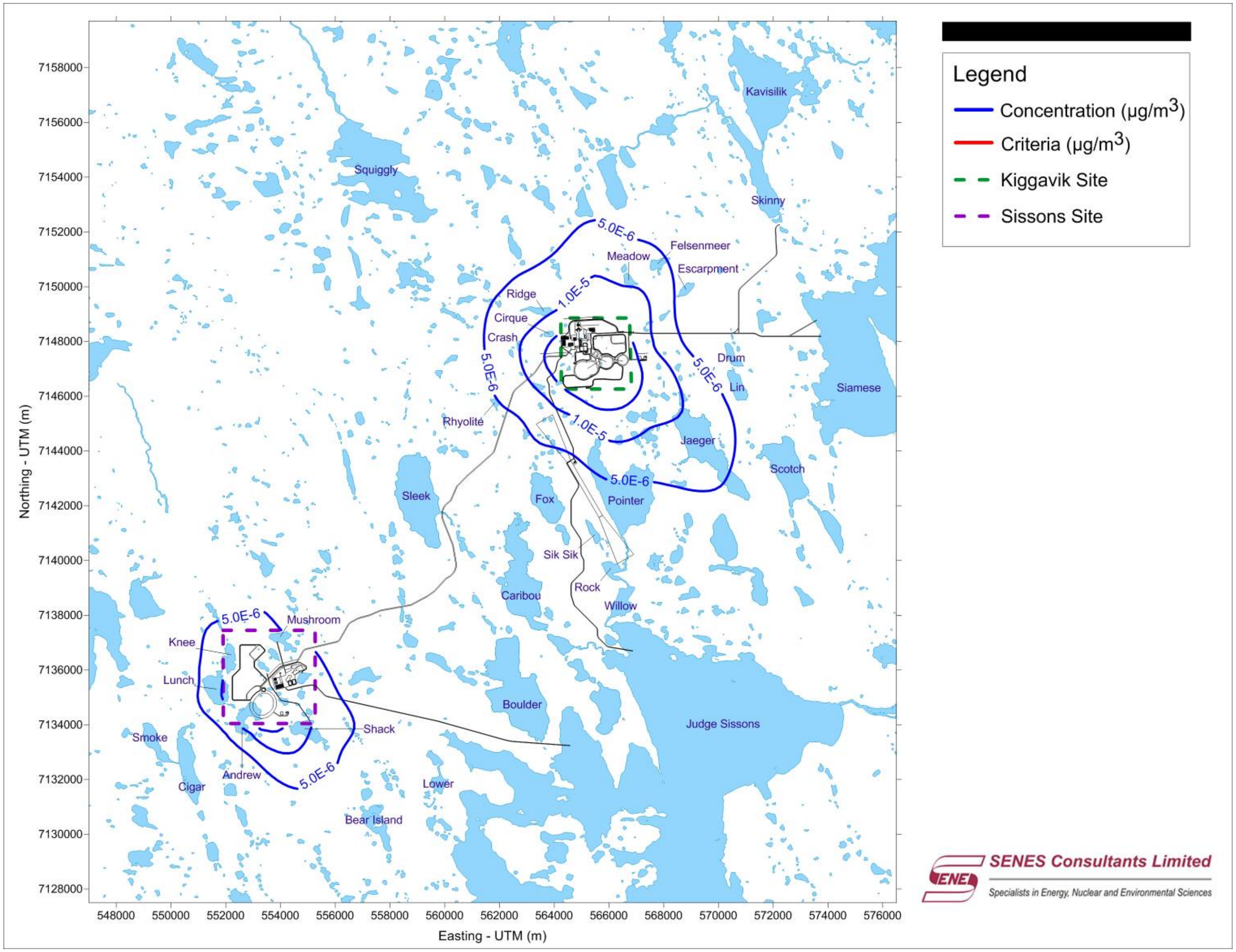


Figure D-109 Final Closure - Incremental Annual Molybdenum Concentration (µg/m³)

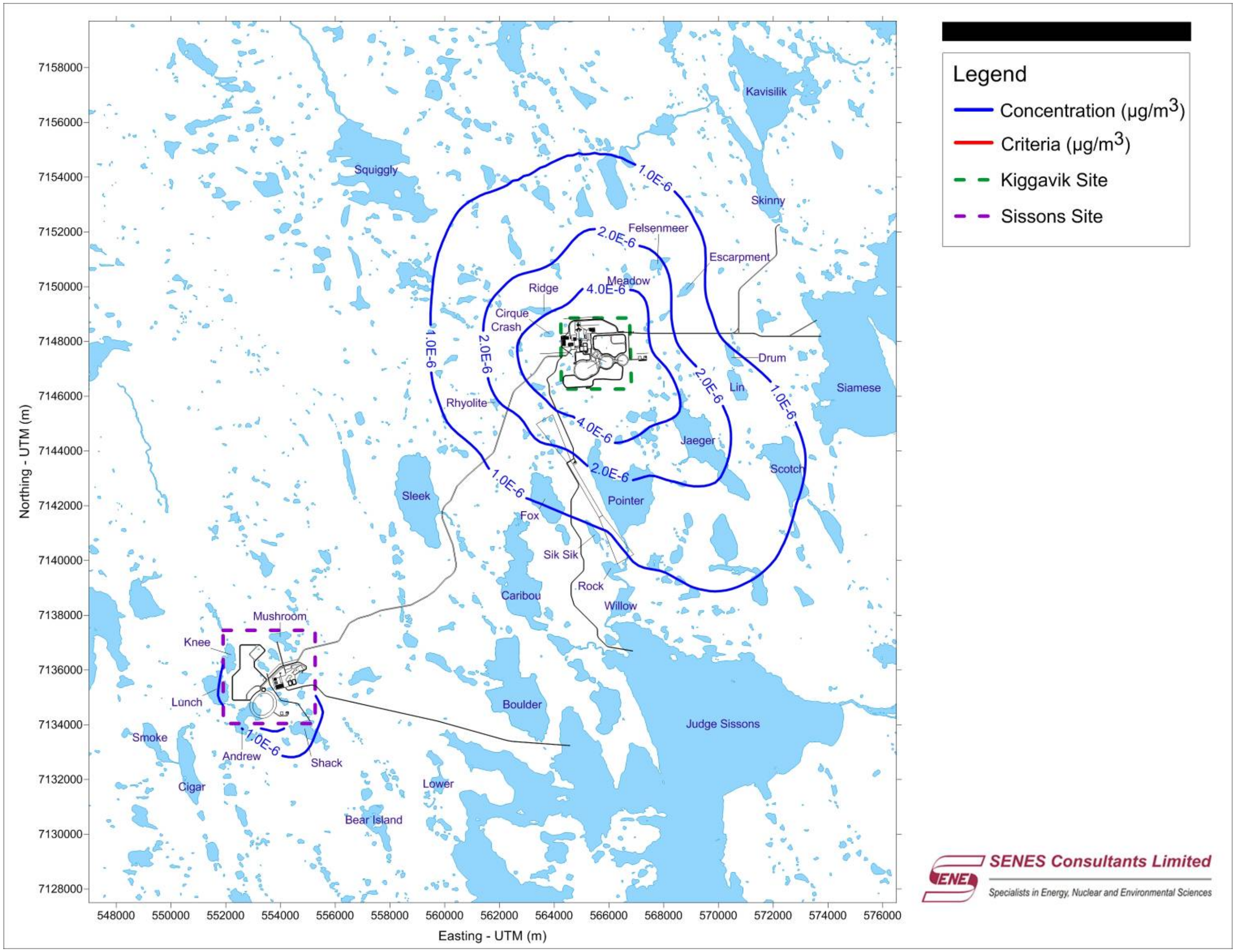


Figure D-110 Final Closure - Incremental Annual Nickel Concentration (µg/m³)

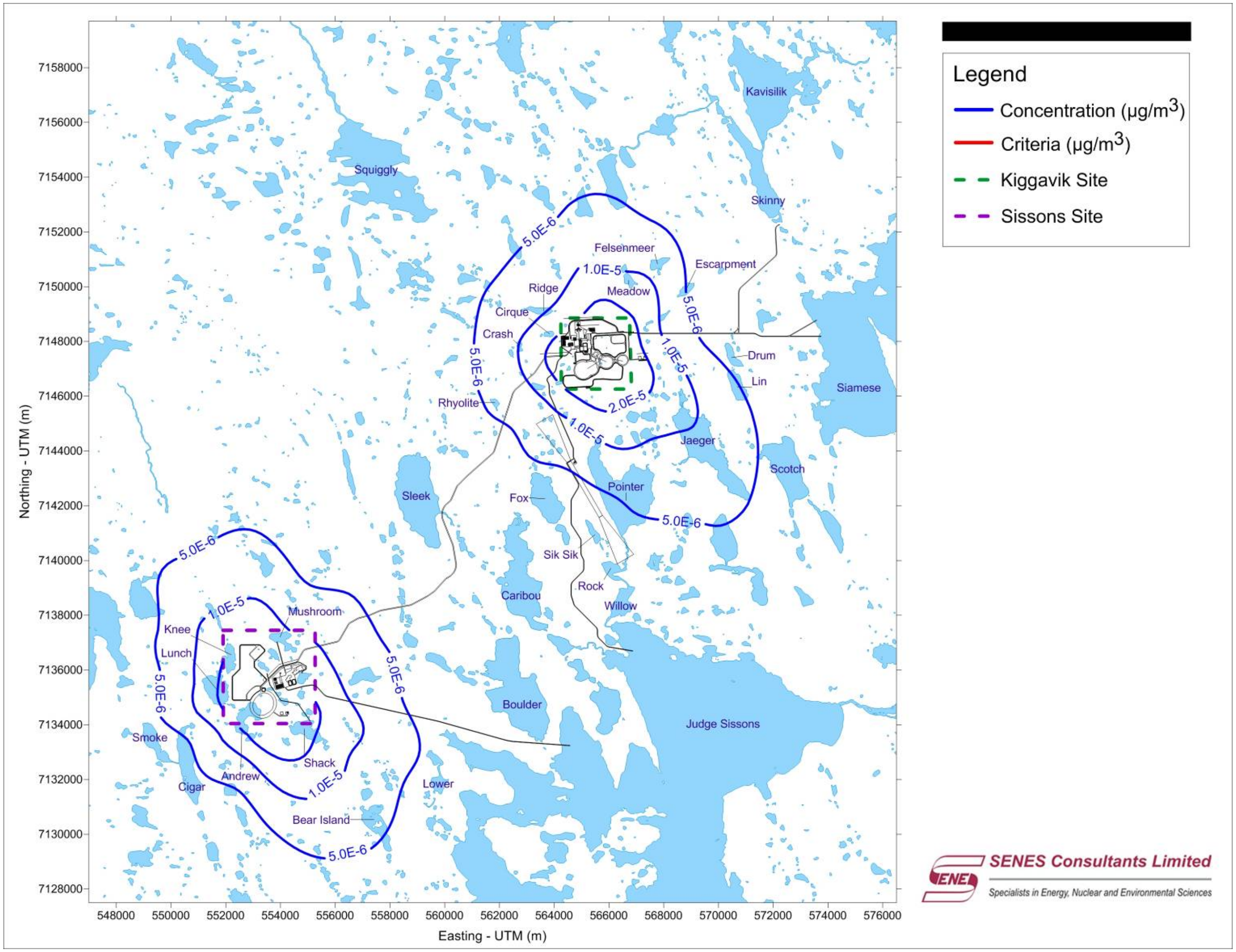


Figure D-111 Final Closure - Incremental Annual Selenium Concentration (µg/m³)

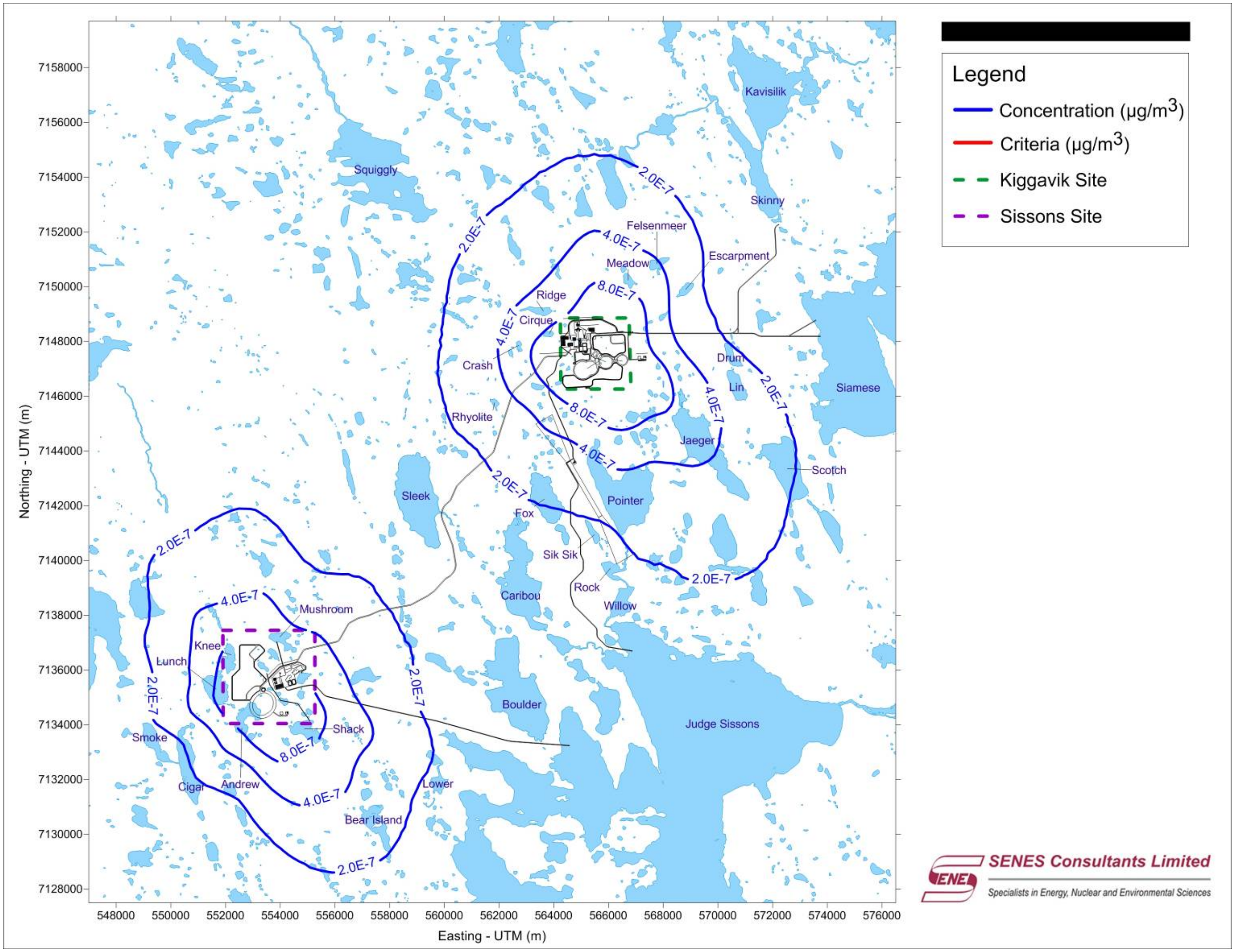


Figure D-112 Final Closure - Incremental Annual Zinc Concentration (µg/m³)

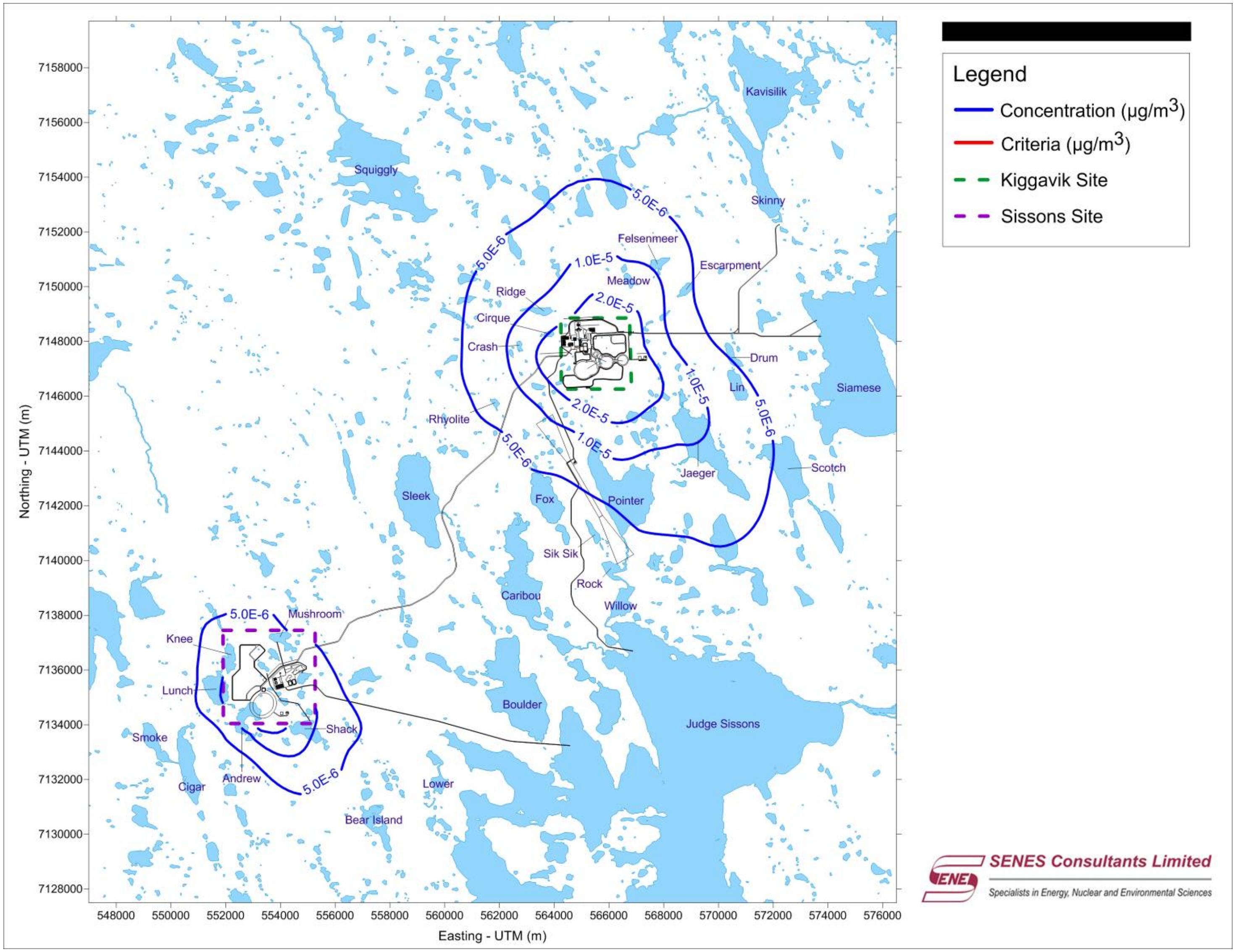


Figure D-113 Final Closure - Incremental Annual NO_2 Concentration (µg/m³)

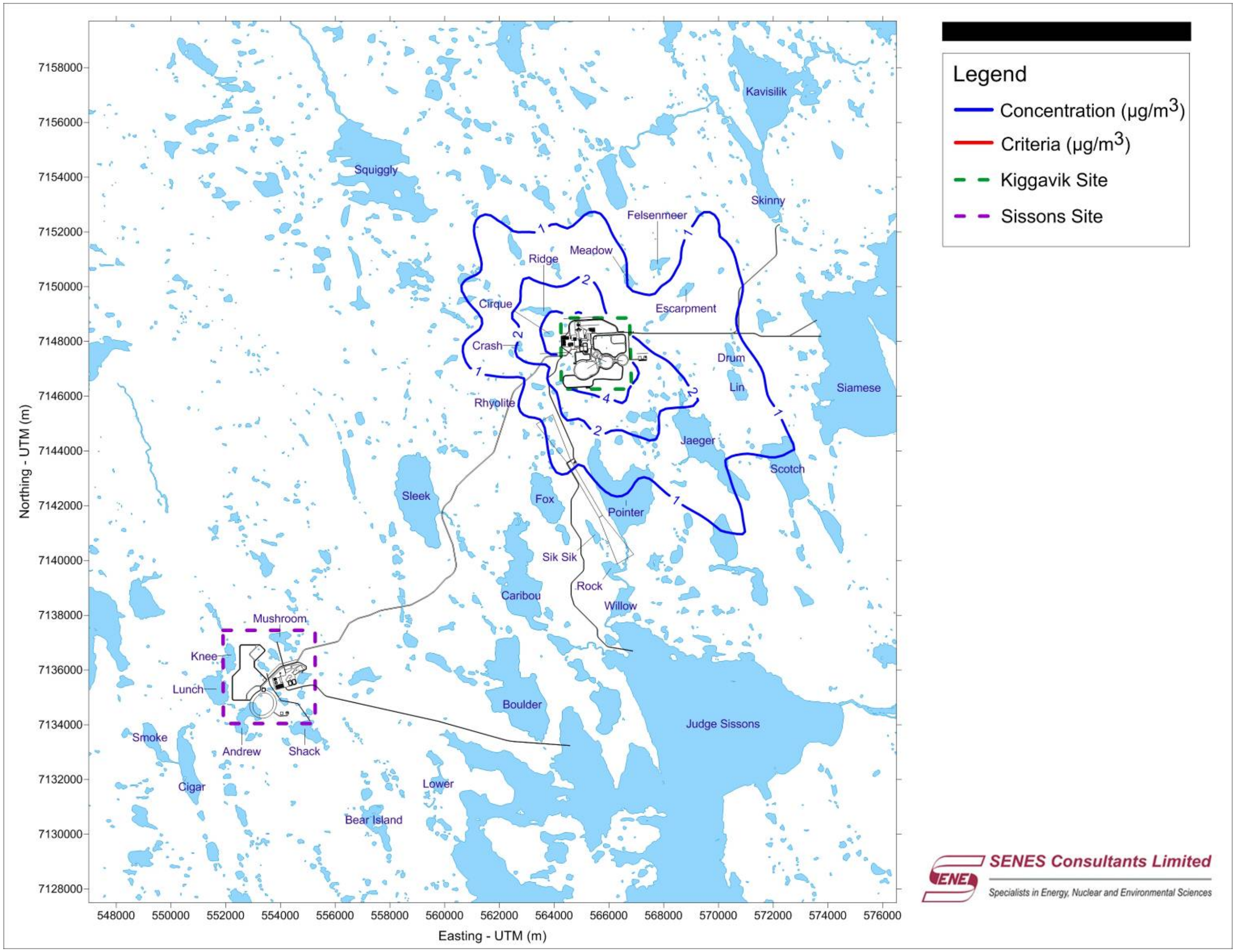


Figure D-114 Final Closure - Incremental Annual SO_2 Concentration (μg/m³)

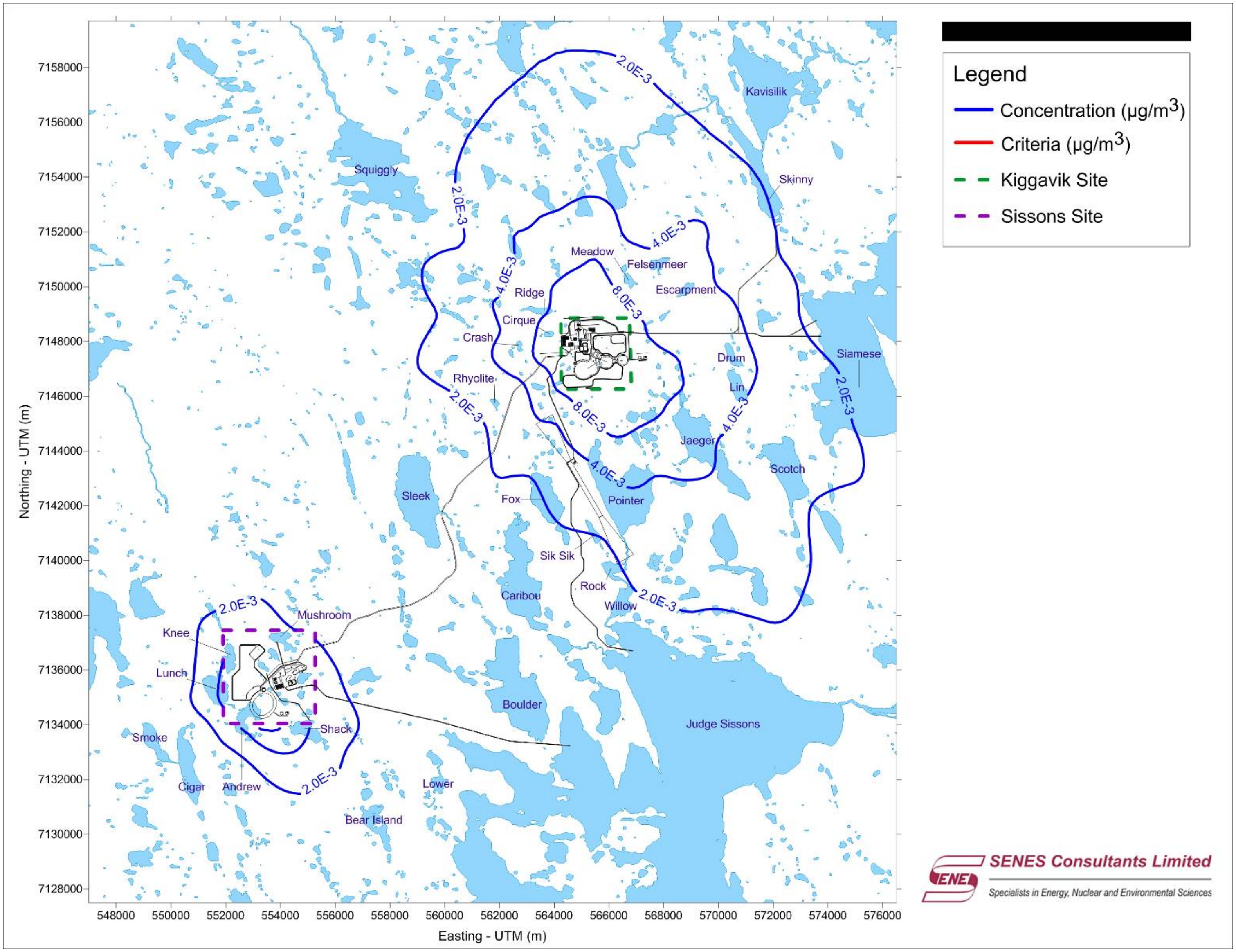


Figure D-115 Final Closure - Incremental Annual Radon Concentration (Bq/m³)

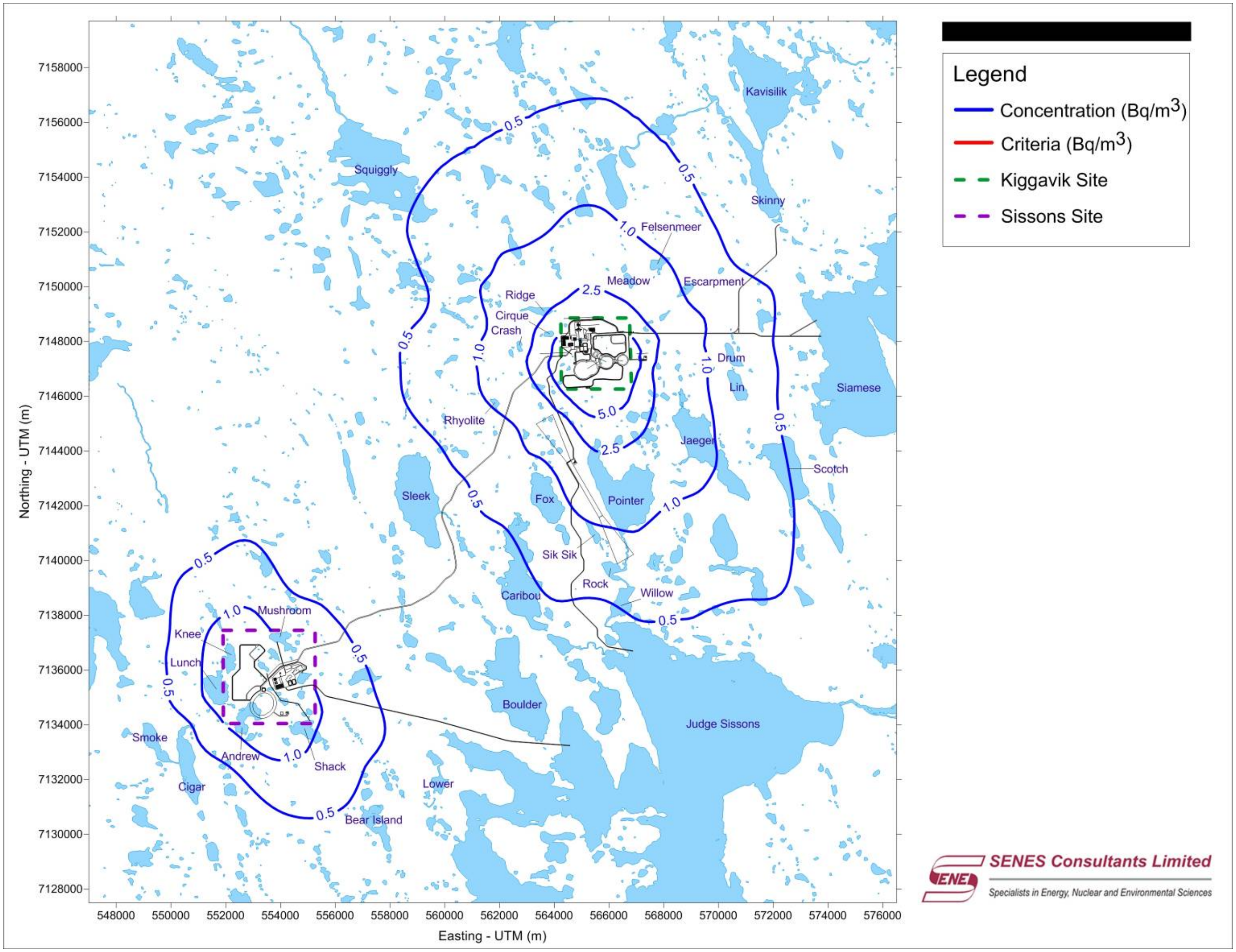


Figure D-116 Final Closure - Incremental Annual Lead-210 or Polonium-210 Concentration (Bq/m³)

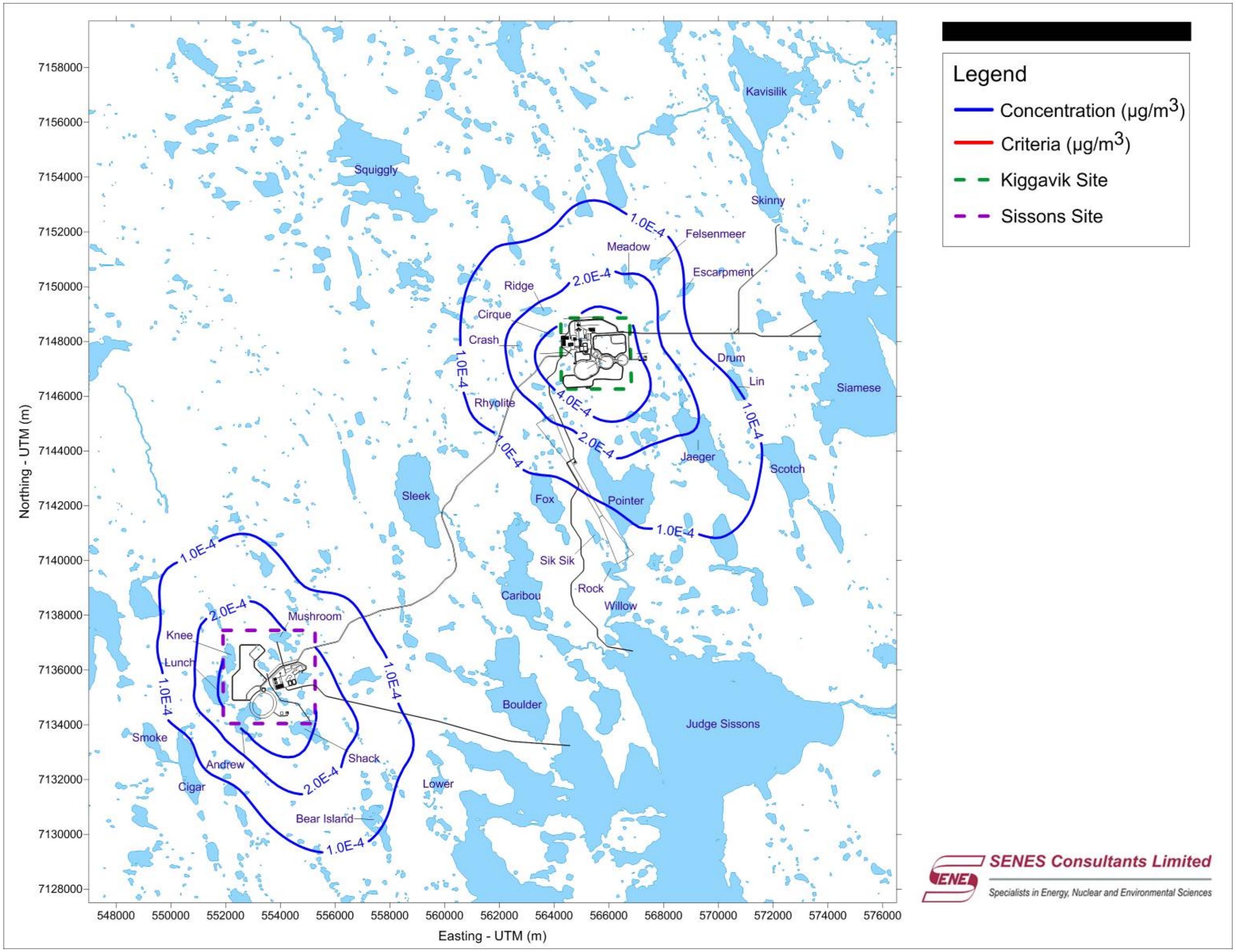


Figure D-117 Post-Closure - Incremental Annual Radon Concentration (Bq/m³)

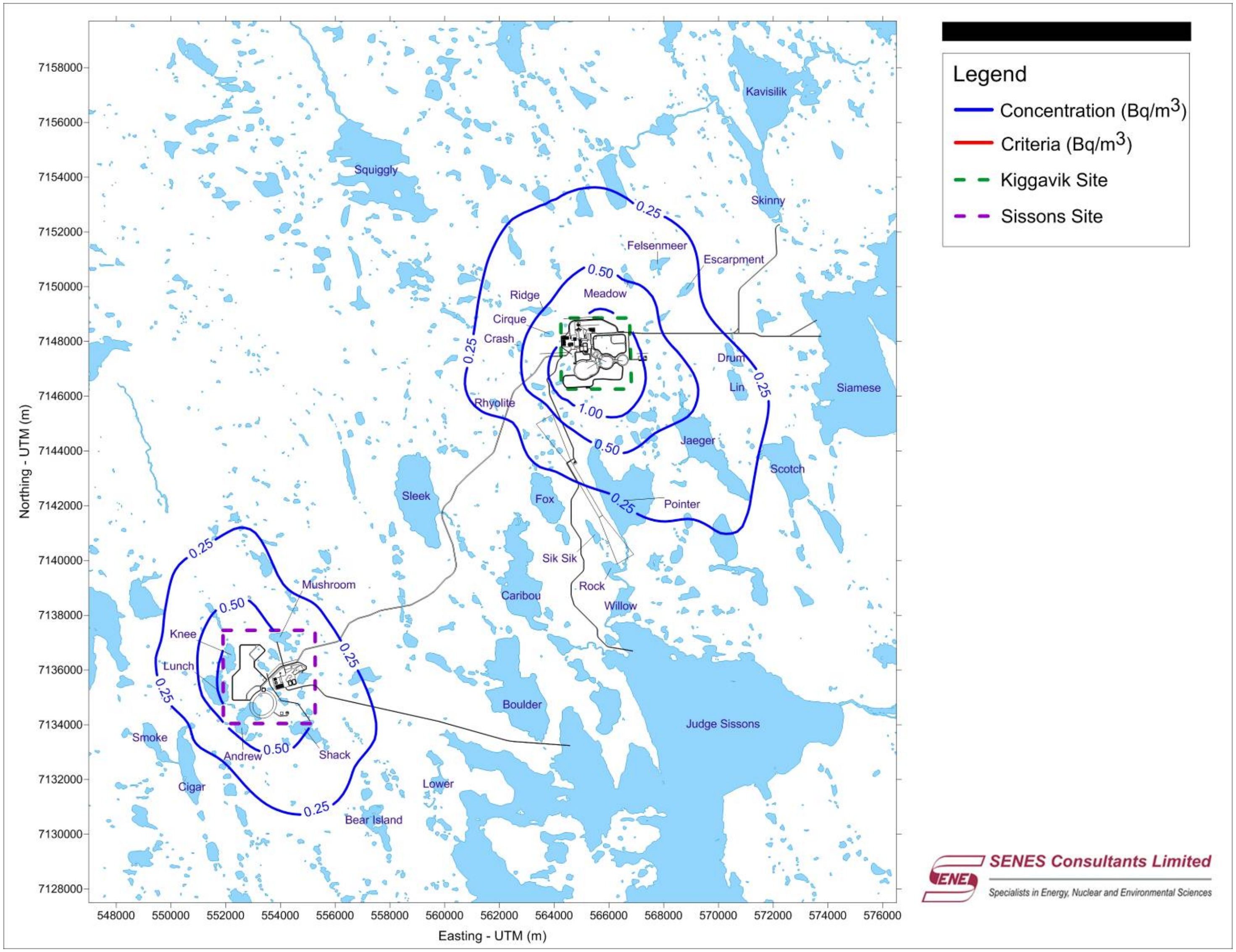


Figure D-118 Baker Lake Dock and Storage Facility - Incremental 24-hr TSP Concentration (µg/m³)

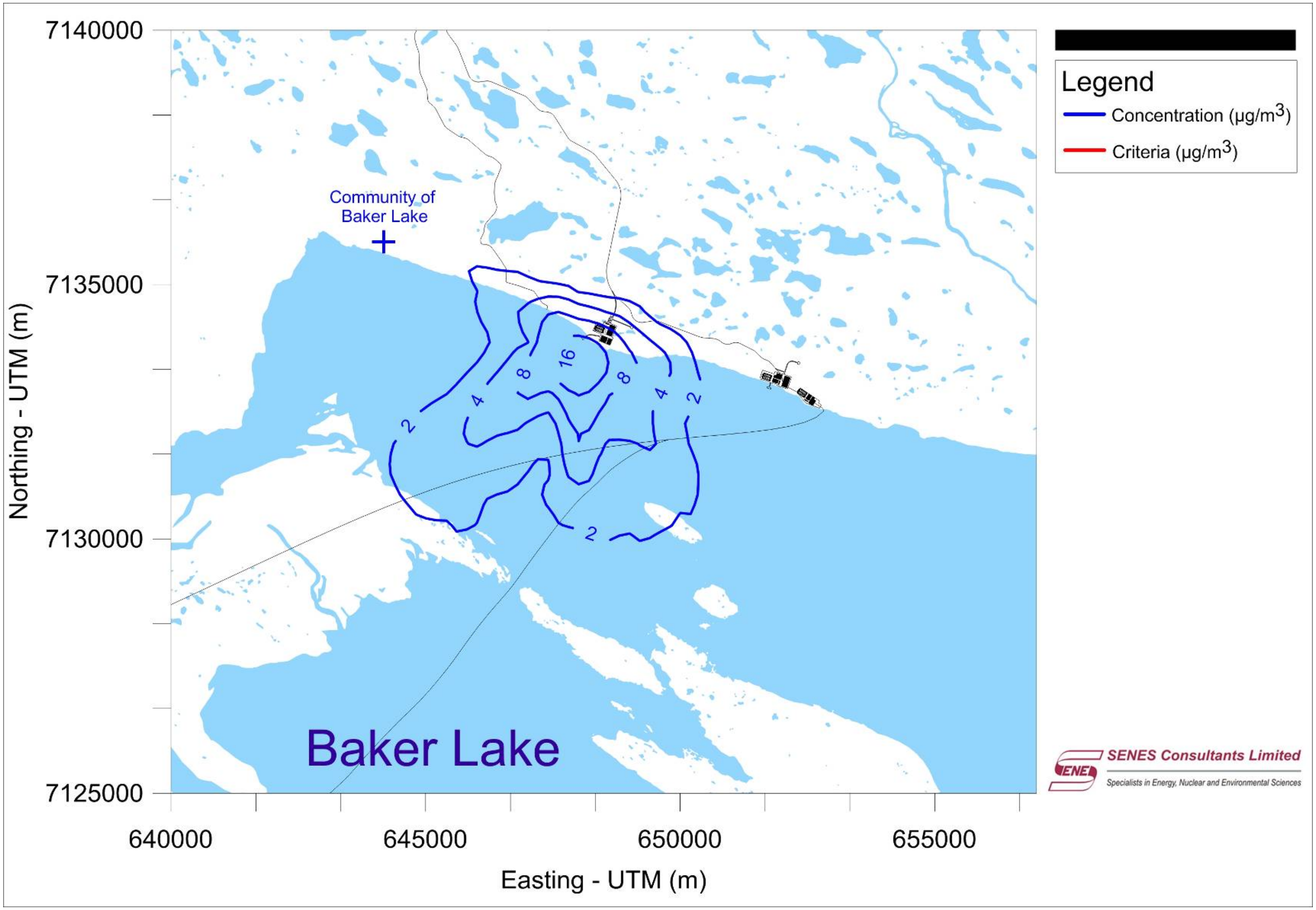


Figure D-119 Baker Lake Dock and Storage Facility - Incremental 24-hr PM_{10} Concentration (µg/m³)

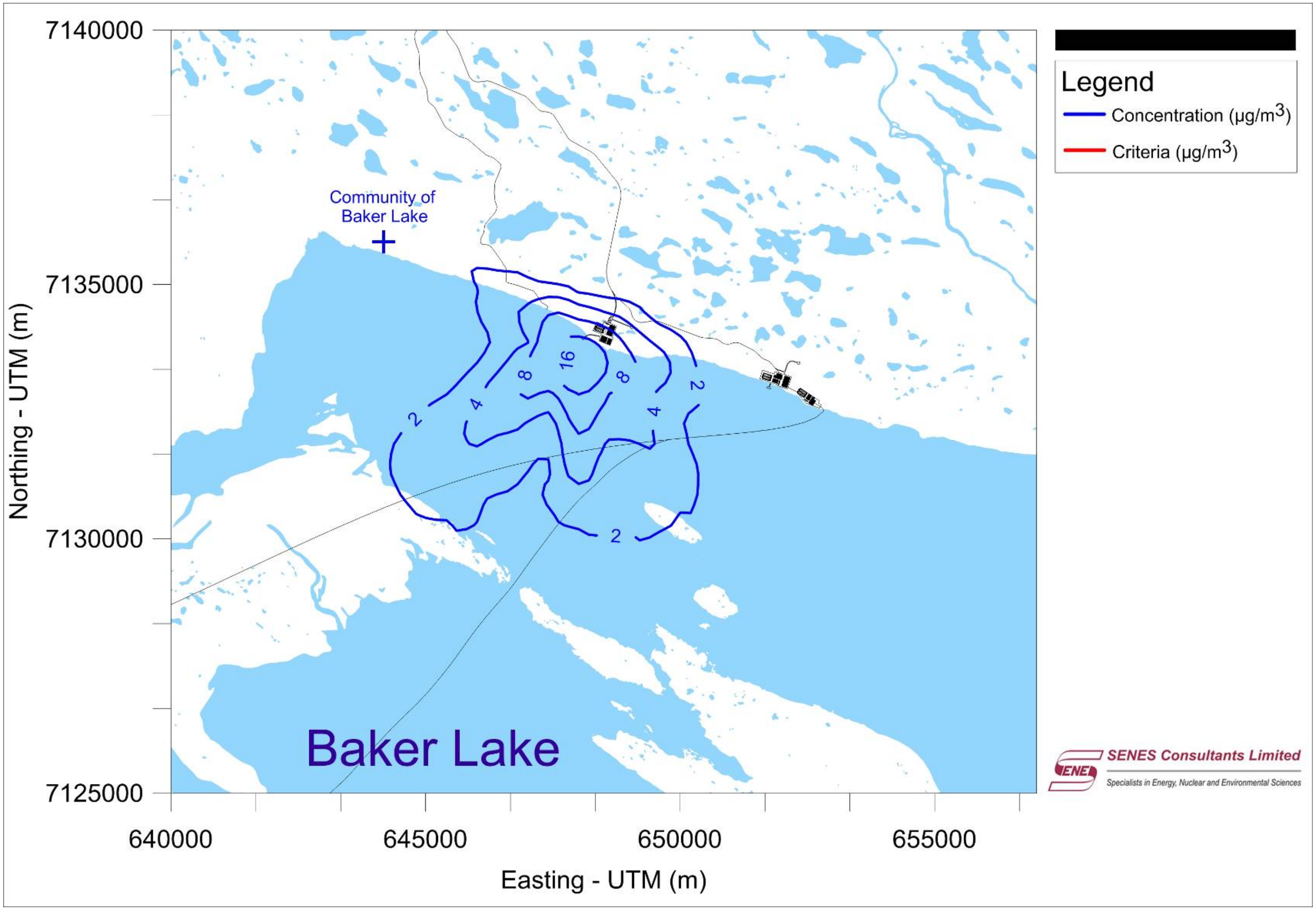


Figure D-120 Baker Lake Dock and Storage Facility - Incremental 24-hr $PM_{2.5}$ Concentration ($\mu g/m^3$)

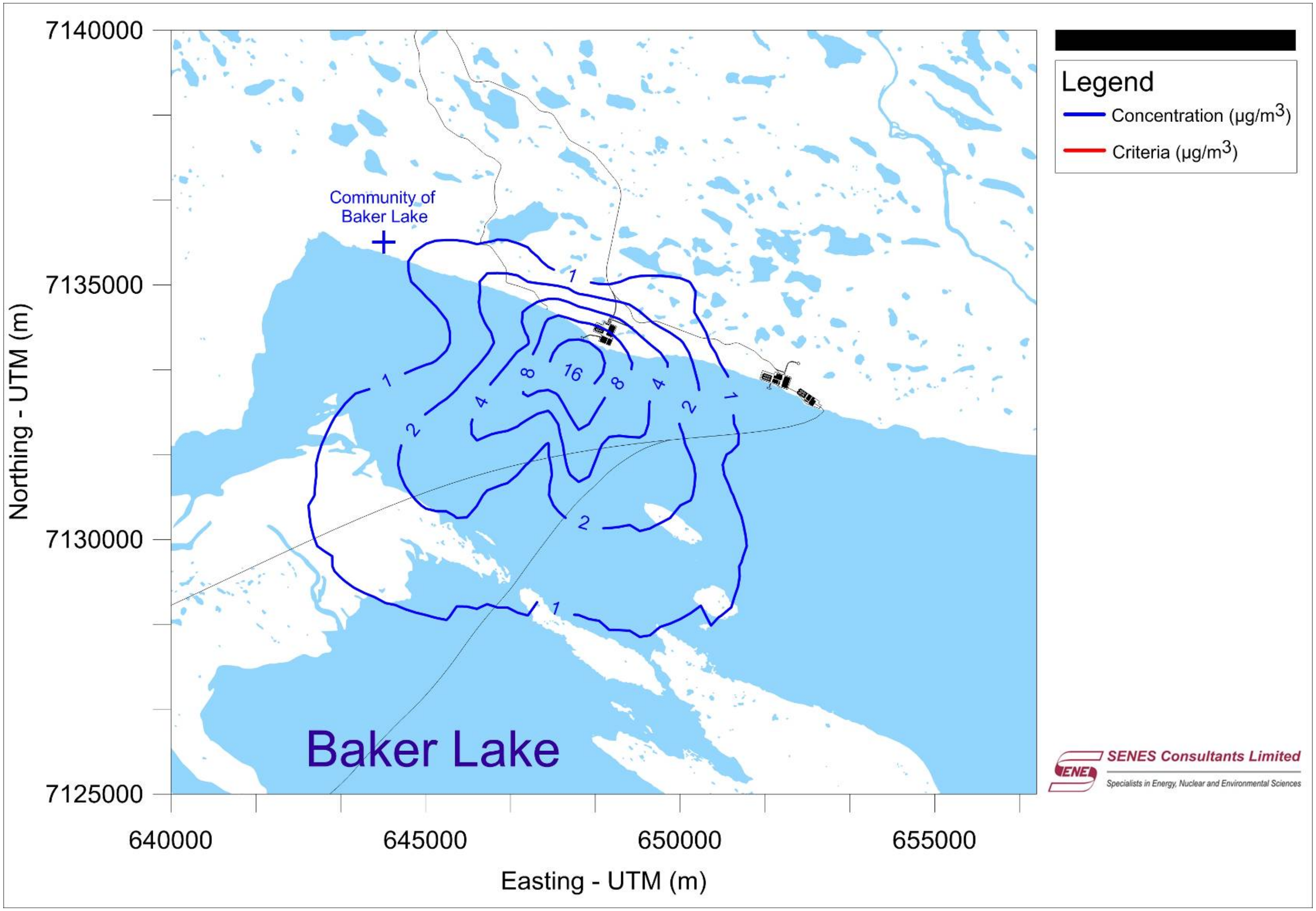


Figure D-121 Baker Lake Dock and Storage Facility - Incremental 1-hr NO_2 Concentration ($\mu g/m^3$)

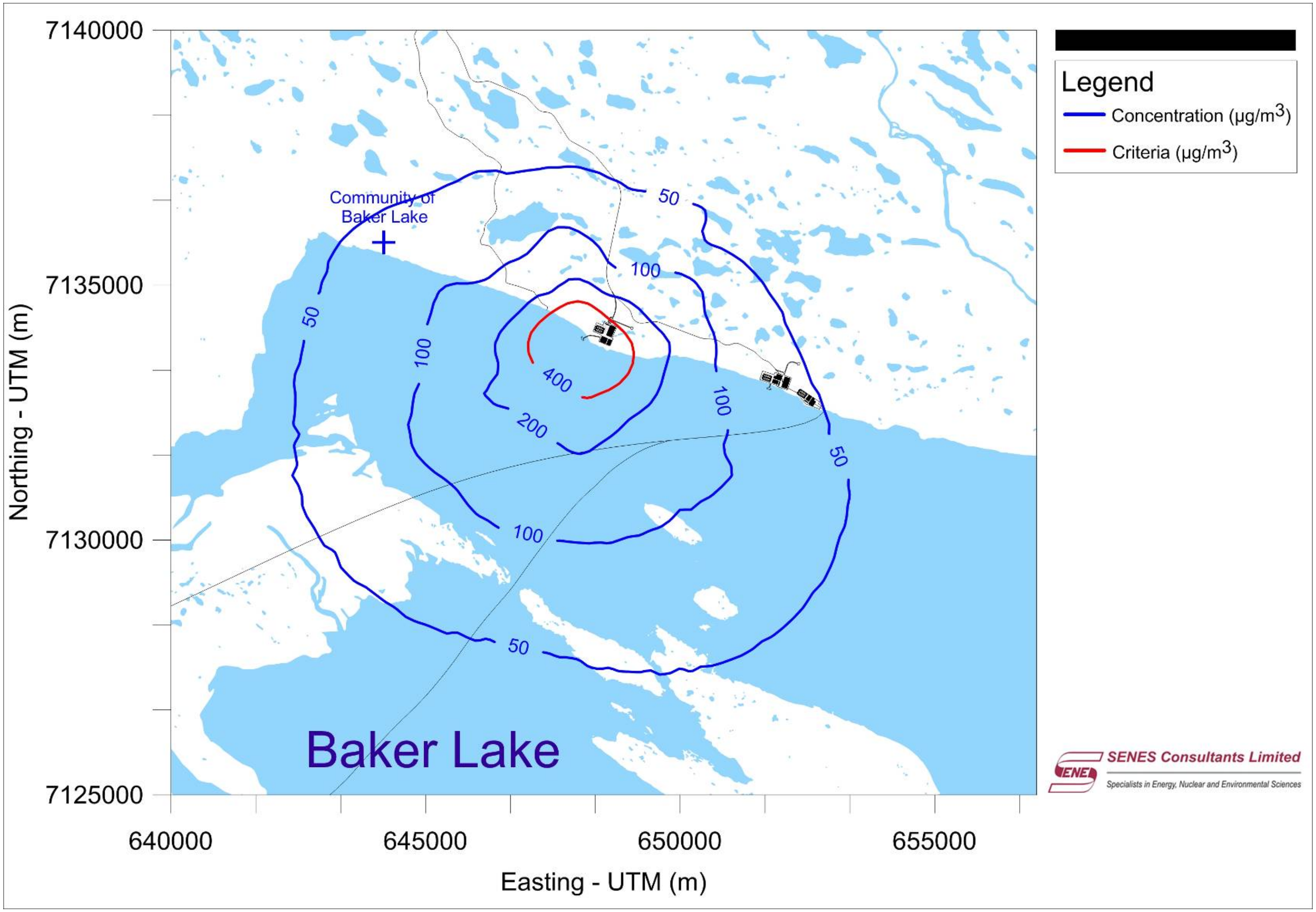


Figure D-122 Baker Lake Dock and Storage Facility - Incremental 24-hr NO_2 Concentration (µg/m³)

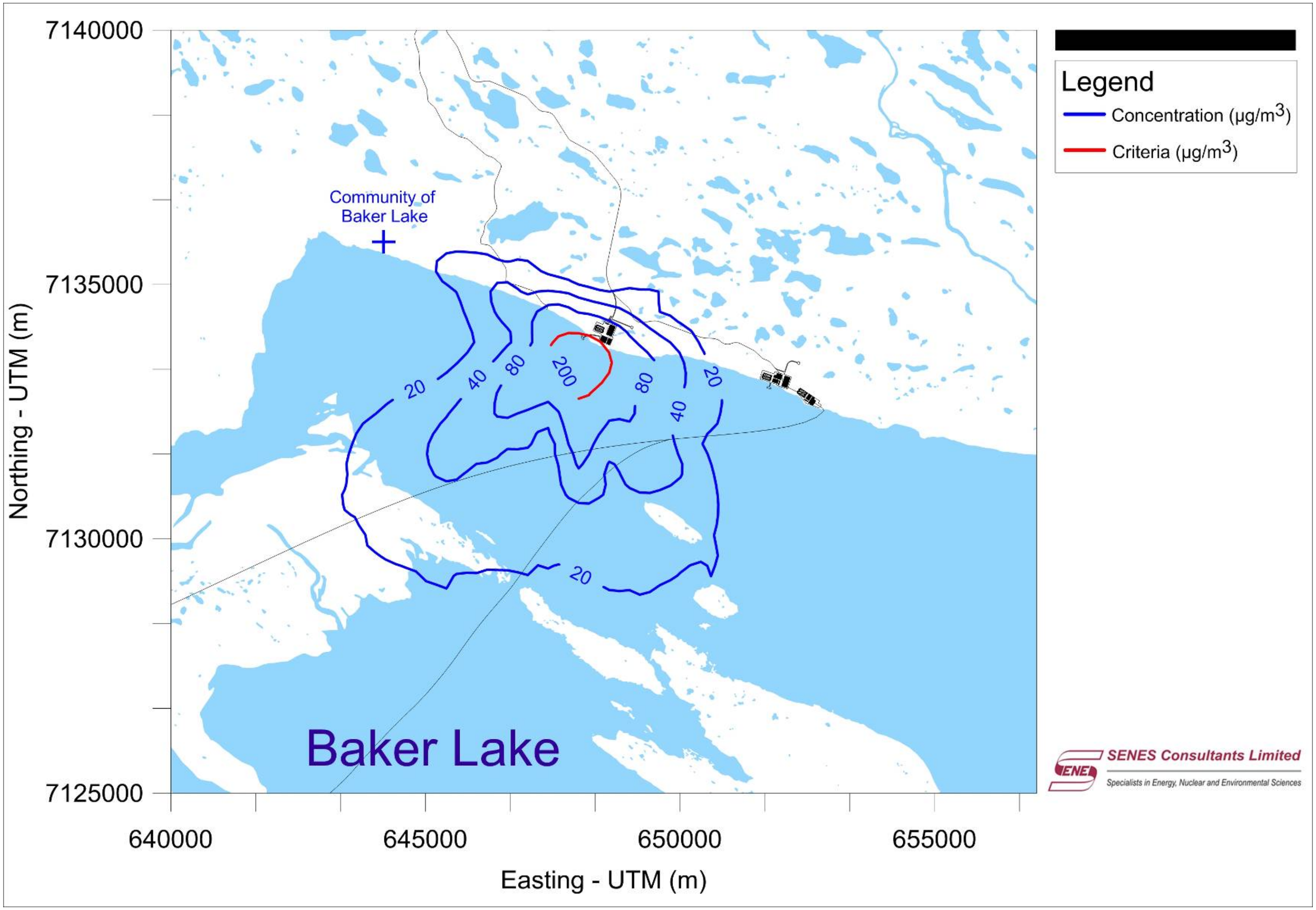


Figure D-123 Baker Lake Dock and Storage Facility - 1-hr NO_2 Exceedances (hours)

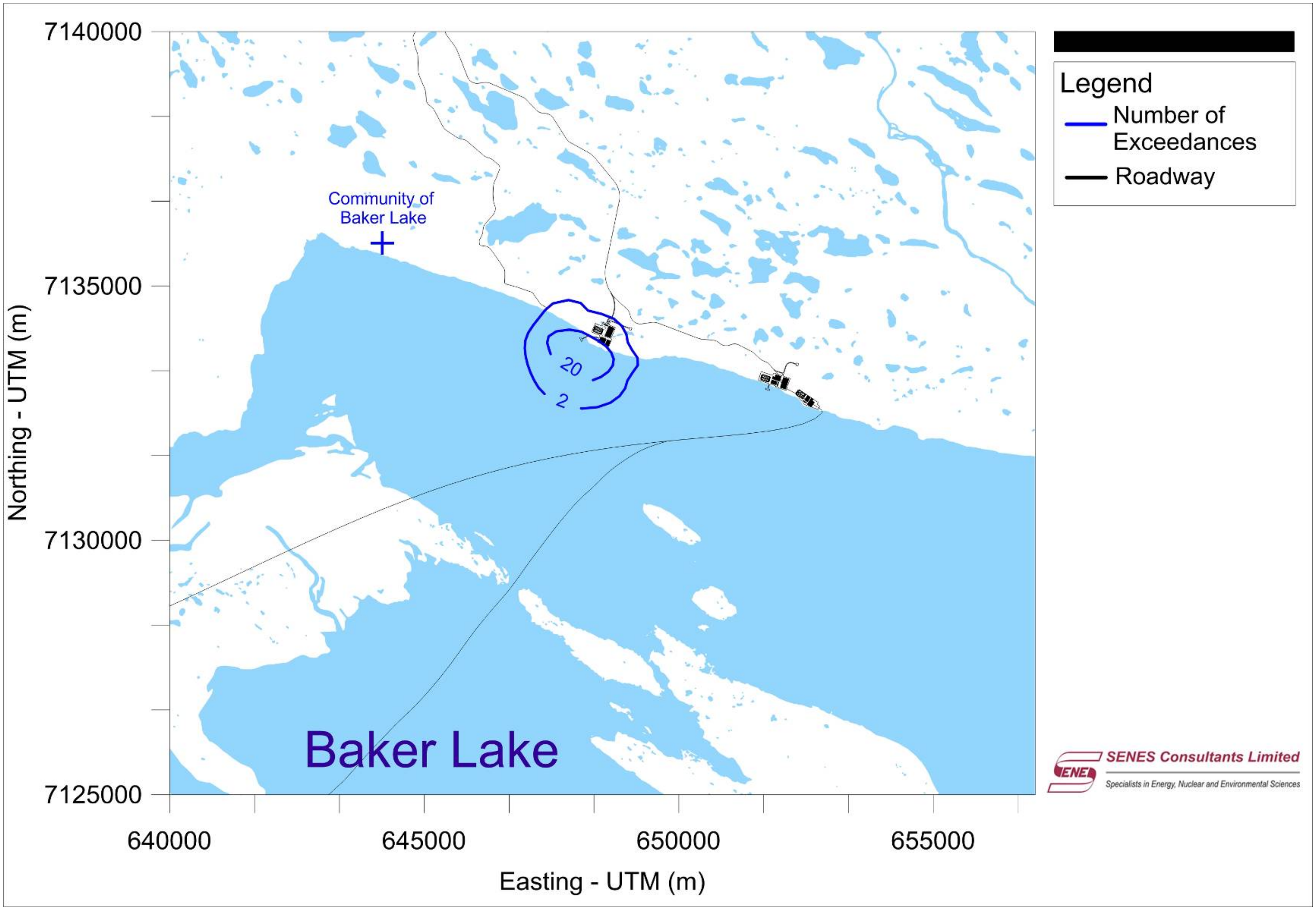


Figure D-124 Baker Lake Dock and Storage Facility - 1-hr NO_2 Exceedances (days)

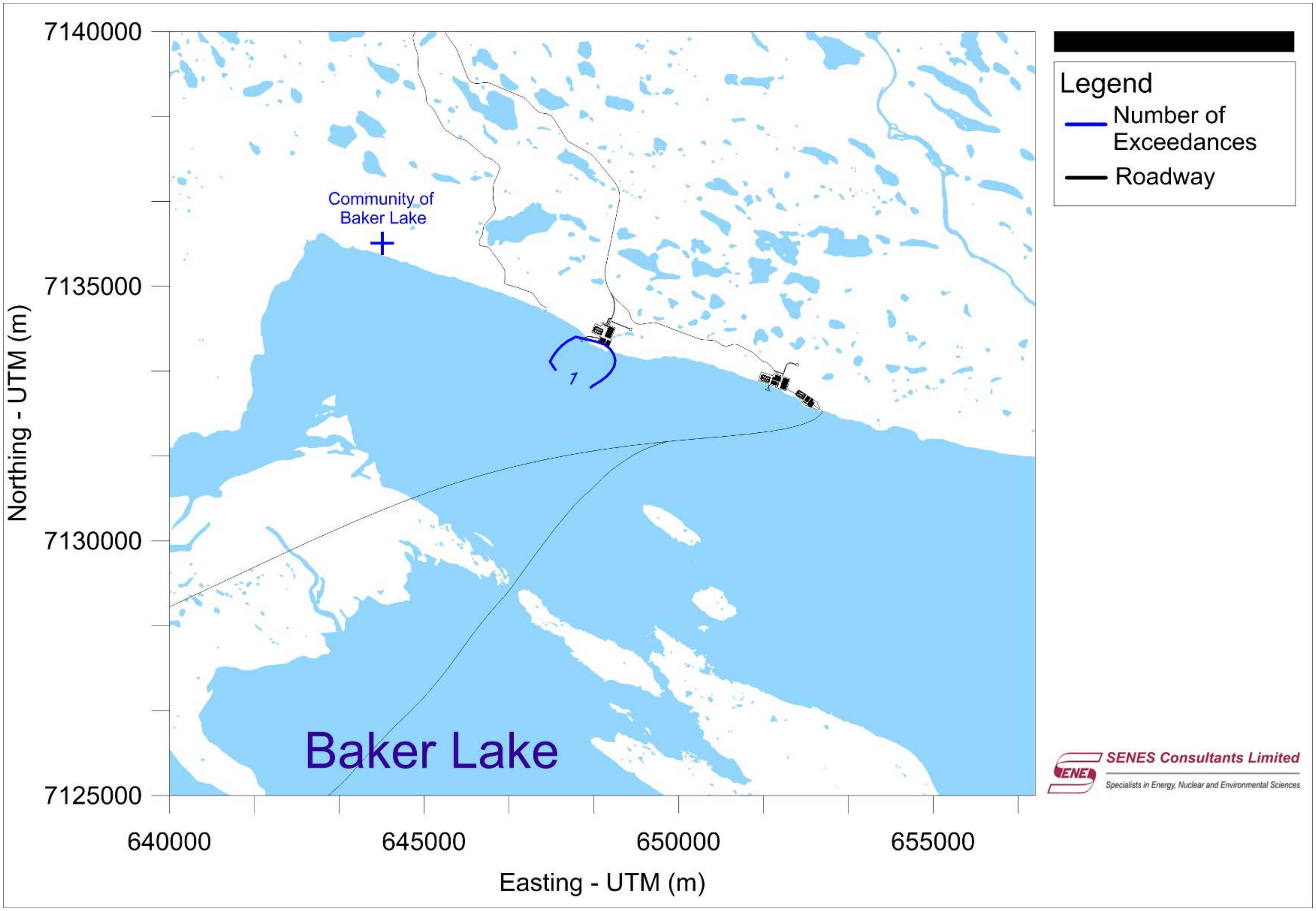


Figure D-125 Baker Lake Dock and Storage Facility - Incremental 1-hr SO_2 Concentration (µg/m³)

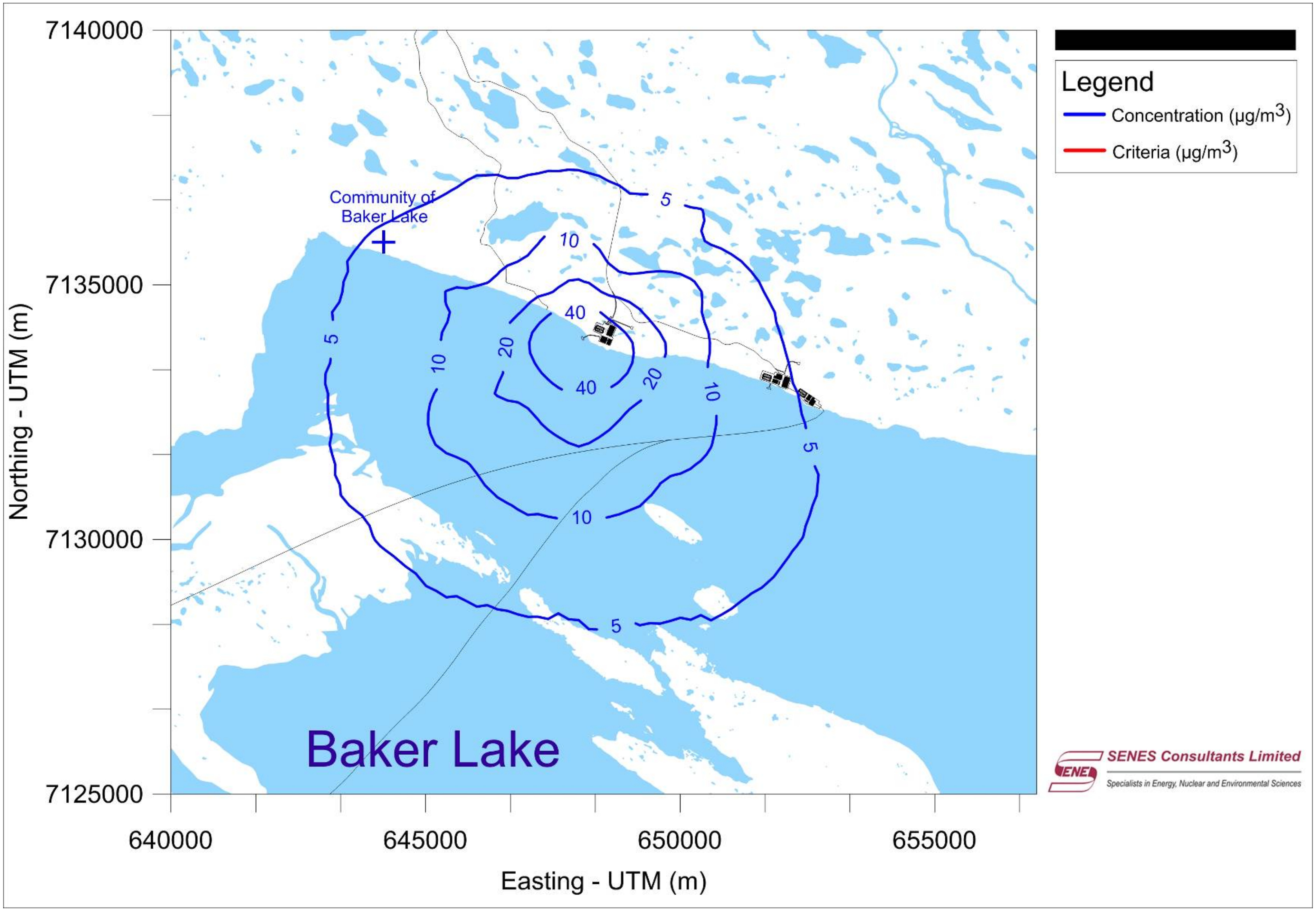


Figure D-126 Baker Lake Dock and Storage Facility - Incremental 24-hr SO_2 Concentration (µg/m³)

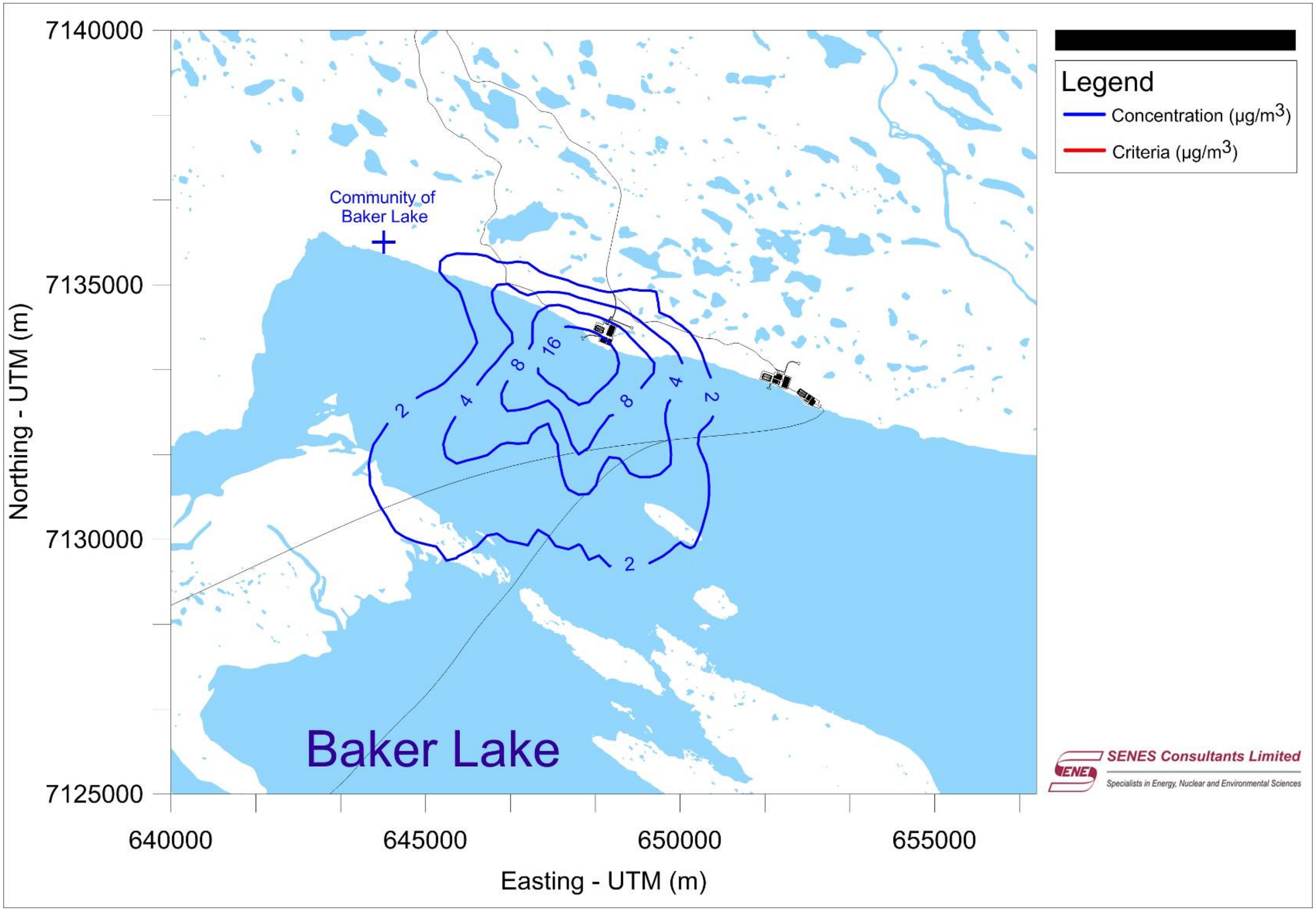


Figure D-127 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 24-hr TSP Concentration (µg/m³)

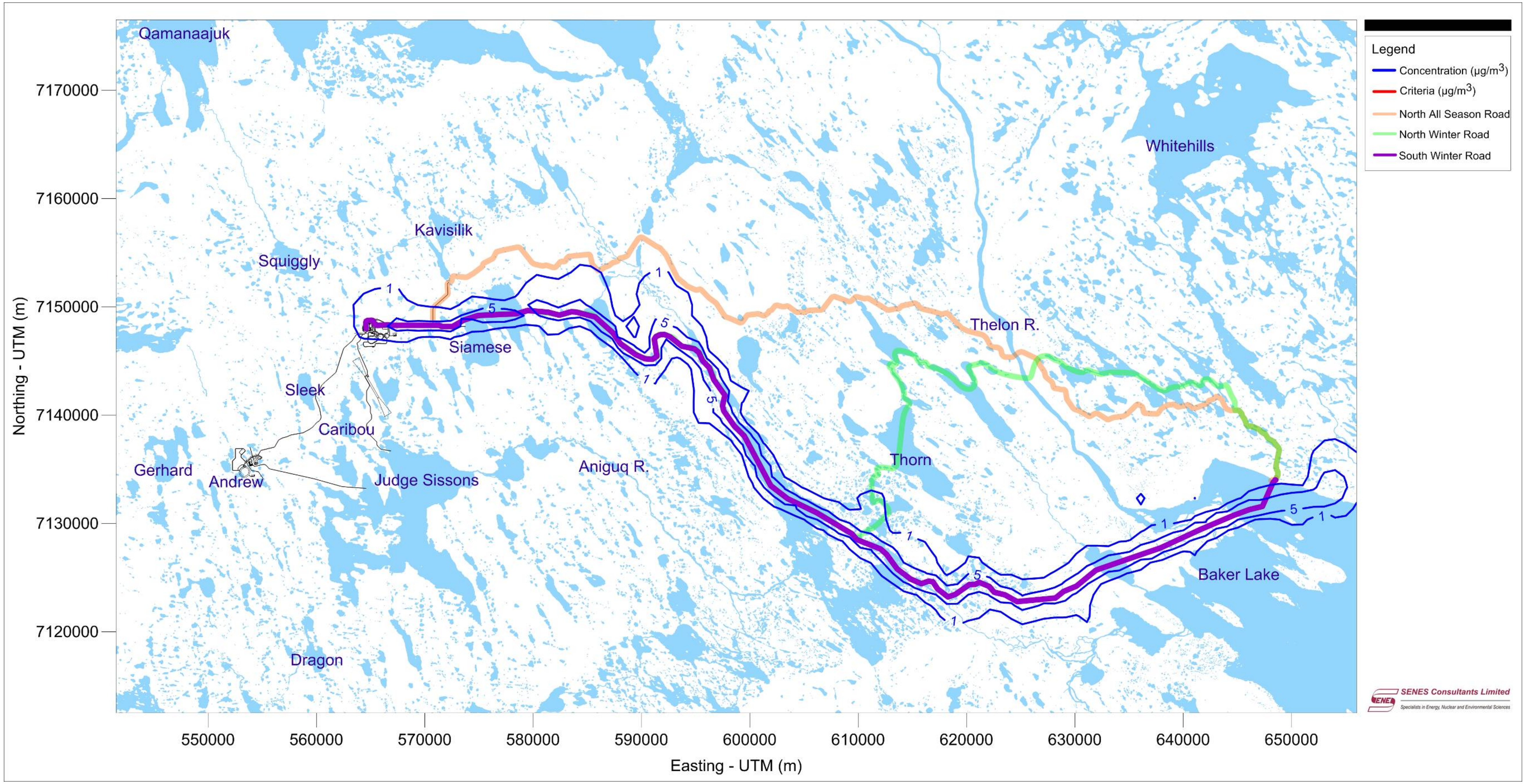


Figure D-128 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 24-hr TSP Concentration (µg/m³)

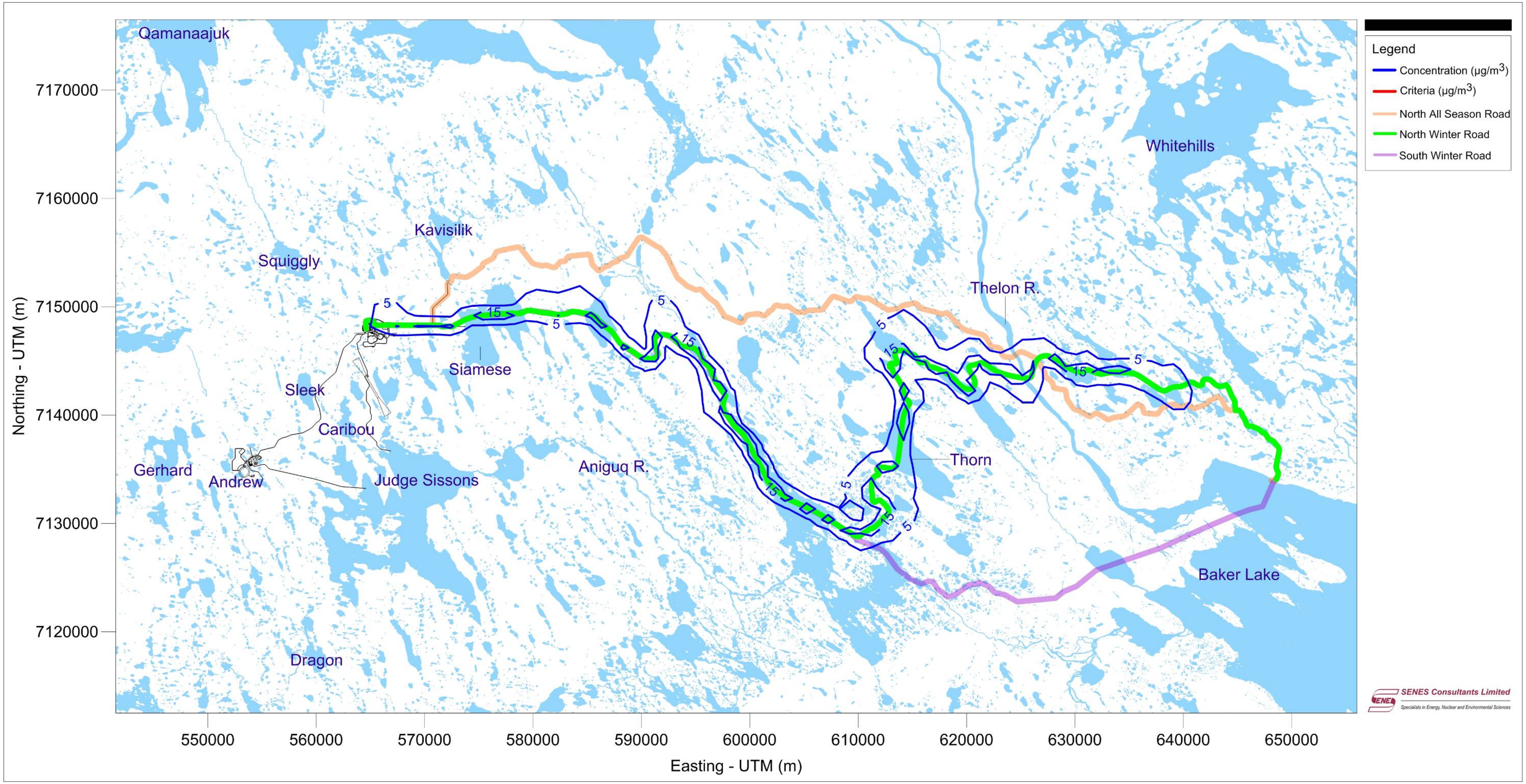


Figure D-129 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 24-hr TSP Concentration (µg/m³)

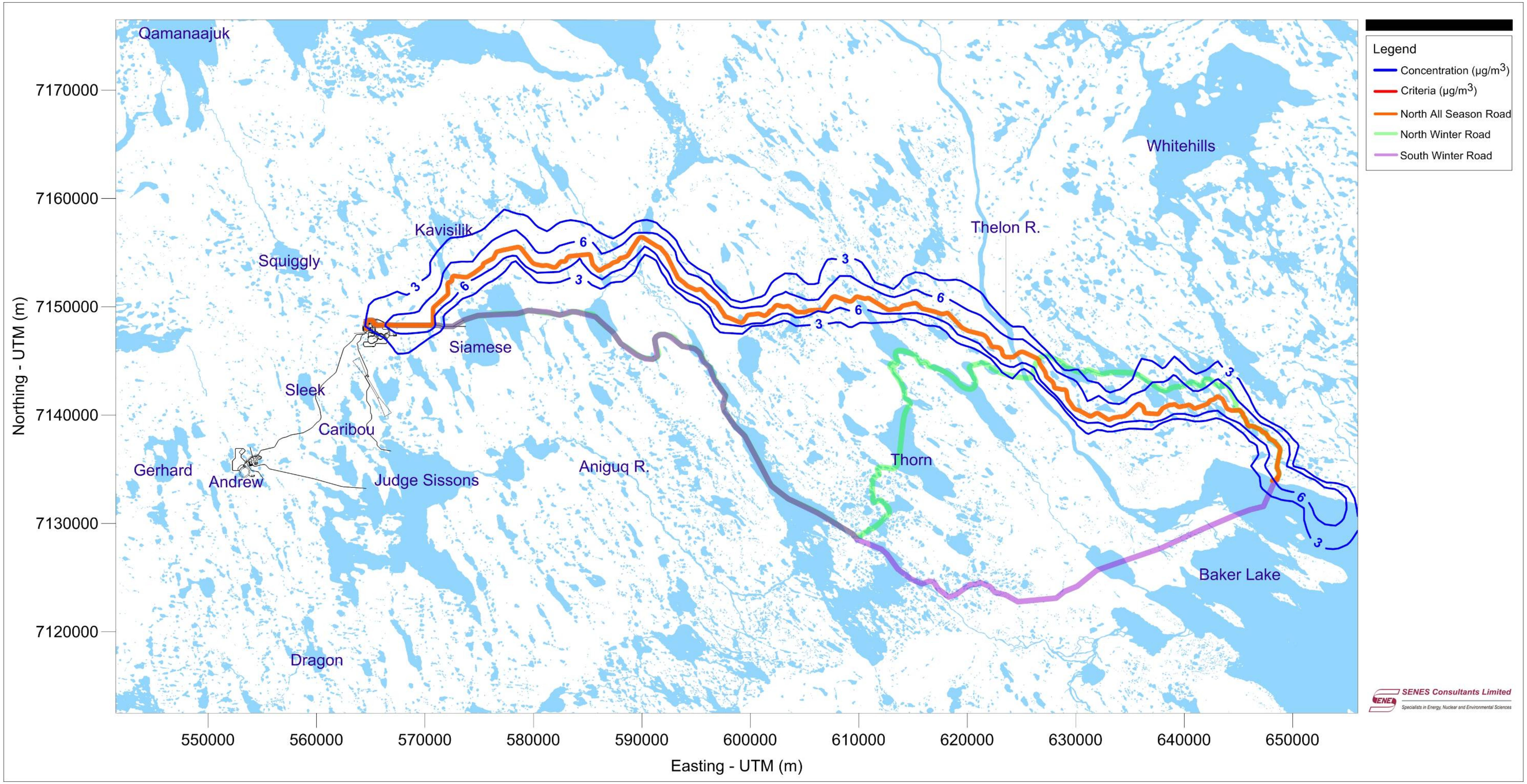


Figure D-130 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental Annual TSP Concentration (µg/m³)

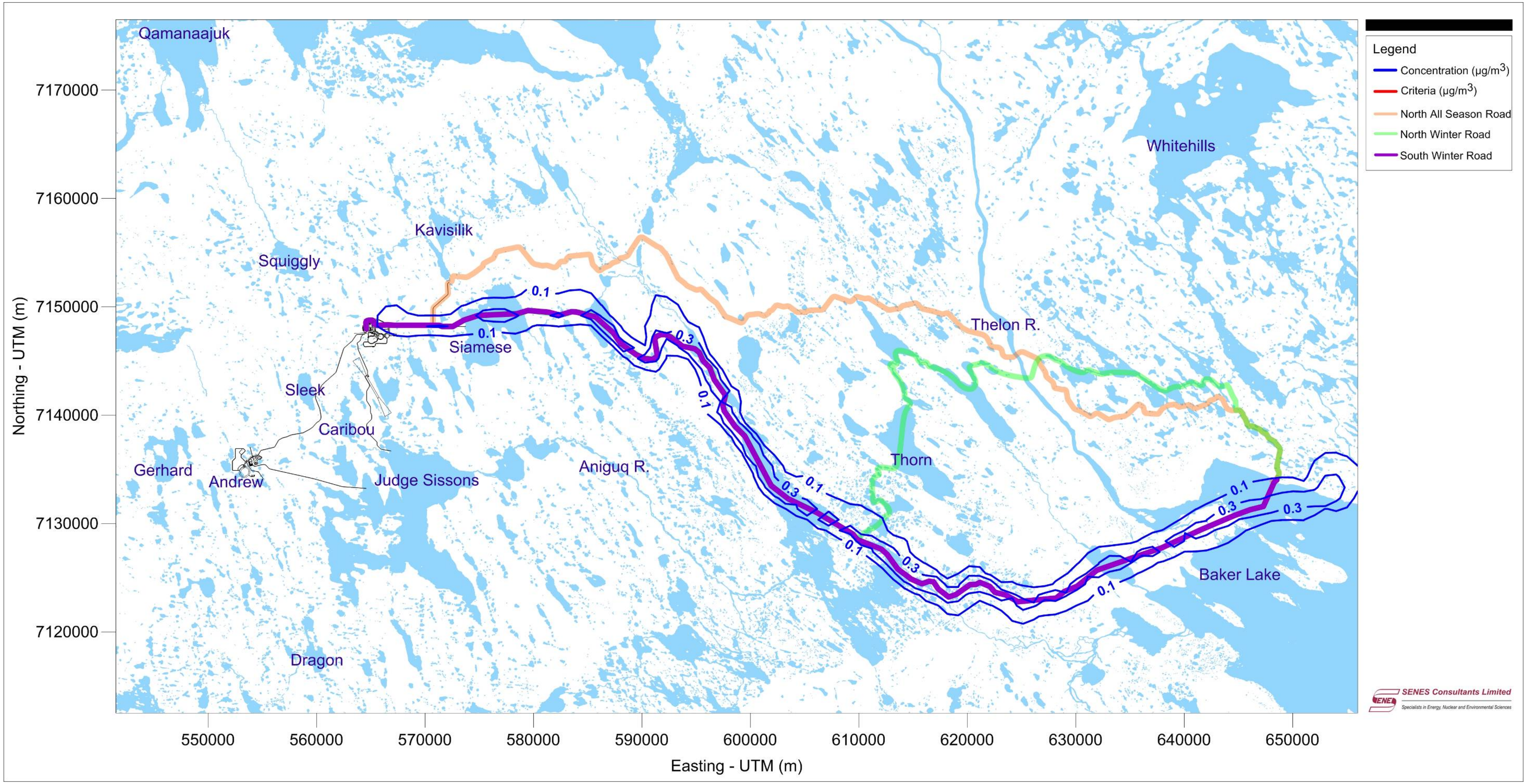


Figure D-131 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental Annual TSP Concentration (µg/m³)

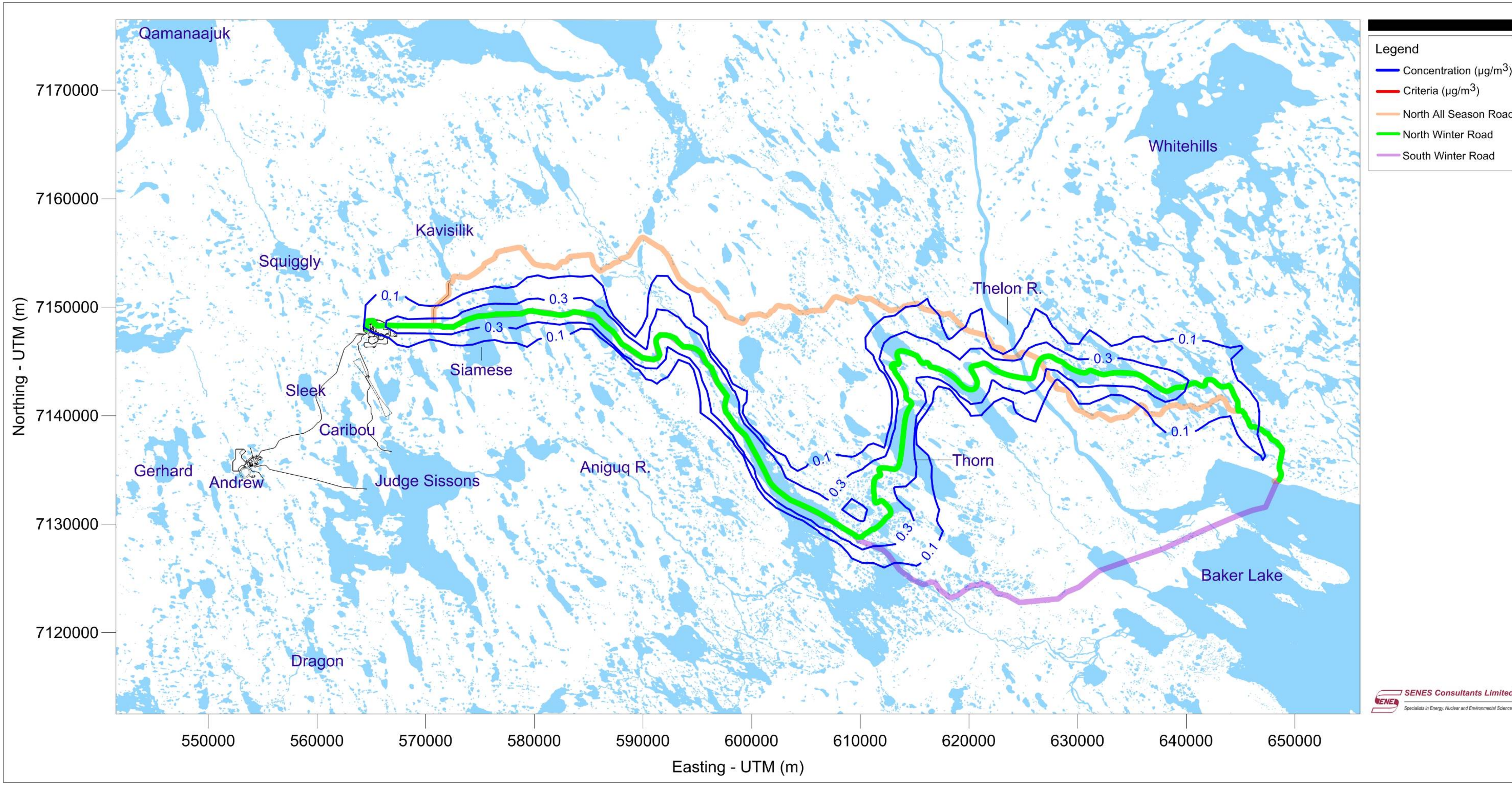


Figure D-132 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental Annual TSP Concentration (µg/m³)

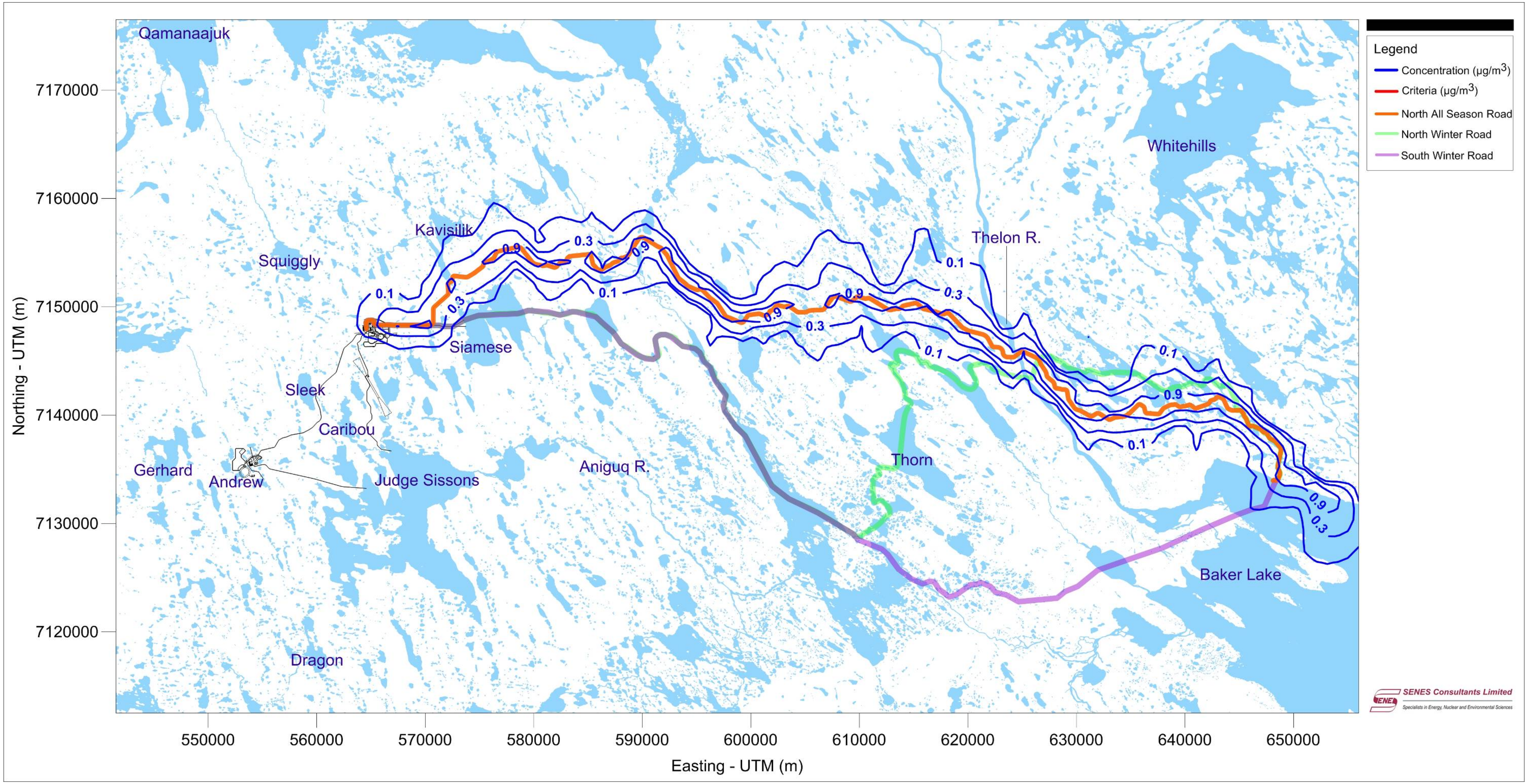


Figure D-133 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 24-hr PM_{10} Concentration (µg/m³)

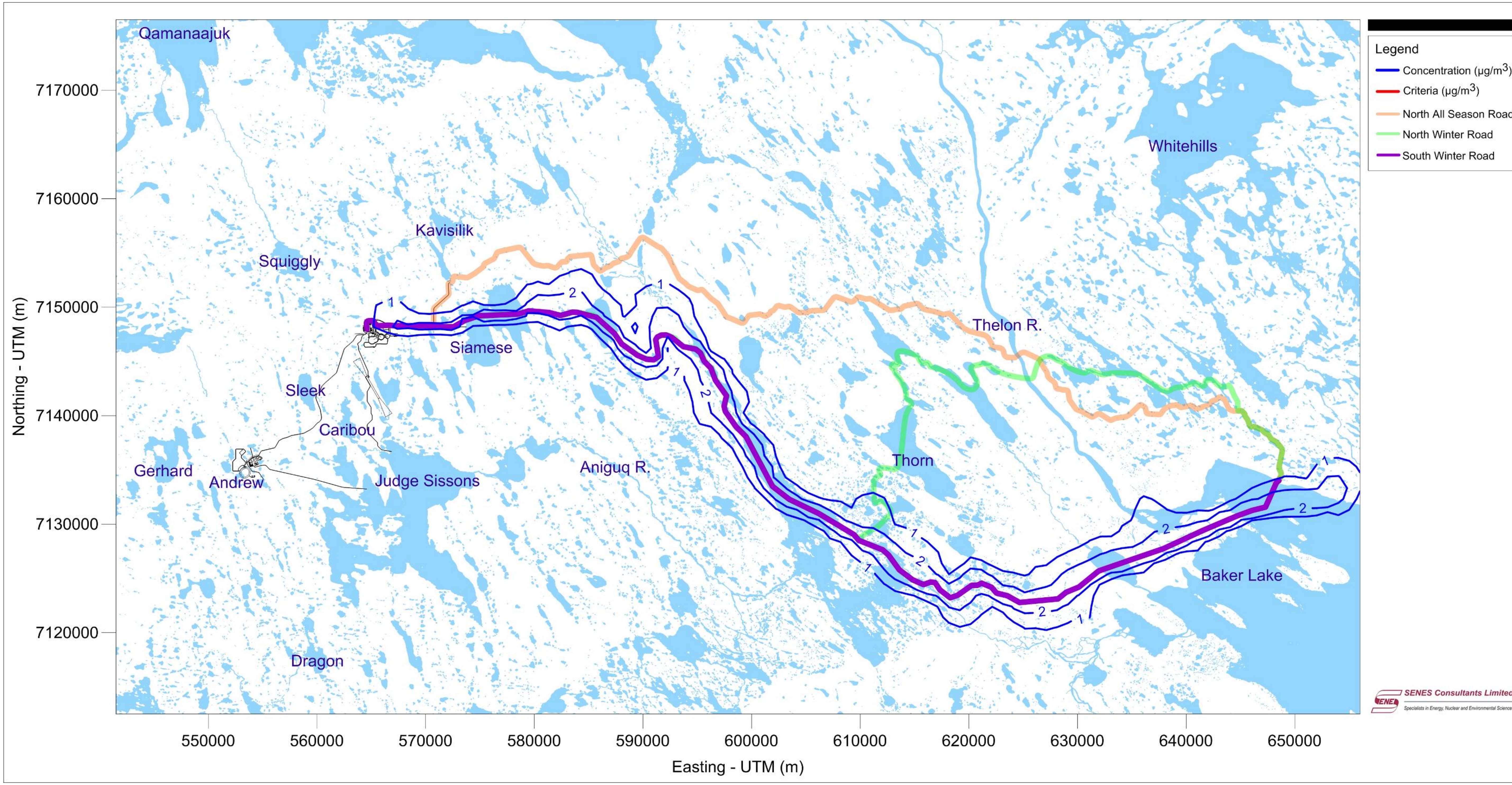


Figure D-134 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 24-hr PM_{10} Concentration (µg/m³)

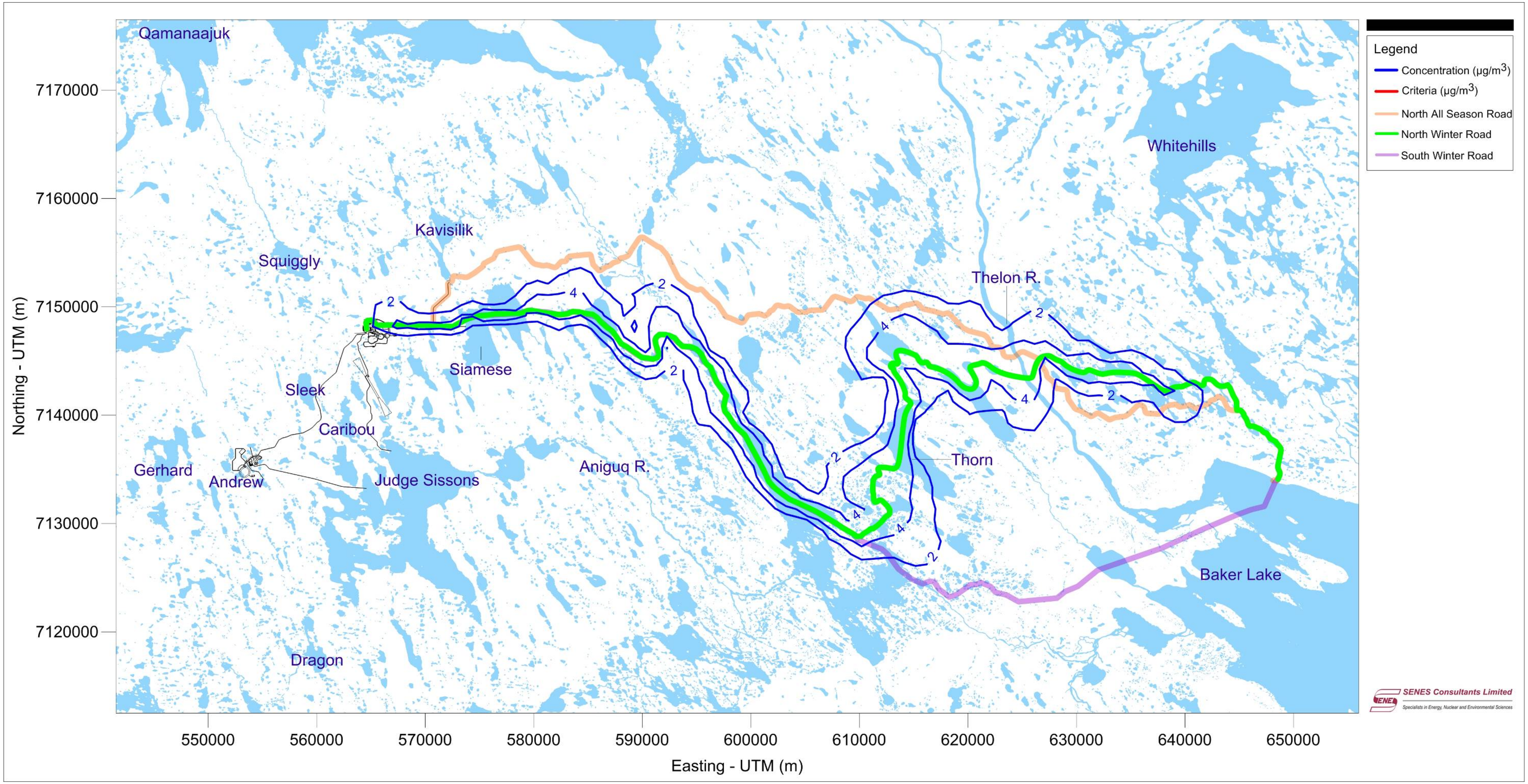


Figure D-135 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 24-hr PM_{10} Concentration (µg/m³)

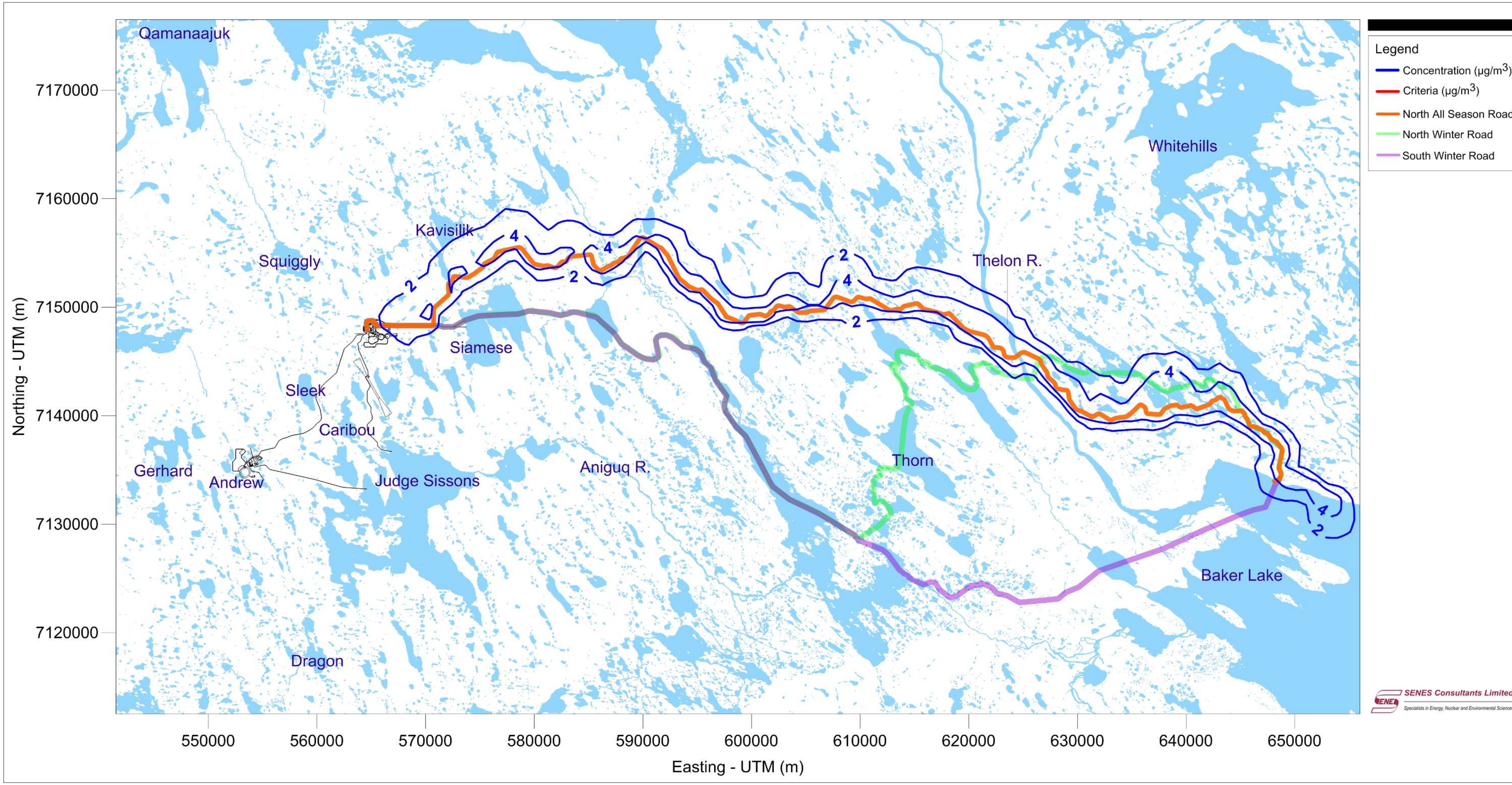


Figure D-136 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental Annual PM_{10} Concentration (µg/m³)

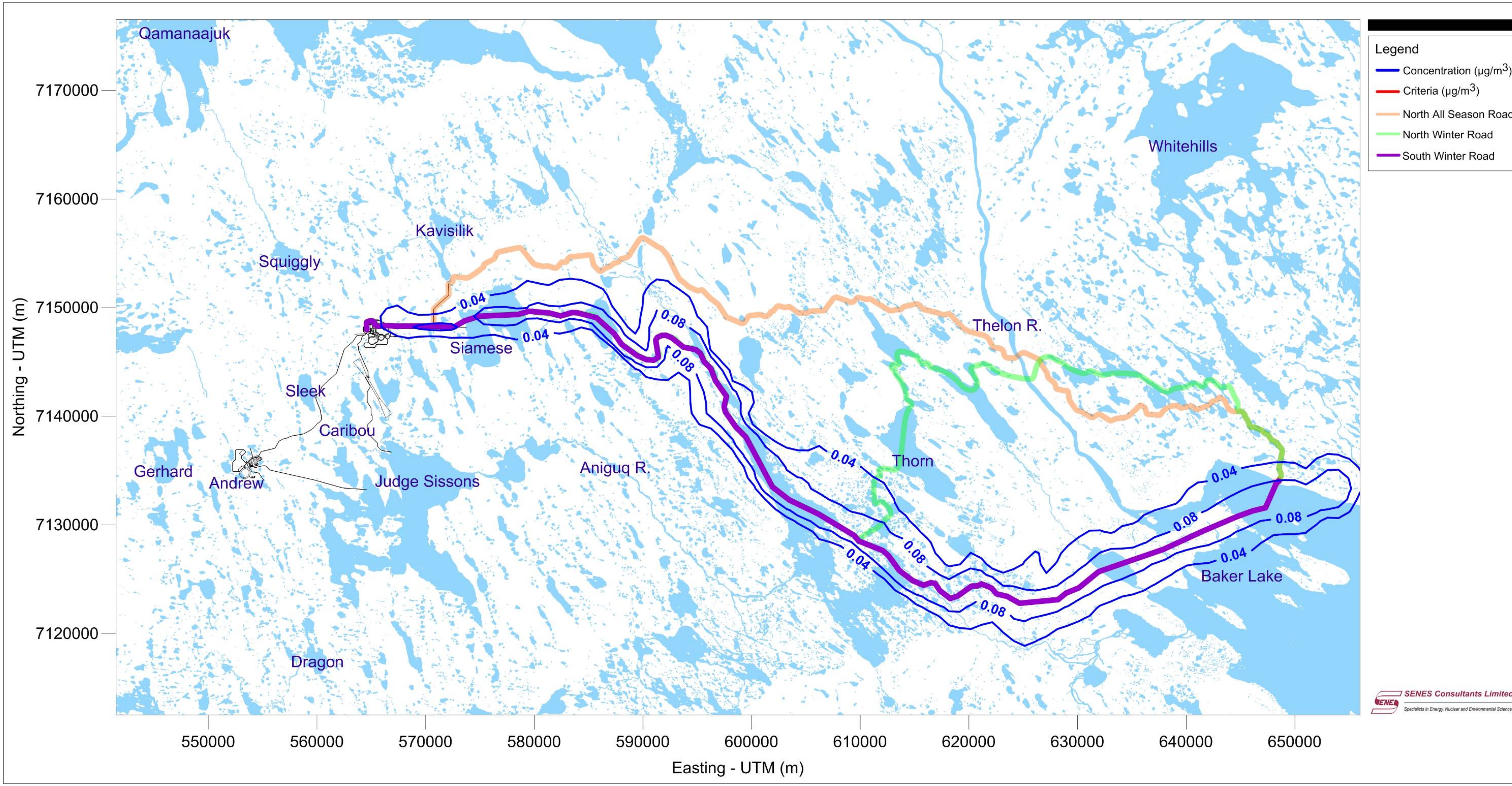


Figure D-137 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental Annual PM_{10} Concentration (µg/m³)

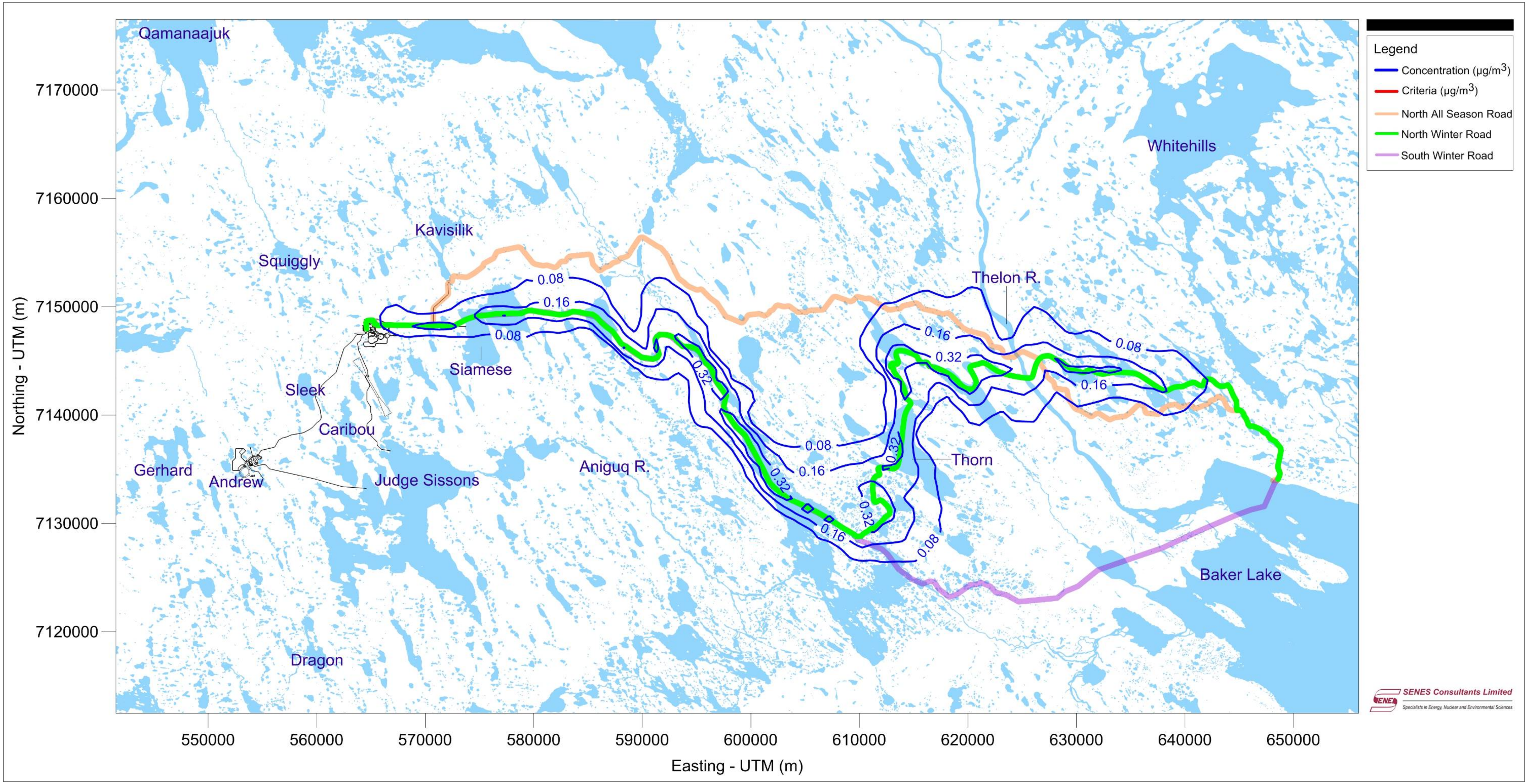


Figure D-138 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental Annual PM_{10} Concentration (µg/m³)

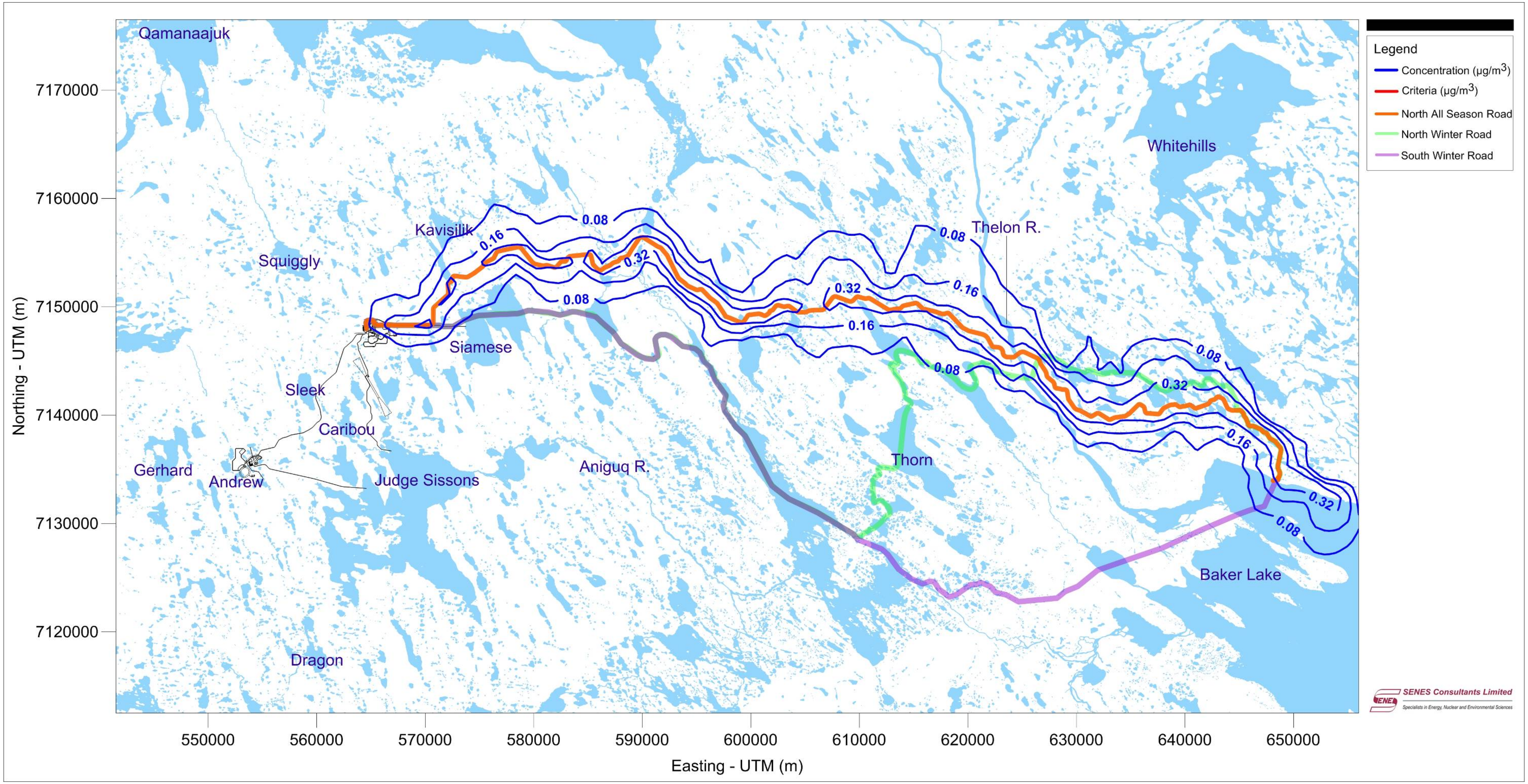


Figure D-139 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 24-hr $PM_{2.5}$ Concentration (µg/m³)

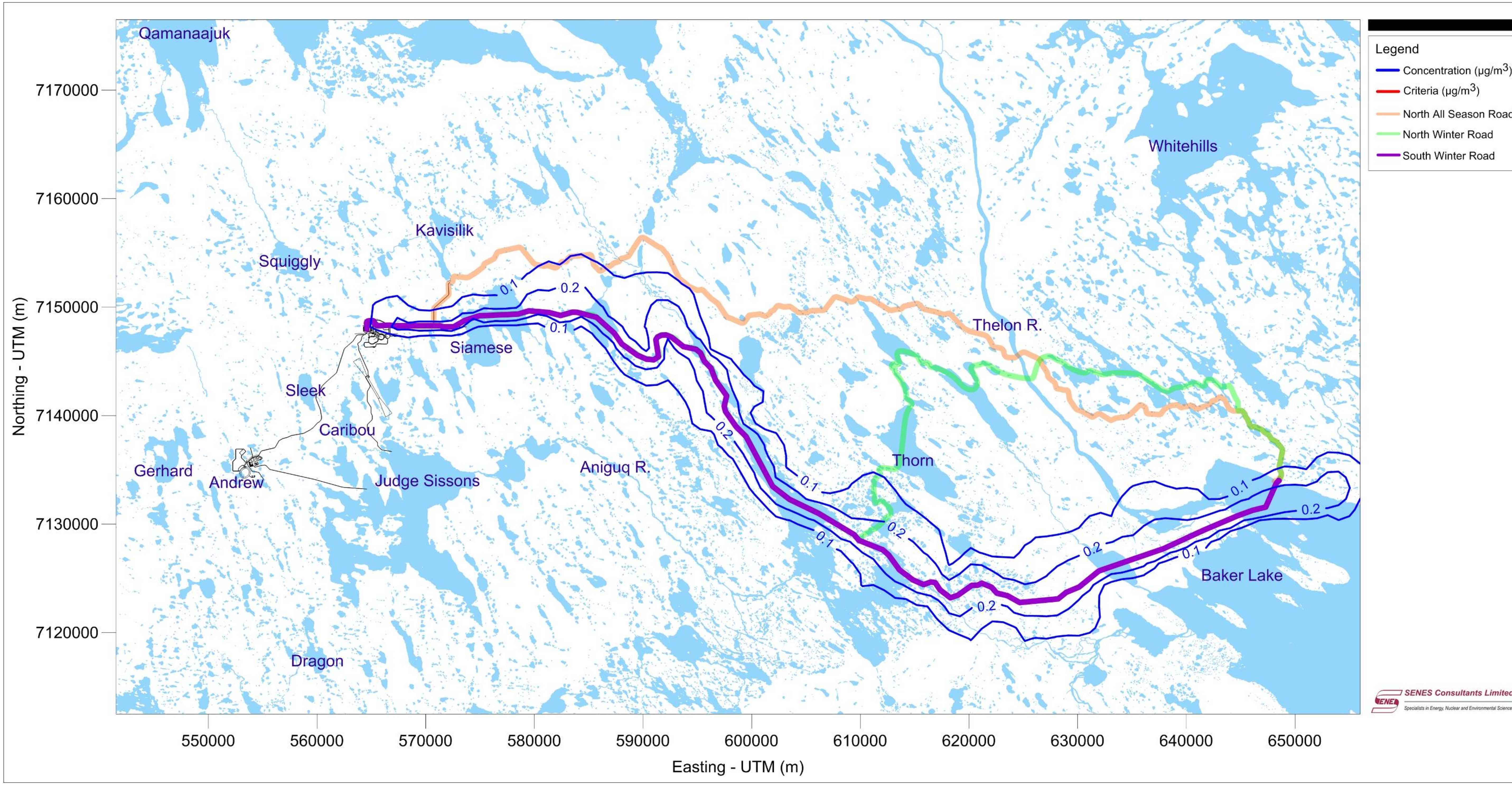


Figure D-140 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 24-hr $PM_{2.5}$ Concentration (µg/m³)

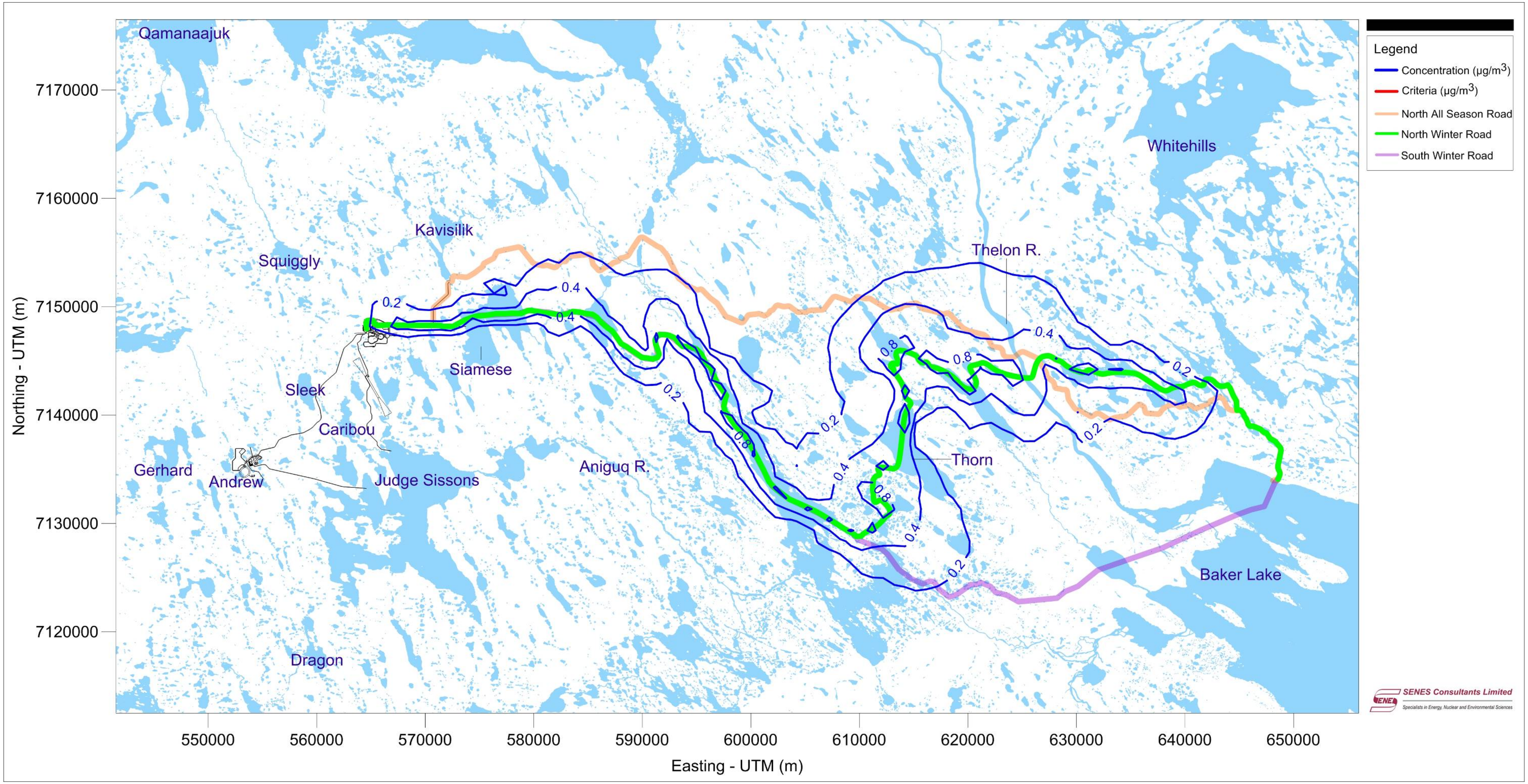


Figure D-141 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 24-hr $PM_{2.5}$ Concentration (µg/m³)

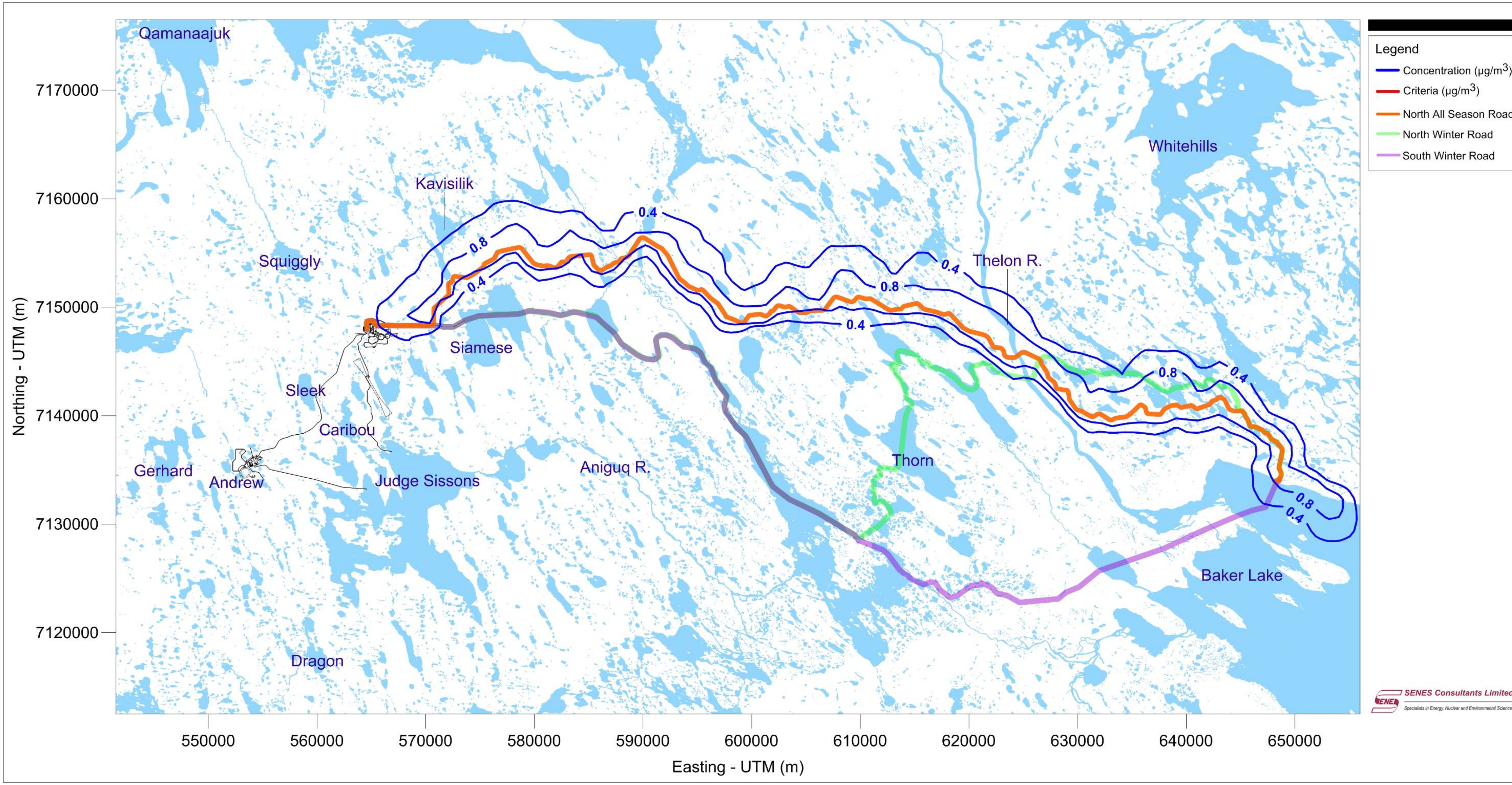


Figure D-142 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

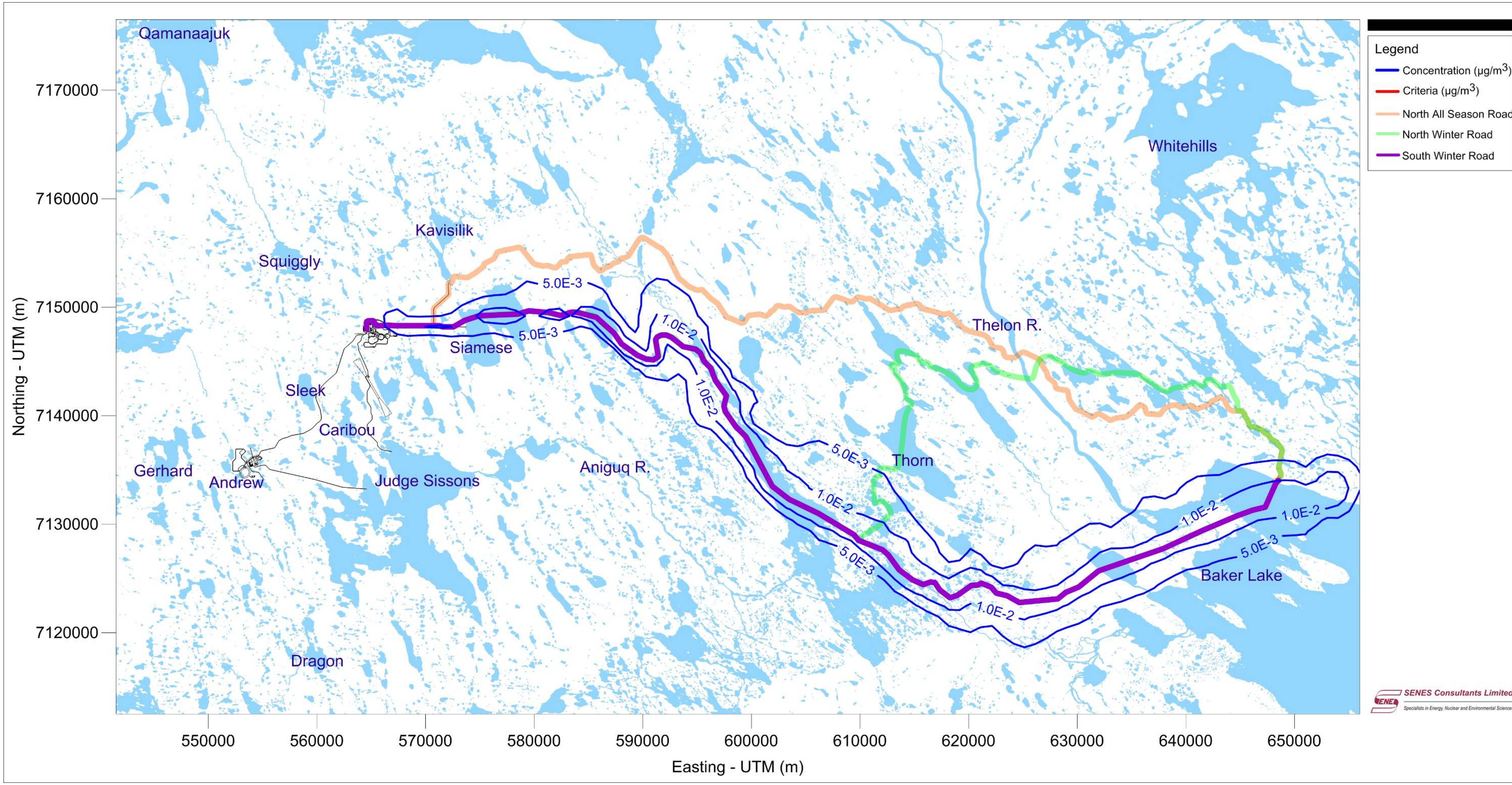


Figure D-143 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

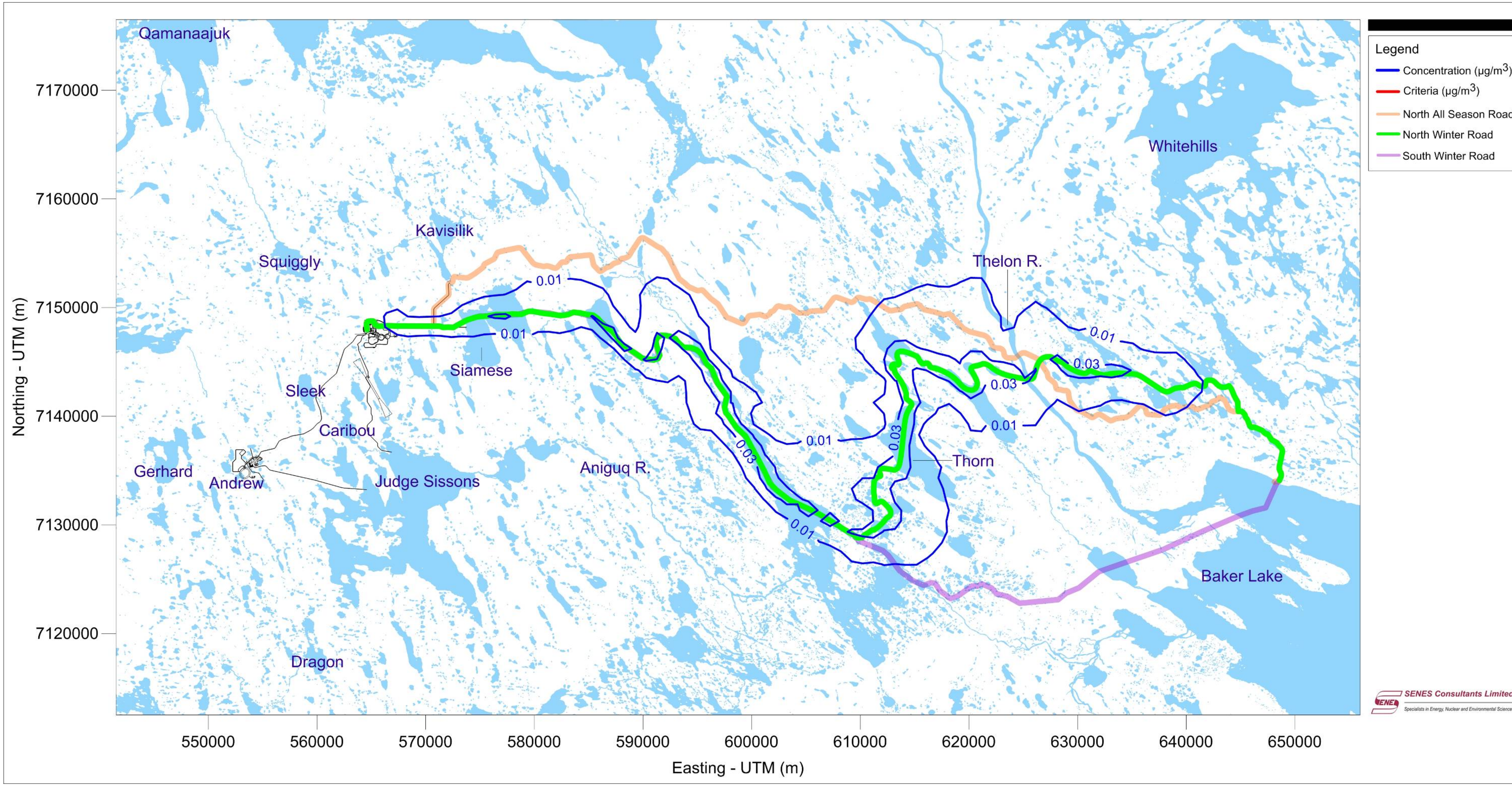


Figure D-144 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental Annual $PM_{2.5}$ Concentration (µg/m³)

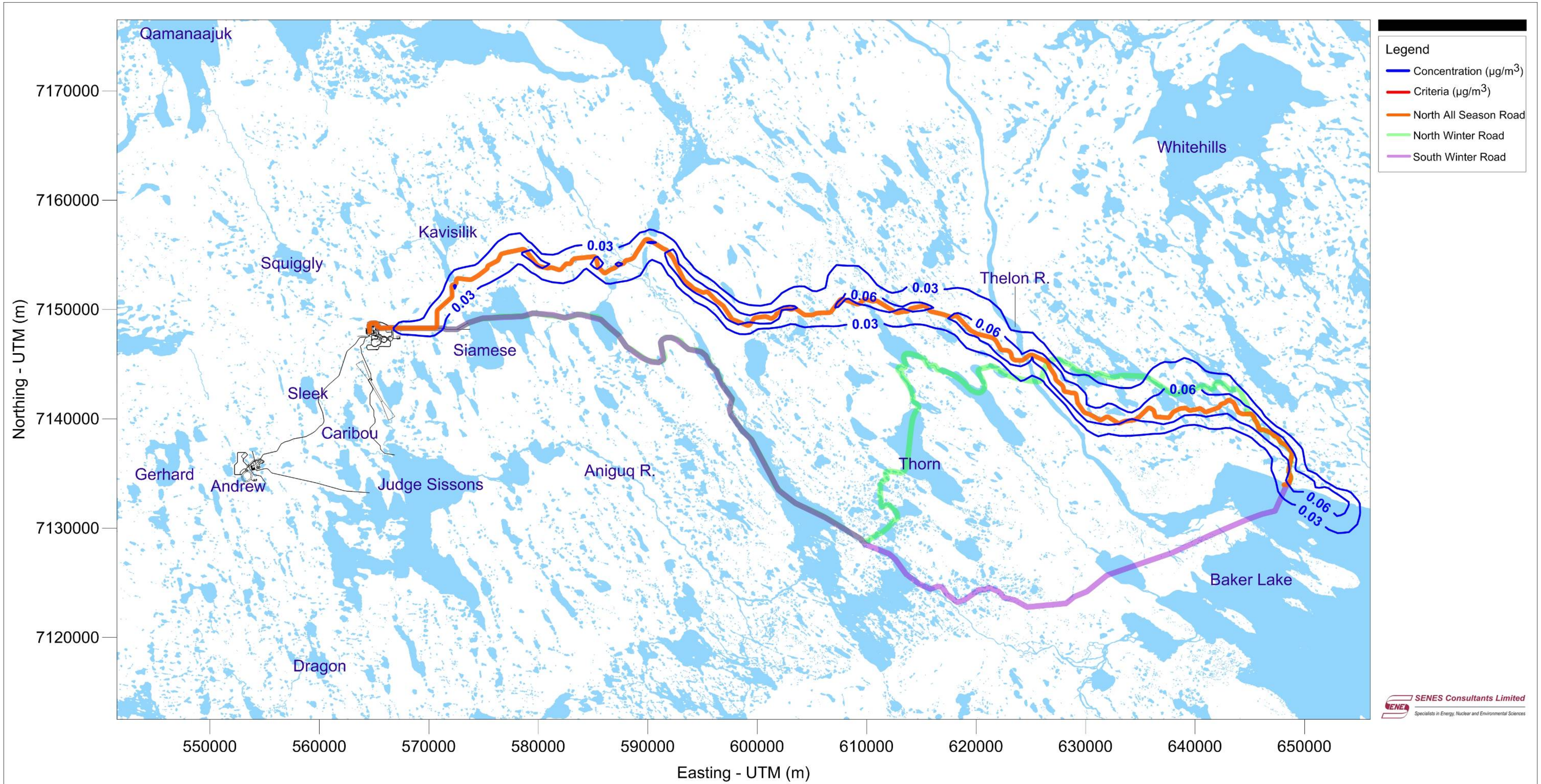


Figure D-145 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 1-hr NO_2 Concentration (µg/m³)

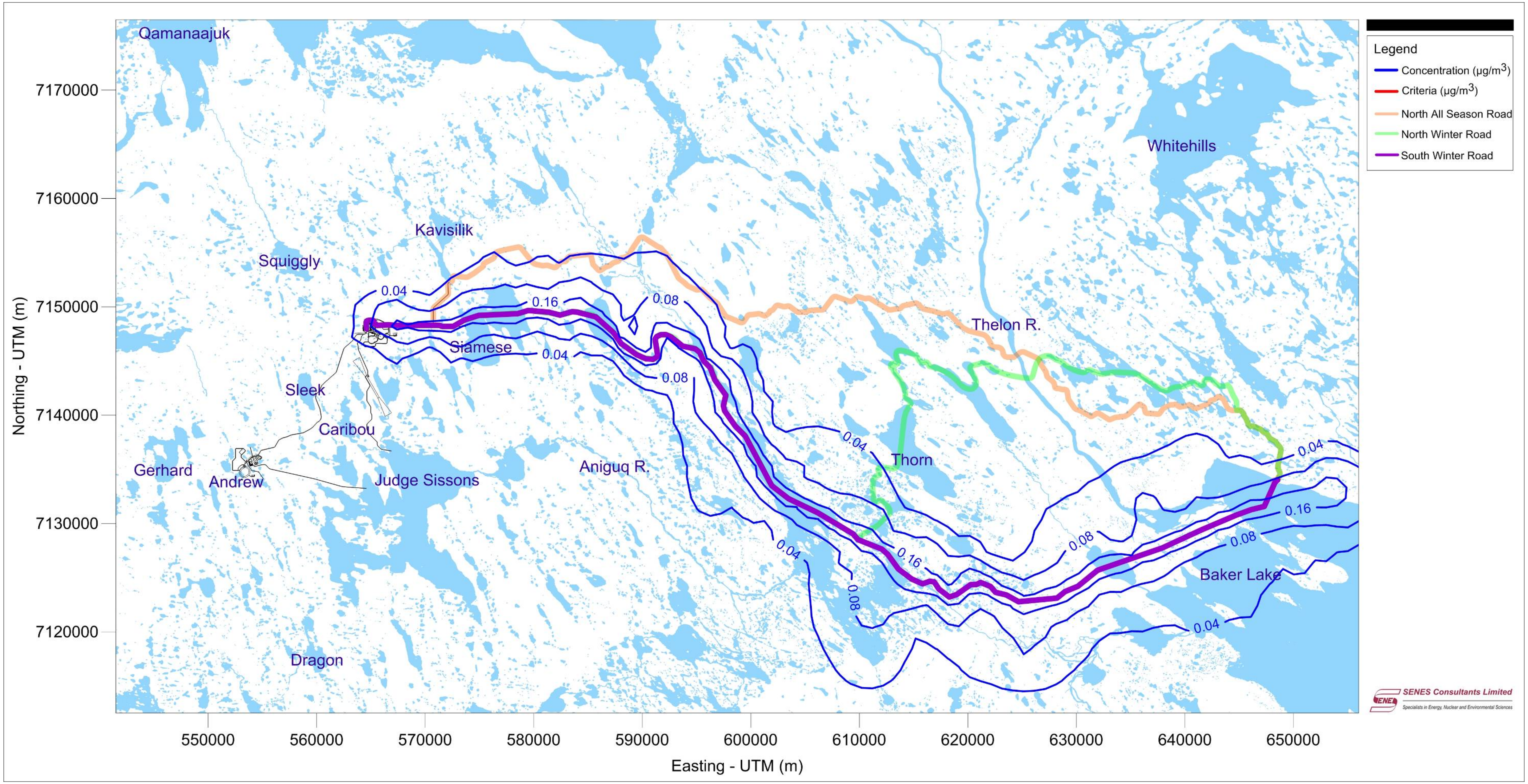


Figure D-146 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 1-hr NO_2 Concentration (µg/m³)

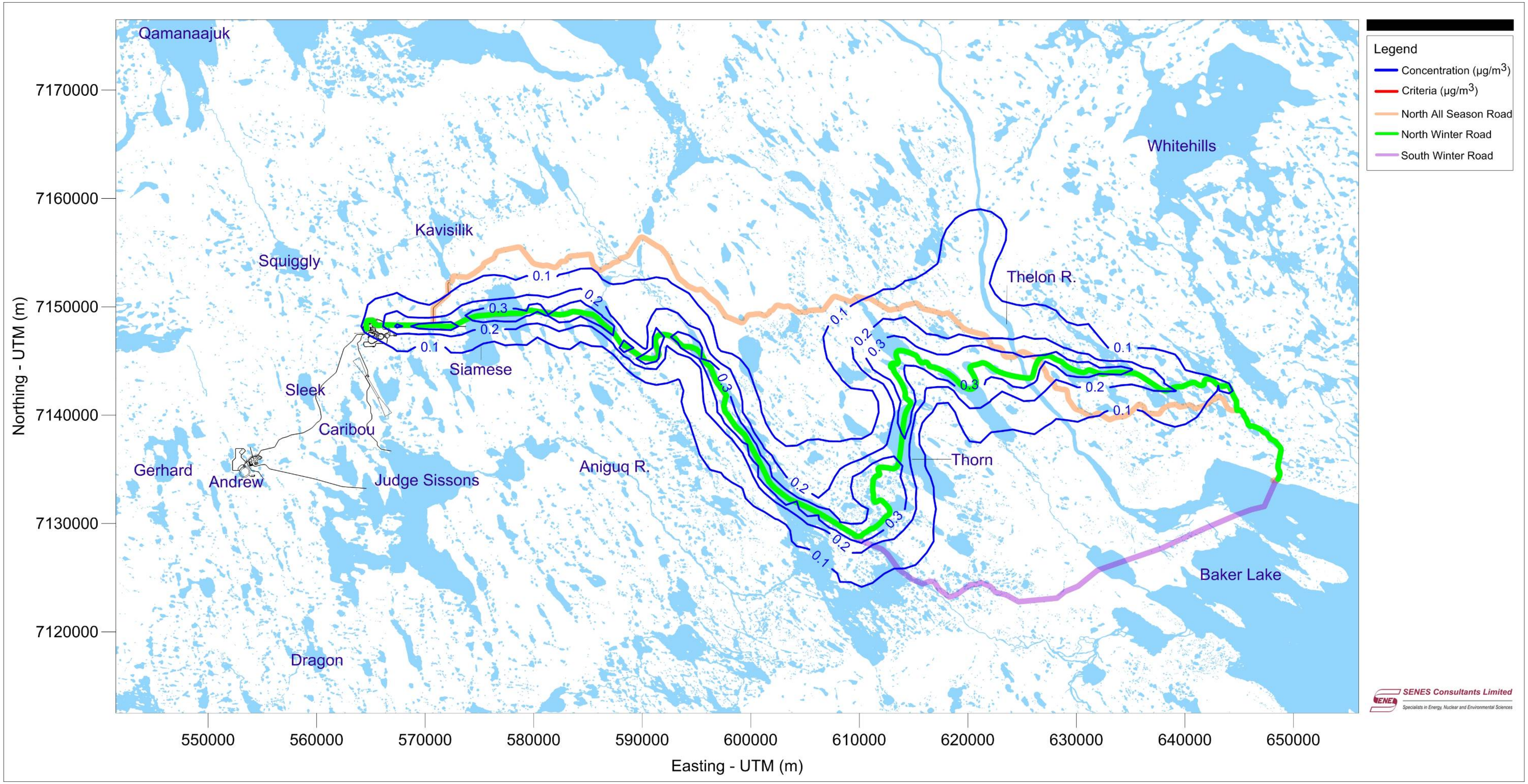


Figure D-147 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 1-hr NO_2 Concentration (µg/m³)

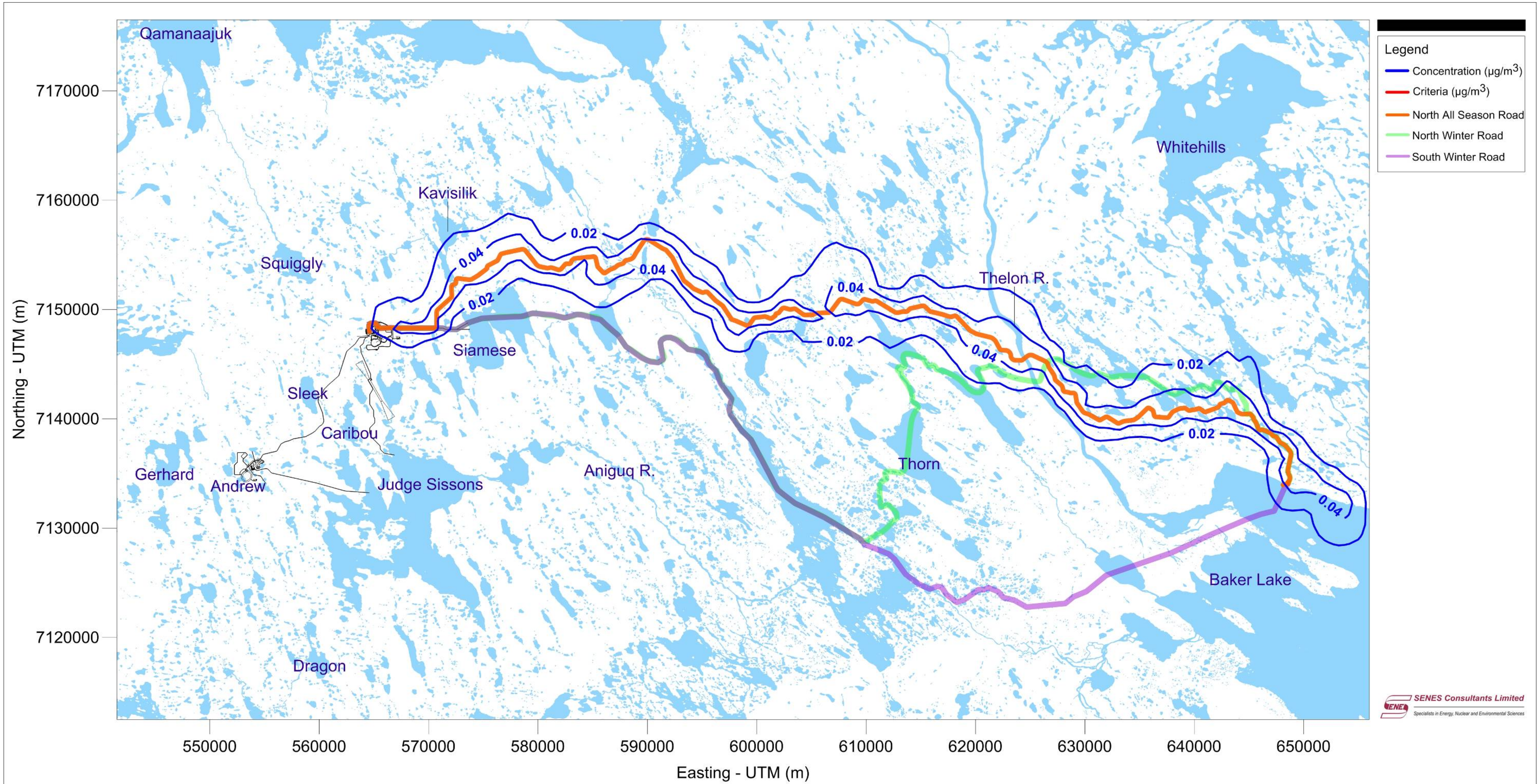


Figure D-148 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 24-hr NO_2 Concentration (µg/m³)

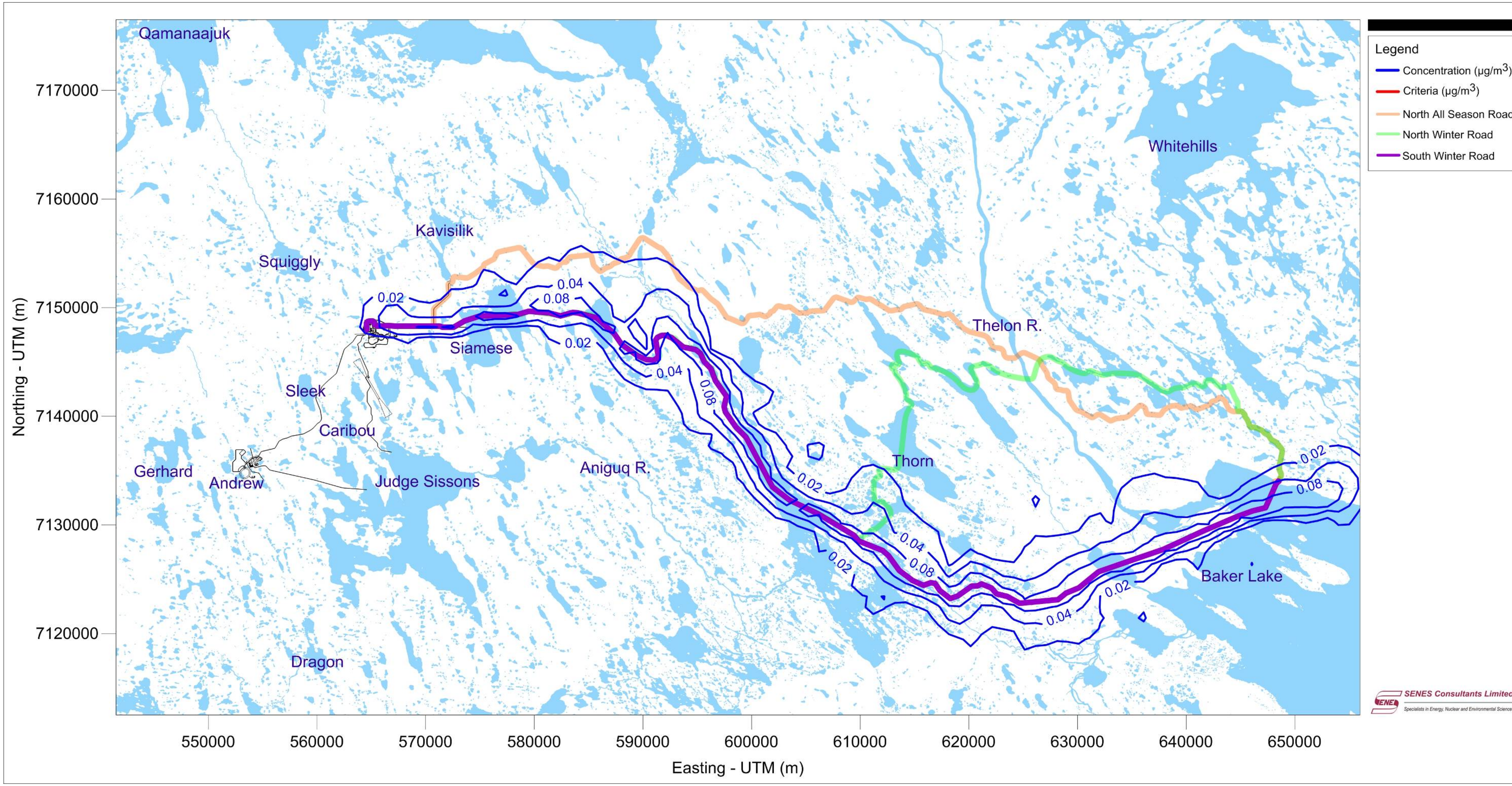


Figure D-149 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 24-hr NO_2 Concentration (µg/m³)

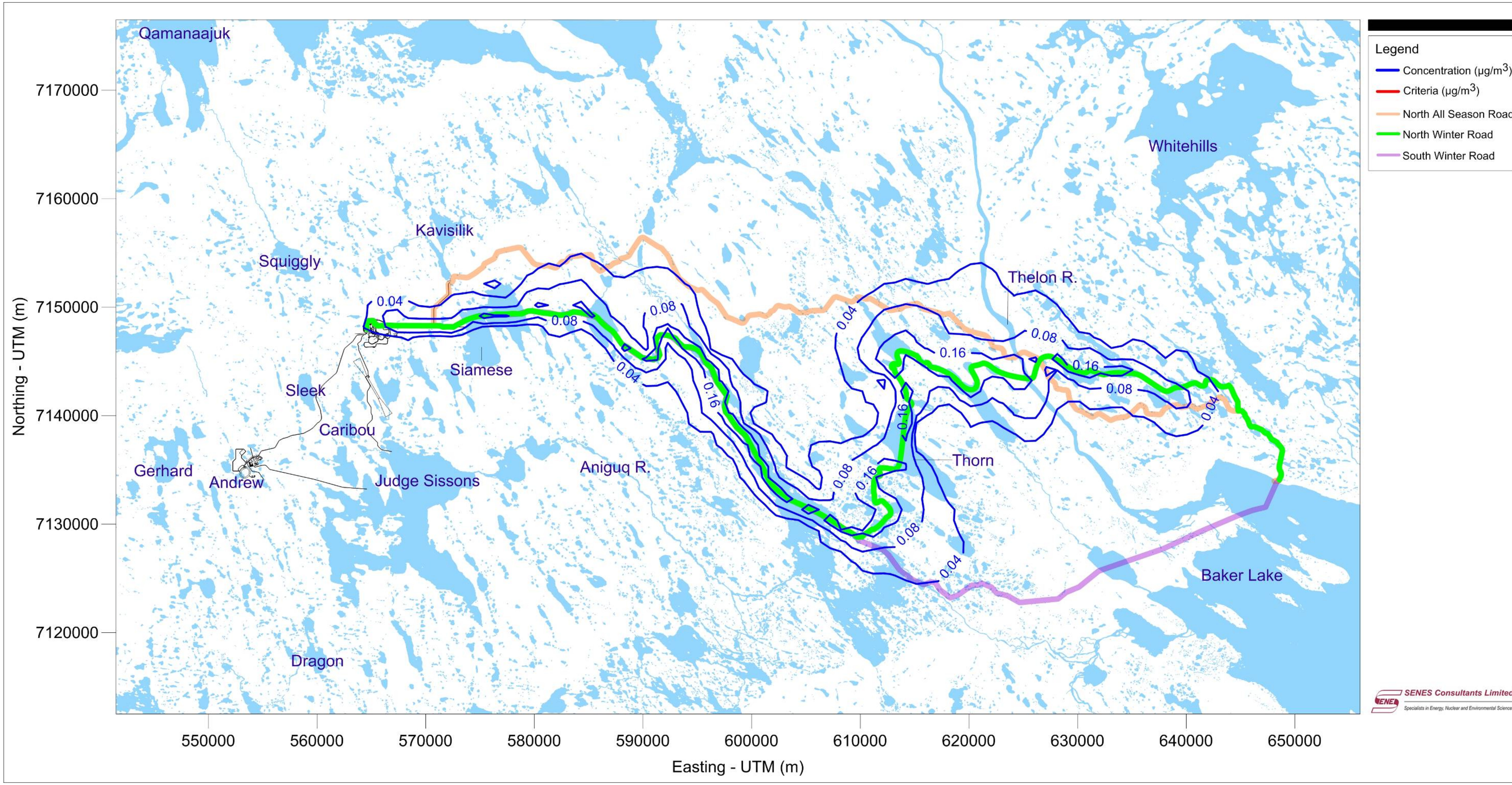


Figure D-150 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 24-hr NO_2 Concentration (µg/m³)

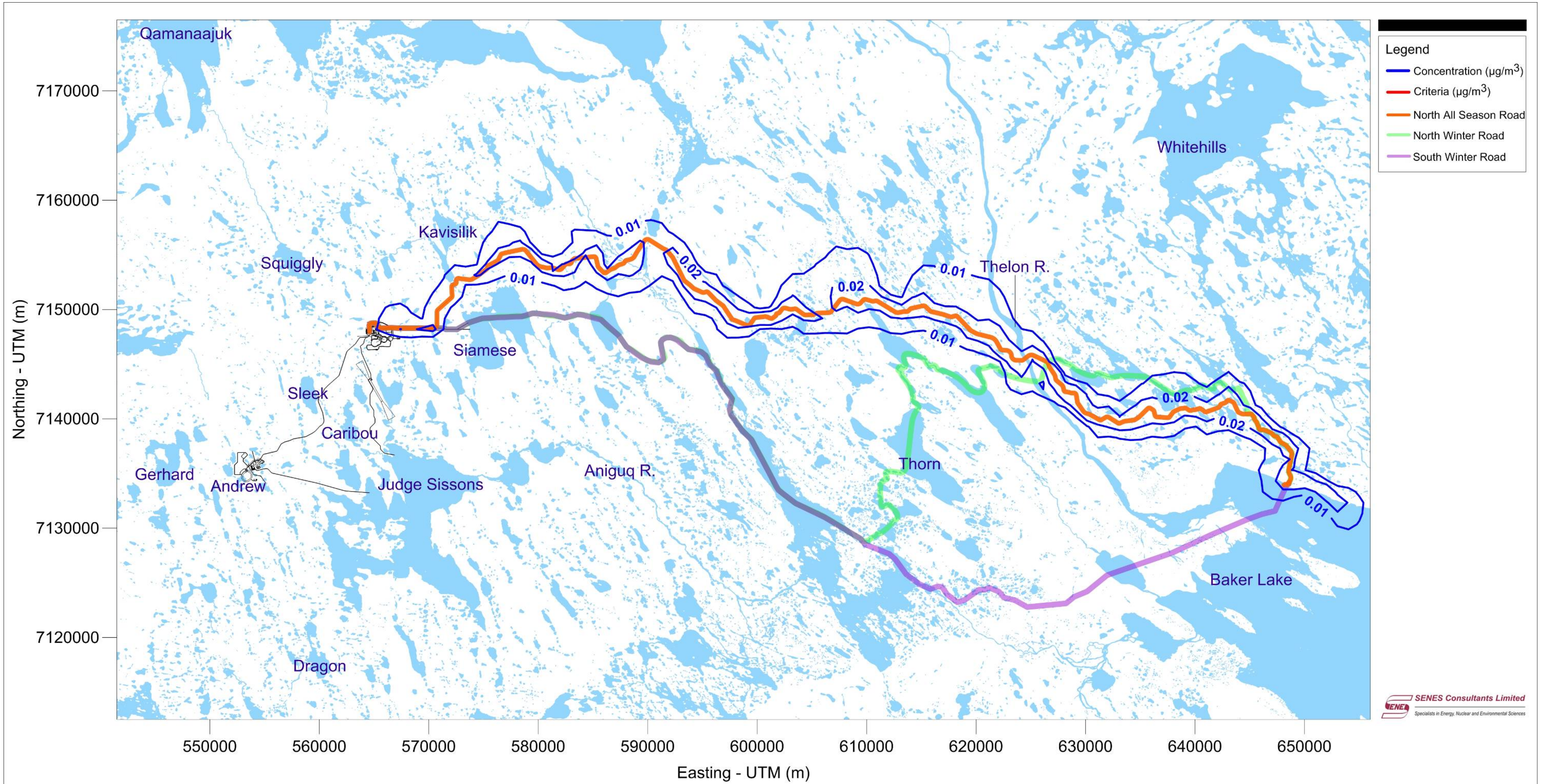


Figure D-151 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental Annual NO_2 Concentration (µg/m³)

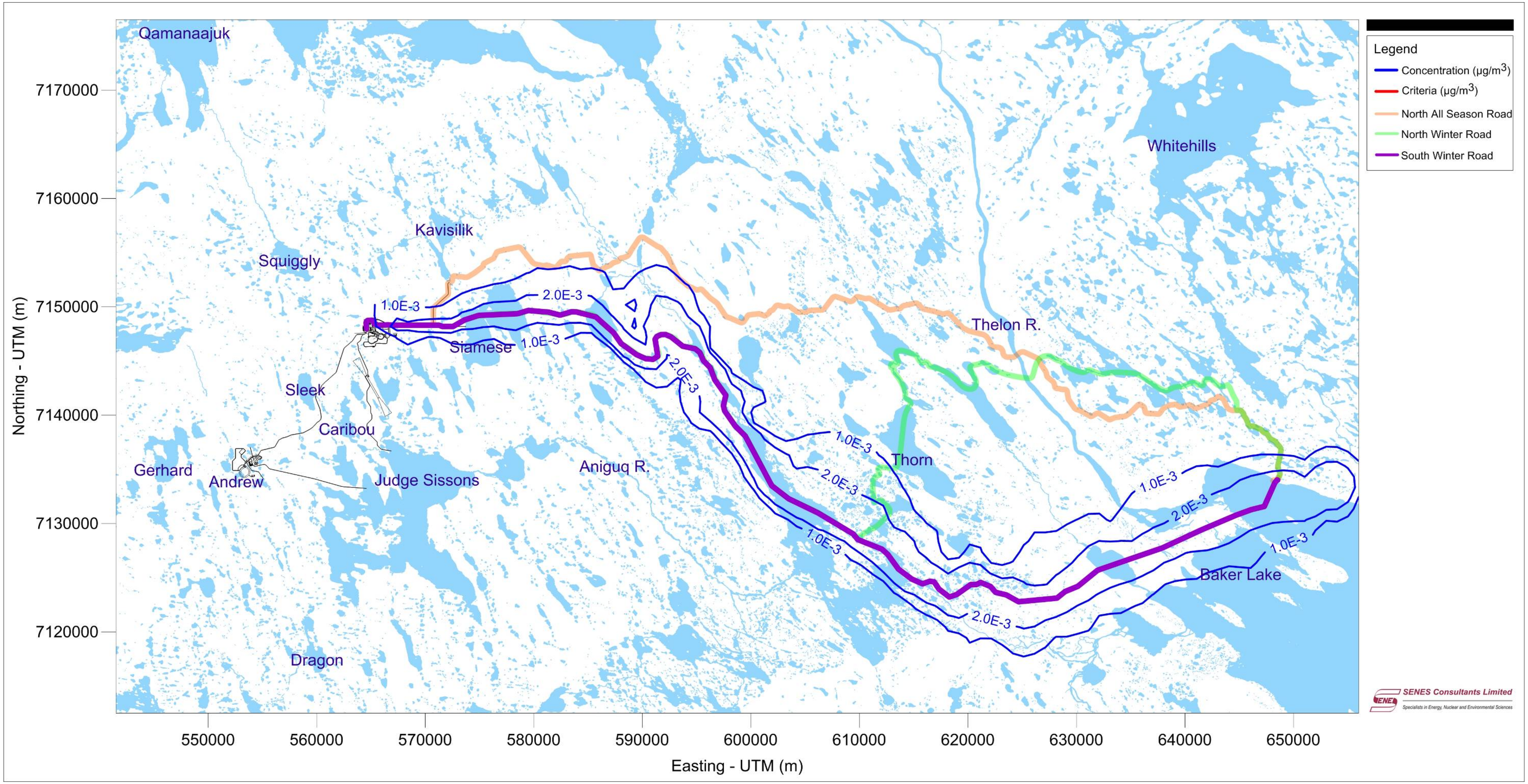


Figure D-152 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental Annual NO_2 Concentration (µg/m³)

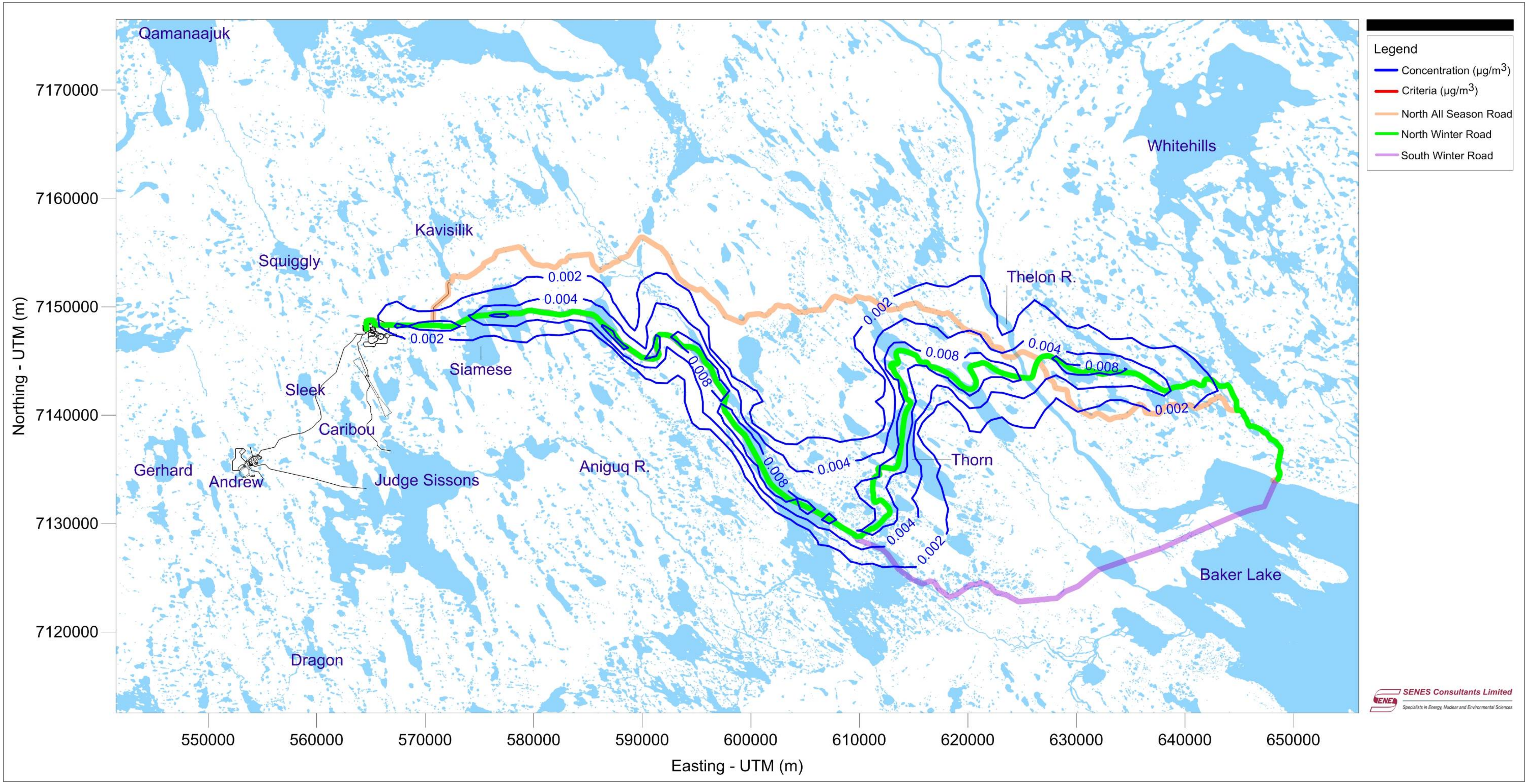


Figure D-153 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental Annual NO_2 Concentration (µg/m³)

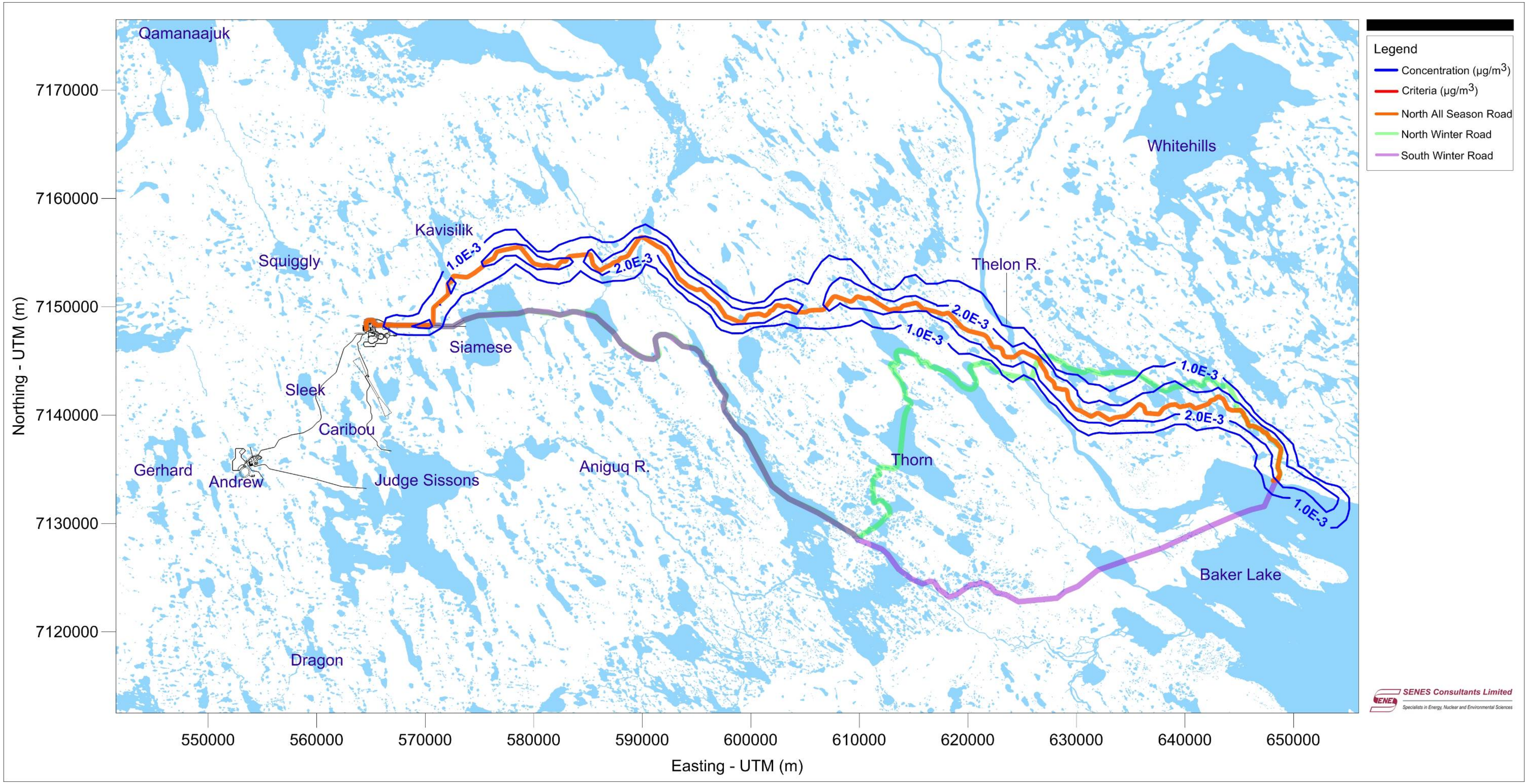


Figure D-154 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 1-hr SO_2 Concentration (µg/m³)

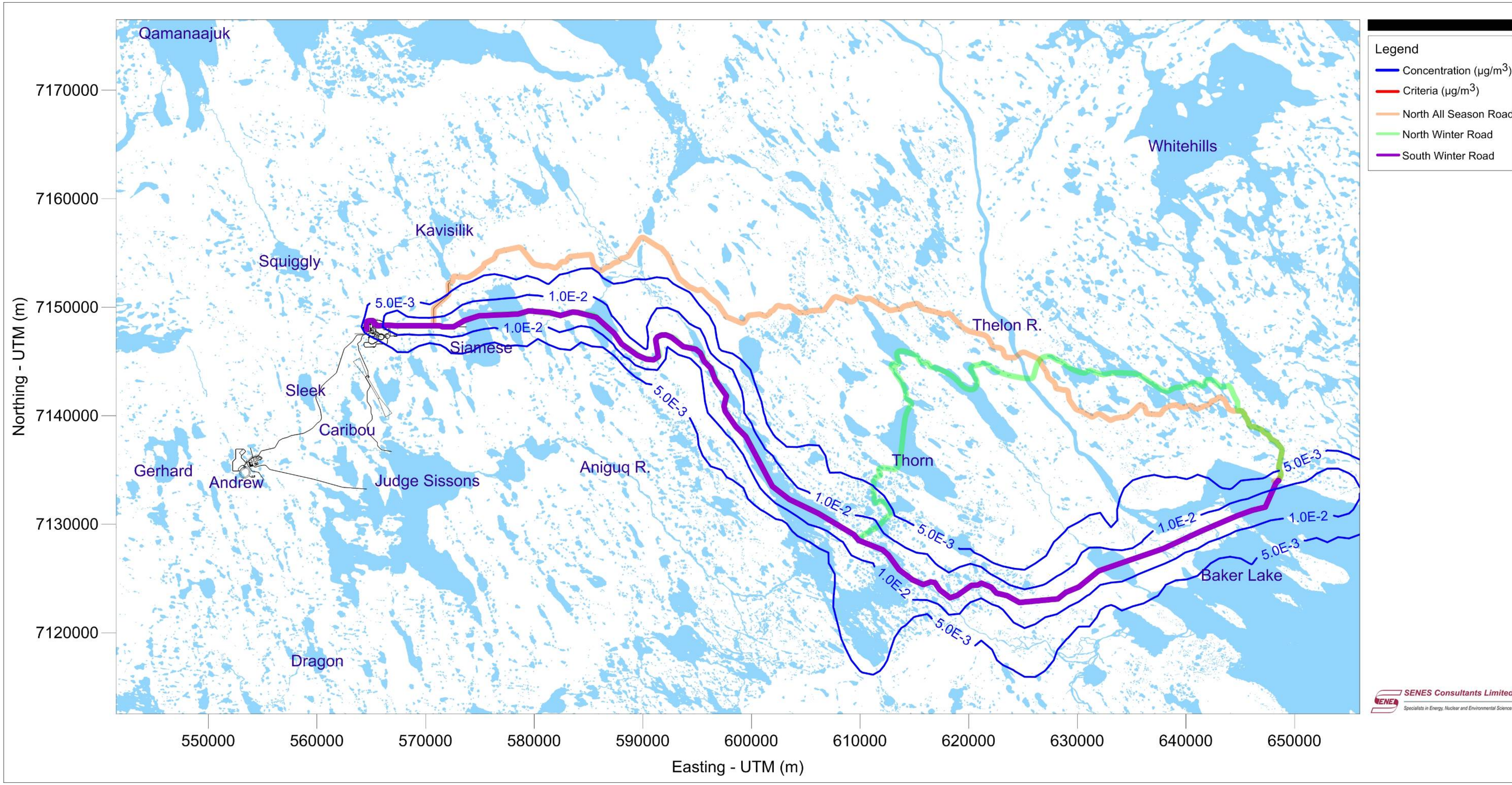


Figure D-155 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 1-hr SO_2 Concentration (µg/m³)

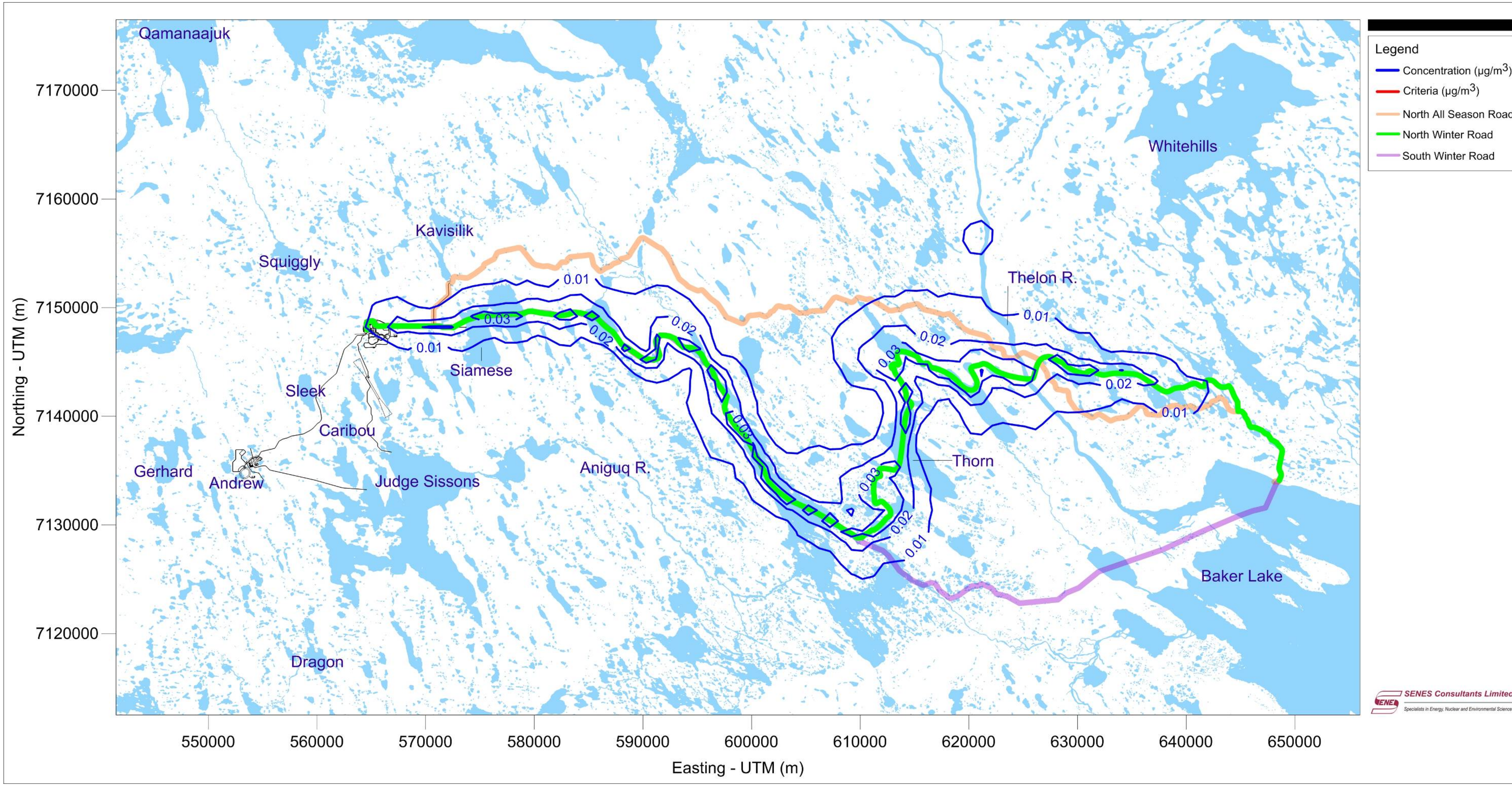


Figure D-156 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 1-hr SO_2 Concentration (µg/m³)

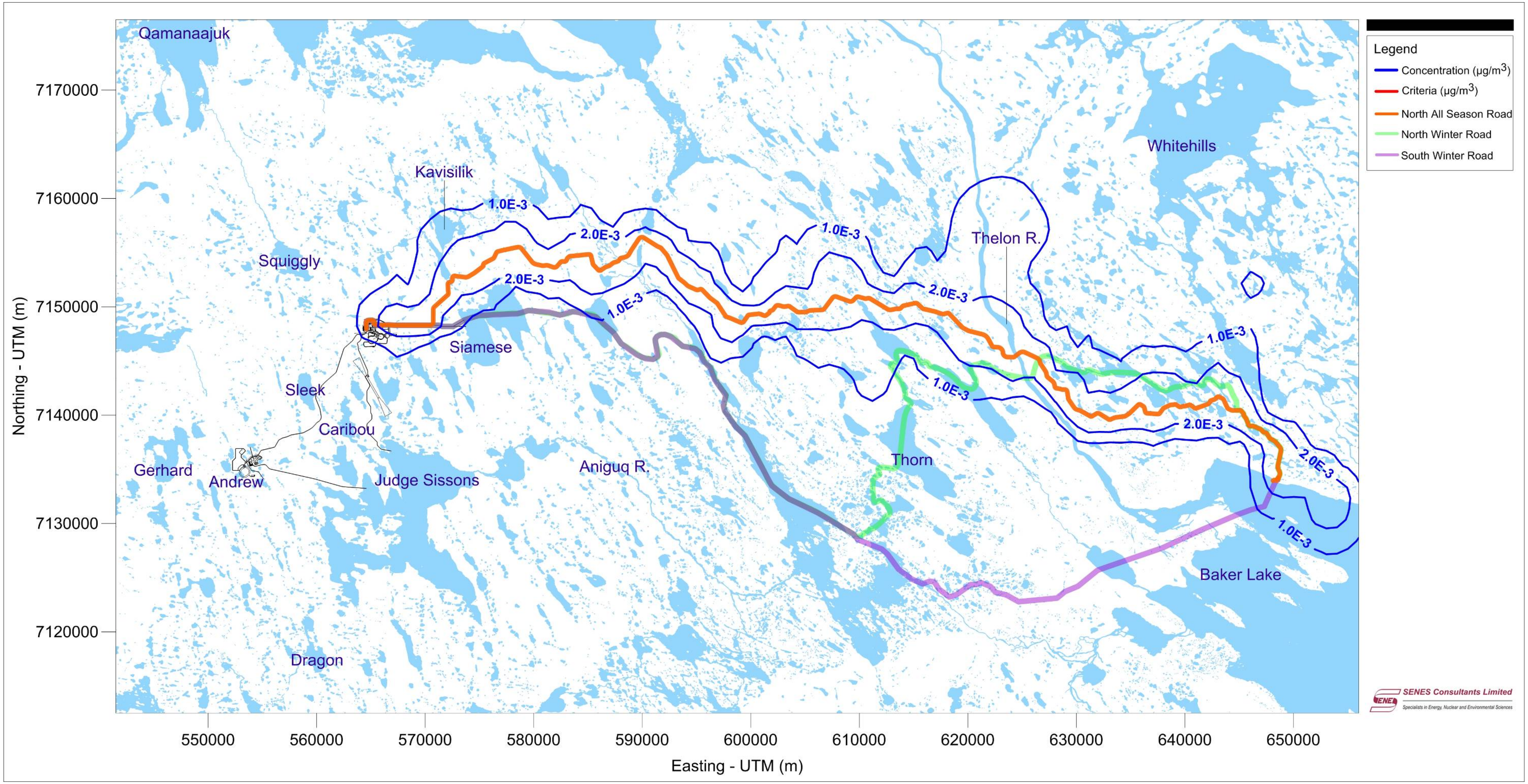


Figure D-157 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental 24-hr SO_2 Concentration (µg/m³)

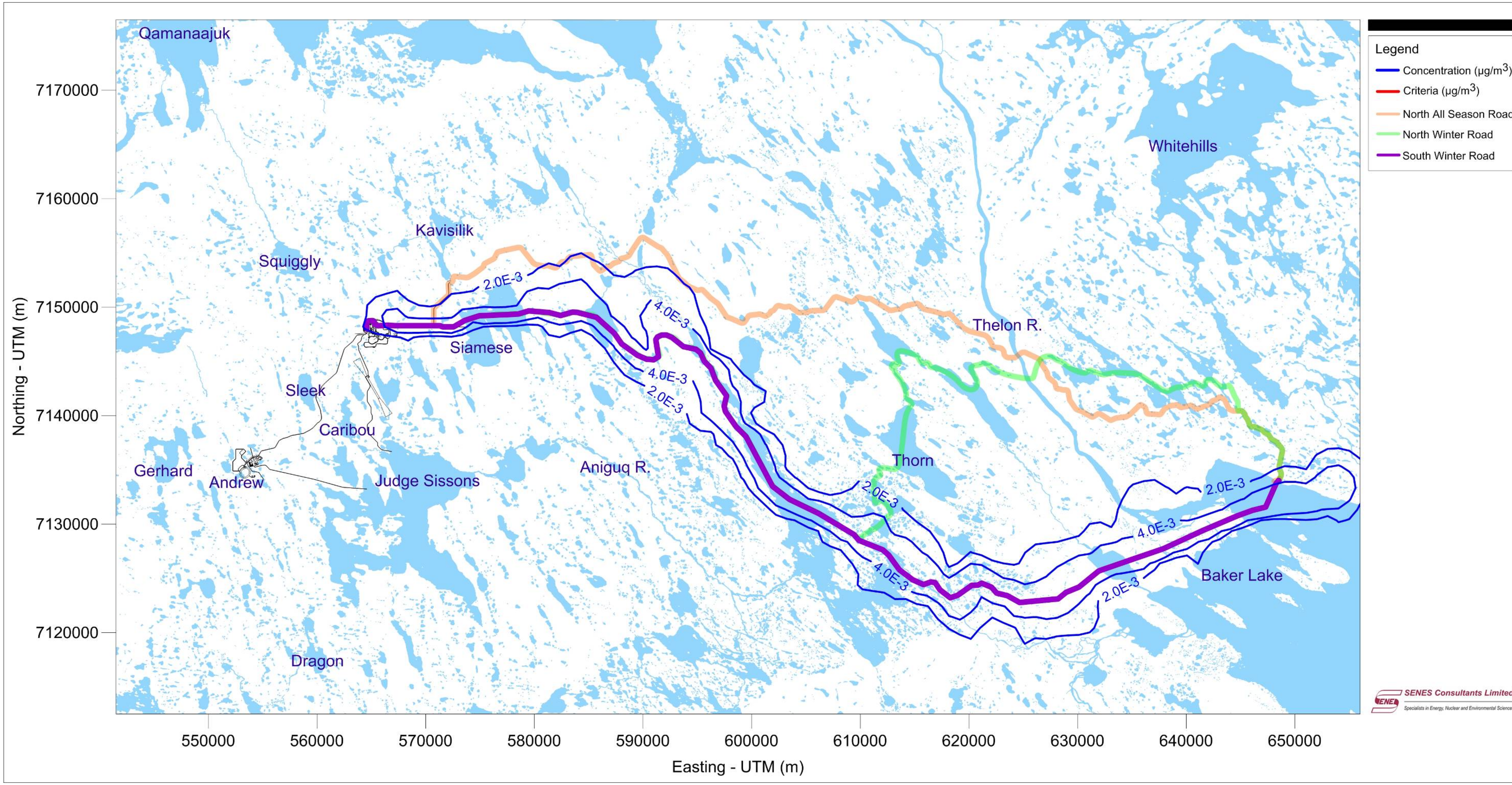


Figure D-158 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental 24-hr SO_2 Concentration (µg/m³)

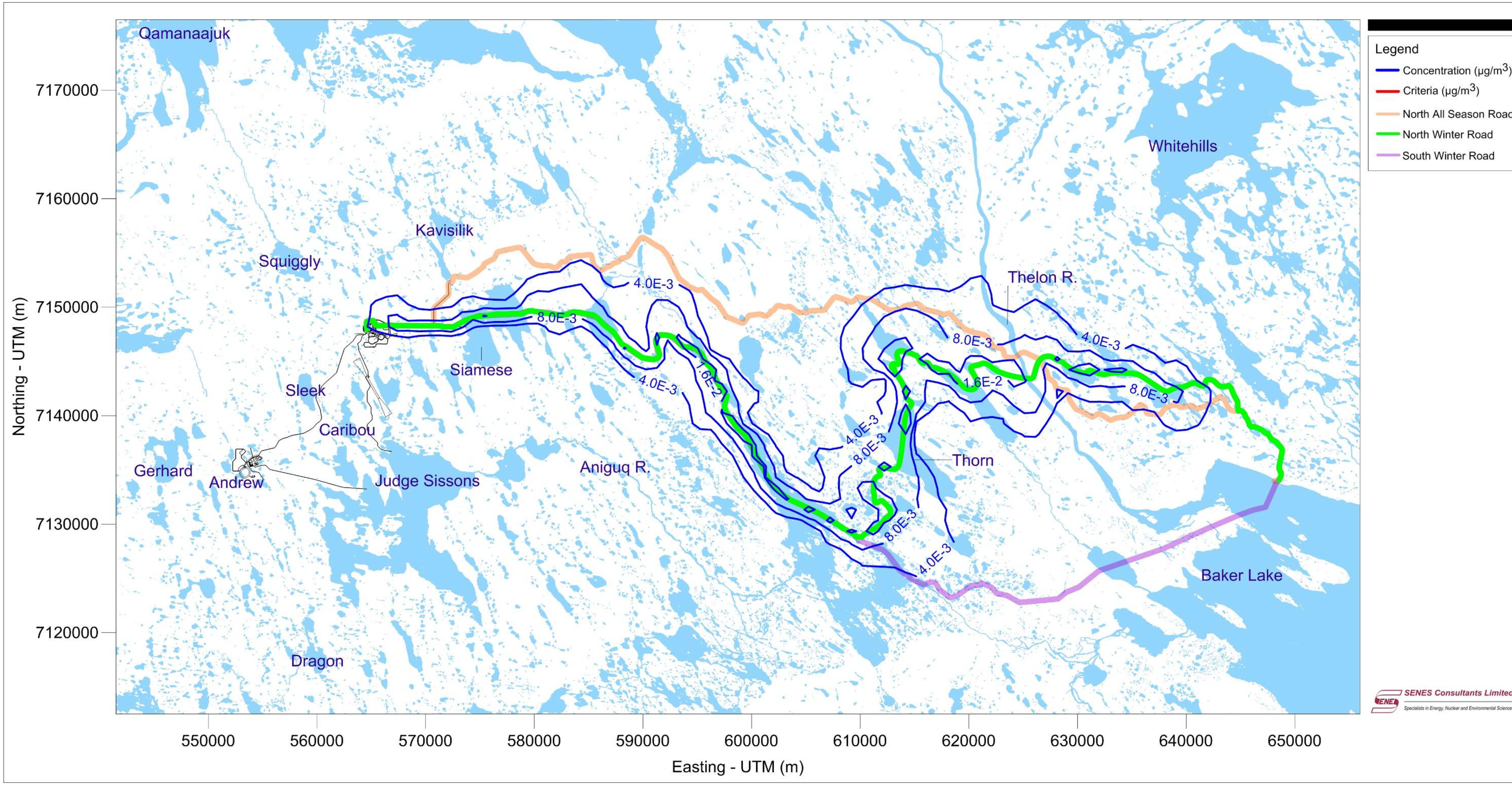


Figure D-159 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental 24-hr SO_2 Concentration (µg/m³)

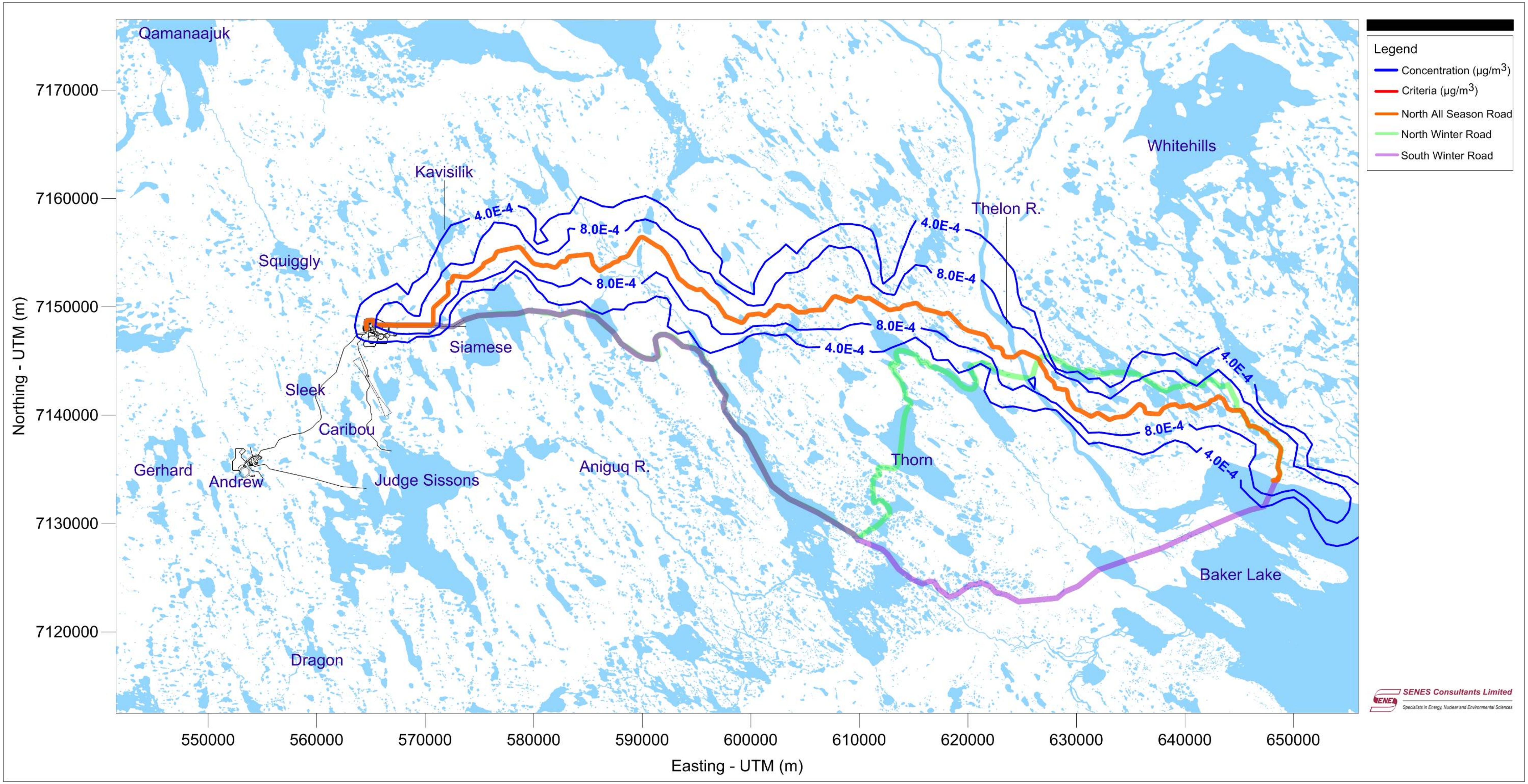


Figure D-160 Kiggavik-Baker Lake Access Road South Winter Road Option - Incremental Annual SO_2 Concentration (µg/m³)

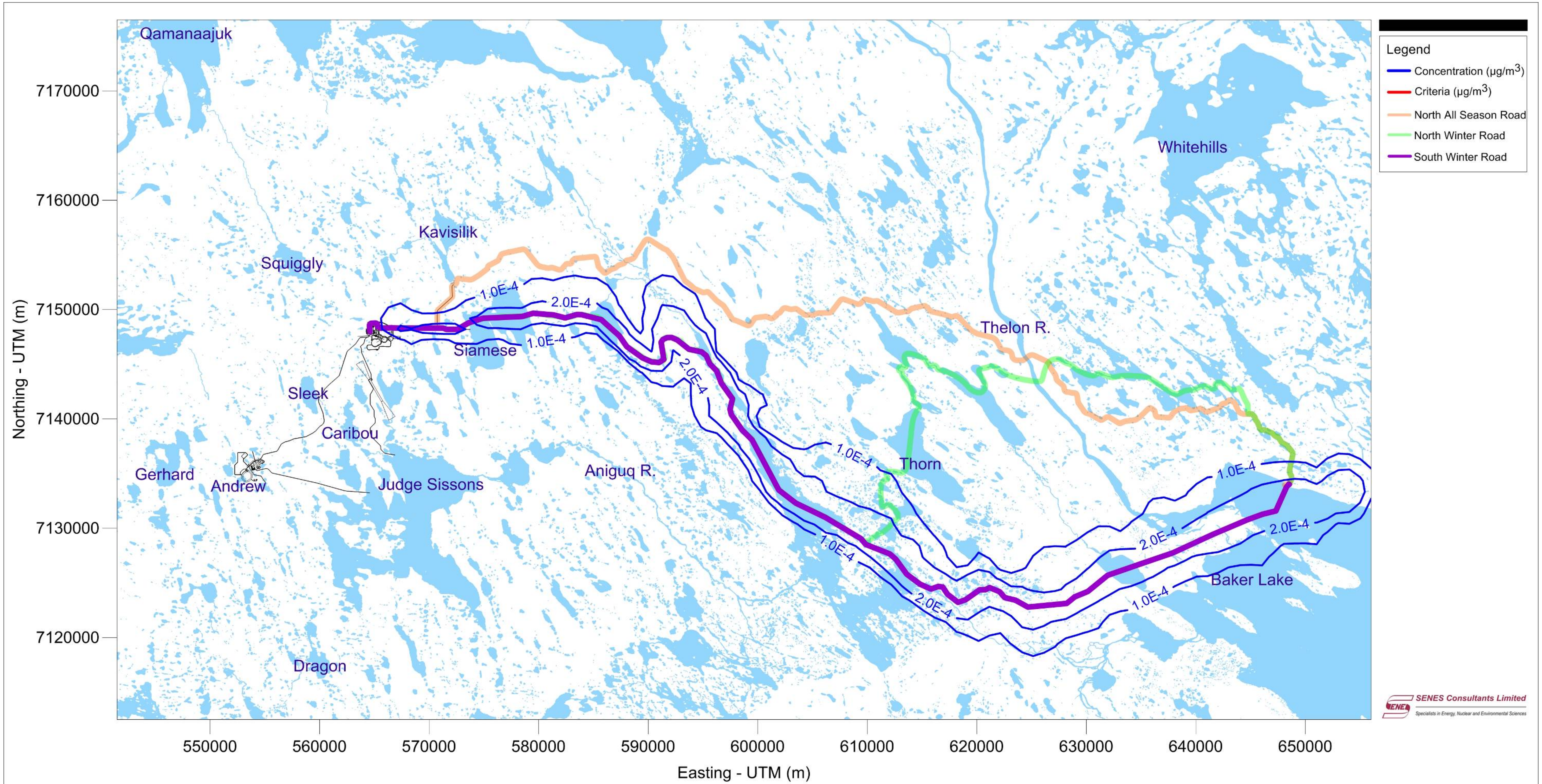


Figure D-161 Kiggavik-Baker Lake Access Road North Winter Road Option - Incremental Annual SO_2 Concentration (µg/m³)

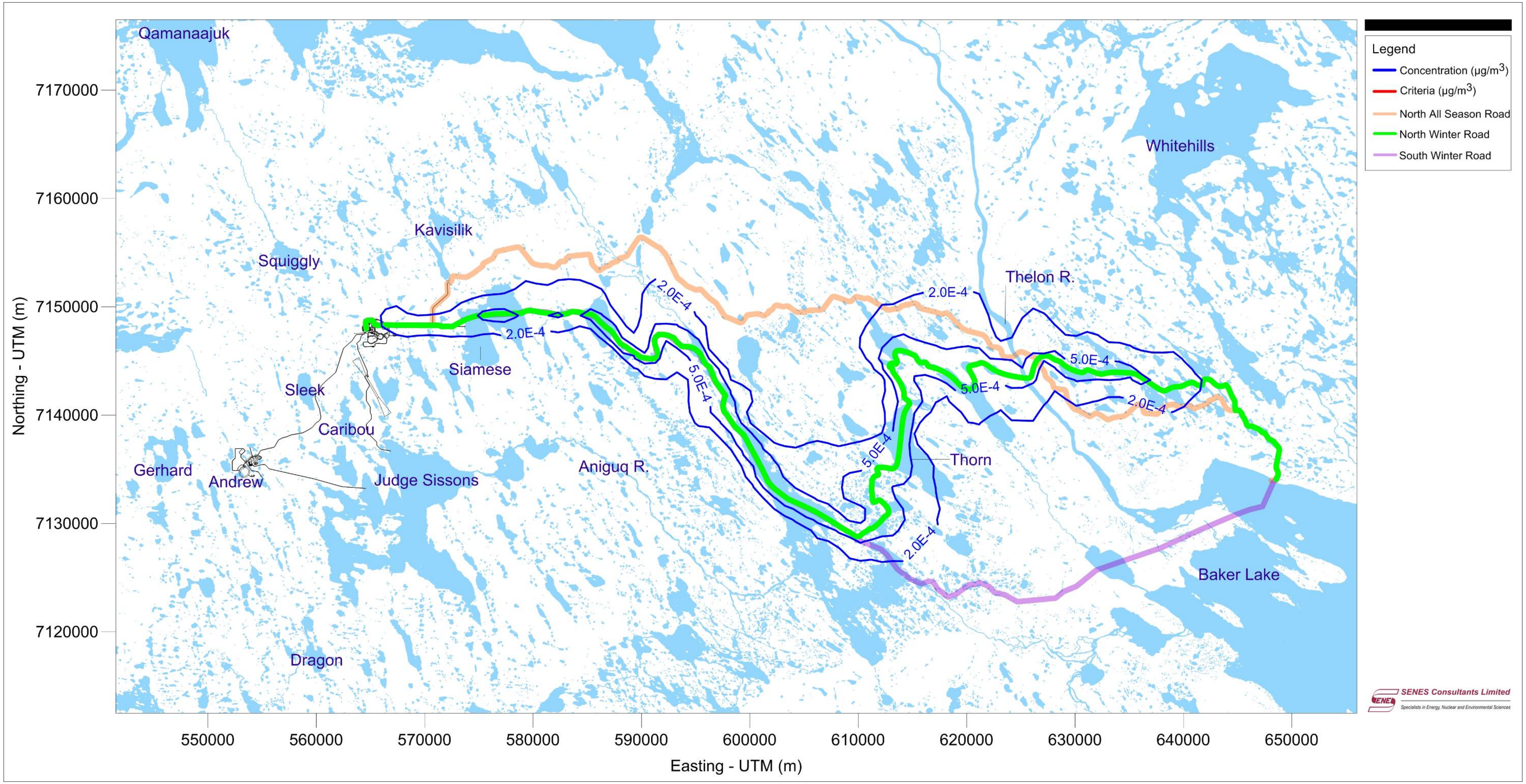


Figure D-162 Kiggavik-Baker Lake Access Road North All-Season Option - Incremental Annual SO_2 Concentration (µg/m³)