AREVA

Kiggavik Project

Final Environmental Impact Statement

Tier 3 Technical Appendix 4B: Air Dispersion Assessment

September 2014

History of Revisions

Revision Number	Date	Details of Revisions
01	December 2011	First Issue with Draft Environmental Impact Statement
02	September 2014	Issued for Final Environmental Impact Statement

Table of Contents

List of Tables

List of Figures

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 mine 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 Project 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 will 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, and form the basis of this air dispersion assessment.

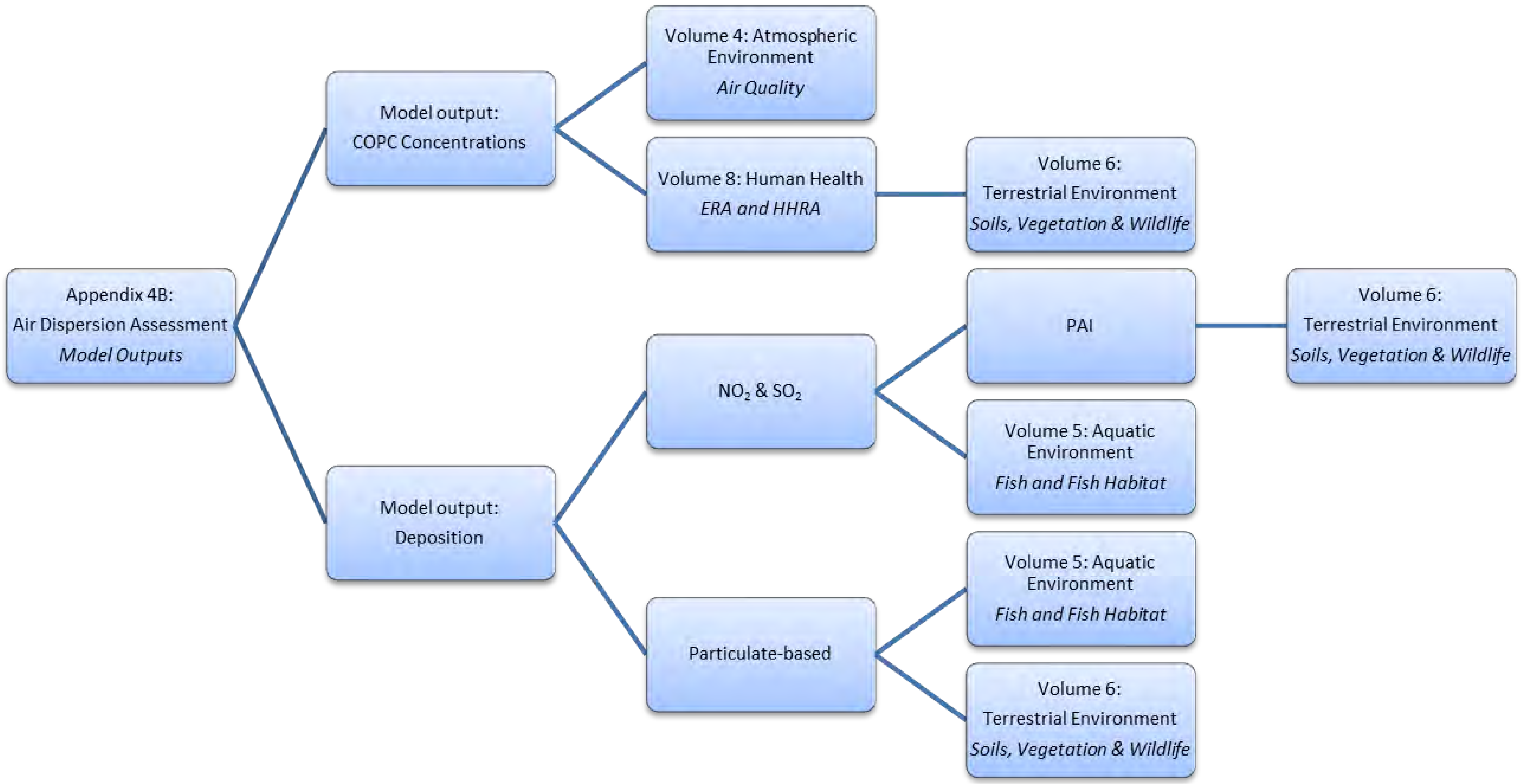
1.2 Purpose and Objectives

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, to outline the approach used for atmospheric dispersion modelling, and to 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 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 predict dust and acidic deposition resulting from the Project using accepted air dispersion modelling; and,
6. To develop a Greenhouse Gas (GHG) emissions 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), the aquatic environment (Volume 5) and the terrestrial environment (Volume 6), and were also used to complete the human health and ecological risk assessment (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, this air dispersion assessment report includes 6 other chapters. 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

The following sections summarize the scope of the air quality assessment. In general, the scope of the assessment was defined based on 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) and considered issues and concerns identified during community and stakeholder engagement sessions. Additional details about how the scope of the assessment was defined are provided in Tier 2, Volume 4, Section 4.

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 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, (an accounting of the total emissions of key COPCs);
- where appropriate, complete CALPUFF air dispersion modelling using the developed emissions inventories; and,
- add baseline COPC concentrations to model predicted results where appropriate, and assess the potential effects to air quality using Nunavut/NWT and federal guidelines, if 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 (i.e., annual) 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. The results of these scenarios form the inputs to the human health and ecological risk assessment (Volume 8). 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. More detailed descriptions 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 the Purpose Built pit 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), this scenario includes open pit mining of Main Zone West pit at Kiggavik and Andrew Lake pit 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, but 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 for these sources.

- **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 that 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 considered for the purpose of this assessment consists of three components: 1) the Kiggavik and Sissons mine sites and interconnecting Kiggavik-Sissons access road (collectively referred to as the Mine Development Area); 2) the Baker Lake Dock and Storage Facility; and 3) the Baker Lake-Kiggavik access road. For the purpose of this assessment, the preferred alternative for the access road is the Winter Access Road. However, the All-Season Access Road option has also been assessed as an alternative.

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 Winter Access Road. The Project Footprint is illustrated in Figure 1.

2.1.3.1 Local Assessment Area

For the purpose of this assessment, the Local Assessment Area (LAA) is defined by 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 measurable effects from Project-specific activities are most likely to occur. The LAA is illustrated in Figure 2.

2.1.3.2 Regional Assessment Area

For the purpose of this assessment, the Regional Assessment Area (RAA) is defined by an area which extends beyond the LAA to encompass a 117 km by 65 km area from Samarook Lake to just east of Whitehills Lake, and includes the Mine Development Area, the Kiggavik-Sissons haul road, the Baker Lake-Kiggavik access road, as well as the community of Baker Lake itself. The RAA 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 (Tier 2, 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 up to 4 years, and that final closure and post-closure activities will require about 10 and 5 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	4	2
Operations	14	15
Final closure	10	2
Post-closure	5	1
Total Project Lifetime (including construction)	**33**	**20**

As outlined in the table above, it was conservatively assumed that construction will occur over a 2 year period instead of 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 5 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 (Section 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 (i.e., dustfall) 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 (Tier 2, Volume 4, Section 6). 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 ambient air quality are described in the following sections.

2.3.1 Nunavut Ambient Air Quality Standards

Nunavut's Environmental Guideline for Ambient Air Quality (Government of Nunavut 2011) has established standards for common air contaminants throughout Nunavut. The standards for TSP, NO_2 and SO_2 have all been adopted from the Canadian National Ambient Air Quality Objectives (NAAQOs), whereas the standard for $PM_{2.5}$ has been adopted from the Canadian Council of the

Ministers of the Environment (CCME) Canada-Wide Standard (CWS) for fine particulate matter (CCME 2000). The Nunavut ambient air quality standards are outlined in Table 2-3 below.

Table 2-3 Nunavut Ambient Air Quality Standards

COPC	Air Quality Standard (µg/m³)		
	1-hour	24-hour	Annual
Total Suspended Particulates (TSP)	-	120	60(1)
Fine Particulate Matter ($PM_{2.5}$)	-	30	-
Nitrogen Dioxide (NO_2)	400	200	60(2)
Sulphur Dioxide (SO_2)	450	150	30(2)

Notes:
Geometric mean
Arithmetic mean

2.3.1.1 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. An ambient air quality standard for PM_{10} has not yet been established in Nunavut or the Northwest Territories, however, as indicated in the Nunavut Environmental Guideline, the CCME is currently assessing the need for a PM_{10} standard for target years beyond 2015 (Government of Nunavut 2011). In the interim, the Ontario Ministry of Environment (MOE) has established an ambient air quality criterion for PM_{10} of 50 µg/m³ (MOE 2012) which many other provinces such as B.C., Newfoundland and Manitoba have adopted. This criterion will also be applied in this assessment in order to provide context to the dispersion modelling results.

As previously mentioned, Nunavut has currently adopted the CWS for $PM_{2.5}$. However, the CCME published revised Canadian Ambient Air Quality Standards (CAAQS) in October 2012 which were enacted under the Canadian Environmental Protection Act (CEPA 1999) on May 25, 2013. The 24-hour $PM_{2.5}$ CWS has been revised to 28 µg/m³ (effective in 2015) and to 27 µg/m³ (effective in 2020) (CCME 2012). The CCME has also established an annual $PM_{2.5}$ CAAQS for 2015 (10.0 µg/m³) and for 2020 (8.8 µg/m³). It has been assumed that Nunavut will adopt the new $PM_{2.5}$ CAAQS and as a result, these standards were considered in this assessment in lieu of the current Canada-Wide Standard for $PM_{2.5}$. Since the operational life of the Project is expected to extend beyond 2020, the 2020 CAAQS were applied in this assessment.

The selected reference levels that were used in this assessment for PM_{10} and $PM_{2.5}$ are outlined in Table 2-4.

Table 2-4 Reference Levels for PM_{10} and $PM_{2.5}$

COPC	Averaging Period	Jurisdiction	Reference Level (µg/m³)
PM_{10}	24-hour	Ontario, BC, Manitoba & Newfoundland AAQC	50
$PM_{2.5}$	24-hour	CAAQS	27(1)
	Annual		8.8(2)

Notes:

(1) Canadian Ambient Air Quality Standard (CAAQS) based on the 98th percentile ambient measurement, averaged over 3 consecutive years applicable to the year 2020 and beyond

(2) Canadian Ambient Air Quality Standard (CAAQS) based on a 3-year consecutive average applicable to the year 2020 and beyond

2.3.2 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 for the purpose of this assessment. Most reference levels used for metals 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) revised in April of 2012 (MOE 2012). Other provinces such as Manitoba and Newfoundland & Labrador have adopted the same levels for selected metals, whereas provinces like Alberta have adopted values from United States. As such, Ontario levels were given preference.

Ontario's AAQC are based on 24-hour exposure levels and are presented in Table 2-5. 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 2-5 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 (in TSP)	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 Table 2-6 below. Unless otherwise stated, the averaging period is 24-hours.

Table 2-6 Other Provincial Air Quality Criteria, Standards or Guidelines for Metals

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:
24-hour averaging period

2.3.3 Airborne Radioactivity

Radioactivity may be associated with particulate matter (i.e., radioactive products from the natural uranium decay series: uranium-238, uranium-234, thorium-230, radium 226, lead-210 and polonium-210) or a gas (i.e., radon-222). There are currently no provincial or federal ambient air quality standards for radioactivity. Instead, effects due to radioactive air emissions are conventionally assessed through an exposure pathways analysis (see Volume 8). However, for the purpose of this air quality assessment, reference air concentrations were developed.

For 24-hour and annual uranium, Ontario MOE criteria (MOE 2012) were adopted and are shown in Table 2-7.

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.

Reference levels for lead-210 (Pb-210) and polonium-210 (Po-210) 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 0.1 millisieverts per year (mSv/y) for a member of the public, continuous exposure for an entire year (8,760 hours per year (h/y)) and an annual inhalation rate of 8,400 cubic metres per year (m^3/y). No reduction in airborne dust concentrations when indoors was conservatively assumed. The dose coefficients were taken from ICRP 119 (2012) and assume particle sizes of 1 µm and a slow rate of clearance from the lungs (ICRP inhalation type "S"). This is the most restrictive inhalation type and results in an overestimate of exposure when considering all the radionuclides.

The resulting radionuclide reference concentrations are tabulated below (Table 2-7). Recall that 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 ecological risk assessment (Volume 8).

Table 2-7 Reference Levels for Radioactivity

Radionuclide	Averaging Period	Jurisdiction	Reference Level
Uranium	24-hour	Ontario MOE	0.3 µg/m³
	Annual		0.03 µg/m³
Radon	Annual	CNSC	60 Bq/m³
Lead-210	Annual	Calculated	0.0021 Bq/m³
Polonium-210	Annual	Calculated	0.0028 Bq/m³

2.3.4 Dust Deposition

Table 2-8 identifies dust deposition (i.e., dustfall) criteria for Alberta and Ontario. These criteria are nuisance based. For the purpose of this assessment, the Ontario Ambient Air Quality Criteria (MOE 2012) were selected as the applicable reference levels.

Table 2-8 Dust Deposition Criteria

Averaging Time	Alberta Residential and Recreational Areas	Alberta Commercial and Industrial Areas	Ontario Ambient Air Quality Criteria	Selected Reference Level
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[(1)]	55 g/m²/year
Notes: (1) Calculated (4.6 g/m²/month x 12 months per year = 55 g/m²/year) Sources: Alberta Environment (2011) and Ontario Ministry of Environment (MOE 2012)				

2.3.5 Potential Acid Input

Table 2-9 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 2-9 Potential Acid Input Loading Thresholds

Sensitivity of Environment	Deposition Load	Loading Threshold
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

When a modelling assessment is completed to assess the effects to ambient air quality, all "background" sources of COPCs must be added to model predicted results in order to provide an accurate representation of the air quality after the proposed Project is in operation. 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. As a result, baseline COPC concentrations were considered in this assessment.

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 TSP, metals and radionuclides during the 2010, 2011, 2012 and 2013 summer field seasons (i.e., June to August) near the exploration camp near the Kiggavik mine site. Details of each sampling campaign are shown in Table 3-1. The Hi-Vols typically ran continuously for 20 to 30 days in order to collect a sufficient amount of sample for detailed metal and radionuclide analysis. Two Hi-Vol samples were collected in 2010 and in 2011, one sample in 2012, and three samples were collected in 2013.

Table 3-1 Hi-Vol Sampling Summary, 2010-2013

Hi-Vol Sample ID	Sampling Year	Sampling Month	Sampling Length (days)
CM-RAD-29JUN10	2010	June	20
CM-RAD-20JUL10	2010	July	28
CM-RAD-07JUL11	2011	July	20
CM-RAD-28JUL11	2011	July	11
2012-01	2012	August	21
2013-01	2013	June	22
2013-02	2013	July	22
2013-03	2013	August	29

Table 3-2 provides the average measured concentrations of TSP, metals and radionuclides over the period 2010 to 2013. Since Hi-Vol filters were exposed for 20+ days, measured concentrations were converted to a 24-hour averaging period using the same methodology that was outlined in Section 2.3.2. In addition, it was conservatively assumed that PM_{10} is 50% of the measured TSP concentration and that $PM_{2.5}$ is 25% of the measured TSP concentration. According to Brook et al. (1997), PM_{10} is on average close to 50% of TSP and $PM_{2.5}$ is on average 50% of PM_{10}. These ratios are based on data collected by the National Air Pollution Surveillance (NAPS) Network in the southern parts of Canada where anthropogenic emissions sources of fine particulate (e.g., vehicles) are generally more abundant. Therefore, the ratios are likely much lower in a northern rural environment like Nunavut, and applying them to measured TSP concentrations is considered conservative.

As shown in Table 3-2, the average measured TSP concentration was 2.9 $\mu g/m^3$ (or 6.9 $\mu g/m^3$ on a 24-hour basis). Most of the metal concentrations were at or below the laboratory detection limit and ranged from a low of 9.9E-06 $\mu g/m^3$ (uranium) to a high of 2.3E-02 $\mu g/m^3$ (boron). With regard to radionuclides, lead-210 had the highest overall concentration at 1.3E-04 $\mu g/m^3$ and radium-226 had the lowest concentration at 9.2E-07 Bq/m^3. Overall, the concentrations of metals and radionuclides were very low considering the extended sampling period used in each sampling campaign. This is not unexpected and is considered typical of a northern rural environment.

Table 3-2 Average Measured Particulate, Metals and Radionuclides at Kiggavik, 2010-2013

Constituent	Average Length of Exposure (days)	Average Measured Concentration (µg/m³)(1)	24-hour Average Concentration (µg/m³)(2)
Total Particulate*	20.9	2.9	6.8
PM_{10}	20.9	1.5	3.4
$PM_{2.5}$	20.9	0.7	1.7
Aluminum (Al)	21.7	2.0E-02	4.6E-02
Antimony (Sb)	21.7	6.8E-04	1.6E-03
Arsenic (As)	21.7	1.2E-04	2.8E-04
Barium (Ba)	21.7	7.0E-04	1.6E-03
Beryllium (Be)	21.7	2.1E-05	4.9E-05
Boron (B)	21.7	2.3E-02	5.4E-02
Cadmium (Cd)	21.7	6.0E-05	1.4E-04
Chromium (Cr)	21.7	2.2E-04	5.1E-04
Cobalt (Co)	21.7	4.0E-05	9.1E-05
Copper (Cu)	21.7	1.5E-02	3.5E-02
Iron (Fe)	21.7	2.2E-02	5.0E-02
Lead (Pb)	21.7	1.1E-03	2.6E-03
Manganese (Mn)	21.7	9.3E-04	2.1E-03
Molybdenum (Mo)	21.7	2.4E-04	5.8E-04
Nickel (Ni)	21.7	1.5E-04	3.4E-04
Selenium (Se)**	24.0	3.5E-05	8.4E-05
Silver (Ag)	21.7	6.9E-05	1.6E-04
Strontium (Sr)	21.7	3.2E-04	7.3E-04
Thallium (Tl)	21.7	1.9E-04	4.3E-04
Tin (Sn)	21.7	5.8E-04	1.3E-03
Titanium (Ti)	21.7	5.2E-04	1.2E-03
Vanadium (V)	19.7	4.9E-05	1.1E-04
Zinc (Zn)	21.7	4.5E-03	1.1E-02
Uranium (U)***	23.8	9.9E-06	2.4E-05
Lead-210	21.7	1.3E-04 Bq/m³	--

Table 3-2 Average Measured Particulate, Metals and Radionuclides at Kiggavik, 2010-2013

Constituent	Average Length of Exposure (days)	Average Measured Concentration (µg/m³)(1)	24-hour Average Concentration (µg/m³)(2)
Polonium-210	21.7	5.4E-05 Bq/m³	--
Radium-226	21.7	9.2E-07 Bq/m³	--
Thorium-230	21.7	1.5E-06 Bq/m³	--
Thorium-232	21.8	1.3E-06 Bq/m³	--
Thorium-234	21.2	2.5E-05 Bq/m³	--

Notes:

Concentrations in units of µg/m³ unless otherwise noted.

PM_{10} and $PM_{2.5}$ calculated assuming PM_{10}= 50% of TSP and $PM_{2.5}$= 50% of PM_{10}

(1) The average 2010-2013 concentration was calculated assuming any measurements less than the laboratory method detection limit (MDL) was equal to the MDL.

(2) Concentrations were converted to a 24-hour averaging period using the conversion method $C1/C2 = (T2/T1)^{0.28}$, where C = concentration and T = averaging period (ADMGO 2009)

* TSP average based on 2011-2013 data

** Selenium data from 2011-2013 was excluded due to anomalously high laboratory detection limit compared to 2010 year

*** Uranium data from 2011 was excluded due to anomalously high laboratory detection compared to other years

Another ambient air quality sampling campaign was carried out near the proposed mine site using low volume air samplers (PQ-100s) to collect samples of TSP, PM_{10} and $PM_{2.5}$ about every three days throughout July 2009 and July 2010. However, a number of unforeseen challenges were experienced with the equipment (e.g., unreliable power supply) which compromised the reliability of the data that was collected. Therefore, the results for 2009 and 2010 are not presented.

Additional PQ-100 monitoring was undertaken again in the summer of 2011. However, upon examining the data, a laboratory error was detected in the gravimetric analysis. Since the filters were digested for the analyses of metals and radionuclides, the filters could not be re-analyzed. Therefore, the results for 2011 were also not included in the baseline assessment.

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 concentration is 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/m^3)

Parameter	Location	June 2008	July 2008	Sept 2008	June 2009	July 2009	August 2009	July 2010	August 2010	Average
Rn-222 PAE (nJ/m^3)	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/m^3)	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 be used to 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 $\mu g/m^3$ 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 $\mu g/m^3$ to 5.5 $\mu g/m^3$ 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 $\mu g/m^3$, 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 which is considered very low, particularly relative to the SO_2 and NO_2 ambient air quality criteria.

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 baseline dustfall amount measured at the Mary River Project 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
Aluminum	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 COPCs 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. Nevertheless, the concentrations of particulate matter, metals and radionuclides outlined in Table 3-2 and total dustfall outlined in Table 3-5 were added to model predicted COPC concentrations and used to assess the potential effects in Section 6. Note that measured Hi-Vol concentrations in Table 3-2 were conservatively assumed to be representative of annual concentrations even though samples were only exposed for 20 to 30 days.

Since the criterion for radon is based on the increment above baseline, a background concentration was not added to the model predicted radon concentrations. Also, as indicated by the measurements at Mary River, baseline NO_2 and SO_2 concentrations are expected to be low enough in the vicinity of the Project site that they would have a minimal contribution relative to the predicted concentrations from the Project. As a result, baseline levels of NO_2 and SO_2 were not added to the model predicted concentrations.

3.2 Greenhouse Gases

Canadian facilities that emit more than 50,000 tonnes of CO_2-equivalent must report their emissions to Environment Canada's Greenhouse Gas (GHG) Inventory. According to the GHG Inventory, the total amount of facility-reported GHG emissions in Canada in 2012 (the most recent year in which data is available) was 256,883 kilotonnes (kt) of CO_2-equivalent. In 2012; facility-reported GHG emissions in Nunavut totalled 203 kt of CO_2-equivalent. Reported 2012 GHG emissions were only from one facility in Nunavut (NU) – Meadowbank Gold Mine.

Environment Canada also generates a National Inventory Report (NIR) which is submitted to the UN Framework Convention on Climate Change (Environment Canada 2014). 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 NIR submission, Canada-wide GHG emissions were 699,000 kt of CO_2-equivalent in 2012. For the same year, GHG emissions in Nunavut were estimated to be 210 kt of CO_2-equivalent. Therefore, according to the National Inventory Report, GHG emissions in Nunavut were approximately 0.03% of the 2012 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 were included as part of the baseline GHG levels in Nunavut. The Nunavut level as reported by in the NIR does not appear to include emissions from this facility. As a result, the GHG emissions estimate of 203 kt of CO_2-equivalent as reported by the Meadowbank Gold Mine to the Environment Canada GHG Inventory was added to the reported Nunavut total in the NIR. Therefore, the baseline level of GHG emissions in Nunavut was considered to be 413 kt of CO_2-equivalent. This value will be used as a measure of comparison for 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	8 kg/tonne ANFO 1 kg/tonne ANFO	AP-42 Chapter 13.3 – Explosives Detonation, Table 13.3-1 (US EPA 1980)
c) 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.
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)

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

Emission Source	Emission Factor or Equation		Reference
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
Acid Plant	SO_2	75 g SO_2/tonne acid produced	Initial Feasibility Study, Section 8.4.11.1 (AREVA 2011)
	NO_x	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
Waste Incinerator	TSP PM_{10} $PM_{2.5}$ NO_x SO_2	20.0 mg/m^3 15.8 mg/m^3 9.0 mg/m^3 22.0 mg/m^3 50 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)
	0.42 Mg of PM_{10}/ha/month		WRAP Fugitive Dust Handbook (Countess Environmental 2006)

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 and Baker Lake Dock and Storage Facility. 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) (Table 4-1), 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 (40% control), watering (or equivalent control method) during summer (75% control) and the existence of frozen surfaces during winter (50% control). 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. 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 Access 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 as 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.

The incinerator will be designed meet the Canada-Wide Standards (CWS) for mercury and dioxins and furans, and as a result, were considered to emit negligible quantities of these COPCs and were not modelled. In addition, emissions of hydrogen chloride (HCl) were considered negligible and not modelled since the type of waste to be incinerated (i.e., organics) will not contain chlorinated compounds. Proper waste segregation will ensure that only organics are incinerated (see Tier 3, Appendix 2S, Waste Management Plan).

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 and Po-210 are 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 4-6 to 4-16. 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 human health and ecological risk assessment (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. As a result, the maximum site-wide totals presented in Tables 4-6 to 4-16, will not necessarily equal the sum of the individual source emission rates provided in the tables.

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 and radionuclide emission rates are provided 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.

Particulate matter emissions from construction of the mine sites were calculated based on the emission factors for general construction activities shown in Table 4-1. It was also assumed that there would be one quarry active at any given time in the vicinity of the construction area. Emissions from the quarry were calculated following the methodology outlined in Section 4.2.1.2.

As shown in Table 4-6, the daily average emission rate of TSP from construction of the mine sites was calculated to be 23.3 g/s. Exhaust emissions from diesel-powered equipment were calculated to be 31.4 g/s for NO_x and 0.2 g/s for SO_2. For each COPC, the total on-site emission rate from the construction scenario is less than that calculated 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 is considered to adequately encompass construction emissions and construction of the mine development area was not carried through to the detailed modelling assessment.

During the construction phase of the mine, the Baker Lake Dock and Storage Facility and the Winter Access Road will be utilized for receiving and shipping construction supplies to the mine development area. The number of anticipated loads during construction will be 2,100 loads per year which is less than the anticipated number of loads (3,920 per year) assessed during mine operations (see Section 4.2.3.1). As a result, the emissions from vehicles along the Winter Access Road as well as from operations at the dock and storage facility will be less during construction of the mine than during operation of the mine. This is illustrated in Table 4-6 which shows the particulate and gaseous COPC emission rates from off-site construction activities (i.e., the Winter Access Road and Baker Lake Dock and Storage Facility). For each COPC, the total off-site emission rate from the construction scenario is less than the rate calculated for the off-site operations scenario (Section 4.2.3). As a result, the assessment of off-site operations adequately encompasses construction emissions. Therefore, off-site construction emissions were not carried through to the detailed modelling assessment.

Table 4-6 Mine Development Area Construction Emission Rate Summary

Construction Emission Source	Emission Rate (g/s)				
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2
Mine Development Area					
Mine Sites: General Construction	20.4	7.5	7.5	28.8	0.2
Borrow quarry (one)	2.9	1.2	0.9	2.6	0.03
Total	**23.3**	**8.7**	**8.4**	**31.4**	**0.2**
Off-Site Sources					
Winter Access Road	17.2	4.2	0.4	0.2	0.01
Baker Lake Dock and Storage Facility	0.1	0.1	0.1	1.9	0.1
Total	**17.3**	**4.3**	**0.5**	**2.1**	**0.1**

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.

4.2.1.3 Construction of the Baker Lake Dock and Storage Area

Construction of the Baker Lake Dock and Storage Facility was also evaluated through an emissions burden analysis. Since construction emissions are generated within the same footprint as operations emissions at the Baker Lake Dock, the emission rates for construction can be compared to the emissions for the operation assessment (Section 4.2.3.2) to determine the potential effect of construction relative to maximum operations. If the emissions from construction are less than or equal to the Baker Lake dock operation emissions, it can be inferred that the potential change in ambient air concentrations will be the same or less and detailed modelling is not required.

For construction of the Baker Lake Dock and Storage Facility, it was assumed that grading/earth moving will be the main source of particulate matter emissions since minimal infrastructure is required at the dock and storage facility. It was also assumed that all grading/earth moving activities would occur over a two week period, resulting in a conservative emission rate estimate. Gaseous emissions from diesel-powered equipment were also calculated.

Emission rates are summarized in Table 4-7 which shows that the daily average emission rate of TSP from the construction of the Baker Lake Dock and Storage Facility is 0.16 g/s. NO_x emissions were calculated to be 0.87 g/s and 0.02 g/s for SO_2. Compared to the emission rates calculated for operations of the Baker Lake Dock and Storage Facility, all COPC emission rates from the construction scenario are less (Section 4.2.3.2). As a result, the assessment of the operations scenario is considered to adequately encompass construction emissions. Therefore, construction of the Baker Lake Dock and Storage Facility was not carried through to the detailed modelling assessment.

Table 4-7 Baker Lake Dock Construction Emissions Rate Summary

Construction Emission Source	Emission Rate (g/s)				
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2
Baker Lake Dock and Storage Facility	1.6E-01	3.9E-02	2.0E-02	8.7E-01	1.7E-02

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 4-8 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 4-9 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 4-10 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 4-11 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 4-8 Period 1 (Year 0 - 1) Maximum Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East Open Pit	1.5E+00	6.0E-01	1.5E-01	1.9E-04	2.7E+00	3.8E-01	2.3E+05
	Main Zone West Open Pit	-	-	-	-	-	-	-
	Centre Zone Open Pit	6.9E+00	2.1E+00	3.4E-01	2.3E-03	5.7E+00	4.0E-01	4.2E+05
	East Zone Open Pit	2.3E+00	8.4E-01	1.8E-01	5.7E-03	3.1E+00	3.8E-01	1.7E+06
	Purpose Built Open Pit	8.7E-01	4.1E-01	1.2E-01	2.2E-04	2.0E+00	3.7E-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	7.0E+05
	Kiggavik Overburden Pile	5.7E+00	1.7E+00	2.8E-01	5.7E-05	5.7E-01	5.6E-03	1.2E+04
	Kiggavik Ore Pile	5.4E-01	2.7E-01	9.8E-02	2.5E-03	2.6E-02	7.5E-03	1.3E+06
	Kiggavik Special Waste Pile	8.4E-01	2.7E-01	1.1E-01	7.6E-04	3.9E-01	1.4E-02	7.1E+05
	Mill	8.8E-02	4.5E-02	1.3E-02	1.2E-04	1.1E-02	2.9E-04	8.4E+04
	Acid Plant	-	-	-	-	3.9E-03	2.4E-02	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	-	-	-	-	-	-	-
Sissons Site	Incinerator at Sissons	-	-	-	-	-	-	-
	On-Site Roads at Kiggavik	9.2E+00	2.4E+00	2.7E-01	9.2E-05	1.2E+00	1.7E-03	-
	Andrew Lake Open Pit	-	-	-	-	-	-	-
	Andrew Lake Mine Rock Pile	-	-	-	-	-	-	-
	Andrew Lake Ore Pile	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	-
	End Grid Special Waste Pile	-	-	-	-	-	-	-
	End Grid Clean Rock Pile	-	-	-	-	-	-	-
	End Grid Special Ore Pile	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-
	On-Site Roads at Sissons	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.9E-03	1.0E-04	-
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	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	-
Maximum Monthly Total Emission Rate		5.0E+01	1.6E+01	4.1E+00	1.4E-02	1.7E+00	8.1E+01	5.2E+06-

Table 4-9 Period 2 (Year 2 - 5) Maximum Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East TMF	-	-	-	-	-	-	3.0E+02
	Main Zone West Open Pit	1.9E+01	5.3E+00	7.0E-01	9.8E-03	8.6E+00	4.0E-01	1.4E+06
	Centre Zone TMF	-	-	-	-	-	-	9.0E+02
	East Zone TMF	-	-	-	-	-	-	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	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 Pile	7.0E-01	3.5E-01	1.1E-01	3.4E-03	2.0E-01	1.1E-02	1.8E+06
	Kiggavik Special Waste Pile	8.2E-01	2.7E-01	1.1E-01	7.4E-04	3.8E-01	1.4E-02	7.6E+05
	Mill	9.4E-01	4.8E-01	1.4E-01	1.3E-03	1.2E-01	3.0E-03	1.2E+06
	Acid Plant	-	-	-	-	4.1E-02	2.6E-01	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	-
Sissons Site	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	-
	On-Site Roads at Kiggavik	9.6E+00	2.5E+00	2.8E-01	9.6E-05	1.2E+00	1.7E-03	-
	Andrew Lake Open Pit	4.6E+00	1.5E+00	2.7E-01	9.1E-04	4.2E+00	3.9E-01	5.9E+05
	Andrew Lake Mine Rock Pile	-	-	-	-	-	-	-
	Andrew Lake Ore Pile	-	-	-	-	-	-	-
	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	1.8E+06
	End Grid Special Waste Pile	6.3E-01	1.9E-01	8.8E-02	1.3E-03	-	-	2.0E+05
	End Grid Clean Rock Pile	6.4E-01	2.0E-01	8.9E-02	1.6E-04	-	-	3.1E+04
	End Grid Special Ore Pile	-	-	-	-	-	-	-
	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	1.4E+05
	On-Site Roads at Sissons	3.1E+01	9.6E+00	1.9E+00	7.5E-03	8.4E+00	9.7E-02	2.2E+06
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	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.2E-03	6.0E-05	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	-
Maximum Monthly Total Emission Rate		8.1E+01	2.7E+01	6.9E+00	2.3E-02	1.0E+02	1.3E+00	1.2E+07

Table 4-10 Period 3 (Year 6 – 13) Maximum Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East TMF	-	-	-	-	-	-	1.0E+03
	Main Zone West TMF	-	-	-	-	-	-	1.6E+03
	Centre Zone TMF	-	-	-	-	-	-	9.0E+02
	East Zone TMF	-	-	-	-	-	-	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 Pile	5.7E-01	2.8E-01	1.0E-01	2.7E-03	9.1E-03	7.3E-03	1.7E+06
	Kiggavik Special Waste 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	1.1E+06
	Acid Plant	-	-	-	-	4.6E-02	2.9E-01	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	-
Sissons Site	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	-
	On-Site Roads at Kiggavik	-	-	-	-	-	-	-
	Andrew Lake Open Pit	2.9E+01	8.0E+00	1.0E+00	1.2E-02	1.1E+01	4.2E-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	7.4E+05
	Andrew Lake Ore Pile	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	2.0E+06
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.8E-04	-	-	2.6E+05
	End Grid Clean Rock Pile	2.3E-01	1.2E-01	4.6E-02	5.8E-05	-	-	3.1E+04
	End Grid Special Ore Pile	2.6E-01	1.3E-01	4.8E-02	1.1E-03	-	-	1.3E+05
	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	3.5E+05
	On-Site Roads at Sissons	4.5E+01	1.4E+01	2.4E+00	1.5E-02	9.7E+00	1.1E-01	2.8E+06
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	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.2E-03	6.0E-05	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	-
Maximum Monthly Total Emission Rate		8.3E+01	2.6E+01	6.5E+00	2.4E-02	1.0E+02	9.2E-01	1.3E+07

Table 4-11 Period 4 (Year 14) Maximum Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East TMF	-	-	-	-	-	-	1.0E+03
	Main Zone West TMF	-	-	-	-	-	-	1.6E+03
	Centre Zone TMF	-	-	-	-	-	-	9.0E+02
	East Zone TMF	-	-	-	-	-	-	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 Pile	4.7E-01	2.4E-01	1.0E-01	3.1E-03	3.8E-01	2.1E-02	2.1E+06
	Kiggavik Special Waste Pile	-	-	-	-	-	-	7.6E+05
	Mill	1.5E-01	7.7E-02	2.3E-02	2.0E-04	1.9E-02	4.9E-04	1.5E+05
	Acid Plant	-	-	-	-	6.7E-03	4.2E-02	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	-	-	-	-	-	-	-
Sissons Site	Incinerator at Sissons	-	-	-	-	-	-	-
	On-Site Roads at Kiggavik	-	-	-	-	-	-	-
	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
	Andrew Lake Ore Pile	-	-	-	-	-	-	-
	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 Special Waste Pile	-	-	-	-	-	-	-
	End Grid Clean Rock Pile	-	-	-	-	-	-	-
	End Grid Special Ore Pile	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-
	End Grid Underground Mine Exhaust	-	-	-	-	-	-	-
	On-Site Roads at Sissons	3.0E-01	7.7E-02	7.7E-03	3.0E-06	6.9E-03	1.0E-04	-
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	-
	Road to Airstrip	1.8E-01	5.2E-02	5.1E-03	1.8E-06	1.4E-02	5.7E-05	-
Maximum Monthly Total Emission Rate		7.8E+00	4.5E+00	2.7E+00	4.3E-03	6.4E+01	1.3E-01	8.4E+06

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 4-12 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 4-12 Maximum Bounding Scenario Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East TMF	-	-	-	-	-	-	1.0E+03
	Main Zone West Open Pit	2.2E+01	6.2E+00	8.3E-01	1.2E-02	1.3E+01	9.1E-01	1.1E+06
	Centre Zone TMF	-	-	-	-	-	-	9.0E+02
	East Zone TMF	-	-	-	-	-	-	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	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	6.7E+05
	Kiggavik Overburden Pile	4.3E+00	1.3E+00	2.4E-01	4.3E-05	4.9E-01	7.7E-03	1.5E+04
	Kiggavik Ore Pile	7.0E-01	3.5E-01	1.1E-01	4.7E-03	2.9E-02	7.5E-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	7.6E+05
	Mill	1.1E+00	5.6E-01	1.6E-01	1.5E-03	1.4E-01	3.6E-03	1.8E+06
	Acid Plant	-	-	-	-	4.9E-02	3.0E-01	-
	Power Plant at Kiggavik	2.0E+00	1.9E+00	1.8E+00	-	6.3E+01	5.8E-03	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	4.9E-01	4.8E-01	4.5E-01	-	1.6E+01	8.6E-04	-
Sissons Site	Incinerator at Sissons	1.1E-02	8.8E-03	5.0E-03	-	5.2E-02	2.8E-02	-
	On-Site Roads at Kiggavik	1.6E+01	4.1E+00	4.6E-01	1.6E-04	2.0E+00	2.9E-03	-
	Andrew Lake Open Pit	3.4E+01	9.2E+00	1.2E+00	1.4E-02	1.6E+01	9.1E-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	7.5E+05
	Andrew Lake Ore Pile	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	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	2.0E+06
	End Grid Special Waste Pile	2.3E-01	1.2E-01	4.6E-02	4.9E-04	-	-	2.6E+05
	End Grid Clean Rock Pile	2.4E-01	1.2E-01	4.7E-02	6.1E-05	-	-	3.1E+04
	End Grid Special Ore Pile	2.5E-01	1.3E-01	4.8E-02	1.3E-03	-	-	1.5E+05
	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	2.8E+05
	On-Site Roads at Sissons	1.6E+01	4.1E+00	4.5E-01	1.6E-04	1.8E+00	2.9E-03	-
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	-
	Road to Baker Lake (1 km segment modelled)	3.2E-01	8.2E-02	8.2E-03	-	4.1E-03	5.6E-05	-
	Road to Airstrip	1.8E-01	5.2E-02	5.0E-03	1.8E-06	1.3E-02	3.7E-05	-
Maximum Monthly Total Emission Rate		1.4E+07	1.8E+02	5.5E+01	1.1E+01	6.7E-02	2.4E+00	7.1E+01

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 access road.

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 Access Road

The Winter Access Road option assessed is shown in Figure 3. Approximately 50% of the Winter Road will cross over land which 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 4-13 summarizes the emission rates calculated for the winter road option.

All-Season Access Road Option

As an alternative to the Winter Road, an All-Season Road 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 4-13.

4.2.3.2 Baker Lake Dock Assessment

At the Baker Lake Dock and Storage Facility, sea-containers and 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 4-14.

Table 4-13 Access Road Options Emission Rate Summary

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

Table 4-14 Baker Lake Facility Operations Emission Rate Summary

Source	Emission Rate (g/s)				
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2
Yard Operations	3.70E-04	3.70E-04	3.59E-04	1.01E-01	1.75E-02
2 Docked Tug-Barges	1.62E-01	1.55E-01	1.43E-01	3.37E+00	2.05E-01
Total	**1.62E-01**	**1.56E-01**	**1.43E-01**	**3.47E+00**	**2.23E-01**

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 4-15 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.

The model used to calculate radon emissions from decommissioned TMFs was based on the methodology recommended by the IAEA Technical Reports Series No. 474 (2013), with additional guidance from U.S. NRC Regulatory Guide 3.46 (1989) and IAEA Technical Reports Series No. 333 (1992). The parameter values were based on default values recommended by IAEA or the NRC guideline, and site-specific values where available. The parameters and their values, as well as equations used in the estimation are provided in Attachment A.

Table 4-16 provides a summary of the radon emission rates from the permanent Type II mine rock stockpiles and the covered TMFs.

Table 4-15 Final closure Emission Rate Summary

Location	Source	Emission Rate (g/s)						
		TSP	PM_{10}	$PM_{2.5}$	U	NO_x	SO_2	Radon (Bq/s)
Kiggavik Site	Main Zone East TMF	8.0E-01	2.4E-01	9.0E-02	7.2E-04	2.9E-01	4.1E-03	8.9E+05
	Main Zone West Open Pit	1.4E+00	3.9E-01	1.5E-01	1.3E-03	5.9E-01	8.2E-03	1.4E+06
	Centre Zone TMF	3.9E-01	1.2E-01	4.7E-02	7.0E-05	1.7E-01	2.4E-03	6.8E+04
	East Zone TMF	-	-	-	-	-	-	6.2E+04
	Purpose Built Open 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	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	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	-
	Incinerator at Kiggavik	2.2E-02	1.8E-02	1.0E-02	-	1.0E-01	5.6E-02	-
	Power Plant at Sissons	-	-	-	-	-	-	-
Sissons Site	Incinerator at Sissons	-	-	-	-	-	-	-
	On-Site Roads at Kiggavik	2.8E-01	7.2E-02	8.1E-03	2.8E-06	3.6E-02	5.3E-05	-
	Andrew Lake Open Pit	9.7E-01	2.7E-01	6.4E-02	4.5E-04	3.3E-01	2.8E-03	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+05
	Andrew Lake Ore Pile	-	-	-	-	-	-	-
	Andrew Lake Overburden Pile	-	-	-	-	-	-	-
	Andrew Lake Clean Rock Pile	-	-	-	-	-	-	2.0E+06
	End Grid Special Waste Pile	-	-	-	-	-	-	-
	End Grid Clean Rock Pile	-	-	-	-	-	-	-
	End Grid Special Ore Pile	-	-	-	-	-	-	-
	Backfill Plant	-	-	-	-	-	-	-
	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	-
Roads	Haul road b/n Kiggavik and Sissons	-	-	-	-	-	-	-
	Road to Baker Lake (1 km segment modelled)	-	-	-	-	-	-	-
	Road to Airstrip	-	-	-	-	-	-	-
Maximum Monthly Total Emission Rate		5.5E+00	3.1E+00	2.2E+00	1.6E-03	7.6E-02	2.4E+00	8.0E+06

Table 4-16 Post-closure Radon Emission Rates

Location	Source Description	Emission Rate (Bq/s)
		Radon
Kiggavik Site	Main Zone East Pit	1.72E+05
	Main Zone West Pit	1.07E+05
	Centre Zone Pit (CZ)	9.45E+04
	East Zone Pit (EZ)	4.36E+04
	Purpose Built Pit (PB)	1.33E+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 4-17 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 (Solomon et al. 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 43.8% increase in the baseline GHG emissions for Nunavut and a 0.03% increase in the baseline GHG emissions for Canada.

Table 4-18 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)	% Change in GHG Emissions due to Project
Canada	699,203	699,384	+0.03%
Nunavut	413	594	+43.8%

Notes:

(a) Includes2012 National Inventory Report GHG emissions, plus 2012 Meadowbank Gold Mine GHG emissions estimate of 203 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 CALPUFF Modelling Approach

The following sections describe the general modelling approach taken, including source type selection, for each of the assessment scenarios. The CALPUFF model options used are outlined in Table 5-1 below. Other details such as source parameterization are provided in Attachment C.

Table 5-1 CALPUFF Model Options

Flag	Default	Used Value	Comments
MGAUSS	1	1	Vertical distribution used in the near field
MCTADJ	3	3	Terrain adjustment method (3 used for partial plume path adjustment)
MCTSG	0	0	Subgrid-Scale complex terrain flag
MSLUG	0	0	Near-field puffs modelled as elongated
MTRANS	1	1	Transitional Plume Rise modelled
MTIP	1	1	Stack-tip downwash
MRISE	1	1	Plume rise for point sources not subject to building downwash 1 = Birggs plume rise, 2 = Numerical plume rise
MBDW	1	2	Method used to simulate building downwash 1 = ISC method; 2 = PRIME method
MSHEAR	0	0	Vertical wind shear modelled above stack top
MSPLIT	0	0	Puff splitting allowed 0 = No; 1 = Yes
MCHEM	1	0	Chemical Transformation Scheme 0 = chemical transformation not modelled 1 = transformation rates computed internally (MESOPUFF II scheme)
MAQCHEM	0	0	Aqueous phase transformation flag (only used if MCHEM =1 or 3)
MWET	1	1	Wet removal modelled 0 = No; 1 = Yes
MDRY	1	1	Dry deposition modelled 0 = No; 1 = Yes
MTILT	0	0	Gravitational settling (plume tilt) modelled

Table 5-1 CALPUFF Model Options

Flag	Default	Used Value	Comments
MDISP	3	2	Methods used to compute dispersion coefficients 2 = (dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) 3 = PG dispersion coefficient for RURAL areas (computed using the ISCST multi-segment approximation) and MP coefficients in urban areas)
MTURBVW	3	3	Sigma measurements used (Used only if MDISP = 1or 5)
MDISP2	3	3	Back-up method used to compute dispersion when measured turbulence data are missing (Used only if MDISP=1 or 5)
MTAULY	0	0	[DIAGNOSTIC FEATURE] Method used for Lagrangian timescale for Sigma-y (used only if MDISP=1,2 or MSIDP2=1,2)
MTAUADV	0	0	[DIAGNOSTIC FEATURE] Method used for Advective-Decay timescale for Turbulence (used only if MDISP=2 or MDISP2=2)
MCTURB	1	1	Method used to compute turbulence sigma-v & sigma-w using micrometeorological variables (Used only if MDISP = 2 or MDISP2 = 2)
MROUGH	0	0	PG sigma y,z adjusted for roughness
MPARTL	1	1	Partial plume penetration of elevated inversion modeled for point sources; 0 = No, 1 = Yes
MPARTLBA	1	1	Partial plume penetration of elevated inversion modeled for buoyant area sources; 0 = No, 1 = Yes
MTINV	0	0	Strength of temp inversion provided in PROFILE.DAT extended records
MPDF	0	0	Probability Distribution Function used for dispersion under convective conditions 0 = No; 1 = Yes
MSGTIBL	0	0	Sub-grid TIBL module used for shore line
MBCON	0	0	Boundary conditions (concentration) modeled
MFOG	0	0	Configure for FOG Model output
MREG	1	0	Test options specified to see if they conform to regulatory values

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 5-2.

Table 5-2 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, average monthly 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 are also depicted in Figure 2.

Concentrations and deposition rates were modelled at defined receptor locations within the modelling domain. A receptor height of 1.5 m was used for the purpose of providing appropriate inputs to the pathways model (Volume 8). 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 human health and ecological risk assessment (Volume 8) and presented in Table 5-3. All receptors, including the receptor grid and sensitive POR are shown graphically in Figure 7.

Table 5-3 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 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 Baker Lake-Kiggavik access road options were modelled separately from activities occurring within the Mine Development Area. However, a 1 km stretch of Baker Lake-

Kiggavik 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 materials containing uranium and metals 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 Baker Lake-Kiggavik 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 and 212 for the Winter Access 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. It was assumed that emissions would only occur for the months December through March for the winter option (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 5-3. 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 option 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 5-3 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 5-3). The modelling domain and receptors used for assessing the Baker Lake Dock and Storage Facility are shown in Figure 11.

5.3.5 Dust Deposition

Dust deposition was modelled using the same inputs as the Maximum Operation Assessment (see Table 4-12). Although dust deposition has applicable criteria with long-term averaging periods (i.e., monthly and annual), the Maximum Operation Assessment (developed to assess COPCs with short-term criteria) was used to determine dust deposition from the Project. Recall that the Maximum Operation Assessment greatly overestimates annual TSP emissions and consequently overestimates the resulting concentrations. Therefore, the results for dust deposition are considered conservative.

Since the pathways assessment required receptor heights of 1.5 m, a separate CALPUFF run was needed for dust deposition which requires ground-based receptor heights (i.e., equal to 0 m). For this run, dry deposition was modelled using the parameters described in Attachment C. Wet deposition was not considered since emissions of dust are greatly supressed during precipitation events; however, to ensure the assessment was conservative, the dust emission rates were not reduced to account for these events and consequently, dry deposition will be overestimated. Additionally, wet deposition of large particles like the dust emitted from unpaved roads, is typically negligible compared to dry deposition.

5.3.6 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 4-9). 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 dry and wet deposition parameters used are provided in Attachment C. 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 rates (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 5-3) and compared to applicable criteria, standards, objectives or guidelines.

For most COPCs, concentrations presented and discussed herein are maximum concentrations which include the addition of background concentrations presented in Section 3.1.3. However, for reasons discussed previously, NO_2, SO_2 and radon concentrations are presented as incremental values above and beyond existing baseline air quality conditions.

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 dust deposition and Potential Acid Input (PAI) are also presented in Section 6.2. 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 concentrations 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 2 km from the edge of each quarry.

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

	UTM Coordinates (m)		Maximum Concentration at a distance of 500 m from the Quarry						
			TSP	PM_{10}	$PM_{2.5}$	NO_2		SO_2	
Quarry	Easting	Northing	24-hour Maximum	24-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum	1-hour Maximum	24-hour Maximum
Q2	573460	7152497	21.4	11.3	7.7	38.6	10.6	0.8	0.2
Q10	615476	7150167	16.3	9.0	6.0	37.2	7.5	0.7	0.1
Q18	642133	7138389	16.7	8.8	5.8	34.1	7.2	0.7	0.1
Background Concentration (µg/m³)			6.8	3.4	1.7	-	-	-	-
Air Quality Criteria (µg/m³)			**120**	**50**	**27**	**400**	**200**	**450**	**150**

Notes:

Concentrations of TSP, PM_{10} and $PM_{2.5}$ include background concentrations.

6.2 Operation Assessments

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

- phased site operations, including Potential Acid Input (PAI);
- maximum operations, including dust deposition;
- 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 ecological 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 may 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. The exception is dust deposition, which was conservatively estimated using the maximum operation assessment.

6.2.1 Phased Operation Assessment

The predicted 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 6-7 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 in Section 3.1.3, with the exception of NO_2, SO_2 and radon, the concentrations presented in the tables and figures 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 primarily 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 and tables 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. As the figures and tables in Attachment D show, all predicted concentrations are below their applicable criteria in the LAA.

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

Sensitive Point of Reception	UTM Coordinates (m)		Annual TSP Concentration (µg/m³) (including background)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	22.5	17.2	7.7	4.3
Community of Baker Lake	644179	7135840	2.9	2.9	2.9	2.9
Judge Sissons Lake Cabin	566550	7137729	3.4	3.7	3.3	3.0
Background Concentration (µg/m³)			**2.9**			
Air Quality Criteria (µg/m³)			**60**			

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 (µg/m³)			
	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	6.2	6.6
Community of Baker Lake	644179	7135840	0.03	0.04	0.04	0.03
Judge Sissons Lake Cabin	566550	7137729	0.8	0.8	0.6	0.4
Air Quality Criteria (µg/m³)			**100**			

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

Sensitive Point of Reception	UTM Coordinates (m)		Annual Uranium Concentration (µg/m³) (including background)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	1.2E-02	1.7E-02	1.0E-02	6.6E-03
Community of Baker Lake	644179	7135840	2.1E-05	2.7E-05	2.6E-05	1.2E-05
Judge Sissons Lake Cabin	566550	7137729	4.4E-04	6.4E-04	4.2E-04	9.3E-05
Background Concentration (µg/m³)			**9.9E-06**			
Air Quality Criteria (µg/m³)			**0.03**			

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	7.7E+00	1.2E+01	1.1E+01	9.1E+00
Community of Baker Lake	644179	7135840	5.1E-03	8.2E-03	7.9E-03	6.5E-03
Judge Sissons Lake Cabin	566550	7137729	1.9E-01	2.9E-01	2.4E-01	2.0E-01
Air Quality Criteria (Bq/m^3)			**60**			

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

Sensitive Point of Reception	UTM Coordinates (m)		Annual Pb-210 Concentration (Bq/m^3) (including background)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	2.8E-04	3.4E-04	2.6E-04	2.1E-04
Community of Baker Lake	644179	7135840	1.3E-04	1.3E-04	1.3E-04	1.3E-04
Judge Sissons Lake Cabin	566550	7137729	1.3E-04	1.4E-04	1.3E-04	1.3E-04
Background Concentration (Bq/m^3)			**1.3E-04**			
Air Quality Criteria (Bq/m^3)			**0.0021**			

Table 6-7 Annual Po-210 Concentration for Operational Periods 1 to 4 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		Annual Po-210 Concentration (Bq/m^3) (including background)			
	Easting	Northing	Period 1 (0-1)	Period 2 (2-5)	Period 3 (6-13)	Period 4 (14)
Accommodation Complex	564900	7148433	2.0E-04	2.6E-04	1.8E-04	1.4E-04
Community of Baker Lake	644179	7135840	5.4E-05	5.4E-05	5.4E-05	5.4E-05
Judge Sissons Lake Cabin	566550	7137729	5.9E-05	6.2E-05	5.9E-05	5.5E-05
Background Concentration (Bq/m^3)			**5.4E-05**			
Air Quality Criteria (Bq/m^3)			**0.0028**			

6.2.1.1 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 do 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 6-8 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:

Total PAI values presented include background PAI.

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 concentrations of COPCs are presented in Tables 6-9 through 6-13 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 also 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 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 and mine site roads.

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 about 30 days of exceedances per year beyond the footprint of the mine sites (otherwise known as off-site) for TSP and for PM_{10} and only 4 days of exceedances of the $PM_{2.5}$ criterion off-site. Additionally, at the Accommodation Complex, there are only 11 out of 365 days where the TSP criterion of 120 µg/m^3 is exceeded. There are 15 days of exceedances for PM_{10} at the Accommodation Complex and zero days for $PM_{.2.5}$.

6.2.2.2 Dust Deposition

As previously mentioned, the deposition model outputs were not used to assess potential effects to air quality in Tier 2, Volume 4. Instead, they were used as inputs to other environmental effects assessments including the aquatic and terrestrial environments (see Volumes 5 and 6, respectively). However, for completeness and transparency, the results are presented here in brief.

The maximum monthly, average annual and total annual dust deposition results are presented graphically in Figure 35, Figure 36 and Figure 37, respectively. Model results are also presented in Table 6-10 at the sensitive POR locations. As can be seen in the figures, dust deposition levels are less than the Indicator Threshold beyond the Project Footprint.

Like TSP concentrations, dust deposition rates are largely a result of emissions from open pit mining activities (particularly haul truck movements in and out of pits) and traffic along the Kiggavik-Sissons access road. This is evident in Figures 35 to 37 which show the highest dust deposition rates in close proximity to the mine sites and the Kiggavik-Sissons access road. However, deposition rates quickly drop off with distance from the mine site and road. For example, Figure 37 shows that in the vicinity of the Kiggavik-Sissons access road, the deposition rate drops from 15 g/m²/year at around 200 m to 5 g/m²/year by 800 m from of the road (a 67% decrease). At about 12 km from the Project Footprint, total annual deposition begins to approach background levels.

The pattern of the dust deposition results for the Kiggavik Project are similar to the findings described in the EKATI Diamond Mine dispersion modelling assessment (Rescan 2006a), which predicted high dust deposition rates around the haul roads that dropped off quickly with increasing distance. The EKATI assessment also predicted that measurable dust deposition rates (i.e., above baseline) occur within a zone of 14 km from the mine site which is not unlike the predictions made here for the Kiggavik Project. The dustfall pattern predicted in the EKATI assessment has since been verified by an ongoing dustfall monitoring program (Rescan 2006b; 2010; 2012) which has shown that zone of influence is between 14 to 20 km. Additionally, dustfall measurements within the vicinity of the haul roads at EKATI show that on average, values drop by about 75% within 90 m of the EKATI haul roads and by 80-90% within 300 m of the haul roads. These results are consistent with the measurements made along the Meadowbank All Weather Access Road, which showed that dustfall values decrease by almost 60% within 100 m of the road (Agnico Eagle Mines Limited 2013). These measurements indicate that dust levels along haul roads actually decrease faster than what was predicted by the model along the Kiggavik-Sissons access road which suggests that the predictions for Kiggaik are conservative. A more detailed comparison to EKATI Mine as well as the Meadowbank Mine dust deposition modelling can be found in Attachment E.

6.2.2.3 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 38 (1-hour NO_2), Figure 39 (24-hour NO_2), Figure 42 (1-hour SO_2) and Figure 43 (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 6-11).

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 39). Figure 38 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 NOx 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 6-12. 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 40 and Figure 41, respectively. As Figure 40 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.

6.2.2.4 Uranium and Metals

The maximum 24-hour average concentration of uranium is presented graphically in Figure 44. 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 6-13).

All predicted maximum 24-hour metal concentrations are well below applicable criteria. In contrast, maximum 24-hour uranium concentrations are marginally above the 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 45. At the Accommodation Complex, the 24-hour uranium AAQC is only exceeded once out of 365 days (Table 6-13). Figure 45 also indicates that the number of exceedances within about 1,100 m 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 Maximum 24-hour Concentrations of TSP, PM_{10} and $PM_{2.5}$ at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)
	Easting	Northing	24-hour Maximum	Frequency of Exceedances 24-hour Max (days per year)	24-hour Maximum	Frequency of Exceedances 24-hour Max (days per year)	24-hour Maximum
Accommodation Complex	564900	7148433	**290.0**	11	**118.6**	15	24.2
Community of Baker Lake	644179	7135840	7.5	n/a	4.0	n/a	1.9
Judge Sissons Lake Cabin	566550	7137729	19.6	n/a	14.5	n/a	3.7
Background Concentration (µg/m³)			**6.8**	-	**3.4**	-	1.7
Air Quality Criteria (µg/m³)			**120**	-	**50**	-	27

Notes:
Concentrations presented include background concentrations.
Red text indicates that a value is greater than the air quality criteria.

Table 6-10 Maximum Monthly, Annual Average and Total Annual Dust Deposition for the Maximum Operation Assessment

Receptor Name	UTM Coordinates (m)		Dust Deposition (including background)		
	Easting	Northing	Maximum Monthly (g/m²/30 days)	Average Annual (g/m²/30 days)	Total Annual (g/m²/year)
Accommodation Complex	564900	7148434	2.3	1.3	15.8
Community of Baker Lake	644179	7135840	0.04	0.04	0.5
Judge Sissons Lake Cabin	566550	7137729	0.2	0.1	1.6
Background Dustfall			0.04 g/m²/30 days	0.04 g/m²/30 days	0.48 g/m²/year
Air Quality Criteria			**7 g/m²/30 days**	**4.6 g/m²/30 days**	**55 g/m²/year**

Table 6-11 Incremental Maximum 1- and 24-hour Concentrations of NO_2 and SO_2 at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		NO_2 (µg/m^3)			SO_2 (µg/m^3)	
	Easting	Northing	Incremental 1-hour Maximum	Frequency of Exceedances 1-hour Max (days per year)	Incremental 24-hour Maximum	Incremental 1-hour Maximum	Incremental 24-hour 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 (µg/m^3)			**400**	-	**200**	**450**	**150**

Notes:
Concentrations predicted as a result of all sources, including blasting.

Table 6-12 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-hour Maximum	Frequency of Exceedances 1-hour 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

Table 6-13 Maximum 24-hour Concentrations of Metals at Sensitive Points of Reception

Sensitive Point of Reception	UTM Coordinates (m)		24-hour Maximum Concentrations (µg/m³) (including background)										
	Easting	Northing	U	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	3.1E-01 (1 day)	1.1E-03	1.9E-04	2.7E-02	3.7E-03	4.1E-02	2.1E-02	8.2E-03	1.1E-02	9.4E-04	2.2E-02
Community of Baker Lake	644179	7135840	9.9E-04	2.9E-04	1.4E-04	6.7E-04	1.1E-04	3.5E-02	2.7E-03	6.0E-04	4.0E-04	4.5E-04	1.1E-02
Judge Sissons Lake Cabin	566550	7137729	1.7E-02	4.4E-04	1.4E-04	5.1E-03	3.3E-04	3.6E-02	3.6E-03	9.5E-04	1.6E-03	5.1E-04	1.2E-02
Background Concentration (µg/m³)			2.4E-05	2.8E-04	1.4E-04	5.1E-04	9.1E-05	3.5E-02	2.6E-03	5.8E-04	3.4E-04	4.5E-04	1.1E-02
Air Quality Criteria (µg/m³)			**0.3**	**0.3**	**0.025**	**0.5**	**0.1**	**50**	**0.5**	**120**	**0.2***	**10**	**120**

Notes:
Red text indicates that a value is greater than the air quality criteria. Number of exceedances is in brackets. Only one (1) exceedance was predicted at the Accommodation Complex.

6.2.3 Access Roads Assessment

Two 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 concentration for each COPC is presented in Table 6-14.

All contour plots are provided in Attachment D, however, for the purpose of comparing and discussing the differences between road options, the predicted annual and 24-hour maximum concentrations of TSP for all road options are presented graphically in Figures 46 through 49. 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 6-14 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 option. The Winter Road option has a lower potential for emissions since only limited sections of this roadway is 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 option. This a result of higher daily traffic counts compared to the All-Season Road. Daily traffic volumes were higher for the Winter Road option because of a narrower operating window of 90 days.

Table 6-14 Overall Maximum Dust and Gaseous Concentrations predicted for each Baker Lake-Kiggavik Access Road Option

Access Road Option	Overall Maximum Concentrations											
	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		NO_2 (µg/m³)			SO_2 (µg/m³)		
	24-hour Maximum	Annual	24-hour Maximum	Annual	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual
All-Season Access Road	61.7	8.0	23.6	3.1	6.1	1.0	1.4E-01	7.0E-02	8.8E-03	1.0E-02	5.4E-03	6.7E-04
Winter Access Road	29.7	4.3	8.1	1.9	0.9	0.7	3.5E-01	2.6E-01	1.5E-02	3.0E-02	2.3E-02	1.3E-03
Background Concentration (µg/m³)	6.8	2.9	3.4	1.5	1.7	0.7	-	-	-	-	-	-
Air Quality Criteria (µg/m³)	**120**	**60**	**50**	**-**	**27**	**8.8**	**400**	**200**	**100**	**450**	**150**	**30**

Notes:

Concentrations of TSP, PM_{10} and $PM_{2.5}$ include background concentrations.

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 maximum predicted 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 6-15. At this sensitive POR, incremental concentrations for all contaminants are well below applicable criteria.

Contour plots showing the concentrations of TSP and NO_2 over short-term averaging periods in and around the Baker Lake dock are provided in Figure 50, Figure 51 and Figure 52. 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 50 shows that incremental 24-hour TSP concentrations are well below the 24-hour criterion of 120 $\mu g/m^3$. 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 53 and the results of the 24-hour NO_2 analysis are presented in Figure 54. 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 6-15 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)		Maximum Concentrations										
			TSP ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		NO_2 ($\mu g/m^3$)			SO_2 ($\mu g/m^3$)		
	Easting	Northing	24-hour Maximum	Annual	24-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual	1-hour Maximum	24-hour Maximum	Annual
Community of Baker Lake	644179	7135840	7.7	2.9	4.3	2.5	60.6	59.9	11.7	0.2	5.5	1.1	0.02
Background Concentration ($\mu g/m^3$)			6.8	2.9	3.4	1.7	0.7	-	-	-	-	-	-
Air Quality Criteria ($\mu g/m^3$)			**120**	**60**	**50**	**27**	**8.8**	**400**	**200**	**100**	**450**	**150**	**30**

Notes:

Concentrations of TSP, PM_{10} and $PM_{2.5}$ include background concentrations.

6.3 Final Closure Assessment

The predicted annual concentrations of TSP, NO_2, uranium and radon for the final closure phase of the Project are presented in Table 6-16. Contour plots for each of these COPCs are presented in Figure 55, Figure 56, Figure 57 and Figure 58, respectively. Annual concentrations for metals are shown in Table 6-17 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 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, 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.

Finally, the radon concentrations predicted at the POR during closure are of the same order of magnitude (Accommodation Complex and Baker Lake POR) or higher (Judge Sissons Cabin POR) than radon levels predicted during the operational phase of the Project. This is partly due to the increase in the amount of exposed surface area of special waste and increased radon emissions as a result. As well, the covered TMFs in the final-closure stage have increased radon emissions compared to unconsolidated and water covered TMFs in the operations phase. Therefore, it can be expected that concentrations at the sensitive POR would be of the same magnitude or higher during closure compared to operations. Also note that the source configuration has changed between operations and final closure. For example, special waste material (a source of radon) has been moved from the special waste stock pile and back filled into open pits and TMFs at the Kiggavik mine site. This change in proximity of special waste relative to the Judge Sissons Lake Cabin in combination with the final closure emission rates has caused the increase in radon concentration relative to operations.

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 6-18 and the annual radon contour plot is provided in Figure 59. As can been seen in both table and figure, the predicted incremental radon concentrations are well below applicable criteria.

Table 6-16 Annual TSP, NO_2, Uranium and Radon Concentrations during Final Closure

Receptor Name	UTM Coordinates (m)		Annual Concentrations			
	Easting	Northing	TSP (µg/m³)	NO_2 (µg/m³)	Uranium (µg/m³)	Radon (Bq/m³)
Camp	564900	7148433	4.0	6.4	6.8E-04	6.4
Baker Lake	644179	7135840	2.9	6.9E-03	1.1E-05	0.01
Judge Sissons Lake	566550	7137729	3.0	4.3E-01	4.9E-05	0.4
		Background Concentration	**2.9 (µg/m³)**	**-**	**9.9E-06**	**-**
		Air Quality Criteria	**60 (µg/m³)**	**100 (µg/m³)**	**0.03 (µg/m³)**	**60 (Bq/m³)**

Notes:
Concentrations of TSP and Uranium include background concentrations.

Table 6-17 Annual Metals Concentrations during Final Closure

Receptor Name	UTM Coordinates (m)		Annual Concentration (µg/m³) (including background)									
	Easting	Northing	As	Cd	Cr	Co	Cu	Pb	Mo	Ni	Se	Zn
Accommodation Complex	564900	7148433	1.2E-04	6.0E-05	2.7E-04	5.1E-05	1.5E-02	1.1E-03	2.5E-04	1.7E-04	2.0E-04	4.6E-03
Community of Baker Lake	644179	7135840	1.2E-04	6.0E-05	2.2E-04	4.0E-05	1.5E-02	1.1E-03	2.4E-04	1.5E-04	2.0E-04	4.5E-03
Judge Sissons Lake Cabin	566550	7137729	1.2E-04	6.0E-05	2.2E-04	4.1E-05	1.5E-02	1.1E-03	2.4E-04	1.5E-04	2.0E-04	4.5E-03
		Background Concentration (µg/m³)	1.2E-04	6.0E-05	2.2E-04	4.0E-05	1.5E-02	1.1E-03	2.4E-04	1.5E-04	2.0E-04	4.5E-03
		Reference Level (µg/m³)	0.06	0.005	0.3	0.02	9.6	0.10	23	0.4	1.9	23

Table 6-18 Post-Closure Incremental Annual Radon Concentration

Receptor Name	UTM Coordinates (m)		Annual Radon Concentration(Bq/m³)
	Easting	Northing	
Accommodation Complex	564900	7148433	1.1E+00
Community of Baker Lake	644179	7135840	3.2E-03
Judge Sissons Lake Cabin	566550	7137729	8.7E-02
		Air Quality Criteria (Bq/m³)	**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 human health and ecological risk assessment (Volume 8).

Over the life of the Project, none of the predicted 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. Predicted dust deposition was also less than its criteria. 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 11 days of exceedances of the TSP criterion of 120 $\mu g/m^3$ and 15 days of exceedances of the PM_{10} criterion of 50 $\mu g/m^3$. 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 4 days. 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 $\mu g/m^3$) nor the 24-hour criteria (200 $\mu g/m^3$) 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.

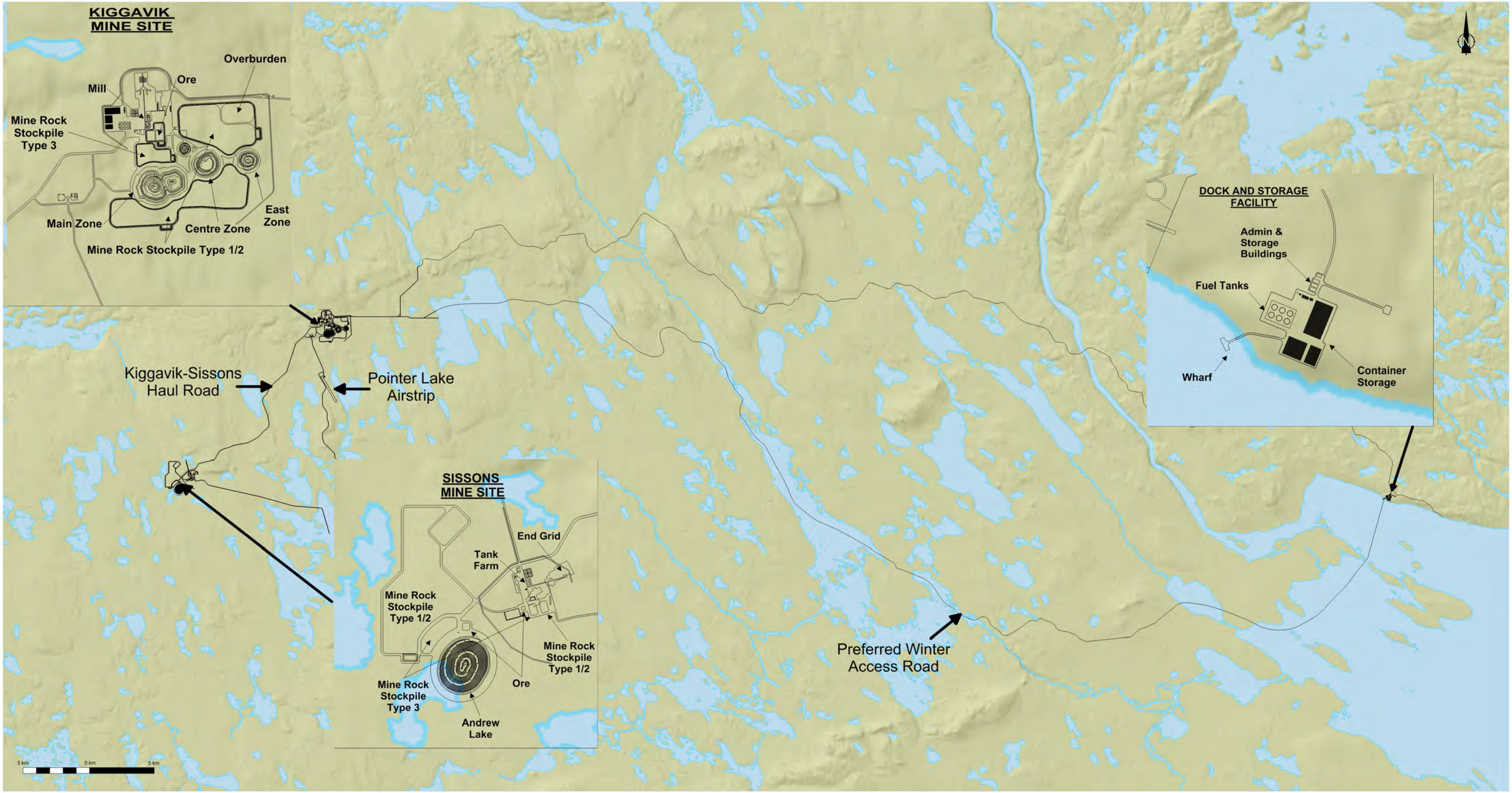
The Baker Lake-Kiggavik Access Road options, Baker Lake Dock and Storage Facility operations, and the borrow quarries were all assessed using separate model runs. With the exception of NO_2 concentrations resulting from dock operations, all predicted annual, 1-hour and 24-hour COPC concentrations for 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 Baker Lake 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 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 sites, including in-pit ramps. Controls such as watering (or equivalent control method) and low vehicle speeds have already been considered in this assessment. Therefore, it is recommended that monitoring of dust take place at the Accommodation Complex and other locations in proximity to the mine sites to verify model results and ensure compliance. If exceedances are observed, enhanced dust controls should be considered at that time. A detailed mitigation and monitoring plan is provided in Appendix 4C.

8 Figures



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 1

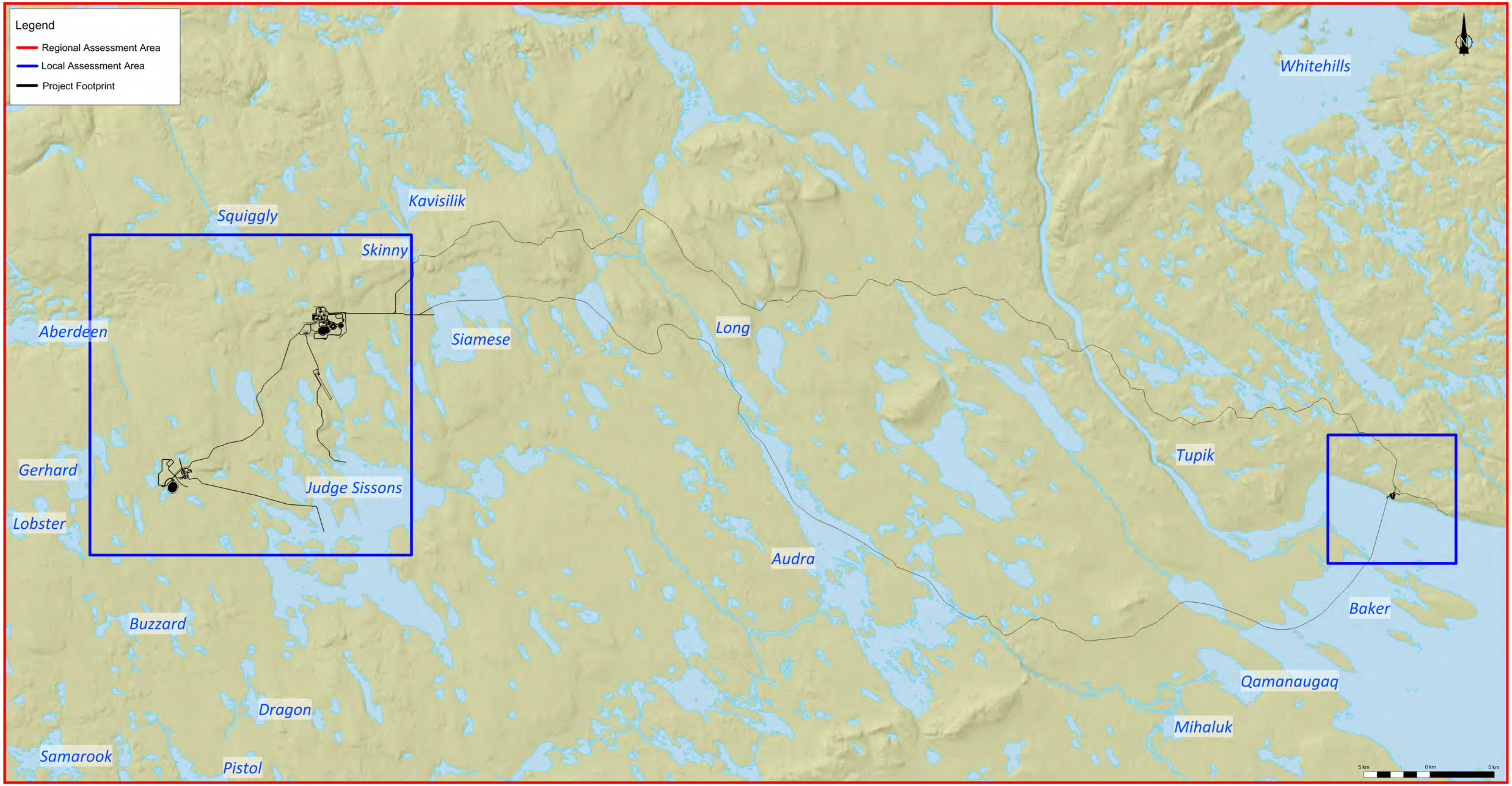
Project Footprint

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 2

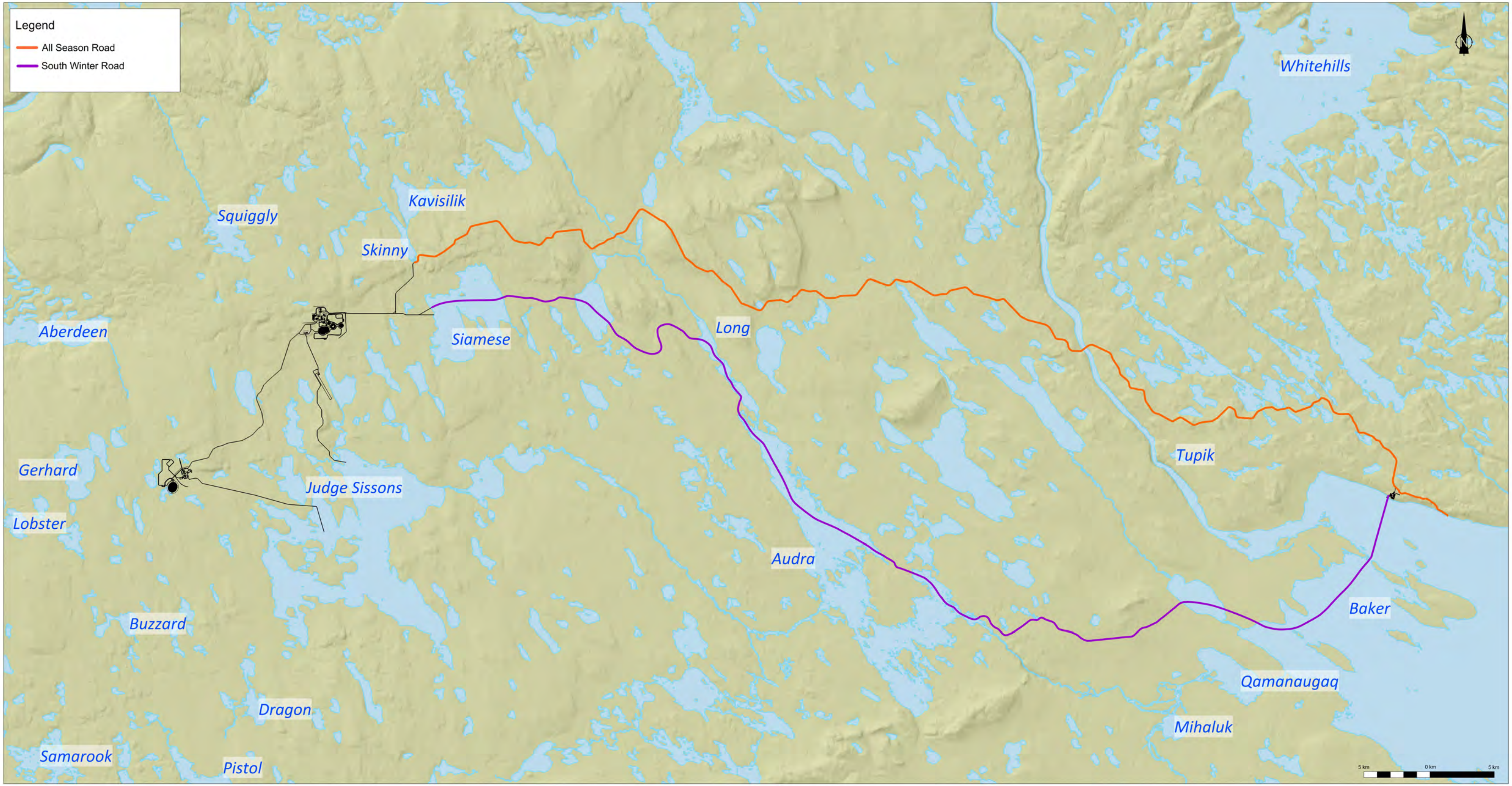
Local and Regional Assessment Areas

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 3

Kiggavik-Baker Lake Access Road Options

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5

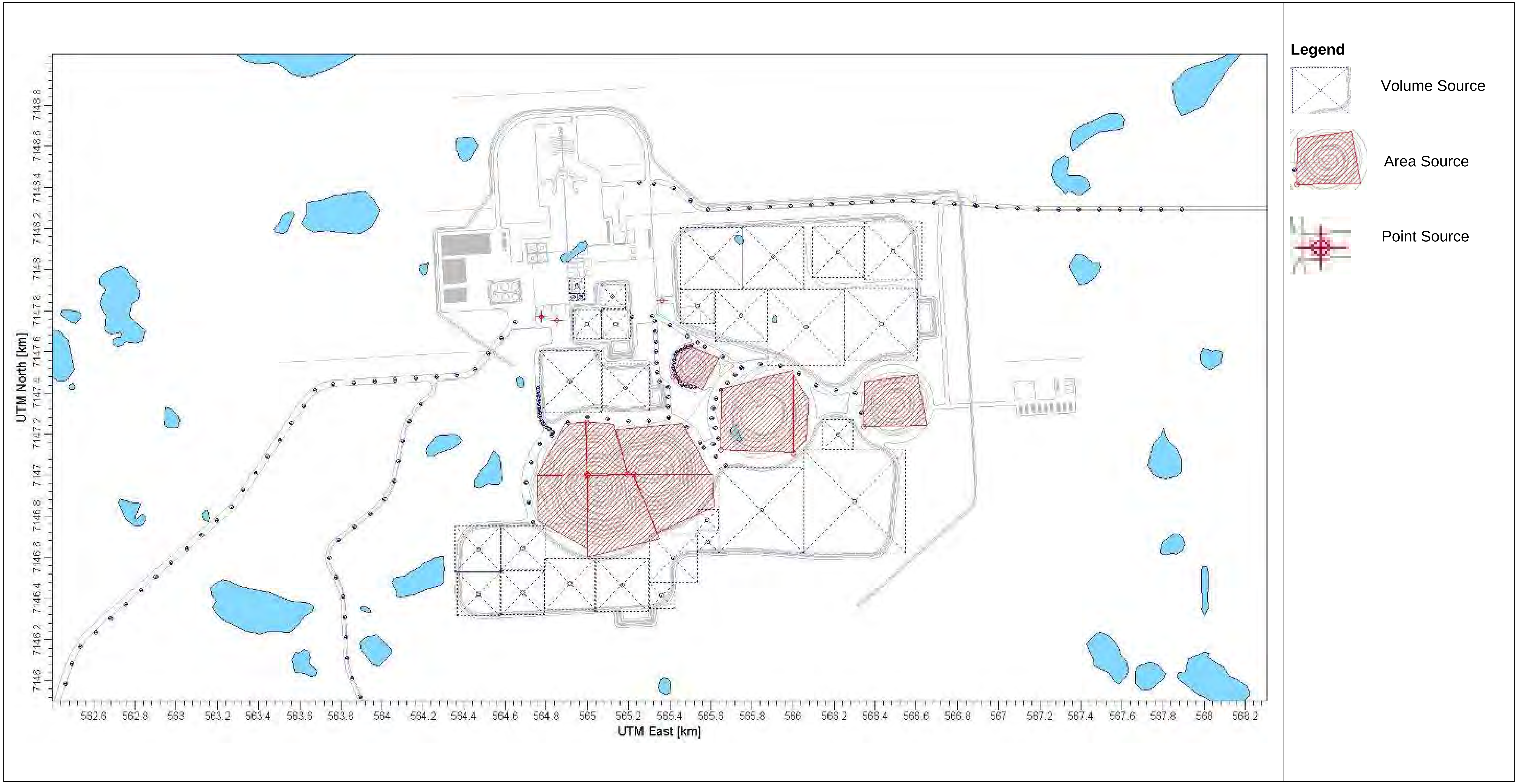


Figure 4 **CALPUFF Model Setup for the Kiggavik Mine Site**

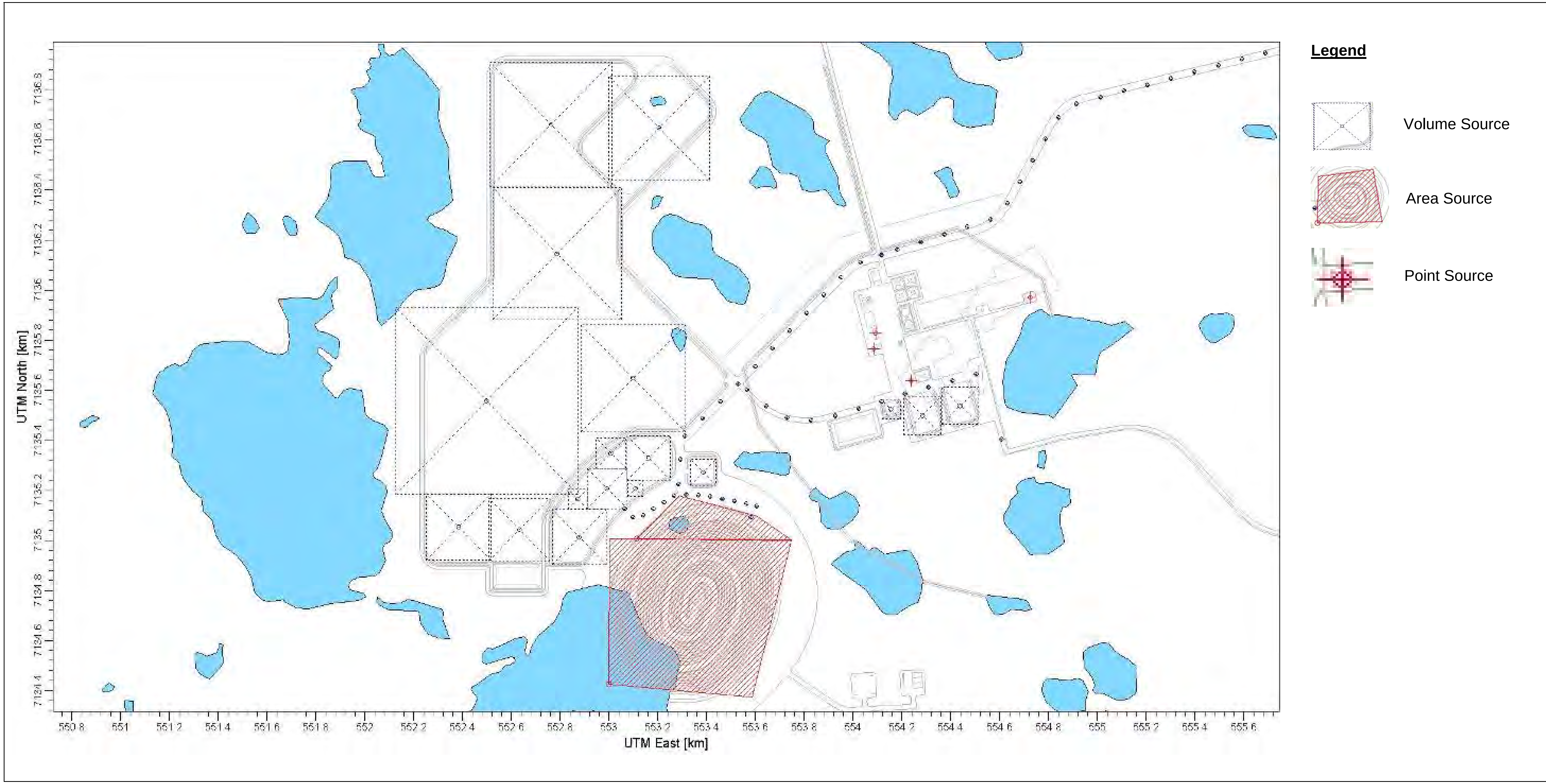
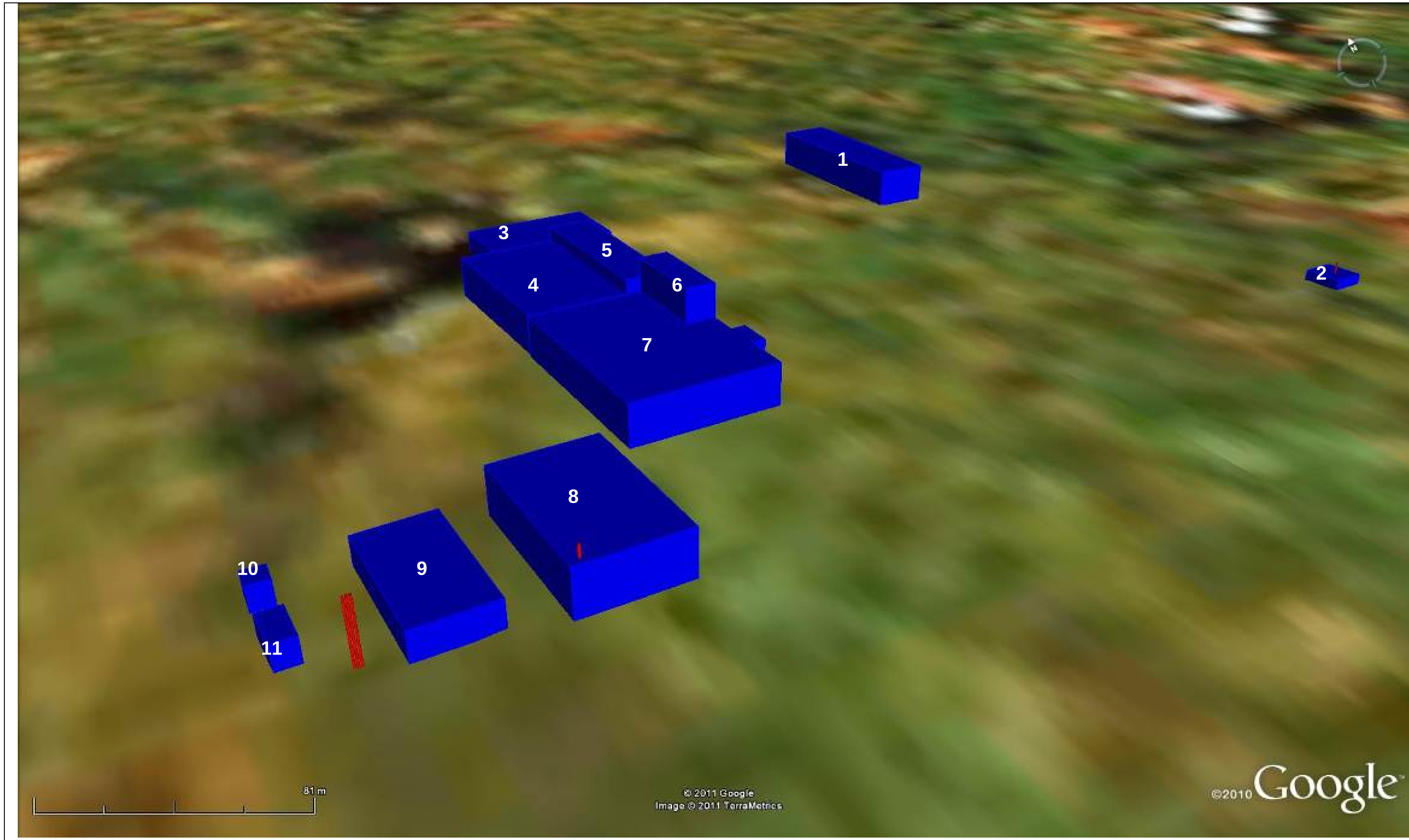
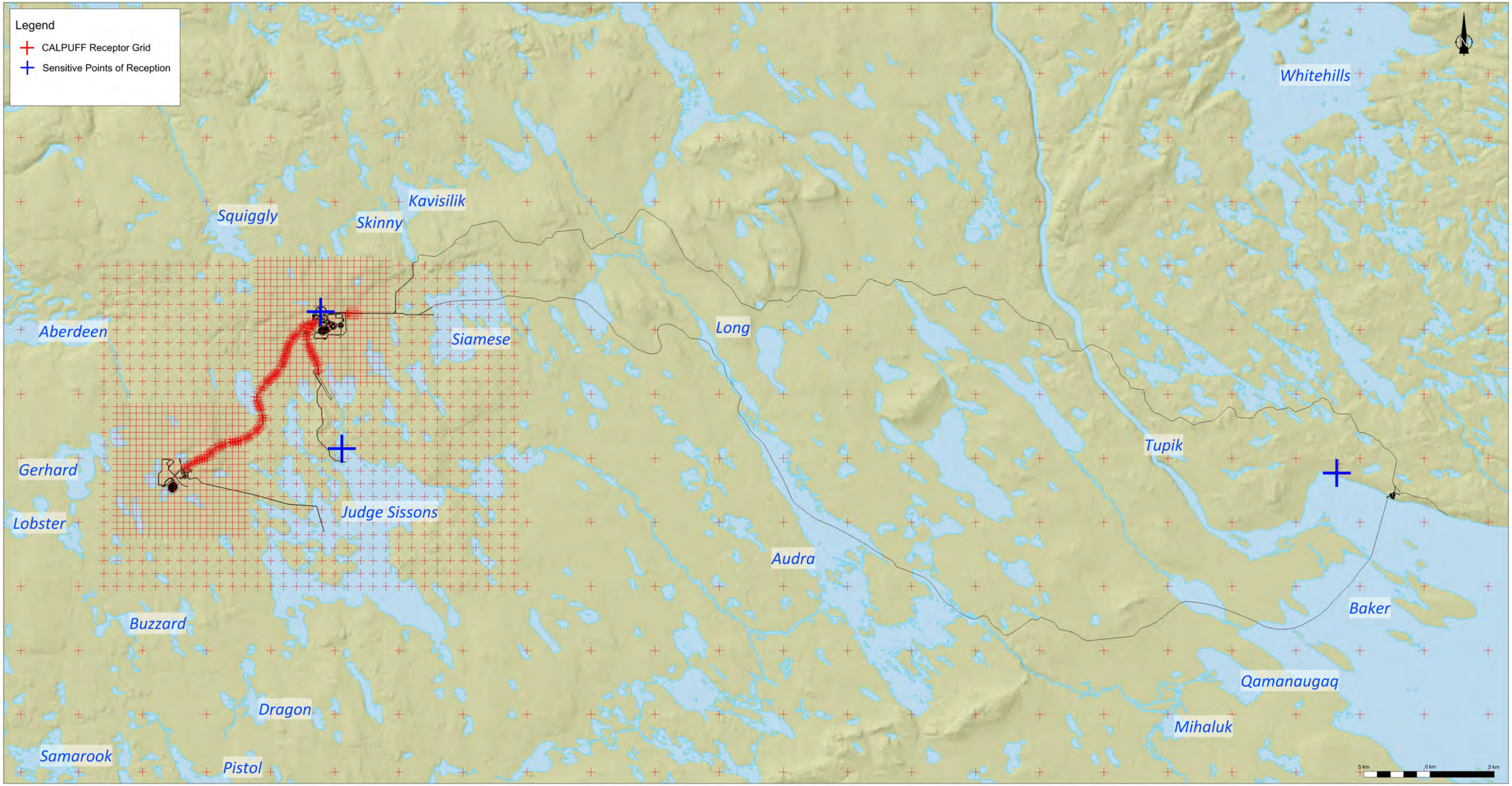


Figure 5 **CALPUFF Model Setup for the Sissons Mine Site**



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



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

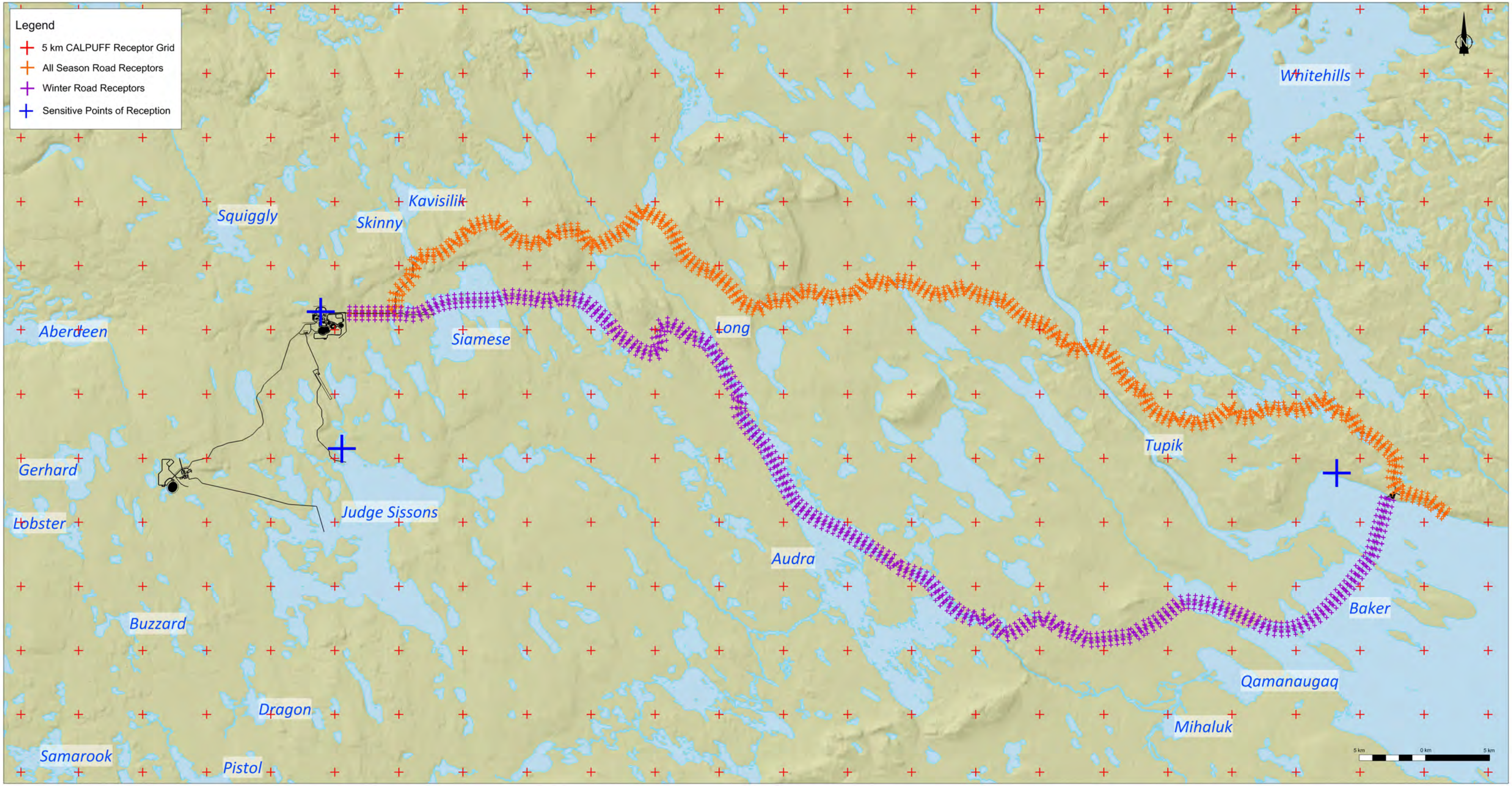
FIGURE 7
Mine Development Area Assessment
CALPUFF Receptor Grid and Sensitive Points of Reception

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 8

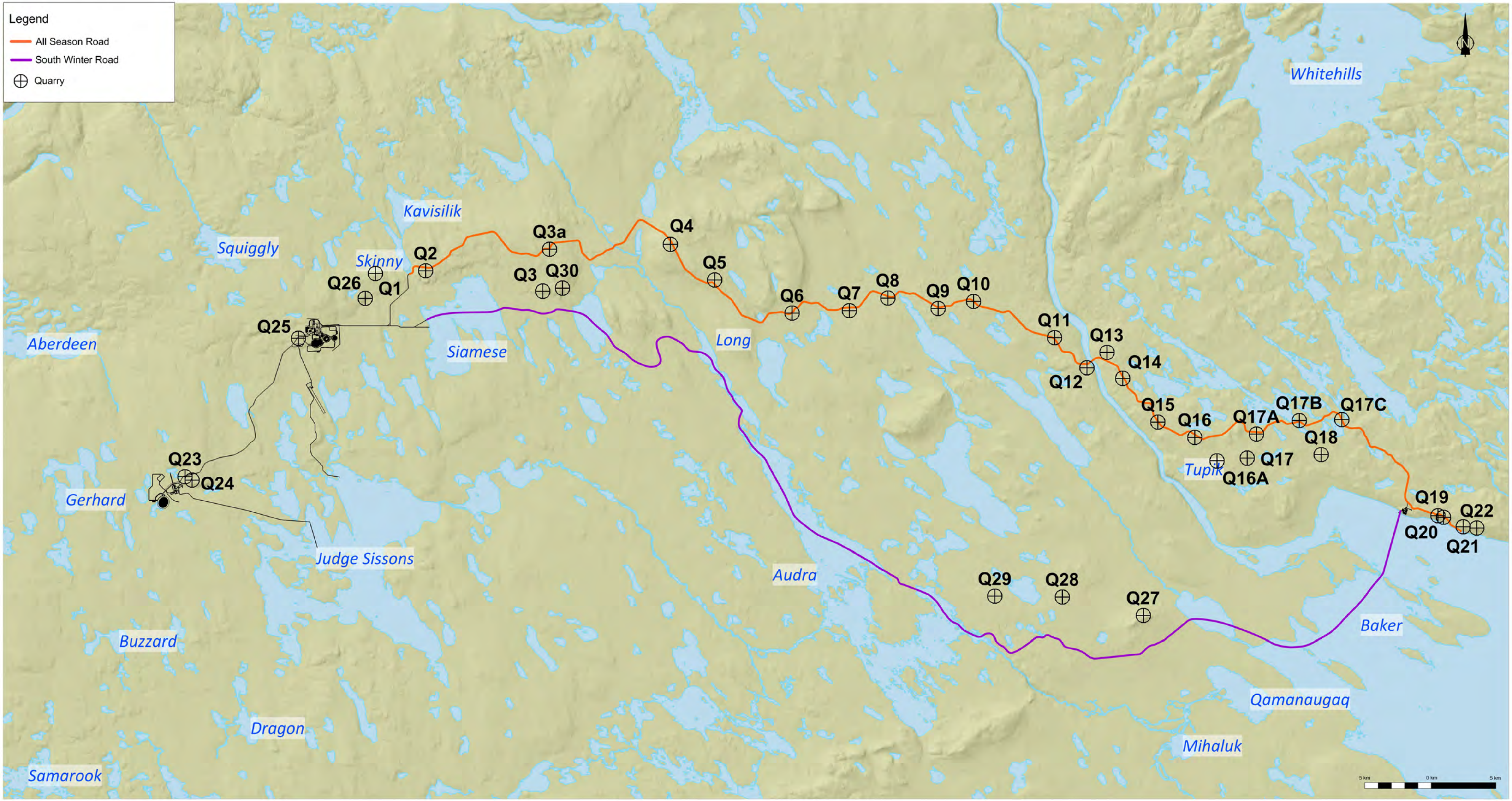
Access Roads Assessment
CALPUFF Receptor Grid and Sensitive Points of Reception

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultants

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 9

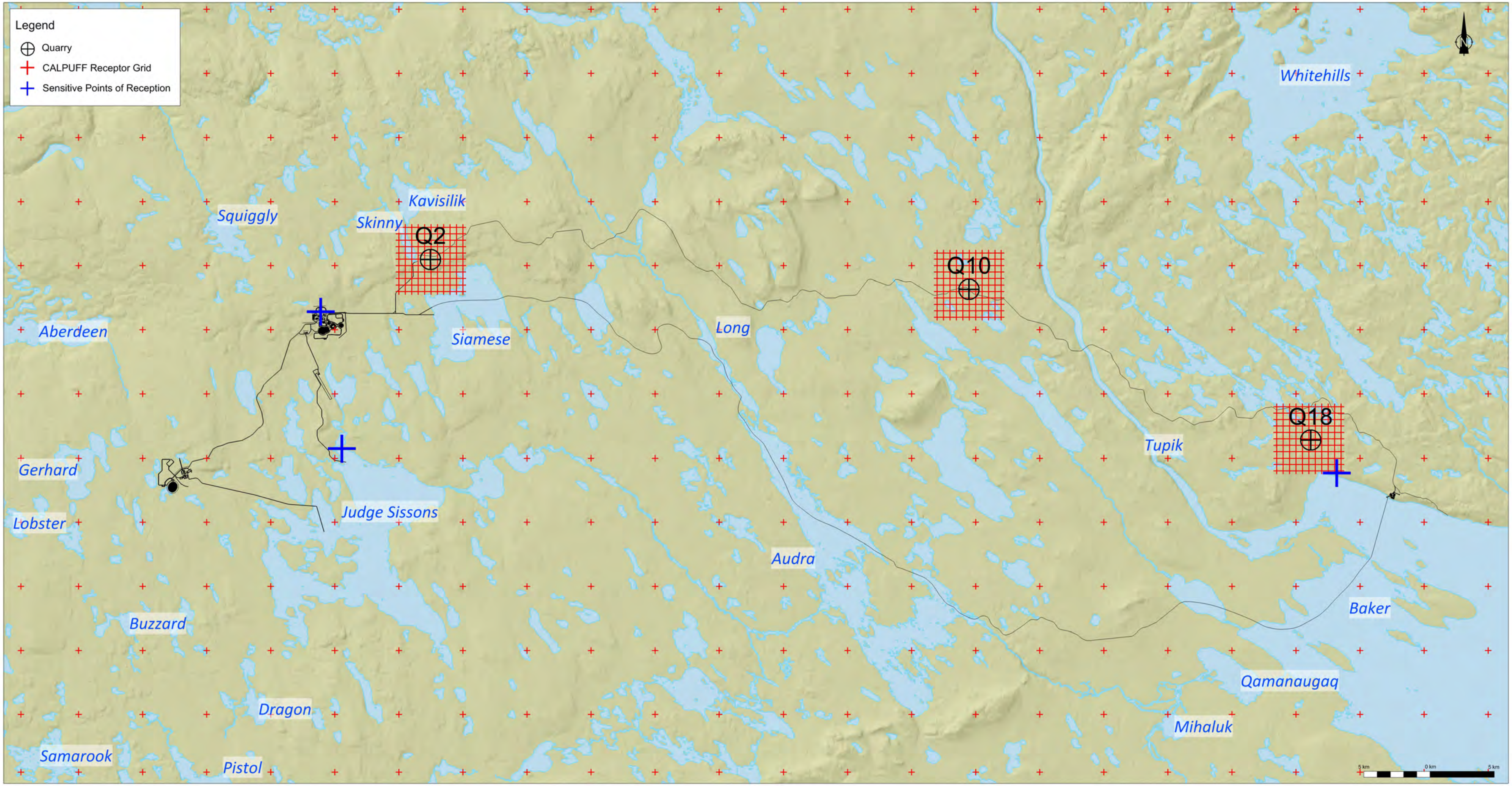
Quarry Locations

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 10

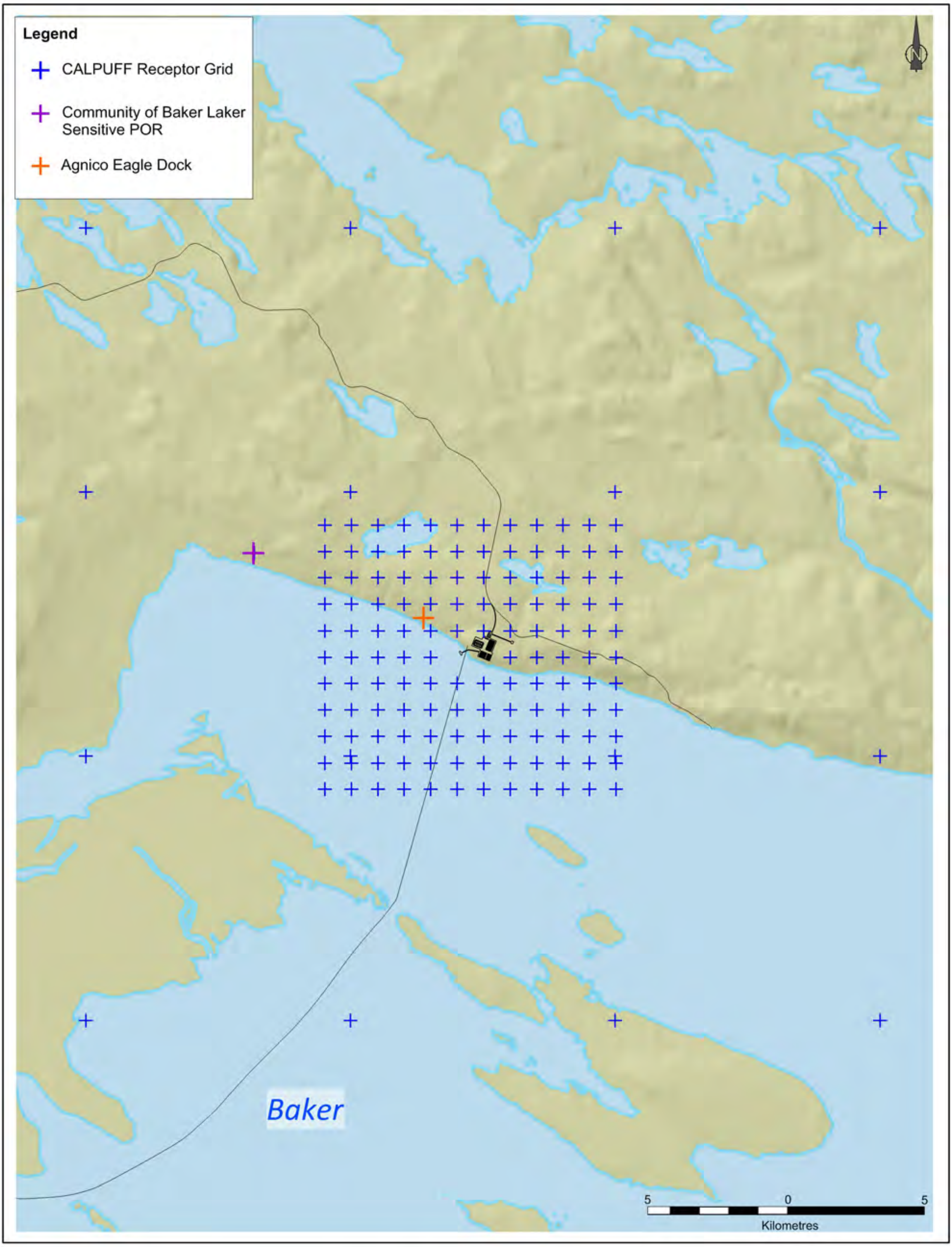
Quarry Assessment
CALPUFF Receptor Grid and Sensitive Points of Reception

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

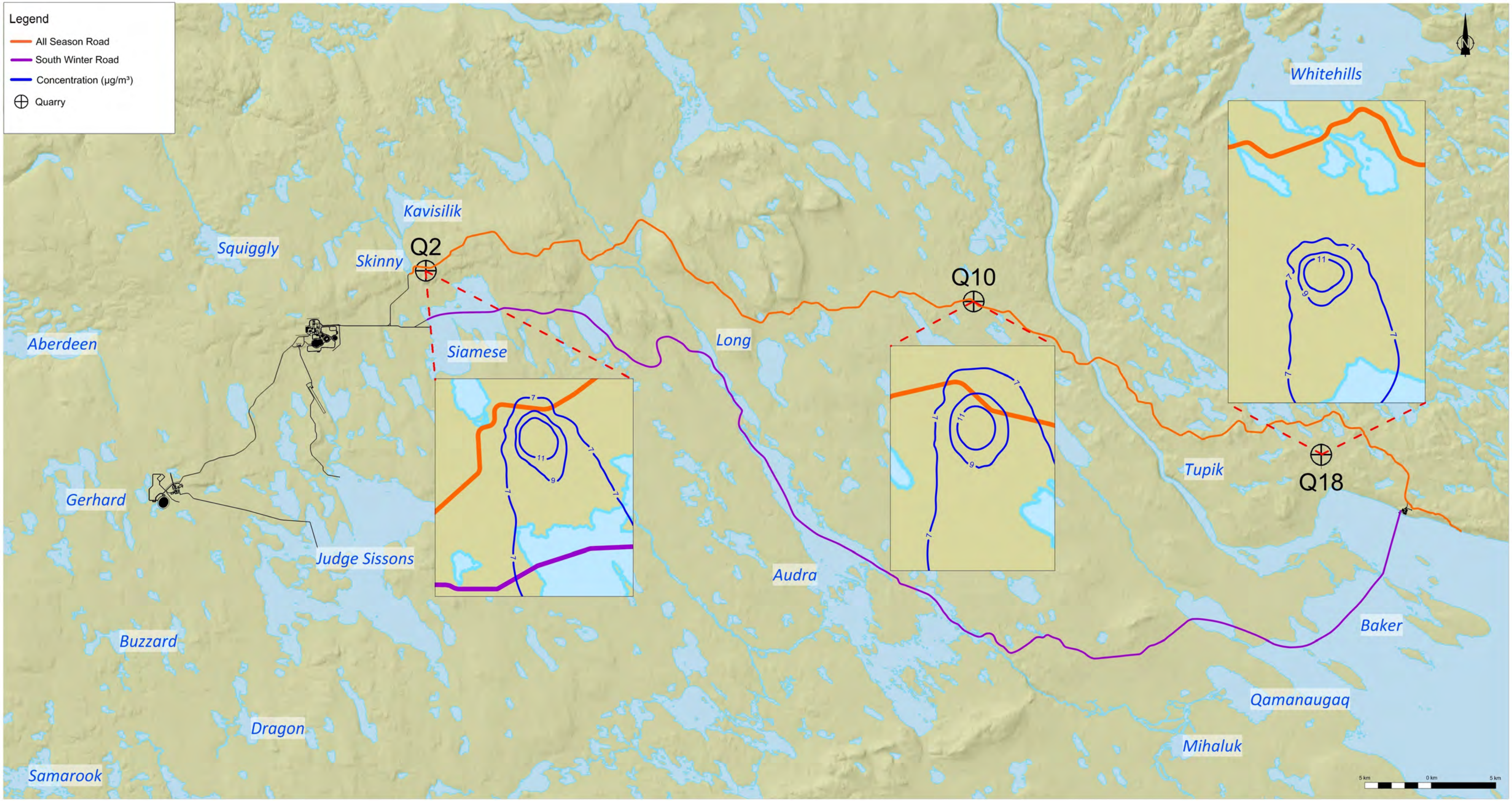
FIGURE 11

Baker Lake Dock and Storage Facility Assessment
CALPUFF Receptor Grid and Sensitive Points of Reception

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 12

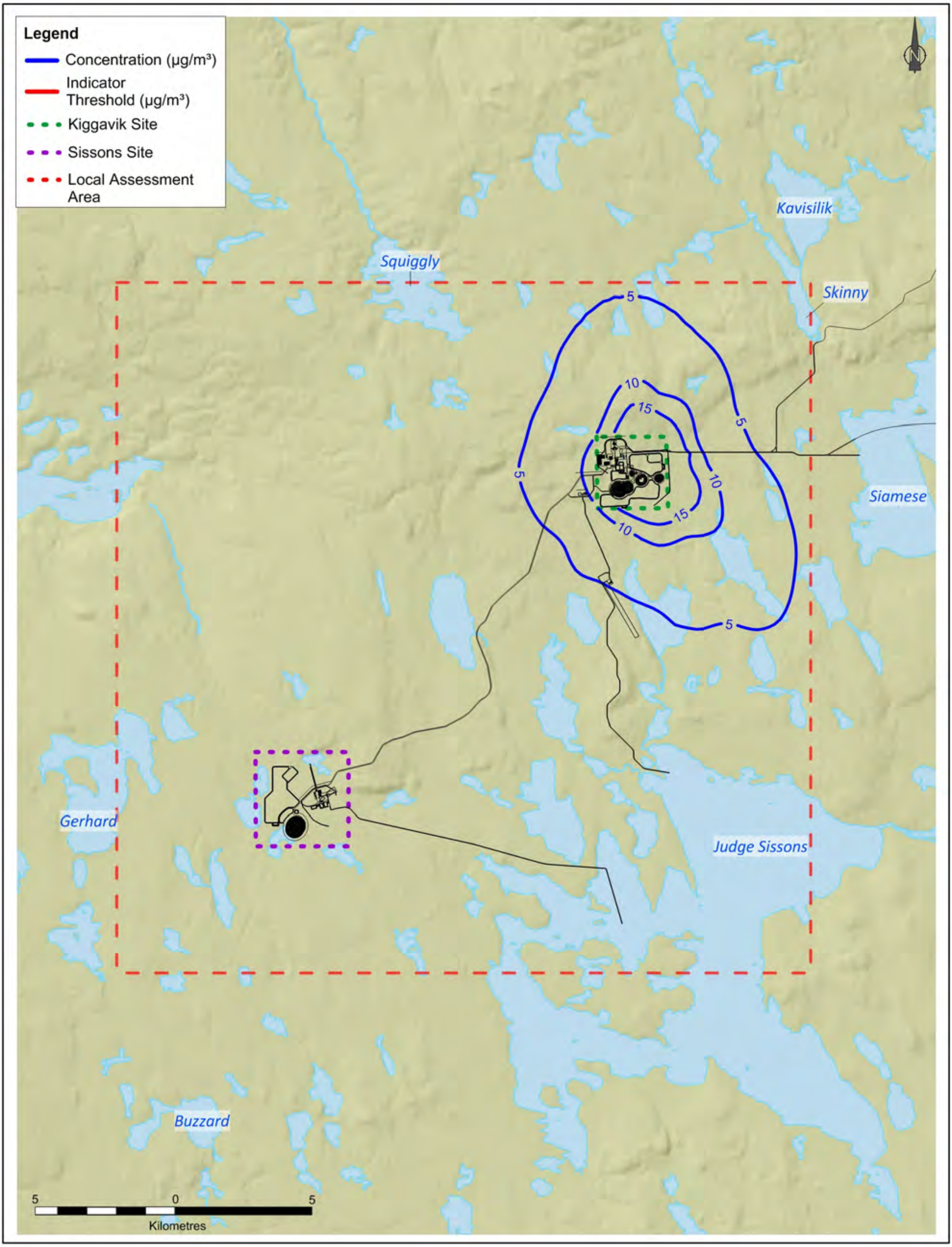
Quarry Assessment
Maximum 24-hour TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4B: AIR QUALITY AND CLIMATE

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

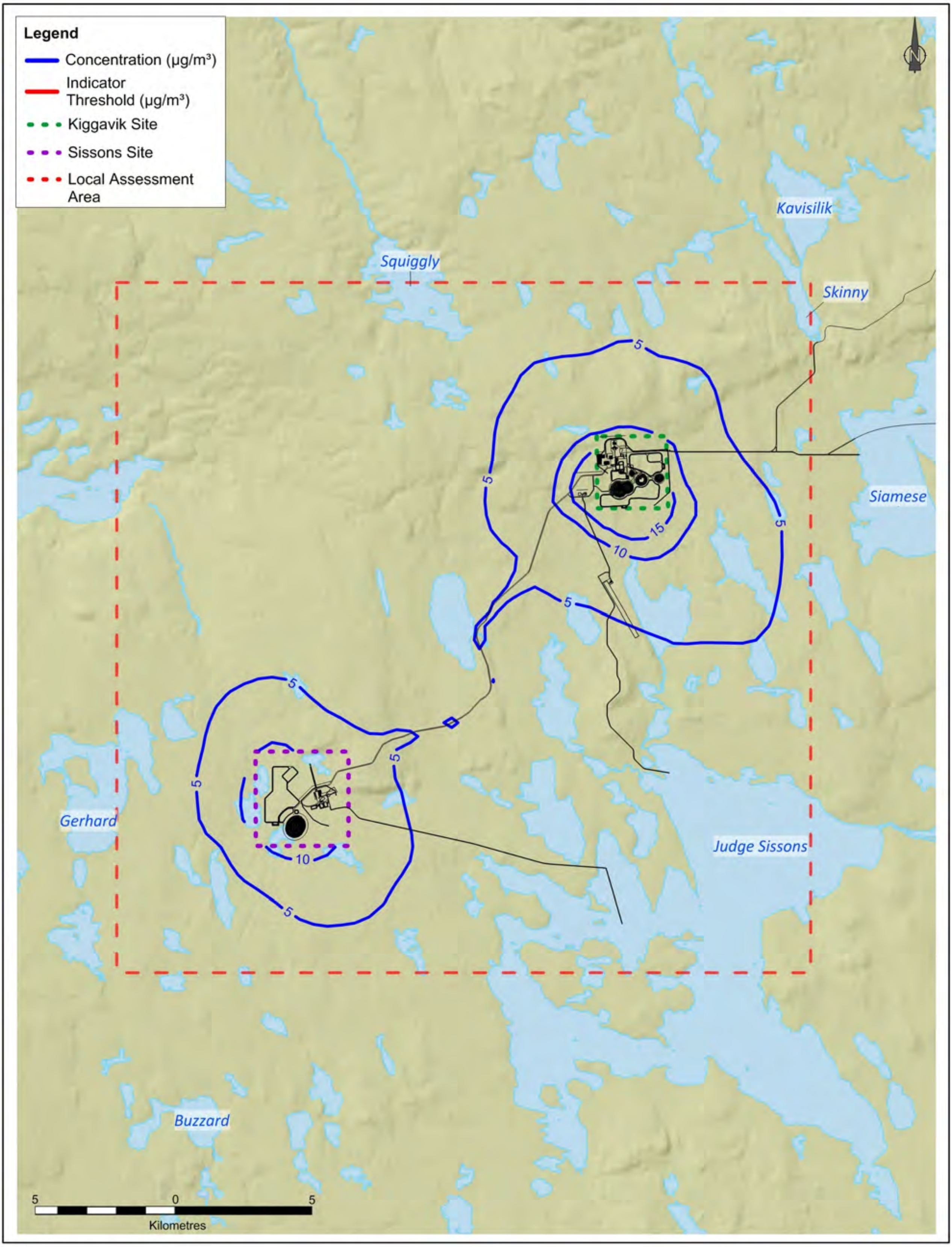
FIGURE 13
Operation Assessment - Phase 1
Annual TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



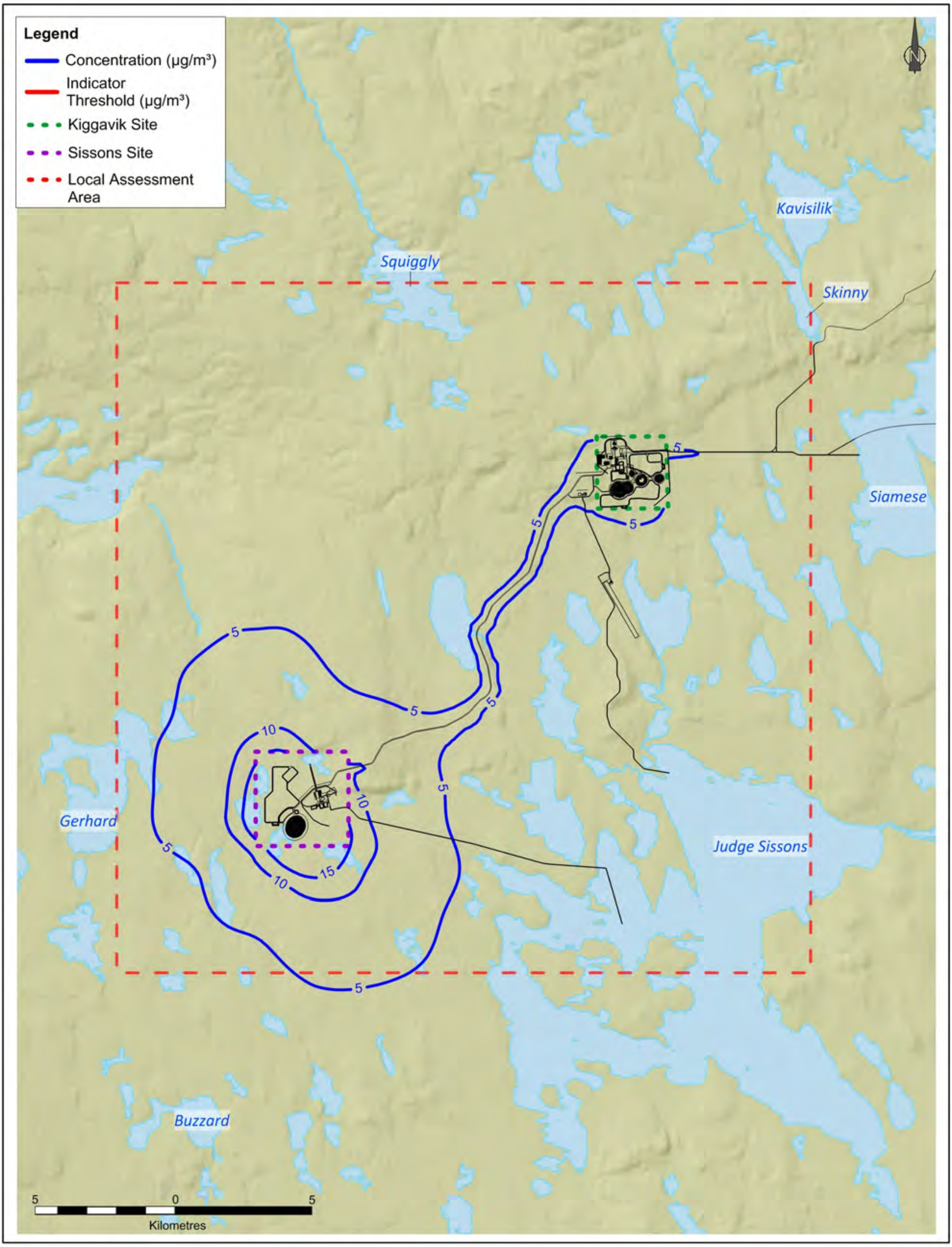
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 14
Operation Assessment - Phase 2
Annual TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



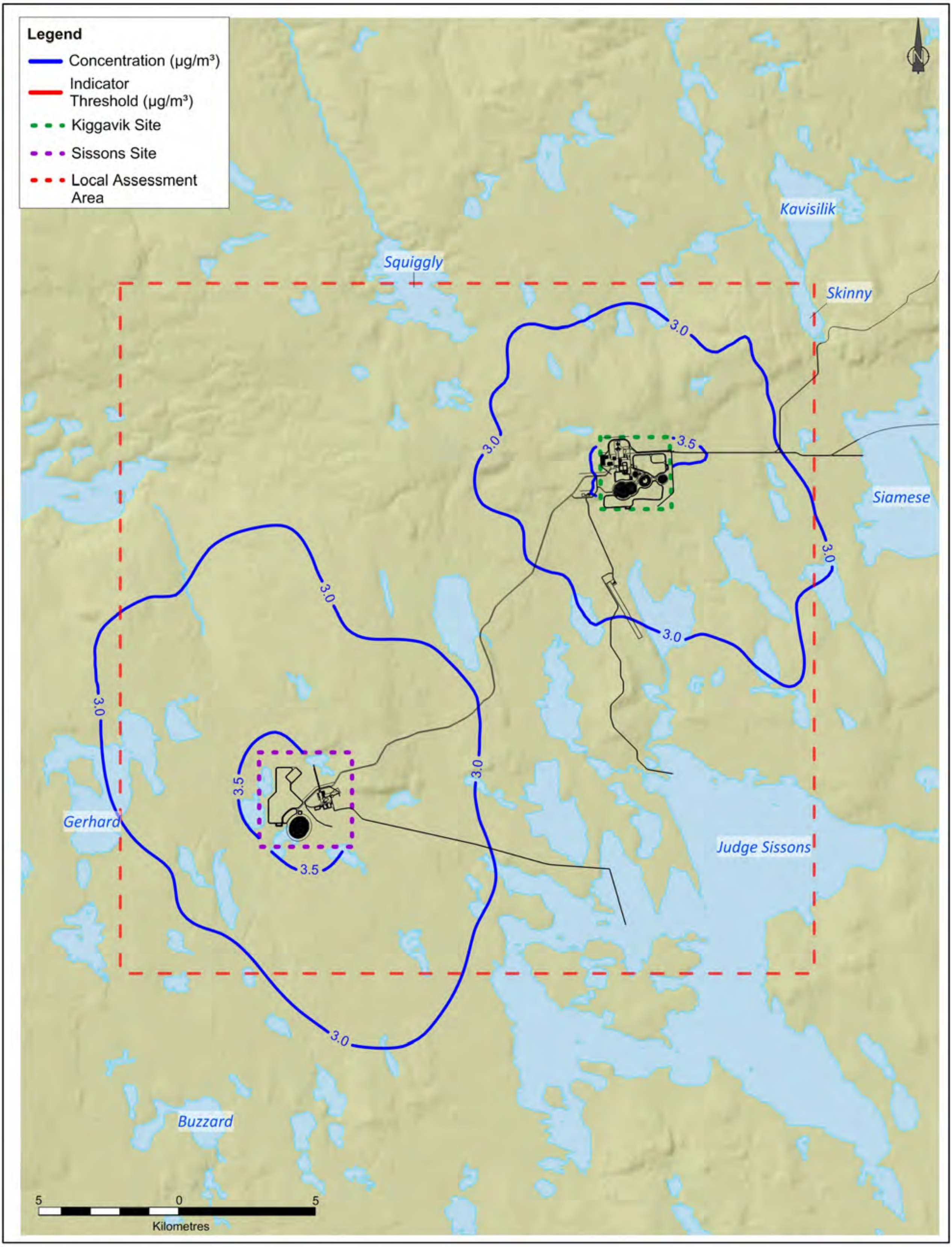
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 15
Operation Assessment - Phase 3
Annual TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

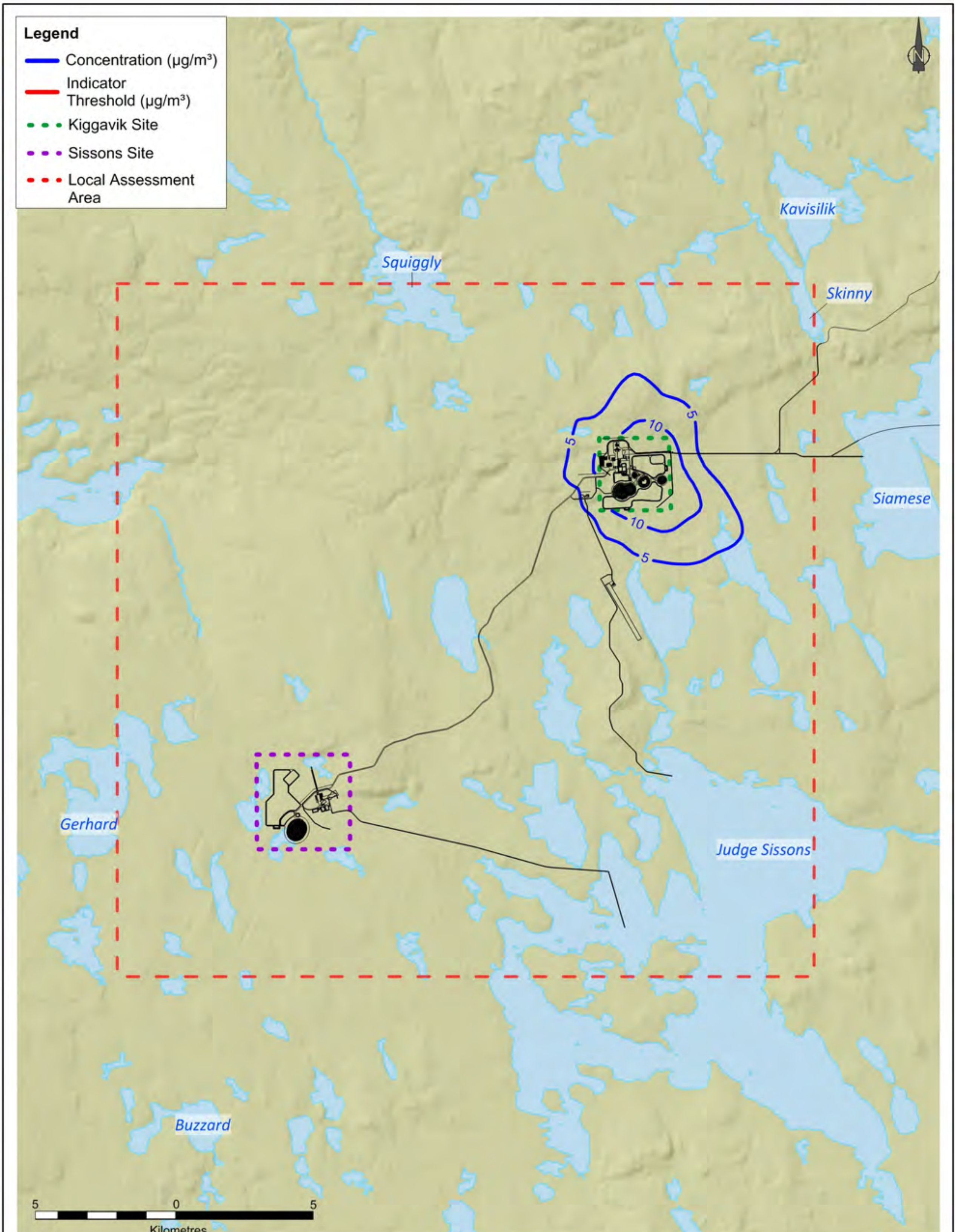
FIGURE 16

Operation Assessment - Phase 4
Annual TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



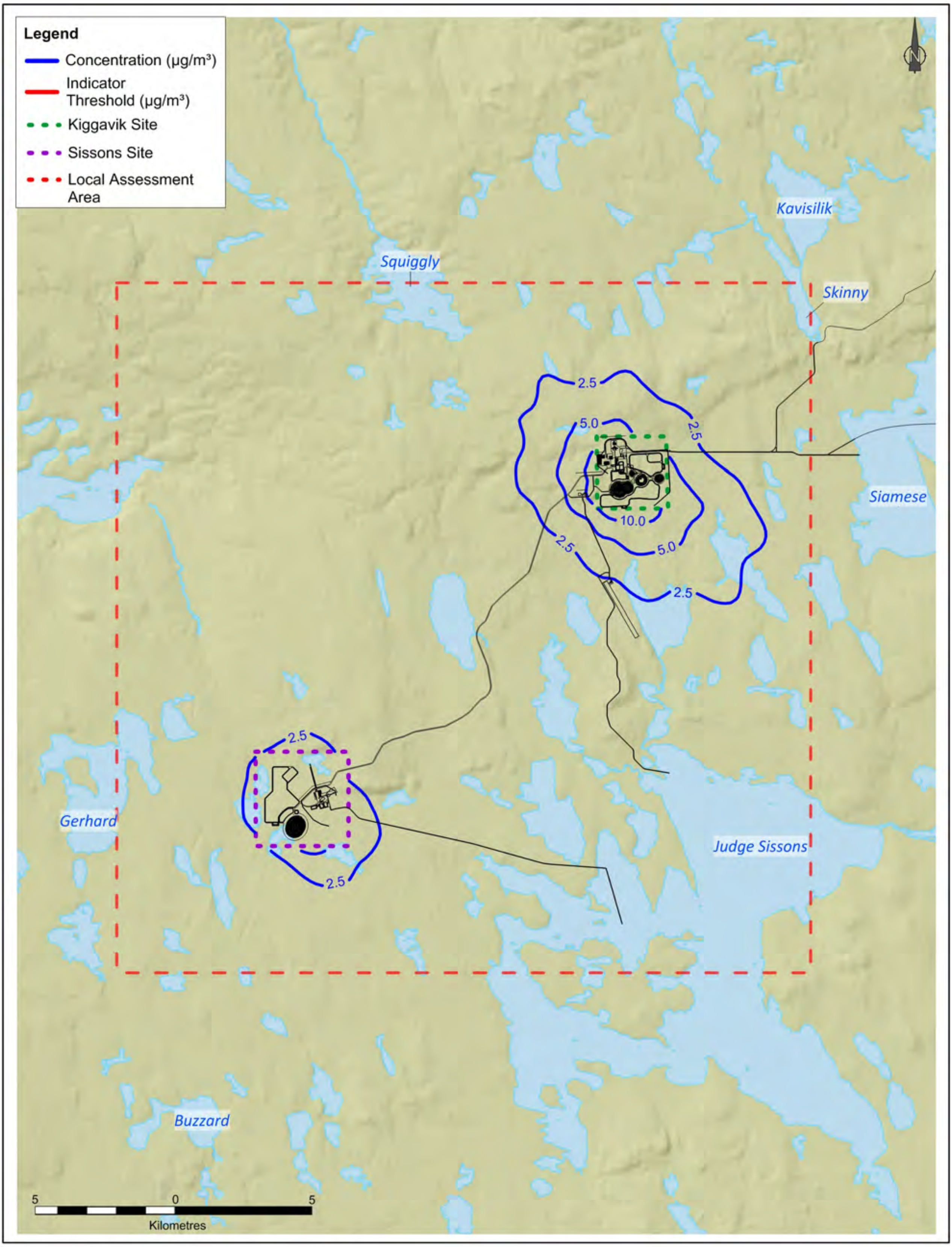
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 17
Operation Assessment - Phase 1
Incremental NO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



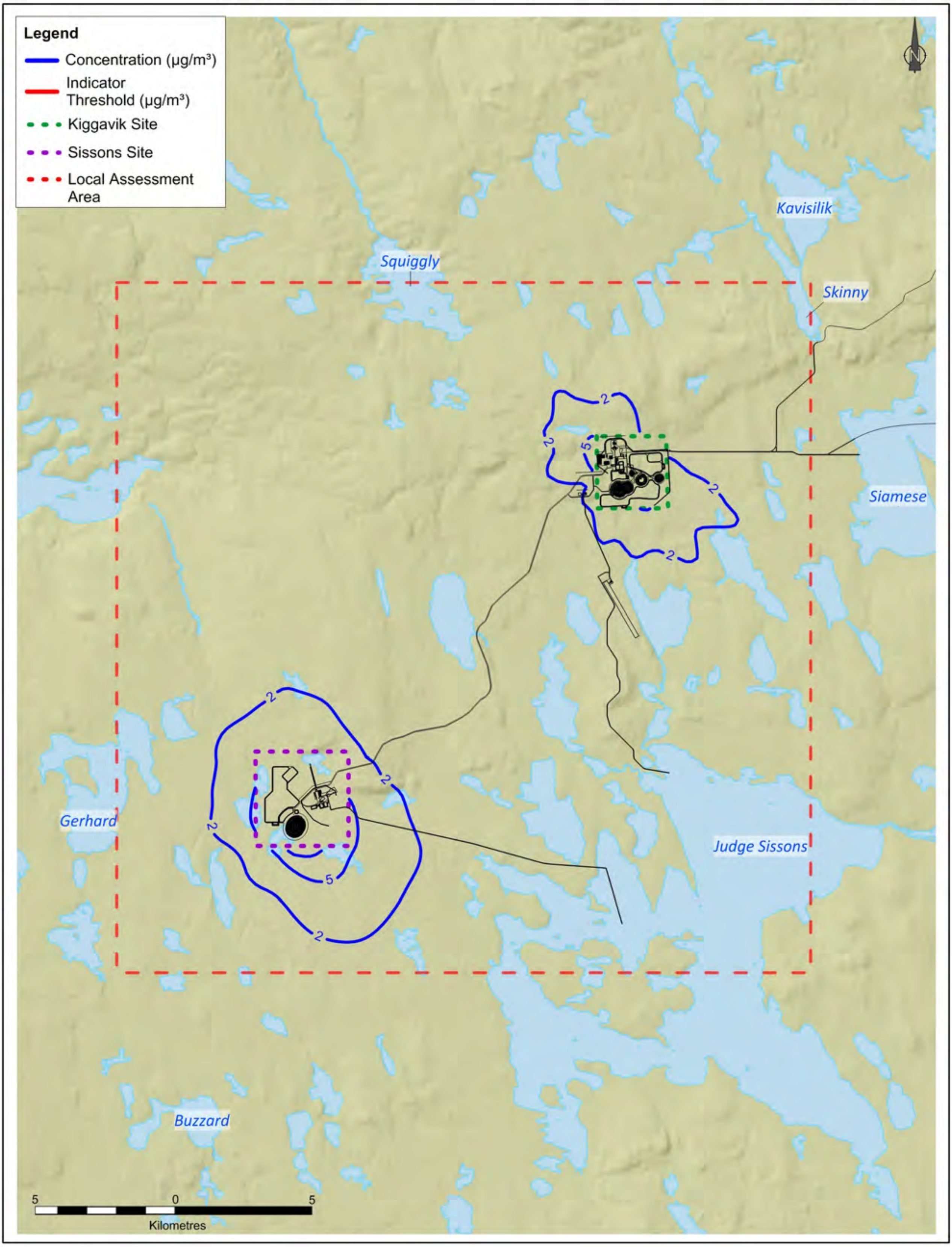
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 18
Operation Assessment - Phase 2
Incremental NO_2 Concentration (μg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



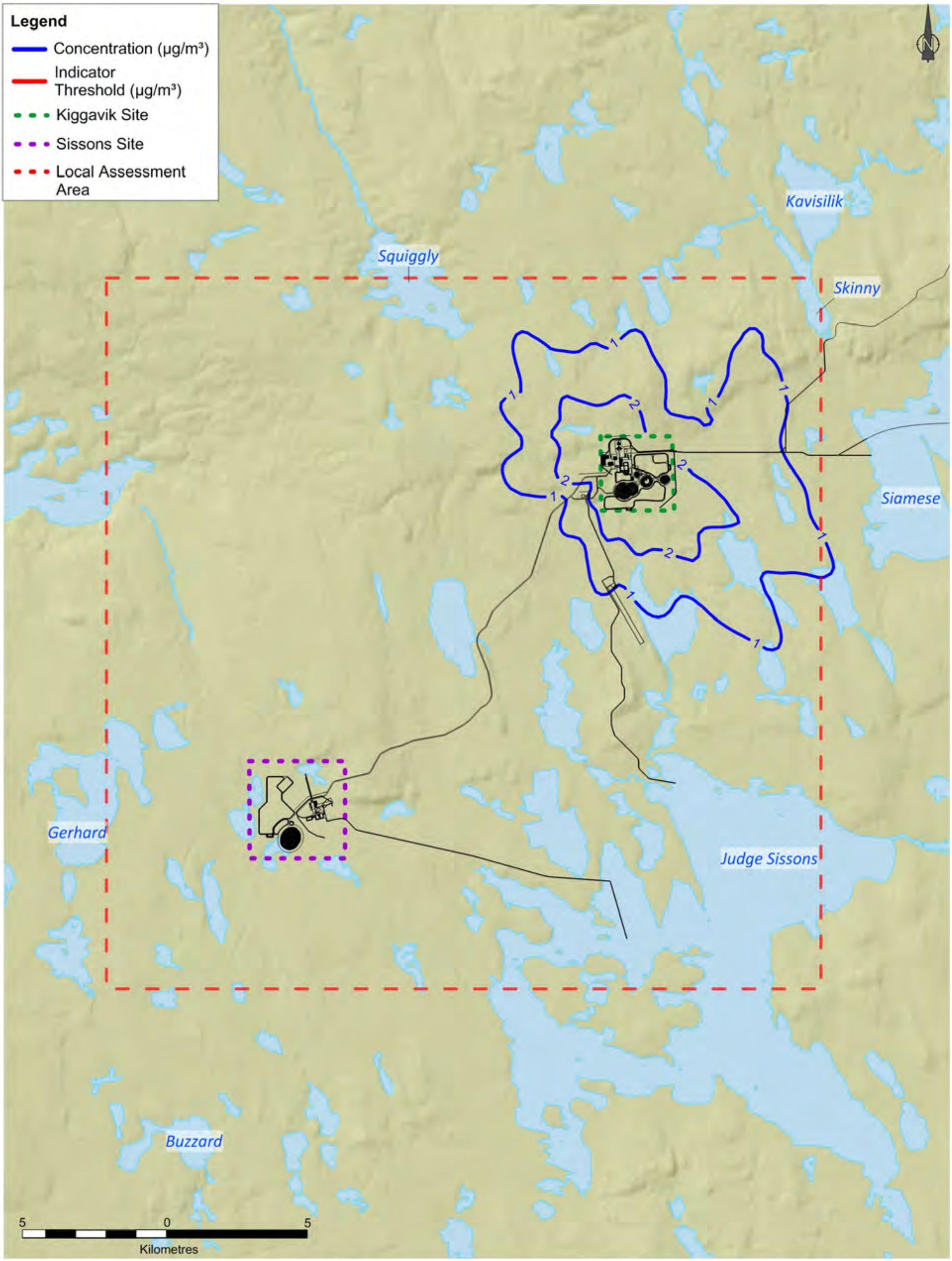
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 19
Operation Assessment - Phase 3
Incremental NO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



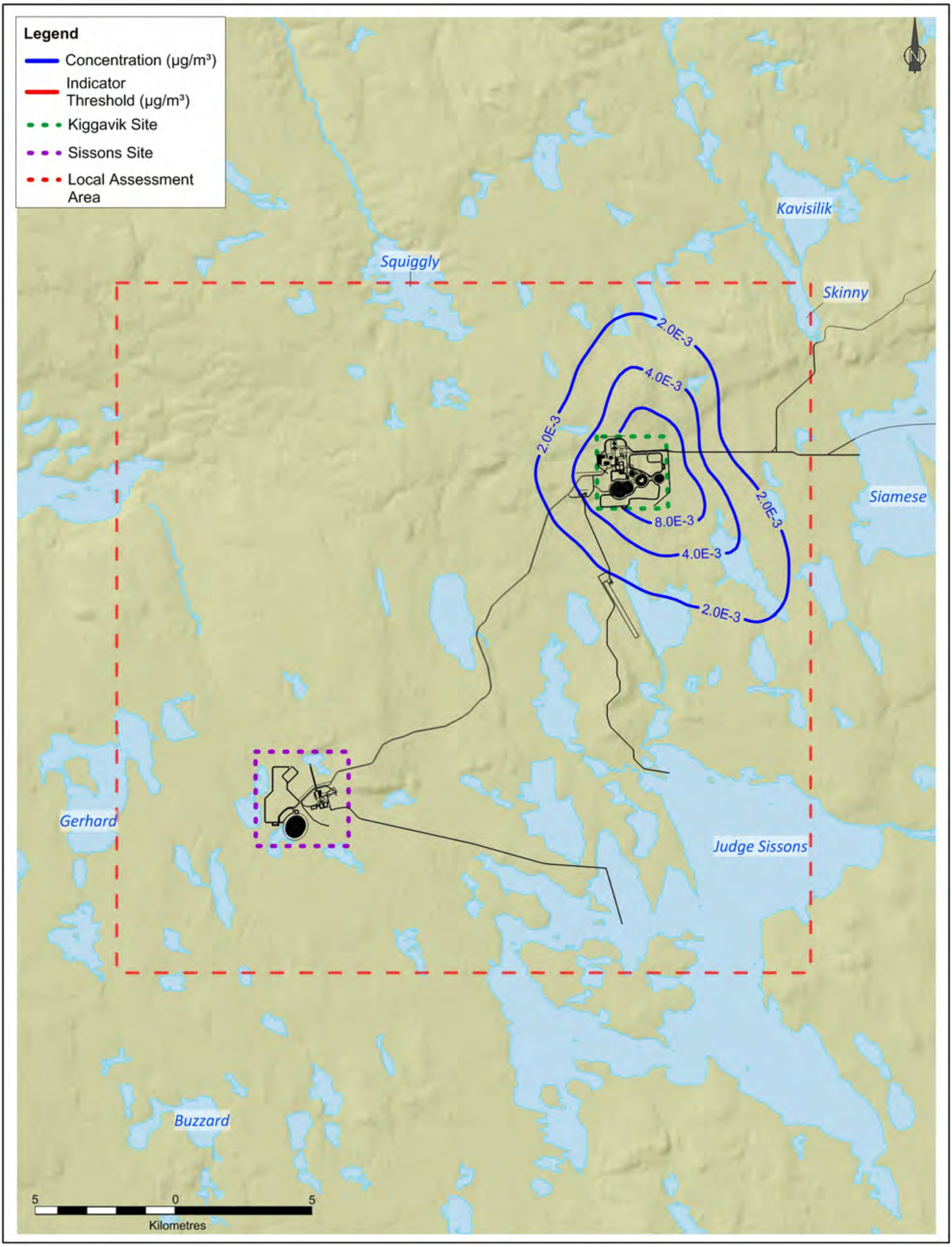
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 20
Operation Assessment - Phase 4
Incremental NO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



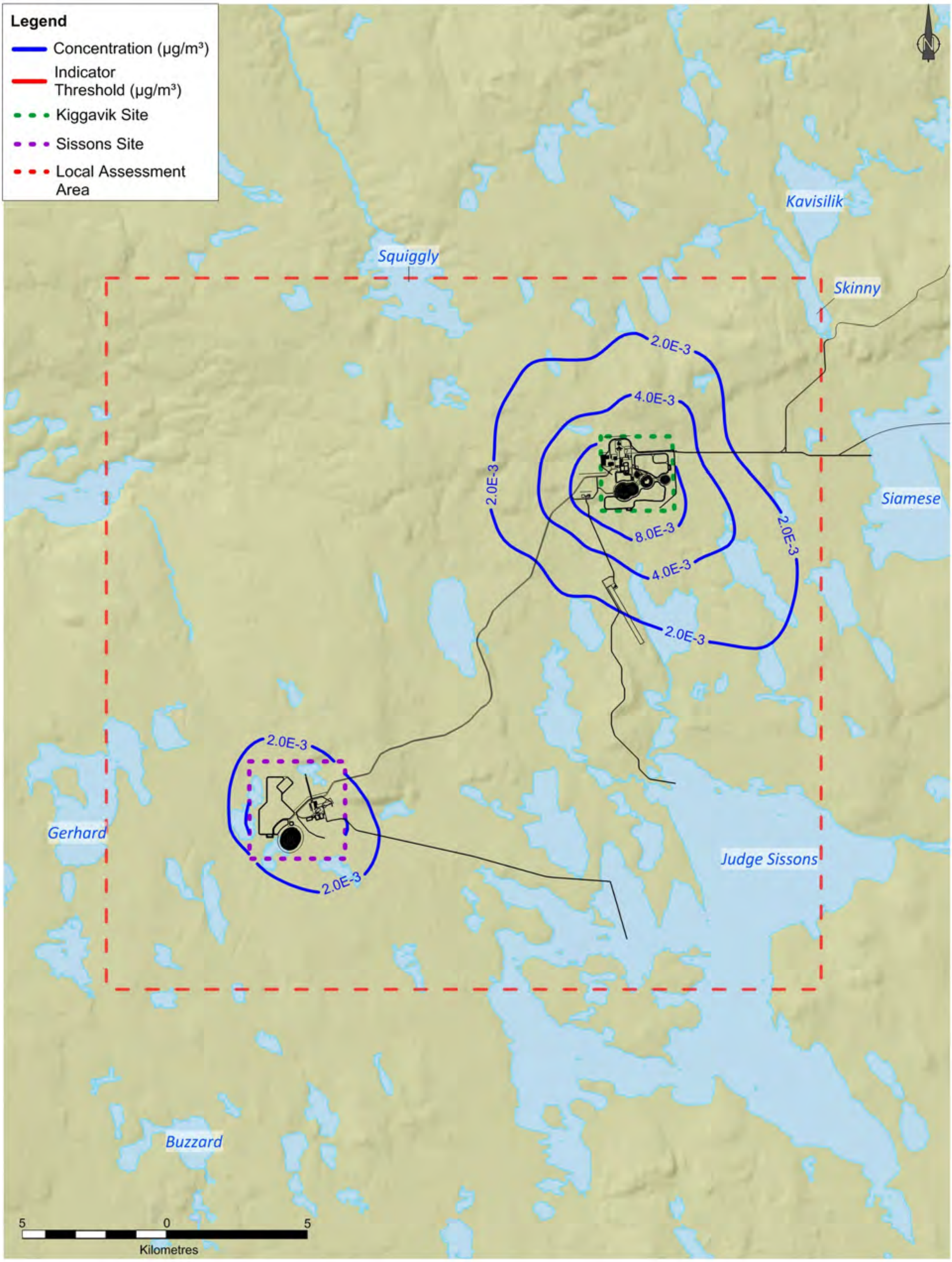
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 21
Operation Assessment - Phase 1
Annual Uranium (U) Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



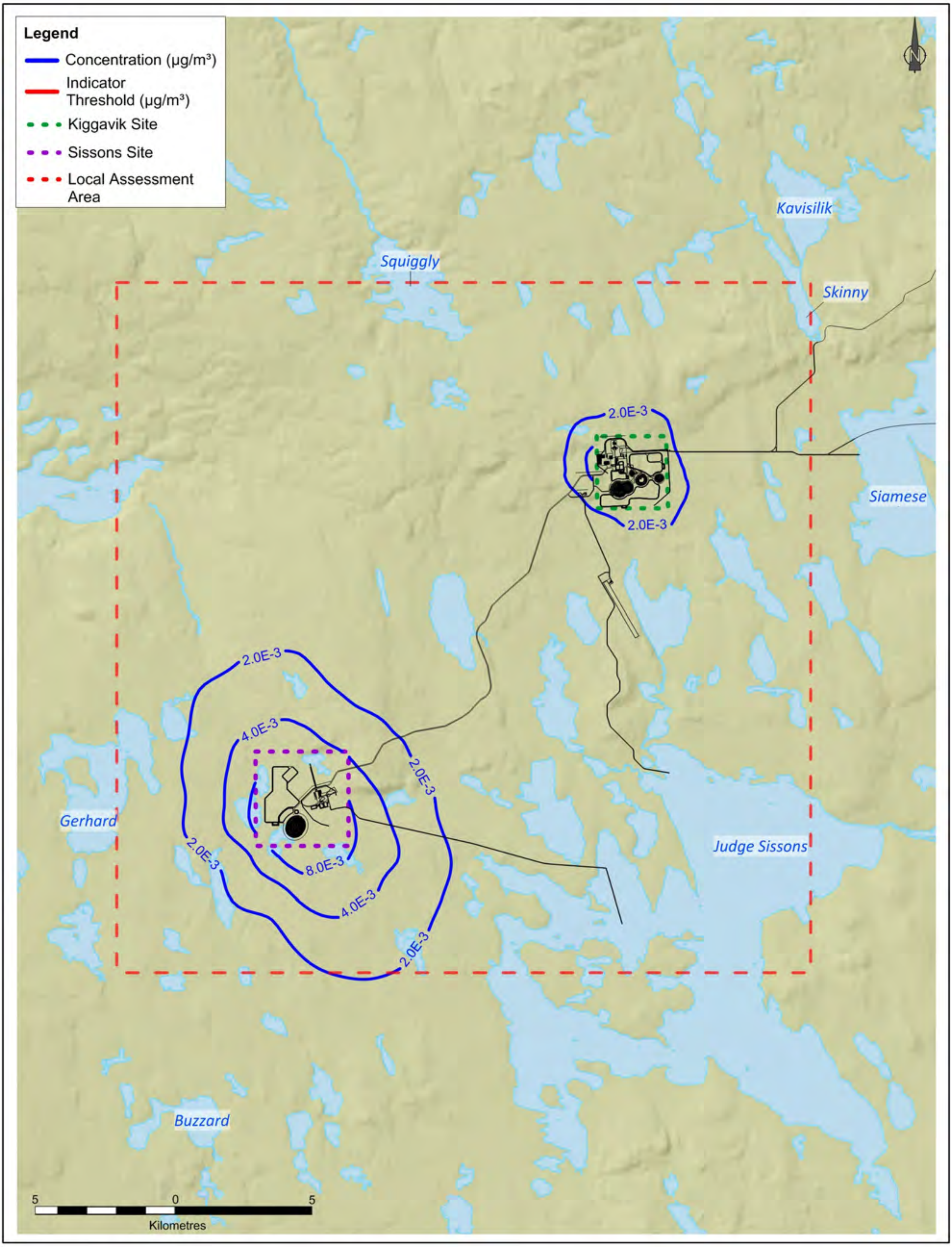
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 22
Operation Assessment - Phase 2
Annual Uranium (U) Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

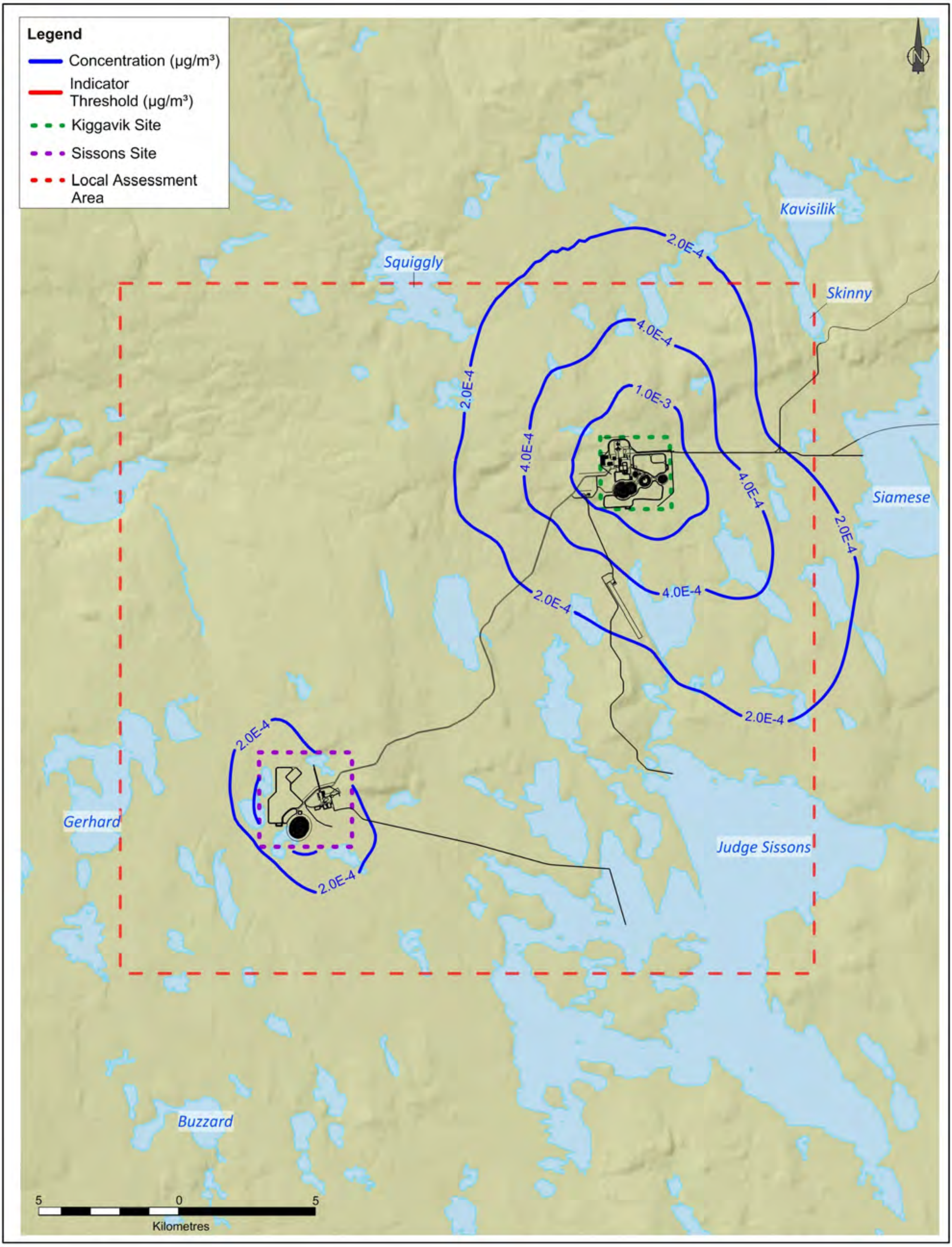
FIGURE 23

Operation Assessment - Phase 3
Annual Uranium (U) Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

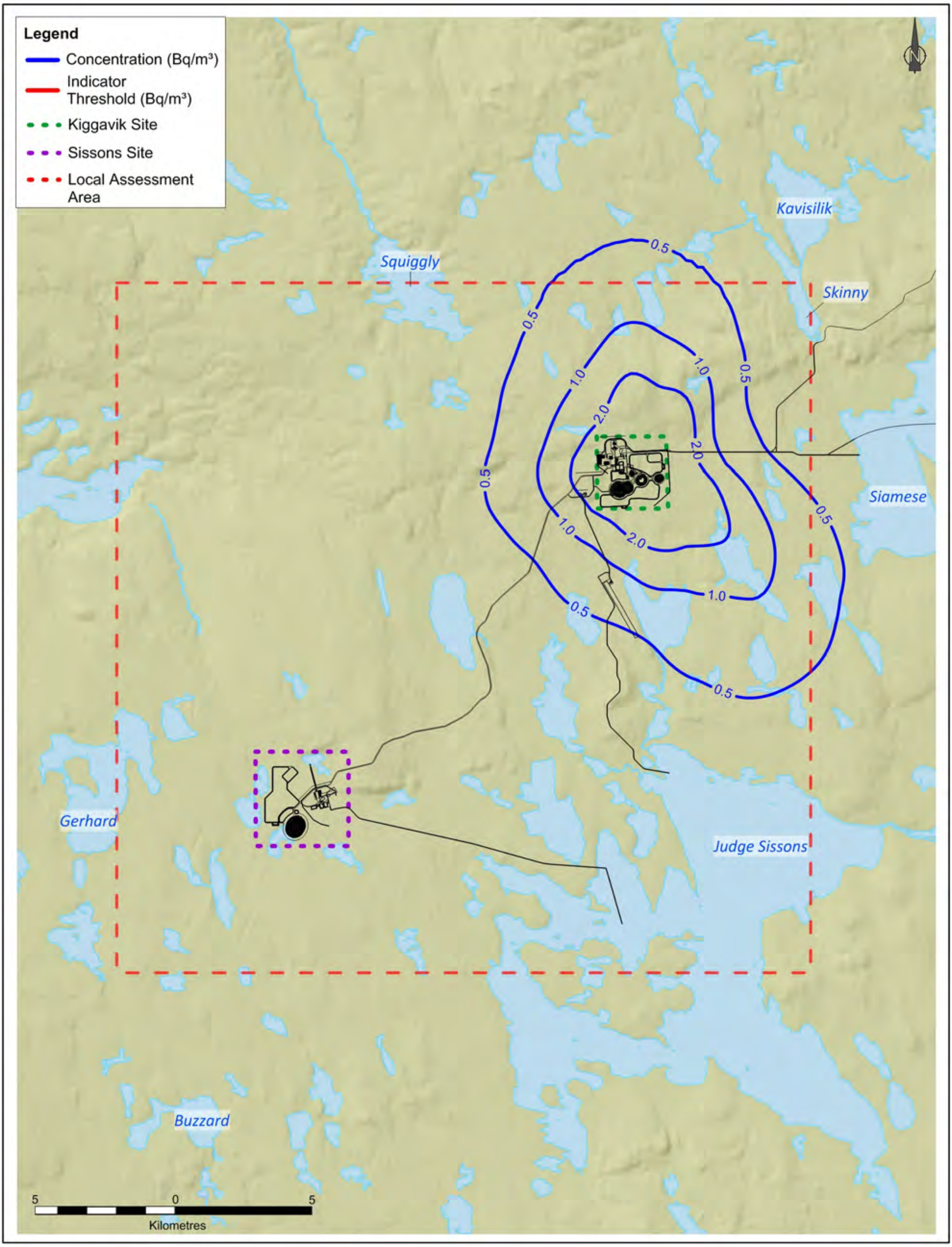
FIGURE 24
Operation Assessment - Phase 4
Annual Uranium (U) Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



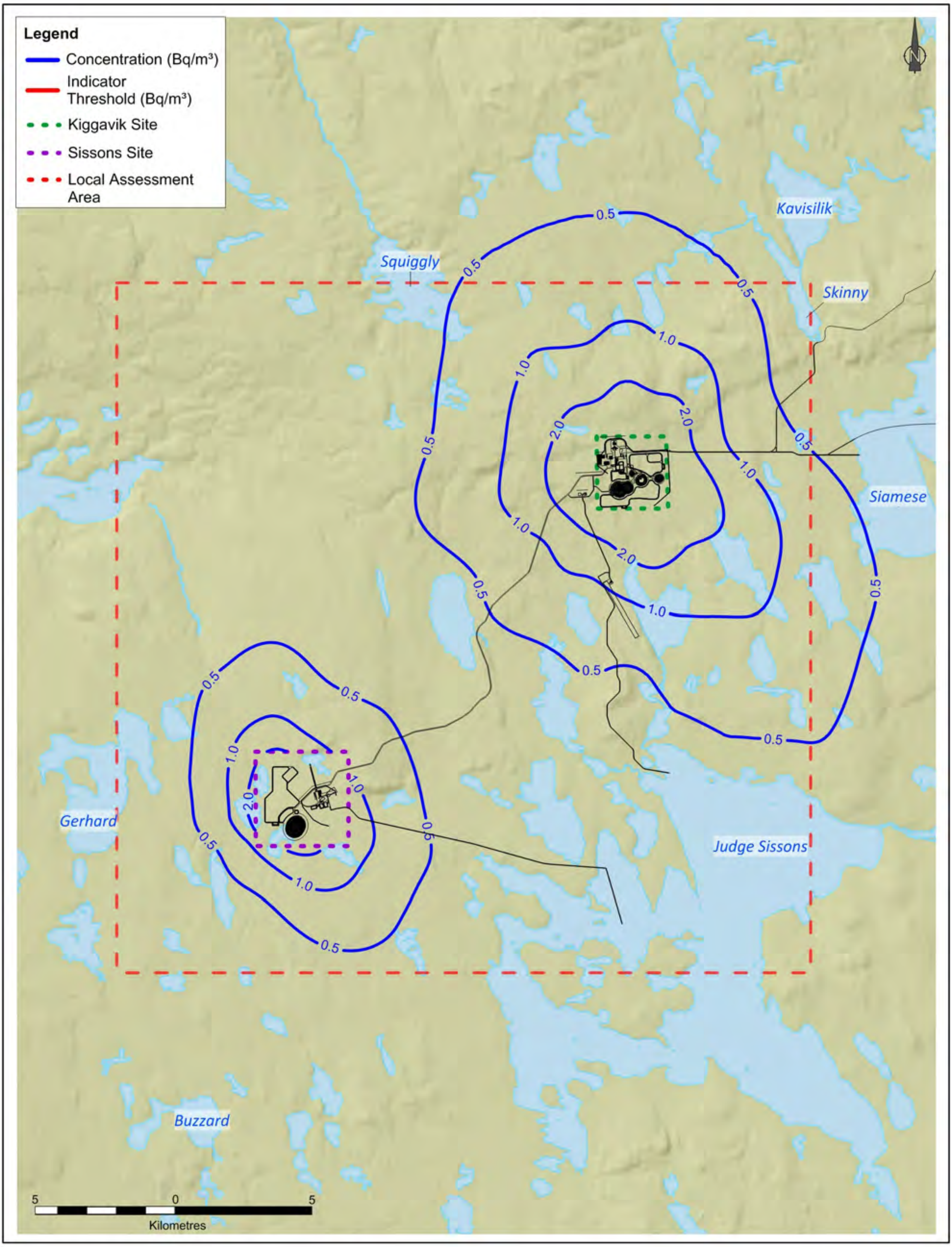
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 25
Operation Assessment - Phase 1
Incremental Annual Radon Concentration (Bq/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



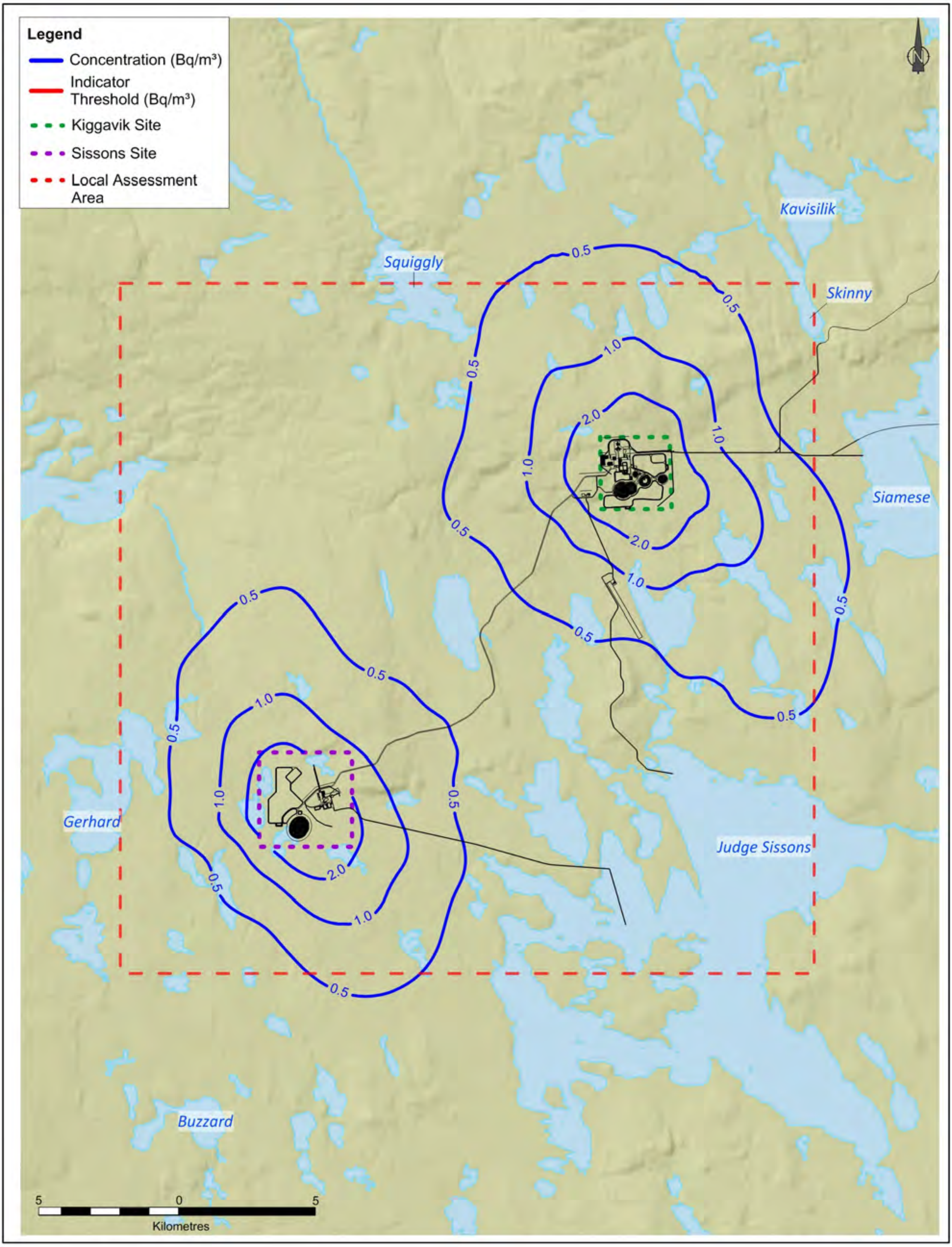
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 26
Operation Assessment - Phase 2
Incremental Annual Radon Concentration (Bq/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

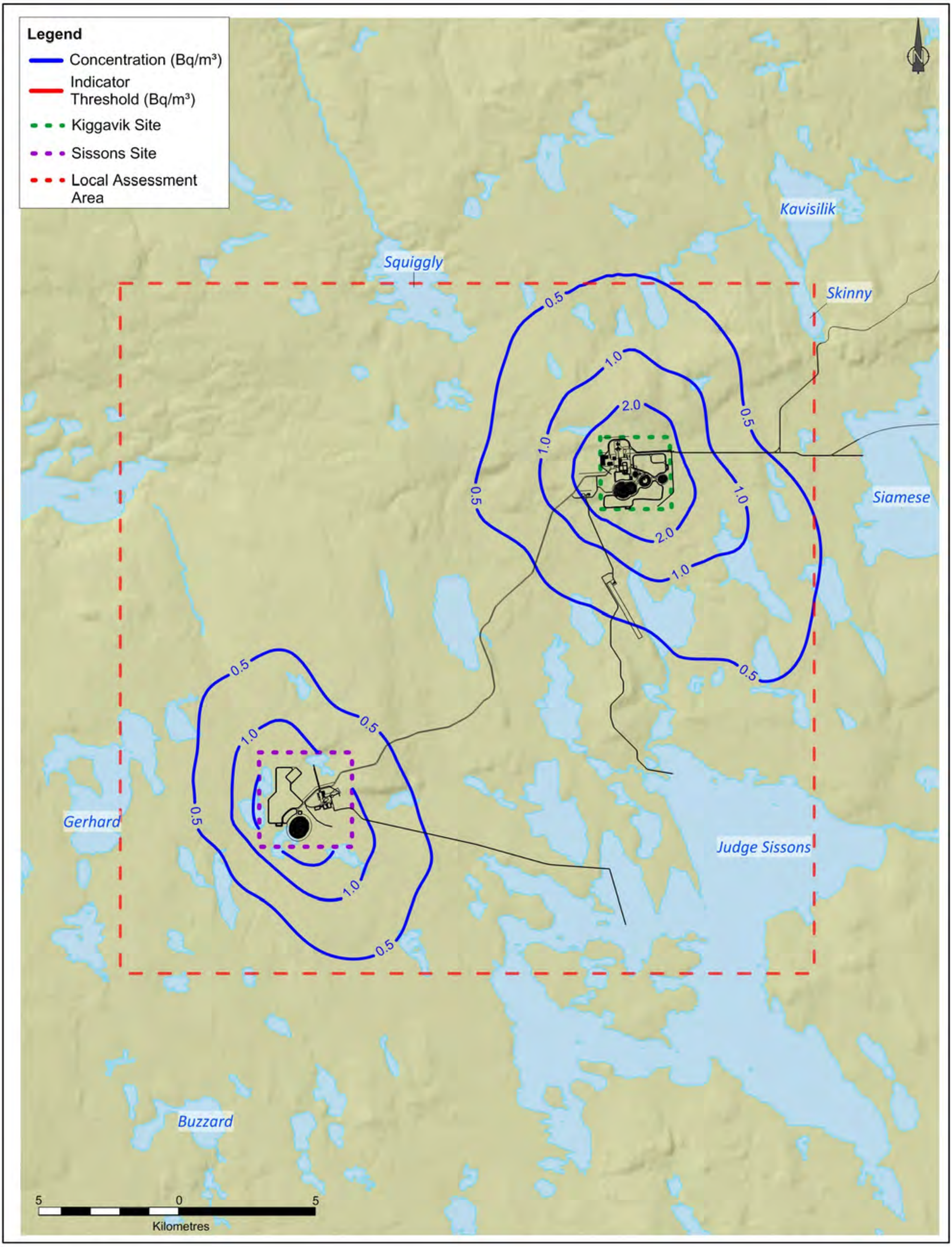
FIGURE 27

Operation Assessment - Phase 3
Incremental Annual Radon Concentration (Bq/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

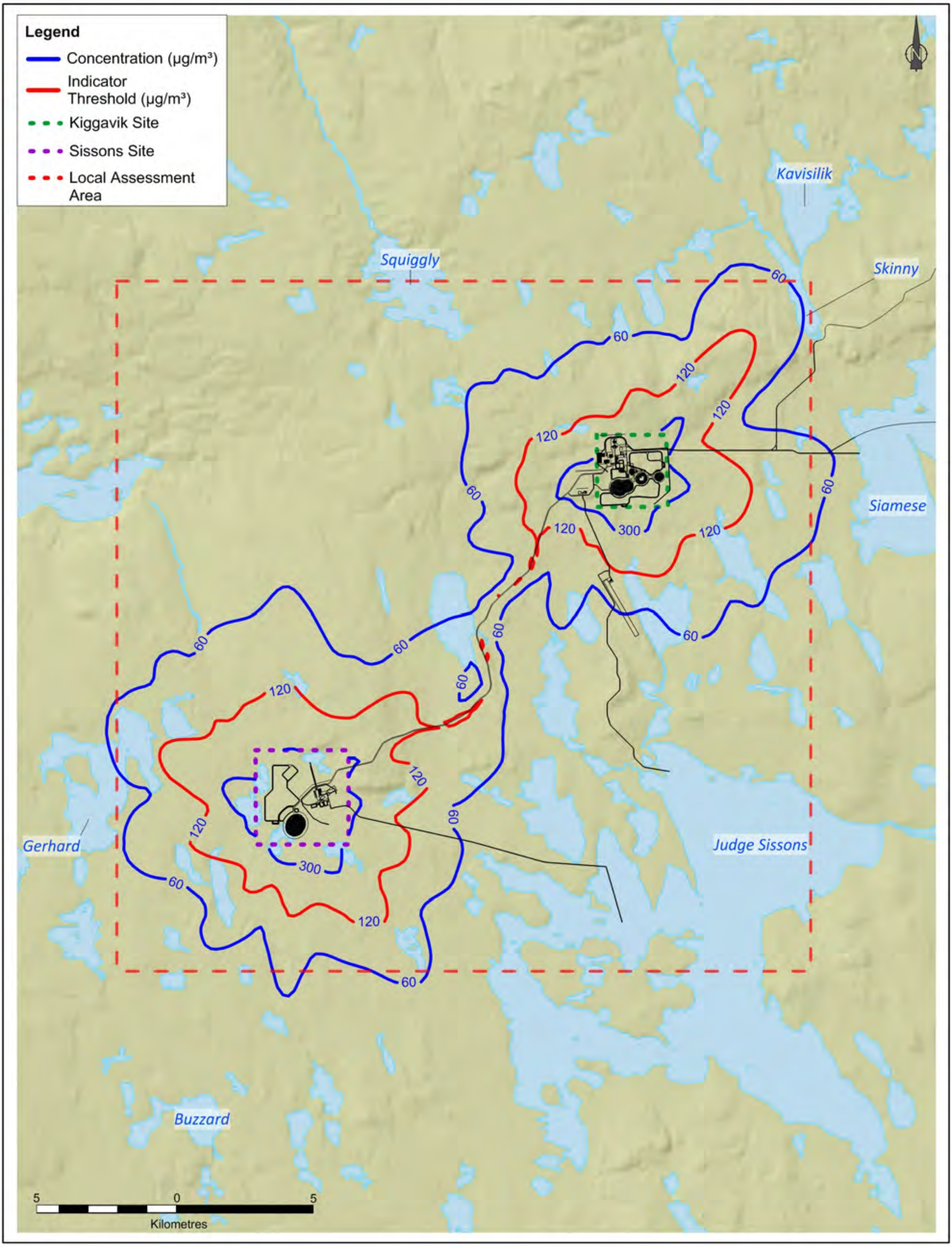
FIGURE 28
Operation Assessment - Phase 4
Incremental Annual Radon Concentration (Bq/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



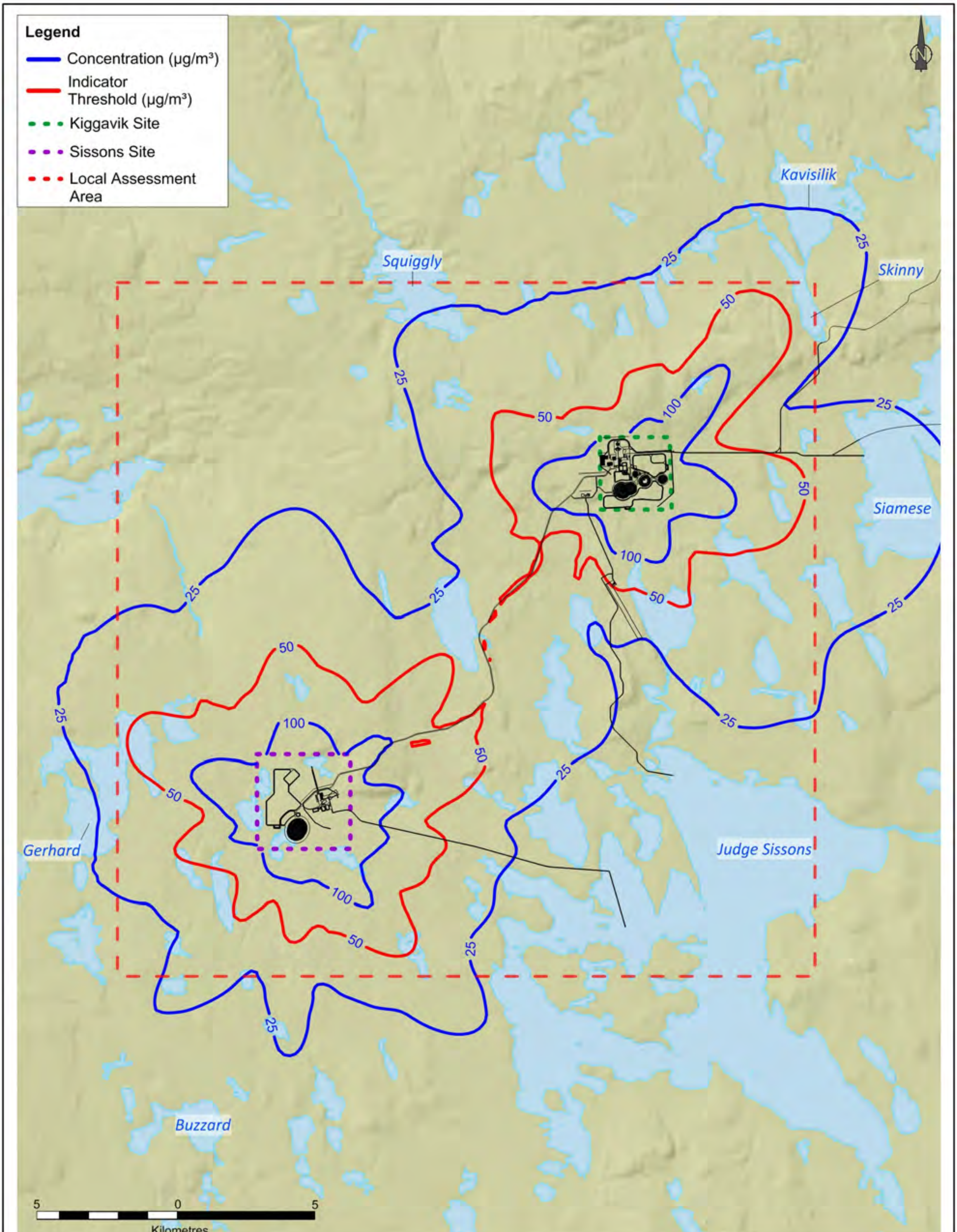
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 29
Maximum Operations Assessment
24-hour TSP Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



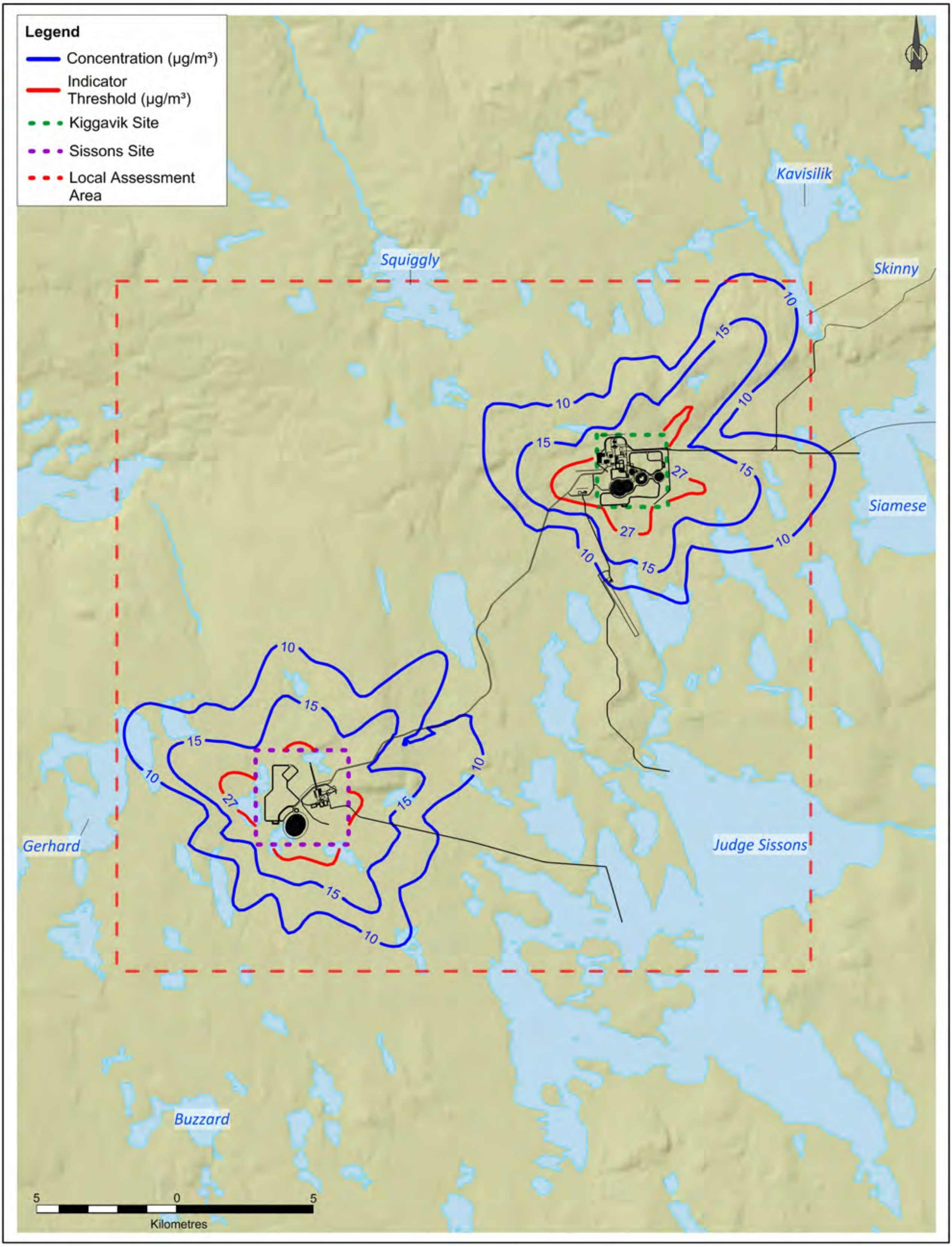
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 30
Maximum Operations Assessment
24-hour PM_{10} Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



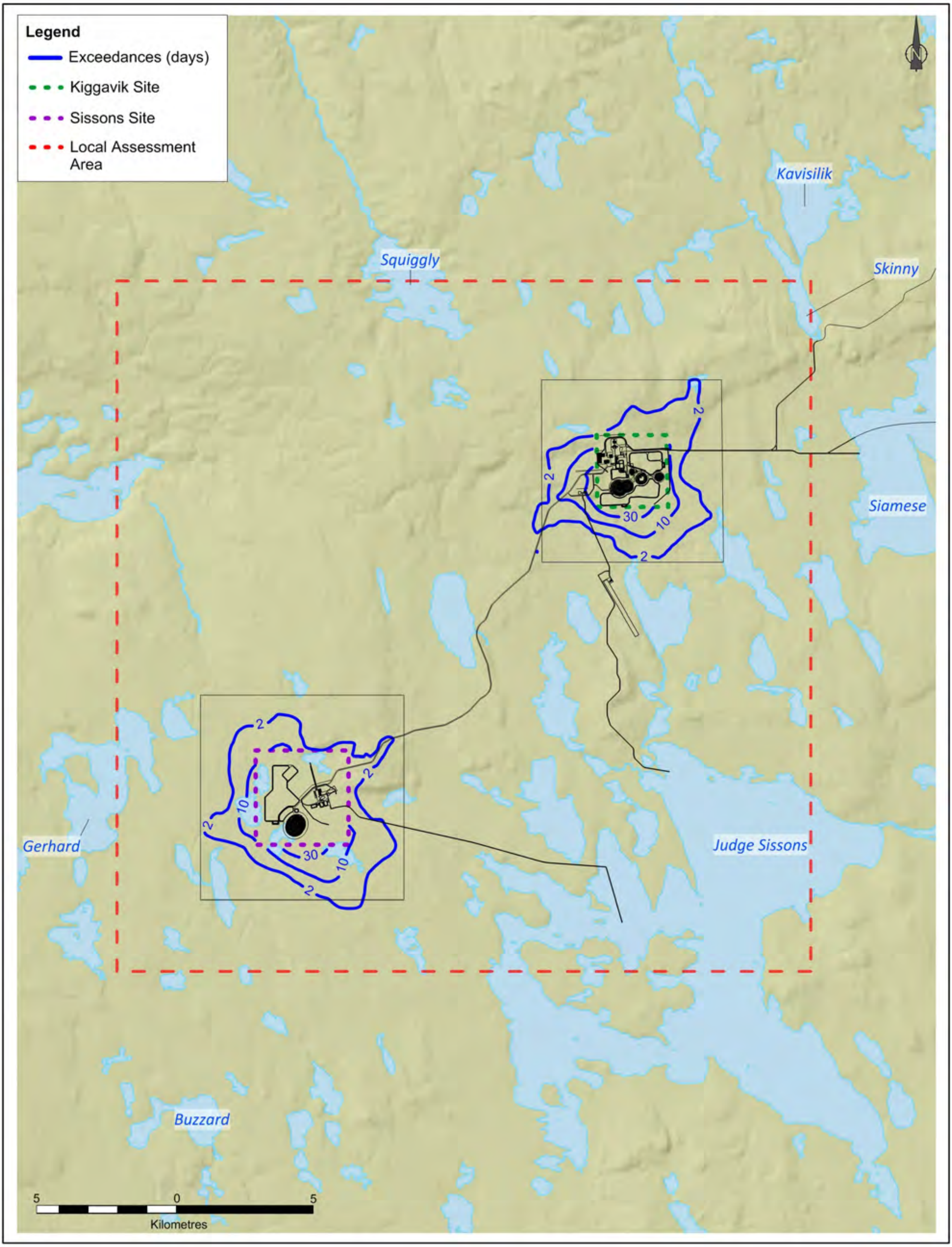
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 31
Maximum Operations Assessment
24-hour $PM_{2.5}$ Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



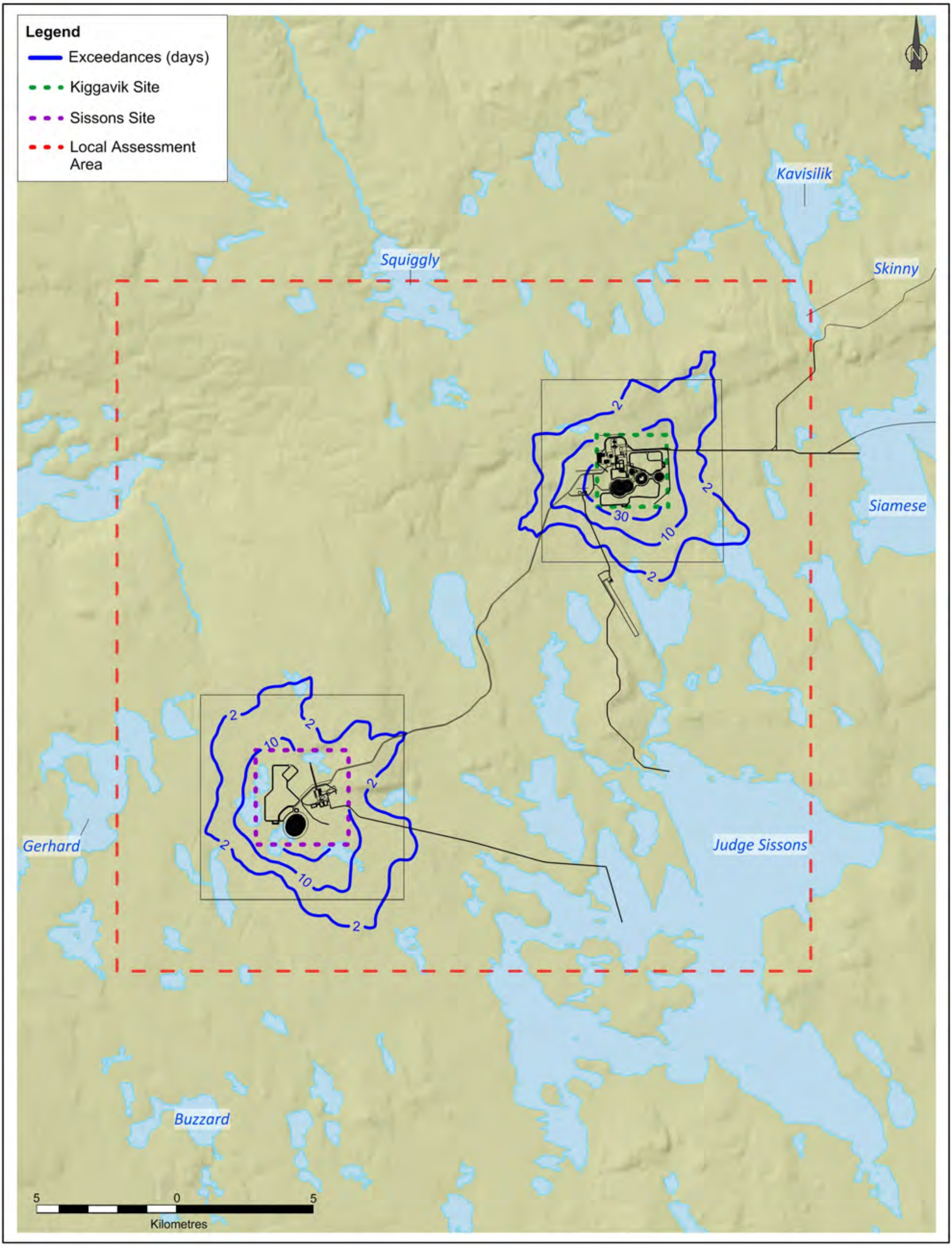
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 32
Maximum Operations Assessment
Exceedances of 24-hour TSP Indicator Threshold (days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

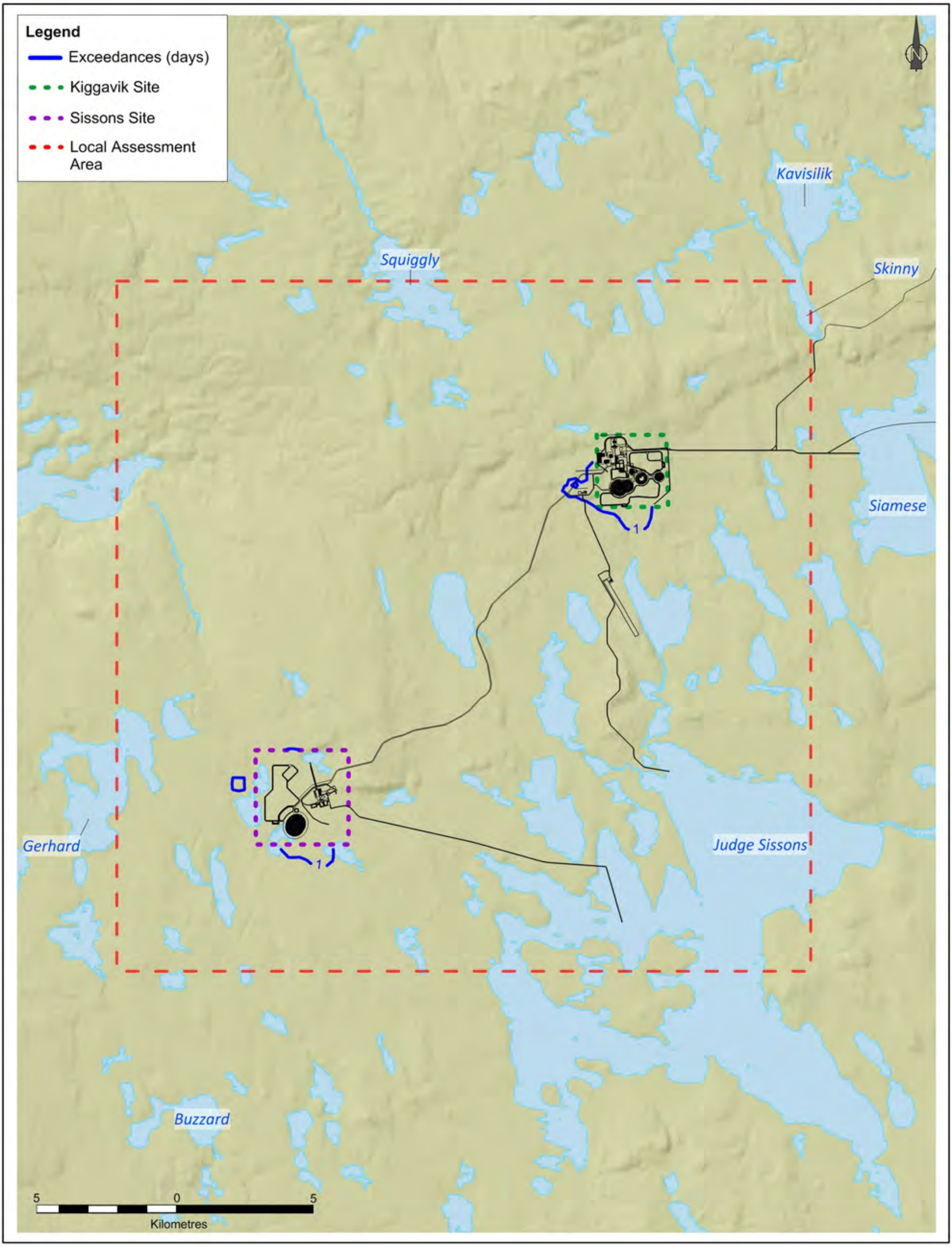
FIGURE 33

Maximum Operations Assessment
Exceedances of 24-hour PM_{10} Indicator Threshold (days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



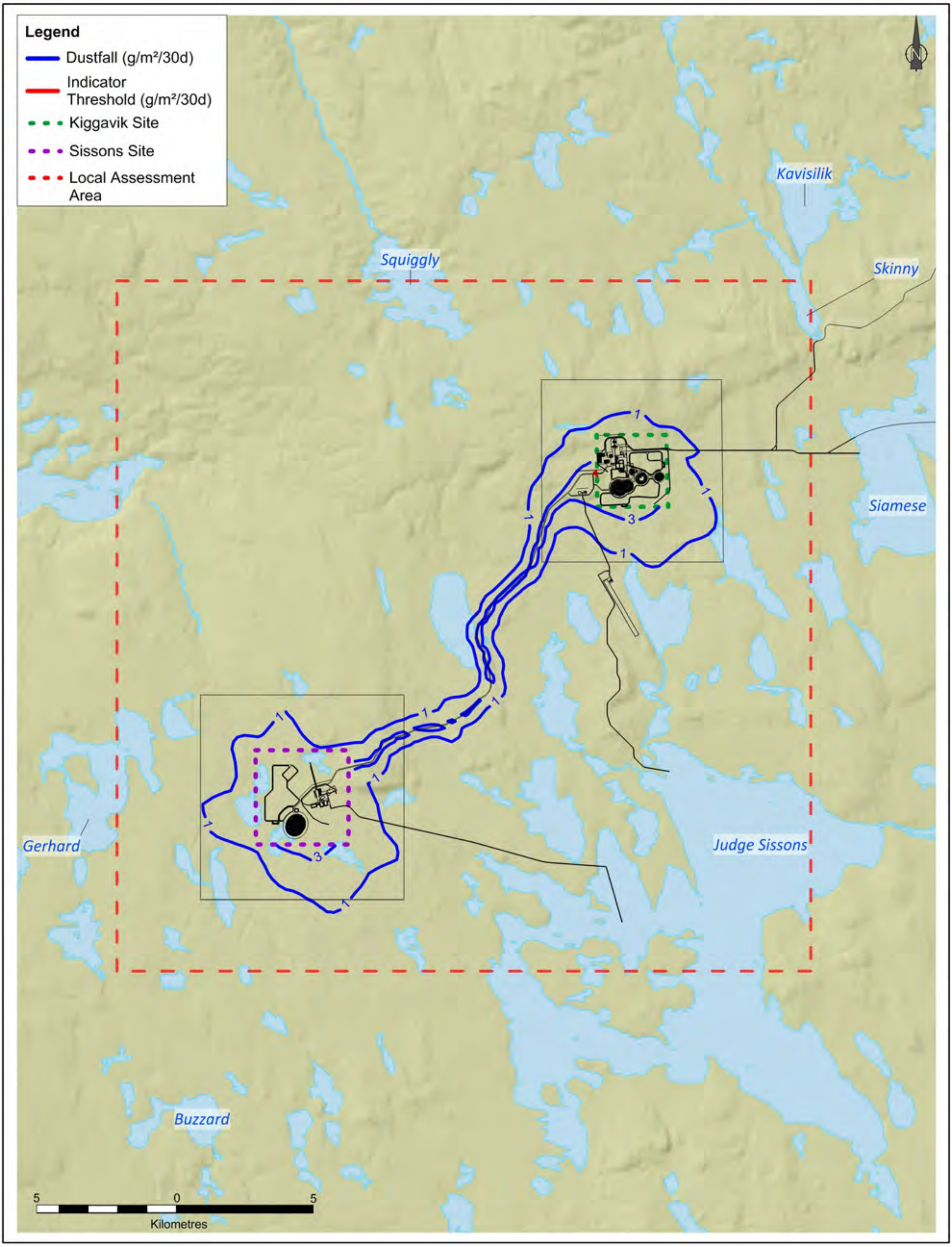
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 34
Maximum Operations Assessment
Exceedances of 24-hour $PM_{2.5}$ Indicator Threshold (days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



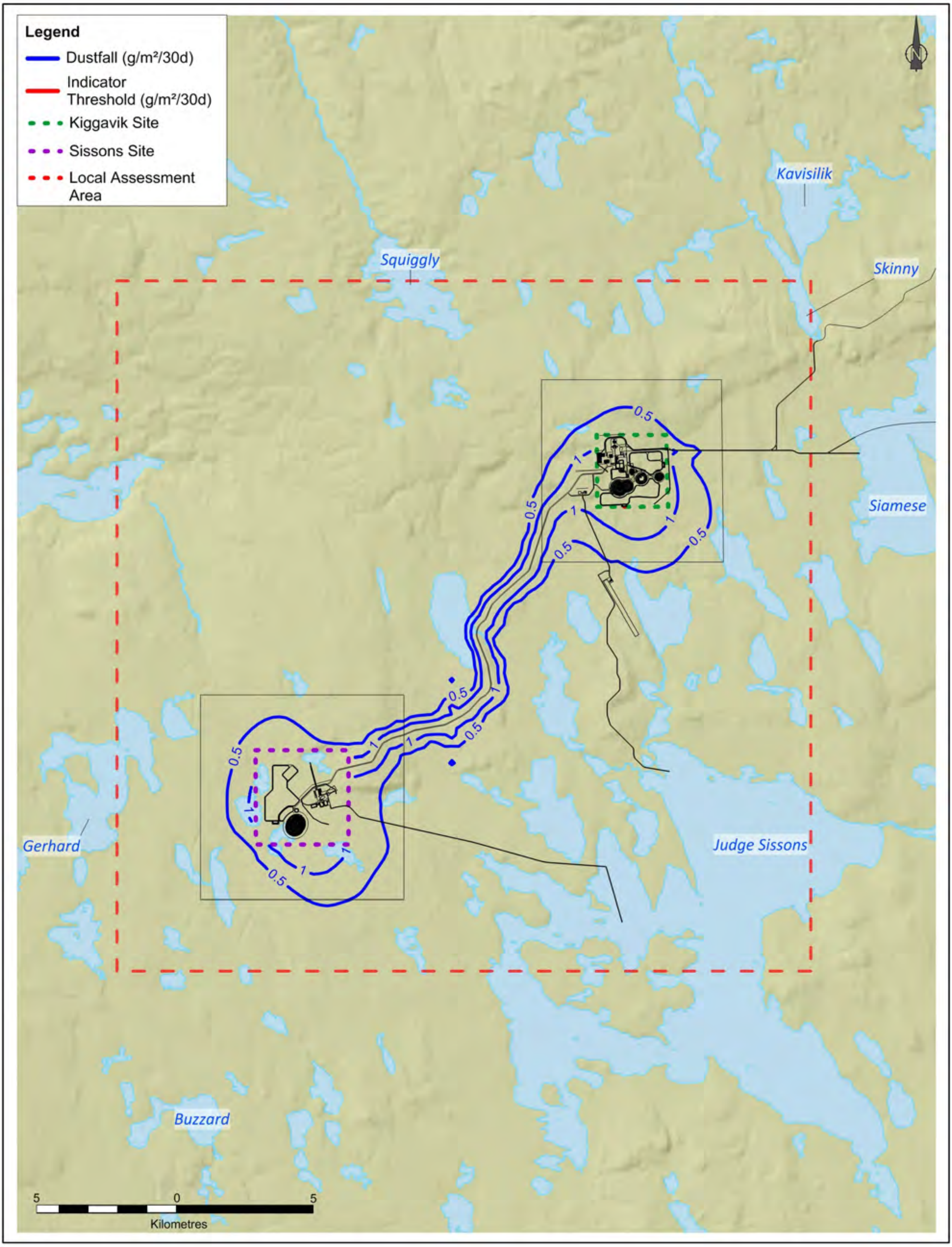
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 35
Maximum Operations Assessment
Maximum Monthly Dust Deposition Rate (g/m²/30 days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



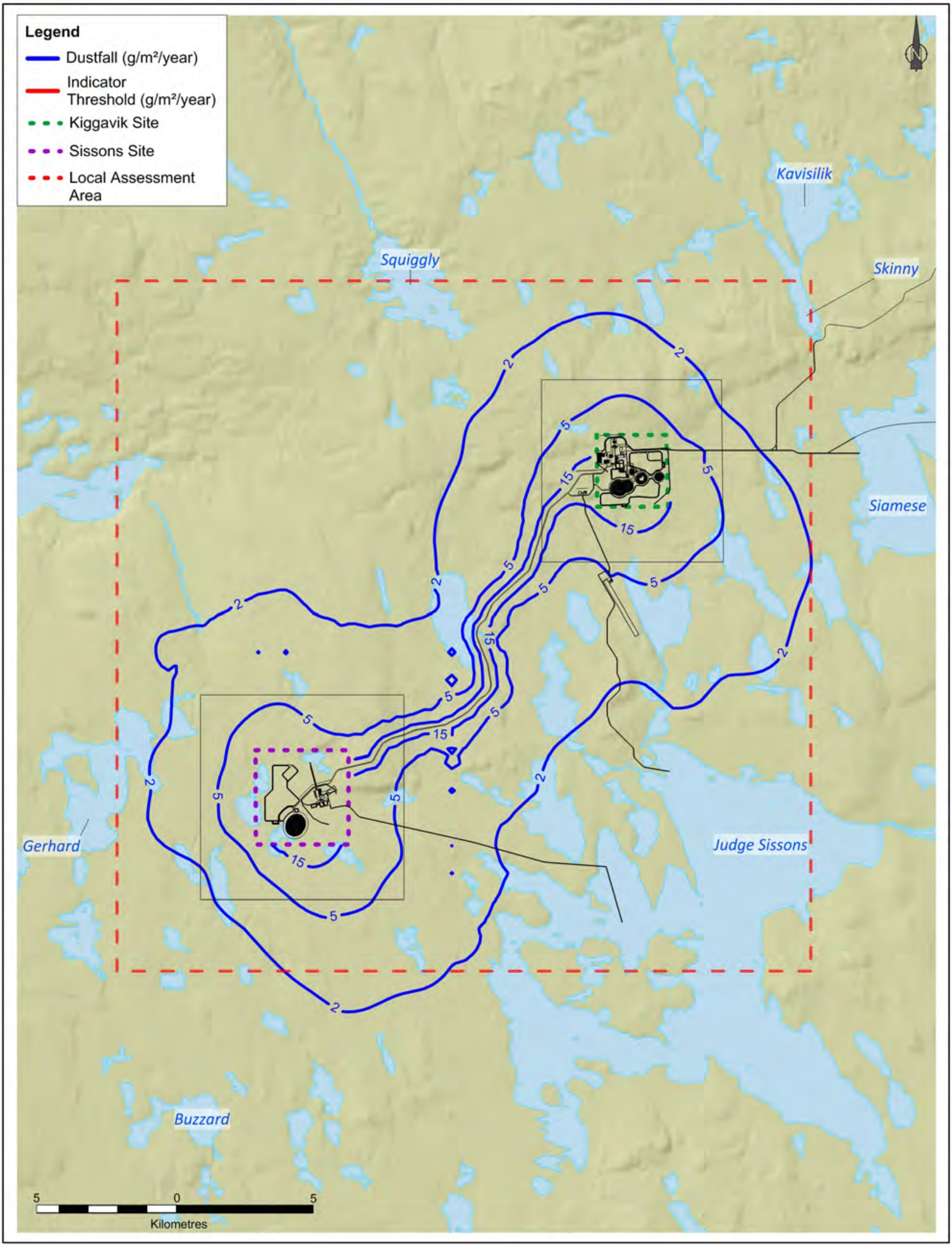
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 36
Maximum Operations Assessment
Average Annual Dust Deposition Rate (g/m²/30 days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



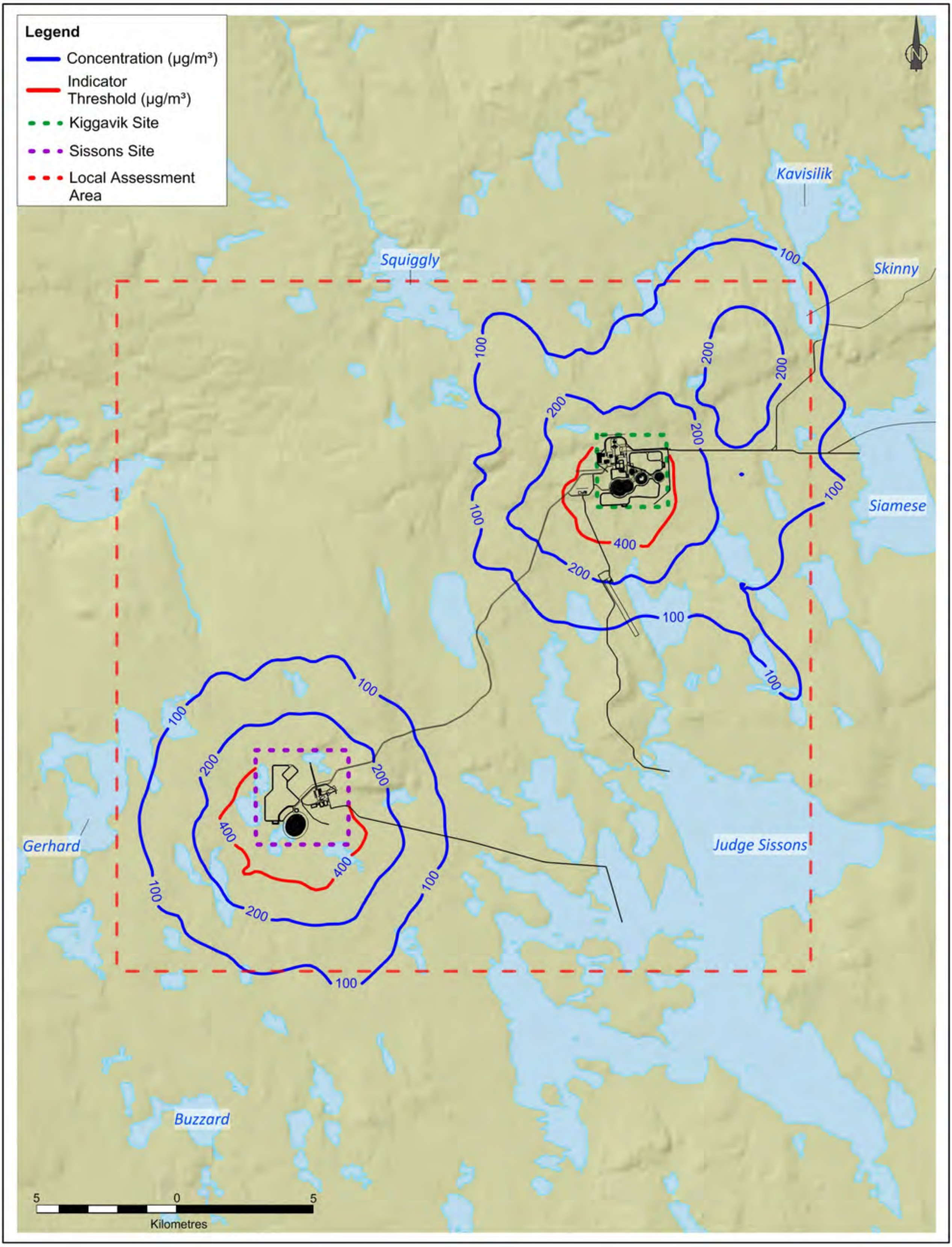
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 37
Maximum Operations Assessment
Total Annual Dust Deposition (g/m²/year)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



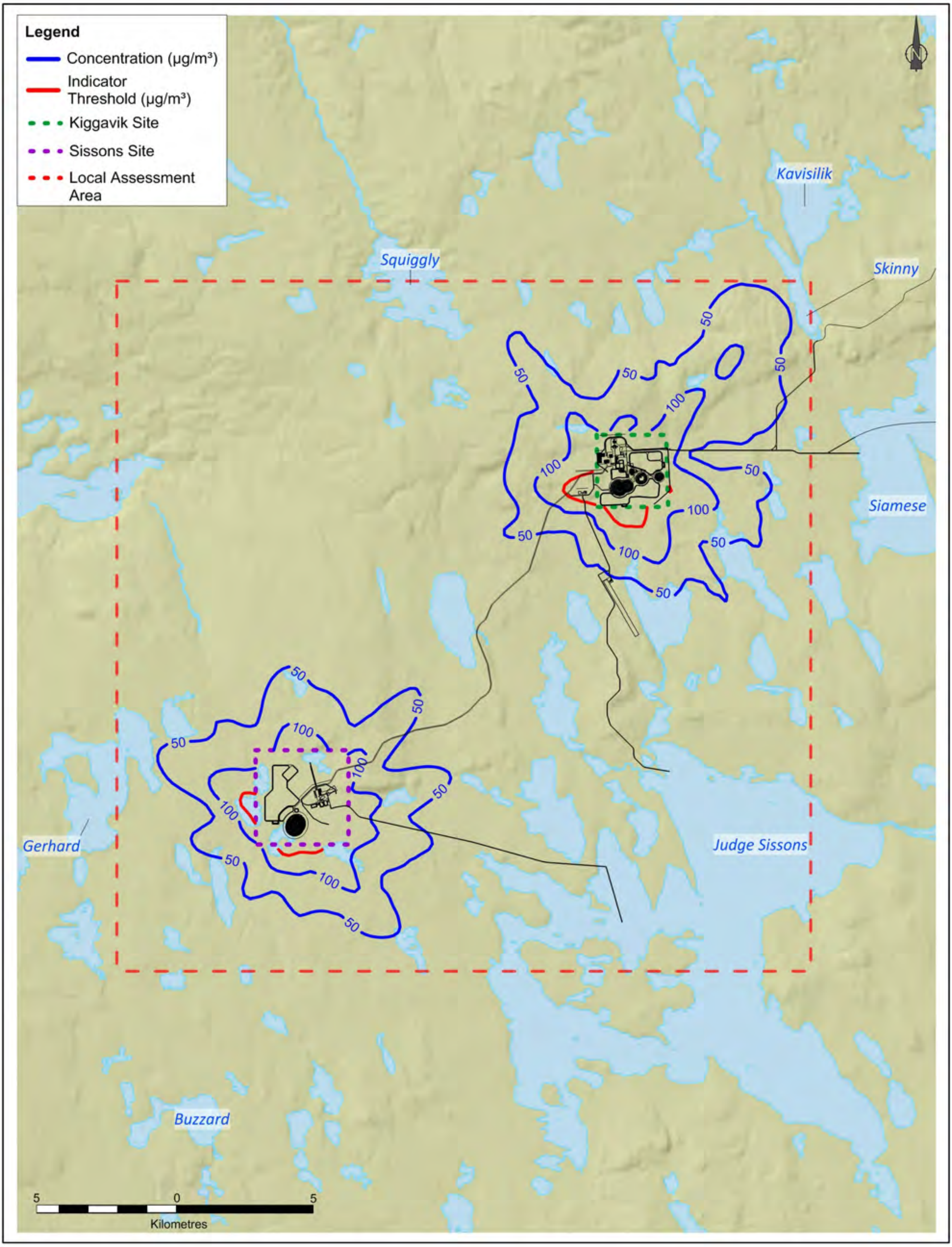
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 38
Maximum Operations Assessment
1-hour NO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



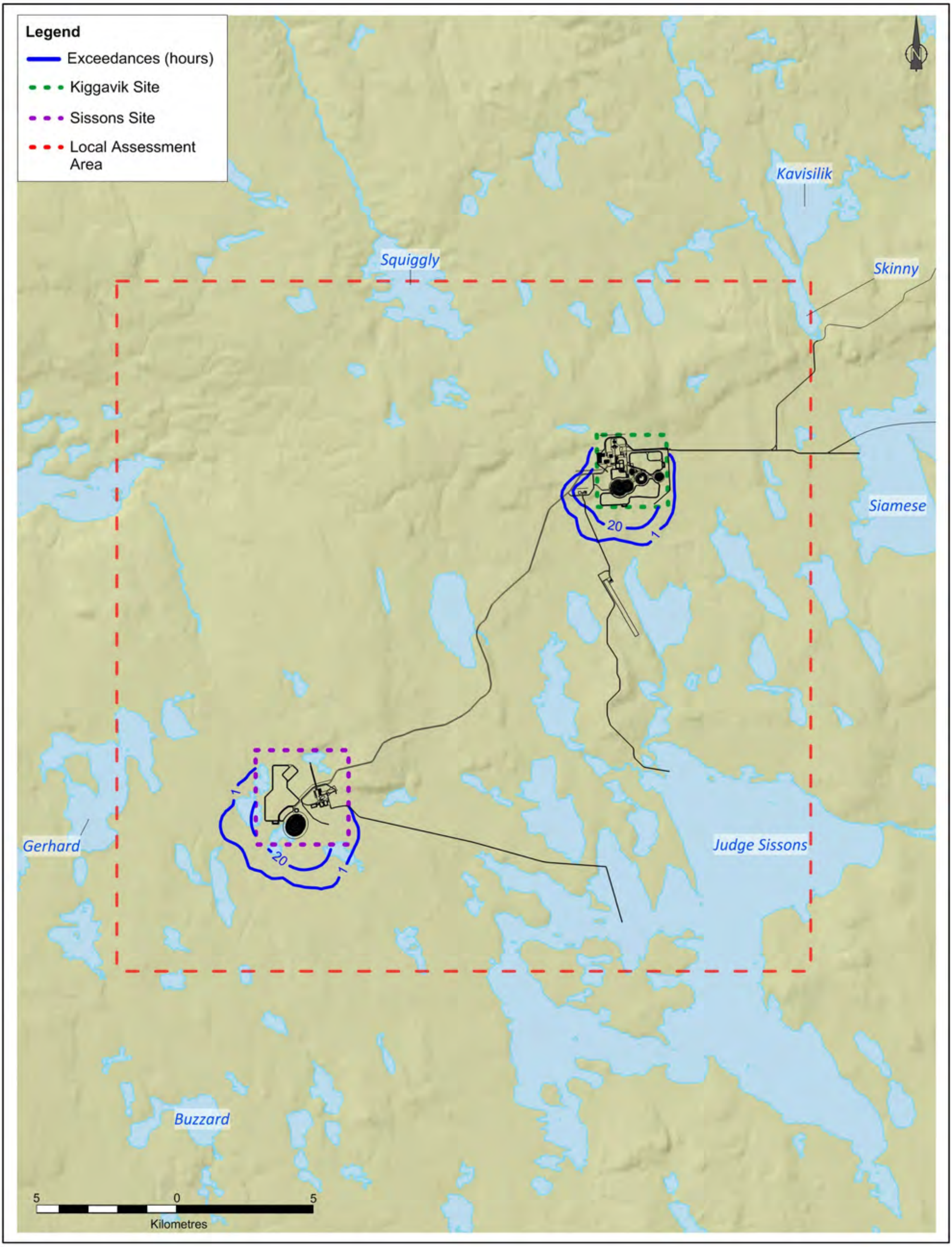
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 39
Maximum Operations Assessment
24-hour NO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

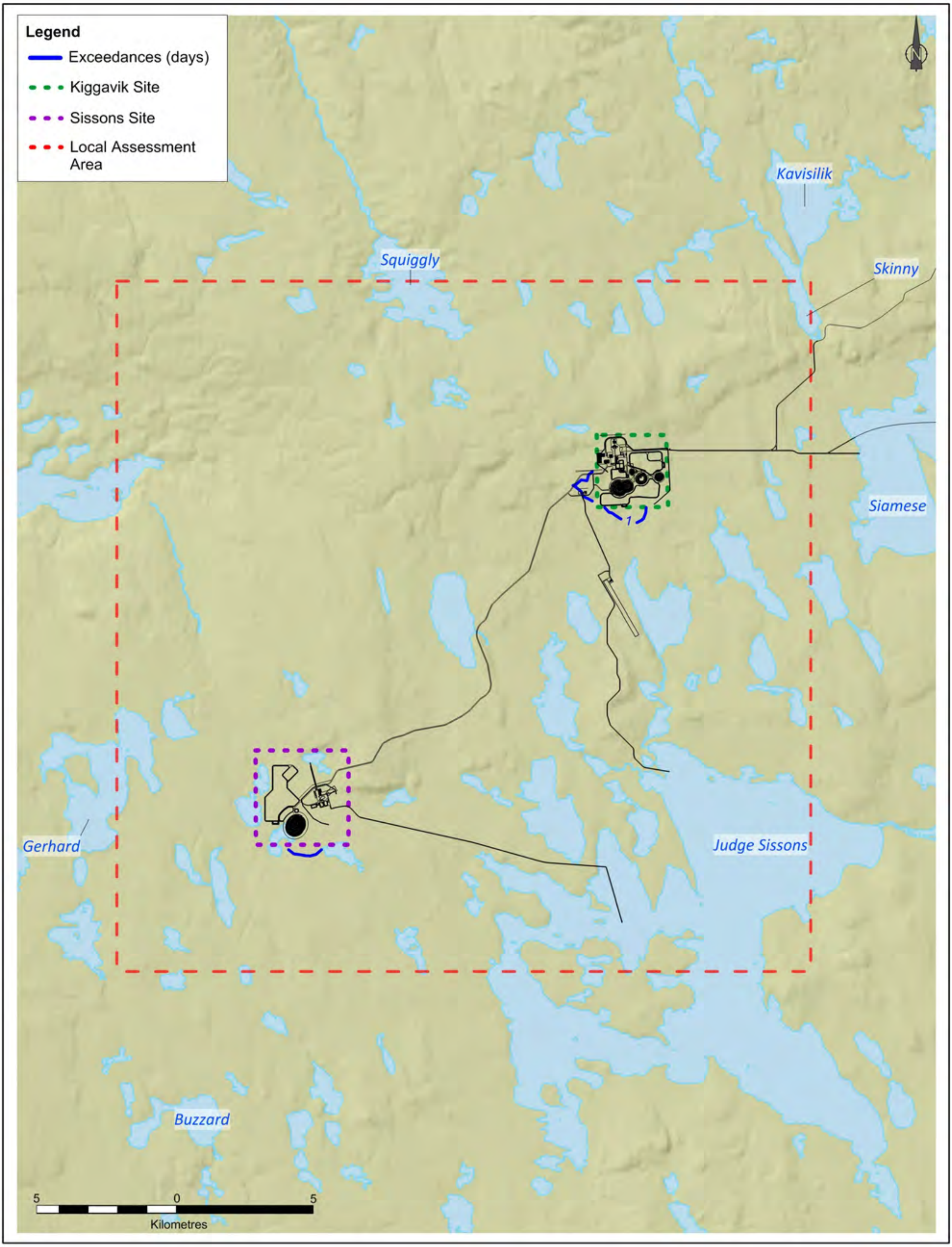
FIGURE 40

Maximum Operations Assessment
Exceedances of 1-hour NO_2 Indicator Threshold (hours)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

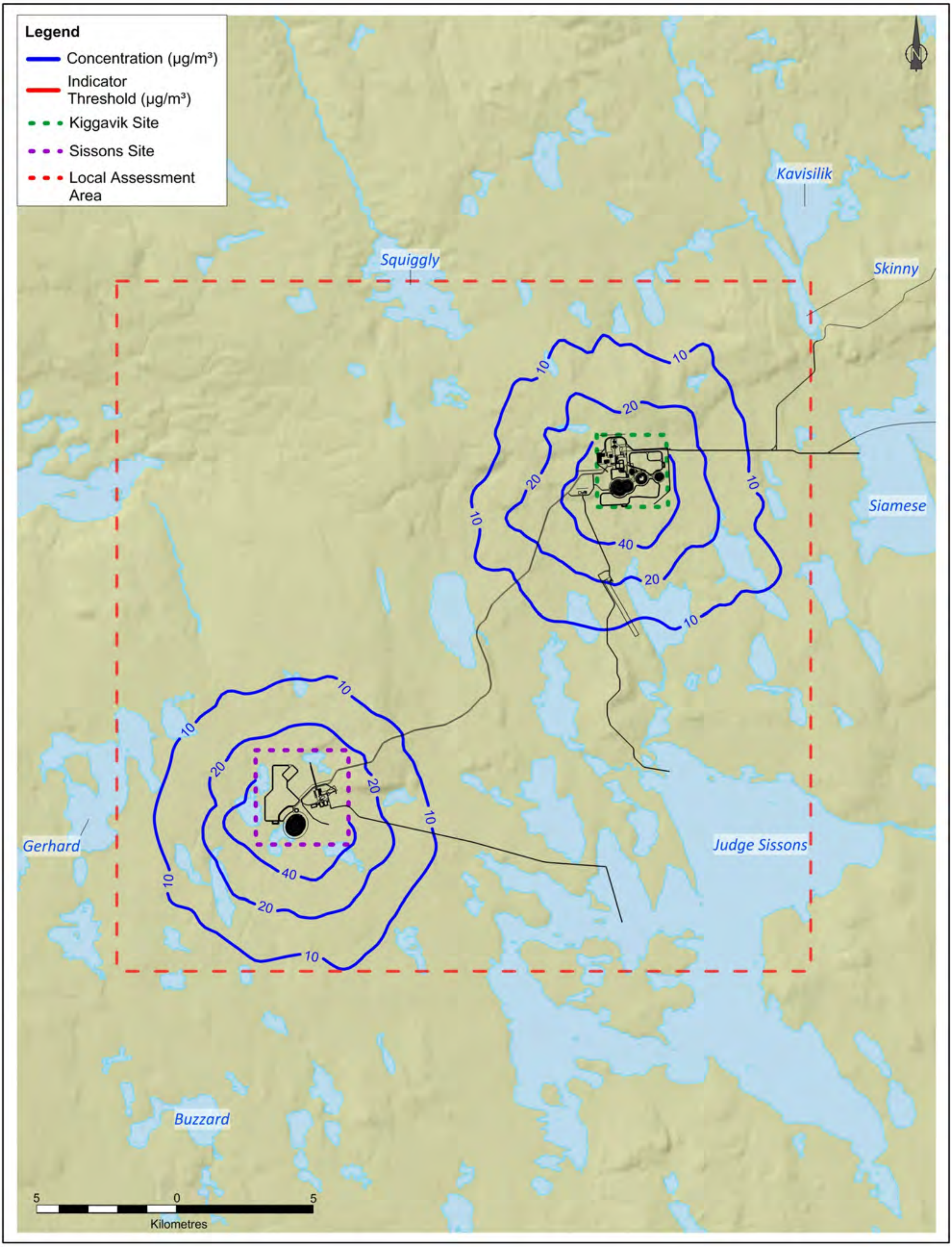
FIGURE 41

Maximum Operations Assessment
Exceedances of 24-hour NO_2 Indicator Threshold (days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



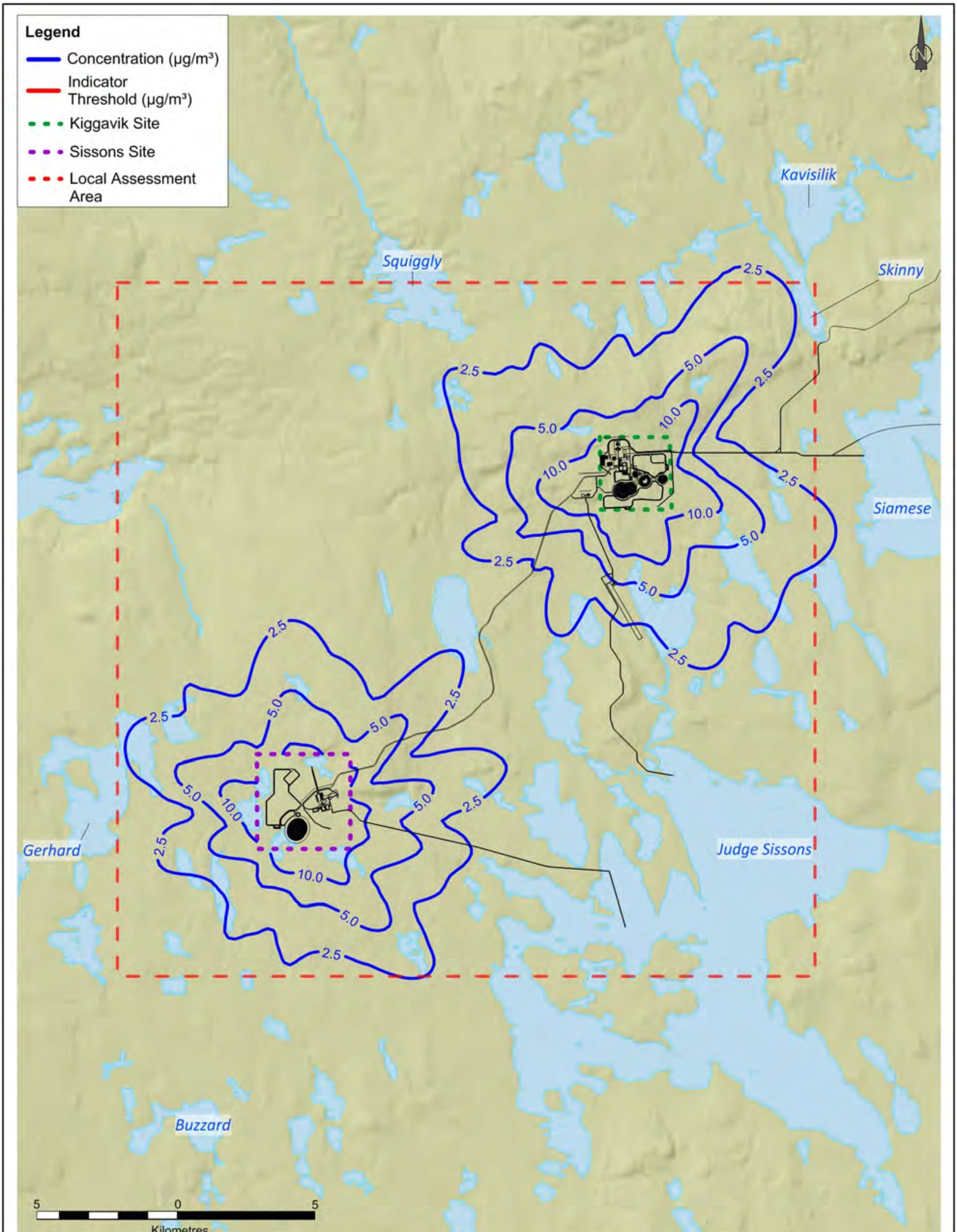
Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.*

FIGURE 42
Maximum Operations Assessment
1-hour SO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

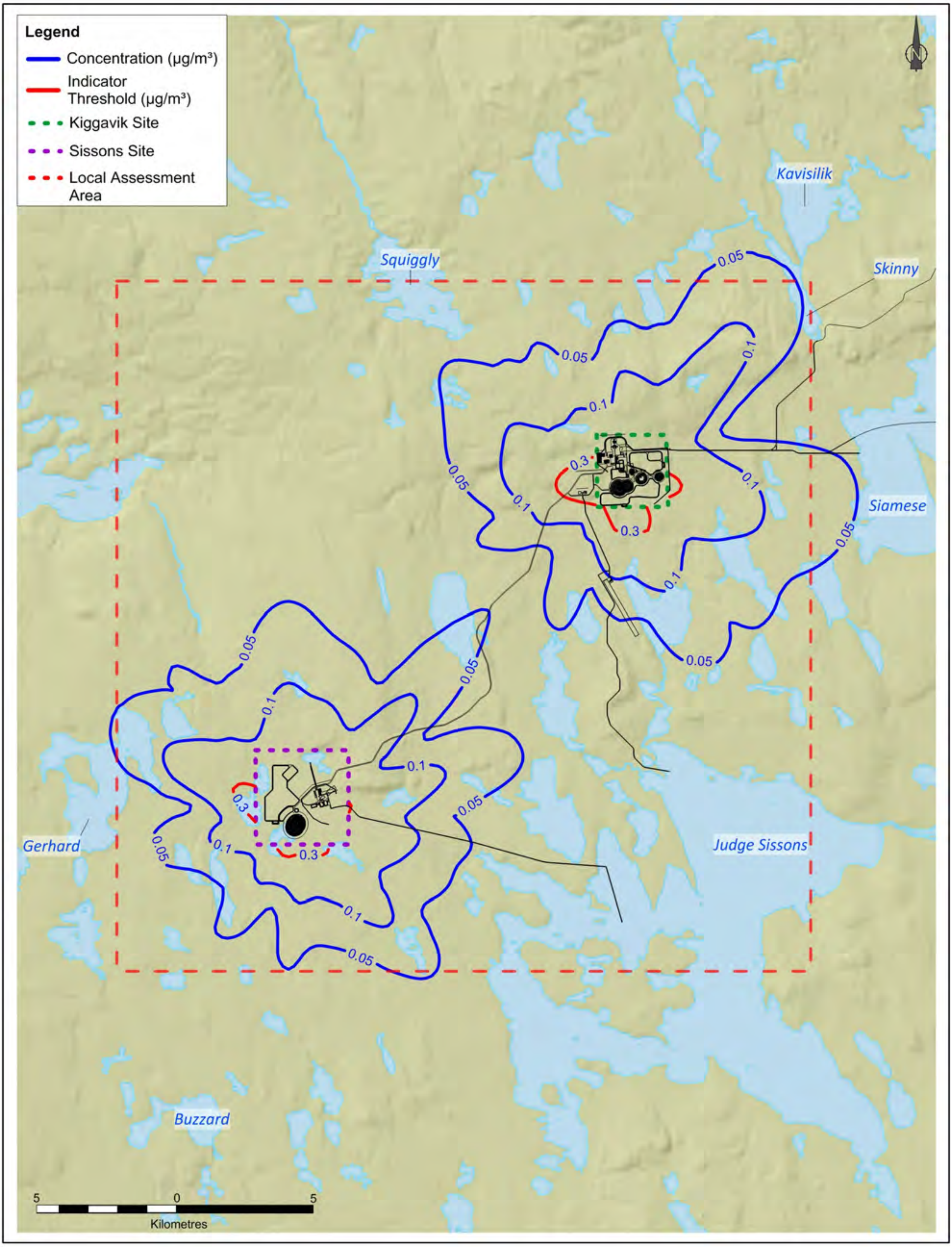
FIGURE 43
Maximum Operations Assessment
24-hour SO_2 Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3X5



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

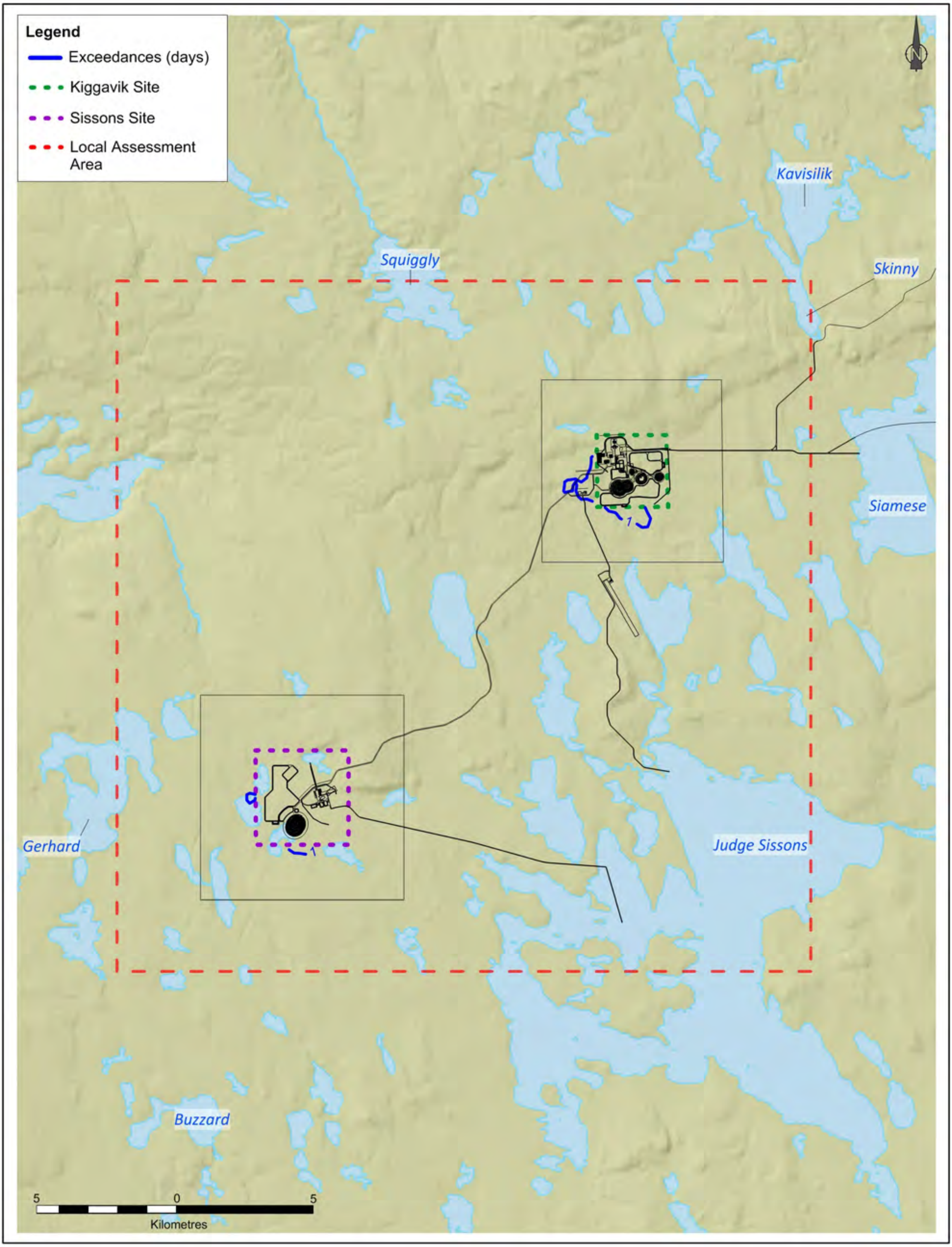
FIGURE 44
Maximum Operations Assessment
24-hour Uranium (U) Concentration (µg/m³)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultants
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE 45

Maximum Operations Assessment
Exceedances of 24-hour Uranium Indicator Threshold (days)

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
Technical Appendix 4B: AIR QUALITY AND CLIMATE

KIGGAVIK OPERATION

AREVA