OPG's DEEP GEOLOGIC

REPOSITORY

FOR LOW & INTERMEDIATE LEVEL WASTE

Atmospheric Environment Technical Support Document

March 2011

Prepared by: Golder Associates Ltd.

NWMO DGR-TR-2011-02

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NWMO DGR-TR-2011-02

Document History

Title:	Atmospheric Environment TSD		
Report Number:	DGR-TR-2011-02		
Revision:	R000	**Date:**	March 2011
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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

Ontario Power Generation (OPG) is undergoing a multi-year planning and regulatory approval process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). Currently, the L&ILW produced as a result of the operation of OPG's nuclear reactors is stored centrally at OPG's Western Waste Management Facility (WWMF) located at the Bruce nuclear site. Although current storage practices are safe and could be continued safely for many decades, OPG's long-term plan is to manage these wastes in a long-term management facility. Throughout this report, OPG's proposal is referred to as the "DGR Project".

The DGR Project includes the site preparation and construction, operations, decommissioning, and abandonment and long-term performance of the DGR. The DGR will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site near the existing WWMF. The underground facilities will include access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. The surface facilities include the underground access and ventilation buildings, Waste Package Receiving Building (WPRB) and related infrastructure.

An environmental assessment (EA) of the proposed DGR Project is required under the provisions of the *Canadian Environmental Assessment Act* (CEAA) because the proponent (OPG) will be required to obtain a licence from the Canadian Nuclear Safety Commission (CNSC) to allow the project to proceed. The findings of the EA are presented in the Environmental Impact Statement (EIS) and Technical Support Documents (TSDs).

ES.2 APPROACH

The approach used for assessing effects of the DGR Project supports the philosophy of EA as a planning tool and decision-making process. The assessment characterizes and assesses the effects of the DGR Project in a thorough, traceable, step-wise manner. The approach used in the assessment includes the following steps:

- describe the project;
- describe the existing environment;
- screen potential project-environment interactions to focus the assessment;
- predict and assess effects, apply mitigation measures to reduce or eliminate the effects and identify residual adverse effects;
- determine significance of residual adverse effects; and
- propose a follow-up program to confirm mitigation measures are effective and the DGR Project effects are as predicted.

The assessment of effects considers direct and indirect effects of the DGR Project, effects of the environment on the project, climate change considerations, and effects of the project on renewable and non-renewable resources. An assessment of the cumulative effects associated with the DGR Project in association with existing and planned projects is addressed in Section 10 of the EIS. Effects are predicted in the context of temporal and spatial boundaries.

The temporal boundaries for the EIS establish the timeframes for which the effects are assessed. Four temporal phases were identified for the DGR Project:

- site preparation and construction phase;
- operations phase;
- decommissioning phase; and
- abandonment and long-term performance phase.

The abandonment and long-term performance phase is discussed in Section 9 of the EIS. Spatial boundaries define the geographical extents within which environmental effects are considered. Therefore, these boundaries become the study areas adopted for the EA. Four study areas were selected for the assessment of the atmospheric environment: the Regional Study Area, Local Study Area, Site Study Area and Project Area. The Project Area, although not specified in the guidelines, was defined to help describe the potential site-specific effects of the DGR Project. Each study area includes the smaller study areas (i.e., they are not geographically separate).

ES.3 VALUED ECOSYSTEM COMPONENTS

While all components of the environment are important, it is neither practicable nor necessary to assess every potential effect of a project on every component. The EA focuses on the components that have the greatest relevance in terms of value and sensitivity, and which are likely to be affected by the project. To achieve this focus, specific Valued Ecosystem Components (VECs) are identified. A VEC is considered to be the 'receptor' for both project-specific effects and cumulative effects. A VEC can be represented by a number of 'indicators', which are features of the VEC that may be affected by the DGR Project (e.g., nitrogen dioxide in air). Each indicator requires specific 'measures' that can be quantified and assessed (e.g., changes in air concentrations of indicators). In essence, the nature and magnitude of the effects of the DGR Project on these VECs has been studied and their significance determined.

The following VECs are used in assessing the effects of the DGR Project on atmospheric environment:

- air quality; and
- noise levels.

ES.4 RESULTS

Project-environment interactions are identified and assessed for potential measurable changes. Measurable emissions to the atmosphere are identified for both air quality and noise indicators. These identified measurable changes are assessed to determine whether they were adverse. The following residual adverse effects are identified after taking mitigation measures into consideration for the atmospheric environment:

- Increase in eight air quality indicators during the site preparation and construction, and decommissioning phases, and seven indicators during the operations phase of the DGR Project. These effects were not assessed to be significant.

- Increase in noise levels during the site preparation and construction phase, and the decommissioning phase. These effects were assessed to be not significant.

In addition, the following conclusions are made regarding the atmospheric environment:

- the atmospheric environment is not expected to adversely affect the DGR Project (e.g., severe weather);
- climate change is not expected to alter the conclusions reached regarding the effects of the DGR Project on air quality and noise levels; and
- the DGR Project is not expected to affect climate change.

Therefore, no significant adverse effects are identified for atmospheric environment VECs.

ES.5 PRELIMINARY FOLLOW-UP PROGRAM

Follow-up monitoring programs are required to:

- verify the key predictions of the EA studies; or
- confirm the effectiveness of mitigation measures, and in so doing, determine if alternative mitigation strategies are required.

It is recommended that a series of follow-up and monitoring programs be implemented to measure changes in air quality and noise levels during the site preparation and construction phase.

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1. INTRODUCTION

Ontario Power Generation (OPG) is undergoing a multi-year planning and regulatory approvals process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). Currently, the L&ILW produced as a result of the operation of OPG-owned nuclear reactors is stored centrally at OPG's Western Waste Management Facility (WWMF) located at the Bruce nuclear site. Although current storage practices are safe and could be continued safely for many decades, OPG's long-term plan is to manage these wastes in a long-term management facility.

A key element of the regulatory approvals process is this environmental assessment (EA), the findings of which are presented in an Environmental Impact Statement (EIS). The EA considers the long-term management of L&ILW currently in interim storage at the WWMF, as well as that produced by OPG-owned and operated nuclear generating stations, in a DGR at the Bruce nuclear site in the Municipality of Kincardine, Ontario. The DGR Project site is shown on Figure 1-1. Throughout this report, OPG's proposal is referred to as the "DGR Project". The DGR Project includes the site preparation and construction, operations, decommissioning, and abandonment and long-term performance of the DGR.

The DGR will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site near the existing WWMF. The underground facilities will include access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. The surface facilities include the underground access and ventilation buildings, Waste Package Receiving Building (WPRB) and related infrastructure. All surface and underground facilities will be located within the boundaries of the OPG-retained lands near the WWMF at the Bruce nuclear site.

OPG is the proponent for the DGR Project. OPG will own, operate and be the licensee for the DGR. The regulatory approvals phase of the DGR Project, including the EA process and the site preparation and construction licensing, has been contracted to the Nuclear Waste Management Organization (NWMO). The NWMO is responsible, with support from OPG, for completing the EA, preparing the EIS and obtaining the site preparation and construction licenses.

1.1 EA PROCESS AND REGULATORY CONTEXT

The EA process was initiated by the submission of a Project Description for the DGR by OPG to the Canadian Nuclear Safety Commission (CNSC) on December 2, 2005. The site preparation and construction licence application for the DGR was submitted by OPG to the CNSC on August 13, 2007. An EA of the proposed DGR Project is required under the provisions of the *Canadian Environmental Assessment Act* (CEAA) because the proponent (OPG) will require a licence from the CNSC to allow the project to proceed. Under the CEAA, the CNSC is identified as the Responsible Authority (RA); however, the Canadian Environmental Assessment Agency also has statutory responsibilities.

Under the CEAA, this type of project is identified in the Comprehensive Study List Regulation. The CNSC issued draft guidelines for a comprehensive study EA of the DGR Project, which were the subject of a public hearing held in Kincardine on October 23, 2006. Following the hearing, CNSC Commission members recommended to the Minister of the Environment that the

DGR Project be referred to a review panel given the public concerns, possibility of adverse environmental effects, the first-of-a-kind nature of the project and concerns regarding the comprehensive study's ability to address all the questions raised [1].

The Minister of the Environment referred the EA of the DGR Project to a joint review panel on June 29, 2007. Draft guidelines for the preparation of the EIS were issued by the Canadian Environmental Assessment Agency and the CNSC for public review on April 4, 2008. The guidelines were finalized on January 26, 2009, a copy of which is included in the EIS as Appendix A. The scope of the EA for the DGR Project includes the site preparation, construction, operations and decommissioning of the above- and below-ground facilities for the long-term management of L&ILW. The EA also addresses the abandonment and long-term performance of the DGR Project.

An EA is a tool to provide an effective means of integrating environmental factors into the planning and decision-making processes in a manner that promotes sustainable development and minimizes the overall effect of a project. The methods used in the EA and presented in the EIS are consistent with the final DGR Project EIS Guidelines and are based on systematic and detailed consideration of the systems, works, activities and events comprising the DGR Project.

1.2 EA REPORTING STRUCTURE

The EA for the DGR Project is documented in an EIS, which is based on the final guidelines and the work detailed in a series of technical support documents (TSDs). In addition, there are parallel technical studies, information from which is also used in preparing the EIS and TSDs. Finally, the findings are summarized in the EIS Summary. Figure 1.2-1 illustrates the relationships between the EIS and summary report, its supporting documents, and the independent technical studies for the DGR Project.

The EIS comprises the following volumes:

- **Volume 1** consolidates and summarizes all aspects of the EIS studies. It includes a description of the EA methods, a description of the DGR Project, a description of the existing environment, an assessment of likely environmental effects, including cumulative effects, a discussion of the proposed follow-up program, and a discussion of the communication and consultation program.
- **Volume 2** contains a series of appendices that support the material in Volume 1, including a copy of the EIS Guidelines, human health assessment and a summary of the community engagement and consultation program along with copies of supporting materials.

The TSDs present information on the existing environment and describes processes used to assess the direct and indirect effects of the DGR Project on the environment. The TSDs, on which the EIS is based, are as follows:

- Atmospheric Environment;
- Hydrology and Surface Water Quality;
- Geology;
- Aquatic Environment;

- Terrestrial Environment;
- Socio-economic Environment;
- Aboriginal Interests;
- Radiation and Radioactivity; and
- Malfunctions, Accidents and Malevolent Acts.

These TSDs are interconnected with one another. Each respective report focuses on the effects of the DGR Project on that particular aspect of the environment, be it through a direct interaction with the DGR Project or through a change identified in another TSD (i.e., an indirect interaction). Cross-references are provided throughout the TSD where it relies on information predicted in another report.

The TSDs assess the direct and indirect effects of the DGR Project as a result of normal conditions, with the exception of the Malfunctions, Accidents and Malevolent Acts TSD. The EIS guidelines require an identification of credible malfunctions and accidents, and an evaluation of the effects of the DGR Project in the event that these accidents or malfunctions occur. All of these effects are discussed and addressed in the Malfunctions, Accidents and Malevolent Acts TSD regardless of the element of the environment that is affected. The reasoning for this is that a single accident is likely to affect multiple elements of the environment. It is important to note that all of the assessments of potential radiation and radioactivity effects of the DGR Project are documented in the Radiation and Radioactivity TSD, regardless of the physical media through which they are transported (e.g., air or water). This was done because of the special importance placed on radiation and radioactivity, and the combined effects to the receiving environment regardless of the path of exposure.

The independent parallel technical study reports used in preparing the EIS include the following:

- Postclosure Safety Assessment [2];
- Geosynthesis [3]; and
- Preliminary Safety Report [4].

This Atmospheric Environment TSD evaluates the non-radiological effects of the site preparation and construction, operations and decommissioning of the DGR Project on the atmospheric environment. The abandonment and long-term performance phase is considered in Section 9 of the EIS. To facilitate this assessment, a description of the existing environmental features is also included.

Predictions made as part of modelling completed for the Atmospheric Environment TSD are used by a number of other disciplines, including the terrestrial environment, socio-economic environment, Aboriginal interests and human health. The predictions used in these assessments are provided in Appendix J of this TSD. These results are then assessed as indirect effects in the Terrestrial Environment TSD, Socio-economic Environment TSD, Aboriginal Interests TSD, and in the EIS (for the human health assessment).

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0 5 10 20 30 40 50

Kilometres

LEGEND

- City
- Highway
- Provincial Highway
- Secondary Highway

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v7.3 2003
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2005
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF THE DGR PROJECT

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 1-1**	
GIS	BC	29 Apr. 2010		
CHECK	AB	29 Apr. 2010		
REVIEW	MAR	29 Apr. 2010		

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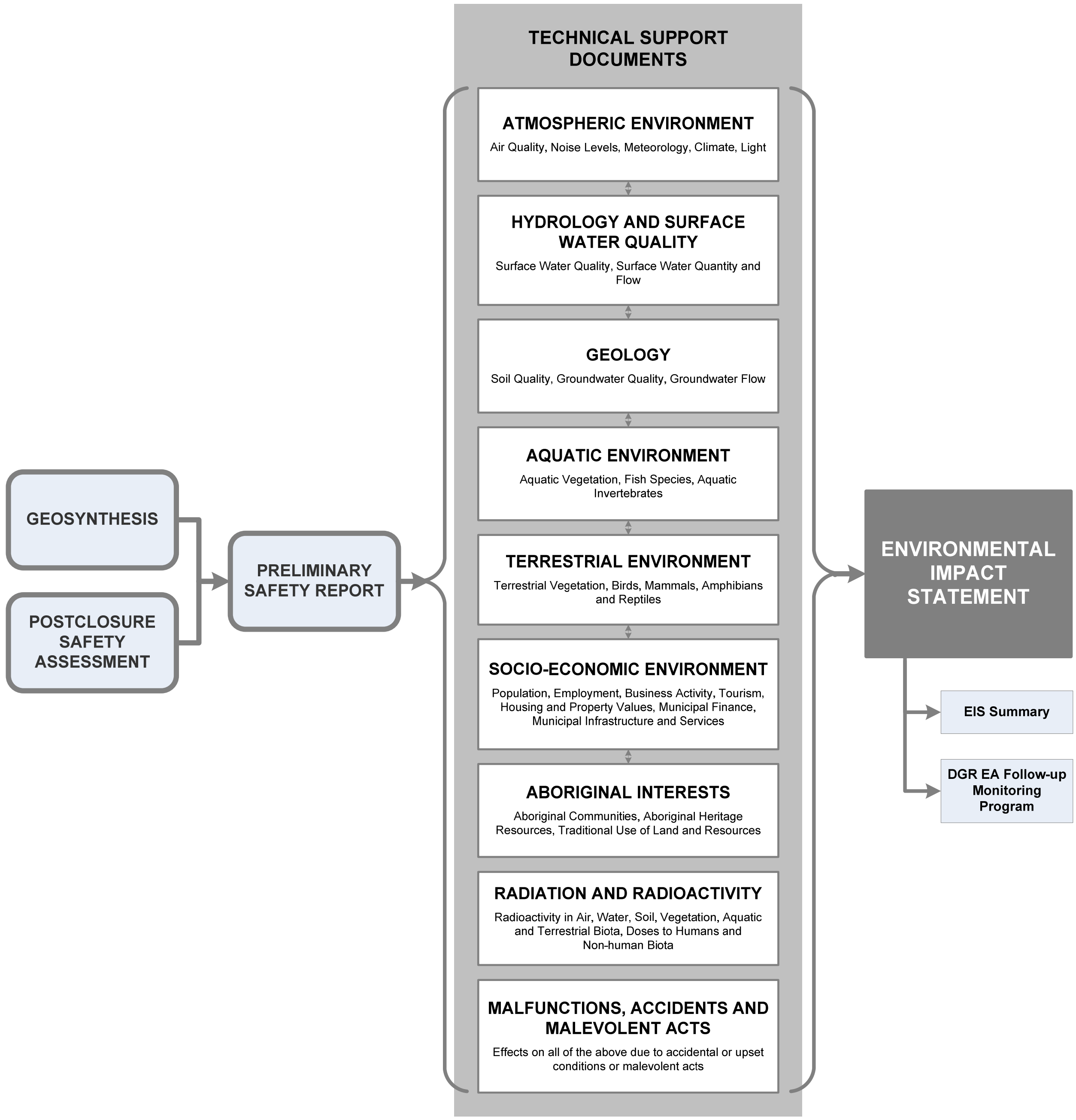

Figure 1.2-1: Organization of EA Documentation

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2. APPROACH

2.1 GENERAL SUMMARY OF EA APPROACH

The approach used for assessing the DGR Project, and documented in this TSD, supports the philosophy of EA as a planning and decision-making process. The assessment characterizes and assesses the effects of the DGR Project in a thorough, traceable, step-wise manner. The approach used in the assessment is illustrated on Figure 2.1-1, and includes the following steps:

- **Describe the Project.** As summarized in Section 3, the project is described as a number of works and activities that could affect the surrounding environment.
- **Describe the Existing Environment.** The existing environment is characterized using available information and field studies, as described in Section 5. The description of the existing environment reflects the cumulative effects of past and existing projects on the environment.
- **Screen to Focus the Assessment.** Two screening steps, first for potential interactions and secondly for measurable change, allow the assessment to focus on where effects are likely to occur. These steps are completed using professional judgement; if there is uncertainty, the interaction is advanced for assessment. The screening steps are completed in Sections 6 and 7.
- **Assess Effects.** Where there is likely to be a measurable change, the effects on the environment are predicted and assessed as to whether or not they are adverse, as described in Section 8. If adverse effects are predicted, mitigation measures to reduce or eliminate the effect are proposed, and residual adverse effects, if any, are identified. Any residual adverse effects are then addressed in Section 10 of the EIS to determine whether they are likely to combine with the effects of other past, present or reasonably foreseeable future projects and activities in the surrounding region to produce cumulative effects.
- **Determine Significance.** All residual adverse effects are then assessed in Section 11 to determine whether the effect is significant, or not, taking into account the magnitude, extent, duration, frequency and irreversibility of the effect.
- **Propose Follow-up Programs.** Finally, follow-up monitoring is proposed to confirm that mitigation measures are effective and the effects are as predicted. Monitoring activities are described in Section 13.

The assessment of effects of the DGR Project focuses on Valued Ecosystem Components (VECs), which are elements of the environment considered to be important for cultural or scientific reasons. Atmospheric environment VECs are defined and described in detail in Section 4. Criteria for determining measurable changes and adverse effects are defined for each individual VEC. The detailed methods for each of these steps, including how they are applied to this particular TSD, are described at the beginning of each of the respective sections.

The screening and assessment steps described above follow a source-pathway-receptor approach. The DGR Project works and activities represent the source of a change, a measurable change to the environment represents a pathway and the VEC represents the receptor. In some cases, VECs may act as both pathways and receptors (e.g., changes in air quality may affect terrestrial biota).

Effects from the DGR Project may occur either directly or indirectly. A direct interaction occurs when the VEC is affected by a change resulting from project work and activity (e.g., air emissions during site preparation can affect the VEC air quality). An indirect interaction occurs when the VEC is affected by a change in another VEC (e.g., changes in the VEC air quality could affect the VEC surface water quality because of deposition of dust).

There are many linkages and connections between aspects of the physical, biophysical and human environments in an integrated EA. The linkages to this TSD are illustrated using an information flow diagram. Figure 2.1-2 presents the flow of information related to the atmospheric environment VECs and where the indirect effects are evaluated. Multi-feature VECs are evaluated in Section 7 of the EIS (e.g., Lake Huron, human health). An assessment of the cumulative effects associated with the DGR Project is addressed in Section 10 of the EIS.

The assessment is completed within the framework of defined temporal and spatial boundaries, and takes into account a precautionary approach and Aboriginal traditional knowledge, where available. These are described in further detail in the following sections.

2.2 PRECAUTIONARY APPROACH

The EA, as a forward-looking planning tool used in the early stages of project development, is based on a precautionary approach. This approach is guided by judgement, based on values and intended to address uncertainties in the assessment. This approach is consistent with Principle 15[1] of the 1992 Rio Declaration on Environment and Development and the Canadian government's framework for applying precaution in decision-making processes [5].

Throughout the EA, the DGR Project has been conservatively considered in a thorough and traceable manner. For example, at each of the screening stages, potential project-related effects are advanced if they cannot be systematically removed from consideration through application of rigorous, sound and credible scientific evidence. In addition, with the exception of malfunctions, accidents and malevolent acts, all identified residual adverse effects are assumed to occur (i.e., probability of occurrence is assumed to be 1.0), and are assessed for significance.

A further precautionary feature incorporated into the assessment method is that the evaluation of potential effects is based on changes to the existing environment and not solely on regulatory compliance. This captures and assesses changes to the existing environment that may fall outside or below applicable regulatory frameworks.

The precautionary approach adopted for the EA of the DGR Project is described further in Section 1 of the EIS, and a summary of how precaution has been taken into account in the assessment of the atmospheric environment is provided at the end of the assessment section (Section 8.4.1).

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[1] Principle 15 of the 1992 Rio Declaration on Environment and Development states that "Where there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

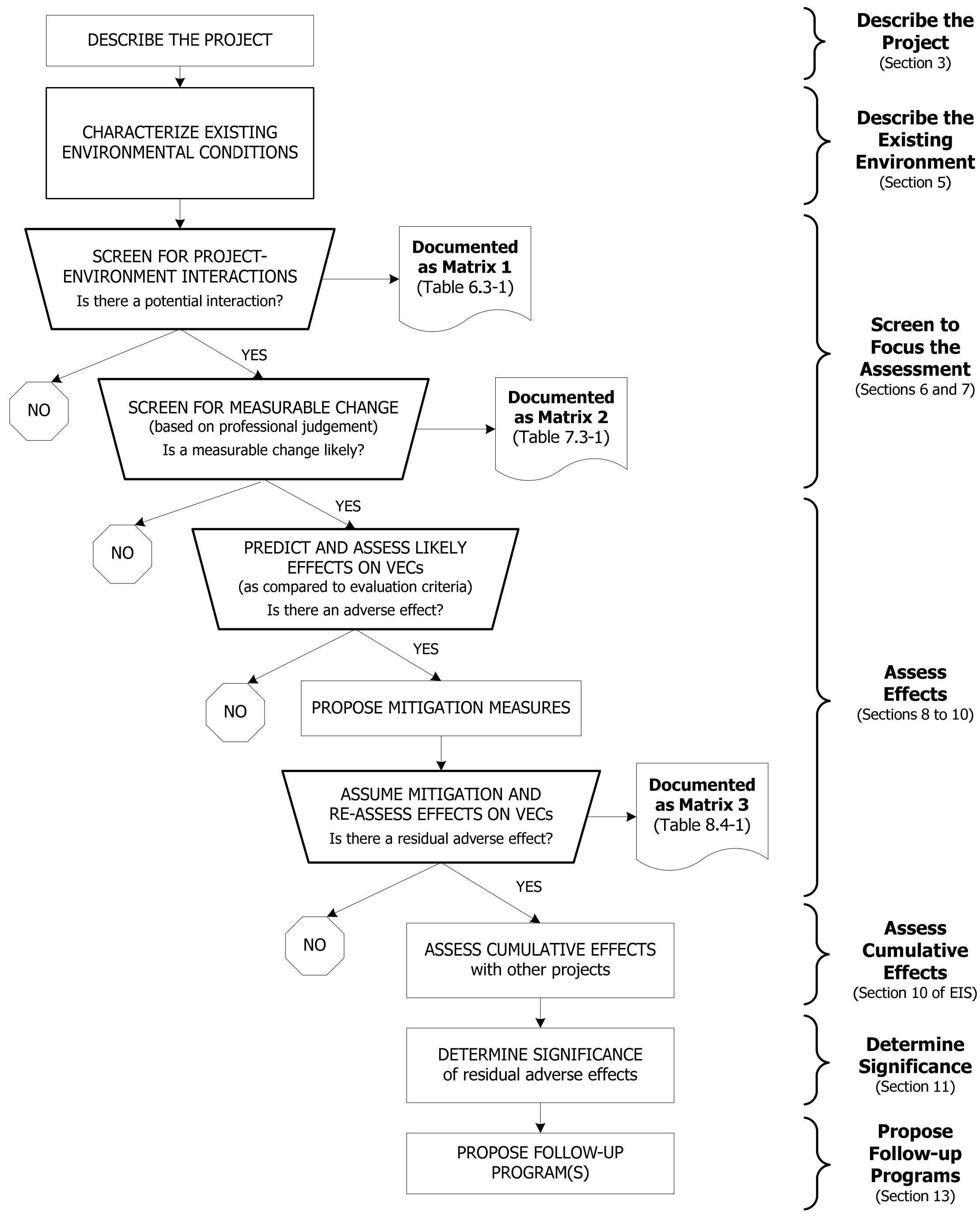

Figure 2.1-1: Methodology for Assessment of Effects

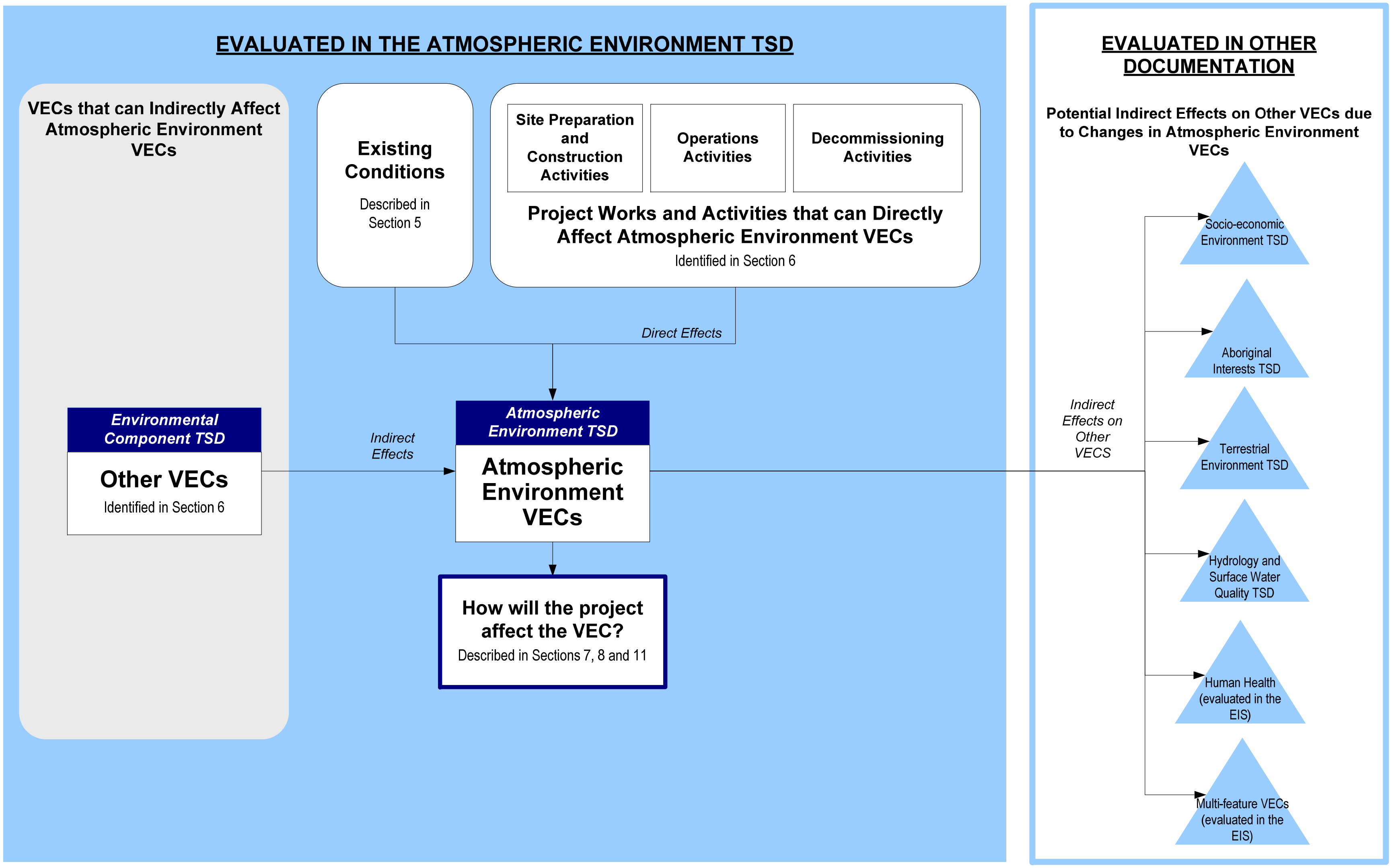

Figure 2.1-2: Information Flow Diagram for the Atmospheric Environment VECs

2.3 ABORIGINAL TRADITIONAL KNOWLEDGE

This EA considers both western science and traditional and local knowledge, where that information is available. Guidance provided by the Canadian Environmental Assessment Agency describes Aboriginal traditional knowledge as knowledge that is held by and unique to Aboriginal peoples [6]. Aboriginal traditional knowledge is a body of knowledge built up by a group of people through generations of living in close contact with nature. It is cumulative and dynamic and builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Traditional ecological knowledge is a subset of Aboriginal traditional knowledge. Traditional ecological knowledge “refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people” [7]. There are four traditional ecological knowledge categories:

- knowledge about the environment;
- knowledge about the use of the environment;
- values about the environment; and
- the foundation of the knowledge system.

In this EA, specific traditional knowledge, where available, is incorporated through the characterization of the existing environment and assessment of effects. Issues of importance to Aboriginal communities were identified as part of the Aboriginal Interests TSD through examination of available information pertaining to general ecological, socio-economic and cultural heritage interests for Ojibway and Métis peoples in Ontario. This examination identified a range of interests raised by Aboriginal communities that can be used to focus this EA relative to potential effects on residents of the Aboriginal communities in the study areas. This examination included the following:

- interests raised by Aboriginal communities in previous studies;
- interests raised by Aboriginal communities in the context of dialogue for the DGR Project; and
- insight into traditional knowledge, and interests of general importance to Ojibway and Métis peoples.

Throughout this TSD, it is highlighted where Aboriginal traditional knowledge and traditional ecological knowledge was available, and has influenced the assessment.

2.4 TEMPORAL AND SPATIAL BOUNDARIES

The assessment of the DGR Project works and activities on the environment is conducted within the framework of temporal and spatial boundaries that are common to all of the environmental components (with some modifications). The particular temporal and spatial boundaries used in the assessment of atmospheric environment are described in the following sections.

2.4.1 Temporal Boundaries

The temporal boundaries for the EA establish the timeframes for which the direct, indirect and cumulative effects are assessed. Four temporal phases were identified for the DGR Project:

- **Site Preparation and Construction Phase**, which includes site preparation and all activities associated with the construction of the DGR Project, up until operations commence with the placement of waste. All of the construction activities at the DGR Project will occur during this phase. The site preparation and construction phase is expected to last approximately five to seven years.
- **Operations Phase**, which covers the period during which waste is emplaced in the DGR Project, as well as a period of monitoring prior to the start of decommissioning. Activities include receipt and on-site handling of waste packages, transfer underground and emplacement of L&ILW in rooms in the DGR Project, and activities necessary to support and monitor operations. The operations phase is expected to last approximately 40 to 45 years with waste being emplaced for the first 35 to 40 years. The length of the monitoring period would be decided at some future time in consultation with the regulator.
- **Decommissioning Phase**, which begins immediately after the operations phase for the DGR. Activities include preparation for decommissioning, decommissioning and may include monitoring following decommissioning. The decommissioning activities, including dismantling surface facilities and sealing the shaft, are expected to take five to six years.
- **Abandonment and Long-term Performance Phase**, which begins once decommissioning activities are completed. This period will include institutional controls for a period up to three hundred years.

These timeframes are intended to be sufficiently flexible to capture the effects of the DGR Project. The assessment of atmospheric environment focuses on the first three phases as there are no activities during the abandonment and long-term performance phase that could interact with the atmospheric environment VECs. The effects of the DGR Project during the abandonment and long-term performance phase are discussed in Section 9 of the EIS.

2.4.2 Spatial Boundaries

Spatial boundaries define the geographical extents within which environmental effects are considered. Therefore, these boundaries become the study areas adopted for the EA.

The DGR Project EIS Guidelines require that the study areas encompass the environment that can reasonably be expected to be affected by the DGR Project, or which may be relevant to the assessment of cumulative effects. Specific study areas are defined by boundaries to encompass all relevant components of the environment including the people, land, water, air and other aspects of the natural environment.

Four study areas were selected for the assessment of the atmospheric environment: the Regional Study Area, Local Study Area, Site Study Area and Project Area. The Project Area, although not specified in the EIS Guidelines, was defined to help describe the potential site-specific effects of the DGR Project. Each study area includes the smaller study areas (i.e., they are not geographically separate). These areas are described in the following sections.

2.4.2.1 Regional Study Area

The Regional Study Area for the Atmospheric Environment TSD (Figure 2.4.2-1) encompasses the areas used to describe the existing air quality in the vicinity of the DGR Project. The Regional Study Area includes the local municipalities within Bruce County as far north as Wiarton. The Regional Study Area for the atmospheric environment also extends east to include the ambient air quality monitoring station in Waterloo, west to include monitoring from Sarnia, and south to include the monitoring station in London.

2.4.2.2 Local Study Area

The Local Study Area (Figure 2.4.2-2) generally corresponds to the 10 km emergency planning zone (centered at the Bruce nuclear site), as identified by Emergency Measures Ontario, and extends into Lake Huron. It is expected that the effects on air quality (should they occur) from the DGR Project will be confined to this area. The Local Study Area is subdivided into two parts; the portion within the Bruce nuclear site and the portion beyond the Bruce nuclear site. The effects on air quality from the DGR Project are assessed at receptor locations beyond the Bruce nuclear site, but within Local Study Area.

The effects on the noise environment from the DGR Project are assessed at residential and seasonal receptors beyond the Bruce nuclear site, but within Local Study Area.

2.4.2.3 Site Study Area

The Site Study Area (Figure 2.4.2-3) corresponds to the property boundary of the Bruce nuclear site, including the exclusion zone.

2.4.2.4 Project Area

The Project Area (Figure 2.4.2-3) corresponds to the boundary of the OPG-retained lands at the centre of the Bruce nuclear site where the DGR Project is being proposed.

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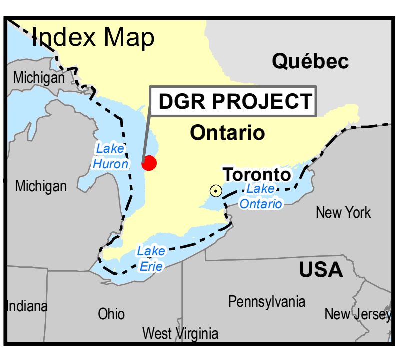
0 5 10 20 30 40 50

Kilometres



LEGEND

- Site Study Area [1]
- Local Study Area
- Regional Study Area
- First Nations' Lands

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

REGIONAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 2.4.2-1**	
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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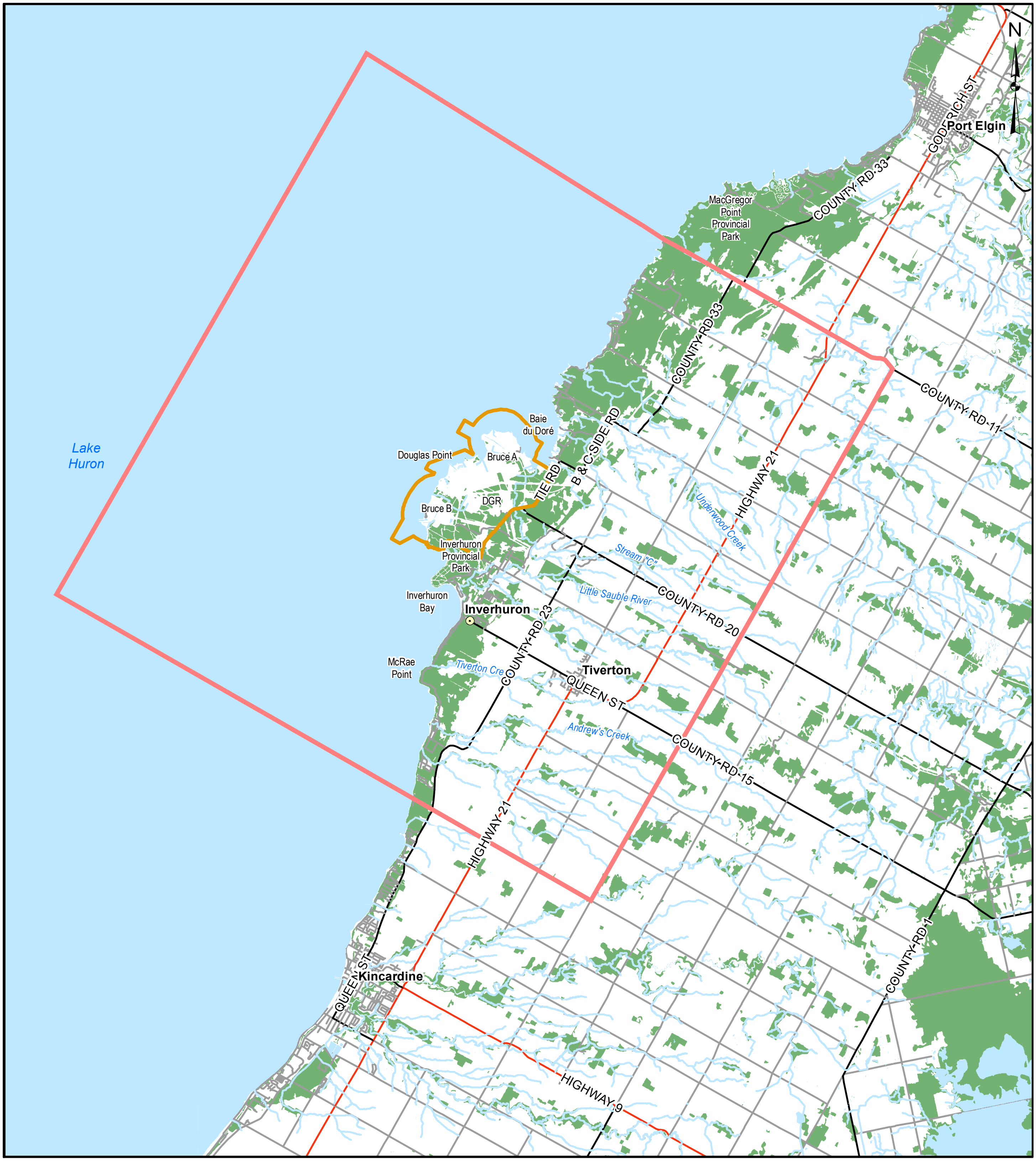

LEGEND

- Site Study Area [1]
- Local Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037		
DESIGN	ASB	17 Oct 2007
GIS	BC	18 May. 2010
CHECK	AB	18 May. 2010
REVIEW	SM	18 May. 2010

SCALE: AS SHOWN R000

FIGURE 2.4.2-2

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LEGEND

- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE 2.4.2-3

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3. PROJECT DESCRIPTION

The assessment of effects requires a detailed description of the DGR Project. The individual works and activities are the physical structures, buildings, systems, components, activities and events comprising the DGR Project. These are collectively referred to as the project works and activities. This section provides an overview of the DGR Project. The specific works and activities required for the DGR Project are summarized in the Basis for the EA in Appendix B. Further details on the DGR Project design can be found in Section 4 of the EIS and in Chapter 6 of the Preliminary Safety Report [4].

3.1 OVERVIEW

The DGR Project will receive L&ILW currently stored in interim facilities at the WWMF, as well as that produced from OPG-owned or operated nuclear generating stations. Low level waste consists of industrial items and materials such as clothing, tools, equipment, and occasional large objects such as heat exchangers, which have become contaminated with low levels of radioactivity. Intermediate level waste (ILW) consists primarily of used reactor components and resins used to clean the reactor water circuits. The capacity of the DGR is a nominal 200,000 m^3 of “as-disposed” waste.

The DGR Project comprises two shafts, a number of emplacement rooms, and support facilities for the long-term management of L&ILW (Figure 3.1-1). The DGR will be constructed over a period of five to seven years. The DGR Project design is the result of a thorough comparison and evaluation of different alternative methods of implementing the project. This includes considerations such as the layout of the DGR and construction methods. The evaluation compared each of the alternative means using technical, safety, environmental and economic factors to identify the preferred alternative. This evaluation is presented in Section 3 of the EIS. This TSD assesses the effects of the preferred alternative means (i.e., the project) on the atmospheric environment.

3.2 SITE DESCRIPTION AND PROJECT LAYOUT

3.2.1 Surface Facilities

The surface DGR facilities will be located on vacant OPG-retained land to the north of the existing WWMF. A new crossing will be constructed over the abandoned rail bed to provide access to the proposed DGR Project site from the WWMF (Figure 3.2.1-1). The surface structures will be grouped in relatively close proximity to facilitate operations and maintenance activities, and provide a compact footprint.

The Waste Package Receiving Building (WPRB) will receive all radioactive waste packages and transfer them to the main shaft cage for transfer underground. A maintenance workshop and stores for essential shaft-related spares and materials will be attached to the WPRB. An office, main control room and amenities building will also form part of the main shaft complex for administrative purposes, control and monitoring of the DGR, and receiving visitors to the DGR. An electrical sub-station will provide power to the entire facility, both surface and underground, and an emergency power supply will maintain critical systems in the event of an outage.

Waste rock piles for the complete excavated volume of rock will be accommodated to the north-east of the two shafts. A stormwater management system of ditches and a pond will be provided to control the outflow of surface runoff and sump discharge water from the site before release into an existing network of ditches at the Bruce nuclear site, and ultimately Lake Huron (Figure 3.2.1-1). The discharge will also be monitored to confirm it meets certificate of approval water quality requirements.

3.2.2 Underground Facilities

The underground DGR facilities will be constructed in limestone bedrock (Cobourg Formation) at a nominal depth of 680 m beneath the OPG-retained lands in the centre of Bruce nuclear site (Figure 3.1-1). The overall underground arrangement enables infrastructure to be kept in close proximity to the main shaft, while keeping the L&ILW emplacement areas away from normally occupied and high use areas.

The DGR will have two vertical shafts (main and ventilation shafts) in an islanded arrangement with a shaft service area in which offices, a workshop, wash bay, refuge stations, lunch room and geotechnical laboratory will be provided. From this centralized area, the two panels of emplacement rooms are connected via access tunnels. A main access tunnel will be driven from the main shaft station to the east, passing the ventilation shaft and then proceeding towards the emplacement room panels. The main access tunnel will continue straight into the Panel 1 access tunnel, while a branch tunnel to the south will lead to the Panel 2 access tunnel. The length of the rooms is nominally 250 m. End walls may be erected once the rooms are filled.

The emplacement rooms will all be aligned with the assumed direction (east-northeast) of the major principal horizontal stresses of the rock mass to minimize the risks of any rock fall in the emplacement rooms.

A ventilation supply system will supply air at a controlled range of temperatures to ensure that freezing does not occur in the main shaft and the atmosphere is kept in a reasonably steady and dry state, which is suitable for workers and limits corrosion of structures and waste packages.

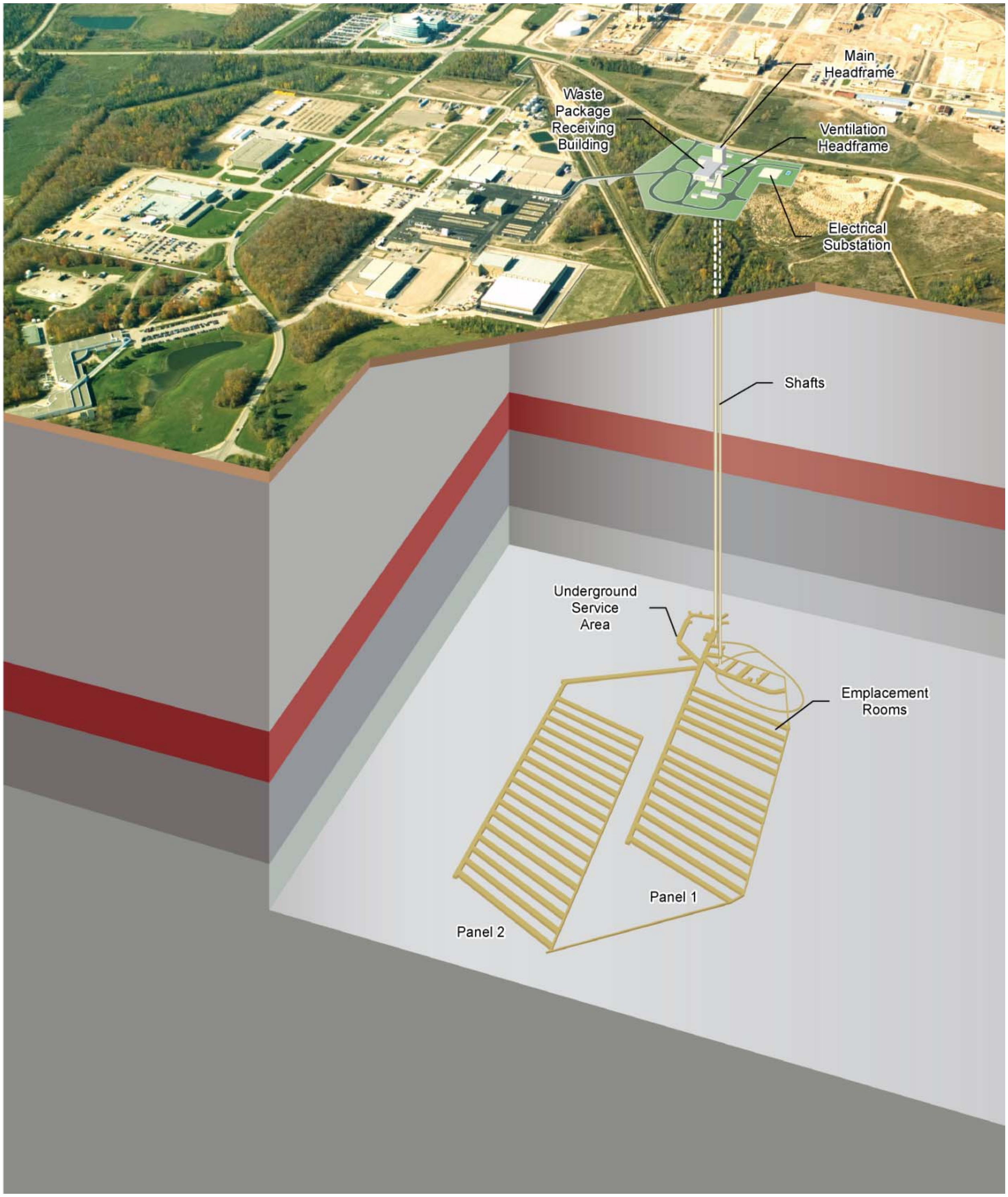

Figure 3.1-1: Schematic of DGR Project

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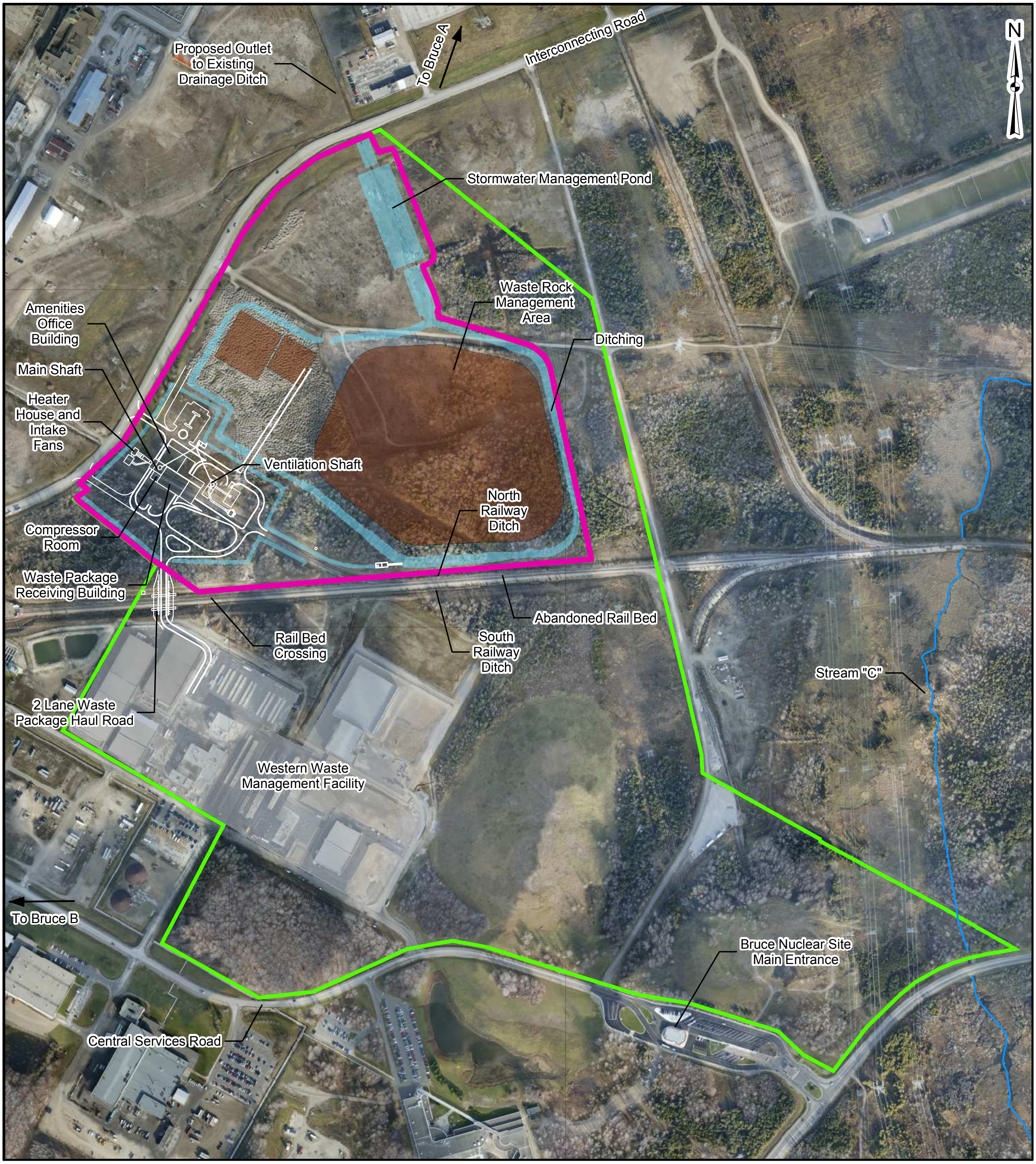

LEGEND

- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Soils and Rock Stockpile
- Stormwater Management System

0 125 250 500

Metres

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LAYOUT OF DGR SURFACE INFRASTRUCTURE

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	AB	16 Mar. 2010	**FIGURE 3.2.1-1**	
GIS	BC	25 Nov. 2010		
CHECK	KC	25 Nov. 2010		
REVIEW	AB	25 Nov. 2010		

Golder Associates
Mississauga, Ontario

REFERENCE

Base Data Provided by 4DM, Nov 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

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4. SELECTION OF VECS

While all components of the environment are important, it is neither practicable nor necessary to assess every potential effect of a project on every component of the environment. An EA focuses on the components that have the greatest relevance in terms of value and sensitivity, and which are likely to be affected by the project. To achieve this focus, specific Valued Ecosystem Components (VECs) are identified. The Canadian Environmental Assessment Agency states that VECs are "*Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process"* [8]. Importance may be determined on the basis of cultural values or scientific concerns. VECs can be an individual valued species or 'guilds' (representing important groups of species within food webs).

From an ecological perspective, VECs can represent features or elements of the natural environment (e.g., a local wetland or stream) considered to be culturally or scientifically important. Such features may be complex, comprising several ecological aspects, and affected by a range of pathways (i.e., routes of exposure or effect). In essence, these ecological feature VECs would encompass a number of individual VECs such as:

- an aspect of the physical environment (e.g., air or water quality);
- an individual wildlife species (e.g., mallard duck or creek chub); or
- a range of species that serve as a surrogate for species that interact similarly with the environment (e.g., benthic invertebrates).

A VEC is considered to be the receptor for both project-specific effects and cumulative effects. A VEC can be represented by a number of indicators. Indicators are features of the VEC that may be affected by the DGR Project (e.g., concentration of particulate matter). Each indicator requires specific 'measures' that can be quantified and assessed (e.g., changes in concentrations of indicator compounds).

VECs are identified using the expertise of the technical specialists with input from regulators and members of the public. The VECs for the DGR Project were available for discussion and comment at the open houses held in October 2007, November 2008, November 2009 and summer/fall 2010. At the November 2008 Open House, the public was encouraged to add VECs to the list and to identify the VECs that were most important to them. The public also had the opportunity to provide input into the list of VECs during the public review of the draft guidelines.

Two VECs are used in assessing the effects of the DGR Project on the atmospheric environment: air quality and noise levels. These VECs were selected to be representative of atmospheric environment likely to be important and susceptible to effects within the spatial context of the DGR Project. The rationale for selection of the VECs and the indicators used in the assessment are described in the following sections and summarized in Table 4-1.

Table 4-1: VECs Selected for the Atmospheric Environment

VEC	Rationale for Selection	Indicator Compounds	Measures
Air Quality	• Has been identified as an important aspect of the environment by both public and regulators • Changes to air quality because of the project are possible	• Nitrogen dioxide (NO_2) • Sulphur dioxide (SO_2) • Carbon monoxide (CO) • Suspended particulate matter (SPM) • Airborne particles with aerodynamic diameters of 10 µm or less (PM_{10}) • Airborne particles with aerodynamic diameters of 2.5 µm or less ($PM_{2.5}$)	• Changes in air concentrations of indicators • Concentrations of indicators
Noise Levels	• Has been identified as an important aspect of the environment by both public and regulators • Changes in noise levels because of the project are possible	• 1-hour energy equivalent noise level (L_{eq})	• Changes in the 1-hour L_{eq} from existing levels • Resulting L_{eq}

Note:
This TSD considers only potential effects of the DGR Project on the atmospheric environment associated with conventional (i.e., non-radiological) parameters. The potential effects of radioactivity on the atmospheric environment are considered in the Radiation and Radioactivity TSD.

The following sections identify and justify the selection of VECs for assessing the effects of the DGR Project on atmospheric environment.

4.1 VALUED ECOSYSTEM COMPONENTS

The following identifies and justifies the selection of VECs for assessing the effects of the DGR Project on the atmospheric environment:

- **Air Quality**: Air quality has been selected as a VEC since it has been identified as an important aspect of the environment by both public and regulators. In addition, emissions from DGR Project works and activities have the potential to alter the existing air quality.
- **Noise Levels**: Noise levels have been selected as a VEC since it has been identified as being important to regulators and stakeholders. Existing noise levels are expected to be influenced by many of the DGR Project works and activities.

4.2 INDICATORS

4.2.1 Air Quality

To evaluate how the DGR Project will affect the air quality VEC, indicator compounds have been selected to focus the assessment. Changes in air quality can have a short, medium or long term effect. For this reason, regulators have established criteria that are based on both compound and averaging time (e.g., 1-hour sulphur dioxide [SO_2]). The indicators used for assessing changes in air quality are a combination of indicator compounds and averaging times, and have been selected using the following criteria:

- the compounds are likely to be emitted from the DGR Project in measurable amounts during site preparation and construction, operations or decommissioning; and
- the indicators (a combination of compound and averaging time) have established regulatory criteria.

The indicator compounds with relevant Canadian ambient regulatory criteria that were selected for evaluating the effects of the DGR Project on the air quality VEC are presented in Table 4.2.1-1. The ambient criteria presented in the table have been established by provincial and federal agencies to be protective of air quality, ecological receptors, human health and aesthetic concerns (i.e., nuisance dust). These criteria are also appropriate for evaluation of collective air quality concerns from multiple sources.

Table 4.2.1-1: Air Quality Criteria for Indicators

Indicators	Criteria ($\mu g/m^3$) [a]
1-hour NO_2	400
24-hour NO_2	200
Annual NO_2	100
1-hour SO_2	900
24-hour SO_2	300
Annual SO_2	60
1-hour CO	35,000
8-hour CO	15,000
24-hour SPM	120
Annual SPM	70
24-hour PM_{10}	50 [b]
24-hour $PM_{2.5}$	30 [c]

Notes:
a National Air Quality Objectives for Canada (Maximum Acceptable Level) [9]
b Ontario Ambient Air Quality Objectives [10]
c 24-h Canada-Wide Standard for $PM_{2.5}$, based on the running 3-year average of 98^{th} percentile [11]

It is noted that Ontario also has a series of project specific regulatory standards, guidelines and limits under Ontario Regulation 419 (O. Reg. 419/05) for some of the indicators. However, the method that these criteria are applied, as guided by the Ontario Ministry of Environment [12], would not be appropriate for evaluating the changes in air quality associated with the DGR Project. Specifically, O. Reg 419/05 considers the emissions from selected stationary sources only. Ontario exempts emission sources associated with construction activities from evaluation [13]. Similarly, evaluations in accordance with O. Reg. 419/05 do not include considerations of background concentrations. Since this assessment considers all of the sources of the Bruce nuclear site (i.e., stationary and mobile) and evaluates the effects of construction, the Canada-wide standards and National Air Quality Objectives for Canada have been used where available.

Only non-radioactive compounds were considered in the atmospheric environment assessment. The assessment of radiological emissions has been included as part of the assessment presented in the Radiation and Radioactivity TSD. In addition, compounds that are not expected to be released from the DGR Project have not been selected despite their presence at the site as a result of the ongoing operations of the Bruce nuclear site. For example, fire training activities may result in the emissions of other compounds; however, these compounds were not used as indicators for the air quality VEC since they will not be emitted as a result of the DGR Project. Therefore, there will not be a change in air quality as a result of the DGR Project for these compounds.

The air quality assessment does not include ozone as an indicator. There are several reasons for its exclusion. The DGR Project will not emit ozone directly. While the DGR Project emits compounds that could be considered precursors for ozone (i.e., NO_X and small quantities of VOCs), there is no expectation that the amounts emitted will cause an increase in ozone on either a local or regional scale. In fact, the precursor emissions are primarily NO_X that can cause a localized reduction in ozone concentrations in the chemical conversion of NO to NO_2. A review of the available air monitoring data (see Appendix E) shows that the ozone concentrations are similar right across the region, suggesting that ozone is a regional air quality issue rather than a local issue. There is currently an Ontario 1-hour ambient air quality criteria (AAWC) of 0.080 parts per million (ppm), and an 8-hour Canada-Wide Standard of 0.065 ppm for ozone.

Finally, there are a number of compounds that may be emitted from the DGR Project that have no regulatory criteria, or are emitted in very small quantities. While these compounds would not be useful or appropriate as indicators or changes in air quality, they may be important for evaluating the effects of the DGR Project on other VECs (e.g., human health). The changes in concentrations of these other compounds were completed as part of the atmospheric assessment, and the results used in the Terrestrial Environment, Hydrology and Surface Water Quality, Socio-economic Environment and Aboriginal Interests TSDs, and in Appendix C of the EIS. The existing and future concentrations of compounds used by other disciplines for assessing the indirect effects of changes in air quality are presented in Appendix J.

4.2.2 Noise Levels

The effect of the DGR Project on noise levels is evaluated using the 1-hour equivalent noise level (L_{eq}). The 1-hour L_{eq} is the energy equivalent continuous sound level, which has the same energy as the time varying signal over a one hour period. However, other noise indicators are available that are not appropriate for the evaluation of the DGR Project noise levels, but are appropriate for evaluating the indirect effects of changes in noise levels on other VECs (e.g., human health). The information regarding the indicators used as inputs in the Terrestrial Environment, Socio-economic Environment and Aboriginal Interests TSDs and in Appendix C of the EIS are presented in Appendix J.

4.3 MEASURES

4.3.1 Air Quality

Two measures are used to evaluate the effects of the DGR Project on the air quality VEC, namely:

- changes in the concentrations of the indicators (i.e., indicator compounds and averaging times for which relevant criteria are available); and
- concentrations of indicators (i.e., indicator compounds and averaging times for which relevant criteria are available).

4.3.2 Noise Levels

The measures used to evaluate the effect of the DGR Project on the noise levels VEC are the change in the 1-hour L_{eq} relative to the existing (i.e., baseline) conditions and the 1-hour L_{eq} levels that will result from the DGR Project. The baseline conditions are established as the quietest daytime and/or night-time hour monitored at set points of reception (Section 5.5).

4.4 NON-VECS DESCRIBED IN THIS TSD

In addition to the two VECs identified for assessing effects of the DGR Project on the atmospheric environment (i.e., air quality and noise levels), this TSD also characterizes the processes that determine how the project interacts with the atmospheric environment (i.e., meteorology). Meteorology is important as it governs the transport, dispersion and deposition of atmospheric emissions associated with the DGR Project. An understanding of the local meteorology is necessary to adequately address and model the air quality in an area. Meteorological data collected at the Bruce nuclear site is used to characterize the existing meteorological conditions. The same data forms an integral part of the meteorological data used as an input to the numerical models used when predicting potential effects of the DGR Project on the atmospheric environment.

The TSD also describes the climate, which is the synthesis of meteorology recorded over a long period of time. It tells us the average or most common conditions (e.g., the mean temperature, the prevailing winds), extremes (e.g., the greatest rainfall, strongest wind) or frequency of events (e.g., the number of rainy days). Long-term climate records are obtained from established stations in the region and used to characterize the conditions that are likely in the region; however, the climate is not constant. Climate change is a shift in the long-term average weather patterns experienced in a region. How the climate has been changing and how the climate is projected to change in the future are important considerations when evaluating the potential effects of the environment on the DGR Project, as well as when evaluating how the DGR Project may affect the environment.

The TSD also provides an analysis of the existing light conditions and how they may change as a result of the DGR Project (see Appendix H). Since changes in light could affect wildlife behaviour, the effects of changes in light conditions are assessed in the Terrestrial Environment TSD.

The TSD also provides analysis of predicted vibrations as a result of blasting associated with the construction of the DGR Project (Appendix I). The effects of vibration on biological receptors are evaluated in the Aquatic and Terrestrial Environment TSD.

Finally, Appendix J provides the modelling results for air quality and noise levels at ecological and human receptors. The potential effects are assessed in the Hydrology and Surface Water Quality TSD, Terrestrial Environment TSD, Socio-economic Environment TSD, Aboriginal Interests TSD, and the human health assessment in the EIS.

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

This section provides a description of the existing environmental conditions in the study areas for the atmospheric environment components of the EA. For the purposes of this TSD, “existing conditions” are defined as those generally present at the site and may reflect effects of the Bruce A and B nuclear generating stations, activities at the WWMF, Douglas Point generating station, Hydro One transmission activities and previous activities within the site. The characterization of the existing environment serves as the baseline condition for which the environmental effects of the DGR Project are predicted and assessed. The discussion includes a description of the relevant existing air quality and existing noise levels. For context, a discussion of meteorology and climate is also provided.

5.1 EXISTING ENVIRONMENT METHODS

The description of the existing environment focuses on VECs identified in Section 4. Information is presented for the study areas with emphasis placed on the areal extents most likely to be affected by the DGR Project. The description of the existing atmospheric environment was done as follows:

- The existing air quality was characterized using a combination of existing information and dispersion models. Field studies were not undertaken to characterize the existing air quality. Adequate data is available from existing sources to characterize regional air quality, and can be used for describing background air quality in the Local Study Area. To fully characterize the variability of air quality within the Local Study Area, air quality as a result of emissions from existing sources at the Bruce nuclear site were modelled, and added to the background air quality, as described in Section 5.1.3.
- The existing noise levels were characterized using a combination of existing information and field studies. Modelling was not used in describing the existing noise levels.

The effects assessment (Section 8) evaluates the potential effects of the DGR Project on the existing environment. The methods used to gather information on which to base the description of the existing atmospheric environment are explained in the following sections.

5.1.1 Sources of Existing Information

The following sources of information were used in the characterization of the existing air quality:

- Ontario Climate Data from the Ontario Climate Data Centre [14];
- Canadian Climate or Average Normals, 1971-2000 from Environment Canada (EC) [15];
- Air Quality in Ontario Reports [16;17;18;19;20;21;22];
- Certificate of Approval (Air), Application for Certificate of Approval for Bruce Power Inc. [23];
- Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment [24]; and
- Bruce A Units 3 & 4 Restart Environmental Assessment [25].

The following sources of information were used in the characterization of the existing noise levels:

- Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment [24];
- Bruce A Units 3 & 4 Restart Environmental Assessment [25];
- Environmental Noise Impact Assessment – Redevelopment of Inverhuron Provincial Park [26]; and
- Bruce Heavy Water Plant Decommissioning Environmental Study Report [27].

5.1.2 Field Studies

Field studies were not undertaken to characterize the existing air quality, since available data can be used to characterize the local and regional air quality.

A field study was conducted to help characterize existing noise levels because of a lack of current site specific data. This field study was divided into two separate activities; continuous noise monitoring and spot noise measurements, which are described as follows:

- Continuous noise monitoring was carried out at various off-site locations to collect the existing noise levels for daytime (0700 to 1900) and night-time (1900 to 0700) periods at points of reception near the site. The monitoring lasted 14 days. This program was designed to augment the 2005 field study program reported in the Bruce A Refurbishment for Life Extension and Continued Operations Project EA [24].
- Spot noise measurements including the spectral content (i.e., frequency components) at the various monitoring locations were carried out during the daytime and night-time periods to characterize the existing noise levels at, and proximate to, the Site Study Area.

5.1.3 Modelled Existing Environment

Available data can be used to characterize the background air quality within the Local Study Area; however, it cannot accurately describe the variations in concentrations that will result from emissions from existing sources at the Bruce nuclear site. These existing sources have been modelled to describe the existing air quality conditions. The approach used to model these existing sources is described below. The existing air quality described in Section 5.4 considers the combination of the background air quality from ambient monitoring stations with the modelled existing air quality from the local sources.

The existing conditions and likely environmental effects for the DGR Project-environment interactions involving air quality are evaluated with the aid of the AERMOD dispersion model (Version 09292). The selection of this model was based on the following capabilities:

- evaluates the various source types and compounds associated with the DGR Project;
- has a technical basis that is scientifically sound, and is in keeping with the current understanding of dispersion in the atmosphere;
- applies formulations that are clearly delineated and are subjected to rigorous independent scrutiny;

- makes predictions that are consistent with observations; and
- is recognized by provincial regulators [28] as one suitable for use.

The EIS Guidelines prepared for the DGR Project highlight the need to provide information regarding the model verification and scientific defensibility, model calibration, model validation, as well as the uncertainty and sensitivity of the model. Table 5.1.3-1 provides a summary of this information. More details regarding model selection and evaluation are provided in Appendix F.

5.1.3.1 Air Quality Dispersion Model

The AERMOD dispersion model (Version 09292), using on-site meteorological data, is employed to evaluate the changes in air quality attributable to the DGR Project. The model was developed by the United States Environmental Protection Agency (U.S. EPA). The model has been identified as appropriate for modelling in Ontario by the Ministry of the Environment (MOE), and maintains consistency with the modelling completed for recent EAs at the Bruce nuclear site [29].

5.1.3.2 Dispersion Meteorology

For the air quality indicator assessment, a five year meteorological data set (2005 through 2009) was created using information from the on-site meteorological tower operated by Bruce Power. Where necessary, this data was augmented with data from stations operated by either the Meteorological Services of Canada (MSC) or the National Weather Service (NWS) in the United States. A summary of the dispersion meteorology has been provided in Section 5.3, and a full discussion of the data appears in Appendix C.

5.1.3.3 Air Dispersion Model Limitations

Air dispersion models employ assumptions that simplify the random processes associated with atmospheric motions and turbulence. While this simplification limits the model’s ability to replicate individual events, the strength of the air dispersion model lies in the ability to predict overall values for a given set of meteorological conditions. As noted, more details regarding the air dispersion model are provided in Appendix F.

Table 5.1.3-1: Reliability Summary for the AERMOD Dispersion Model

Model Name	Developer	Use in Assessment	Verification	Calibration	Validation	Uncertainty and Sensitivity
AERMOD (Version 09292)	United States Environmental Protection Agency	Predict air quality concentrations	• AERMOD was developed to replace the long-standing ISC model as the model recommended by the U.S. EPA • AERMOD is based on Gaussian plume dispersion theory [30] that has been used for more than 30 years • The application of specific algorithms have been updated to reflect current understanding of dispersion theory [30]	• Five years of on-site meteorological data were used in the modelling (Section 5.4, Appendix F) • Surrounding land use used as inputs to the model pre-processor (Appendix F) • Digital terrain data for the Bruce nuclear site and surrounding area input to the model	• AERMOD has been adopted by the U.S EPA as its preferred and recommended dispersion model [31] • Prior to adoption, the U.S. EPA completed a rigorous review of the model performance [32;33]	• AERMOD is based on known theory, and proven to reliably produce repeatable results • Uncertainty associated with emissions is managed by making conservative assumptions • Predictions are sensitive to fluctuations in meteorology, which can be managed by using a five year data set • Five years of data should include the full range of meteorological conditions

5.2 ABORIGINAL TRADITIONAL KNOWLEDGE

No specific Aboriginal traditional knowledge was available to help in characterizing the existing atmospheric environment conditions. During past assessments, Aboriginal concerns have been raised regarding the effects of changes in air quality on their health, as described more fully in the Aboriginal Interests TSD. Results from the Atmospheric Environment TSD have been used as inputs to the human health assessment prepared in the EIS.

5.3 METEOROLOGY, CLIMATE AND CLIMATE CHANGE

Within the atmospheric environment, the physical processes referred to as meteorology and climate will have profound effects on how emissions from the DGR Project may affect air quality. Meteorology refers to the day-to-day, or hour-to-hour variations in parameters such as wind, precipitation or temperature. Climate, on the other hand, represents the expected values for parameters such as wind, precipitation or temperature. The climate of an area is described using normals, which are averages calculated over a 30 year period (the latest accepted normals period is 1971 to 2000) [15]. It is also widely accepted that the climate is changing [34], and consideration of these changes needs to be incorporated in the assessment (see Section 8).

5.3.1 Data Sources

In evaluating the potential air quality effects from the DGR Project, a five-year dispersion meteorological data set (i.e., 2005 through 2009) was developed. The MOE [28] and the U.S. EPA [31] both recommend using a full five year dispersion meteorological data set when evaluating the emissions from a project to ensure that the full range of possible conditions are evaluated.

A five year dispersion meteorological data set was developed using data collected at the Bruce nuclear site (2005 to 2009). On-site data was chosen for use in the modelling so that the effects of Lake Huron and local topography are reflected in the dispersion modelling. It was identified in the review of the available data (see Appendix C) that the data from the 50 m tower would be more reliable; however, data from the 10 m level on that tower was most appropriate for use. Since the majority of the sources of emissions at the DGR Project are located close to the ground, data from the lower (i.e., 10 m) level was more appropriate for use as dispersion meteorology. Data from the MSC station at the airport in Wiarton, Ontario was used to provide the additional meteorological observations that were not available from the on-site station. Finally, upper air data used in describing the boundary level profile were taken from the station in Gaylord, Michigan. On-site meteorological data (i.e., the 10 m level on the 50 m tower) is more appropriate for use in modelling emissions at the Bruce nuclear site than data from other stations in the region (i.e., Kincardine and Hanover). Neither the Kincardine nor Hanover stations collect data to the MSC requirements used for on-site data collection at the Bruce nuclear site or for the data collected at either Wiarton or Gaylord, Michigan.

Climate data from the Wiarton and Paisley climate stations were selected to describe the long-term climate for the region, as well as for comparison with the dispersion meteorology. The data used to describe the region's climate consists of climate normals data from 1971 to 2000 for the Wiarton Airport – WMO ID 71633 (meets standards of the World Meteorological Organization for stations that transmit observations in international meteorological formats) and Paisley climate station, as published by Environment Canada [15]. Other stations in the region (i.e., Kincardine and Hanover) do not meet the same exacting standards for data quality. The locations of the meteorological and climate stations used in this assessment are shown on Figure 5.3.1-1.

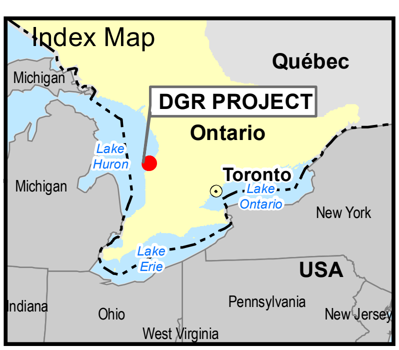
Prior to developing the dispersion meteorology data set, on-site meteorological observations from both the 50 and 10 m tower were compared to selected archived weather maps to identify whether the data recorded at the Bruce nuclear site matched with regional weather patterns. Generally, archived weather patterns matched the on-site observations reasonably well, with data from the 50 m tower showing a better correlation than from the 10 m tower. Of the two levels of data available from the 50 m tower, both showed good agreement with archived weather maps and data, with one exception. The data from the 10 m level on the 50 m tower showed the influence of local topographic features and influences of lake-land interactions (e.g., lake breezes). These localized meteorological phenomena were considered to be appropriate when modelling the emissions from the DGR Project since they reflect the surface winds occurring at the site (i.e., the 50 m tower is located adjacent to the Project Area).

The dispersion meteorological data developed for use in assessing the DGR Project was also compared to climate normals data from both the stations in Wiarton and Paisley. The temperatures, precipitation, and winds speeds and direction for the dispersion meteorology show a good agreement with the climate normals for both Wiarton and Paisley.

5.3.2 Temperatures

Surface temperature is an indirect measure of the energy present in the lower levels of the atmosphere. This energy is important for dispersion as it drives local meteorology and affects regional weather patterns. All surface temperature heights are assumed to be 2 m above ground level (the typical height for temperature measurement).

Table 5.3.2-1 provides a summary of the dispersion meteorology seasonal temperatures used in assessing the DGR Project. For the purposes of this assessment, the four seasons of the year include: March, April, May (Spring); June, July, August (Summer); September, October, November (Fall); and December, January, February (Winter). For comparison, Table 5.3.2-2 provides a similar summary of the seasonal temperature normals for Wiarton Airport.



LEGEND

- On-site Meteorological Tower
- Meteorological and Climate Station
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF CLIMATE AND METEOROLOGICAL DATA SOURCES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE 5.3.1-1

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Table 5.3.2-1: Seasonal Temperature Summary for the Dispersion Meteorology

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	5.9	18.8	10.7	-3.1	8.2
Daily Maximum (°C)	9.7	22.2	13.8	-0.3	11.4
Daily Minimum (°C)	1.9	14.9	7.4	-5.8	4.7
Extreme Maximum (°C)	28.3	31.8	29.3	17.2	31.8
Extreme Minimum (°C)	-18.7	3.4	-9.3	-21.1	-21.1
Days per Year with Maximum Above 30°C	0	2	0	0	2
Days per Year with Minimum Below -10°C	2	0	0	20	23

Notes:
The numbers in the table above are calculated using the five-year dispersion meteorology (2005 to 2009). The values are correct, but because of rounding may not appear to match the totals shown above.
Temperature data from the on-site 50 m tower is collected at a height of 10 m, rather than the typical 2 m height used for collecting data at Wiarton and Paisley.
Source: [35]

Table 5.3.2-2: Seasonal Temperature Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	4.5	17.4	8.3	-5.7	6.1
Daily Maximum (°C)	9.5	22.8	12.6	-1.7	10.8
Daily Minimum (°C)	-0.6	11.9	4.1	-9.6	1.4
Extreme Maximum (°C)	30.5	35.0	35.6	18.1	35.6
Extreme Minimum (°C)	-30.7	-1.6	-18.0	-36.4	-36.4
Days per Year with Maximum Above 30°C	0	3	0	0	3
Days per Year with Minimum Below -10°C	9	0	1	41	50

Notes:
The numbers in the table above are calculated using the 1971 through 2000 climate normals. The values are correct, but because of rounding may not appear to match the totals shown above.
Source: [15]

5.3.3 Precipitation

Although not directly used in the dispersion modelling, precipitation can have an influence on the emission rates for fugitive dust sources, as well as the rate at which particles and gases could be removed from the air via wet deposition. Tables 5.3.3-1 and 5.3.3-2 provide summaries of the seasonal precipitation data covering the period for the dispersion meteorology and climate normals for Wiarton Airport, respectively.

Table 5.3.3-1: Seasonal Precipitation for Dispersion Meteorology

Parameter	Spring	Summer	Fall	Winter	Year
Average Rainfall (mm)	170.8	205.7	251.7	90.2	718.4
Average Snowfall (cm)	52.1	0.0	58.0	303.4	413.6
Average Total Precipitation (mm) [a]	217.8	205.7	301.6	345.3	1,070.3
Extreme Daily Precipitation (mm)	42.2	62.0	67.4	30.9	67.4
Days with Measurable Precipitation	38	32	48	71	190

Notes:
The numbers in the table above are calculated using the five-year dispersion meteorology (2005 to 2009). The values are correct, but because of rounding may not appear to match the totals shown above.
a Average rainfall (mm) and average snowfall (cm) cannot be directly added together to equal average total precipitation.
Source: [35]

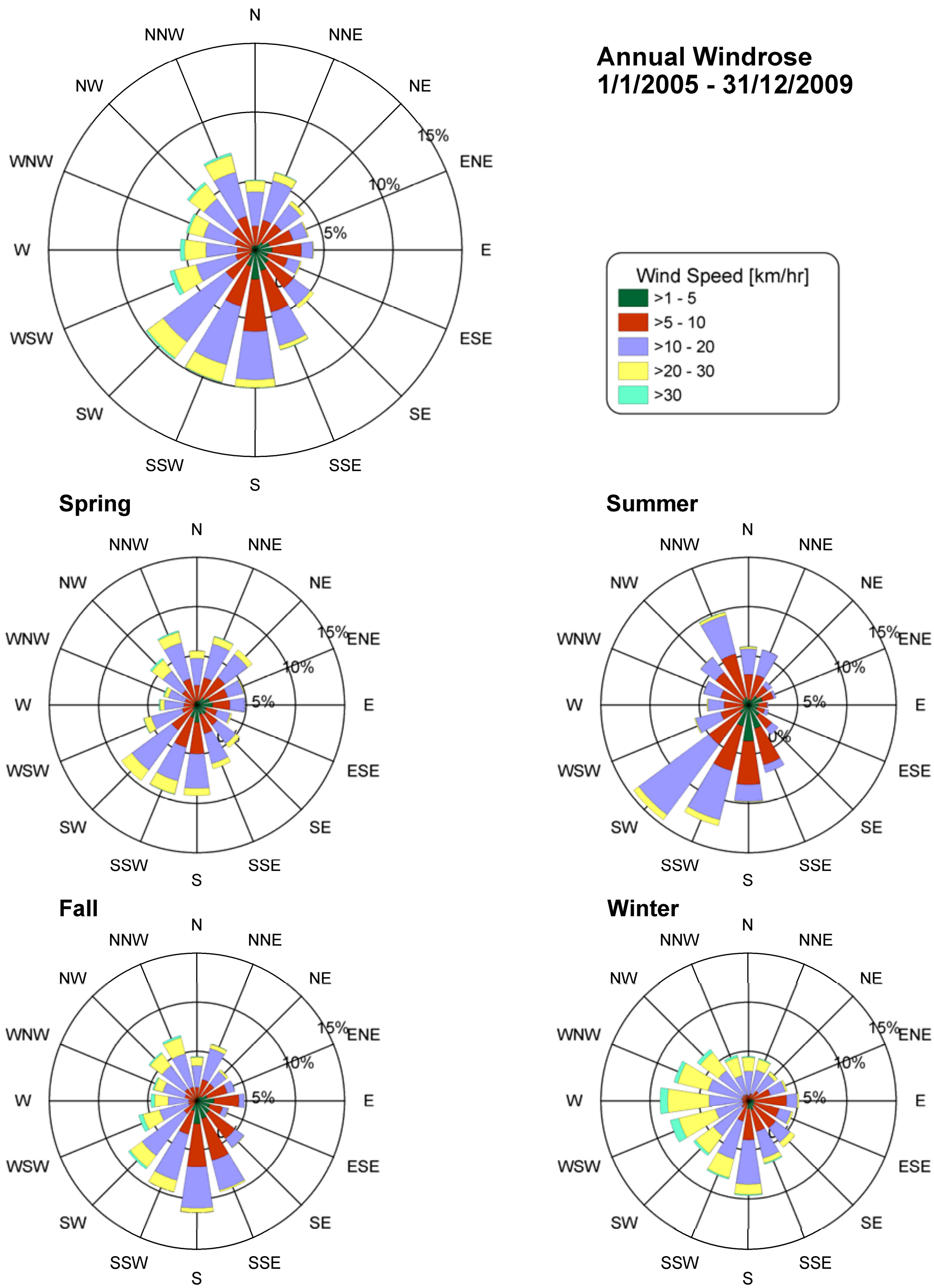
Table 5.3.3-2: Seasonal Precipitation Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Average Rainfall (mm)	165.8	230.8	268.9	74.9	740.4
Average Snowfall (cm)	62.8	0.0	52.1	311.6	426.6
Average Total Precipitation (mm) [a]	216.8	230.8	310.9	282.8	1,041.3
Extreme Daily Precipitation (mm)	48.8	104.6	88.6	48.6	104.6
Days with Measurable Precipitation	39	32	48	64	183

Notes:
The numbers in the table above are calculated using the 1971 through 2000 climate normals. The values are correct, but because of rounding may not appear to match the totals shown above.
a Average rainfall (mm) and average snowfall (cm) cannot be directly added together to equal average total precipitation.
Source: [15]

5.3.4 Wind Speed and Direction

Wind speed and wind direction are important parameters in determining the dispersion meteorology of an area. Wind speeds and directions also vary by the time of day and time of year. Figure 5.3.4-1 shows wind-roses for the annual and seasonal wind speed and direction for the dispersion meteorology used to evaluate the DGR Project. A wind-rose figure is often used to illustrate the frequency of wind direction and the magnitude of the wind speed. The lengths of the bars on the wind-rose indicate the frequency and speed of the wind. The wind direction (blowing from) is illustrated by the orientation of the bar in one of 16 cardinal directions.



Note: Wind roses calculated using the five-year dispersion meteorology (2005 to 2009).

Figure 5.3.4-1: Annual and Seasonal Wind-Roses for Dispersion Meteorology

The annual wind-rose illustrates an even distribution of lower wind speeds (<11 km/h) from all directions and a higher frequency of stronger wind speeds (>11 km/h) from wind directions between the south and southwest, as well as winds from the north-northwest. Wind speeds and directions from the southerly direction are common throughout the year, which is consistent with the occurrence of more intense and active low pressure systems and fall-winter-spring storm formation during these months. The storm track also converges over the Great Lakes Basin, bringing a variety of storm types, with stronger and gustier winds. The strongest wind speeds occur during the fall and winter months (again, related to the increased storm formation and tracking over the region), while the spring and summer months experience an increase in the frequency of winds from the dominant southwest quadrant. The winter winds are clearly dominated from the westerly component of the wind rose.

There are also a number of distinct patterns associated with the variations of wind direction by time of day. Table 5.3.4-1 presents a summary of the winds for the dispersion meteorology used to evaluate the DGR Project in a form comparable to the climate normals for wind speed and direction provided by MSC. Table 5.3.4-2 provides a summary of the monthly wind normals for the Wiarton Airport station.

5.3.5 Other Meteorological and Climate Parameters

There are a number of other parameters used when describing the existing meteorology and climate for the DGR Project. These parameters, which have been fully described in Appendix C, include the following:

- relative humidity and dew point;
- atmospheric stability;
- inversions and mixing heights;
- atmospheric pressure;
- solar radiation, cloud cover and bright sunshine;
- geophysical parameters; and
- severe and unusual weather.

5.3.6 Climate Change

It is now widely accepted that climate is changing; therefore, consideration of these changes needs to be incorporated in the EA of the DGR Project. Traditionally, scientists looked to past weather records to provide guidance for predicting future conditions. Historic climate trends for this TSD are determined using the temperature archives obtained for Wiarton Airport for the period from 1971 through 2000. Potential trends in temperature and precipitation are evaluated by fitting a linear model to the data using the Sen’s nonparametric method. The statistical significance of the observed trends is determined using the Mann-Kendall test. The Mann-Kendall test is used to detect a monotonic trend of a time series with no seasonal cycle. The analysis uses a two-tail test to determine significance at the 90th, 95th, 99th and 99.9th percentile levels. A trend that is not determined to be significant at the 90th percentile is classified as being “not significant”.

Table 5.3.4-1: Monthly Wind Summary for Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Speed (km/h)	14.9	15.1	12.5	12.2	10.2	8.3	8.7	8.9	9.7	12.1	13.4	15.3	11.8
Most Prevalent Direction	S	S	S	SW	SW	SW	SW	N	S	S	S	W	S

Notes:
The numbers in the table above are calculated using the five-year dispersion meteorology (2005 to 2009).
Source: [35]

Table 5.3.4-2: Monthly Wind Normals for Wiarton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Speed (km/h)	17.1	14.7	14.6	14.4	11.8	10.5	10.2	10.3	11.9	14.5	15.9	16.0	13.5
Most Prevalent Direction	S	S	S	N	SW	SW	SW	SW	S	S	S	S	S

Notes:
The numbers in the table above are calculated using the 1971 through 2000 climate normals.
Source: [15]

Table 5.3.6-1 provides a listing of the normals, trends and trend significance for temperature. The data show an increasing trend in temperature for each season, as well as an overall annual temperature increase. However, only the trend during the winter was determined to be statistically significant.

Table 5.3.6-1: Annual and Seasonal Temperature Trends for Wiarton

Parameter	Annual	Spring	Summer	Fall	Winter
Temperature (°C), 1971 to 2000	6.1	4.5	17.4	8.3	-5.7
Trend (°C/decade), 1971 to 2000	+0.31	+0.50	+0.26	+0.05	+0.68
Level of significance	not statistically significant	not statistically significant	not statistically significant	not statistically significant	significant at the 90th percentile

Table 5.3.6-2 provides a listing of the normals, trends and trend significance for precipitation. There is more variability with the historic precipitation trends than there is for temperature. There is no apparent trend during the spring and summer, a decreasing trend in the fall and an increasing trend during the winter. Overall, there is an increasing trend in annual precipitation. None of the historic precipitation trends are determined to be statistically significant.

Table 5.3.6-2: Annual and Seasonal Precipitation Trends for Wiarton

Parameter	Annual	Spring	Summer	Fall	Winter
Precipitation (mm), 1971 to 2000	1,041.3	216.8	230.8	310.9	282.8
Trend (%/decade), 1971 to 2000	+0.13	+3.23	-0.51	+4.41	-4.65
Level of significance	not statistically significant	not statistically significant	not statistically significant	not statistically significant	not statistically significant

While past trends have traditionally been used to provide guidance for the future, reliance is shifting to global climate models, which incorporate accepted understandings of climate mechanisms and standardized scenarios reflecting potential human development in the future. There are seven climate change models that have been approved by the Intergovernmental Panel on Climate Change (IPCC) and are widely accepted around the world. These models include the following:

- Australian Commonwealth Scientific and Industrial Research Organization model (CSIRO);
- the Japanese Centre for Climate Research Studies model (CCSR);
- the German Deutsches Klimarechenzentrum model (ECHAM4);
- the United Kingdom Hadley Centre model (HADCM3);
- the United States National Centre for Atmospheric Research model (NCAR-PCM);
- the United States Geophysical Fluid Dynamic Laboratory model (GFDL); and
- the Canadian Climate Centre (CGM3) model.

For the purposes of the EA, climate change forecasts from the Canadian CGM3 model are chosen because the CGM3 model is designed to predict changing climate in the mid to upper latitudes, and in particular, North America. In total, the CGM3 predictions for the following forecast periods are considered:

- 2011 to 2040;
- 2041 to 2070; and
- 2071 to 2100.

The forecast data from the CGM3 model are presented as the change in climate relative to the predicted 1971 to 2000 baseline obtained using the same model. This change represents the change between the 30-year average for the modelled future conditions and the predicted average for the 30-year baseline period (i.e., 1971 to 2000). In total, forecasts for five future scenarios were considered (see Appendix D). These scenarios were put forward by the IPCC to represent differing levels of greenhouse gas emissions associated with possible future economic and social conditions globally. The model forecasts are then ranked on the basis of temperature, for each season and the year, as a whole. This allows the determination of a "low", "average" and "high" forecast for each season and each time horizon. The "low" ranking signifies the lowest result of the forecast scenarios. The "high" ranking signifies the highest result of the forecast scenarios. The "average" ranking signifies the average of the forecast scenarios considered.

Tables 5.3.6-3 and 5.3.6-4 provide summaries of the past and future trends for temperature and precipitation, respectively. The tables describe how climate in the region has been changing, as well as how it is projected to change over the life of the DGR Project. These data are used to evaluate how climate change may affect the conclusions reached regarding the assessment of the effects of the DGR Project on the selected VECs.

Appendix D provides further details regarding the climate change assessment methods, how the climate has changed in the region over the past 30 years, as well as how the climate is projected to change over the life of the DGR Project. In addition, Appendix D provides additional information describing how changes in climate are projected to affect the environment that interacts with the DGR Project.

5.4 EXISTING AIR QUALITY

5.4.1 Existing Air Quality in the Regional Study Area

The existing air quality in the Regional Study Area is characteristic of the general air quality in Southwestern Ontario, and has been described using monitoring data from stations operated by the MOE. While the MOE prepares reports that summarize these data [16;17;18;19;20;21;22], these reports take several years to become available. However, the MOE recently started to make all of the hourly air quality data collected at its stations available for use [36]. This electronic data was obtained from the four stations nearest to the DGR Project Area (see Figure 5.4.1-1). The relative locations of each of the air monitoring stations selected to describe the existing air quality in the Regional Study Area are summarized in Table 5.4.1-1.
Table 5.4.1-2 provides a summary of the monitoring data available from each of these stations. The table illustrates how some additional parameters have been added in recent years, while others have been discontinued.

Table 5.3.6-3: Historic and Future Temperature Trends

Criteria	1971-2000 Normals (°C)	1971-2000 Trend (°C/decade)	2011-2040 Forecast (°C/decade)			2041-2070 Forecast (°C/decade)			2071-2100 Forecast (°C/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	6.1	+0.31	+0.00	+0.41	+1.05	+0.15	+0.34	+0.66	+0.20	+0.33	+0.51
Spring	4.5	+0.50	+0.00	+0.45	+1.09	+0.14	+0.35	+0.69	+0.19	+0.34	+0.54
Summer	17.4	+0.26	+0.00	+0.43	+1.10	+0.15	+0.34	+0.69	+0.21	+0.34	+0.52
Fall	8.3	+0.05	+0.00	+0.36	+1.02	+0.12	+0.30	+0.63	+0.19	+0.32	+0.49
Winter	-5.7	+0.68	+0.00	+0.40	+0.99	+0.16	+0.33	+0.63	+0.21	+0.33	+0.50

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts.

Table 5.3.6-4: Historic and Future Precipitation Trends

Season	1971-2000 Normals (mm)	1971-2000 Trend (mm/decade)	2011-2040 Forecast (%/decade)			2041-2070 Forecast (%/decade)			2071-2100 Forecast (%/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	1,041.3	+0.13%	+0.00%	+1.44%	+3.57%	+0.36%	+1.11%	+2.09%	+1.39%	+1.30%	+2.25%
Spring	216.8	+3.23%	+0.00%	+2.59%	+5.39%	+0.62%	+1.51%	+2.72%	+1.88%	+2.24%	+4.05%
Summer	230.8	-0.51%	+0.00%	-1.65%	-3.40%	-0.95%	-1.13%	-0.42%	-0.68%	-0.85%	-0.61%
Fall	310.9	+4.41%	+0.00%	+2.09%	+4.35%	+2.28%	+1.67%	+2.75%	+2.11%	+1.65%	+1.85%
Winter	282.8	-4.65%	+0.00%	+2.39%	+7.30%	-0.27%	+1.82%	+3.08%	+2.05%	+1.92%	+3.32%

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts.

0 5 10 20 30 40 50

Kilometres

LEGEND

- Ambient Air Quality Monitoring Station
- First Nations' Lands
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF AMBIENT AIR QUALITY MONITORING STATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
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FIGURE 5.4.1-1

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Table 5.4.1-1: Ambient Air Quality Monitoring Station Location Information

City	Location	Station ID	Approximate Distance from the DGR Project (km)	Direction from the DGR Project
Kitchener	Kitchener — West Ave./Homewood	26060	140	Southeast
London	London — 900 Highbury Ave.	15025	150	South-southeast
Sarnia	Sarnia — Front St./CN Tracks, Centennial Park	14064	170	South-southwest
Tiverton	Tiverton — Lot C/Concession 5, Visitor Info	18007	7	South-southeast

Table 5.4.1-2: Availability of Ambient Air Quality Data

City	Station ID	Electronic Data Availability					Periodic Data	
		NO_2	SO_2	CO	O_3	$PM_{2.5}$	SPM	PM_{10}
Kitchener	26060	2000-2002 2004-2007	2000-2003 2006	2000-2003	2000-2007	2003-2007	2000-2005	2000-2005
London	15025	2000-2007	2000-2002 2004-2007	2000-2002 2004-2007	2000-2007	2003-2007	2000-2005	2000-2005
Sarnia	14064	2000-2007	2000-2007	2000-2001	2000-2007	2003-2007	2000-2005	2000-2005
Tiverton	18007	2007	2007	NA	2000-2007	2003-2007	NA	NA

Note:
"NA" Indicates that data for the parameter were not available at that station.

The graphs in the following sections present simplified box-and-whisker plots showing the available concentration data. The box on the figures represents the bounds of the middle 50% of the data points. The top of the box represents the 75th percentile concentration, while the bottom of the box represented the 25th percentile concentration. The line through the middle of the box represents the median, or 50th percentile concentration. The blue diamond represents the average concentration. On these figures, the whiskers extend up to the maximum, and down to the minimum concentration. Additional monitoring data at the stations is provided in Appendix E.

Although gaseous monitoring equipment records concentrations in units of parts per million parts (ppm) or parts per billion parts (ppb), regulatory criteria are established on the basis of micrograms per cubic metre (µg/m³). In this section, tabular monitoring results for gaseous compounds are presented in the units in which they are monitored. However, to facilitate the comparison of monitoring to criteria, graphs for gaseous compounds show axes with both ppm and µg/m³.[2] The conversion from ppm to µg/m³ is unique to each compound. In contrast, particulate monitoring equipment records concentrations in units of µg/m³. Particulate concentrations in µg/m³ cannot be converted to ppm, but are directly comparable to the criteria.

5.4.1.1 Oxides of Nitrogen

Oxides of nitrogen (NO_X) in the atmosphere are composed primarily of two compounds: nitrogen dioxide (NO_2) and nitric oxide (NO). Emissions of NO_X occur mainly from high-temperature combustion processes. In Ontario, the transportation sector accounts for approximately 64% of the NO_X emissions [20]. Although the majority of NO_X emissions are in the form of NO, these rapidly oxidize in the presence of hydrocarbons and sunlight to form NO_2. The NO_2 also reacts to form nitrate precursors, which contribute to the secondary formation of fine particulate matter ($PM_{2.5}$). Nitrogen dioxide (NO_2) was selected as an indicator for this assessment since it is the only oxide of nitrogen (NO_X) that has ambient criteria in Canada. Literature indicates that NO_2 can affect bronchial activity in asthmatics, and people suffering from bronchitis at levels as low as 470 µg/m³ [37]. There are no known effects on human health or vegetation associated with NO.

A summary of the available 1-hour NO_2 monitoring results (see Table 5.4.1-2) is presented in Table 5.4.1-3. Figure 5.4.1-2 presents a graphical summary of the 1-hour NO_2 concentrations measured at the ambient monitoring stations. There were no hourly readings that exceeded the ambient air quality criteria (AAQC) in Ontario of 0.200 ppm (i.e., 200 ppb).

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[2] The µg/m³ axis is based on a conversion at 25°C and 101.3 kPa and may differ from the AAQC. The ppm values match the AAQC explicitly.

Table 5.4.1-3: Ambient 1-hour NO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	**2nd %-ile**	**25th %-ile**	**50th %-ile**	**Average**	**75th %-ile**	**98th %-ile**	**Maximum**
Kitchener	0.000	0.002	0.006	0.010	0.012	0.016	0.039	0.071
London	0.000	0.002	0.007	0.012	0.014	0.019	0.042	0.151
Sarnia	0.000	0.002	0.006	0.011	0.014	0.019	0.039	0.156
Tiverton	0.000	0.000	0.001	0.002	0.003	0.004	0.014	0.034
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Note:
"%-ile" = percentile

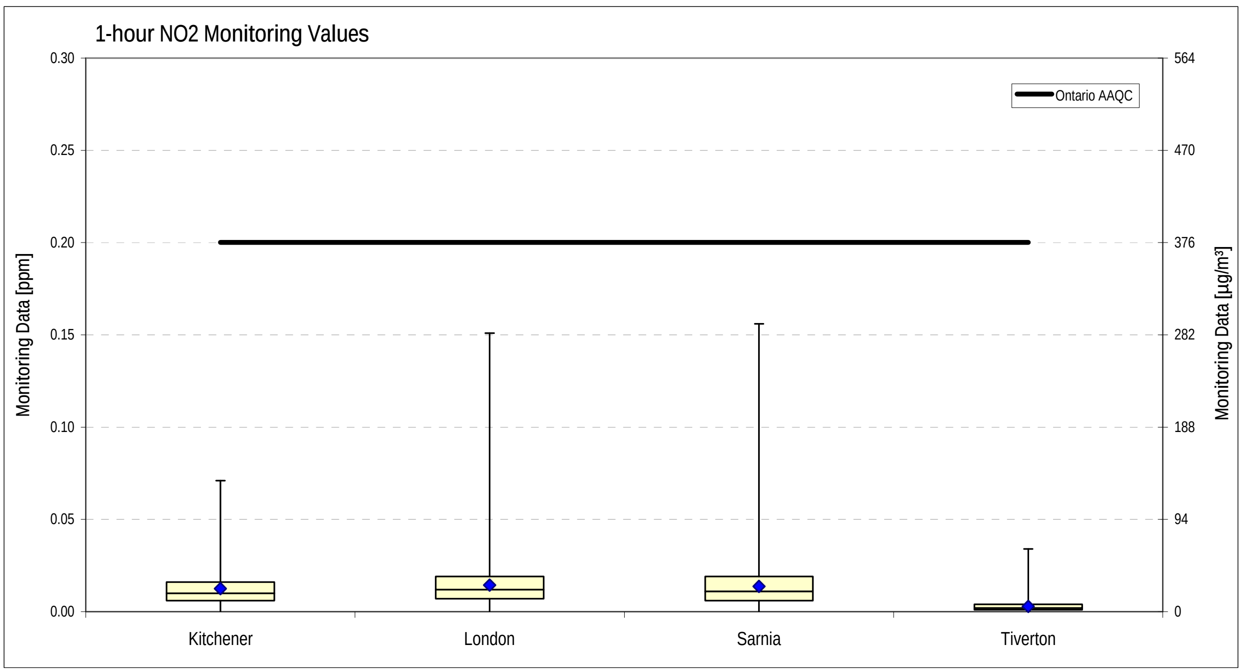

Figure 5.4.1-2: Ambient 1-Hour NO_2 Monitoring Results

Table 5.4.1-4 and Figure 5.4.1-3 provide summaries of the available 24-hour NO_2 concentrations measured at the ambient monitoring stations (see Table 5.4.1-2). None of the 24-hour ambient monitoring results exceed the AAQC of 0.100 ppm (i.e., 100 ppb). Annual data are not reported in Ontario for NO_2. Instead, the average value of the data reported is used to represent the annual data.

Table 5.4.1-4: Ambient 24-hour NO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.001	0.004	0.007	0.011	0.012	0.016	0.030	0.050
London	0.002	0.004	0.009	0.013	0.014	0.018	0.034	0.059
Sarnia	0.001	0.003	0.009	0.013	0.014	0.018	0.032	0.050
Tiverton	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.014
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

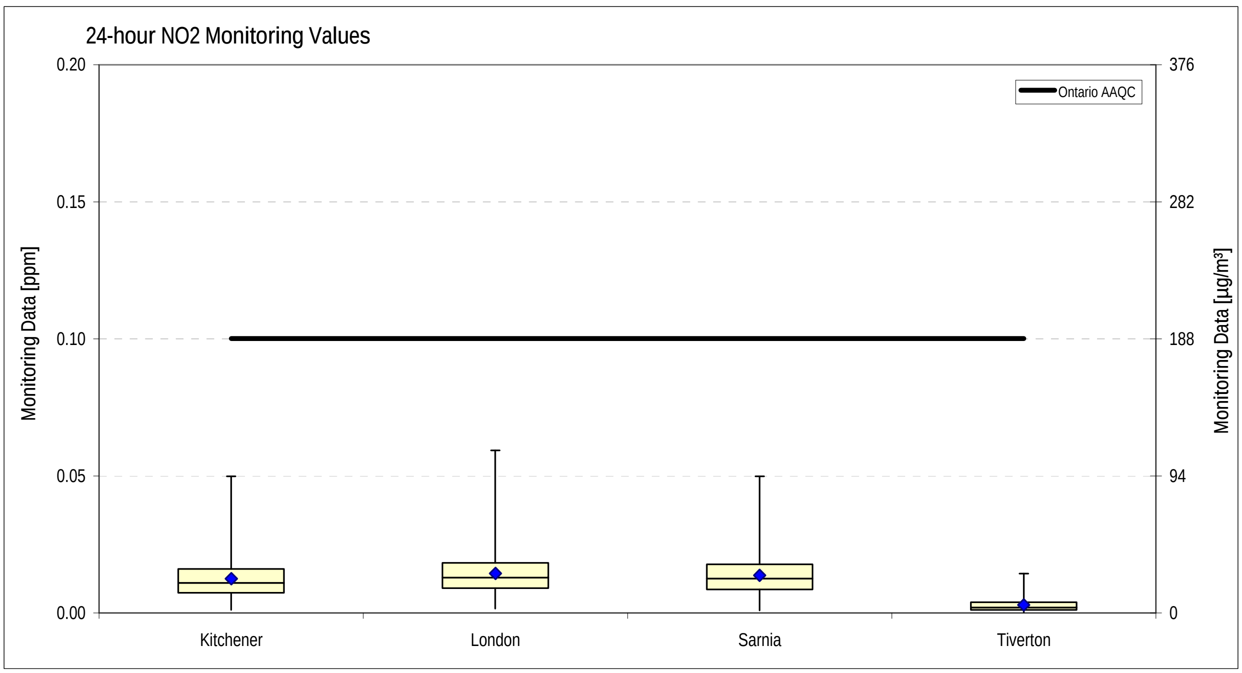

Figure 5.4.1-3: Ambient 24-Hour NO_2 Monitoring Results

5.4.1.2 Sulphur Dioxide

Sulphur dioxide (SO_2) is formed when sulphur in fuel reacts with oxygen during the combustion process. Elevated concentrations of SO_2 can have a direct effect on vegetation and, when present at sufficiently high levels can also affect respiratory function in humans. Emissions of SO_2 are a precursor to acid rain and fine particulate matter (i.e., $PM_{2.5}$). Seventy-one percent of SO_2 emissions in the province of Ontario can be attributed to smelting operations and power generation [20].

Table 5.4.1-5 and Figure 5.4.1-4 present summaries of the 1-hour SO_2 concentrations (see Table 5.4.1-2). As illustrated in the figure, there were no hourly readings that exceeded the

AAQC of 0.250 ppm, at Kitchener, London or Tiverton. There were only two hours during the eight years of available data when the hourly concentrations in Sarnia exceeded the Ontario AAQC (one hour during each of 2001 and 2002).

Table 5.4.1-5: Ambient 1-hour SO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	**2^{nd} %-ile**	**25^{th} %-ile**	**50^{th} %-ile**	**Average**	**75^{th} %-ile**	**98^{th} %-ile**	**Maximum**
Kitchener	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.142
London	0.000	0.000	0.001	0.002	0.003	0.003	0.011	0.039
Sarnia	0.000	0.000	0.001	0.002	0.009	0.006	0.086	0.263
Tiverton	0.000	0.000	0.000	0.001	0.001	0.002	0.009	0.026
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Note:
"%-ile" = percentile

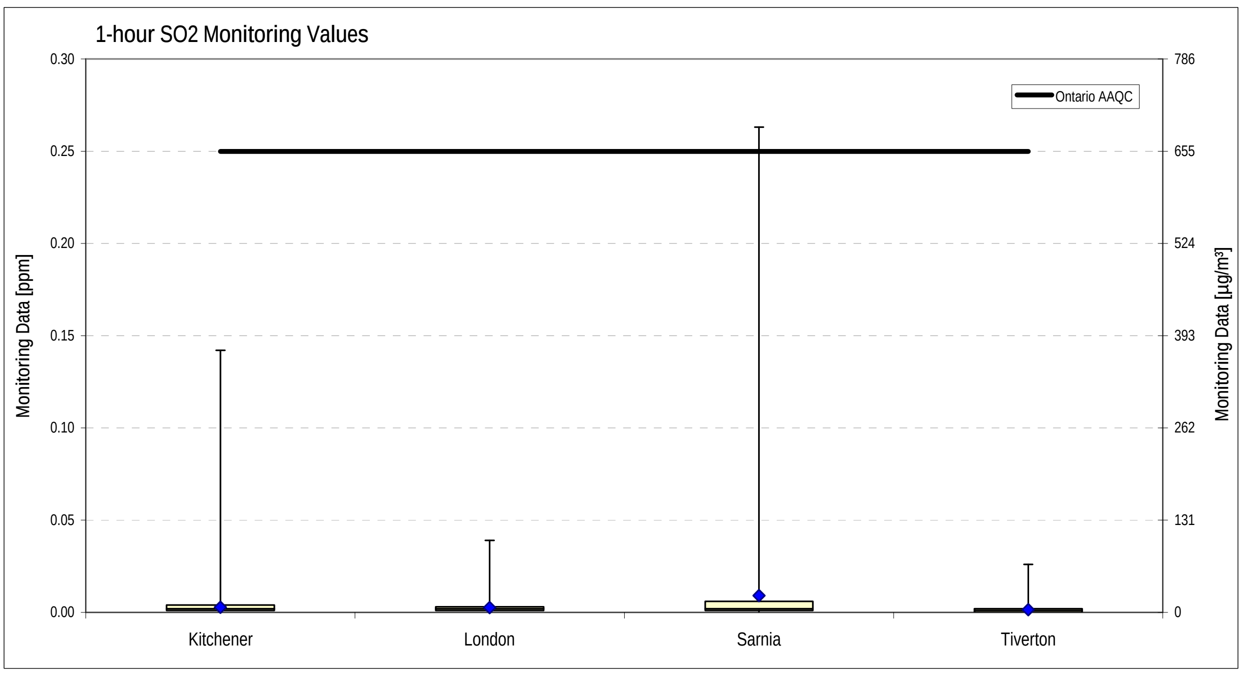

Figure 5.4.1-4: Ambient 1-Hour SO_2 Monitoring Results

Table 5.4.1-6 and Figure 5.4.1-5 provide summaries of the available 24-hour SO_2 concentrations measured at the ambient monitoring stations (see Table 5.4.1-2). None of the 24-hour ambient monitoring results at the Kitchener, London or Tiverton stations exceeded the daily AAQC of 0.100 ppm (i.e., 100 ppb). However, there were four days during the eight years of available data when the 24-hour concentrations in Sarnia exceeded the Ontario AAQC (two days during each of 2001 and 2006).

Table 5.4.1-6: Ambient 24-hour SO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.000	0.001	0.002	0.003	0.004	0.009	0.017
London	0.000	0.000	0.001	0.002	0.002	0.003	0.009	0.016
Sarnia	0.000	0.000	0.002	0.004	0.009	0.011	0.047	0.131
Tiverton	0.000	0.000	0.000	0.001	0.001	0.002	0.006	0.009
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

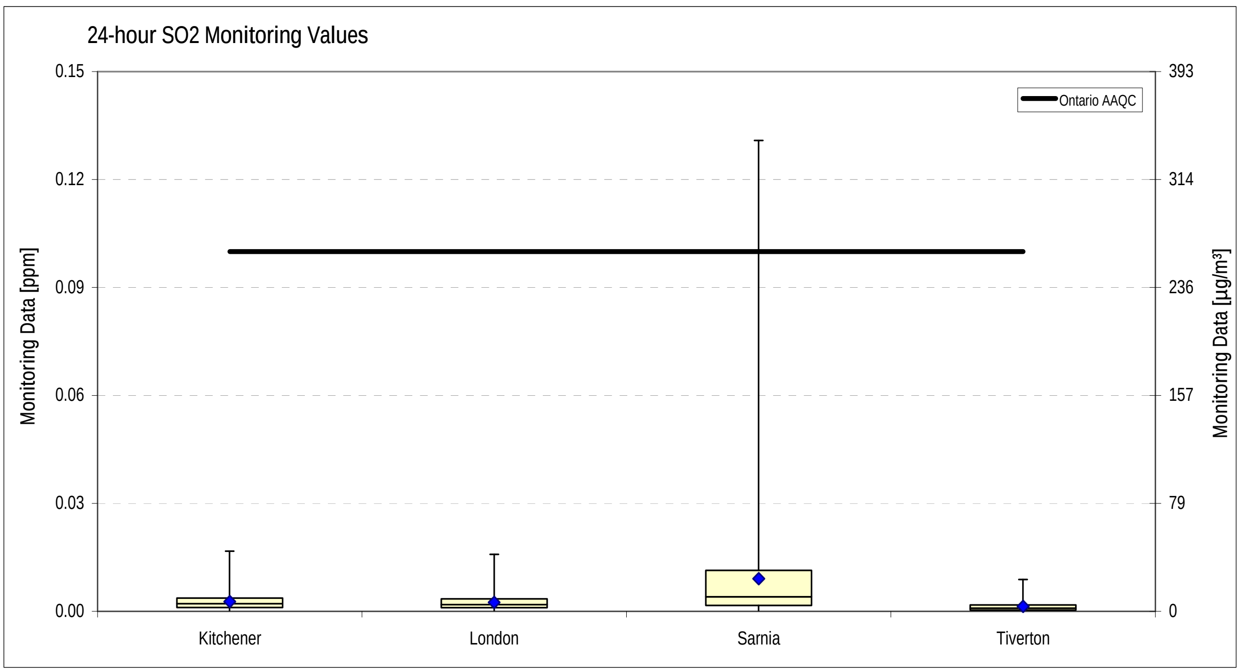

Figure 5.4.1-5: Ambient 24-Hour SO_2 Monitoring Results

Annual data for SO_2 are not reported in Ontario. Instead, the average value of the data reported is used to represent the annual data.

5.4.1.3 Carbon Monoxide

Carbon monoxide (CO) is produced primarily through the incomplete combustion of hydrocarbons. The main source of CO produced in Ontario is from the transportation sector [20]. CO is a colourless, odourless, tasteless gas that can replace oxygen in the bloodstream, reducing the oxygen that is delivered to organs and tissues.

A summary of the available 1-hour CO monitoring results is presented in Table 5.4.1-7. Figure 5.4.1-6 presents a graphical summary of the 1-hour CO concentrations measured at the Kitchener, London and Sarnia monitoring stations (see Table 5.4.1-2). Ambient CO data were not available at the Tiverton station. As illustrated in the figure, all of the stations with monitored data had hourly readings significantly lower than the AAQC of 30 ppm.

Table 5.4.1-7: Ambient 1-hour CO Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.070	0.260	0.380	0.428	0.540	1.050	5.380
London	0.000	0.000	0.060	0.160	0.198	0.270	0.710	3.500
Sarnia	0.000	0.000	0.230	0.330	0.356	0.450	0.870	3.860
Tiverton	—	—	—	—	—	—	—	—
AAQC (ppm)	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**

Notes:
— Data not available
"%-ile" = percentile

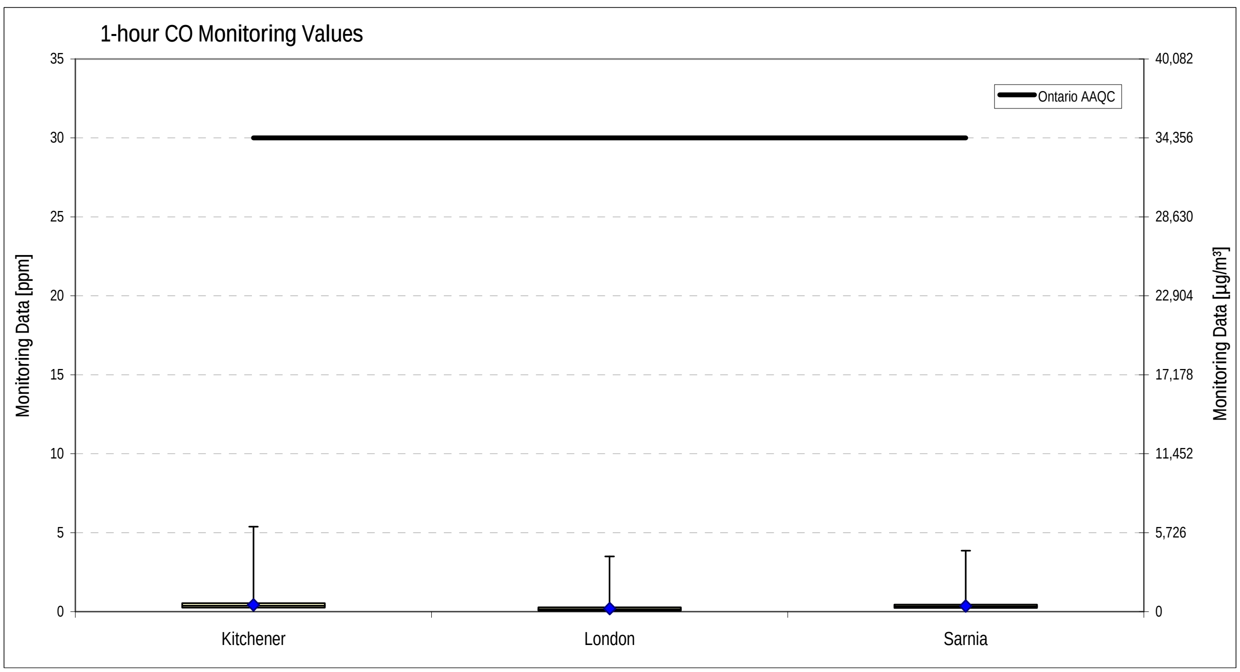

Figure 5.4.1-6: Ambient 1-Hour CO Monitoring Results

Table 5.4.1-8 and Figure 5.4.1-7 provide summaries of the available 8-hour CO concentrations measured at the ambient monitoring stations (see Table 5.4.1-2). No monitoring data for CO were available at the Tiverton station for the given time period (2000 through 2007). The table and graph illustrate that the recorded 8-hour CO levels at the remaining stations were well below the AAQC of 13 ppm.

Table 5.4.1-8: Ambient 8-hour CO Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.046	0.131	0.339	0.471	0.526	0.639	1.488	2.783
London	0.000	0.014	0.126	0.219	0.263	0.346	0.780	1.434
Sarnia	0.000	0.084	0.315	0.414	0.446	0.558	0.916	1.686
Tiverton	—	—	—	—	—	—	—	—
AAQC (ppm)	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**

Notes:
— Data not available
"%-ile" = percentile

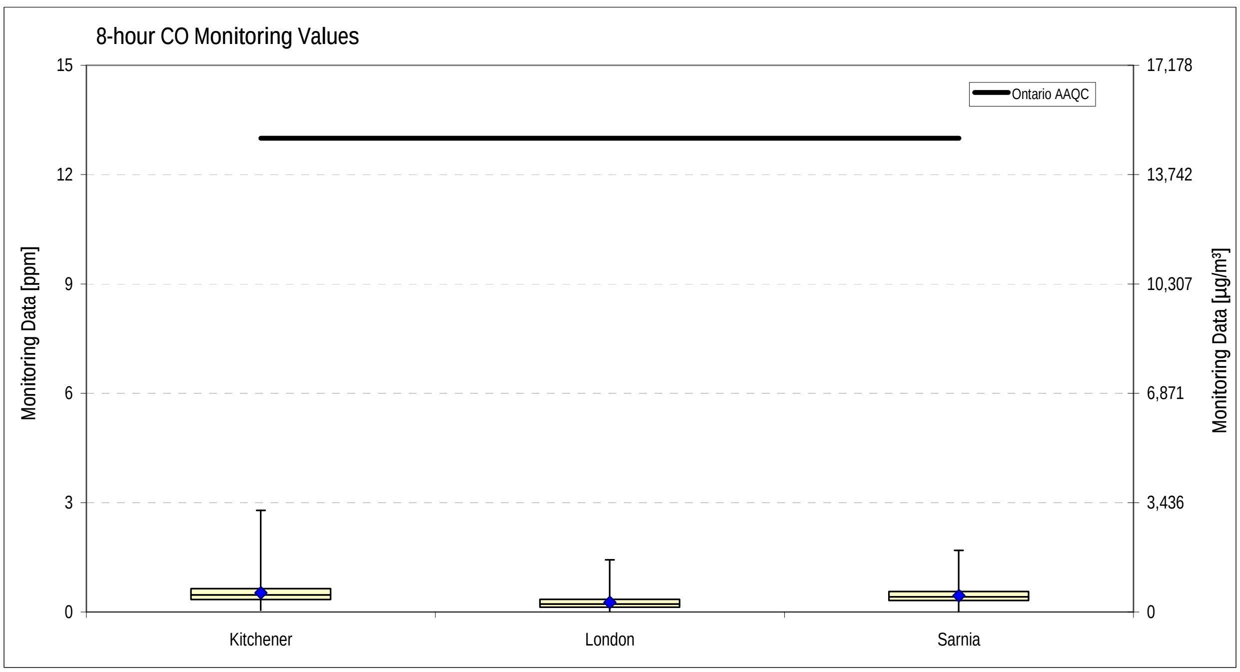

Figure 5.4.1-7: Ambient 8-Hour CO Monitoring Results

5.4.1.4 Ozone

Ozone (O_3) is an essential part of the upper atmosphere that protects us from most of the sun's harmful ultra-violet radiation. Ozone can also be present at the earth's surface. Ground-level ozone can be attributed to three causes in Canada, namely photochemical ozone formation, stratospheric intrusion and long-range transport.

Photochemical ozone formation is one of the key ingredients of urban smog that is associated with large American cities, such as Los Angeles. Photochemical ozone forms when large volumes of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) are present during the right meteorological conditions. This type of ozone formation occurs during the daylight hours in the summer months when hot, sunny, stagnant conditions favour the necessary chemical reactions.

The transport of ozone over long distances occurs in several regions of Canada. In southern Ontario, photochemical ozone is frequently transported into Canada from larger cities in the United States.

Ozone was not identified as a key indicator for the assessment as the DGR Project does not directly emit ozone, nor does it emit precursor compounds in sufficient volumes to results in enhanced ozone formation. However, ozone is important in the conversion of nitric oxide (NO), the major constituent of NO_X emissions, to nitrogen dioxide (NO_2) in the atmosphere.

A summary of the available 1-hour ozone monitoring results (see Table 5.4.1-2) is presented in Table 5.4.1-9. Figure 5.4.1-8 presents a graphical summary of the 1-hour ozone concentrations measured at the ambient monitoring stations. As illustrated in the figure, all of the stations had hourly readings that exceeded the AAQC of 0.080 ppm (i.e., 80 ppb). Table 5.4.1-10 lists the number of days per year (2000 through 2007) when hourly ozone exceeded the AAQC.

Table 5.4.1-9: Ambient 1-hour O_3 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.000	0.001	0.015	0.026	0.027	0.036	0.066	0.109
London	0.000	0.001	0.013	0.023	0.025	0.034	0.065	0.116
Sarnia	0.000	0.001	0.014	0.025	0.026	0.035	0.066	0.128
Tiverton	0.000	0.008	0.023	0.031	0.032	0.039	0.068	0.136
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

Table 5.4.1-10: Days per Year when 1-hour O_3 Exceeds the AAQC

City	Days per Year with 1-hour O_3 Greater than AAQC							
	2000	2001	2002	2003	2004	2005	2006	2007
Kitchener	6	16	17	11	2	9	1	8
London	5	14	21	9	2	5	1	6
Sarnia	7	18	22	9	2	21	8	19
Tiverton	8	16	20	13	3	6	4	20

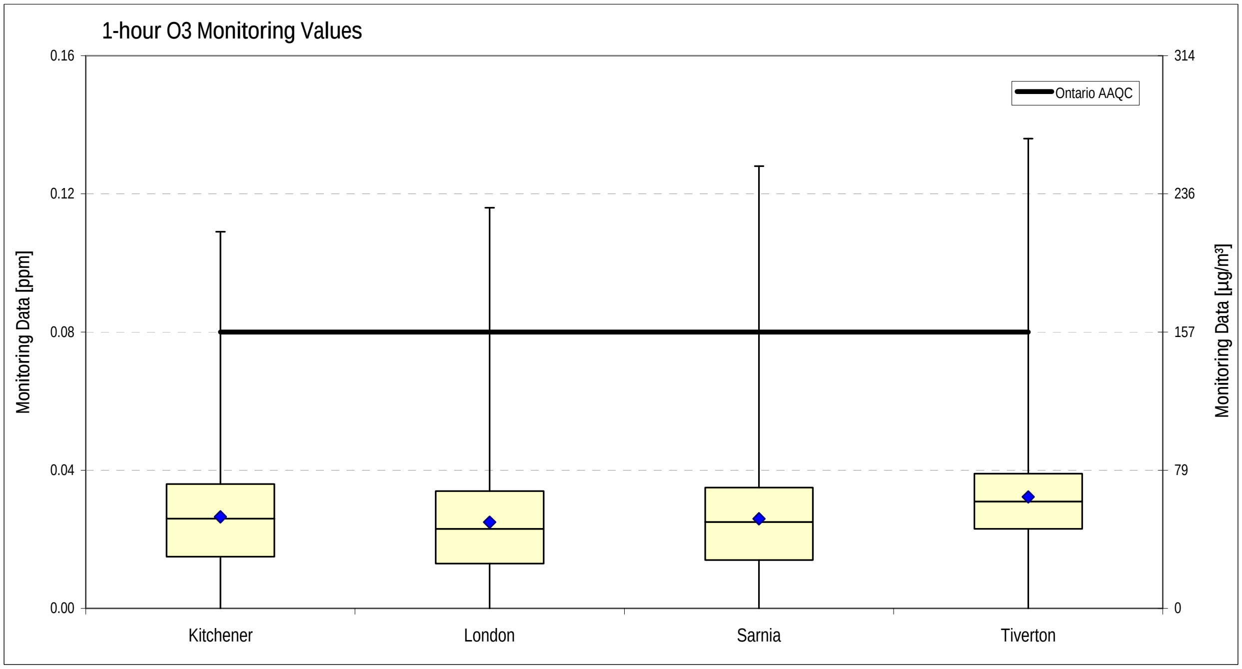

Figure 5.4.1-8: Ambient 1-Hour O_3 Monitoring Results

As seen in Table 5.4.1-10, the number of days when 1-hour ozone exceeds the AAQC varies from one year to the next. However, the number of days when 1-hour ozone exceeds the AAQC tends to be similar at all four stations in a given year (with the exception of 2005 at Sarnia and 2007 at Sarnia and Tiverton).

Table 5.4.1-11 and Figure 5.4.1-9 provide summaries of the available maximum 8-hour ozone concentrations measured at the ambient monitoring stations (see Table 5.4.1-2). Currently there is no 8-hour AAQC for ozone, but there is a Canada-Wide Standard [11] that has been used for comparison to the data. Maximum 8-hour ozone concentrations at all of the stations exceeded the Canada-Wide Standard of 0.065 ppm (i.e., 65 ppb). However, compliance with the Canada-Wide Standard is based on the fourth highest 8-hour value annually, averaged over a 3-year period [11]. These are presented in Appendix E. The values were all above the Canada-Wide Standard of 0.065 ppm.

Table 5.4.1-11: Ambient 8-hour O_3 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	**2^{nd} %-ile**	**25^{th} %-ile**	**50^{th} %-ile**	**Average**	**75^{th} %-ile**	**98^{th} %-ile**	**Maximum**
Kitchener	0.002	0.009	0.026	0.035	0.036	0.045	0.075	0.104
London	0.001	0.009	0.024	0.032	0.035	0.044	0.074	0.108
Sarnia	0.000	0.008	0.025	0.034	0.036	0.044	0.077	0.113
Tiverton	0.004	0.015	0.029	0.036	0.039	0.045	0.079	0.115
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
“%-ile” = percentile

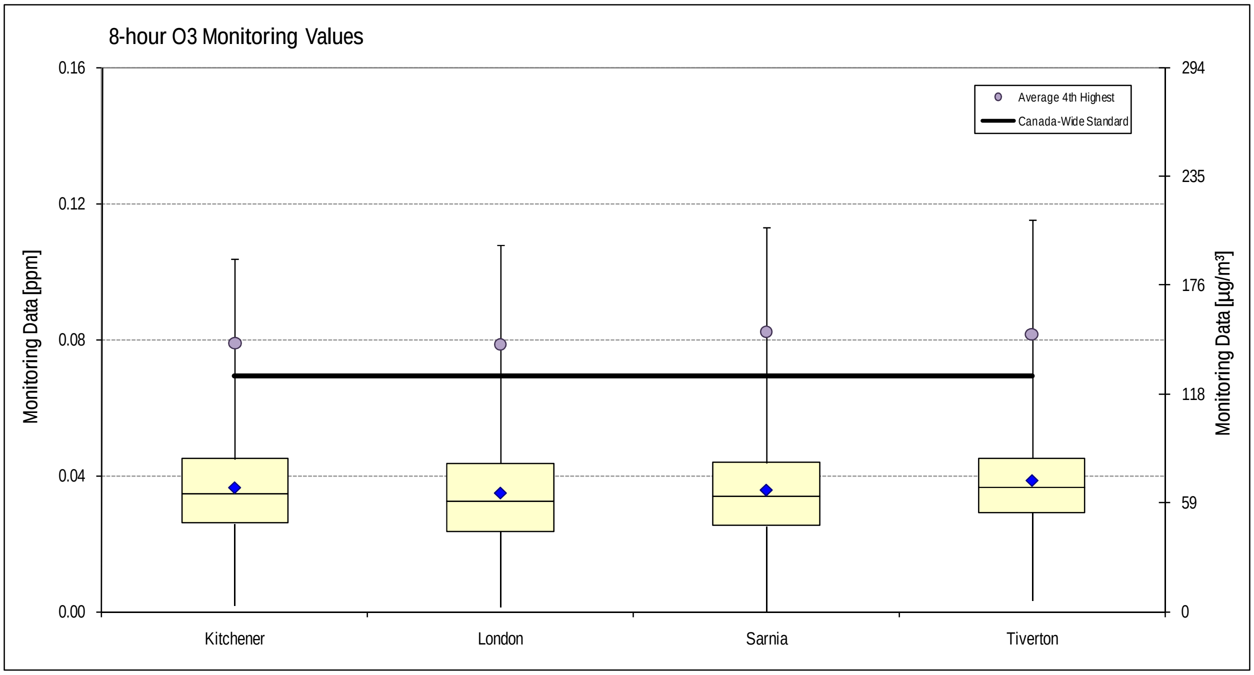

Figure 5.4.1-9: Ambient 8-Hour O_3 Monitoring Results

5.4.1.5 Fine Particulate Matter

Airborne particulate matter in Ontario is described using three size categories. Suspended particulate matter (SPM) is the largest category and includes those airborne particles with an aerodynamic diameter less than 44 µm. The portion of the SPM with aerodynamic diameters of 10 µm, or less is referred to as PM_{10}. The PM_{10} sized particles are small enough to be inhaled into the upper respiratory tract. The fraction of the SPM and PM_{10} with an aerodynamic diameter of 2.5 µm or less is referred to and $PM_{2.5}$. The $PM_{2.5}$ sized particles are small enough to be drawn into the lungs, and are sometimes described as the respirable fraction of airborne particles. While periodic monitoring of SPM and PM_{10} is still done in Ontario, only the continuous $PM_{2.5}$ monitoring data is available electronically for review and presentation.

A summary of the available daily $PM_{2.5}$ monitoring results (see Table 5.4.1-2) is presented in Table 5.4.1-12. Figure 5.4.1-10 presents a graphical summary of the 24-hour $PM_{2.5}$ concentrations measured at the ambient monitoring stations. While there is no AAQC for $PM_{2.5}$, the Canada-Wide Standard [11] has been used to compare to the data. As illustrated in the figure, all of the stations, with the exception of Tiverton, recorded 98^{th} percentile daily $PM_{2.5}$ levels that were higher than the Canada-Wide Standard level of 30 µg/m³. However, compliance with the Canada-Wide Standard is based on the 98^{th} percentile of the monitoring data, averaged over a 3-year period. Table 5.4.1-13 presents a summary of the 3-year rolling 98^{th} percentile $PM_{2.5}$ concentrations for comparison to the Canada-Wide Standard.

Table 5.4.1-12: Ambient 24-hour $PM_{2.5}$ Monitoring Results

City	Ambient Monitoring Results (µg/m³)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.0	1.1	3.5	6.0	8.3	10.4	30.7	48.3
London	0.4	1.3	5.3	8.0	9.8	12.1	31.3	45.6
Sarnia	0.0	3.1	6.3	9.5	12.1	15.4	37.9	75.5
Tiverton	0.0	0.4	1.8	3.7	6.0	7.8	26.4	53.3
Canada-Wide Standard (µg/m³) [a]	**—**	**—**	**—**	**—**	**—**	**—**	**30**	**—**

Notes:
a Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile
— Not available

Table 5.4.1-13: Summary of 24-hour $PM_{2.5}$ Monitoring Results for Comparison to the Canada-Wide Standard

City	3-Year 98th Percentile 24-hour $PM_{2.5}$ (µg/m³) [a]		
	2003 to 2005	2004 to 2006	2005 to 2007
Kitchener	32.0	30.1	28.9
London	34.3	31.3	27.9
Sarnia	39.9	37.1	35.8
Tiverton	28.2	25.8	24.7
Canada-Wide Standard (µg/m³) [b]	**30**	**30**	**30**

Notes:
a $PM_{2.5}$ monitoring data were available from 2003 to 2007 (see Table 5.4.1-2)
b Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.

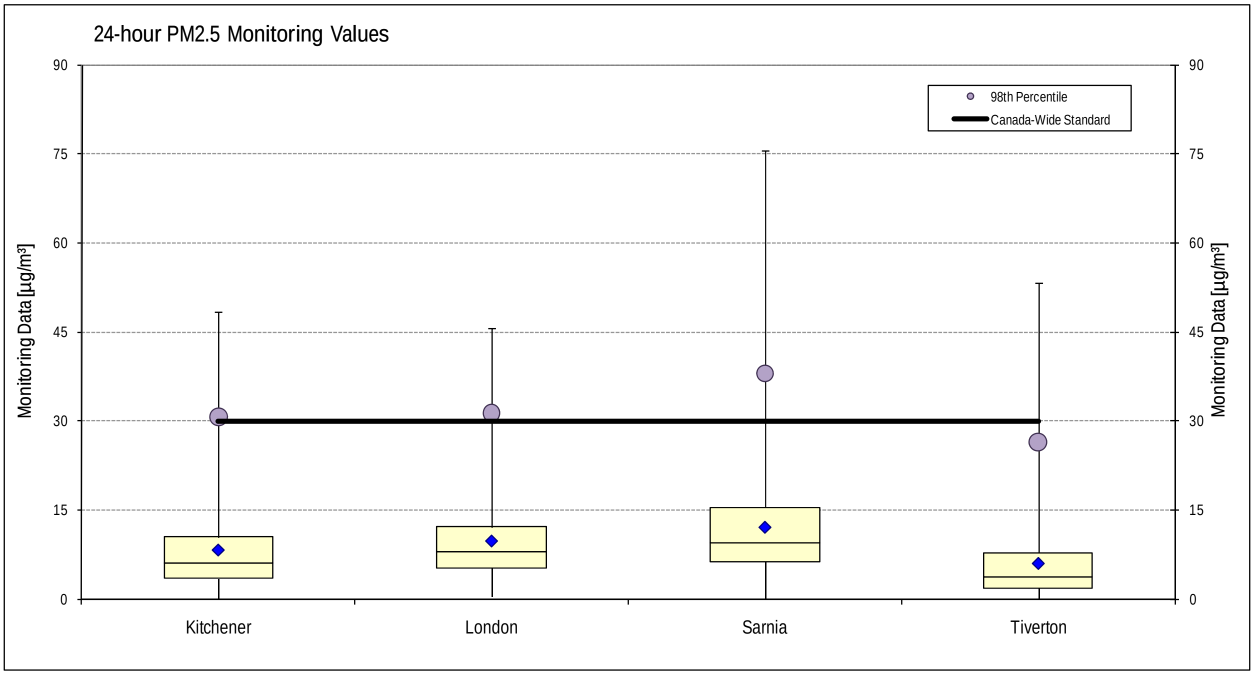

Figure 5.4.1-10: Ambient 24-Hour $PM_{2.5}$ Monitoring Results

As seen in the above table, the following describes the level of compliance with the Canada-Wide Standard for $PM_{2.5}$:

- the $PM_{2.5}$ levels in Kitchener exceeded the Canada-Wide Standard of 30 µg/m³ for two of the 3-year periods (2003 to 2005 and 2004 to 2006) for which monitoring data were available;
- the $PM_{2.5}$ levels in London exceeded the Canada-Wide Standard for two 3-year periods (2003 to 2005 and 2004 to 2006);
- the $PM_{2.5}$ levels in Sarnia exceeded the Canada-Wide Standard of 30 µg/m³ for each of the 3-year periods (2003 to 2005, 2004 to 2006, 2005 to 2007) for which monitoring data were available; and
- the $PM_{2.5}$ levels in Tiverton met the Canada-Wide Standard of 30 µg/m³ for each of the 3-year periods (2003 to 2005, 2004 to 2006, 2005 to 2007) for which monitoring data were available.

5.4.1.6 Background Air Quality

Air monitoring data collected within the Regional Study Area represent the combined effect of emissions from sources near each of the monitoring stations, as well as the effect of the emissions transported into the region. The emissions transported into the region could be considered to be the ‘background air quality’. Based on feedback from regulators, and expert judgement, the 90^{th} percentile of the available monitoring data is considered a conservative estimate of background air quality [38].

Table 5.4.1-14 provides a listing of the 90th percentile concentrations from the air monitoring stations in the Regional Study Area, as well as background concentrations derived from the monitoring results. In those cases where data are available from the station in Tiverton, the 90th percentile data from Tiverton was used to define the background concentrations. For indicators where data were not available, results from the station in London were used. Tiverton is the obvious choice, when available, given its proximity to the Bruce nuclear site and thus a closer representation of the Regional Study Area. London was selected in cases where Tiverton was not available as it was considered to be less influenced by nearby industries and transportation routes than either Kitchener or Sarnia. Air quality in Sarnia is heavily influenced by local industries and could give unrealistic estimates compared to the remote location at the Bruce nuclear site. Similarly, the monitoring station in Kitchener appears to be influenced by local traffic.

Table 5.4.1-14: Background Air Quality

Indicator	Background (µg/m³)	90th Percentile of Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
1-hour NO_2	13.2	13.2	47.0	52.7	52.7
24-hour NO_2	12.0	12.0	41.0	43.7	45.4
Annual NO_2	5.4	5.4	23.4	25.8	27.0
1-hour SO_2	10.5	10.5	15.7	55.0	15.7
24-hour SO_2	9.3	9.3	14.8	64.3	14.1
Annual SO_2	3.6	3.6	7.2	23.8	6.6
1-hour CO	816.5	—	816.5	678.5	517.5
8-hour CO	945.9	—	945.9	823.4	606.6
24-hour SPM	52.1 [a]	—	—	—	—
Annual SPM	23.0 [a]	—	—	—	—
24-hour PM_{10}	22.7 [a]	—	—	—	—
24-hour $PM_{2.5}$	13.6	13.6	17.4	22.8	19.1

Notes:

a The background levels of SPM and PM_{10} are derived from background $PM_{2.5}$ data, using the limited SPM and PM_{10} data available. A description for the derivation of these background values is provided in Appendix E.

— Data not available

5.4.2 Existing Air Quality in the Local Study Area

As described in Section 5.1, the existing air quality in the Local Study Area is described using a combination of background air quality and the modelled air quality resulting from the emissions from existing sources at the Bruce nuclear site. The AERMOD dispersion model (Version 09292) was run to predict maximum concentrations resulting from existing sources at the Bruce nuclear site. The background air quality for the region was then added to these predictions to yield existing air quality in the Local Study Area.

5.4.2.1 Modelled Air Quality from Existing Sources

To model the existing air quality in the Local Study Area, the emissions associated with the existing operations at the Bruce nuclear site are input to the same dispersion model used to evaluate the effects of the DGR Project on air quality. While there are currently four units operating at Bruce B and two units operating at Bruce A, the existing conditions are considered to be those that would correspond with the completion of the refurbishment activities described in Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment [24], such that all eight existing units are operational.

Table 5.4.2-1 lists the daily emission rates from the Bruce nuclear site (including the Bruce Power facilities, Atomic Energy of Canada Limited (AECL) facilities and OPG facilities) that were used to characterize the air quality in the Local Study Area from existing sources. These sources are consistent with those presented in the *Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment Atmospheric Environment Technical Support Document* [29] and the Certificate of Approval (Air) [23] for Bruce A and B, and are detailed in Appendix F. However, the emissions from the Bruce nuclear site are not constant throughout the day. During times when the worker shifts are changing, traffic volumes will be at a maximum, and the emissions will be at their peak. Therefore, the dispersion modelling is conducted using these peak hourly emission rates.

Table 5.4.2-1: Existing Daily Emissions at the Bruce Nuclear Site

Indicator Compound	Average Daily Emission Rates (kg/d)			
	Bruce Power [a]	WWMF	Passenger Vehicles [b]	Fugitive Dust [c]
NO_X	2,442.02	6.05	0.36	—
SO_2	5,921.84	1.73	0.00	—
CO	282.86	0.00	7.11	—
SPM	485.16	0.27	0.02	0.64
PM_{10}	411.41	0.27	0.02	0.11
$PM_{2.5}$	270.09	0.27	0.01	0.00

Notes:
a Bruce Power includes Bruce Power facilities, including Bruce Power worker vehicles travelling on-site.
b Includes tailpipe emissions from all of the OPG worker vehicles on-site.
c Includes all fugitive dust, including road dust, generated by on-site traffic.
— Indicates that data is not available

Table 5.4.2-2 provides a summary of the dispersion modelling results for those compounds and averaging periods that were used when evaluating how emissions from the DGR Project could affect air quality. The table lists results for the Local Study Area, outside of the Bruce nuclear site. Consistent with guidance in Ontario [28], concentrations within the Site Study Area would be excluded when comparing modelling results to criteria or standards. The environment, from an air quality perspective, begins at the Bruce nuclear site fenceline[3].

Table 5.4.2-2: Modelled Air Quality in the Local Study Area from Existing Sources

Indicator	Maximum Modelled Concentration ($\mu g/m^3$) [a]
1-hour NO_2	97.2
24-hour NO_2	14.5
Annual NO_2	1.4
1-hour SO_2	308.4
24-hour SO_2	42.0
Annual SO_2	1.4
1-hour CO	764.1
8-hour CO	255.9
24-hour SPM	18.9
Annual SPM	2.1
24-hour PM_{10}	3.3
24-hour $PM_{2.5}$	1.8

Note:
a The maximum predicted value from the model at any receptor location. The maximums were predicted to occur at the fenceline of the Bruce nuclear site.

3 Airborne concentrations within the fenceline are not considered part of the environment from a permitting perspective, but are the subject of occupational health and safety concerns, which are addressed in the Preliminary Safety Report [4].

5.4.2.2 Existing Air Quality in the Local Study Area

Table 5.4.2-3 provides a summary of the existing air quality in the Local Study Area.

Table 5.4.2-3: Existing Air Quality in the Local Study Area

Indicator	Maximum Modelled Concentration from Existing Sources [a] (µg/m³)	Background Air Quality [b] (µg/m³)	Existing Air Quality [c, d] (µg/m³)
1-hour NO_2	97.2	13.2	110.4
24-hour NO_2	14.5	12.0	26.5
Annual NO_2	1.4	5.4	6.8
1-hour SO_2	308.4	10.5	318.9
24-hour SO_2	42.0	9.3	51.3
Annual SO_2	1.4	3.6	5.0
1-hour CO	764.1	816.5	1,580.6
8-hour CO	255.9	945.9	1,201.8
24-hour SPM	18.9	52.1	71.0
Annual SPM	2.1	23.0	25.1
24-hour PM_{10}	3.3	22.7	26.0
24-hour $PM_{2.5}$	1.8	13.6	15.4

Notes:
a See Table 5.4.2-2.
b See Table 5.4.1-14.
c Existing air quality represent the sum of maximum modelled concentrations from existing sources and background air quality.
d The numbers in the table above are correct, but because of rounding may not appear to add up to the existing air quality concentrations shown above.

5.5 NOISE LEVELS

The existing noise environment has been characterized using available monitoring data, supplemented by a focused noise field investigation. This investigation, conducted in May 2007, included monitoring in the Local Study Area, and some Site Study Area noise measurements. The effects of the DGR Project are expected to be negligible in the Regional Study Area.

5.5.1 Field Programs

The noise field study program is divided into two separate activities; continuous noise monitoring and spot noise measurements, which are described as follows:

- Continuous noise monitoring was carried out at three off-site locations (i.e., R1, R2 and R3, see Figure 5.5.1-1) to collect the existing noise levels for daytime (0700 to 1900) and night-time (1900 to 0700) periods at points of reception near the site. The

monitoring period lasted 14 days for the 2007 field study program, which built on the 2005 field study program reported in the Bruce A Refurbishment for Life Extension and Continued Operations Project EA [24].
- Spot noise measurements, including the spectral content (i.e., frequency components) at the various monitoring locations (on- and off-site) were carried out during the daytime and night-time periods to characterize the nature of existing noise levels at, and proximate to, the Site Study Area.

Continuous noise monitoring was carried out at points of reception R1 and R2 between May 4 and 11, 2005, with acoustical parameters logged every hour over a continual 182 hours of monitoring. Additionally, continuous long-term noise monitoring at R3 was completed between May 8 and 22, 2007. These off-site noise points of reception are described as follows (see Figure 5.5.1-1):

- R1 – Off-site Monitoring Location One is located on Albert Road adjacent to Inverhuron Provincial Park, approximately 3 km from Bruce B and greater than 4 km from Bruce A. The acoustic environment at this location is dominated by sounds of nature; however, road traffic noise from Albert Road and Concession 2 is also audible at this location. It was noted during the field program that Bruce nuclear site operations were not audible at this location during daytime and night-time site visits.
- R2 – Off-site Monitoring Location Two is located across Baie du Doré approximately 2 km from Bruce A and greater than 5 km from Bruce B. The acoustic environment at this location is dominated by water noise on the shore of Lake Huron and other sounds of nature. Noise emissions from Bruce A were faintly discernable at this location during the field program.
- R3 – Off-site Monitoring Location Three is located within Inverhuron Park at an existing camp site and is located approximately 5 km from Bruce A and 2 km from Bruce B. The acoustic environment at this location is dominated by sounds of nature and water noise on the shore of Lake Huron. Noise from the Bruce nuclear site was barely audible from this location.

All continuous ambient sound level measurements were carried out using Larson-Davis Model 720 Type 2 sound level meters (serial numbers 7200481 and 7200490). The sound level meters were calibrated using a Larson-Davis acoustic calibrator set to generate a 114 dB tone at 1,000 Hz.

The long-term noise monitoring was carried out with the sound level meters set on the “A” weighting scale (denoted as dBA). This scale simulates the response of the human ear. The instruments were calibrated both before and after the monitoring period and the calibration was verified.

Overall, a total of 182 and 333 hourly values were recorded in the 2005 and 2007 monitoring programs, respectively. The recorded data included the following acoustical indices:

- L_{eq} – Energy averaged equivalent sound level;
- L_{95} – Sound level exceeded 95% of the time;
- L_{90} – Sound level exceeded 90% of the time;
- L_{50} – Sound level exceeded 50% of the time; and
- L_{10} – Sound level exceeded 10% of the time.

0 0.5 1 2
Kilometres

LEGEND

- Noise Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

NOISE MONITORING AND MEASUREMENT LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE 5.5.1-1

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For reference, Table 5.5.1-1 provides a listing of noise levels from common activities for comparing the background and predicted noise levels associated with the DGR Project. The noise levels listed in the table represent average values and could vary from one situation to the next.

Table 5.5.1-1: Summary of Noise Levels Associated with Common Activities

Activity	Noise Level (dBA)
Aircraft landing	>100
Crusher operations at 30 m	85
Car travelling 100 km/h passing 15 m away	80
Normal conversation	60
Background noise level in a typical suburb	50
Whispered speech	30

Source: [39]

5.5.2 Existing Noise Levels (Local and Site Study Areas)

Of the study areas defined, the characterization of the existing noise environment and the assessment of DGR Project noise effects on the existing noise environment are limited to the Local and Site Study Areas. For the purposes of characterizing the baseline against which the assessment is carried out, receptor locations in the Local Study Area are defined as off-site locations (i.e., beyond the Bruce nuclear site property boundary, which defines the Site Study Area) such as residential dwellings, cottages and parks. Establishing the existing noise levels is limited to the identified locations (Figure 5.5.1-1) as they represent the nearest sensitive points of reception in various directions from the property boundary of the Bruce nuclear site. On-site (within the Site Study Area) noise measurements are used to assist in preparing the acoustic model and assist other environmental components (e.g., terrestrial environment) in evaluating the potential effects of the DGR Project as they relate to their VECs. The following receptors, which are carried forward in the noise assessment, are illustrated on Figure 5.5.1-1 and described in Section 5.5.1.

Review of the reference documents noted in Section 5.1.1 [24;25;26;27] provided ambient noise data for two of the three identified points of reception. It was determined that additional field studies were required to further supplement the data at R3 (see Figure 5.5.1-1).

5.5.2.1 Noise Monitoring Results

Table 5.5.2-1 summarizes the results of the off-site noise monitoring program. The table lists the measured minimum and maximum hourly sound level (i.e., L_{eq}), as well as the associated L_{90} measured at each of the off-site monitoring locations (shown on Figure 5.5.1-1). This data indicates that the existing off-site noise levels are reflective of a rural environment (i.e., sound levels are generally less than 50 dBA) and are characterized by sounds of nature (i.e., rustling leaves, waves on the shore of Lake Huron, and birds).

Table 5.5.2-1: Summary of Noise Levels at Off-Site Monitoring Locations

Location	Minimum / Maximum 1-Hour L_{eq} (dBA)	Associated 1-Hour L_{90} (dBA)	Date	Time
R1 – Albert Road	36.3 (min)	35.7	May 6, 2005	23:00 – 00:00
	74.3 (max)	40.2	May 5, 2005	15:00 – 16:00
R2 – Baie du Doré	37.2 (min)	35.7	May 6, 2005	00:00 – 01:00
	76.1 (max)	36.3	May 4, 2005	11:00 – 12:00
R3 – Inverhuron Park	34.6 (min)	34.5	May 22, 2007	03:00 – 04:00
	65.8 (max)	43.3	May 9, 2007	10:00 – 11:00

Table 5.5.2-2 summarizes the minimum and maximum hourly L_{eq} sound levels recorded within the MOE defined periods of day (Daytime, Evening and Night-time) at R1 [40]. As noted, the sound environment at R1 (Albert Road) is dominated by sounds of nature. Activities from the Bruce nuclear site were not audible during the daytime and night-time site visits.

Table 5.5.2-2: Detailed Summary of Sound Levels Recorded at R1 in 2005

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 4	Wednesday	Daytime	41	51
May 5	Thursday	Daytime	44	74
May 6	Friday	Daytime	41	57
May 7	Saturday	Daytime	42	51
May 8	Sunday	Daytime	38	57
May 9	Monday	Daytime	42	54
May 10	Tuesday	Daytime	44	49
May 11	Wednesday	Daytime	44	56
May 4	Wednesday	Evening	37	47
May 5	Thursday	Evening	38	45
May 6	Friday	Evening	36	43
May 7	Saturday	Evening	39	45
May 8	Sunday	Evening	38	51
May 9	Monday	Evening	37	43
May 10	Tuesday	Evening	39	42
May 11	Wednesday	Evening	40	58
May 4 - 5	Wednesday/Thursday	Night-time	37	48
May 5 - 6	Thursday/Friday	Night-time	37	54

Table 5.5.2-2: Detailed Summary of Sound Levels Recorded at R1 in 2005 (continued)

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 6 - 7	Friday/Saturday	Night-time	36	56
May 7 - 8	Saturday/Sunday	Night-time	38	47
May 8 - 9	Sunday/Monday	Night-time	36	46
May 9 - 10	Monday/Tuesday	Night-time	41	47
May 10 - 11	Tuesday/Wednesday	Night-time	39	49

Note:
a MOE defines the daytime as being from 07:00-19:00, evening from 19:00-23:00; and night-time from 23:00-07:00.
Source: [25]

The sound levels measured at this location in 2007 ranged from a low L_{eq} of 36 dBA to a high of 74 dBA. The maximum L_{eq} sound level was likely recorded during a localized event, or series of events, near the noise monitor as weather conditions during the monitoring period were calm and with no precipitation. Based on measurements recorded during this monitoring period, it is determined that the minimum existing hourly L_{eq} used for determining magnitude at this location would be 36 dBA.

Typically, the single hour L_{eq} sound levels increased during the daytime hours and decreased during the evening and night-time periods. These sound levels ranged between 40 and 50 dBA approximately 65% of the time. In addition, the associated L_{90} sound levels ranged between 30 and 40 dBA 84% of the time. These results confirm the rural nature of the point of reception. Furthermore, the L_{90} is likely more representative of the existing noise of the Bruce nuclear site, and local traffic along Albert Road and Concession 2 at this point of reception location (i.e., the L_{90} is less affected by transient noise events than the L_{eq}).

Table 5.5.2-3 summarizes the minimum and maximum hourly L_{eq} sound levels recorded within the MOE defined periods of day (Daytime, Evening and Night-time) at R2. As noted, off-site monitoring Location Two (R2) is located across Baie du Doré from Bruce A. Bruce A was barely audible during field monitoring at this location and was not the dominant noise source. The dominant noise sources at this location were breaking waves from the lake, other sounds of nature and traffic noise along Concession 6 and Tie Road. Sound levels measured at this location ranged from a low L_{eq} of 37 dBA to a high of 76 dBA. Similar to R1, the maximum L_{eq} sound level was likely recorded during a localized event, or series of events occurring within the same hour, near the noise monitor as weather conditions during the monitoring period were calm and with no precipitation. Based on measurements recorded during this monitoring period, it is determined that the minimum existing hourly L_{eq} used for determining magnitude at this location would be 37 dBA.

Table 5.5.2-3: Detailed Summary of Sound Levels Recorded at R2 in 2005

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 4	Wednesday	Daytime	37	76
May 5	Thursday	Daytime	41	47

Table 5.5.2-3: Detailed Summary of Sound Levels Recorded at R2 in 2005 (continued)

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 6	Friday	Daytime	38	46
May 7	Saturday	Daytime	39	49
May 8	Sunday	Daytime	39	50
May 9	Monday	Daytime	40	64
May 10	Tuesday	Daytime	40	56
May 11	Wednesday	Daytime	38	43
May 4	Wednesday	Evening	41	64
May 5	Thursday	Evening	39	50
May 6	Friday	Evening	38	45
May 7	Saturday	Evening	49	51
May 8	Sunday	Evening	46	56
May 9	Monday	Evening	42	46
May 10	Tuesday	Evening	47	59
May 11	Wednesday	Evening	46	48
May 4 - 5	Wednesday/Thursday	Night-time	39	55
May 5 - 6	Thursday/Friday	Night-time	37	58
May 6 - 7	Friday/Saturday	Night-time	37	50
May 7 - 8	Saturday/Sunday	Night-time	41	60
May 8 - 9	Sunday/Monday	Night-time	41	57
May 9 - 10	Monday/Tuesday	Night-time	40	51
May 10 - 11	Tuesday/Wednesday	Night-time	38	50

Note:
a MOE defines the daytime as being from 07:00-19:00, evening from 19:00-23:00; and night-time from 23:00-07:00.
Source: [25]

The one hour L_{eq} sound levels at this location (R2) increased during the daytime hours and decreased during the evening and night-time periods; however, the pattern was less apparent when compared with R1. These sound levels ranged between 40 and 50 dBA approximately 69% of the time. In addition, the associated L_{90} sound levels ranged between 30 and 40 dBA 72% of the time. These results confirm the rural nature of this point of reception. Furthermore, the L_{90} is likely more representative of the noise of the existing Bruce nuclear site, and more specifically Bruce A operations, at this point of reception location (i.e., the L_{90} is less affected by transient noise events than the L_{eq}).

Table 5.5.2-4 summarizes the minimum and maximum hourly L_{eq} sound levels recorded within the MOE defined periods of day (Daytime, Evening and Night-time) at R3. As noted, off-site monitoring Location Three (R3) is located within Inverhuron Provincial Park, at an existing campsite closest to the Bruce B station. During the field studies, noise from operations at the Bruce nuclear site was barely audible, and was not the dominant noise source at the monitoring location. The dominant noise sources were sounds of nature and noise from breaking waves off of the lake. Sound levels measured at this location ranged from a low L_{eq} of 35 dBA to a high of 66 dBA. Similar to R1 and R2, the maximum L_{eq} sound level was likely recorded during a localized event, or series of events occurring within the same hour, near the noise monitor as weather conditions during the monitoring period did not include precipitation and high winds. Based on measurements recorded during this monitoring period, it is determined that the minimum existing hourly L_{eq} used for determining magnitude at this location would be 35 dBA.

Table 5.5.2-4: Detailed Summary of Sound Levels Recorded at R3 in 2007

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 13	Sunday	Day	38	56
May 14	Monday	Day	42	54
May 15	Tuesday	Day	53	64
May 16	Wednesday	Day	54	57
May 17	Thursday	Day	46	54
May 18	Friday	Day	41	47
May 19	Saturday	Day	44	49
May 20	Sunday	Day	52	58
May 21	Monday	Day	40	52
May 22	Tuesday	Day	37	38
May 8	Tuesday	Evening	42	45
May 9	Wednesday	Evening	44	48
May 10	Thursday	Evening	37	39
May 11	Friday	Evening	49	50
May 12	Saturday	Evening	50	52
May 13	Sunday	Evening	35	37
May 14	Monday	Evening	52	60
May 15	Tuesday	Evening	46	61
May 16	Wednesday	Evening	54	56
May 17	Thursday	Evening	53	55
May 18	Friday	Evening	36	40
May 19	Saturday	Evening	42	43
May 20	Sunday	Evening	55	56
May 21	Monday	Evening	36	52
May 8 - 9	Tuesday/Wednesday	Night-time	38	55

Table 5.5.2-4: Detailed Summary of Sound Levels Recorded at R3 in 2007 (continued)

Date	Day	Time of Day [a]	Minimum L_{eq} (dBA)	Maximum L_{eq} (dBA)
May 9 - 10	Wednesday/Thursday	Night-time	38	48
May 10 - 11	Thursday/Friday	Night-time	36	48
May 11 - 12	Friday/Saturday	Night-time	46	49
May 12 - 13	Saturday/Sunday	Night-time	47	50
May 13 - 14	Sunday/Monday	Night-time	35	38
May 14 - 15	Monday/Tuesday	Night-time	54	60
May 15 - 16	Tuesday/Wednesday	Night-time	55	61
May 16 - 17	Wednesday/Thursday	Night-time	49	55
May 17 - 18	Thursday/Friday	Night-time	49	54
May 18 - 19	Friday/Saturday	Night-time	36	49
May 19 - 20	Saturday/Sunday	Night-time	42	52
May 20 - 21	Sunday/Monday	Night-time	53	55
May 21 - 22	Monday/Tuesday	Night-time	35	43

Note:

a MOE defines the daytime as being from 07:00-19:00, evening from 19:00-23:00; and night-time from 23:00-07:00.

The one hour L_{eq} sound levels at this location typically were at a minimum during the night-time periods and increased during the daytime periods, but a distinct pattern as observed at both R1 or R2 was less evident. These sound levels ranged between 30 and 50 dBA approximately 61% of the time. In addition, the associated L_{90} sound levels ranged between 30 and 50 dBA approximately 70% of the time. Upon removing the extraneous data (e.g., data acquired during periods of high wind gusts), the L_{eq} sound levels ranged between 30 and 50 dBA approximately 73% of the time. In addition, the associated L_{90} sound levels ranged between 30 and 50 dBA approximately 79% of the time. These results confirm the rural nature of this point of reception. Furthermore, the L_{90} is likely more representative of the existing noise of the Bruce nuclear site, and more specifically Bruce B operations, at this point of reception location.

When assessing the potential for adverse effects of the DGR Project on noise levels, the quietest existing hourly noise level for each of the three monitoring locations is used, because changes are most noticeable during the quietest hour of any day. Table 5.5.2-5 summarizes the minimum hourly noise levels for each of the three off-site noise receptors considered in the assessment.

Table 5.5.2-5: Existing Noise Levels at Off-Site Noise Monitoring Locations

Location	Minimum 1-Hour L_{eq} (dBA)	Date	Time
R1 – Albert Road	36	May 6, 2005	23:00 – 00:00
R2 – Baie du Doré	37	May 6, 2005	00:00 – 01:00
R3 – Inverhuron Park	35	May 22, 2007	03:00 – 04:00

5.6 SUMMARY OF EXISTING ENVIRONMENT

Table 5.6-1 provides a summary of the existing atmospheric environment by VEC.

Table 5.6-1: Summary of Existing Atmospheric Environment

VEC	Existing Environment
Air Quality	• Monitoring data are used to describe the existing air quality in the Regional Study Area and indicated that air quality across the region does not vary dramatically from one station to the next. Although air quality at the regional stations occasionally exceed the relevant Ontario criteria, these situations are not common. • Monitoring data from the regional stations were also used to describe the background air quality in the Local Study Area. Background air quality was conservatively calculated as the 90^{th}-percentile concentration from the nearest station with data. Overall, the background air quality complies with the relevant criteria. • Modelling was used to describe the air quality resulting from emissions from existing sources at the Bruce nuclear site. Existing air quality in the Local Study Area was calculated by adding the background air quality monitored at regional stations to the maximum modelled concentrations for the existing sources at the Bruce nuclear site. The existing air quality in the Local Study Area complies with relevant criteria.
Noise Levels	• Monitoring data are used to fully describe the existing noise levels in the Local Study Area. The monitoring results indicate that the noise levels in the Local Study Area are consistent with typical rural environments. Noise from the operations at the Bruce nuclear site was audible at receptors R2 and R3.

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6. INITIAL SCREENING OF PROJECT-ENVIRONMENT INTERACTIONS

The first screening considers whether there is a potential for the DGR Project to interact with the atmospheric environment VECs.

6.1 INITIAL SCREENING METHODS

Following the description of the DGR Project, identification of VECs, and description of the existing environment, the project works and activities are screened to determine those with the potential to interact with the atmospheric environment VECs. The screening is conducted based on the general description of the existing environmental conditions. This allows the EA to focus on issues of key importance, where the potential interactions between the DGR Project and the atmospheric environment are likely. The analyses are based on the experience of the technical specialists supported by information collected from field studies and information from earlier EAs carried out for projects at the Bruce nuclear site. The screening is conducted by VEC for site preparation and construction, operations, and decommissioning phases of the DGR Project.

Atmospheric environment VECs interact with the DGR Project directly (e.g., emission of indicator compounds) and indirectly (e.g., changes in a VEC that could result in changes in air quality). While both direct and indirect interactions are carried forward through this assessment, no indirect effects on the atmospheric environment VECs were identified. Where a mechanism for interaction is identified, the individual project work or activity is advanced for further consideration of measurable changes. Where no potential interaction is identified, no further screening or assessment is conducted. The analyses at this stage are based on qualitative data, as well as the professional judgement and experience of the EA team with regard to the physical and operational features of the project and their potential interactions with the environment.

The results of the screening are documented in an interaction matrix. A potential project-VEC interaction is marked with a '•' on Matrix 1 (Section 6.3).

If, following the evaluation of project-environment interactions, there are no potential interactions between a VEC and a project work and activity or other VEC, the VEC may not be considered further.

6.2 IDENTIFICATION OF DGR PROJECT-ENVIRONMENT INTERACTIONS

In the initial screening, all works and activities associated with the DGR Project are identified and analyzed for possible interactions with the atmospheric environment VECs. As shown in the Basis for the EA (Appendix B), the DGR Project includes the following project works and activities:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;

- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- presence of the DGR Project;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

The abandonment of the DGR facility work and activity is considered in this TSD as being at the end of the decommissioning phase. The abandonment and long-term performance phase is not considered in the assessment as no activities are expected to occur during this phase. It is considered in Section 9 of the EIS.

This TSD considers normal operations and non-radiological effects only. Abnormal conditions are considered in the Malfunctions, Accidents and Malevolent Acts TSD. Radiological effects are considered in the Radiation and Radioactivity TSD. In the following sections, each work and activity is evaluated for potential direct and indirect interactions with the VECs.

6.2.1 Direct Interactions

6.2.1.1 Site Preparation

Site preparation will involve the preparation of the ground and site infrastructure for construction. Site preparation would begin after receipt of a Site Preparation Licence and would include clearing approximately 30 ha of the site and preparing the construction laydown areas. Infrastructure, such as stormwater management and road upgrades, would also be constructed during this phase. The expected site preparation activities will include earth-moving activities and conventional construction activities.

Prior to undertaking the planned construction works, a number of activities have a potential to interact with air quality and noise levels as part of site preparation. These activities include:

- land clearance, grubbing and preparation of laydown areas;
- stormwater management system construction; and
- road network construction.

These activities may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, site preparation is advanced to the second screening step presented in Section 7.

6.2.1.2 Construction of Surface Facilities

Construction of surface facilities will include waste transfer, material handling, shaft headframes and the construction of all other temporary and permanent surface facilities at the site. Construction would start after receipt of the construction licence. All of the surface structures for the DGR Project will be constructed during the initial site preparation and construction phase. Surface structures will include:

- temporary structures; and

- permanent surface structures, including the main shaft area, ventilation shaft area, crossing over the abandoned rail bed and site support facilities.

The construction activities associated with building the surface structures may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, construction of surface facilities is advanced to the second screening step presented in Section 7.

6.2.1.3 Excavation and Construction of Underground Facilities

Excavation and construction of underground facilities will include excavation of the shafts to the repository, underground access ways, emplacement rooms and support rooms, and installation of underground infrastructure. Underground construction would start following construction of the surface facilities.

The construction activities associated with shaft excavation and underground facilities may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, excavation and construction of underground facilities is advanced to the second screening step presented in Section 7.

6.2.1.4 Above-ground Transfer of Waste

Above-ground transfer of waste will occur during the operations phase of the DGR Project and will include receipt of L&ILW at the DGR Project Waste Package Receiving Building (WPRB) and on-site transfer to the shaft.

These activities may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, above-ground transfer of wastes is advanced to the second screening step presented in Section 7.

6.2.1.5 Underground Transfer of Waste

Underground transfer of waste will take place during the operations phase of the DGR Project and will include receipt at base of shaft, transfer from the shaft to underground waste transport vehicle and placement into the final emplacement rooms. Once an emplacement room has been completely filled it may be sealed off to the rest of the repository. Underground transfer of wastes will commence following the completion of all infrastructure and commencement of transfer of wastes from the WWMF. Emplacement activities will be followed by a period of monitoring to assess whether the DGR Project is performing as expected prior to decommissioning.

These activities may cause increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, underground transfer of wastes is advanced to the second screening step presented in Section 7.

6.2.1.6 Decommissioning of the DGR Project

Decommissioning of the DGR Project will include all activities required to close the repository and will occur during the decommissioning phase. This phase includes dismantling the equipment and decontaminating and demolishing the surface facilities, and sealing the repository and shafts.

These activities may cause temporary increases in emissions of combustion products, dust and noise into the atmosphere, which could affect the air quality and noise levels. Accordingly, decommissioning of the DGR Project is advanced to the second screening step presented in Section 7.

6.2.1.7 Abandonment of DGR Facility

Activities may include removal of access controls. Timing of abandonment of the DGR facility will be based on discussion with the regulator. These activities are likely to be minor in nature and are not expected to interact with air quality and noise levels. Therefore, no further consideration is warranted.

6.2.1.8 Presence of the DGR Project

Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security. Therefore, there is no potential interaction with either air quality and noise levels, and thus does not warrant further consideration in this TSD.

6.2.1.9 Waste Management

Waste management represents all activities required to manage waste during all three phases of the DGR Project. During construction, waste management will include managing the waste rock along with conventional waste management. During operations, waste management would include the management of conventional and radiological wastes from the underground and above-ground operations. Decommissioning waste management may include management of conventional and construction wastes.

Material handling of waste rock during construction and decommissioning, as well as transportation-related effects from the waste management activities potentially interacts with air quality and noise levels through tailpipe and fugitive dust emissions, and through noise from vehicles and work activities. Accordingly, these interactions are advanced to the second screening step presented in Section 7.

6.2.1.10 Support and Monitoring of DGR Life Cycle

Support and monitoring of the DGR life cycle will include all activities to support the safe construction, operation and decommissioning of the DGR Project. This activity includes site water management (groundwater, surface water and shaft dewatering), ventilation, and support services. Support services include the compressed air supply, electrical and lighting, operation of the emergency diesel generator, electric heating supply, security systems, air and water quality monitoring, and emergency response. These activities will be ongoing throughout all phases of the DGR Project.

Equipment such as air compressors, electrical power systems, and ventilation systems may have combustion and/or noise emissions. Accordingly, support and monitoring of the DGR life cycle potentially interact with air quality and noise levels, and are advanced to the second screening step presented in Section 7.

6.2.1.11 Workers, Payroll and Purchasing

Workers, payroll and purchasing will include all workers required during each phase to implement the DGR Project. Worker vehicles are also considered in this activity. These vehicles will produce tailpipe, road dust and noise emissions. Accordingly, the workers, payroll and purchasing potentially interact with air quality and noise levels, and are advanced to the second screening step provided in Section 7.

6.2.2 Indirect Interactions

No potential indirect effects on the air quality and noise level VECs were identified.

6.3 SUMMARY OF FIRST SCREENING

Table 6.3-1 provides a summary of the initial screening for the DGR Project. Small dots (•) on this matrix represent potential DGR Project-environment interactions involving air quality and noise levels. These interactions are advanced to Section 7 for a second screening to determine those interactions that may result in a measurable change to the atmospheric environment.

Table 6.3-1: Matrix 1 – Summary of the First Screening for Potential Interactions with VECs

Project Work and Activity	Air Quality			Noise Levels		
	C	O	D	C	O	D
Direct Interactions						
Site Preparation	•	—	—	•	—	—
Construction of Surface Facilities	•	—	—	•	—	—
Excavation and Construction of Underground Facilities	•	—	—	•	—	—
Above-ground Transfer of Waste	—	•	—	—	•	—
Underground Transfer of Waste	—	•	—	—	•	—
Decommissioning of the DGR Project	—	—	•	—	—	•
Abandonment of the DGR Facility	—	—		—	—	
Presence of the DGR Project						
Waste Management	•	•	•	•	•	•
Support and Monitoring of DGR Life Cycle	•	•	•	•	•	•

Table 6.3-1: Matrix 1 – Summary of the First Screening for Potential Interactions with VECs in the Atmospheric Environment (continued)

Project Work and Activity	Air Quality			Noise Levels		
	C	O	D	C	O	D
Workers, Payroll and Purchasing	•	•	•	•	•	•
Indirect Interactions						
Changes in Air Quality	—	—	—			
Changes in Noise Levels				—	—	—
Changes in Surface Water Quantity and Flow						
Changes in Surface Water Quality						
Changes in Soil Quality						
Changes in Groundwater Quality						
Changes in Groundwater Flow						

Notes:
C = Site Preparation and Construction Phase
O = Operations Phase
D = Decommissioning Phase
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 11.
The abandonment and long-term performance phase is not included in the matrix as no activities occur during this phase. The abandonment of the DGR facility work and activity occurs immediately following decommissioning within the decommissioning phase and does not encompass the entirety of the abandonment and long-term performance phase.

• Potential project-environment interaction
— Activity does not occur during this phase
Blank No potential interaction

Following the screening of potential DGR Project-environment interactions, all VECs identified had a potential interaction with the DGR Project. Therefore, as summarized in Table 6.3-2, all of the VECs proposed in Table 4-1 are carried forward for further assessment.

Table 6.3-2: Advancement of Atmospheric Environment VECs

VEC	Retained?	Rationale
Air Quality	Yes	There are several potential direct interactions
Noise Levels	Yes	There are several potential direct interactions

7. SECOND SCREENING FOR MEASURABLE CHANGES

The second screening considers the DGR Project works and activities advanced from Section 6 to determine if the identified interactions are likely to cause a measurable change to the atmospheric environment VECs.

7.1 SECOND SCREENING METHODS

Each of the identified potential interactions identified in the first screening is evaluated to determine those likely to result in a measurable change in the environment. For the purposes of the assessment, a measurable change in the environment is defined as a change that is real, observable or detectable compared with existing conditions.

To determine likely direct measurable changes, all of the DGR Project works and activities found to have potential interactions with the atmospheric environment VECs are further screened by calculating and reviewing associated air and noise emissions. For air quality and noise levels, a measurable change is considered to occur where there are likely air and noise emissions as a result of the DGR Project works and activities (i.e., if there is an emission, regardless of magnitude it is carried forward). These DGR Project-related emissions are advanced for assessment in Section 8.

A predicted change that is trivial, negligible or indistinguishable from background conditions will not be considered measurable. A measurable change on a VEC is marked with a '■' on Matrix 2 (Section 7.3).

7.2 DIRECT CHANGES

All project works and activities for all phases of the DGR Project were found to have potential interactions with air quality and noise levels, with the exception of the abandonment of the DGR facility and presence of the DGR Project. Each work and activity is screened in the following paragraphs, first for likely measurable changes to the air quality VEC, and then for likely changes to the noise levels VEC.

7.2.1 Site Preparation

7.2.1.1 Air Quality

Table 7.2.1-1 lists the emissions of the air quality indicator compounds associated with the various activities that will occur during site preparation. The site preparation activities include three distinct components of work, each with corresponding equipment and activities that have been identified in the Basis for the EA (see Appendix B). Although these components may not all occur at the same time, the table illustrates that there are likely to be air emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change air quality and are advanced for assessment in Section 8. The equipment and processes used to model the emissions and the emissions calculations are presented in Appendix F.

Table 7.2.1-1: Air Emissions Associated with Site Preparation

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b]		
	Land Clearance, Grubbing and Preparation of Laydown Areas	Stormwater Management System Construction	Road Network Construction
NO_X	40.72	28.82	31.12
SO_2	0.08	0.06	0.06
CO	25.13	17.84	20.90
SPM	59.50	44.70	44.36
PM_{10}	12.44	9.31	9.35
$PM_{2.5}$	7.50	5.57	5.75

Notes:

a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour. The emissions were calculated by multiplying the number of pieces of equipment identified in Project Description by the level of activity associated with the equipment. The resulting number was then multiplied by emissions factors, as described in Appendix F.

7.2.1.2 Noise Levels

Table 7.2.1-2 provides a summary of the overall sound power data for each noise source considered in the assessment for site preparation. The site preparation activities include three distinct components: land clearance, grubbing and preparation of laydown areas; stormwater management system construction; and road network construction. Each component and its associated equipment and activities are identified in the Basis for EA (see Appendix B). Although these components may not all occur at the same time, the table illustrates that there are likely to be noise emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change noise levels and are advanced for assessment in Section 8.

Table 7.2.1-2: Noise Emissions Associated with Site Preparation

Source	Number of Sources			Overall Sound Power (dBA) [a,b]
	Land Clearance, Grubbing and Preparation of Laydown Areas	Stormwater Management System Construction	Road Network Construction	
Articulated Trucks (Cat 730)	2	2	0	109
Bulldozer (Cat D9T WH)	1	1	1	115
Compactors (Cat CS-683)	0	0	1	109
Excavator (Cat 340D)	1	1	0	102

Table 7.2.1-2: Noise Emissions Associated with Site Preparation (continued)

Source	Number of Sources			Overall Sound Power (dBA) [a,b]
	Land Clearance, Grubbing and Preparation of Laydown Areas	Stormwater Management System Construction	Road Network Construction	
Feller Buncher (Cat 522)	1	0	0	114
Front End Loader (Cat 988H)	1	1	1	115
Motor Grader (CAT 140)	1	0	1	116
Pavers (Cat BG-240C)	0	0	1	106

Notes:

a Overall sound power source references provided in Appendix G.

b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour.

Equipment models are provided for modelling purposes only and may not be exactly what is used.

7.2.2 Construction of Surface Facilities

7.2.2.1 Air Quality

All of the surface structures for the DGR Project will be constructed during the initial site preparation and construction phase. While specific equipment associated with the construction of surface facilities work and activity was not identified explicitly in the project description, the equipment is included in the overall construction fleet used to calculate emissions. These activities are expected to result in measurable emissions; therefore, this work and activity has been advanced for assessment in Section 8.

7.2.2.2 Noise Levels

All of the surface structures for the DGR Project will be constructed during the initial site preparation and construction phase. While specific equipment associated with the construction of surface facilities work and activity was not identified explicitly in the project description, the equipment is included in the overall construction fleet used to calculate emissions. These activities are expected to result in measurable emissions; therefore, this work and activity has been advanced for assessment in Section 8.

7.2.3 Excavation and Construction of Underground Facilities

7.2.3.1 Air Quality

The repository access will be through two shafts, the main shaft and the ventilation shaft. Shaft construction is assumed to begin in the second year of construction. The main shaft and ventilation shaft will be excavated simultaneously using drill and blast methods and will provide access to the repository and a means of ventilating the repository during the operations phase.

Table 7.2.3-1 lists the emissions of the air quality indicator compounds associated with the various activities, including blasting, that will occur during the excavation and construction of underground facilities work and activity. There are three distinct activities associated with the excavation and construction of underground facilities work and activity. Although these activities may not all occur at the same time, the table illustrates that there are likely to be air emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change air quality and are advanced for assessment in Section 8.

Table 7.2.3-1: Air Emissions Associated with Excavation and Construction of Underground Facilities

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b]		
	Excavation of Shafts	Construction of Emplacement Rooms	Installation of Underground Infrastructure
NO_X	117.05	209.98	20.78
SO_2	0.23	0.42	0.04
CO	79.90	138.20	17.20
SPM	56.26	79.69	1.13
PM_{10}	17.00	24.78	1.13
$PM_{2.5}$	12.56	17.71	1.13

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour. The emissions were calculated by multiplying the number of pieces of equipment identified in Project Description by the level of activity associated with the equipment. The resulting number was then multiplied by emissions factors, as described in Appendix F.

7.2.3.2 Noise Levels

Table 7.2.3-2 provides a summary of the overall sound power data for each continuous noise source considered in the assessment for the excavation and construction of the underground facilities work and activity. There are three distinct activities associated with the excavation and construction of the underground facilities work and activity. Although many of these pieces of equipment may be below grade during much of the phase, the assessment has conservatively assessed that they will be at or near the surface during the early stages of construction.

It is noted that blasting noise is not continuous and is different in character when compared to construction and/or operations noise. Including blasting noise with these predictions would not be appropriate. Noise from blasting would not likely measurably change the 1 hour L_{eq} (the indicator for noise levels). Blasting is further discussed in Appendix I.

Although these activities may not all occur at the same time, the table illustrates that there are likely to be noise emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change noise levels and are advanced for assessment in Section 8.

Table 7.2.3-2: Noise Emissions Associated with Excavation and Construction of Underground Facilities

Source	Number of Sources			Overall Sound Power (dBA) [a,b]
	Excavation of Shafts	Construction of Emplacement Rooms	Installation of Underground Infrastructure	
Articulated Trucks (Cat 730)	2	3	0	109
Batch Plant [c]	1	1	0	116
Bulldozer (Cat D9T WH)	1	1	0	115
Concrete Truck	4	4	4	104
Explosives Carrier/Loader	2	2	0	115
Front End Loader (Cat 988H)	1	1	0	115
Jumbo Atlas Copco Boomer E3 C	2	2	0	119
Loader (Cat 988H) - Batch Plant	1	1	0	115
Motor Grader	0	1	0	116
Shotcrete Transmixer	2	2	2	108
Sprayer	2	2	0	107
Hoist House [d]	2	1	0	92
Headframe [d]	2	2	0	92

Notes:
a Overall sound power source references provided in Appendix G.
b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour.
c Modelled as individual sources but summarized here as a single source.
d Source of noises may include machinery, cables, etc.
Equipment models are provided for modelling purposes only and may not be exactly what is used.
Blasting noise is not included here as it is not continuous and is different in character when compared to construction and/or operations noise. See Appendix I for additional information on blasting.

7.2.4 Above-ground Transfer of Waste

7.2.4.1 Air Quality

Table 7.2.4-1 lists the emissions of the air quality indicator compounds associated with the various activities that will occur during the above-ground transfer of waste work and activity. The table illustrates that there are likely to be air emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change air quality and are advanced for assessment in Section 8.

Table 7.2.4-1: Air Emissions Associated with Above-ground Transfer of Waste

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b, c]	
	Transport from WWMF to DGR Project	Receipt of Wastes at DGR Project Surface Facilities
NO_X	5.59	3.28
SO_2	0.01	0.01
CO	3.46	2.32
SPM	0.20	0.17
PM_{10}	0.20	0.17
$PM_{2.5}$	0.20	0.17

Notes:

a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely all of the equipment will be operating concurrently over an hour. The emissions were calculated by multiplying the number of pieces of equipment identified in Project Description by the level of activity associated with the equipment. The resulting number was then multiplied by emissions factors, as described in Appendix F.

c As described in the EIS Guidelines the scope of the project includes the transfer of L&ILW from the WWMF and emplacement in the DGR. Shielding and reprocessing activities have not been included as they are captured under the existing operating licence for the WWMF.

7.2.4.2 Noise Levels

Table 7.2.4-2 provides a summary of the overall sound power data for each noise source considered in the assessment for the above-ground transfer of waste work and activity. The table illustrates that there are likely to be noise emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change noise levels and are advanced for assessment in Section 8.

Table 7.2.4-2: Noise Emissions Associated with the Above-ground Transfer of Waste

Source	Number of Above-ground Transfer of Waste Sources	Overall Sound Power (dBA) [a,b]
Diesel Generator (3,500 kW) Back up	1	118
Flat-bed transporters/tracks	1	105
Forklifts Large	1	99
Forklifts Small	1	99

Notes:

a Overall sound power source references provided in Appendix G.

b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour.

7.2.5 Underground Transfer of Waste

7.2.5.1 Air Quality

Table 7.2.5-1 lists the emissions of the air quality indicator compounds associated with the various activities that will occur during the underground transfer of waste work and activity. The table illustrates that there are likely to be air emissions as a result of this work and activity. These DGR Project-related emissions are likely to measurably change air quality and are advanced for assessment in Section 8.

Table 7.2.5-1: Air Emissions Associated with Underground Transfer of Waste

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b]		
	Receipt of Wastes at DGR Project Underground Facilities	Emplacement of Waste in DGR Project	Closure of Emplacement Rooms
NO_X	0.00	5.92	0.00
SO_2	0.00	0.01	0.00
CO	0.00	4.31	0.00
SPM	0.00	0.33	0.00
PM_{10}	0.00	0.33	0.00
$PM_{2.5}$	0.00	0.33	0.00

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour. The emissions were calculated by multiplying the number of pieces of equipment identified in the Project Description by the level of activity associated with the equipment. The resulting number was then multiplied by emissions factors, as described in Appendix F.

7.2.5.2 Noise Levels

Table 7.2.5-2 provides a summary of the overall sound power data for each noise source considered in the assessment for the underground transfer of waste work and activity. The table illustrates that there are likely to be noise emissions as a result of this work and activity. These DGR Project-related emissions are not likely to measurably change noise levels as the sources are located underground. Therefore, they are not advanced for assessment.

Table 7.2.5-2: Noise Emissions Associated with the Underground Transfer of Waste

Source	Number of Underground Transfer of Waste Sources	Overall Sound Power (dBA) [a]
Forklifts Large	1	99
Forklifts Small	1	99
Hoist House [b]	1	92

Table 7.2.5-2: Noise Emissions Associated with the Underground Transfer of Waste (continued)

Source	Number of Underground Transfer of Waste Sources	Overall Sound Power (dBA) [a]
Headframe [b]	1	92

Notes:
a Overall sound power source references provided in Appendix G.
b Source of noises may include machinery, cables, etc.

7.2.6 Decommissioning of the DGR Project

7.2.6.1 Air Quality

Combustion emissions and fugitive dust associated with decommissioning of the DGR Project are expected to be measurable; however, the air quality during the decommissioning phase is likely to be bounded by the measurable changes identified by the site preparation and construction phase. Accordingly, the DGR Project-related air emissions are likely to result in measurable changes to air quality and are advanced to Section 8 for assessment.

7.2.6.2 Noise Levels

Noise emissions associated with decommissioning of the DGR Project are expected to be measurable; however, the noise emissions during the decommissioning phase are likely to be bounded by the measurable changes identified in the site preparation and construction phase. Accordingly, the DGR Project-related noise emissions are likely to result in measurable changes to noise levels, and are advanced to Section 8 for assessment.

7.2.7 Waste Management

7.2.7.1 Air Quality

The tailpipe emissions associated with waste management are expected to be measurable during all phases of the DGR Project; however, the air emissions during the decommissioning phase are likely to be bounded by the measurable changes identified by the site preparation and construction phase. Table 7.2.7-1 sets out a listing of the air and emission sources associated with this work and activity. Accordingly, the DGR Project-related air emissions are likely to result in measurable changes to air quality and are advanced to Section 8 for assessment.

Table 7.2.7-1: Activities Associated with Waste Management

Component	Air Emissions
Conventional Waste Management	Road dust attributed to the on-site transport of waste and vehicle tailpipe emissions
Radiological Waste Management	Road dust attributed to the on-site transport of waste and vehicle tailpipe emissions
Waste Rock Management	Movement and handling of waste rock

7.2.7.2 Noise Levels

The noise emissions associated with waste management are expected to be measurable during all phases of the DGR Project; however, the noise emissions during the decommissioning phase are likely to be bounded by the measurable changes identified by the site preparation and construction phase. Table 7.2.7-2 sets out a listing of the noise emission sources associated with this work and activity. Accordingly, the DGR Project-related noise emissions are likely to result in measurable changes to noise levels, and are advanced to Section 8 for assessment.

Table 7.2.7-2: Activities Associated with Waste Management

Component	Noise Emissions
Conventional Waste Management	Noise levels attributed to the on-site transport of waste
Radiological Waste Management	Noise levels attributed to the on-site transport of waste
Waste Rock Management	Movement and handling of waste rock

7.2.8 Support and Monitoring of DGR Life Cycle

Support and monitoring of the DGR life cycle will include all activities to support the safe construction, operation and decommissioning of the DGR Project. This activity includes site water management (groundwater, surface water and shaft dewatering), ventilation, and support services. Support services include the compressed air supply, electrical and lighting, operation of the emergency diesel generator, electric heating supply, security systems, air and water quality monitoring, and emergency response. These activities will be ongoing throughout all phases of the DGR Project.

7.2.8.1 Air Quality

Table 7.2.8-1 lists the emissions of the air quality indicator compounds associated with the support and monitoring of DGR life cycle work and activity. Specifically, an emergency diesel generator is attributed to this work and activity and will be operated during the site preparation and construction, and operations phases of the DGR Project. These DGR Project-related emissions are likely to measurably change air quality and are advanced for assessment in Section 8.

Table 7.2.8-1: Air Emissions Associated with Support and Monitoring of DGR Life Cycle

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b]		
	Site Support Services	Ventilation	Water Management
NO_X	19.71	0.00	0.00
SO_2	0.02	0.00	0.00
CO	12.20	0.00	0.00
SPM	0.70	0.00	0.00
PM_{10}	0.70	0.00	0.00

Table 7.2.8-1: Air Emissions Associated with Support and Monitoring of DGR Life Cycle (continued)

Indicator Compounds [a]	Daily Emissions (kg/d) for Components [b]		
	Site Support Services	Ventilation	Water Management
$PM_{2.5}$	0.70	0.00	0.00

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b The numbers in the above table represent the emissions associated with all of the equipment identified in the Project Description (Section 4 of the EIS). It is unlikely that all of the equipment will be operating concurrently over an hour. The emissions were calculated by multiplying the number of pieces of equipment identified in Project Description by the level of activity associated with the equipment. The resulting number was then multiplied by emissions factors, as described in Appendix F.

7.2.8.2 Noise Levels

Table 7.2.8-2 provides a summary of the overall sound power data for each noise source considered in the assessment for the support and monitoring of DGR life cycle work and activity. These DGR Project-related noise emissions are likely to measurably change noise levels and are advanced for assessment in Section 8.

Table 7.2.8-2: Noise Emissions Associated with Support and Monitoring of DGR Life Cycle

Source	Number of Sources				Overall Sound Power (dBA) [a]
	Site Support Services	Ventilation (Fresh Air Raise)	Water Management	Monitoring Programs	
Intake Fans	0	1	0	0	125
Exhaust Fan (93 kW Each)	0	2	0	0	117
Air Compressor Plant (louvers), 2 X 186 kW	1	0	0	0	116
Electrical Sub-Station (10 000 kVA)	1	0	0	0	91
Diesel Generator (3,500 kW) Back up	1	0	0	0	118

Notes:
a Overall sound power source references provided in Appendix G.

7.2.9 Workers, Payroll and Purchasing

7.2.9.1 Air Quality

All phases of the DGR Project will require an increased workforce. The traffic bringing the workers to-and-from the site is expected to be measurable, as shown in Table 7.2.9-1. These vehicles will produce measurable amounts of tailpipe emissions, as well as emissions of road dust. Accordingly, a likely measurable change to air quality is identified as a result of workers, payroll and purchasing, and is advanced to Section 8 for assessment.

Table 7.2.9-1: Traffic Volumes Associated with Workers, Payroll and Purchasing

Source	Peak Hourly Traffic by Project Phase (vehicles/hour) [a]		
	Site Preparation and Construction [b]	Operation [b]	Decommissioning [b]
Peak Hourly Traffic by Project Phase [a]	218	25	— [c]

Notes:
a Conservatively assumes that all of the workers will travel to the site in individual vehicles.
b Traffic volumes represent the incremental increase in traffic relative to the baseline operations.
c Traffic volumes during decommissioning are not available, but are expected to be less than during the site preparation and construction phase.

7.2.9.2 Noise Levels

The traffic volumes associated with bringing the workers to-and-from the site is expected to increase, as shown in Table 7.2.9-2. These vehicles will produce measurable noise levels. Accordingly, likely measurable changes to noise levels are identified as a result of workers, payroll and purchasing, and is advanced to Section 8 for assessment.

Table 7.2.9-2: Traffic Volumes and Sound Power Associated with Workers, Payroll and Purchasing

Source	Peak Hourly Traffic by Project Phase (vehicles/hour) [a]			Overall Sound Power (dBA) [b]
	Site Preparation and Construction	Operations	Decommissioning	
Heavy Vehicles - DGR Construction (Main Gate)	22	0	— [d]	104 [e]
Vehicles - DGR Construction and Support Workers (Main Gate) [a,c]	218	25	— [d]	75 – 98

Notes:
a Conservatively assumes that all of the workers will travel to the site in individual vehicles.
b Overall sound power source references provided in Appendix G2
c Traffic volumes represent the incremental increase in traffic relative to the baseline operations.
d Traffic volumes during decommissioning are not available, but are expected to be less than during construction.
e Sound Power Level estimated in CadnaA using road traffic noise prediction guidelines based on RLS90 [41].

7.3 SUMMARY OF SECOND SCREENING

Table 7.3-1 provides a summary of the second screening for the DGR Project. Squares (■) on this matrix represent likely DGR Project-environment interactions resulting in a measurable change in air quality and noise levels. These interactions are advanced to Section 8 for a third screening to determine those interactions that may result in a likely effect on atmospheric environment VECs.

Table 7.3-1: Matrix 2 – Summary of the Second Screening for Measurable Change on VECs

Project Work and Activity	Air Quality			Noise Levels		
	C	O	D	C	O	D
Direct Measurable Changes						
Site Preparation	■	—	—	■	—	—
Construction of Surface Facilities	■	—	—	■	—	—
Excavation and Construction of Underground Facilities	■	—	—	■	—	—
Above-ground Transfer of Waste	—	■	—	—	■	—
Underground Transfer of Waste	—	■	—	—	•	—
Decommissioning of the DGR Project	—	—	■	—	—	■
Abandonment of the DGR Facility	—	—		—	—	
Presence of the DGR Project						
Waste Management	■	■	■	■	■	■
Support and Monitoring of DGR Life Cycle	■	■	■	■	■	■
Workers, Payroll and Purchasing	■	■	■	■	■	■
Indirect Measurable Changes						
Changes in Air Quality	—	—	—			
Changes in Noise Levels				—	—	—
Changes in Surface Water Quantity and Flow						
Changes in Surface Water Quality						
Changes in Soil Quality						
Changes in Groundwater Quality						
Changes in Groundwater Flow						

Notes:
C = Site Preparation and Construction Phase
O = Operations Phase
D = Decommissioning Phase

The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 11. The abandonment and long-term performance phase is not included in the matrix as no activities occur during this phase. The abandonment of the DGR facility work and activity occurs immediately following decommissioning within the decommissioning phase and does not encompass the entirety of the abandonment and long-term performance phase.

• Potential project-environment interaction
■ Measurable change
— Activity does not occur during this phase
Blank No potential interaction

Following the screening for measurable changes, all VECs identified had a measurable change as a result of the DGR Project. Therefore, as summarized in Table 7.3-2, all of the VECs proposed in Table 4-1 will be carried forward for further assessment.

Table 7.3-2: Advancement of Atmospheric Environment VECs to Assessment

VEC	Retained?	Rationale
Air Quality	Yes	There will be measurable emissions during site preparation and construction, operations, and decommissioning
Noise Levels	Yes	There will be measurable emissions during site preparation and construction, operations, and decommissioning

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8. IDENTIFICATION AND ASSESSMENT OF ENVIRONMENTAL EFFECTS

The assessment of effects predicts and describes the likely environmental effects, mitigation measures and residual adverse effects on the atmospheric environment VECs that could reasonably be expected as a result of the DGR Project.

8.1 ASSESSMENT METHODS

8.1.1 Identify Adverse Effects on the Atmospheric Environment

All measurable changes identified in the second screening (Section 7) are advanced for assessment within the framework of the applicable VECs. Consistent with accepted EA practice, quantitative and qualitative methods, including professional expertise and judgement, are used to predict and describe the DGR Project-specific effects to allow for a detailed assessment.

If a likely environmental effect is identified, the effect is assessed as being either beneficial or adverse. Any adverse effects on VECs attributable to the DGR Project are advanced for consideration of possible mitigation measures. Beneficial effects, if any, are also identified during this step and marked with a ‘+’ on matrix, but are not considered further in this TSD. The results of the assessment are recorded in Matrix 3 (Section 8.4).

Numerical models are used to predict future conditions for both the air quality and noise levels VECs, which are then compared to the relevant evaluation criteria to determine whether adverse effects of the DGR Project on the atmospheric environment are likely to occur.

Section 8.1.1.1 describes the methods used to predict the likely effects of the DGR Project on air quality, and the thresholds used to determine whether the predicted likely effects would be adverse. Section 8.1.1.2 describes the methods used to predict the likely effects of the DGR Project on noise levels, and the thresholds used to determine whether the predicted likely effects would be adverse.

8.1.1.1 Air Quality

The likely effects of the DGR Project on air quality are evaluated using the AERMOD dispersion model (Version 09292), as described in Section 5.1.3 and Appendix F. For the air quality VEC, adverse effects are considered to be likely if the maximum concentrations of the air quality indicators resulting from the project are predicted to be higher than the maximum concentrations of the air quality indicators for the existing conditions. As shown in Table 8.1.1-1, any predicted increase in maximum concentrations relative to existing conditions is considered to be a likely adverse effect on the air quality VEC.

Table 8.1.1-1: Thresholds for Determining Adverse Effects on Air Quality

Indicators	Adverse Effects to Air Quality Unlikely if Maximum Predicted Concentrations	Adverse Effects to Air Quality Possible if Maximum Predicted Concentrations
1-hour NO_2 (µg/m³)	≤Existing [a]	>Existing
24-hour NO_2 (µg/m³)	≤Existing	>Existing
Annual NO_2 (µg/m³)	≤Existing	>Existing
1-hour SO_2 (µg/m³)	≤Existing	>Existing
24-hour SO_2 (µg/m³)	≤Existing	>Existing
Annual SO_2 (µg/m³)	≤Existing	>Existing
1-hour CO (µg/m³)	≤Existing	>Existing
8-hour CO (µg/m³)	≤Existing	>Existing
24-hour SPM (µg/m³)	≤Existing	>Existing
Annual SPM (µg/m³)	≤Existing	>Existing
24-hour PM_{10} (µg/m³)	≤Existing	>Existing
24-hour $PM_{2.5}$ (µg/m³)	≤Existing	>Existing

Notes:
a Predicted existing concentrations are presented in Table 5.4.2-3, and include the combined effect of background concentrations and predicted concentrations from existing sources in the Local Study Area.

8.1.1.2 Noise Levels

The likely effects of the DGR Project on noise levels are evaluated with the aid of the CadnaA noise model, which uses the ISO 9613 noise prediction formulations [42]. This model allows for the incorporation of the following environmental factors that can result in noticeable changes in noise levels:

- attenuation because of the distance between the noise source and receiver location;
- absorption of acoustic energy by the atmosphere;
- loss of acoustic energy as it travels around or over hills, or intervening buildings; and
- loss of acoustic energy as it passes over the ground (i.e., ground impedance).

In addition to the attenuation factors listed above, constructed features can be used to reduce the noise levels further, including: buildings, weather/acoustic enclosures, noise barriers, silencers, and exhaust mufflers.

To accurately account for these factors and features, the noise assessment relies on numeric models. The selection of appropriate models to support the noise assessment ensures that the results of the assessment are credible and indicative of the conditions likely to occur should the DGR Project proceed. The selection of this model considered several capabilities:

- incorporates site specific terrain data;
- evaluates the various source types associated with the DGR Project;

- has a technical basis that is scientifically sound, and is in keeping with the current understanding of the propagation of sound in the outdoors;
- applies a prediction program that has undergone scrutiny for correct implementation of established ISO methods;
- makes predictions that are consistent with observations; and
- is recognized by Ontario provincial regulators as one suitable for use.

The DGR Project EIS Guidelines highlight the need to provide information regarding the model verification and scientific defensibility, model calibration, model validation, as well as the uncertainty and sensitivity of the model. Table 8.1.1-2 provides a summary of this information for the model used in the noise assessment. A more detailed discussion of the model selection and evaluation process is provided in Appendix G.

CadnaA Noise Model

The Computer Aided Noise Attenuation (CadnaA) prediction model (version 3.72.131), developed by DataKustik GmbH is widely accepted for evaluating noise from industrial projects, including mining projects world-wide. The model algorithms are based on ISO 9613 Acoustics: Attenuation of Sound During Propagation Outdoors (International Organization for Standardization, 1993 and 1996) [42]. In addition, this model has been independently validated for its implementation of the ISO standard [43].

The model has the ability to simulate emission sources including roads, vessels and industrial facilities. Noise sources are characterized by entering the sound power and/or sound pressure octave band spectrum associated with each source. Other parameters including building dimensions, frequency of use, hours of operation, and enclosure attenuation ratings also define the nature of sound emissions. The ISO 9613 prediction method is conservative as it assumes that all receptors are downwind from the noise source or that a moderate ground based temperature inversion exists. In addition, ground cover and physical barriers, either natural (terrain-based) or constructed and atmospheric absorption are included as they relate specifically to the DGR Project.

Table 8.1.1-2: Reliability Summary for the CadnaA Noise Model

Model Name	Developer	Use in Assessment	Verification	Calibration	Validation	Uncertainty and Sensitivity
CadnaA	DataKustik GmbH	Predicting noise levels associated with on-site activities, equipment and operations	• CadnaA implements the ISO standards for noise propagation outdoors • ISO 9613 • Drew *et. al.*, 2005 [43] • See Appendix G	• CadnaA predictions were calibrated using measurements at the project site • See Appendix G	• CadnaA predictions are continuously validated • Drew et. al., 2005 [43] • See Appendix G	• ISO 9613 is based on known theory and proven to reliably produce repeatable results • CadnaA predictions of sound energy are sensitive to inputs (i.e., doubling sources will result in a doubling of acoustic energy at receptors) • Uncertainty associated with emissions is managed by making conservative assumptions (i.e. all construction equipment for certain construction works and activities operating concurrently)

For the noise level VEC, adverse effects were considered to be likely if the predicted noise levels resulted in a change from existing conditions that would be perceptible to humans [39]. An adverse effect was considered to be likely if the predicted noise levels exceed the quietest existing hourly noise levels (see Table 5.5.2-5) by more than 3 dB, as shown in Table 8.1.1-3.

Table 8.1.1-3: Thresholds for Determining Adverse Effects on Noise Levels

Indicators	Effects to Noise Level Receptors Unlikely if Change in Noise Levels	Effects to Noise Level Receptors Possible if Change in Noise Levels
Change in 1-h L_{eq} relative to Quietest Existing Noise Levels	≤ 3 dB	> 3 dB

8.1.2 Consider Mitigation Measures

When the assessment of effects indicates that an adverse effect on one of the atmospheric environment VECs is likely, technically and economically feasible mitigation measures are proposed to address the identified effect.

8.1.3 Identify Residual Adverse Effects

Once mitigation measures are proposed, the potential adverse effect is re-evaluated with the mitigation measures in place to identify any residual adverse effects. If a residual adverse effect on a VEC is identified, it is marked with a '◆' in Matrix 3 (Section 8.4). Residual adverse effects are advanced to Section 11 for an assessment of significance.

8.2 AIR QUALITY

8.2.1 Linkage Analysis

Existing conditions for air quality were described using a combination of available monitoring data and dispersion modelling and showed the following results.

- Monitoring data were used to describe the existing air quality in the Regional Study Area and indicated that air quality across the region does not vary dramatically from one station to the next. Although, air quality at the regional stations occasionally exceed the relevant Ontario criteria, these situations are not common.
- Monitoring data from the regional stations were also used to describe the background air quality in the Local Study Area. Background air quality was calculated as the 90^{th}-percentile concentration from the nearest station with data.
- Modelling was used to fully describe the air quality resulting from existing sources at the Bruce nuclear site.
- Existing air quality in the Local Study Area was calculated by adding the background air quality from regional monitoring data to the maximum modelling results for the existing sources at the Bruce nuclear site. The existing air quality in the Local Study Area complies with relevant criteria.

Direct effects of the DGR Project on air quality were identified during each of the site preparation and construction, operations, and decommissioning phases of the project. Specifically, the direct effects were identified for the following works and activities:

- Site preparation (site preparation and construction phase) – the site preparation activities will result in the release of fugitive dust emissions associated with the construction activities, as well as the release of tailpipe emissions from on-site equipment.
- Construction of surface facilities (site preparation and construction phase) – construction of surface facilities will result in the release of fugitive dust emissions associated with the construction activities, as well as the release of tailpipe emissions from on-site equipment.
- Excavation and construction of underground facilities (site preparation and construction phase) – the excavation and construction of underground facilities will result in the release of fugitive dust from excavation and material handling activities, as well as tailpipe emissions from on-site equipment.
- Above-ground transfer of waste (operations phase) – the above-ground transfer of waste will result in the release of fugitive dust from road traffic, as well as tailpipe emissions from on-site equipment.
- Underground transfer of waste (operations phase) – the underground transfer of waste will result in the release of tailpipe emissions from on-site equipment.
- Decommissioning of the DGR (decommissioning phase) – the decommissioning of the DGR will result in the release of fugitive dust from on-site road traffic, as well as tailpipe emissions from on-site equipment.
- Waste management (all DGR Project phases) – waste management will result in the release of fugitive dust from on-site road traffic, as well as tailpipe emissions from on-site equipment.
- Site support (all DGR Project phases) – site support involves the operation of an emergency diesel generator that will result in combustion emissions.
- Workers, payroll and purchasing (all DGR Project phases) – the construction, operation and decommissioning of the DGR will require a workforce. The workers traveling to and from the Bruce nuclear site will result in the release of on-site fugitive road dust and tailpipe emissions from traffic. These emissions could affect air quality.

No potential indirect effects were identified for air quality. However, changes in air quality resulting from the DGR Project activities could have an indirect effect on VECs in the terrestrial environment, hydrology and surface water quality, geology, Aboriginal interests and socio-economic environment. These are described in the respective TSDs. In addition, changes in air quality could have an effect on human health, which is described in the EIS.

8.2.2 In-design Mitigation

In determining the air emissions associated with the DGR Project works and activities, consideration was given to those mitigation measures that were considered to be integral to the design and implementation of the works and activities. These mitigation measures, which are considered to be typical and consistent with best practices, were incorporated into the emission estimates presented in Section 8.2.3.1, and therefore were incorporated in the effects predictions presented in Section 8.2.3.2. The air mitigation measures that were included in the air quality assessment of the DGR Project have been summarized in Table 8.2.2-1.

8.2.3 Direct Effects

8.2.3.1 Emissions

Site Preparation and Construction Phase

The works and activities during the site preparation and construction phase will be staged over a period of approximately six years, and will not all occur at the same time. To characterize the effects of those site preparation and construction phase works and activities advanced from the second screening (see Section 7) on air quality, the air emissions were grouped into selected stages through the site preparation and construction phase.

For the purposes of this assessment, the following five stages were identified:

- Stage 1: the site preparation and construction phase when emissions from the site preparation, construction of surface facilities works and excavation of the shafts activities are determined to be at their highest;
- Stage 2: the site preparation and construction phase when components of excavation and construction of underground facilities are at their highest; specifically, shaft excavation;
- Stage 3: the site preparation and construction phase when components of construction of underground facilities are at their highest; specifically, emplacement room construction;
- Stage 4: the site preparation and construction phase when components of construction of underground facilities are at their highest; specifically, installation of underground infrastructure; and
- Stage 5: the site preparation and construction phase when components of construction of underground facilities and road network construction are at their highest.

Table 8.2.2-1: Air Quality In-design Mitigation

Mitigation Measure	Mitigation Specifics	Works and Activities Affected	Compound Affected by Mitigation Measure	How Was the Mitigation Incorporated in the Assessment
Site Preparation and Construction Phase				
Watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas	Equipment will be available and maintained on-site to water roadways as required [a]	• Site preparation • Workers, payroll and purchasing	• SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions
Maintain on-site vehicles and equipment	On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order	• Site preparation • Excavation and construction of underground facilities	• NO_2 • CO • SO_2 • SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions
Operations Phase				
Maintain on-site vehicles and equipment	On-site vehicles and equipment engines will meet Tier 2 emission standards and be maintained in good working order	• Above-ground transfer of wastes • Underground transfer of wastes	• NO_2 • CO • SO_2 • SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions

Notes:

a The modelling assumed an effective 75% reduction of particulate matter emissions on a daily basis would be achieved.

The emissions for each of the above stages were determined (see Table 8.2.3-1) and used to identify the bounding stage for the site preparation and construction phase. The first stage, when site preparation works and activities are occurring at their highest level, was determined to be the bounding emission case for the site preparation and construction phase. During this stage the collective emissions from all activities are at their highest. Air emissions associated with site support and monitoring of DGR life cycle, workers, payroll and purchasing and construction waste management were conservatively considered to be constant throughout the five stages identified, and are included in Table 8.2.3-1.

Table 8.2.3-1: Daily Site Preparation and Construction Phase Emissions

Indicator Compound [a]	Daily Emission Rate (kg/d) [b]				
	Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts	**Stage 2: Excavation of Shafts**	**Stage 3: Construction of Emplacement Rooms**	**Stage 4: Installation of Underground Infrastructure**	**Stage 5: Installation of Underground Infrastructure and Road Network Construction**
NO_X	243.5	157.7	250.7	271.4	297.5
SO_2	0.5	0.3	0.5	0.5	0.6
CO	168.6	113.9	172.2	189.4	207.2
SPM	207.3	59.2	82.7	83.8	120.8
PM_{10}	49.3	18.7	26.5	27.6	35.4
$PM_{2.5}$	32.3	14.0	19.2	20.3	25.1

Notes:

a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b The numbers in the above table were calculated by summing the emissions associated with the individual activities, as shown in Section 7, that occur concurrently during each phase.

Table 8.2.3-2 lists the emissions of the bounding site preparation and construction phase stage used as inputs to the dispersion modelling. These emissions represent all Stage 1 (site preparation) emissions (see Table 8.2.3-1), which includes emissions associated with the workers, payroll and purchasing and construction waste management works and activities. The dispersion modelling presented later in this section includes the effects of the combined site preparation and construction phase (see Table 8.2.3-2) and existing emissions (see Table 5.4.2-1).

Table 8.2.3-2: Daily Site Preparation and Construction Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d) [b]			
	Shafts	Vehicles [c]	Fugitive Dust [d]	Site Equipment
NO_X	31.91	5.25	—	206.31
SO_2	0.06	0.02	—	0.41
CO	27.19	12.09	—	129.28
SPM	1.72	0.19	197.87	7.47
PM_{10}	1.70	0.19	39.91	7.47
$PM_{2.5}$	1.68	0.18	22.97	7.47

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b Adding the numbers in the rows above yielded the totals shown in the Stage 1 column of Table 8.2.3-1.
c Includes tailpipe emissions from delivery vehicles and all of the OPG and DGR Project worker vehicles on-site.
d Includes all fugitive dust, including road dust, generated by on-site traffic.
— Not applicable.

Operations Phase

Table 8.2.3-3 lists the emissions of the operations phase used as inputs to the dispersion modelling. The dispersion modelling presented later in this section includes effects of the combined operations phase (see Table 8.2.3-3) and existing emissions (see Table 5.4.2-1).

Table 8.2.3-3: Daily Operations Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d)				
	Vent Raise	Emergency Generator	Vehicles [b]	Fugitive Dust [c]	Site Equipment
NO_X	5.92	19.71	0.04	—	8.87
SO_2	0.01	0.02	0.00	—	0.02
CO	4.31	12.20	0.82	—	5.78
SPM	0.33	0.70	0.00	0.13	0.37
PM_{10}	0.33	0.70	0.00	0.02	0.37
$PM_{2.5}$	0.33	0.70	0.00	0.00	0.37

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b Includes tailpipe emissions from all of the OPG and DGR Project worker vehicles on-site.
c Includes all fugitive dust, including road dust, generated by on-site traffic.
— Not applicable.

Decommissioning Phase

The emissions during the decommissioning phase are expected to be similar to, or less than the emissions from the site preparation and construction phase (see Table 8.2.3-2).

8.2.3.2 Effects Predictions

Site Preparation and Construction Phase

Table 8.2.3-4 provides a summary of the site preparation and construction phase dispersion modelling results for those compounds and averaging periods that are used when evaluating how emissions from the DGR Project could affect air quality in the Local Study Area.

Table 8.2.3-4: Site Preparation and Construction Phase Air Quality Predictions in the Local Study Area

Indicator Compound	Maximum Modelled Concentration (µg/m³) [a]	Background Concentration (µg/m³) [b]	Maximum Site Preparation and Construction Phase Concentration (µg/m³) [c]
1-hour NO_2	308.5	13.2	321.7
24-hour NO_2	129.2	12.0	141.2
Annual NO_2	13.1	5.4	18.5
1-hour SO_2	308.4	10.5	318.9
24-hour SO_2	42.0	9.3	51.3
Annual SO_2	1.4	3.6	5.0
1-hour CO	1,687.7	816.5	2,504.2
8-hour CO	649.8	945.9	1,595.7
24-hour SPM	224.8	52.1	276.9
Annual SPM	7.7	23.0	30.7
24-hour PM_{10}	52.6	22.7	75.3
24-hour $PM_{2.5}$	32.1	13.6	45.7

Notes:
a Includes emissions from existing and site preparation and construction phase project sources in the Local Study Area. The maximum modelled concentrations were predicted to occur at the fenceline of the Bruce nuclear site.
b From Table 5.4.1-14.
c The maximum site preparation and construction phase concentrations represent the sum of modelled existing and site preparation and construction phase sources in the Local Study Area and background air quality.

Operations Phase

Table 8.2.3-5 provides a summary of the operations phase dispersion modelling results for those compounds and averaging periods that are used when evaluating how emissions from the DGR Project could affect air quality in the Local Study Area.

Table 8.2.3-5: Operations Phase Air Quality Predictions in the Local Study Area

Indicator Compound	Maximum Modelled Concentration (µg/m³) [a]	Background Concentration (µg/m³) [b]	Maximum Operations Phase Concentration (µg/m³) [c]
1-hour NO_2	138.4	13.2	151.6
24-hour NO_2	55.8	12.0	67.8
Annual NO_2	2.2	5.4	7.6
1-hour SO_2	308.4	10.5	318.9
24-hour SO_2	42.0	9.3	51.3
Annual SO_2	1.4	3.6	5.0
1-hour CO	781.3	816.5	1,597.8
8-hour CO	256.4	945.9	1,202.3
24-hour SPM	19.4	52.1	71.5
Annual SPM	2.1	23.0	25.1
24-hour PM_{10}	4.2	22.7	26.9
24-hour $PM_{2.5}$	2.3	13.6	15.9

Notes:
a Includes emissions from existing and operations phase project sources in the Local Study Area. The maximum modelled concentrations were predicted to occur at the fenceline of the Bruce nuclear site.
b From Table 5.4.1-14.
c The maximum operations phase concentrations represent the sum of modelled existing and operations phase sources in the Local Study Area and background air quality.

Decommissioning Phase

The emissions during the decommissioning phase are expected to be similar to, or less than the emissions during the site preparation and construction phase. Therefore, the potential effects would be bounded by those for the site preparation and construction phase presented in Table 8.2.3-4.

8.2.3.3 Adverse Effects

Site Preparation and Construction Phase

As described in Section 8.1.1.1, adverse effects on air quality were assumed to occur if the maximum site preparation and construction phase concentrations for the indicator compounds exceed the corresponding maximum existing concentrations. Both the site preparation and construction phase and existing concentrations include background air quality. Table 8.2.3-6 provides a comparison of the site preparation and construction phase to the existing concentrations. Those air quality indicator compounds for which adverse effects to air quality were predicted to occur are examined for possible application of mitigation measures in Section 8.2.4.

Table 8.2.3-6: Site Preparation and Construction Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area [a]	Maximum Site Preparation and Construction Phase Concentration (µg/m³) in Local Study Area [b]	Increase Over Existing Concentration (µg/m³) in Local Study Area [c]	Likely Adverse Effect?
1-hour NO_2	110.4	321.7	+211.3	**adverse effect**
24-hour NO_2	26.5	141.2	+114.7	**adverse effect**
Annual NO_2	6.8	18.5	+11.7	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	2,504.2	+923.6	**adverse effect**
8-hour CO	1,201.8	1,595.7	+393.9	**adverse effect**
24-hour SPM	71.0	276.9	+205.9	**adverse effect**
Annual SPM	25.1	30.7	+5.6	**adverse effect**
24-hour PM_{10}	26.0	75.3	+49.3	**adverse effect**
24-hour $PM_{2.5}$	15.4	45.7	+30.3	**adverse effect**

Notes:
a From Table 5.4.2-3.
b From Table 8.2.3-4.
c The increases over existing concentrations are calculated as the difference between the maximum site preparation and construction phase concentrations and the maximum existing concentrations. These maximums may not occur at the same location.

Operations Phase

As described in Section 8.1.1.1, adverse effects on air quality are assumed to occur if the maximum operations phase concentrations for the indicator compounds exceed the maximum existing concentrations. Both the operations phase and existing concentrations include background air quality. Table 8.2.3-7 provides a comparison of the operations phase to the existing concentrations. Those air quality indicator compounds for which adverse effects to air quality were predicted to occur are examined for possible application of mitigation measures in Section 8.2.4.

Table 8.2.3-7: Operations Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area [a]	Maximum Operations Phase Concentration (µg/m³) in Local Study Area [b]	Increase Over Existing Concentration (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	151.6	+41.2	**adverse effect**
24-hour NO_2	26.5	67.8	+41.3	**adverse effect**
Annual NO_2	6.8	7.6	+0.8	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	1,597.8	+17.2	**adverse effect**
8-hour CO	1,201.8	1,202.3	+0.5	**adverse effect**
24-hour SPM	71.0	71.5	+0.5	**adverse effect**
Annual SPM	25.1	25.1	0	no adverse effect
24-hour PM_{10}	26.0	26.9	+0.9	**adverse effect**
24-hour $PM_{2.5}$	15.4	15.9	+0.5	**adverse effect**

Notes:
a From Table 5.4.2-3.
b From Table 8.2.3-5.
c The increases over existing concentrations are calculated as the difference between the maximum site preparation and construction phase concentrations and the maximum existing concentrations. These maximums may not occur at the same location.

Decommissioning Phase

The emissions during the decommissioning phase are expected to be similar to, or less than those predicted for the site preparation and construction phase. Therefore, potential adverse effects are bounded by those predicted for the site preparation and construction phase, as presented in Table 8.2.3-6.

8.2.4 Additional Mitigation Measures

As discussed in Section 8.2.2, in-design mitigation measures were considered to be integral to the design and implementation of the works and activities. No additional mitigation measures were considered in the assessment of changes in air quality as a result of the DGR Project.

8.2.5 Residual Adverse Effects

The identified mitigation measures that are economically feasible, as identified in Table 8.2.2-1, were incorporated as an integral component of the DGR Project design and implementation for the purposes of assessing the changes in air quality attributable to the DGR Project. Residual adverse effects of the DGR Project on air quality are identified as those likely adverse effects that remain after the implementation of mitigation measures.

Table 8.2.5-1 provides a summary of the identified adverse effects of the DGR Project on air quality, along with an identification of whether residual adverse effects will remain after the implementation of mitigation measures. The significance of the residual adverse effects of the DGR Project on air quality is assessed in Section 11.

Table 8.2.5-1: Residual Adverse Effects on Air Quality

Adverse Effect	Mitigation Measures	Residual Adverse Effects
Site Preparation and Construction Phase		
1-hour NO_2	• Considered integral to the DGR Project (see Section 8.2.2) • Included in predictions	**Residual adverse effect**
24-hour NO_2		
Annual NO_2		
1-hour CO		
8-hour CO		
24-hour SPM		
Annual SPM		
24-hour PM_{10}		
24-hour $PM_{2.5}$		
Operations Phase		
1-hour NO_2	• Considered integral to the DGR Project (see Section 8.2.2) • Included in predictions	**Residual adverse effect**
24-hour NO_2		
Annual NO_2		
1-hour CO		
8-hour CO		
24-hour SPM		
24-hour PM_{10}		
24-hour $PM_{2.5}$		
Decommissioning Phase		
Assumed to be similar, or less, than the site preparation and construction phase	• Considered integral to the DGR Project (see Section 8.2.2) • Included in predictions	**Residual adverse effect**

The residual adverse effects of the DGR Project on air quality, as shown in Table 8.2.5-1, are evaluated for significance in Section 11.

8.3 NOISE LEVELS

8.3.1 Linkage Analysis

Existing conditions for noise were described using a combination of monitoring and short duration measurements and showed the following:

- The noise levels in the Local Study Area are consistent with typical rural environments; and
- Noise from operations at the Bruce nuclear site were audible at receptors R2 and R3.

Measurable changes on noise levels were identified during each of the site preparation and construction, operations, and decommissioning phases of the DGR Project. Specifically, measurable changes as follows were identified.

- Site preparation (site preparation and construction phase) – the site preparation activities will result in the release of noise emissions associated with the construction activities.
- Construction of surface facilities (site preparation and construction phase) – the construction of the surface facilities involves the installation and operation of an emergency diesel generator that will result in increased noise emissions.
- Excavation and construction of underground facilities (site preparation and construction phase) – the excavation and construction of underground facilities will result in increased noise emissions from excavation and material handling activities.
- Above-ground transfer of waste (operations phase) – the above-ground transfer of waste will result in increased noise levels from waste transportation.
- Decommissioning of the DGR (decommissioning phase) – the decommissioning of the DGR will result in noise levels associated with road traffic and on-site equipment.
- Waste management (all DGR Project phases) – waste management will result in increased noise levels from road traffic, as well as noise emissions from on-site equipment.
- Site support (all DGR Project phases) – site support involves the operation of an emergency diesel generator that will result in noise emissions.
- Workers, payroll and purchasing (all DGR Project phases) – the construction, operation and decommissioning of the DGR will require a workforce. The workers traveling to and from the Bruce nuclear site will result in noise emissions from traffic.

No indirect effects were identified for noise levels. However, changes in noise levels resulting from the DGR Project activities could have an indirect effect on VECs in the Terrestrial Environment, and Socio-economic Environment TSDs. These are described in Section 8 of their respective TSDs. In addition, changes in noise levels have the potential to have indirect effects on human health. These are described in Appendix C of the EIS.

8.3.2 In-design Mitigation

In determining the noise emissions associated with the DGR Project works and activities, consideration was given to those mitigation measures that were considered to be integral to the design and implementation of the works and activities. These mitigation measures, which are not considered to be unusual, or beyond best practices, were incorporated into the emission estimates presented in Section 8.2.3.1, and therefore were incorporated in the effects predictions presented in Section 8.2.3.1. The noise mitigation measures that were included in the noise assessment have been summarized in Table 8.3.2-1.

Table 8.3.2-1: Noise Levels In-design Mitigation

Mitigation Measure	Mitigation Specifics	Works and Activities Affected	Property Affected by Mitigation Measure	How Was the Mitigation Incorporated in the Assessment
Site Preparation and Construction Phase				
Maintain on-site vehicles and equipment	On-site vehicles and equipment will be equipped with appropriate silencers and maintained in good working order	• Site preparation • Excavation and construction of underground facilities • Above-ground transfer of wastes	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Tight Footprint	Construction areas have been located close to the project footprint to limit vehicle travel routes	• Site preparation • Excavation and construction of underground facilities	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Operations Phase				
Maintain on-site vehicles and equipment	On-site vehicles and equipment will be equipped with appropriate silencers and maintained in good working order	• Above-ground transfer of waste • Workers, payroll and purchasing	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Maintain fresh air and return air raise fans	Fans maintained in good working order	• Above-ground transfer of wastes	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions

8.3.3 Direct Effects

8.3.3.1 Emissions

Site Preparation and Construction Phase

The works and activities during the site preparation and construction phase will be staged over a period of approximately six years, and will not all occur at the same time. To characterize the effects of those site preparation and construction phase works and activities advanced from the second screening (see Section 7) on noise levels, it is necessary to identify the noise emissions that could occur during the site preparation and construction phase.

The noise emissions for each of the years were determined (see Table 8.3.3-1) and used to identify the bounding scenario for the site preparation and construction phase. Specifically, the first year was identified as contributing the most to measurable noise levels. Noise emissions associated with workers, payroll and purchasing and construction waste management were considered to be constant throughout the site preparation and construction phase to carry out a conservative assessment, and are considered in Table 8.3.3-1 for average daily site preparation and construction phase emissions.

Table 8.3.3-1: Site Preparation and Construction Phase Noise Emission Sources

Source	Site Preparation and Construction Phase Year						
	One	Two	Three	Four A [a]	Four B [a]	Five	Six +
Air Compressor Plant	0	1	1	1	1	1	1
Articulated Trucks (Cat 730) Land Clearance	2	0	0	0	0	0	0
Articulated Trucks (Cat 730) Re-used Material Transfer	2	2	2	2	3	3	3
Articulated Trucks (Cat 730) Storm Water	2	0	0	0	0	0	0
Batch Plant Concrete Truck Blower	1	1	1	1	1	1	1
Batch Plant Hopper Blower	1	1	1	1	1	1	1
Batch Plant Truck Concrete Loading	4	4	4	4	4	4	4
Batch Plant Truck Rinsing	4	4	4	4	4	4	4
Bulldozer (Cat D9T WH) Land Clearance	1	0	0	0	0	0	0
Bulldozer (Cat D9T WH) Road Construction	1	0	0	0	0	0	1

Table 8.3.3-1: Site Preparation and Construction Phase Noise Emission Sources (continued)

Source	Site Preparation and Construction Phase Year						
	One	Two	Three	Four A [a]	Four B [a]	Five	Six +
Bulldozer (Cat D9T WH) Storm Water	1	0	0	0	0	0	0
Bulldozer (Cat D9T WH) Waste Rock Pile Construction	1	1	1	1	1	1	1
Cement Storage Hopper Blower	1	1	1	1	1	1	1
Concrete Truck	4	4	4	4	4	4	4
Compactors (Cat CS-683) Land Clearance	0	0	0	0	0	0	0
Compactors (Cat CS-683) Road Construction	1	0	0	0	0	0	1
Diesel Generator (3,500 kW) Back up - Operation	0	1	1	1	1	1	1
Electrical Sub-Station	1	1	1	1	1	1	1
Excavator (Cat 340D) Land Clearance	1	0	0	0	0	0	0
Excavator (Cat 340D) Storm Water	1	0	0	0	0	0	0
Excavator (Cat 340D) Waste Rock Pile	0	0	0	0	0	0	0
Exhaust Fans	0	2	2	2	2	2	2
Explosives carrier/loader	2	2	2	2	2	2	2
Feller Buncher (Cat 522) Land Clearance	1	0	0	0	0	0	0
Intake Fans with Heater House	0	2	2	2	2	2	2
Front End Loader (Cat 988H)	3	0	0	0	0	0	1
Front End Loader (Cat 988H) Waste Rock Pile	1	1	1	1	1	1	1
Headframe	0	2	2	2	2	2	2
Heavy Vehicles - DGR Construction (Main Gate)	22	22	22	22	22	22	22
Hoist House	0	2	2	1	1	1	1

Table 8.3.3-1: Site Preparation and Construction Phase Noise Emission Sources (continued)

Source	Site Preparation and Construction Phase Year						
	One	Two	Three	Four A [a]	Four B [a]	Five	Six +
Jumbo Atlas Copco Boomer E3 C	2	2	2	2	2	2	2
Loader (Cat 988H) - batch plant	1	1	1	1	1	1	1
Motor Grader (CAT 140)	2	0	0	0	1	1	2
Pavers (Cat BG-240C) Road Construction	1	0	0	0	0	0	1
Shotcrete Transmixer	2	2	2	2	2	4	4
Sprayer	2	2	2	2	2	2	2
Vehicles - DGR Construction and Support Workers (Main Gate)	218	218	218	218	218	218	218

Note:

a Year 4 has been split into A (shaft sinking) and B (lateral development) as these two activities both occur during this year but would not occur concurrently.

Table 8.3.3-2 lists the overall sound power data of the bounding site preparation and construction phase emissions used as inputs to the noise prediction model (Year 1). Although some of these pieces of equipment may be below grade during much of the phase, the assessment has conservatively assessed that they will be at or near the surface during the early stages of construction. The noise modelling presented later in this section includes the combined effects of the site preparation and construction phase emissions (see Table 8.3.3-2) and existing noise levels (see Table 5.5.2-1).

Table 8.3.3-2: Bounding Site Preparation and Construction Phase Noise Emissions

Source	Quantity	Overall Sound Power Level (dBA) [a]
Articulated Trucks (Cat 730) Land Clearance	2	109
Articulated Trucks (Cat 730) Re-used Material Transfer	2	109
Articulated Trucks (Cat 730) Storm Water	2	109
Batch Plant Concrete Truck Blower	1	108
Batch Plant Hopper Blower	1	104
Batch Plant Truck Concrete Loading	4	109
Batch Plant Truck Rinsing	4	109
Bulldozer (Cat D9T WH) Land Clearance	1	115

Table 8.3.3-2: Bounding Site Preparation and Construction Phase Noise Emissions (continued)

Source	Quantity	Overall Sound Power Level (dBA) [a]
Bulldozer (Cat D9T WH) Road Construction	1	115
Bulldozer (Cat D9T WH) Storm Water	1	115
Bulldozer (Cat D9T WH) Waste Rock Pile Construction	1	115
Cement Storage Hopper Blower	1	104
Concrete Truck	4	104
Compactors (Cat CS-683) Road Construction	1	109
Electrical Substation	1	91
Excavator (Cat 340D) Land Clearance	1	102
Excavator (Cat 340D) Storm Water	1	102
Explosives carrier/loader	2	115
Feller Buncher (Cat 522) Land Clearance	1	114
Front End Loader (Cat 988H)	3	115
Front End Loader (Cat 988H) Waste Rock Pile	1	115
Heavy Vehicles - DGR Construction (Main Gate)	22	104
Jumbo Atlas Copco Boomer E3 C	2	119
Loader (Cat 988H) - batch plant	1	115
Motor Grader (CAT 140)	2	116
Pavers (Cat BG-240C) Road Construction	1	106
Shotcrete Transmixer	2	108
Sprayer	2	107
Vehicles - DGR Construction and Support Workers (Main Gate)	218	98

Notes:
a Overall sound power source references provided in Appendix G.

Operations Phase

Table 8.3.3-3 lists the overall sound power levels for the bounding operations phase emissions used as inputs to the noise prediction model. The modelling presented later in this section includes the combined effects of the operations phase emissions (see Table 8.3.3-3) and baseline (see Table 5.5.2-1).

Table 8.3.3-3: Operations Phase Emissions

Source	Quantity	Overall Sound Power Level (dBA) [a]
Air Compressor Plant	1	116
Diesel Generator (3,500 kW) Back-up [b]	1	118
Electrical Sub-Station	1	91
Exhaust Fans	2	117
Flat-bed Transporter/Truck	1	105
Forklifts Large	1	99
Forklifts Small	1	99
Intake Fans	1	125
Headframe [c]	2	92
Hoist House [c]	1	92
Vehicles - DGR Employees (Main Gate)	25	75

Notes:
a Overall sound power source references provided in Appendix G.
b Diesel generator was conservatively assessed with a weather enclosure only.
c Sources of noise may include machinery, cabling, etc.

Decommissioning Phase

The emissions during the decommissioning phase are bounded by the emissions from the site preparation and construction phase and are likely to be below those emissions presented in Table 8.3.3-2.

8.3.3.2 Effects Predictions

Site Preparation and Construction Phase

Table 8.3.3-4 provides a summary of the site preparation and construction phase noise modelling results for the receptor locations (see Figure 5.5.1-1) used to evaluate how noise emissions from the DGR Project could affect noise levels in the Local Study Area. The table also includes the predicted ambient noise levels that are likely to occur when the noise from the site preparation and construction phase works and activities are combined with the existing noise levels[4].

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[4] Noise levels are added logarithmically. Two noise sources that generate 50 dBA each at one location will result in an overall noise level of 53 dBA. See Appendix G for a sample calculation.

Table 8.3.3-4: Site Preparation and Construction Phase Noise Predictions

Receptor	Existing Noise Levels (dBA)	Predicted Site Preparation and Construction Phase Noise Levels (dBA)	Ambient Noise Levels During Site Preparation and Construction Phase (dBA)
R1 – Albert Road	36	33	38
R2 – Baie du Doré	37	40	42
R3 – Inverhuron Provincial Park	35	32	37

Operations Phase

Table 8.3.3-5 provides a summary of the operations phase noise modelling results for those receptors that were used when evaluating how noise emissions from the project could affect noise levels in the Local Study Area. The table also includes the predicted ambient noise levels that are likely to occur when the noise from the operations phase works and activities are combined with the existing noise levels. The waste rock pile was not included as a barrier or source of noise attenuation in the modelling predictions, but would likely have an attenuating effect at some receptors.

Table 8.3.3-5: Operations Phase Noise Predictions

Receptor	Existing Noise Levels (dBA)	Predicted Operations Phase Noise Levels (dBA)	Ambient Noise Levels During Operations Phase (dBA)
R1 – Albert Road	36	34	38
R2 – Baie du Doré	37	37	40
R3 – Inverhuron Provincial Park	35	32	37

Decommissioning Phase

The emissions during the decommissioning phase are bounded by the emissions from the site preparation and construction phase and therefore, the noise levels are likely to be below those predictions presented in Table 8.3.3-4.

8.3.3.3 Adverse Effects

Site Preparation and Construction Phase

As described in Section 8.1.1.2, only increases in noise levels of more than 3 dB are considered to be adverse effects. As shown in the following table, an adverse noise effect is identified. Table 8.3.3-6 provides a comparison of the predicted site preparation and construction phase noise levels along with the corresponding baseline results. The application of possible mitigation measures is examined in Section 8.3.4.

Table 8.3.3-6: Site Preparation and Construction Phase Adverse Effects to Noise Levels in the Local Study Area

Receptor	Ambient Noise Levels During the Site Preparation and Construction Phase (dBA)	Baseline Noise Levels (dBA)	Project-related Change Relative to Baseline (dB)	Likely Adverse Effect?
R1 – Albert Road	38	36	+2	no adverse effect
R2 – Baie du Doré	42	37	+5	**adverse effect**
R3 – Inverhuron Provincial Park	37	35	+2	no adverse effect

Note: A change in noise levels >3 is considered an adverse effect

Operations Phase

As described in Section 8.1.1.2, only increases in noise levels of more than 3 dB are considered to have adverse effects. As shown in the following table, there are no adverse noise effects identified. Table 8.3.3-7 provides a comparison of the predicted operations phase noise levels along with the corresponding baseline results. The application of possible mitigation measures is examined in Section 8.3.4.

Table 8.3.3-7: Operations Phase Adverse Effects to Noise Levels in the Local Study Area

Receptor	Ambient Noise Levels During the Operations Phase (dBA)	Baseline Noise Levels (dBA)	Project-related Change Relative to Baseline (dB)	Likely Adverse Effect?
R1 – Albert Road	38	36	+2	no adverse effect
R2 – Baie du Doré	40	37	+3	no adverse effect
R3 – Inverhuron Provincial Park	37	35	+2	no adverse effect

Decommissioning Phase

The emissions during the decommissioning phase are bounded by the emissions from the site preparation and construction phase and therefore, the potential adverse effects are similar to those predicted for that phase, as presented in Table 8.3.3-6.

8.3.4 Additional Mitigation Measures

As discussed in Section 8.3.2, in-design mitigation measures considered to be integral to the design and implementation of the works and activities. No additional mitigation measures were considered in the assessment of changes in noise levels as a result of the DGR Project.

8.3.5 Residual Adverse Effects

The identified mitigation measures that are economically feasible, as identified in Table 8.3.2-1, were incorporated as an integral component of the DGR Project design and implementation for the purpose of assessing the changes in noise levels attributable to the DGR Project. Residual adverse effects of the DGR Project on noise levels are identified as those likely adverse effects that remain after the implementation of mitigation measures.

Table 8.3.5-1 provides a summary of the identified adverse effects of the DGR Project on noise levels, along with an identification of whether residual adverse effects will remain after the implementation of mitigation measures. The significance of the residual adverse effects of the DGR Project on noise levels are assessed in Section 11.

Table 8.3.5-1: Residual Adverse Effects on Noise Levels

Adverse Effect	Mitigation Measures	Residual Adverse Effects
Site Preparation and Construction Phase		
Increase in L_{eq} by 5 dB at R2 – Baie du Doré	• Considered integral to the project • Included in predictions	**Residual adverse effect**
Decommissioning Phase		
Assumed to be the same, or less than the site preparation and construction phase	• Considered integral to the project • Included in predictions	**Residual adverse effect**

The residual adverse effects of the DGR Project on noise levels, as shown in Table 8.3.5-1, are evaluated for significance in Section 11.

8.4 SUMMARY OF ASSESSMENT

Table 8.4-1 provides a summary of the third screening for the DGR Project. Diamonds (◆) on this matrix represent likely DGR Project-environment interactions resulting in a residual adverse effect on air quality and noise levels. These interactions are advanced to Section 11 for a consideration of significance.

Table 8.4-1: Matrix 3 – Summary of the Third Screening for Residual Adverse Effects on VECs

Project Work and Activity	Air Quality			Noise Levels		
	C	O	D	C	O	D
Direct Effects						
Site Preparation	◆	—	—	◆	—	—
Construction of Surface Facilities	◆	—	—	◆	—	—
Excavation and Construction of Underground Facilities	◆	—	—	◆	—	—
Above-ground Transfer of Waste	—	◆	—	—	■	—
Underground Transfer of Waste	—	◆	—	—	•	—
Decommissioning of the DGR Project	—	—	◆	—	—	◆
Abandonment of the DGR Facility	—	—		—	—	
Presence of the DGR Project						
Waste Management	◆	◆	◆	◆	■	◆
Support and Monitoring of DGR Life Cycle	◆	◆	◆	◆	■	◆
Workers, Payroll and Purchasing	◆	◆	◆	◆	■	◆
Indirect Effects						
Changes in Air Quality	—	—	—			
Changes in Noise Levels				—	—	—
Changes in Surface Water Quantity and Flow						
Changes in Surface Water Quality						
Changes in Soil Quality						
Changes in Groundwater Quality						
Changes in Groundwater Flow						

Notes:
C = Site Preparation and Construction Phase
O = Operations Phase
D = Decommissioning Phase
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 11. The abandonment and long-term performance phase is not included in the matrix as no activities occur during this phase. The abandonment of the DGR facility work and activity occurs immediately following decommissioning within the decommissioning phase and does not encompass the entirety of the abandonment and long-term performance phase.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
— Activity does not occur during this phase
Blank No potential interaction

8.4.1 Application of a Precautionary Approach in the Assessment

Conservatism is built into the assessment of the atmospheric environment using a bounding assessment approach for the site preparation and construction phase. For example, the assessment of the potential effects of the DGR Project on air quality considers conservative emission rates during the site preparation and construction phase. Specifically, all of the equipment and activities identified during a particular year were assumed to be operating at their maximum rate concurrently. In addition, traffic associated with the construction workforce was assumed to be at its maximum level (i.e., peak hourly traffic) throughout the site preparation and construction phase.

8.4.2 Application of Traditional Knowledge in the Assessment

Specific Aboriginal traditional knowledge was not available for inclusion in the Atmospheric Environment TSD. However, general concerns regarding air quality and noise levels on Aboriginal communities and traditional foods have been communicated in past assessments. The Atmospheric Environment TSD assesses the effects of the DGR Project on air quality and noise levels at the edge of the Bruce nuclear site, which is the closest point of continuous exposure for both Aboriginal and non-Aboriginal people. The aesthetic and nuisance effects associated with changes in air quality and noise levels caused by the DGR Project were evaluated in the Aboriginal Interests TSD. Finally, the potential effects of changes in air quality and noise levels on the health of Aboriginal people, including those burial ground on Bruce nuclear site for ceremonial purposes, are presented as part of the EIS (Section 7.11 and Appendix C).

8.4.3 Cumulative Effects

Effects of the DGR Project have the potential to act cumulatively with those of other projects. The EIS Guidelines require that the EA considers the cumulative effects of past, present and reasonably foreseeable future projects. The description of the existing environmental conditions presented in Section 5 includes the cumulative effects of past and existing projects. The assessment completed in Section 8 considers the effects of the DGR Project in combination with those of past and present projects.

Residual adverse effects on air quality and noise levels are expected to occur during the site preparation and construction, operations, and decommissioning phases. The potential for cumulative effects associated with the residual adverse effects on atmospheric environment VECs with past, present and reasonably foreseeable future projects is presented in Section 10 of the EIS.

9. EFFECTS OF THE ENVIRONMENT ON THE PROJECT

9.1 ASSESSMENT METHODS

The EA must include a consideration of how the environment could adversely affect the DGR Project. For example, the EA evaluates how hazards such as severe weather are likely to affect the DGR Project. This assessment was accomplished using the method illustrated on Figure 9.1-1. Firstly, potential conditions in the environment that may affect the project are identified. The level of effect these environmental conditions could have on the DGR Project are evaluated based on past experience at the site and professional judgement of the study team. The assessment of effects of the environment on the DGR Project focuses on those conditions associated with the atmospheric environment (e.g., extreme weather, thunderstorms). For each environmental condition that could potentially affect the DGR Project, the mitigation measures incorporated into the project design are identified and evaluated for effectiveness. This evaluation is based on the available data, and the experience and judgement of the study team.

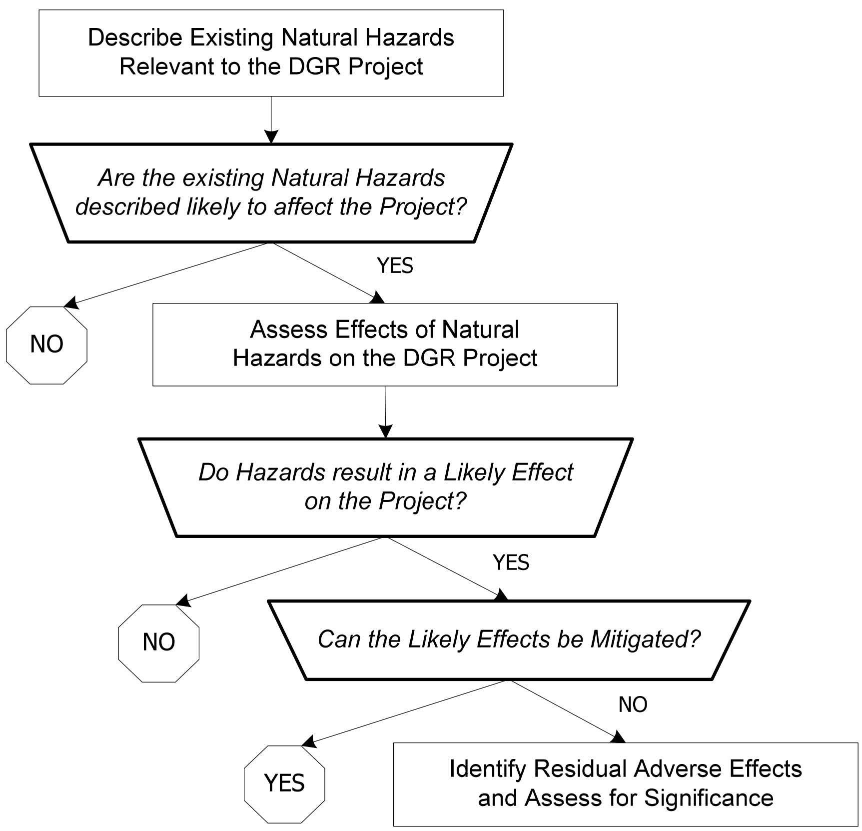


Figure 9.1-1: Method to Assess Effects of the Environment on the DGR Project

Identified residual adverse effects, if any, are then advanced to Section 11 for an assessment of significance.

9.2 ASSESSMENT OF EFFECTS OF THE CURRENT ATMOSPHERIC ENVIRONMENT ON THE DGR PROJECT

The atmospheric environment can have an effect on the integrity and viability of the DGR Project. This section of the TSD examines the effects of the atmospheric environment on the DGR Project, and focuses on the effects of severe weather conditions (i.e., thunderstorms, hail storms, tornadoes and ice storms).

9.2.1 Thunderstorms

Thunderstorms represent the final stage of the growth of convective instability in a humid atmosphere. Thunderstorms can damage external structures through high winds, heavy rain and lightning. An example of severe thunderstorms were those associated with Hurricane Hazel in 1954. These severe thunderstorms had wind speeds up to 120 km/h and 18 cm of rain fell in less than 24 hours [44]. These thunderstorms damaged transportation infrastructure, power lines, homes and other light structures.

The frequency of thunderstorm occurrence at the Bruce nuclear site is expected to be similar to that at Wiarton Airport, the location of the nearest meteorological station that records thunderstorms. For the period 1961 to 1990, Wiarton Airport averaged 28 thunderstorms per year [45].

However, the DGR Project will be designed to the National Building Code and the DGR Project shaft collar is designed to be above the probable maximum flood and probable maximum precipitation event (see Hydrology and Surface Water Quality TSD). In addition, the majority of the project structures are located well below ground and would not be directly affected by severe weather events. Therefore, any thunderstorms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of power failures that may result from thunderstorms are addressed in the Malfunctions, Accidents and Malevolent Acts TSD.

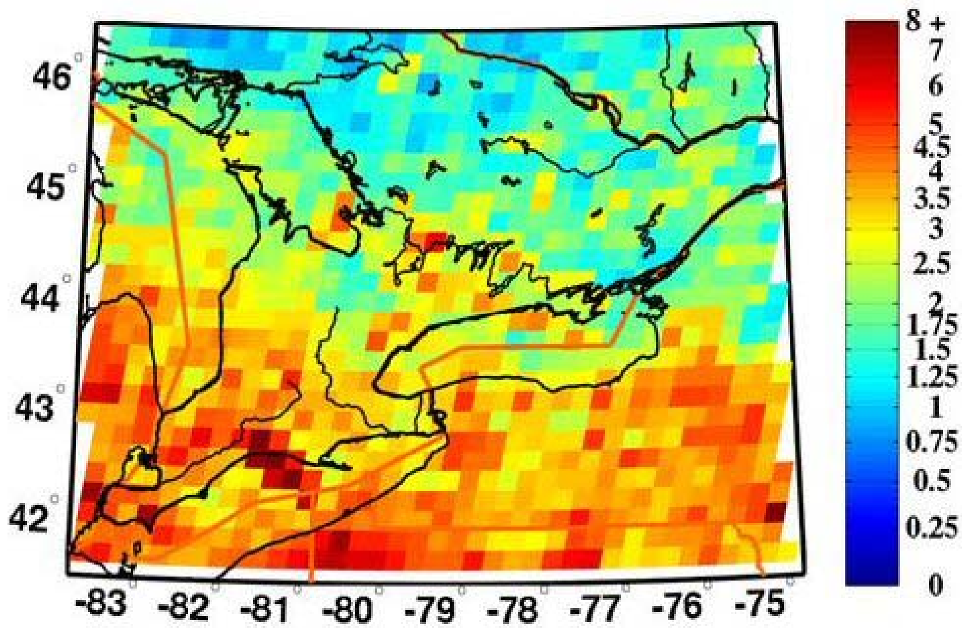
9.2.2 Lightning

Lightning is an atmospheric discharge of electricity, which typically occurs during thunderstorms. In the atmospheric electrical discharge, a leader of a bolt of lightning can travel at speeds of 60,000 m/s, and can reach temperatures approaching 30,000 °C (54,000 °F).

Lightning flashes range in Canada from about 2.0 to 2.9 million times a year, including about once every three seconds during the summer months. This is based on observations collected during the past 10 years from the Canadian lightning detection network [46].

Lightning climatology is still young in Canada; Environment Canada installed a national lightning network in 1997-98 and began collecting data on lightning strikes throughout Canada. Even though lightning climatology is limited (1999 to 2008) Environment Canada has developed a "flash density" map indicating the number of flashes per square kilometre per year.

As illustrated on Figure 9.2.2-1, extreme south-western Ontario shows a large area of lightning activity (3.0 to 5.0 flashes per square kilometre). A second maximum is located along a line from the southern tip of Georgian Bay to southeast of Barrie (2.5 to 4.5 flashes per square kilometre). The two highland areas in southern Ontario, Algonquin Park and the Dundalk Highlands experience lightning much less frequently than the low land areas surrounding them. The Bruce nuclear site had an average of 2.0 to 3.0 flashes per square kilometre for the period 1999 to 2008.



Source: [46]

Figure 9.2.2-1: Lightning Climatology 1999 to 2008 Southern Ontario (flashes per square kilometre per year)

The DGR Project is designed to withstand severe weather events. The headframe, which is the tallest DGR Project structure, will be designed with lightning protection, using technology that is will advanced in the mining industry. The majority of the project structures are located well below ground and would not be directly affected by severe weather events. The headframes design includes lightning protection. This technology is well advanced in the mining industry. Therefore, any lightning strikes that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of power failures and fires that could result from lightning storms are considered in the Malfunctions, Accidents and Malevolent Acts TSD.

9.2.3 Hail Storms

Hailstorms, associated exclusively with severe thunderstorms, are warm season phenomena; typically occurring between May and September. Hailstorms can damage external structures through high winds and the impact of falling hail. Currently, statistics on the frequency and prevalence of hail storms are not available. However, OPG reports that there have been no occurrences of hail damage to the WWMF structures over the last 30 years.

The DGR Project is designed to the National Building Code to withstand severe weather events. In addition, the majority of the project structures are located well below ground and would not be directly affected by hail storm events. Therefore, any hail storms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted.

9.2.4 Tornadoes

Excessive atmospheric instability, rapid rates of vertical temperature change and strong shear in wind speed and wind direction are required to cause tornadoes, which are usually associated with severe thunderstorms [47]. A tornado system may be triggered when cold air from the north meets with warm, moist air from the lower Great Lakes. The cold air undercuts the warm air and forces it up to great heights, producing convection clouds. If, at the same time, the air stream is diverging at upper levels, the warm air is drawn up even faster. This creates highly turbulent storm clouds where a tornado funnel may appear. More than one tornado may develop out of a single storm system and each funnel may travel some distance before lifting and dissipating. Tornadoes can damage external structures through high velocity winds.

Tornadoes have a random distribution and are extremely localized. A few tornadoes or near-tornadoes are reported in southern Ontario each year, but these are not as intense or damaging as tornadoes in the United States south and west of the Great Lakes [47]. In the Regional Study Area, one to two tornadoes per 10,000 km^2 can be expected annually [47].

The majority of the DGR Project structures are located well below ground and would not be directly affected by tornado events. The headframes and surface structures are designed to the National Building Code and are designed for a 100-year design life. Therefore, any tornadoes that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted.

The effects of tornadoes on the integrity of the hoist have been considered in the Malfunctions, Accidents and Malevolent Acts TSD.

9.2.5 Ice Storms

Ice storms are caused when the atmosphere is layered, with a layer of warm air above the denser cold air near the ground surface. As precipitation falls in the warm layer, rain forms. The rain then falls into the shallow cold layer and freezes. Ice storms can damage light structures such as power transmission lines through the weight of accumulated ice.

Ice storms occur in eastern Ontario and Quebec, and less frequently in southwestern Ontario around the Bruce nuclear site. On average, Ottawa and Montreal receive freezing precipitation on 12 to 17 days a year, which generally lasts only a few hours. For the period of 1961 to 1990 freezing precipitation occurred nine days per year on average at Wiarton Airport [45]. In January 1998, a severe ice storm occurred in eastern Ontario and Quebec. Over 90 mm of freezing drizzle fell during the five day storm in 1998. The January 1998 ice storm caused significant damage to transmission lines and sub-transmission systems. However, it did not damage any generating stations, because these have greater structural integrity for reasons other than resisting ice and wind loading [48].

Since the majority of the project structures are located well below ground they would not be directly affected by ice storm events. In addition, the physical hoist mechanisms are fully enclosed within the headframe structure. In the event of an ice storm, there is the potential for a loss of power that would affect the DGR facilities, including the hoist. However, the DGR Project has included emergency backup power systems that would engage in the eventuality of a power loss. Therefore, any ice storms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted.

The effects of power failures from all eventualities are considered in the Malfunctions, Accidents and Malevolent Acts TSD.

9.3 SUMMARY

No effects of the atmospheric environment on the DGR Project were identified that required advancement to Section 11 for an evaluation of significance.

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10. CLIMATE CHANGE CONSIDERATIONS

The DGR Project EIS Guidelines require a consideration of whether the DGR Project and EA conclusions are sensitive to changes in climatic conditions. For the purpose of this TSD, climate change is considered over the life of the DGR Project spanning the site preparation and construction, operations, and decommissioning phases only. Shifts in climate that occur from one epoch to the next have been considered as part of the Postclosure Safety Assessment Report [2], and their effects on the DGR Project are described in the EIS (Section 9).

The requirement of the guidelines to consider climate change is addressed through the following considerations:

- How will the future environment affect the DGR Project?
- How will the DGR Project affect the future environment?
- How will the DGR Project affect climate change (e.g., contribution to climate change by the emission of greenhouse gases)?

The methods used to consider the effects of climate change are described in the following sections. Establishing how the climate may change over the life of the DGR Project is an initial requirement for addressing the first two considerations. A determination of how climate has been changing and how it might change over the DGR Project life considered in this TSD is based on 30-year climate normals, literature review and the professional experience of the study team. The climate models used to predict high, medium and low climate change scenarios for the Regional Study Area are described in Section 10.1. These predicted climate change scenarios are used by all environmental disciplines for the assessment of the consequences of climatic conditions on the first two considerations.

10.1 DESCRIPTION OF PREDICTED CHANGES IN CLIMATE

Climate represents the long-term expected values for parameters such as temperature, precipitation and winds. The climate of an area is described using normals, which are averages calculated over a 30 year period (the latest accepted normals period is from 1971 to 2000) [34]. It is now widely accepted that climate is changing; therefore, consideration of these changes needs to be incorporated in the EA carried out for the DGR Project. Traditionally, scientists looked to past weather records to provide guidance for predicting future conditions. Historic climate trends for the DGR Project are determined using the temperature archives observed at Wiarton Airport over the period from 1971 through 2000. While past trends have traditionally been used to provide guidance to the future, reliance is shifting to global climate models, which incorporate accepted understandings of climate mechanisms and standardized scenarios reflecting potential human development in the future.

Tables 10.1-1 and 10.1-2 provide a summary of the past and future trends for temperature and precipitation, respectively. The tables describe how climate in the region has been changing, as well as how it is projected to change over the life of the DGR Project through the end of the decommissioning phase. These data are used to evaluate how climate change may affect the conclusions reached regarding the assessment of the effects of the DGR Project on the selected VECs. Appendix D provides further details on the predicted changes in climate.

Table 10.1-1: Historic and Future Temperature Trends

Criteria	1971-2000 Normals (°C)	1971-2000 Trend (°C/decade)	2011-2040 Forecast (°C/decade)			2041-2070 Forecast (°C/decade)			2071-2100 Forecast (°C/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	6.1	+0.31	+0.00	+0.41	+1.05	+0.15	+0.34	+0.66	+0.20	+0.33	+0.51
Spring	4.5	+0.50	+0.00	+0.45	+1.09	+0.14	+0.35	+0.69	+0.19	+0.34	+0.54
Summer	17.4	+0.26	+0.00	+0.43	+1.10	+0.15	+0.34	+0.69	+0.21	+0.34	+0.52
Fall	8.3	+0.05	+0.00	+0.36	+1.02	+0.12	+0.30	+0.63	+0.19	+0.32	+0.49
Winter	-5.7	+0.68	+0.00	+0.40	+0.99	+0.16	+0.33	+0.63	+0.21	+0.33	+0.50

Notes:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D the for derivation of climate data.

Table 10.1-2: Historic and Future Precipitation Trends

Season	1971-2000 Normals (mm)	1971-2000 Trend (mm/ decade)	2011-2040 Forecast (%/decade)			2041-2070 Forecast (%/decade)			2071-2100 Forecast (%/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	1,041.3	+0.13%	+0.00%	+1.44%	+3.57%	+0.36%	+1.11%	+2.09%	+1.39%	+1.30%	+2.25%
Spring	216.8	+3.23%	+0.00%	+2.59%	+5.39%	+0.62%	+1.51%	+2.72%	+1.88%	+2.24%	+4.05%
Summer	230.8	-0.51%	+0.00%	-1.65%	-3.40%	-0.95%	-1.13%	-0.42%	-0.68%	-0.85%	-0.61%
Fall	310.9	+4.41%	+0.00%	+2.09%	+4.35%	+2.28%	+1.67%	+2.75%	+2.11%	+1.65%	+1.85%
Winter	282.8	-4.65%	+0.00%	+2.39%	+7.30%	-0.27%	+1.82%	+3.08%	+2.05%	+1.92%	+3.32%

Notes:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D for the derivation of climate data.

10.2 EFFECTS OF THE FUTURE ENVIRONMENT ON THE DGR PROJECT

10.2.1 Methods

Changes to the climate are predicted to occur over the lifetime of the DGR Project; therefore, it is also necessary to assess how the predicted future environment may affect the DGR Project. For example, climate change might result in new or more severe weather hazards. The method used to assess these changes is shown on Figure 10.2.1-1.

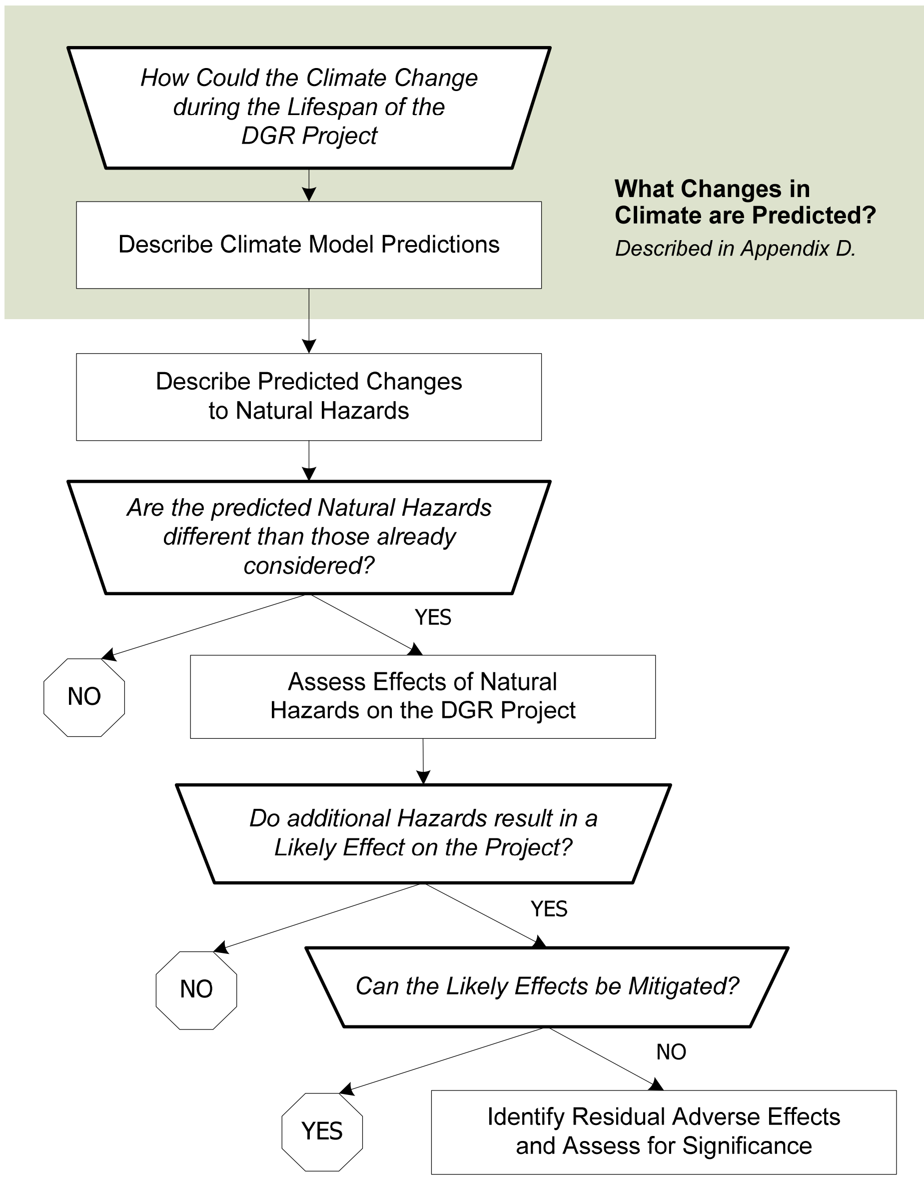

Figure 10.2.1-1: Method to Assess Effects of the Future Environment on the DGR Project

Once the future environment is established, the evaluation of changed and/or additional natural hazards on the DGR Project is carried out in a similar fashion to the assessment of effects of the current environment on the DGR Project (Section 9). The assessment addresses only predicted hazards that are different or in addition to those considered in the assessment of existing natural hazards. The EA predictions of future hazards as a result of a changing climate relies upon both qualitative and quantitative evaluations based on available data and technical experience, with consideration for the design and contingency measures incorporated into the DGR Project to mitigate likely effects. Identified residual adverse effects are advanced to Section 11 for an assessment of significance.

10.2.2 Assessment of Effects of the Future Atmospheric Environment on the DGR Project

The effects of the environment on the DGR Project for the air quality and noise subcomponents are associated with severe weather events. While there have been suggestions that the frequency and intensity of severe weather events is increasing as a result of climate change [49], Environment Canada indicates that "…there is not yet enough scientific evidence to show a link between increasing severe weather and a changing climate" [50]. There is, however, evidence that the frequency of severe weather events were increasing during the 20th century [50]. Figure 10.2.2-1 illustrates this increasing trend of severe weather events in Canada by showing the number of weather-related disasters recorded in each decade over the last 100 years. Environment Canada considers weather-related disasters as unusual weather events that result in the loss of property or life.

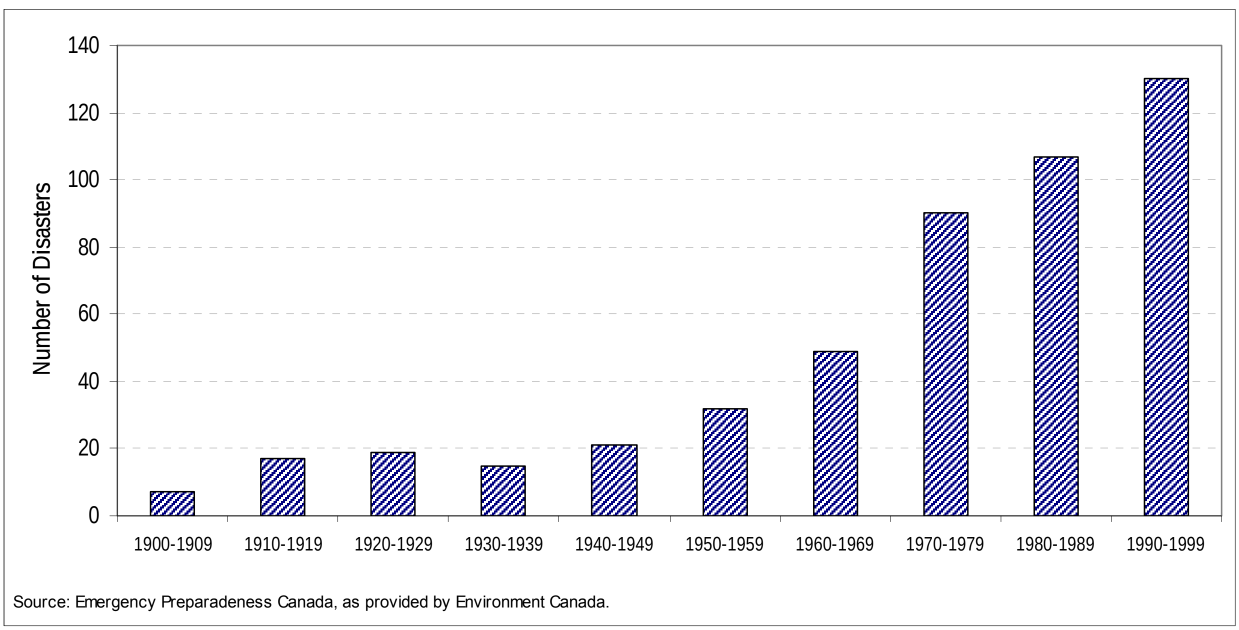

Figure 10.2.2-1: Trend in Weather Related Disasters in Canada

Despite the greater number of severe weather events recorded since 1970, these events have not affected the operation of the facilities at the Bruce nuclear site. The facilities have incorporated a consideration of the potential effects of extreme weather in their design and have been constructed to withstand the effects of such events. Therefore, increases in the frequency of severe weather events that could potentially be related to climate change should have no more effect on the DGR Project than past severe weather events. Accordingly, no further consideration is warranted.

10.3 EFFECTS OF THE DGR PROJECT ON THE FUTURE ENVIRONMENT

10.3.1 Methods

Climate change may result in an environment that is different from the current environment as less severe winters or increased precipitation might alter the habitat or behaviour of VECs. Climate-related changes to VECs may result in changed or additional effects of the DGR Project compared with those predicted on the current environment. The method used to assess these changes is shown on Figure 10.3.1-1.

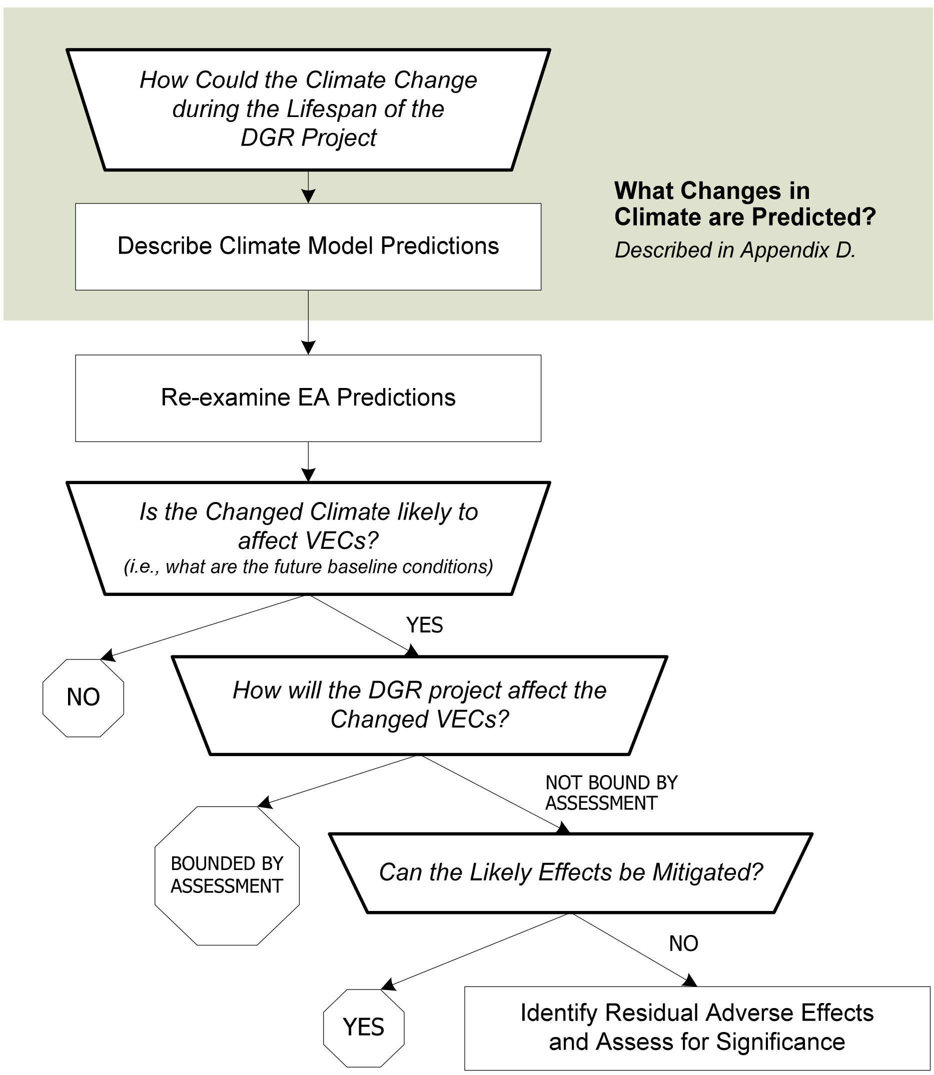

Figure 10.3.1-1: Method to Assess Effects of the DGR Project on the Future Environment

The assessment of the effects of the DGR Project on VECs in a changed future environment begins with re-examining the EA predictions for the current environment by identifying whether or not the VECs might be altered as a result of climate change. The effects of the DGR Project on the altered VECs are then assessed to determine whether they are bounded by the predictions made for the effects assessment for the current environment (Section 8). All additional or different effects are fully assessed, using a similar method to that followed for assessing effects of the DGR Project on the current environment. Effects that cannot be fully mitigated will result in residual adverse effects, which are forwarded for an assessment of significance in Section 11.

10.3.2 Assessment of the DGR Project on the Future Atmospheric Environment VECs

The future climate forecasts (Tables 10.1-1 and 10.1-2) suggest that the climate in the vicinity of the DGR Project will get warmer and be wetter than historically observed in the region. Generally, the rates at which temperatures are increasing (°C per decade) are similar to the rates of warming observed over the period of 1971 to 2000.

The Global Climate Models (GCMs) suggest that precipitation will increase at a rate much higher than that observed for the period of 1971 to 2000. However, these differences are not the same for all seasons. For example, the GCMs forecast an increase in winter precipitation, which contrasts with the decreasing trend over the past 30 years. In addition, the models are projecting much drier summer months.

Changes in temperature and precipitation can affect air quality in a number of ways. Firstly, changes in precipitation and soil moisture content can result in reduced or increased emissions of dust. A review of the GCM forecast suggests that precipitation will increase at a greater rate relative to the past, while temperatures will increase at a similar rate. This suggests that the soil would have greater moisture and emissions of fugitive dust would be decreased. However, the greatest increase in precipitation is forecast during the winter months. During the summer months, precipitation is forecast to decrease suggesting that soil moisture will be lower and fugitive dust emissions higher, which is consistent literature [51].

While this could suggest a potential increase in the dust emissions from the DGR Project; however, equipment will be available and maintained on-site to water roadways as required (see Table 8.2.2-1). Therefore, any potential increase in dust emissions will be mitigated. The climate during the site preparation and construction phase is expected to be similar to today's climate. Therefore, decreased soil moisture content over the long term would not have a measurable effect on the air quality VEC since dust emissions that could be affected by changes in soil moisture will occur under the current climate conditions.

Changes in temperature and precipitation can also affect how emissions from the DGR Project are dispersed in the atmosphere. Firstly, plumes from stacks will not rise as far during warm conditions as the plume rise is a function of the difference between the exhaust and ambient temperatures. However, there are no large stacks associated with the DGR Project. Therefore, there would be no measurable effect on the air quality VEC as a result of increases in temperature.

Increased precipitation could indicate an increase in the number of hours when clouds are present. During sunny conditions, dispersion is at its greatest and would be decreased with increased cloud cover. However, Kharin, et al [52] suggests that increases in precipitation will be experienced as increased intensities rather than an increasing number of hours of precipitation. Therefore, there should be no measurable effect on the air quality VEC as a result of increased precipitation.

Changing climate is not projected to affect noise levels.

Table 10.3.2-1 summarizes the potential effects of climate change on atmospheric environment VECs, and describes whether these changes could affect the conclusions presented for assessment of direct effects in Section 8.

Table 10.3.2-1: Effects of Climate Change on Atmospheric Environment VECs

VECs	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Air Quality	• Changes in temperature and precipitation can result in changes in soil moisture • Decreased soil moisture could result in higher dust emissions	• Most dust emissions will occur during site preparation and construction • Equipment will be available and maintained on-site to water roadways as required, therefore, any change in emissions will be mitigated	• No changes to the EA conclusions
	• Increased temperatures can result in decreased plume rise and associated dispersion	• There are no large stacks associated with the DGR Project	• No changes to the EA conclusions
	• Increased precipitation could result in more cloud cover • Increased cloud cover could result in decreased dispersion	• Increased precipitation is associated with increased intensity rather than increased duration • There should be no measurable increase in the number of hours of cloud cover	• No changes to the EA conclusions
Noise Levels	• No potential increases in noise levels associated with climate change	• The effects to noise propagation would not be measurable	• No changes to the EA conclusions

10.4 EFFECTS OF THE DGR PROJECT ON CLIMATE CHANGE

10.4.1 Methods

The DGR Project may also contribute to how the climate is changing (e.g., through changes in the levels of greenhouse gas emissions). The assessment will quantify the direct and indirect changes as a result of the DGR Project on the atmospheric environment and climate change and put them into context on a sector, provincial and national basis.

10.4.2 Assessment of Effects of the DGR Project on Climate Change

10.4.2.1 Greenhouse Gas Considerations

Although the DGR Project will have low levels of greenhouse gas (GHG) emissions during the operations phase, the activities required to construct and support the operations of the DGR Project will result in direct (i.e., emitted from combustion sources) and indirect (i.e., emissions associated with changes in land use) greenhouse gas emissions. This section describes and quantifies the direct and indirect GHG emissions associated with the site preparation and construction phase and operations phase of the DGR Project, and helps put those emissions into perspective on a sector, provincial and national basis. Direct GHG emissions during the decommissioning phase would be similar to those during the site preparation and construction phase, assuming no change in the vehicle technology available for the decommissioning of the DGR Project.

Direct GHGs

Table 10.4.2-1 lists the annual direct GHG emissions in kilotonnes (kt) of CO_2 equivalents (CO_2e) from the DGR Project during both the site preparation and construction and operations phases.

Table 10.4.2-1: Direct Project Greenhouse Gas Emissions

Source	Annual GHG Emissions (kt CO_2e/a)					
	Site Preparation and Construction Phase					Operations Phase
	Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts	Stage 2: Excavation of Shafts	Stage 3: Construction of Emplacement Rooms	Stage 4: Installation of Underground Infrastructure	Stage 5: Installation of Underground Infrastructure and Road Network Construction	
Bruce Power	0.00	0.00	0.00	0.00	0.00	0.00
WWMF	0.00	0.00	0.00	0.00	0.00	0.00
Vent Raise	2.39	2.39	7.56	9.11	9.11	0.44
Emergency Diesel Generator	0.00	0.93	0.93	0.93	0.93	0.93
Traffic	0.12	0.12	0.12	0.12	0.12	0.01
Fugitive Dust	0.00	0.00	0.00	0.00	0.00	0.00

Table 10.4.2-1: Direct Project Greenhouse Gas Emissions (continued)

Source	Annual GHG Emissions (kt CO_2e/a)					
	Site Preparation and Construction Phase					Operations Phase
	Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts	Stage 2: Excavation of Shafts	Stage 3: Construction of Emplacement Rooms	Stage 4: Installation of Underground Infrastructure	Stage 5: Installation of Underground Infrastructure and Road Network Construction	
Site Equipment	15.85	8.13	10.06	10.06	12.06	0.67
Total Scenario Emissions	**18.36**	**11.57**	**18.68**	**20.23**	**22.22**	**2.05**

Indirect GHG Emissions

Changes in land use can also be a source of indirect GHG emissions that the Intergovernmental Panel on Climate Change (IPCC) identifies for inclusion in emission inventories. In calculating the indirect GHG emissions associated with the DGR Project, consideration has been given to the following items flagged by the IPCC [53]:

- vegetation clearing; and
- forest litter.

Each of these categories of indirect GHG emissions is described below.

Vegetation Clearing

Clearing trees and growing vegetation during site preparation would remove a quantity of carbon from storage. The IPCC good practice guidance [54] offers a number of ways to account for vegetation clearing, based on how much of the timber is salvaged and used commercially. In calculating the emissions for the DGR Project, it was conservatively assumed that there would be no timber salvage, and that cleared timber would be left in place to decay over 10 years [54].

Forest Litter

In a living forest, the litter layer acts as a transport medium for carbon that falls from the trees. The litter layer decomposes the organic matter and transfers the carbon to the soils. The litter under an active forest is considered to be in balance [54] transferring as much carbon to the soils as it acquires from falling leaves and twigs. However, this decaying matter could release its carbon to the atmosphere once the trees are removed. The litter layer beneath vegetation cleared as part of the DGR Project was conservatively assumed to release its carbon to the atmosphere over 20 years [54].

Table 10.4.2-2 summarizes the annual indirect GHG emissions in kilotonnes (kt) as a result of the DGR Project.

Table 10.4.2-2: Indirect Project Greenhouse Gas Emissions

Land Use Category	Area Cleared During Site Preparation and Construction Phase (ha)	Annual GHG Emissions (kt CO_2e/a)		
		Vegetation Clearing	Forest Litter	Total
Cultural Barren	0.02	0.00	0.00	0.00
Cultural Grassland	0.00	0.00	0.00	0.00
Cultural Meadow	0.00	0.00	0.00	0.00
Industrial Barren	21.76	0.00	0.00	0.00
Industrial Land	0.00	0.00	0.00	0.00
Beach	0.00	0.00	0.00	0.00
Forest, Conifer	0.00	0.00	0.00	0.00
Forest, Deciduous	0.00	0.00	0.00	0.00
Forest, Mixedwoods	8.87	0.15	0.04	0.18
Marsh, Meadow	0.00	0.00	0.00	0.00
Marsh, Shallow	0.00	0.00	0.00	0.00
Swamp, Deciduous	0.00	0.00	0.00	0.00
Swamp, Mixedwoods	0.00	0.00	0.00	0.00
Total	30.64	0.15	0.04	0.18

DGR Project GHG Emissions in Context

Table 10.4.2-3 compares the direct and indirect GHG emissions from the site preparation and construction phase of the DGR Project with the Ontario power sector, Ontario provincial total and Canadian national GHG emissions for 2005 [55]. The total GHG emissions from the site preparation and construction of the DGR Project are insignificant in comparison to these totals.

Table 10.4.2-3: Site Preparation and Construction Phase GHG Emissions in Context

Source		Annual GHG Emissions (kt CO_2e/a)	Project as a Relative Percentage
DGR Project	Direct [a]	22.22	—
	Indirect [b]	0.18	
	Total	22.40	
Ontario Power Sector [c]		34,176	0.066%
Ontario Provincial Total [c]		201,000	0.011%
Canadian National Total [c]		747,000	0.0030%

Notes:
a The direct GHG emissions correspond to the site preparation and construction phase Stage 5 emissions listed in Table 10.4.2-1.
b The indirect GHG emissions listed in Table 10.4.2-2.
c Emissions represent the reported values for 2005 [55].
— Not applicable.

Table 10.4.2-4 compares the direct and indirect GHG emissions from the operations phase of the DGR Project to the Ontario power sector, Ontario provincial total and Canadian national GHG emissions for 2005 [55]. The total GHG emissions from the operation of the DGR Project are insignificant in comparison to these totals.

Table 10.4.2-4: Operations Phase GHG Emissions in Context

Source		Annual GHG Emissions (kt CO_2e/a)	Project as a Relative Percentage
DGR Project	Direct [a]	2.05	—
	Indirect [b]	0.18	
	Total	2.23	
Ontario Power Sector [c]		34,176	0.0065%
Ontario Provincial Total [c]		201,000	0.0011%
Canadian National Total [c]		747,000	0.00030%

Notes:
a The direct GHG emissions correspond to the operations phase emissions listed in Table 10.4.2-1.
b The indirect GHG emissions listed in Table 10.4.2-2.
c Emissions represent the reported values for 2005 [55].
— Not applicable.

10.4.2.2 Effects of DGR Project GHG Emissions on Climate

A review of literature from the IPCC confirms that the majority of scientists feel that there is compelling evidence to link observed and forecast changes in climate to the release of man-made greenhouse gas emissions. However, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) indicates in its guidance document for practitioners [56] that "…unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured." To illustrate this, the GHG emissions associated with the project are compared to the GHG emissions associated with the forecast changes in climate expected over the project life. Table 10.4.2-5 compares the global and DGR Project-related emissions, and can be seen to reasonably support the conclusion that the GHG emissions from the DGR Project will not have a measurable effect on climate. Therefore, the effect of the project on climate would be insignificant.

Table 10.4.2-5: Comparison of Project and Global GHG Emissions and Potential Effects to Climate Change

Parameter	SRES Scenario A1B	SRES Scenario A2	SRES Scenario B1	Project
Change in GHG emissions relative to the 2000 global baseline [a]	+59.7%	+109.3%	+18.6%	+0.00013%
Change in annual temperature for the 2041 to 2070 horizon [b]	+1.65 °C	+1.60 °C	+0.75 °C	Cannot be measured [c]
Change in annual precipitation for the 2041 to 2070 horizon [b]	+5.65%	+4.25%	+1.80%	Cannot be measured [d]

Notes:
a The global baseline emissions for 2000 were listed by the IPCC as 16,927 Mt CO_2e/a [57].
b Changes were calculated as the difference between the baseline and scenario forecasts for the 2041 to 2070 time horizon.
c On the basis of proportionality, the GHG emissions from the DGR Project could represent an increase of less than 0.00001 °C in the annual temperature. Such a change would not be measurable.
d On the basis of proportionality, the GHG emissions from the DGR Project could represent an increase of less than 0.000013% in the annual precipitation. Such a change would not be measurable.

10.5 SUMMARY

No effects of climate change related to atmospheric environment are advanced to Section 11 for an evaluation of significance.

11. SIGNIFICANCE OF RESIDUAL ADVERSE EFFECTS

This section includes an evaluation of the significance of the residual adverse effects identified for the DGR Project on the atmospheric environment VECs. An assessment of the cumulative effects associated with the DGR Project is addressed in Section 10 of the EIS.

11.1 ASSESSMENT METHODS

Residual adverse effects were identified in the assessment (Sections 8 though 10) and are assessed to determine if the residual adverse effect is significant. Significance is rated using criteria applicable to the atmospheric environment. The criteria used for judging and describing the significance of effects are shown in Table 11.1-1.

Table 11.1-1: Effects Criteria and Levels for Determining Significance

Effects Criteria	Effects Level Definition		
Magnitude (of effect)	**Low**	**Medium**	**High**
	The effects level definitions for magnitude are provided in Table 11.1.1-1 and Table 11.1.2-1		
Geographic Extent (of effect)	**Low**	**Medium**	**High**
	Effect is within the Site Study Area.	Effect extends into the Local Study Area.	Effect extends into the Regional Study Area.
Timing and Duration (of conditions causing the effect)	**Low**	**Medium**	**High**
	Conditions causing effect are evident during the site preparation and construction phase, or during the decommissioning phase.	Conditions causing effect are evident during the operations phase.	Conditions causing effect extend beyond any one phase.
Frequency (of conditions causing effect)	**Low**	**Medium**	**High**
	Conditions or phenomena causing the effect occur infrequently; (e.g., <1% of the time).	Conditions or phenomena causing the effect occur at regular, although infrequent intervals (e.g., approximately 10% of the time).	Conditions or phenomena causing the effect occur at regular and frequent intervals (i.e., >10% of the time).
Degree of Irreversibility (of effect)	**Low**	**Medium**	**High**
	Effect is readily (i.e., immediately) reversible.	Effect is reversible with time.	Effect is not reversible (i.e., permanent).

Residual adverse effects on both the air quality and noise levels VEC were identified. The criteria used to evaluate magnitude are specific to each of the VECs under consideration. The following sections summarize the effects level definitions on magnitude for the atmospheric environment VECs. Only non-negligible (i.e., measurable) effects are carried forward for an assessment of significance.

Probability of occurrence was not explicitly included as a criterion for the assessment of significance of residual adverse effects. The assessment recognizes the widest, reasonable range of likely residual adverse effects without specific regard for their respective probability of occurrence.[5] The focus is on evaluating the possible impact of such effects on the environment and VECs, and the consideration of feasible mitigation measures that can be incorporated to control, reduce or eliminate the effect.

The level of significance is assigned by using a decision tree model illustrated on Figure 11.1-1. The magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. The social and/or ecological importance of the VEC being affected is then considered to determine the overall significance of the effect.

This decision tree is specific to atmospheric environment and the effects level criteria defined in Tables 11.1.1-1 and 11.1.2-1. Some of the guiding principles are described below.

- All effects of low magnitude would result in a low environmental consequence and would not be considered significant. Low magnitudes are assigned for indicators where the maximum concentration is less than half of the relevant criteria. Since criteria are established to protect the environment and the health of people, effects less than half of those thresholds would be considered to have a low consequence.
- Effects that are limited to the Site Study Area (i.e., low extent) would result in a low environmental consequence and would not be considered significant. Ambient air quality and noise criteria are established to protect people beyond the site[6]. For this assessment, the site is defined by the limits of the Site Study Area.
- Effects with a high magnitude that extend beyond the Site Study Area have the potential to be of a high consequence if the frequency is high or the effects of a high magnitude extend beyond the Local Study Area.

The residual adverse effect can be determined to be:

- not significant;
- may not be significant; or
- significant.

An effect that "may not be significant" is one that in the professional judgement of the specialists would not be significant; however, follow-up monitoring should be implemented to confirm significant adverse effects do not occur.

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5 As noted in Section 2.2 in regards to the application of a precautionary approach, all identified residual adverse effects, with the exception of malfunctions, accidents and malevolent acts, are assumed to occur for the purposes of this assessment.

6 Airborne concentrations within the fenceline are not considered part of the environment from a permitting perspective, but are the subject of occupational health and safety concerns, which are addressed in the Preliminary Safety Report.

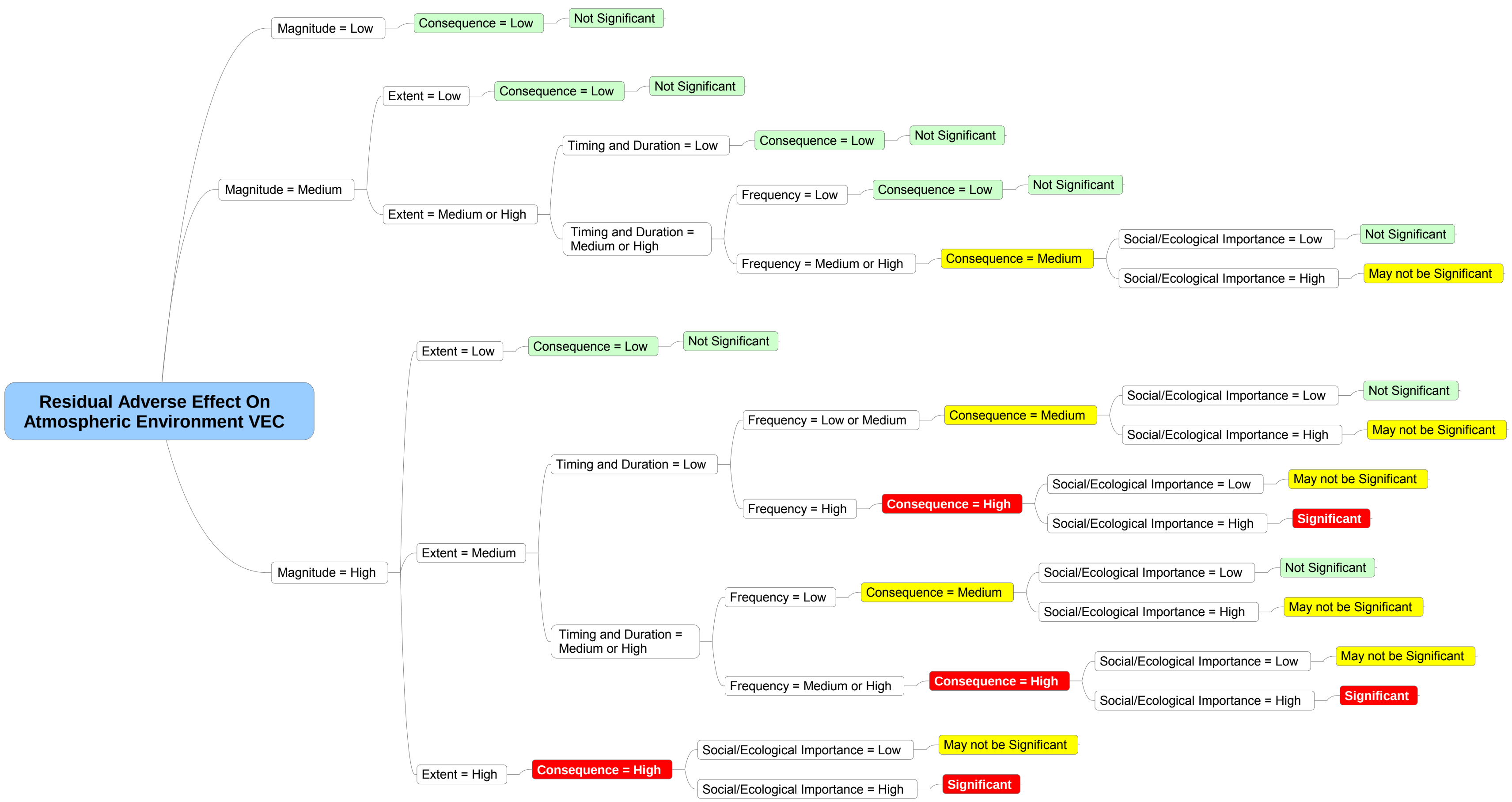

Figure 11.1-1: Determination of Significance of Residual Adverse Effects

11.1.1 Air Quality

As the dispersion modelling (Section 8.2.3.2) considers the cumulative activities at the Bruce nuclear site, a change from the existing conditions was considered essential for an adverse effect to be considered likely. Table 11.1.1-1 presents the magnitude criteria levels used in the assessment of significance for air quality. If the predicted maximum concentrations exceeded the relevant criteria (see Table 11.1.1-1 and Section 4.2.1), the effect was considered to be of high magnitude. A moderate magnitude is assigned when the maximum prediction was between 50 and 100% of the relevant criteria. Maximum predictions less than 50% of the relevant criteria are considered to be effects of a low magnitude. All effects with either a low, moderate or high magnitude that are likely following the application of mitigation are considered to be residual adverse effects and are advanced for an evaluation of significance.

Table 11.1.1-1: Effects Magnitude Levels for Air Quality

Criteria	Magnitude Level Definition		
	Low [a]	Medium [b]	High [b]
1-hour NO_2 (µg/m³)	≤200	≤400	>400
24-hour NO_2 (µg/m³)	≤100	≤200	>200
Annual NO_2 (µg/m³)	≤50	≤100	>100
1- hour SO_2 (µg/m³)	≤450	≤900	>900
24- hour SO_2 (µg/m³)	≤150	≤300	>300
Annual SO_2 (µg/m³)	≤30	≤60	>60
1- hour CO (µg/m³)	≤17,500	≤35,000	>35,000
8- hour CO (µg/m³)	≤7,500	≤15,000	>15,000
24- hour SPM (µg/m³)	≤60	≤120	>120
Annual SPM (µg/m³)	≤35	≤70	>70
24- hour PM_{10} (µg/m³)	≤25	≤50[c]	>50[c]
24- hour $PM_{2.5}$ (µg/m³)	≤15	≤30[d]	>30[d]

Notes:
a The low threshold was set at 50% of the relevant criteria.
b National Ambient Air Quality Objectives [9].
c Ontario Ambient Air Quality Objectives [10].
d Canada-Wide Standard [11].

11.1.2 Noise Levels

Table11.1.2-1 summarizes the criteria used to assign the effects magnitude for changes in noise levels. These criteria are based on how humans respond to noise rather than established regulatory limits, as described in Section 4. Specifically, changes in noise levels for the quietest hour that would be hardly perceptible (i.e., less than or equal to 3 dB) are considered to be negligible (i.e., not adverse). A noticeable change in the quietest hour (i.e., greater than 3 dB, but less than or equal to 6 dB change) is classified as having a low magnitude. Readily noticeable changes in the L_{eq} for the quietest hour (i.e., greater than 6 dB, but less than or equal to 10 dB) are considered to be of medium magnitude. Disturbing changes in the noise levels for the quietest hour (i.e., greater than 10 dB) are classified as having a high magnitude [58]. Changes classified as having a low, medium or high magnitude remaining after the application of mitigation measures are considered to be residual adverse effects and advanced for an evaluation of significance in Section 11.5.

Table 11.1.2-1: Effects Magnitude Levels for Noise

Indicator	Measure	Low	Medium	High
Energy Equivalent Noise Levels	Change relative to the quietest 1-hour L_{eq}	>3 and ≤6 dB	>6 and ≤10 dB	>10 dB

Source: [58]

11.2 SITE PREPARATION AND CONSTRUCTION PHASE

11.2.1 Air Quality

During the site preparation and construction phase, residual adverse effects on the air quality VEC were identified for eight individual indicators. Of these, four were predicted to have residual adverse effects that result in a low magnitude (see Table 11.1.1-1) and thus a low consequence (see Figure 11.1-1). Therefore, these are considered not significant.

Two indicators (i.e., 1-hour and 24-hour NO_2) were classified as having a medium magnitude. While the maximum predictions for these indicators were below the relevant criteria, they were higher than 50% of the criteria. These indicators were determined to have a low consequence (see Figure 11.1-1), and thus considered not significant.

The remaining three individual indicators (i.e., 24-hour SPM, 24-hour PM_{10}, and 24-hour $PM_{2.5}$) were predicted to have residual adverse effects that result in a high magnitude (i.e., maximum predictions are greater than the respective criteria). All of the high magnitudes were restricted to the Local Study Area, in the immediate vicinity of the Bruce nuclear site, and have durations that are low (see Table 11.1-1). The frequency for the indicators with high magnitudes are low (see Table 11.1-1). In fact, high magnitude predictions occurred on only nine days of the 5-years of dispersion modelling (i.e., <0.5% of the time). Therefore, these were assigned a moderate consequence and classified as may not be significant (see Figure 11.1-1). Significant impacts are not expected for these indicators during the site preparation and construction phase; however, monitoring would be required to determine the level of effects and effectiveness of the proposed mitigation (including the in-design mitigation).

Table 11.2.1-1 provides a listing of the effects criteria for each of the air quality indicators where a residual adverse effect was predicted during the site preparation and construction phase. In order to determine significance, the values in each row of the table are used to step through the decision tree illustrated on Figure 11.1-1. Therefore, significance may vary by indicator, as discussed above. Those indicators with the highest level of significance are discussed collectively in Section 11.5.

Table 11.2.1-1: Summary of Predicted Air Quality Effects Criteria during Site Preparation and Construction Phase

Criteria	Effects Criteria				
	Magnitude	Duration	Extent	Frequency	Irreversibility
1-hour NO_2 (µg/m³)	Medium	Low	Medium	Low	Low
24-hour NO_2 (µg/m³)	Medium	Low	Medium	Low	Low
Annual NO_2 (µg/m³)	Low	Low	Medium	High	Low
1-hour CO (µg/m³)	Low	Low	Medium	High	Low
8-hour CO (µg/m³)	Low	Low	Medium	High	Low
24-hour SPM (µg/m³)	High	Low	Medium	Low	Low
Annual SPM (µg/m³)	Low	Low	Medium	High	Low
24-hour PM_{10} (µg/m³)	High	Low	Medium	Low	Low
24-hour $PM_{2.5}$ (µg/m³)	High	Low	Medium	Low	Low

11.2.2 Noise Levels

During the site preparation and construction phase, emissions from the DGR Project were predicted to result in residual adverse effects for the noise levels VEC. These effects were classified to be of a low magnitude, medium extent, low duration and low irreversibility. The frequency is considered high (i.e., continuous). However, adverse effects will only be present approximately 24% of the time. While the noise levels resulting from DGR Project activities were assumed to be continuous, the existing noise levels fluctuate throughout the day (see Section 5.5.2). Overall, this adverse effect was classified as a “low consequence”, which is considered to be “not significant”.

11.3 OPERATIONS PHASE

11.3.1 Air Quality

During the operations phase, residual adverse effects on the air quality VEC were identified for seven individual indicators. Five of these were predicted to have residual adverse effects that result in a low magnitude (see Table 11.1.1-1) and thus a low consequence (see Figure 11.1-1). Therefore, these are considered not significant.

The remaining three individual indicators (i.e., 24-hour SPM, 24-hour PM_{10}, and 24-hour $PM_{2.5}$) were predicted to have residual adverse effects that result in a medium magnitude (i.e., maximum predictions are less than the respective criteria, but greater than half of the criteria). All of the medium magnitudes were restricted to the Local Study Area, in the immediate vicinity of the Bruce nuclear site. The duration is medium (see Table 11.1-1) and the frequency for the medium magnitude indicators range from low to medium (see Table 11.1-1). Therefore, these were assigned a low consequence and classified as not significant (see Figure 11.1-1).

Table 11.3.1-1 provides a listing of the effects criteria for each of the air quality indicators where a residual adverse effect was predicted during the site preparation and construction phase. In order to determine significance, the values in each row of the table are used to step through the decision tree illustrated on Figure 11.1-1. Therefore, significance may vary by indicator, as discussed above. Those indicators with the highest level of significance are discussed collectively in Section 11.5.

Table 11.3.1-1: Summary of Predicted Air Quality Effects Criteria during Operations Phase

Criteria	Effects Criteria				
	Magnitude	Duration	Extent	Frequency	Irreversibility
1-hour NO_2 (µg/m³)	Low	Medium	Medium	High	Low
24-hour NO_2 (µg/m³)	Low	Medium	Medium	High	Low
Annual NO_2 (µg/m³)	Low	Medium	Medium	High	Low
1-hour CO (µg/m³)	Low	Medium	Medium	High	Low
8-hour CO (µg/m³)	Low	Medium	Medium	High	Low
24-hour SPM (µg/m³)	Medium	Medium	Medium	Medium	Low
24-hour PM_{10} (µg/m³)	Medium	Medium	Medium	Medium	Low
24-hour $PM_{2.5}$ (µg/m³)	Medium	Medium	Medium	Low	Low

11.3.2 Noise Levels

During the operations phase, emissions from the DGR Project were predicted to result in no residual adverse effects for the noise levels VEC.

11.4 DECOMMISSIONING PHASE

The effects of the DGR Project on air quality and noise levels during the decommissioning phase are considered to be similar to, or lower than those experienced during the site preparation and construction phase.

11.5 SIGNIFICANCE OF RESIDUAL ADVERSE EFFECTS

Residual adverse effects during the site preparation and construction, operations, and decommissioning phases were identified for both the air quality and noise levels VECs. Table 11.5-1 provides a summary of the assessment of significance for all identified residual adverse effects. For air quality, where significance may vary by indicator, the indicators with the highest level of significance are discussed collectively in the table.

Table 11.5-1: Summary of Residual Adverse Effects and Significance Levels

VEC	Magnitude	Geographic Extent	Timing and Duration [a]	Frequency	Degree of Irreversibility	Overall Assessment
Site Preparation and Construction Phase						
Air Quality	**High** • Predicted values for more than one indicator exceeds the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the site preparation and construction phase	**Low** • Conditions or phenomena causing the effect occur infrequently (i.e., <1%)	**Low** • Effect is readily (i.e., immediately) reversible	**May Not Be Significant** (See Section 11.2.1)
Noise Levels	**Low** • A noise level indicator value exceeds the baseline values by 5 dB	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the site preparation and construction phase	**High** • The noise effects are expected to occur on a daily basis	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 11.2.2)
Operations Phase						
Air Quality	**Medium** • None of the predicted values exceed relevant criteria • predicted values for more than one indicator exceed 50% of the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Medium** • Effect is evident during the operations phase	**Medium** • Conditions or phenomena causing the effect occur at regular, although infrequent intervals (i.e., <10%)	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 11.3.1)

Table 11.5-1: Summary of Residual Adverse Effects and Significance Levels (continued)

VEC	Magnitude	Geographic Extent	Timing and Duration [a]	Frequency	Degree of Irreversibility	Overall Assessment
Decommissioning Phase						
Air Quality	**High** • Predicted values for more than one indicator exceeds the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the decommissioning phase	**Low** • Conditions or phenomena causing the effect occur infrequently (i.e., <1%)	**Low** • Effect is readily (i.e., immediately) reversible	**May Not Be Significant** (See Section 11.4)
Noise Levels	**Low** • A noise level indicator value exceeds the baseline values by 5 dB	**Medium** • The effect extends to the Local Study Area	**Medium** • Effect is evident during the decommissioning phase	**High** • The noise effects are expected to occur on a daily basis	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 11.4)

Note:

a The duration in the above table is based on the magnitudes of the identified effects. For example, a high magnitude is predicted during the site preparation and construction phase. Therefore, the duration for this effect (i.e., the effect of a high magnitude) is low. In a similar manner, activities during the operations phase are predicted to have a medium magnitude on air quality. Because these occur during the operations phase, these effects (i.e., the effects of a moderate magnitude) were assigned a medium duration.

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12. EFFECTS OF THE PROJECT ON RENEWABLE AND NON-RENEWABLE RESOURCES

The DGR Project EIS Guidelines (Appendix A of the EIS) require the EA to consider the effects of the DGR Project on resource sustainability. For context, non-renewable resources are also discussed in this section.

12.1 METHODS

Potential project-environment interactions (as identified for the assessment of effects of the DGR Project) are reconsidered in a context of their likelihood of affecting resource sustainability or availability through all time frames. Likely effects are predicted, described and their significance assessed by considering "renewable resources" and "non-renewable resources" as VECs. In addition, the ability of the present generation and future generations to meet their own needs is evaluated, based on the professional judgement of the technical specialists.

One goal of the assessment is to determine whether renewable and non-renewable resources would be affected by the DGR Project to the point where they are not sustainable or appreciably depleted. Sustainability is defined in a manner consistent with the United Nation's definition of sustainable development as "*economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".

12.2 LIKELY EFFECTS

Air quality and noise levels are not considered renewable or non-renewable resources and thus no further assessment is warranted.

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13. PRELIMINARY FOLLOW-UP PROGRAM

The guidelines stipulate that the need for, and the requirements of, any follow-up program for the DGR Project be identified. A follow-up program may be required to determine that the environmental and cumulative effects of the DGR Project are consistent with predictions reported in the EIS. It can also be used to verify that mitigation measures are effective once implemented and determine whether there is a need for additional mitigation measures. A preliminary follow-up plan is provided below. The follow-up program is designed to be appropriate to the scale of the DGR Project and the effects identified through the EA process.

Follow-up monitoring programs are generally required to:

- verify the key predictions of the EA studies; or
- confirm the effectiveness of mitigation measures, and in doing so, determine if alternative mitigation strategies are required.

The CNSC will provide the regulatory oversight to ensure that OPG has implemented all appropriate mitigation measures and that the follow-up monitoring is designed and carried out. The CNSC compliance program can be used as the mechanism for ensuring the final design and implementation of the follow-up program and reporting of the follow-up program results.

13.1 INITIAL SCOPE OF THE FOLLOW-UP PROGRAM

Table 13.1-1 summarizes the recommended follow-up monitoring programs for the Atmospheric Environment assessment. The recommendations identify the general timeframe for follow-up and monitoring (site preparation and construction, operations and/or decommissioning phase). The preliminary follow-up monitoring program has been prepared and is submitted along with the EIS.

Table 13.1-1: Recommended Follow-up Monitoring for the Atmospheric Environment

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Air Quality	Site Preparation and Construction Phase	• To verify that the PM_{10} and $PM_{2.5}$ emission rates used in the assessment were reasonable, but conservative • To verify the predicted concentrations of PM_{10} and $PM_{2.5}$ • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Continuous during the site preparation and construction phase with a re-evaluation at the end of each year • The monitoring equipment (diatomaceous continuous analyzer) to be set up in a secure location near the Main Entrance to the Bruce nuclear site; between the construction activities and the property boundary
		• To verify that the NO_X emission rates used in the assessment were reasonable, but conservative • To verify the predicted concentrations of NO_X and NO_2 • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Continuous during the site preparation and construction phase with a re-evaluation at the end of each year • The monitoring equipment to be set up in a secure location near the Main Entrance to the Bruce nuclear site; between the construction activities and the property boundary • The monitoring (continuous NO_X analyzers) for NO_X and NO_2 to be co-located with the PM_{10} and $PM_{2.5}$ analyzer
Noise Levels	Site Preparation and Construction Phase	• To confirm that the construction noise predictions presented in the assessment were reasonable, but conservative • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Integrating sound level meter • Noise monitoring campaign of sufficient duration to confirm construction noise predictions presented in the assessment. This campaign would include a series of continuous noise readings taken at R1, R2 and R3 for a period of at least 48 hours

13.2 PERMITTING REQUIREMENTS

The follow-up program described above may be a requirement of the CNSC licence. In addition, it is expected that the DGR Project will be subject to a number of permitting requirements. Those permits related to the atmospheric environment include, but may not be limited to:

- Ontario Ministry of the Environment Certificate of Approval (Air and Noise) – Section 9 of the *Ontario Environmental Protection Act*, requires that equipment, structures or processes that may discharge a contaminant, as defined by the Act, to the atmosphere must be approved before construction, alteration, extension or replacement of the equipment. Approval is also required for the ongoing operation of any equipment that may discharge a contaminant to the atmosphere. Most industrial processes, equipment or modifications to industrial processes and equipment require a Certificate of Approval (Air and Noise), unless specifically exempted (e.g., Ontario Regulation 524/98: Certificate of Approval Exemptions – Air).
- Regardless of compliance with Section 9, every facility is also required to meet the air quality standards, as stated in Ontario Regulation 419/05 (O.Reg.419/05). This regulation includes new atmospheric dispersion models and air quality standards, as compared to its predecessor, Ontario Regulation 346/90 (O.Reg.346/90).

Additionally, the DGR Project may be subject to the reporting under requirements under Section 46 of the *Canadian Environmental Protection Act*, SC 1999 (National Pollutant Release Inventory [NPRI]). Organizations that meet certain reporting thresholds are required annually to submit a NPRI report to Environment Canada. The report must quantify the releases to air, water, land and material recovery of listed substances. The reporting thresholds are regularly reviewed and updated.

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14. CONCLUSIONS

This TSD evaluated the potential effect of the DGR Project on the atmospheric environment. The evaluation conclusions are highlighted below. Measurable emissions to the atmospheric environment of air quality and noise level indicator compounds were identified. These were evaluated to determine adverse effects. The residual adverse effects were evaluated and it is concluded that they do not result in significant adverse effects to the atmospheric environment, as described below.

- Increases in eight air quality indicator compounds were predicted during the site preparation and construction, and decommissioning phases and seven air quality indicators during the operations phase. While these effects were not assessed to be significant, the magnitudes for 24-hour SPM, 24-hour PM_{10} and 24-hour $PM_{2.5}$ were determined to be high. Follow-up monitoring has been proposed to confirm that significant adverse effects do not occur.
- Increases in noise levels were predicted during the site preparation and construction, and the decommissioning phases. These effects were assessed to be not significant.

Follow-up monitoring is recommended for the site preparation and construction phase, with a re-evaluation at the beginning of each year, to confirm the following:

- to verify the predicted concentrations for air quality indicator compounds; and
- to verify that the mitigation measures considered integral to the project are being incorporated as planned, and are effective.

Specifically, continuous monitoring of PM_{10} and $PM_{2.5}$ is recommended for the site preparation and construction phase with a re-evaluation at the end of each year. It is recommended that the monitors be securely located between the DGR Project and the property boundary.

Additionally, a noise campaign of sufficient duration to confirm construction noise predictions presented in the assessment is recommended during the site preparation and construction phase of the DGR Project. This campaign would include continuous noise readings taken at R1, R2 and R3 for at least 48 hours.

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APPENDIX A: LIST OF ACRONYMS, UNITS AND TERMS

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LIST OF ACRONYMS

Acronym	Descriptive Term
AAQC	Ambient Air Quality Criteria
AECL	Atomic Energy of Canada Limited
CadnaA	Computer Aided Noise Attenuation Prediction Model
CEAA	Canadian Environmental Assessment Act
CGM3	Canadian Climate Change Model
CNSC	Canadian Nuclear Safety Commission
CofA	Certificate of Approval
CO	Carbon Monoxide
DGR	Deep Geologic Repository
EA	Environmental Assessment
EC	Environment Canada
EIS	Environmental Impact Study
FPTCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment
GHG	Greenhouse Gas
Golder	Golder Associates Ltd.
HCII	Specific Impact or Impulse Level
ILW	Intermediate Level Waste
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
L&ILW	Low and Intermediate Level Waste
L_{90}	Equivalent Noise Level 90th Percentile
L_d	Daytime Equivalent Noise Level
L_{eq24}	Whole Day Equivalent Noise Level
L_{eq}	Energy Equivalent Noise Level
L_n	Night-time Equivalent Noise Level
MOE	Ministry of the Environment
MSC	Meteorological Services of Canada
NO_2	Nitrogen Dioxide
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NPRI	National Pollutant Release Inventory
NWMO	Nuclear Waste Management Organization
NWS	National Weather Service

Acronym	Descriptive Term
O_3	Ozone
OPG	Ontario Power Generation Inc.
$PM_{2.5}$	Airborne Particles with Aerodynamic Diameters of 2.5 μm or less
PM_{10}	Airborne Particles with Aerodynamic Diameters of 10 μm or less
QA/QC	Quality Assurance/Quality Control
RA	Responsible Authority
SO_2	Sulphur Dioxide
SPM	Suspended Particulate Matter
TSD	Technical Support Document
VEC	Valued Ecosystem Component
VOC	Volatile Organic Compound
WHO	World Health Organization
WPRB	Waste Package Receipt Building
WWMF	Western Waste Management Facility
U.S. EPA	United States Environmental Protection Agency

LIST OF UNITS

Symbol	Units
%	Percent
%HA	Percent Highly Annoyed
°C	Degrees Celsius
cm	Centimetre
dB	Decibels
dB_{lin}	Un-weighted Decibels
dBA	A-weighted Decibels
g/L	Grams per Litre
ha	Hectares
Hz	Hertz
kg/d	Kilograms per Day
km	Kilometres
km^2	Square Kilometres
km/h	Kilometres per Hour
kt CO_2e/a	Kilotonnes of Carbon Dioxide per Year
kW	Kilowatt
M	Metres
m/s	Metres per Second
m^3	Cubic Metres (volume)
µm	Micrometre
µg/m^3	Microgram per Cubic Metre
mg/L	Milligrams per Litre
Mm	Millimetres
ppb	Parts per Billion
ppm	Parts per Million
t	Tonne

GLOSSARY OF TERMS

Aboriginal traditional knowledge – Knowledge that is held by, and unique to, Aboriginal peoples. Aboriginal traditional knowledge is a body of knowledge built up by a group of people through generations of living in close contact with nature. It is cumulative and dynamic and builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Bruce nuclear site – The 932 hectare (9.32 km2) parcel of land located within the administrative boundaries of the Municipality of Kincardine in Bruce County. Two operating nuclear stations are located on the site. The site is owned by OPG but has been leased to Bruce Power since May 2001. However, parts of the site, including land on which WWMF is located, have been retained by OPG. See also OPG-retained lands.

Bruce Power – The licensed operator of the Bruce A and Bruce B nuclear generating stations.

Canadian Nuclear Safety Commission (CNSC) – The Canadian federal agency responsible for regulating nuclear facilities and materials, including management of all radioactive waste in Canada.

Canadian Environmental Assessment Agency (CEAA) – The federal body accountable to the Minister of the Environment. The Agency works to provide Canadians with high-quality environmental assessments that contribute to informed decision making, in support of sustainable development.

Closure – The administrative and technical actions directed at a repository at the end of its operating lifetime. For example covering the waste (for a near surface repository), backfilling and/or sealing of rooms, tunnels and/or shafts (for a geological repository), and termination or completion of activities in any associated structures.

Decommissioning – Those actions taken, in the interest of health, safety, security and protection of the environment, to retire a licensed activity/facility permanently from service and render it to a predetermined end-state condition.

Deep Geologic Repository (or DGR, or Repository) – The underground portion of the deep geologic repository facility for low- and intermediate-level waste. Initially, the repository includes the access-ways (shafts, ramps and/or tunnels), underground service areas and installations, and emplacement rooms. In the postclosure phase it also includes the engineered barrier systems. The repository includes the waste emplaced within the rooms and excludes the excavation damage zone.

Descriptive Geosphere Site Model – A description of the present day 3-dimensional physical and chemical characteristics of a specific site as they relate to implementation of the Deep Geologic Repository concept. The model is based on the integration of multi-disciplinary geoscientific data that, in part, relies on multiple lines of evidence to constrain uncertainty and/or non-unique in interpretation.

Direct Effect – A direct effect occurs when the VEC is affected by a change that results from a project work and activity.

DGR Project Site – The portion of the Project Area that will be affected by the site preparation and construction of surface facilities (i.e., the surface footprint).

Dispersion – A small scale, spreading and mixing process resulting from dissolved substances traveling at different velocities along and between flow paths through a porous or fractured medium. The spreading of the dissolved substance in the direction of bulk flow is known as longitudinal dispersion. Spreading in directions perpendicular to bulk flow is known as transverse dispersion.

Emplacement Room – A portion of the underground repository into which waste packages are permanently placed. Rooms are bounded by the host rock for floor, ceiling and walls on most sides, and by a wall or access tunnel on one side.

Geosynthesis – The assembly of all the geologically-based evidence relevant to the repository safety case; the integration of multi-disciplinary geoscientific data relevant to the development of a descriptive conceptual geosphere model; explanation of a site-specific descriptive conceptual geosphere model within a systematic and structured framework.

Indirect Effect – An indirect effect occurs when the VEC is affected by a change in another VEC.

Intermediate-Level Waste (ILW) – Radioactive non-fuel waste, containing significant quantities of long-lived radionuclides (generally refers to half-lives greater than 30 years).

Low Level Storage Building (LLSB) - Refers to a series of buildings at OPG's Western Waste Management Facility for the interim storage of low-level waste.

Low-Level Waste (LLW) – Radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC), and which contains primarily short-lived radionuclides (half-lives shorter than or equal to 30-years).

OPG-retained Land – The parcels of land at the Bruce nuclear site for which control has been retained by OPG. This includes the WWMF, certain landfills, and the Heavy Water Plant Lands.

Precautionary Approach – The precautionary approach is ultimately guided by judgement, based on values and is intended to address uncertainties in the assessment. This approach is consistent with Principle 15 of the 1992 Rio Declaration on Environment and Development. Principle 15 of 1992 Rio Declaration on Environment and Development and the Canadian government’s framework for applying precaution in decision-making processes.

Receptor – Any person or environmental entity that is exposed to radiation, or a hazardous substance, or both. A receptor is usually an organism or a population, but it could also be an abiotic entity such as surface water or sediment.

Risk – A multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential exposures. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences.

Traditional ecological knowledge – Traditional ecological knowledge is a subset of Aboriginal traditional knowledge. Traditional ecological knowledge refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people. There are four traditional ecological knowledge categories: knowledge about the environment; knowledge about the use of the environment; values about the environment; and the foundation of the knowledge system.

Valued Ecosystem Component (VEC) – VECs are features of the environment selected to be a focus of the environmental assessment because of their ecological, social, or economic value, and their potential vulnerability to the effects of the DGR Project.

Waste Package Receiving Building (WPRB) – The building at the DGR surface where waste packages arrive for transfer underground.

Western Waste Management Facility (WWMF) – The centralized processing and storage facility at the Bruce nuclear site for OPG's L&ILW and for the dry storage of used fuel from Bruce nuclear generating stations.

APPENDIX B: BASIS FOR THE EA

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Table B-1: Basis for the EA

Project Works and Activities	Description
Site Preparation	Site preparation would begin after receipt of a Site Preparation Licence and would include clearing approximately 30 ha of the DGR Project site and preparing the construction laydown areas. Activities would include: • Removal of brush and trees and transfer by truck to on-site storage; • Excavation for removal and stockpiling of topsoil and truck transfer of soil to stockpile on-site; • Grading of sites, including roads, construction laydown areas, stormwater management area, ditches; • Receipt of materials including gravel, concrete, and steel; • Installation of construction roads and fencing; • Receipt and installation of construction trailers and associated temporary services; and • Install and operate fuel depot for construction equipment.
Construction of Surface Facilities	Construction of surface facilities will include the construction of the waste transfer, material handling, shaft headframes and all other temporary and permanent facilities at the site. Activities would include: • establish a concrete batch plant; • receipt of construction materials, including supplies for concrete, gravel, and steel by road transportation; • excavation for and construction of footings for permanent buildings, and for site services such as domestic water, sewage, electrical; • construction of permanent buildings, including headframe buildings associated with main and ventilation shafts; • receipt and set up of equipment for shaft sinking; • construction of abandoned rail bed crossing between WWMF and the DGR site; • fuelling of vehicles; and • construction of electrical substation and receipt and installation of standby generators.
Excavation and Construction of Underground Facilities	Excavation and construction of underground facilities will include excavation of the shafts, installation of the shaft and underground infrastructure (e.g., ventilation system) and the underground excavation of the emplacement and non-storage rooms. Activities will include: • drilling and blasting (use of explosives) for construction of main and ventilation shafts, and access tunnels and emplacement rooms; • receipt and placement of grout and concrete, steel and equipment; • dewatering of the shaft construction area by pumping and transfer to the above-ground stormwater management facility; • temporary storage of explosives underground for construction of emplacement rooms and tunnels; • receipt and installation of rock bolts and services; and • installation of shotcrete.
Above-ground Transfer and Receipt of Waste	Above-ground handling of wastes will occur during the operations phase of the DGR Project and will include receipt of L&ILW from the WWMF at the staging area in the DGR Waste Package Receiving Building (WPRB) and on-site transfer to shaft. Above-ground handling of wastes includes: • receipt of disposal-ready waste packages from the WWMF by forklift or truck • offloading of waste packages at the WPRB; • transfer of waste packages within the WPRB by forklift or rail cart; • temporary storage of waste packages inside the WPRB.

Table B-1: Basis for the EA (continued)

Project Works and Activities	Description
Underground Transfer of Waste	Underground handling of wastes will take place during the operations phase of the DGR Project and will include: • receipt of waste packages at the the main shaft station; • offloading from cage and transfer of waste packages by forklift to emplacement rooms; • rail cart transfer of some large packages (Heat Exchangers/Shield Plug Containers) to emplacement rooms; • installation of end walls on full emplacement rooms; • remedial rock bolting and rock wall scaling; • fuelling and maintenance of underground vehicles and equipment; • receipt and storage of fuel for underground vehicles. Emplacement activities will be followed by a period of monitoring to ensure that the DGR facility is performing as expected prior to decommissioning.
Decommissioning of the DGR Project	Decommissioning of the DGR Project will require a separate environmental assessment before any activities can begin. Decommissioning of the DGR Project will include all activities required to seal shafts and remove surface facilities including: • removal of fuels from underground equipment; • removal of surface buildings, including foundations and equipment; • receipt and placement of materials, including concrete, asphalt, sand, bentonite for sealing the shaft; • construction of concrete monolith at base of two shafts, removal of shaft infrastructure and concrete liners, and reaming of some rock from the shafts and shaft stations; • sealing the shaft; and • grading of the site. The waste rock pile (limestones) will be covered and remain on-site.
Abandonment of the DGR Facility	Timing of abandonment of the DGR facility will be based on discussion with the regulator. Activities may include removal of access controls.
Presence of the DGR Project	Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security over the life cycle of the DGR Project. This includes the aesthetics and vista of the DGR facility.
Waste Management	Waste management represents all activities required to manage waste during the DGR Project. During construction waste management will include managing the waste rock along with conventional waste management. During operations, waste management would include managing conventional and radiological wastes from the underground and above-ground operations. Decommissioning waste management may include management of conventional and construction wastes. Activities include: • transfer of waste rock, by truck to the WRMA; • placement of waste rock on the storage pile; • collection and transfer of construction waste to on-site or licensed off-site facility; • collection and transfer of domestic waste to licensed facility; • collection, processing and management of any radioactive waste produced at the DGR facility; • collection, temporary storage and transfer of toxic/hazardous waste to licensed facility.

Table B-1: Basis for the EA (continued)

Project Works and Activities	Description
Support and Monitoring of DGR Life Cycle	Support and monitoring of DGR life cycle will include all activities to support the safe construction, operation, and decommissioning of the DGR Project. This includes: • operation and maintenance of the ventilation fans, heating system, electrical systems, fire protection system, communications services, sewage and potable water system and the standby generator; • collection, storage, and disposal of water from underground sumps, and of wastewater from above-and below ground facilities; • management of surface drainage in a stormwater management facility; • monitoring of air quality in the facility, exhaust from the facility, water quality of run-off from the developed area around the shafts and Waste Rock Management Area, water quality from underground shaft sumps and geotechnical monitoring of various underground openings; • maintenance and operation of fuel depots above-ground (construction only) and below-ground; and • administrative activities above- and below-ground involving office space, lunch room and amenities space.
Workers, Payroll and Purchasing	Workers, payroll and purchasing will include all workers required during each phase to implement the DGR Project. Activities include: • spending in commercial and industrial sectors; • transport of materials purchased to the site; and • workers travelling to and from site.

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APPENDIX C: METEOROLOGY AND CLIMATE

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C1. INTRODUCTION

The physical processes of the atmosphere will have profound effects on air quality, and the transport and dispersion of emissions from the DGR Project. These processes can be grouped, and referred to, as meteorology and climate.

Meteorology refers to the day-to-day, or hour-to-hour, variations in parameters such as wind, precipitation or temperature. A five-year set of hourly meteorological data has been compiled for use in modelling changes in air quality dispersion modelling, which represent the range of meteorological conditions likely to occur at the DGR Project.

Climate, on the other hand, represents the expected values for parameters such as wind, precipitation or temperature. The climate of an area is described using normals, which are averages calculated over a 30 year period (the latest accepted normals period is from 1971 to 2000) [C1].

This appendix summarizes the various parameters that comprise the dispersion meteorology and compare them to long-term climate normals. Comparison of the dispersion meteorology to the long-term normals will help ascertain whether the five-year dispersion meteorological data set is representative of the long-term conditions (i.e., climate normals) for the region.

C2. DATA SOURCES

C2.1 CLIMATE DATA SOURCES

Climate data from the Wiarton and Paisley climate stations was selected to describe the long-term climate for the region, as well as for comparisons with the dispersion meteorology. The data used to describe the region’s climate consists of climate normals data from 1971 to 2000 for the Wiarton Airport – WMO ID 71633 (meets standards of the World Meteorological Organization for stations that transmit observations in international meteorological formats) and Paisley climate station, as published by Environment Canada [C2]. Table C2.1-1 provides details on the climate data sources and parameters used. Data from the station in Wiarton would be considered to be of greater quality because of its WMO designation. The locations of the meteorological and climate stations used in this assessment are shown on Figure C2.1-1.

Table C2.1-1: Climate Data Sources and Parameters

Station	Years	Parameters
Wiarton	1971-2000	temperature, precipitation, winds
Paisley	1971-2000	temperature, precipitation, winds

0 10 20 40 60 80 100

Kilometres

LEGEND

- On-site Meteorological Tower
- Meteorological and Climate Station
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF CLIMATE AND METEOROLOGICAL DATA SOURCES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE C2.1-1**	
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

C2.2 METEOROLOGICAL DATA SOURCES

In evaluating the potential air quality effects from the DGR Project, a five-year dispersion meteorological data set (i.e., 2005 through 2009) was developed. The Ontario Ministry of Environment [C3] and the U.S. EPA [C4] both recommend using a full five year dispersion meteorological data set when evaluating the emissions from a project to ensure that the full range of possible conditions are evaluated. In selecting the appropriate data to use in the modelling, the decision process illustrated on Figure C2.2-1 was followed.

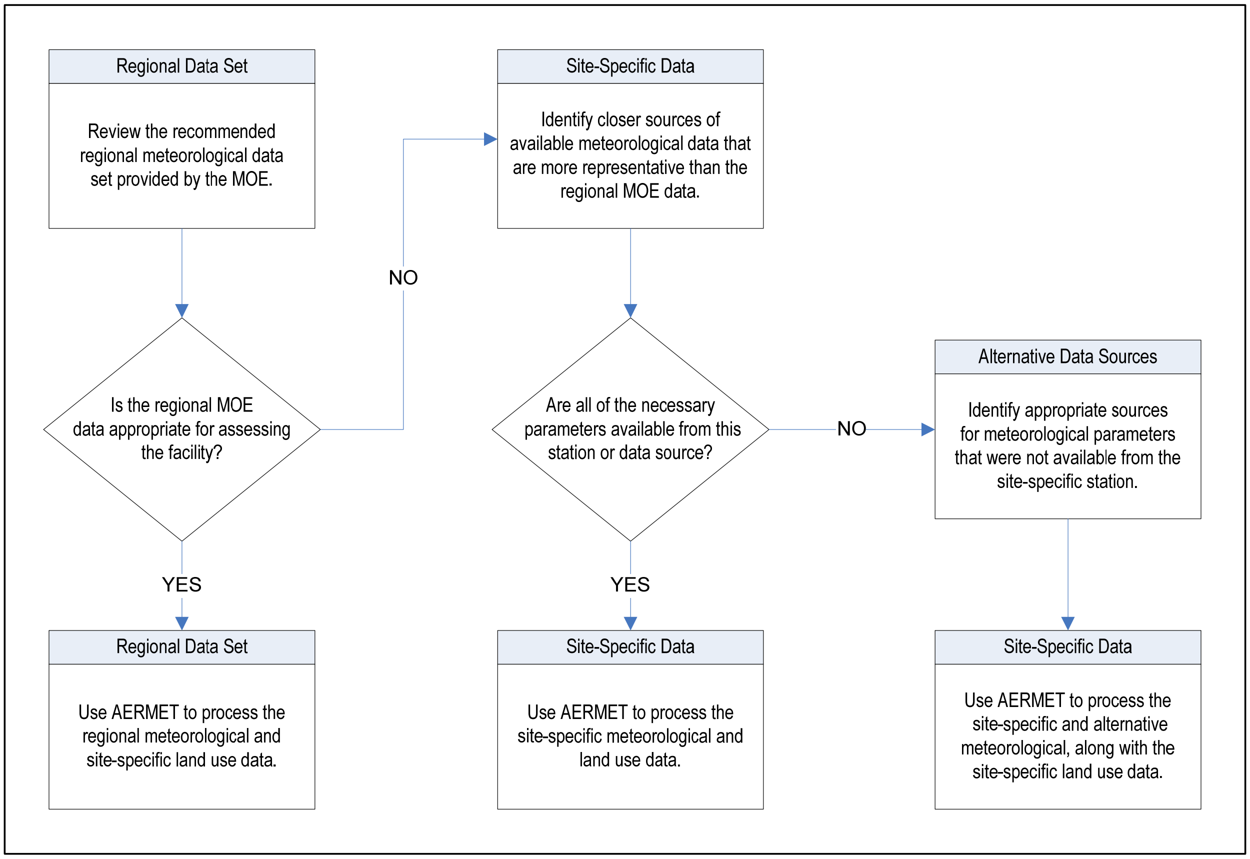


Figure C2.2-1: Decision Process to Select Data Sources for Dispersion Meteorology

The "decision process" used in selecting the five year dispersion meteorological data set used to evaluate emissions from the DGR Project is described below:

- **Review of the Regional Meteorological Data Set**: The Ontario Ministry of Environment has prepared a series of five-year regional meteorological data sets and recommends that it be used when running the AERMOD dispersion model for permitting purposes in the province. However, the regional meteorological modelling set recommended for use at the Bruce nuclear site is based on surface data from Pearson International Airport in Toronto and upper air observations from Buffalo, NY. This station is located approximately 170 km to the southwest of the DGR Project, in an area of distinctly different land use and topography. The regional meteorological data from

Pearson International Airport were not considered to be suitable for use in this assessment for evaluating the emissions from the DGR Project since the facility is located on the shores of Lake Huron, and will be greatly influenced by winds and weather across the lake.

- **Bruce Power On-site Meteorological Data**: There are two meteorological stations located at the Bruce nuclear site; a short 10 m tall tower and a fully instrumented 50 m-tower. A review of the towers' data suggested that the information from the 50 m-tower would be more reliable. However, because the majority of the sources of emissions at the DGR Project are located close to the ground, data from the lower (i.e., 10 m) level on the 50 m-tower was considered to be more appropriate for use as dispersion meteorology.
- **Identify Suitable Sources for Missing Data**: A suitable Meteorological Services of Canada (MSC) data source was located at the airport in Wiarton Ontario. This station was used to provide the additional meteorological observations that were not available from the on-site station. The specific data used from the Wiarton station were cloud cover, cloud ceiling height, cloud opacity, surface pressure, station pressure, relative humidity, and precipitation. The necessary upper air sounding data were obtained from the National Weather Service (NWS) Gaylord, Michigan, upper air station.

As mentioned above, the Wiarton station data provides additional weather parameters such as cloud cover, cloud ceiling height, cloud opacity, surface pressure, station pressure relative humidity, and precipitation. The on-site 50 m-tower provides temperature readings at the 10 m height, and wind measurements at 10 and 50 m heights. Table C2.2-1 summarizes the number of hours of data used for dispersion modelling from each station. The on-site surface temperature data from the 10 m height at the 50 m-tower provided most of the hourly temperatures. When this data was missing, the corresponding hourly data from the Wiarton station were substituted. The hourly wind data were taken from the 50 m-tower at the 10 m height, as noted above. In those situations when winds were missing at the 10 m height, the corresponding hourly value was rarely available at the 50 m level (i.e., both the 10 and 50 m winds were missing). Therefore, data from the Wiarton station were used when winds from the on-site 50 m-tower were not available. The dispersion meteorology prepared for use in the assessment was complete, and there were no holes where data were missing.

Table C2.2-1 Number of Hours of Data for Dispersion Modelling

Parameter	Period	Hours of Data Used		
		On-site 50 m-Tower (10 m height)	On-site 50 m-Tower (50 m height)	Wiarton Station
Wind Direction	2005-2009	43,216	0	608
Wind Speed	2005-2009	43,216	0	608
Surface Temperature	2005-2009	42,062	0	1,762

Once the available meteorological data were compiled, they needed to be processed to be suitable for use in the AERMOD dispersion model. The meteorological input files used by the AERMOD dispersion model are generated using the AERMET pre-processor, which is designed to be run in the following three stages:

- the first stage extracts the data and assesses data quality;
- the second stage merges the available data for 24-hour periods and writes these data to an intermediate file; and
- the third and final stage reads the merged data file and develops the necessary boundary layer parameters for dispersion calculations by AERMOD.

Figure C2.2-2 illustrates the steps followed in processing the meteorological data for use by AERMOD, and shows how quality assurance of the meteorological data is performed at four critical junctures before the data set is used by AERMOD. The AERMET pre-processor produces two meteorological data files. The first file contains boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length) as well as wind speeds, wind directions, and temperature at a reference-height. The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind.

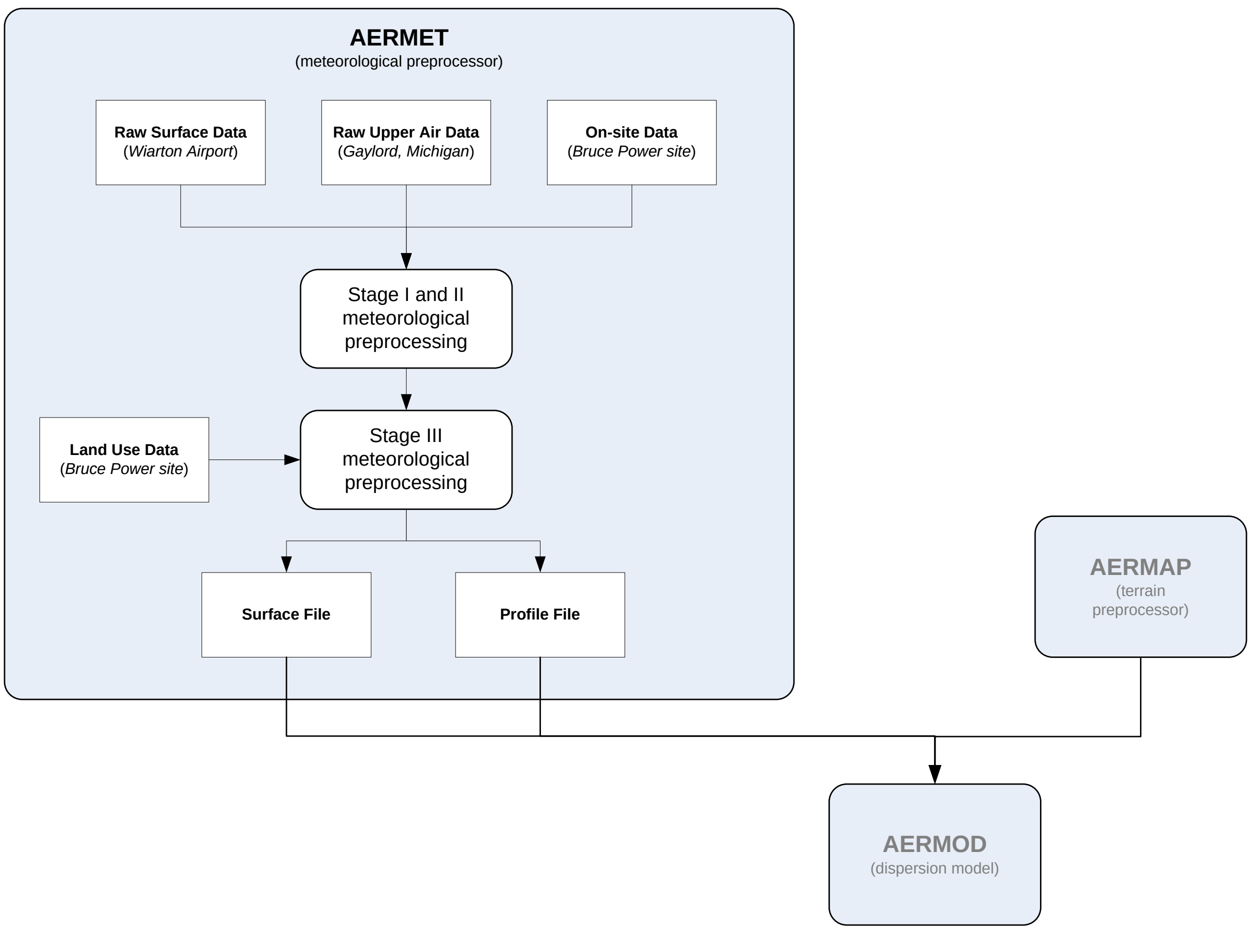


Figure C2.2-2: Flow Diagram for the AERMET Pre-Processor

The following sections describe the meteorology and climate used in the assessment.

C2.3 COMPARISON OF DISPERSION METEOROLOGY WITH REGIONAL STATIONS

Prior to developing a dispersion meteorology data set, on-site meteorological observations from both the 50 and 10 m tower were compared to selected archived weather maps to identify whether the data recorded at the Bruce nuclear site matched with regional weather patterns. This was done by a Canadian Meteorological and Oceanographic Society (CMOS) certified meteorologist. Generally, archived weather patterns matched the on-site observations reasonably well, with data from the 50 m tower showing a better correlation than from the 10 m tower. Of the two levels of data available from the 50 m tower, both showed good agreement with archived weather maps and data, with one exception. Under certain conditions, the data from the 10 m level on the 50 m tower showed the influence of local topographic features and influences of lake-land interactions (e.g., lake breezes). Given the relatively low release height of the sources at the DGR Project, these localized phenomena were considered to be appropriate when modelling the emissions.

In the following sections, the dispersion meteorological data developed for use in assessing the DGR Project have been compared to climate normals data from both the stations in Wiarton and Paisley. The following conclusions can be made:

- Temperature: The temperatures for the dispersion meteorology fall within the range of the climate normals for both Wiarton and Paisley.
- Precipitation: The precipitation used in the dispersion modelling comes from hourly observations at Wiarton. The five year dispersion meteorology falls within the range of the climate normals observed at Wiarton. Observed normals at Paisley are also similar to those for Wiarton and the dispersion meteorology.
- Wind speed and direction: Monthly wind speeds and directions for the dispersion meteorology are compared to the climate normals for both Wiarton and Paisley. This comparison shows a good agreement on a monthly basis.

C3. TEMPERATURES

Surface temperature is an indirect measure of the energy present in the lower levels of the atmosphere. This energy is important for dispersion as it drives local meteorology and affects regional weather patterns. All surface temperatures are measured at heights of between 1.5 and 2 m above ground level (the typical height for temperature measurement).

Figure C3-1 provides a comparison of the monthly and seasonal temperatures for the five-year dispersion meteorological data set used to evaluate the DGR Project (i.e., 2005 through 2009) to the long-term temperature normals for Wiarton. The figure confirms that the mean monthly temperatures for the dispersion meteorology generally fall within the expected range of temperatures defined by the Wiarton climate normals.

Table C3-1 provides a summary of the monthly temperatures for the dispersion meteorology used in assessing the DGR Project.

Table C3-2 provides a summary of the dispersion meteorology seasonal temperatures used in assessing the DGR Project. For the purposes of this assessment, the four seasons of the year include, March, April, May (Spring); June, July, August (Summer); September, October, November (Fall); and December, January, February (Winter).

Tables C3-3 and C3-4 provide a summary of the long-term monthly and seasonal temperature normals for the Wiarton Airport, respectively. Tables C3-5 and C3-6 provide a summary of the long-term monthly and seasonal temperature normals for Paisley, respectively.

The climate data for Wiarton presented in Tables C3-3 and C3-4, show similar long-term monthly and seasonal temperature trends. Therefore it is reasonable to conduct comparisons between the Wiarton climate data and the dispersion meteorology.

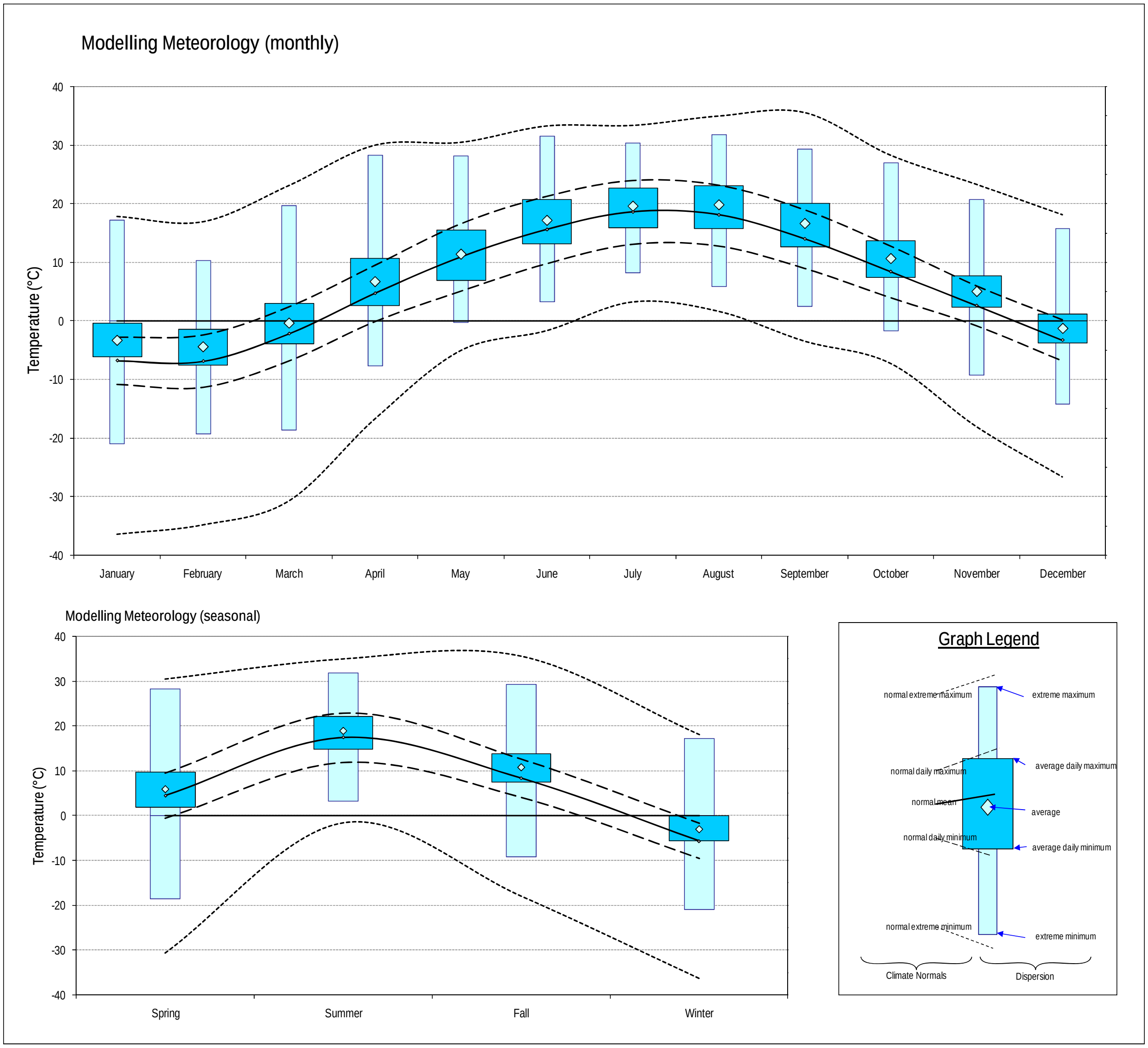


Figure C3-1: Summary of Temperature Data for the Dispersion Meteorology

Table C3-1: Monthly Temperature Summary for the Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-3.4	-4.5	-0.4	6.7	11.4	17.1	19.6	19.8	16.6	10.6	5.0	-1.3	8.2
Standard Deviation (°C)	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily Maximum (°C)	-0.4	-1.5	3.0	10.6	15.5	20.8	22.7	23.1	20.1	13.7	7.7	1.2	11.4
Daily Minimum (°C)	-6.2	-7.6	-3.9	2.6	6.9	13.1	15.9	15.7	12.6	7.4	2.4	-3.8	4.7
Extreme Maximum (°C)	17.2	10.3	19.7	28.3	28.2	31.6	30.3	31.8	29.3	27.0	20.7	15.7	31.8
Extreme Minimum (°C)	-21.1	-19.4	-18.7	-7.8	-0.3	3.2	8.2	5.8	2.4	-1.7	-9.3	-14.3	-21.1
Days per Year with Above 30°C	0	0	0	0	0	1	0	1	0	0	0	0	2
Days per Year with Below -10°C	9	9	3	0	0	0	0	0	0	0	0	2	23

Note:
— Because only five data points are available from the dispersion meteorology (e.g., five January average temperatures), a standard deviation was not calculated.

Table C3-2: Seasonal Temperature Summary for the Dispersion Meteorology

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	5.9	18.8	10.7	-3.1	8.2
Daily Maximum (°C)	9.7	22.2	13.8	-0.3	11.4
Daily Minimum (°C)	1.9	14.9	7.4	-5.8	4.7
Extreme Maximum (°C)	28.3	31.8	29.3	17.2	31.8
Extreme Minimum (°C)	-18.7	3.4	-9.3	-21.1	-21.1
Days per Year with Maximum Above 30°C	0	2	0	0	2
Days per Year with Minimum Below -10°C	2	0	0	20	23

Table C3-3: Monthly Temperature Normals for Wiarton

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-6.8	-6.9	-2.2	4.7	10.9	15.6	18.6	18.1	14.0	8.4	2.6	-3.3	6.1
Standard Deviation (°C)	2.8	2.9	2.3	1.7	1.8	1.4	1.2	1.3	1.2	1.6	1.6	2.6	0.9
Daily Maximum (°C)	-2.8	-2.4	2.4	9.5	16.6	21.3	24.0	23.2	19.0	12.8	6.0	0.2	10.8
Daily Minimum (°C)	-10.8	-11.3	-6.8	-0.1	5.1	9.8	13.1	12.8	9.0	4.0	-0.8	-6.8	1.4
Extreme Maximum (°C)	17.8	16.9	23.1	30.0	30.5	33.3	33.4	35.0	35.6	28.3	23.3	18.1	35.6
Extreme Minimum (°C)	-36.4	-34.8	-30.7	-16.7	-5.0	-1.6	3.3	1.7	-3.4	-7.2	-18.0	-26.6	-36.4
Days per Year with Above 30°C	0	0	0	0	0	1	1	1	0	0	0	0	3
Days per Year with Below -10°C	16	16	9	0	0	0	0	0	0	0	1	9	50

Note: The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.

Table C3-4: Seasonal Temperature Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	4.5	17.4	8.3	-5.7	6.1
Daily Maximum (°C)	9.5	22.8	12.6	-1.7	10.8
Daily Minimum (°C)	-0.6	11.9	4.1	-9.6	1.4
Extreme Maximum (°C)	30.5	35.0	35.6	18.1	35.6
Extreme Minimum (°C)	-30.7	-1.6	-18.0	-36.4	-36.4
Days per Year with Maximum Above 30°C	0	3	0	0	3
Days per Year with Minimum Below -10°C	9	0	1	41	50

Note: The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.

Table C3-5: Monthly Temperature Normals for Paisley

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-7.0	-6.9	-2.2	5.1	11.5	15.9	18.9	18.2	14.1	8.2	2.5	-3.8	6.2
Standard Deviation (°C)	2.6	2.8	2.4	2.0	1.9	1.5	1.2	1.3	0.9	1.8	1.6	2.6	0.8
Daily Maximum (°C)	-3.2	-2.6	2.5	10.2	17.8	22.1	25.0	24.0	19.5	12.8	5.9	-0.5	11.1
Daily Minimum (°C)	-10.7	-11.3	-6.8	-0.1	5.2	9.6	12.7	12.4	8.8	3.5	-0.9	-7.1	1.3
Extreme Maximum (°C)	12.2	14.0	23.0	28.5	32.2	33.9	34.5	35.0	32.8	27.2	21.0	18.5	35.0
Extreme Minimum (°C)	-37.2	-40.0	-33.0	-18.9	-6.1	-2.2	2.2	0.0	-5.5	-8.3	-17.5	-31.0	-40.0
Days per Year with Above 30°C	0	0	0	0	0	0	0	0	0	0	0	0	0
Days per Year with Below -10°C	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: "—" Indicates that data is not available for this parameter.

Table C3-6: Seasonal Temperature Normals for Paisley

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	4.8	17.7	8.3	-5.9	6.2
Daily Maximum (°C)	10.2	23.7	12.7	-2.1	11.1
Daily Minimum (°C)	-0.6	11.6	3.8	-9.7	1.3
Extreme Maximum (°C)	32.2	35.0	32.8	18.5	35.0
Extreme Minimum (°C)	-33.0	-2.2	-17.5	-40.0	-40.0
Days per Year with Maximum Above 30°C	0	0	0	0	0
Days per Year with Minimum Below -10°C	0	0	0	0	0

C4. RELATIVE HUMIDITY AND DEW POINT

Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity (which depends on the current air temperature). A reading of 100 percent relative humidity means that the air is totally saturated with water vapour and cannot hold any more. Relative humidity is an important metric used in meteorology, as it indicates the likelihood of precipitation, dew or fog. High humidity makes people feel hotter outside in the summer, because it reduces the effectiveness of sweating, it also has an effect on the efficiency and performance of building cooling systems [C5].

Dew Point is the temperature to which a given parcel of air must be cooled, at a constant barometric pressure, for water vapour to condense into visible water. The condensed water is referred to as dew, so the dew point is basically the saturation point of a parcel of air.

Dew point and relative humidity are related in that a high relative humidity indicates that the dew point is closer to the current air temperature. For example, if the relative humidity is 100%, the dew point is equal to the current temperature.

The dew point depression is the difference between the actual ambient air temperature and the calculated dew point temperature for any air parcel. For example, a temperature of 25°C results in a dew point temperature of 10°C; the difference between the two is called the dew point depression. In this case, 15°C is a large difference. More moisture in the air parcel results in a smaller difference, but will have a higher relative humidity.

Temperature has a diurnal cycle; on clear and calm days the air temperature usually rises from a minimum (near sunrise) to a maximum (mid afternoon) and falls off thereafter into the evening and night. Relative humidity also exhibits a diurnal cycle. If the air mass stays constant with no additional moisture added to it, then the relative humidity varies inversely with the air temperature (i.e., relative humidity is highest when the temperature is lowest and vice versa).

Figure C4-1 illustrates the differences between the average daytime and night-time relative humidity and dew point depression at the DGR Project site. The figure illustrates daytime relative humidity averages of 70.5% and at night-time it is higher, with an average of 80.4%.

Dew point depression data also confirms that the average daytime dew point spread is 6°C, and during night-time is 3.5°C, indicating the air mass is closer to its point of condensation and more humid.

Figure C4-2 illustrates the fluctuations of dew point depression by hour of day and season. It is clear in this figure that night-time humidity is higher and seems to indicate that the local air mass is closer to its condensation point, as indicated by the smaller dew point spread.

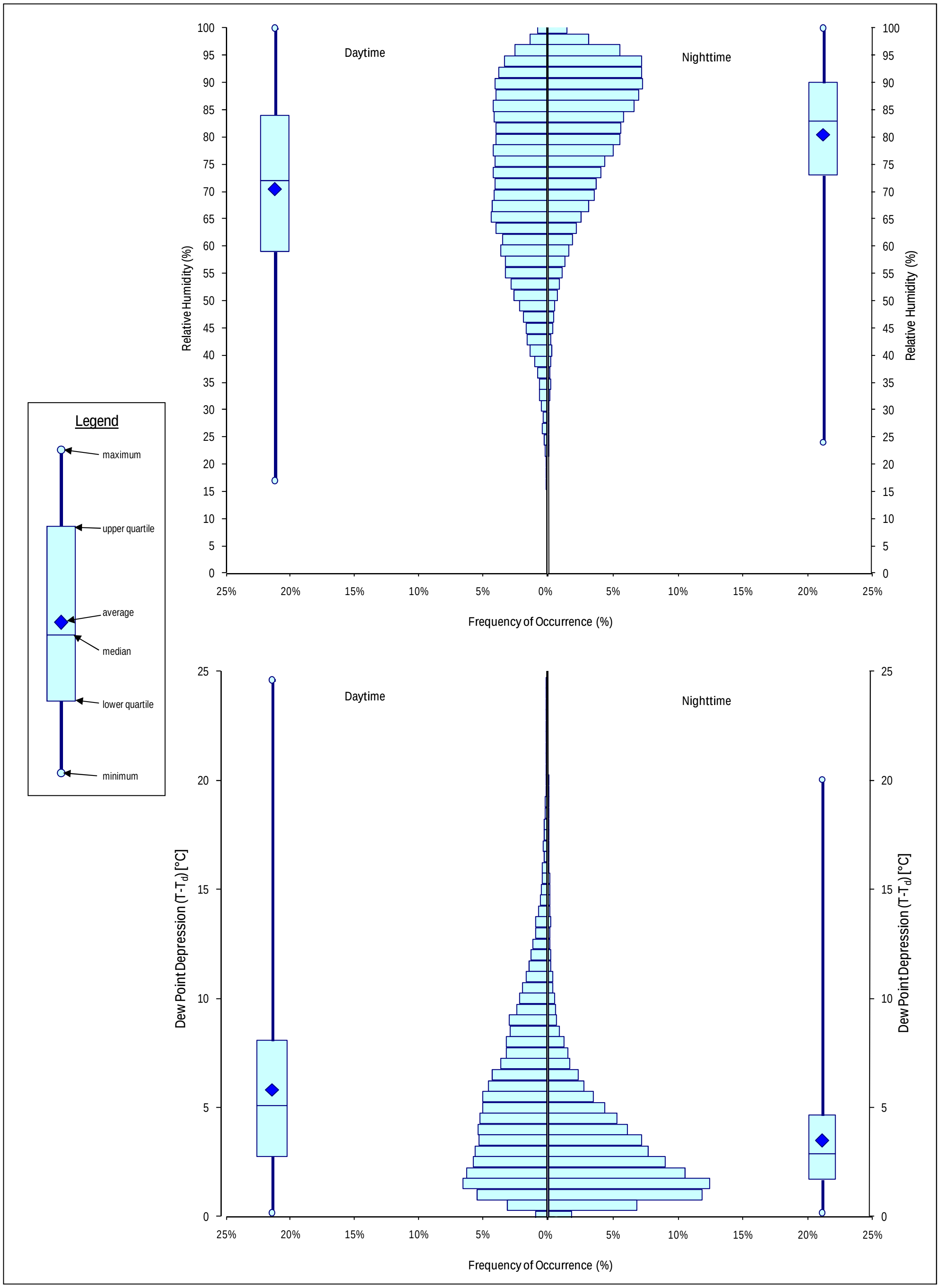


Figure C4-1: Diurnal Comparison of Relative Humidity and Dew Point Depression for the Dispersion Meteorology

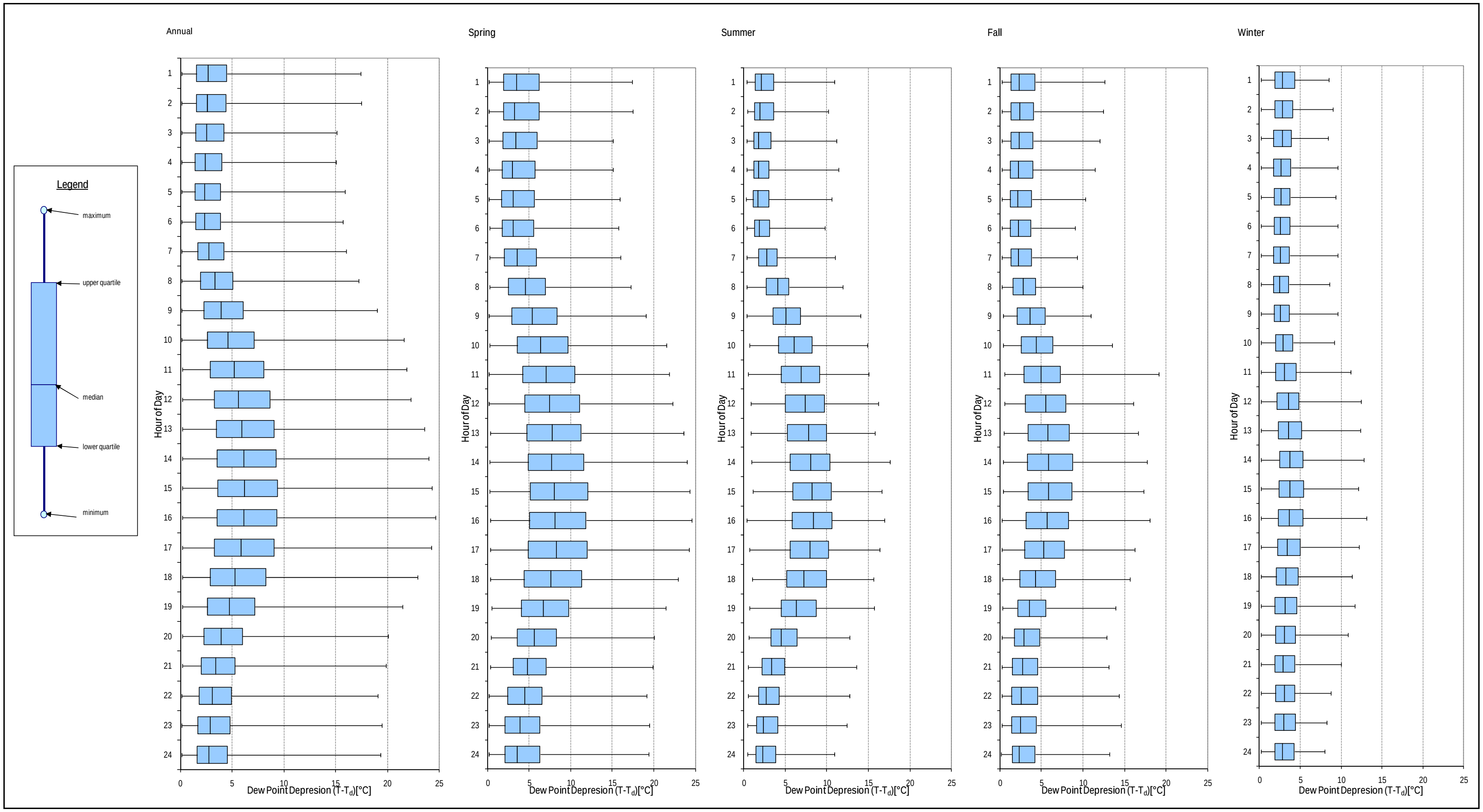


Figure C4-2: Fluctuations of Dew Point Depression by Hour of Day and Season

C5. PRECIPITATION

Although not directly used in the dispersion modelling, precipitation can have an influence on the emission rates for fugitive dust sources, as well as the rate at which particles and gases are removed from the air via wet deposition. This data is illustrated on Figure C5-1. Tables C5-1 and C5-2 provide a summary of the monthly and seasonal precipitation data for the dispersion meteorology.

Tables C5-3 and C5-4 provide a summary of the monthly and seasonal precipitation normals for the Wiarton Airport, respectively. Tables C5-5 and C5-6 provide a summary of the monthly and seasonal precipitation normals for Paisley, respectively. These tables demonstrate generally similar precipitation patterns and totals at both stations. The wettest season (total precipitation) is the fall with 311 mm of precipitation and the driest is spring with 217 mm.

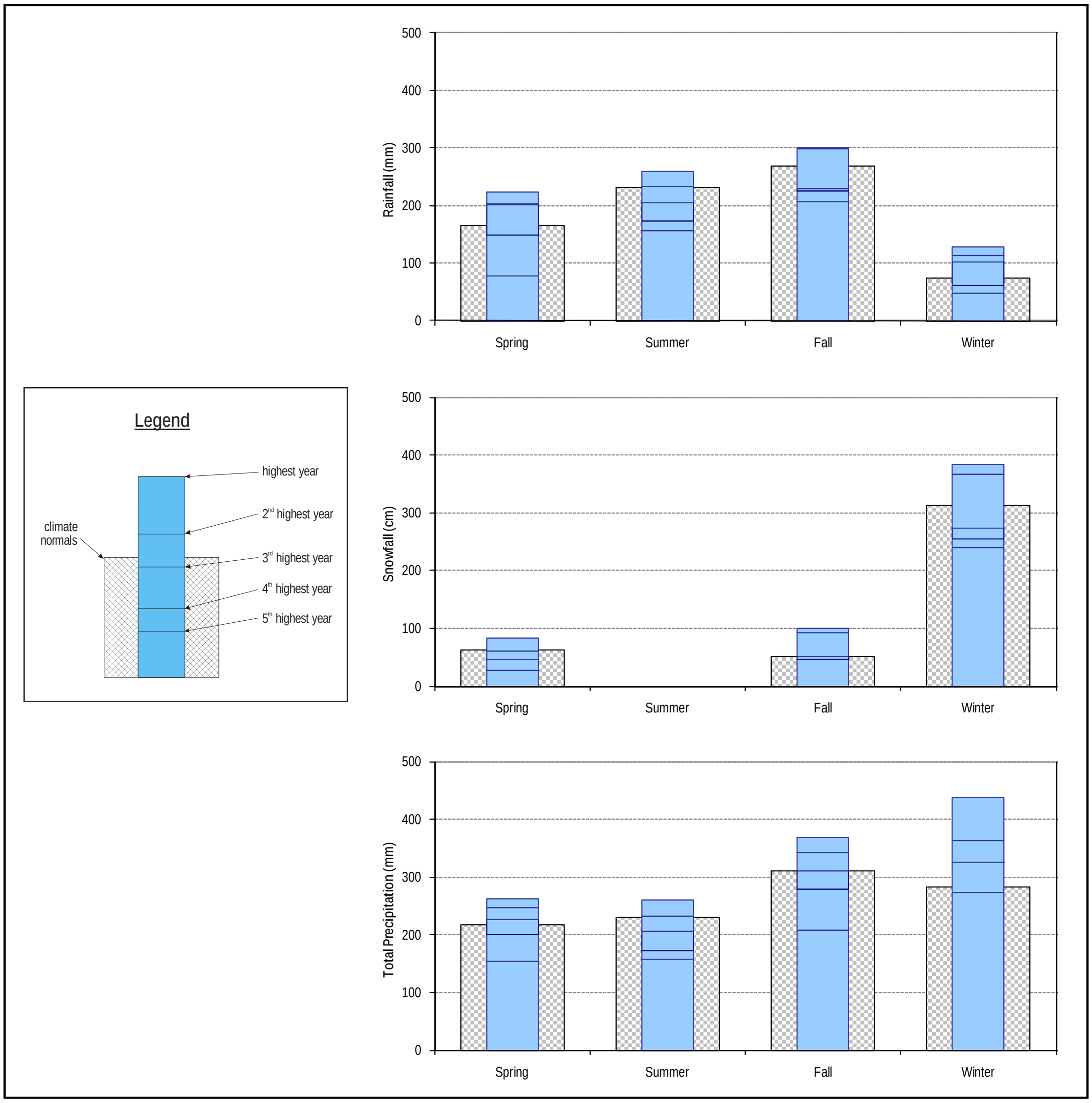


Figure C5-1: Summary of Precipitation Data for the Dispersion Meteorology

Table C5-1: Monthly Precipitation for Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	35.7	20.6	39.0	63.3	68.5	73.2	80.2	52.3	80.0	104.3	67.4	33.9	718.4
Snowfall (cm)	86.5	98.8	30.6	21.5	0.0	0.0	0.0	0.0	0.0	4.4	53.6	118.2	413.6
Precipitation (mm) [a]	106.7	101.6	65.2	84.1	68.5	73.2	80.2	52.3	80.0	108.7	112.8	137.0	1,070.3
Extreme Daily Precipitation (mm)	18.6	29.0	24.8	42.2	30.0	62.0	50.6	25.9	67.4	32.0	25.6	30.9	67.4
Days per Year with Measurable Precipitation	25	20	13	13	12	11	12	10	12	17	19	26	190

Notes:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal precipitation

Table C5-2: Seasonal Precipitation for Dispersion Meteorology

Parameter	Spring	Summer	Fall	Winter	Year
Rainfall (mm)	170.8	205.7	251.7	90.2	718.4
Snowfall (cm)	52.1	0.0	58.0	303.4	413.6
Total Precipitation (mm) [a]	217.8	205.7	301.6	345.3	1,070.3
Extreme Daily Precipitation (mm)	42.2	62.0	67.4	30.9	67.4
Days per Year with Measurable Precipitation	38	32	48	71	190

Notes:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal total precipitation

Table C5-3: Monthly Precipitation Normals for Wiarton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	21.8	20.7	36.6	54.9	74.3	74.4	71.2	85.2	104.3	86.9	77.7	32.4	740.4
Snowfall (cm)	125.2	74.3	46.4	15.3	1.1	0.0	0.0	0.0	0.0	4.4	47.7	112.1	426.6
Precipitation (mm) [a]	105.3	68.0	73.4	68.1	75.3	74.4	71.2	85.2	104.3	91.0	115.6	109.5	1,041.3
Extreme Daily Precipitation (mm)	47.6	48.6	47.2	45.3	48.8	67.8	104.6	73.4	88.6	69.3	46.0	45.5	104.6
Days per Year with Measurable Precipitation	24	18	15	12	12	11	10	11	14	16	19	22	183

Notes:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal precipitation

Table C5-4: Seasonal Precipitation Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Rainfall (mm)	165.8	230.8	268.9	74.9	740.4
Snowfall (cm)	62.8	0.0	52.1	311.6	426.6
Precipitation (mm) [a]	216.8	230.8	310.9	282.8	1,041.3
Extreme Daily Precipitation (mm)	48.8	104.6	88.6	48.6	104.6
Days per Year with Measurable Precipitation	39	32	48	64	183

Note:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal precipitation

Table C5-5: Monthly Precipitation Normals for Paisley, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	18.4	23.4	50.7	60.1	75.4	76.4	73.9	101.2	111.0	97.2	74.3	40.6	802.6
Snowfall (cm)	125.7	69.6	37.7	10.3	0.1	0.0	0.0	0.0	0.0	1.0	36.4	109.4	390.1
Precipitation (mm) [a]	144.0	93.0	88.4	70.3	75.5	76.4	73.9	101.2	111.0	98.2	110.7	150.0	1,192.7
Extreme Daily Precipitation (mm)	45.7	43.7	45.8	43.0	43.2	65.4	88.6	117.6	79.0	38.6	45.4	53.3	117.6
Days per Year with Measurable Precipitation	23	18	16	14	12	12	10	12	15	17	18	22	187

Notes:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal precipitation

Table C5-6: Seasonal Precipitation Normals for Paisley, Ontario

Parameter	Spring	Summer	Fall	Winter	Year
Rainfall (mm)	186.2	251.5	282.5	82.4	802.6
Snowfall (cm)	48.1	0.0	37.4	304.7	390.1
Precipitation (mm) [a]	234.2	251.5	319.9	387.0	1,192.7
Extreme Daily Precipitation (mm)	45.8	117.6	79.0	53.3	117.6
Days per Year with Measurable Precipitation	42	34	50	62	187

Notes:
The numbers in the table above are correct, but as a result of rounding may not appear to add up to the yearly totals shown above.
a Rainfall (mm) and snowfall (cm) cannot be directly added together to equal precipitation

C6. WIND SPEED AND DIRECTION

Wind speed and wind direction are important parameters in determining the dispersion meteorology of an area. Wind speeds and directions also vary by the time of day and time of year. Figure C6-1 shows wind-roses for the annual, the daytime, and night-time wind speeds and directions for the dispersion meteorology used when evaluating the DGR Project. Figure C6-2 shows wind-roses for the annual and seasonal wind speed and direction for the dispersion meteorology used to evaluate the DGR Project. A “wind-rose” figure is often used to illustrate the frequency of wind direction and the magnitude of the wind speed. The lengths of the bars on the wind-rose indicate the frequency and speed of the wind. The wind direction (blowing from) is illustrated by the orientation of the bar in one of 16 cardinal directions.

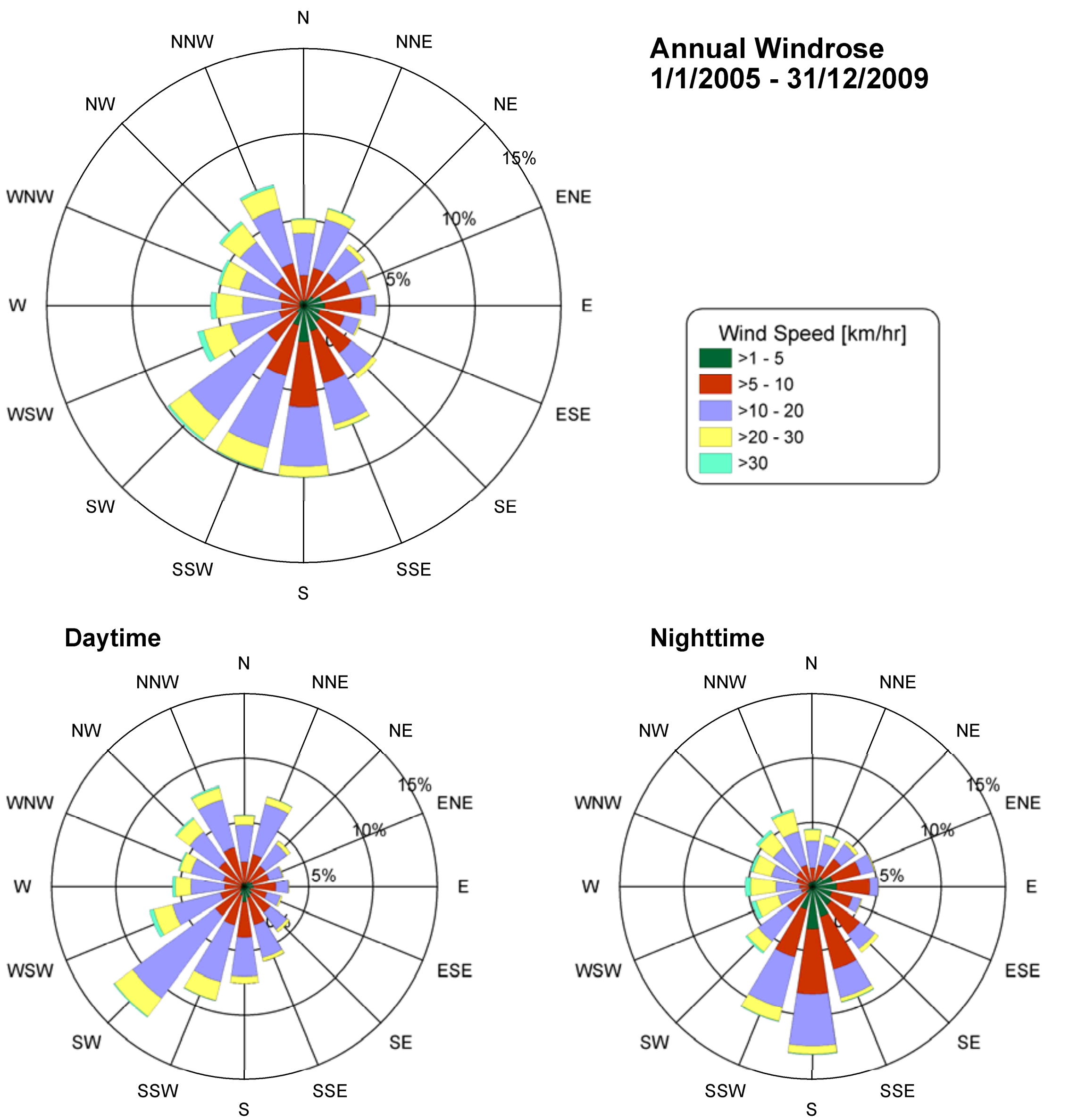


Figure C6-1: Diurnal Wind-Roses for Dispersion Meteorology

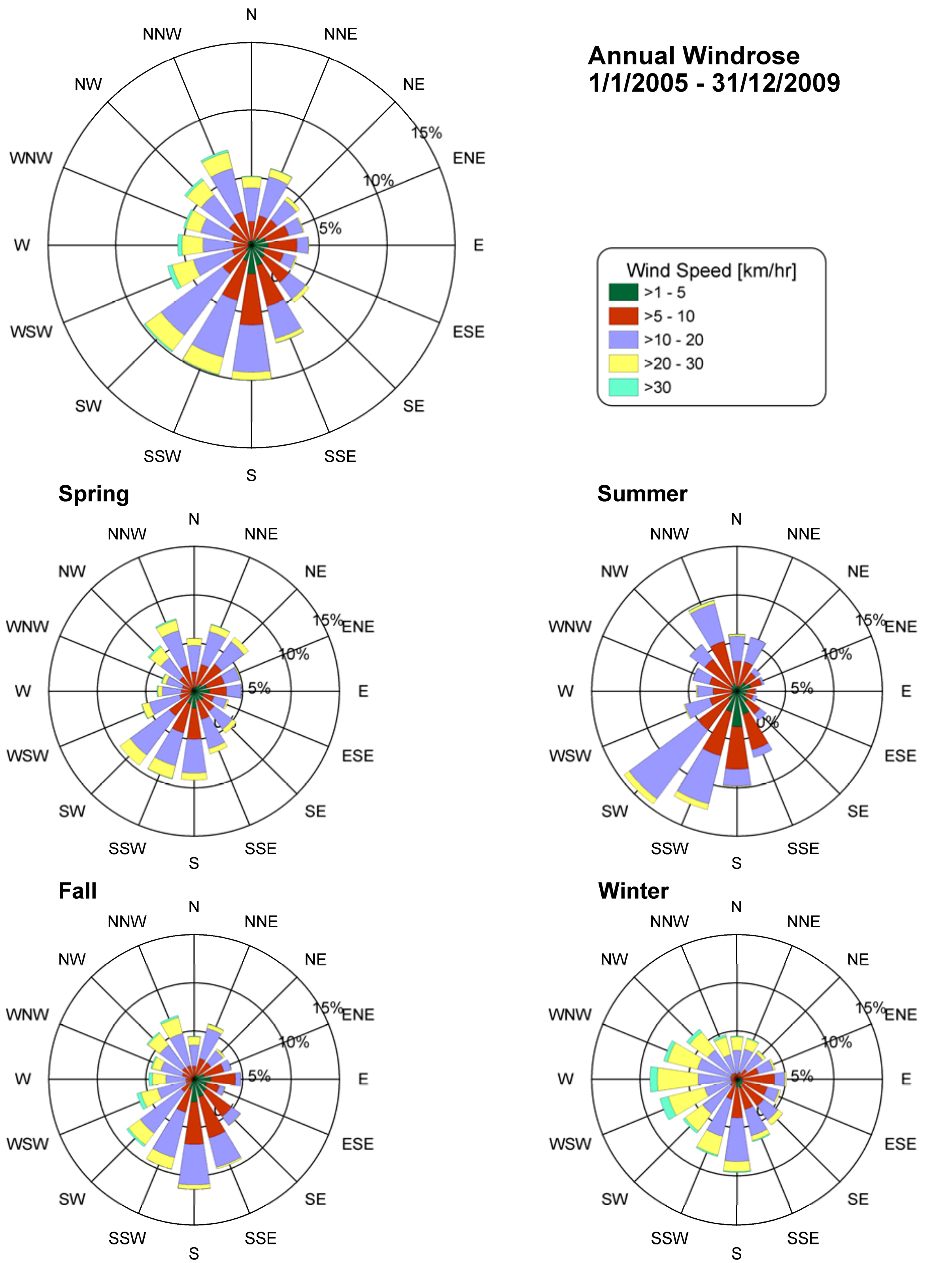


Figure C6-2: Annual and Seasonal Wind-Roses for Dispersion Meteorology

The annual wind-rose illustrates an even distribution of lower wind speeds (<11 km/h) from all directions and a higher frequency of stronger wind speeds (>11 km/h) from wind directions between the south and southwest, as well as winds from the north-northwest. Wind speeds and directions from the southerly direction are common throughout the year, which is consistent with the occurrence of more intense and active low pressure systems and fall-winter-spring storm formation during these months. The storm track also converges over the Great Lakes Basin, bringing a variety of storm types, with stronger and gustier winds. The strongest wind speeds occur during the fall and winter months (again, related to the increased storm formation and tracking over the region), while the spring and summer months experience an increase in the frequency of winds from the dominant southwest quadrant. The winter winds are clearly dominated from the westerly component of the wind rose.

Figure C6-3 illustrates the differences between the daytime and night-time wind speeds at the DGR Project site. Generally, the daytime and night-time wind speeds are similar.

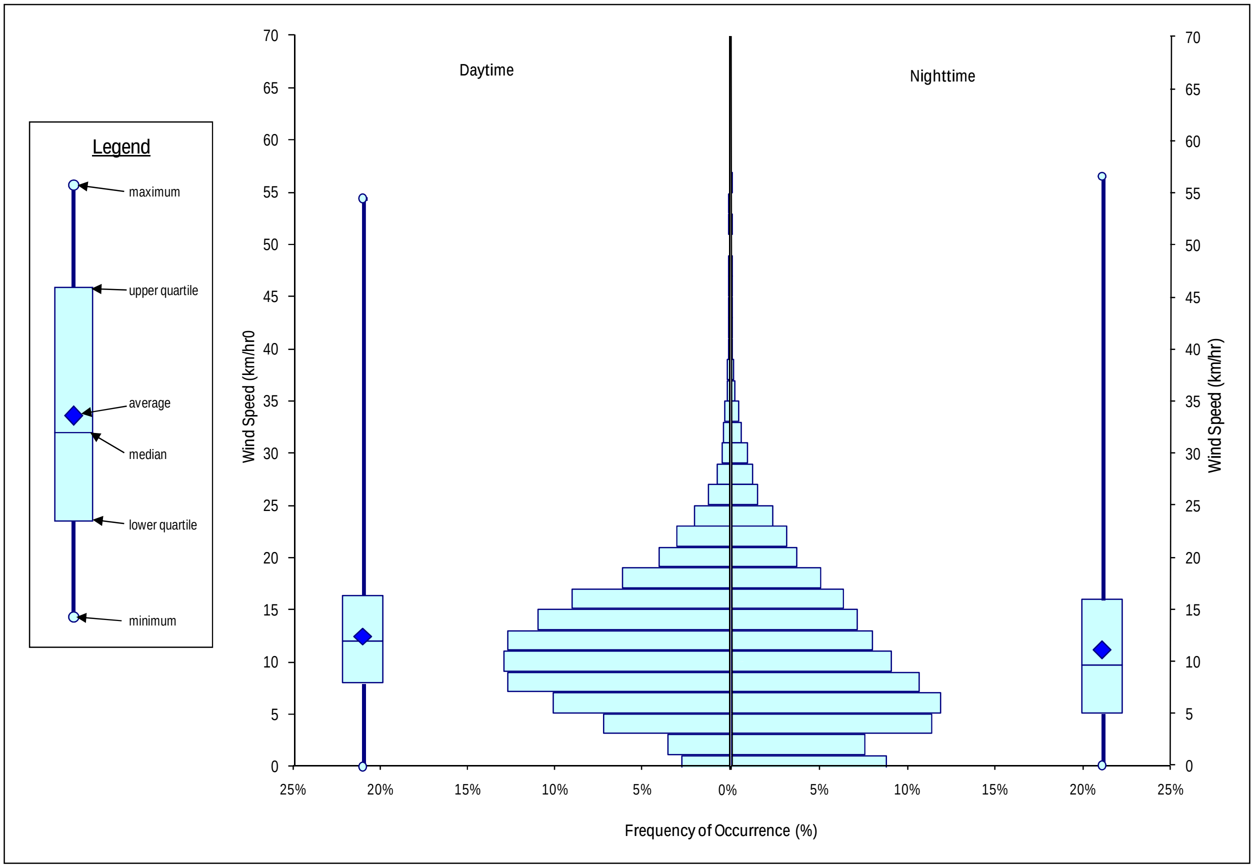


Figure C6-3: Diurnal Wind Speeds for Dispersion Meteorology

However, there are changes in the wind speeds during the day, as illustrated on Figure C6-4. This figure shows that the wind speeds, tend to increase towards the middle of the day, especially in the summer months when the sun effects are expected to be greatest and local land and lake breezes develop. Lake breezes develop when the synoptic or gradient winds are very light to non-existent; mostly clear skies are needed to allow the solar heating to warm the land. During the morning the land warms up significantly and the air above it becomes warmer, lighter and begins to rise. This causes a pressure gradient to develop between the air over land and that over the lake, which is cooler because of the lake water being cooler than the land. This cooler air begins to flow on shore to replace the warmer lighter air; this is the lake breeze phenomena. This is very evident in the spring and summer when wind speed increases in the late afternoon. In contrast, there is little change in the hourly wind speeds during the winter months when the sun effects are at their lowest and the wind speeds are governed more by synoptic and weather system effects.

There are also a number of distinct patterns associated with the variations of wind direction by time of day. Table C6-1 presents a summary of the winds for the dispersion meteorology used to evaluate the DGR Project in a form comparable to the climate normals for wind speed and direction provided by MSC. Tables C6-2 and C6-3 provide a summary of the monthly wind normals for the Wiarton Airport and Paisley MSC stations, respectively. The data shows that the wind normals are closely matched.

Figure C6-4 illustrates the fluctuations of wind speed by hour of day, while Figure C6-5 illustrates the fluctuations in annual wind direction by hour of the day. Figures C6-6 through to C6-9 shows the seasonal (spring, summer, fall and winter) fluctuations in wind direction by hour of day. Annually, the most prevalent wind direction is Southerly at the 2nd hour, and the least prevalent is Easterly at the 15th hour.

Each season has it differences in wind direction. These are illustrated in a series of graphs for the dispersion meteorology. In spring (Figure C6-6), the dominant wind direction is Southerly at the 23rd hour and the least prevalent direction is West at the 22nd hour. In summer (Figure C6-7), the prevalent winds are South at the 1st hour and the least prevalent direction is East at the13th hour. In fall (Figure C6-8), the dominant wind direction is South at the 24th hour, and the least prevalent direction is East at the 14th hour. Lastly, in winter (Figure C6-9), the dominant wind direction is West at the 19th hour, and the least prevalent direction is Northeast at the 20th hour.

The differences in temporal wind direction for the seasons are closely related to the storm track and frequency of low pressure area traveling through the region, especially in the fall-winter-spring seasons. In the summer, there are influences from Lake Huron and lake breeze development in the late afternoons.

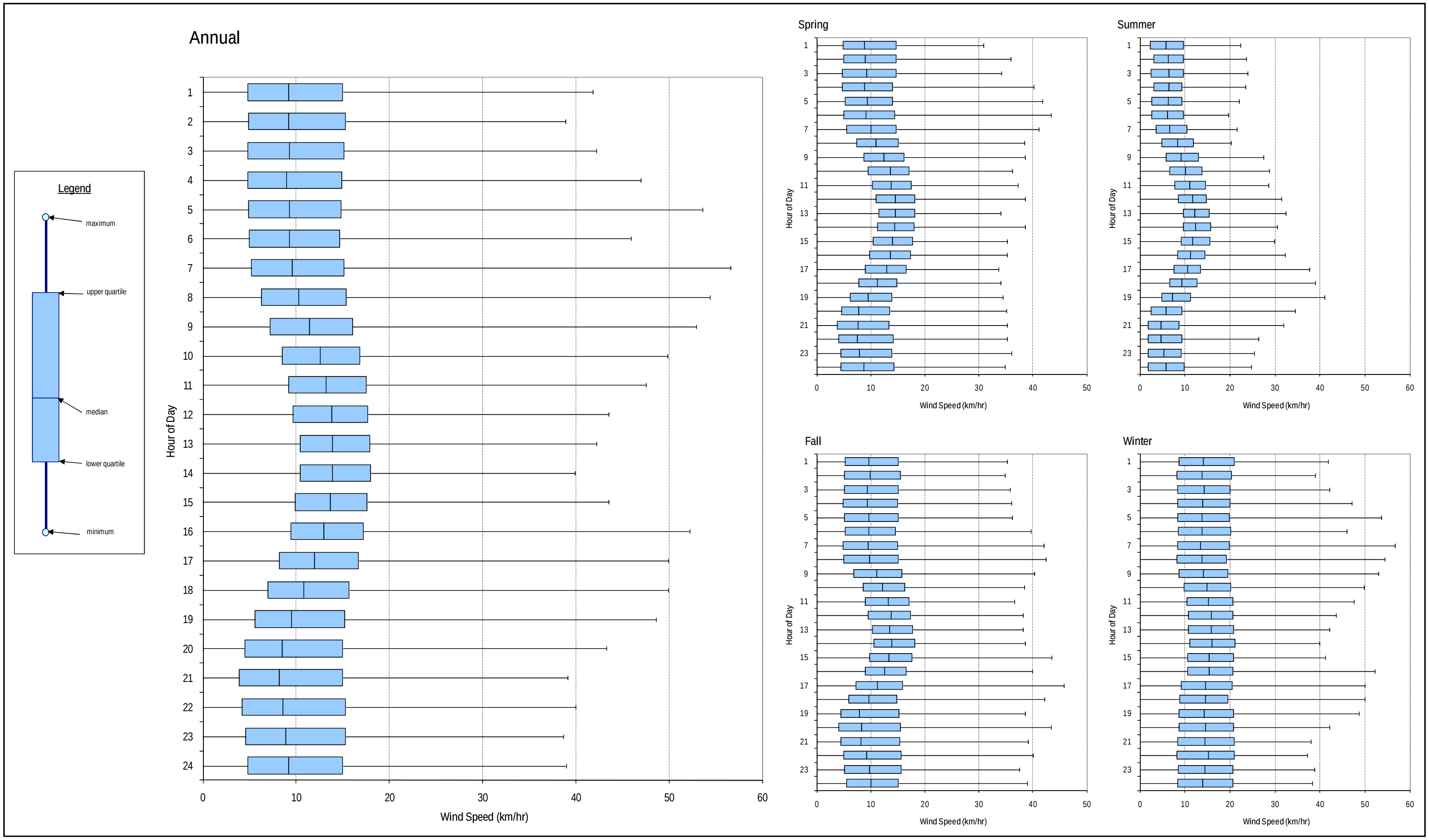


Figure C6-4: Fluctuations of Wind Speed by Hour of Day for Dispersion Meteorology

Table C6-1: Monthly Wind Summary for Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Speed (km/h)	14.9	15.1	12.5	12.2	10.2	8.3	8.7	8.9	9.7	12.1	13.4	15.3	11.8
Most Prevalent Direction	S	S	S	SW	SW	SW	SW	N	S	S	S	W	S

Table C6-2: Monthly Wind Normals for Wiarton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Speed (km/h)	17.1	14.7	14.6	14.4	11.8	10.5	10.2	10.3	11.9	14.5	15.9	16.0	13.5
Most Prevalent Direction	S	S	S	N	SW	SW	SW	SW	S	S	S	S	S

Table C6-3: Monthly Wind Normals for Paisley, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Speed (km/h)	18.2	15.7	16.0	15.9	12.9	11.8	10.6	10.5	11.9	14.3	16.9	17.1	—
Most Prevalent Direction	SW	SW	NW	NW	NW	SW	SW	SW	SW	SW	SW	SW	—

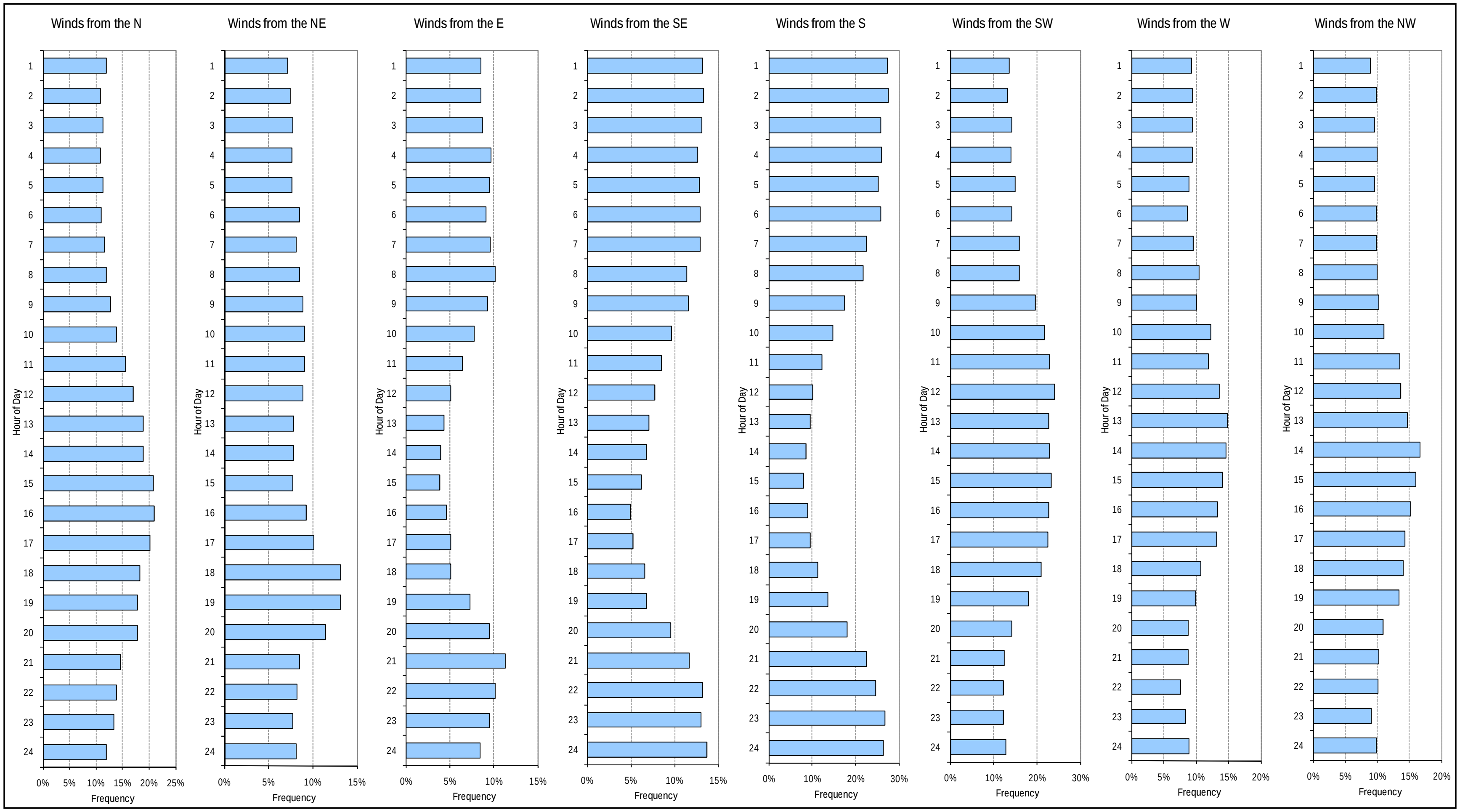


Figure C6-5: Fluctuations in Annual Wind Direction by Hour of Day for Dispersion Meteorology

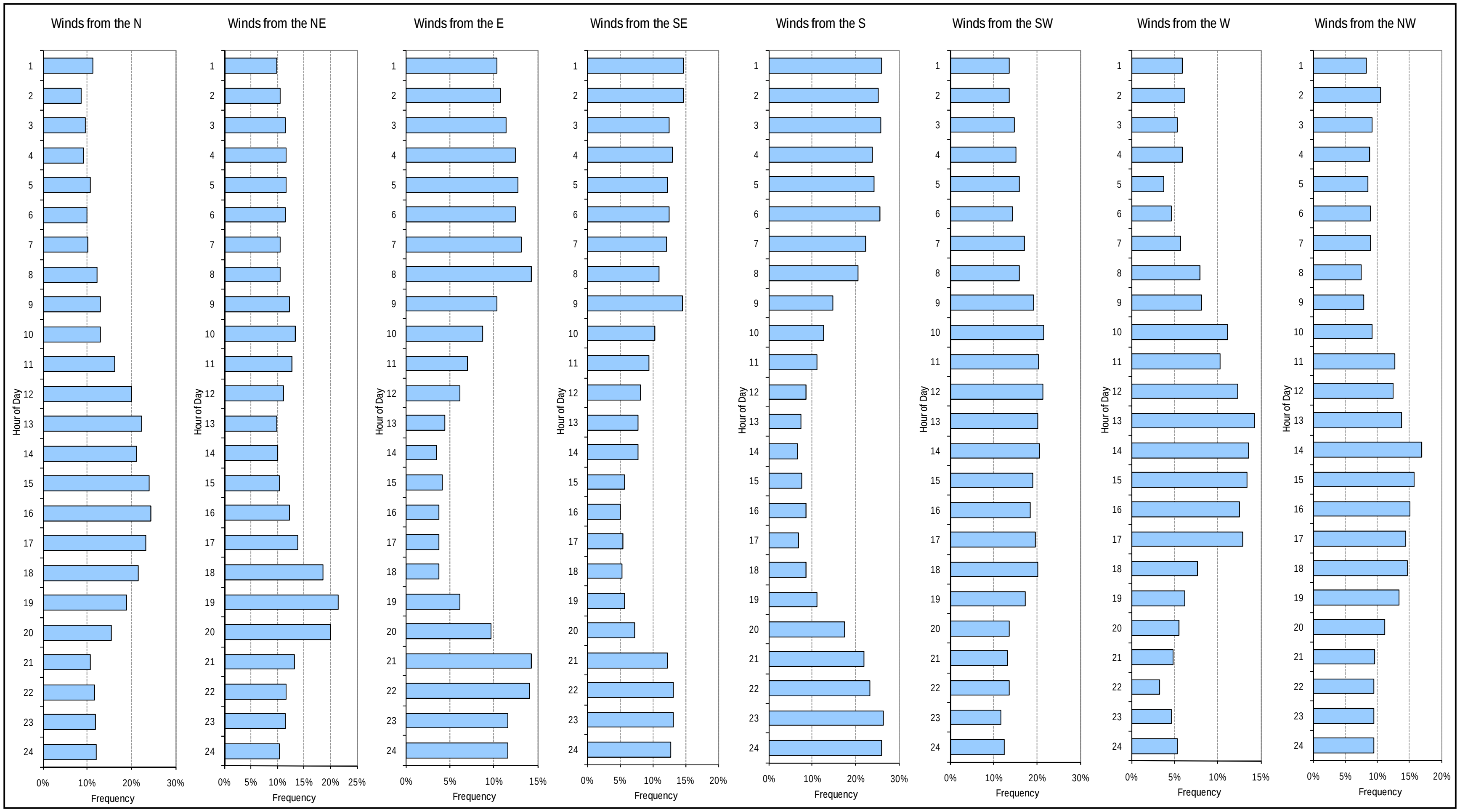


Figure C6-6: Fluctuations in Spring Wind Direction by Hour of Day for Dispersion Meteorology

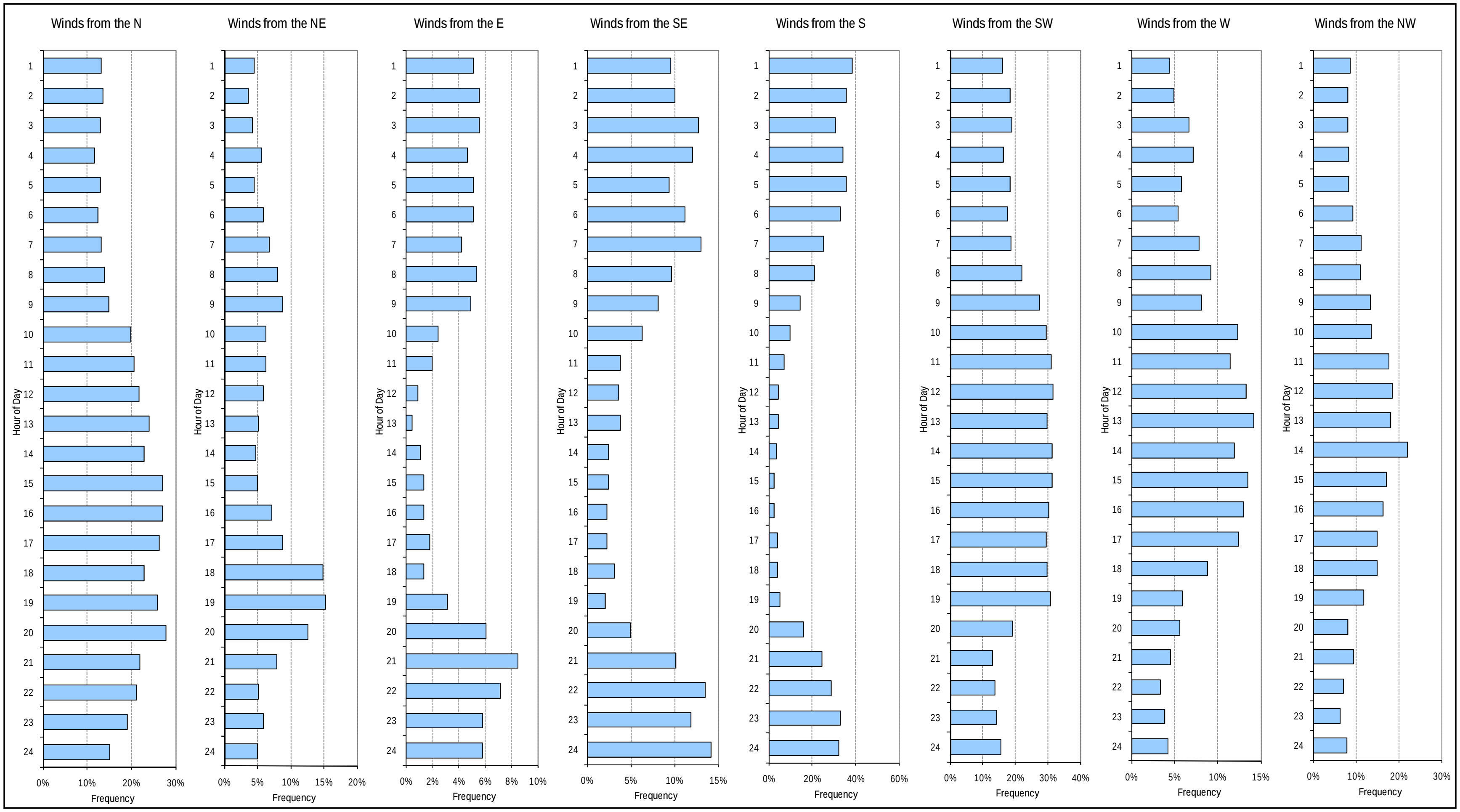


Figure C6-7: Fluctuations in Summer Wind Direction by Hour of Day for Dispersion Meteorology

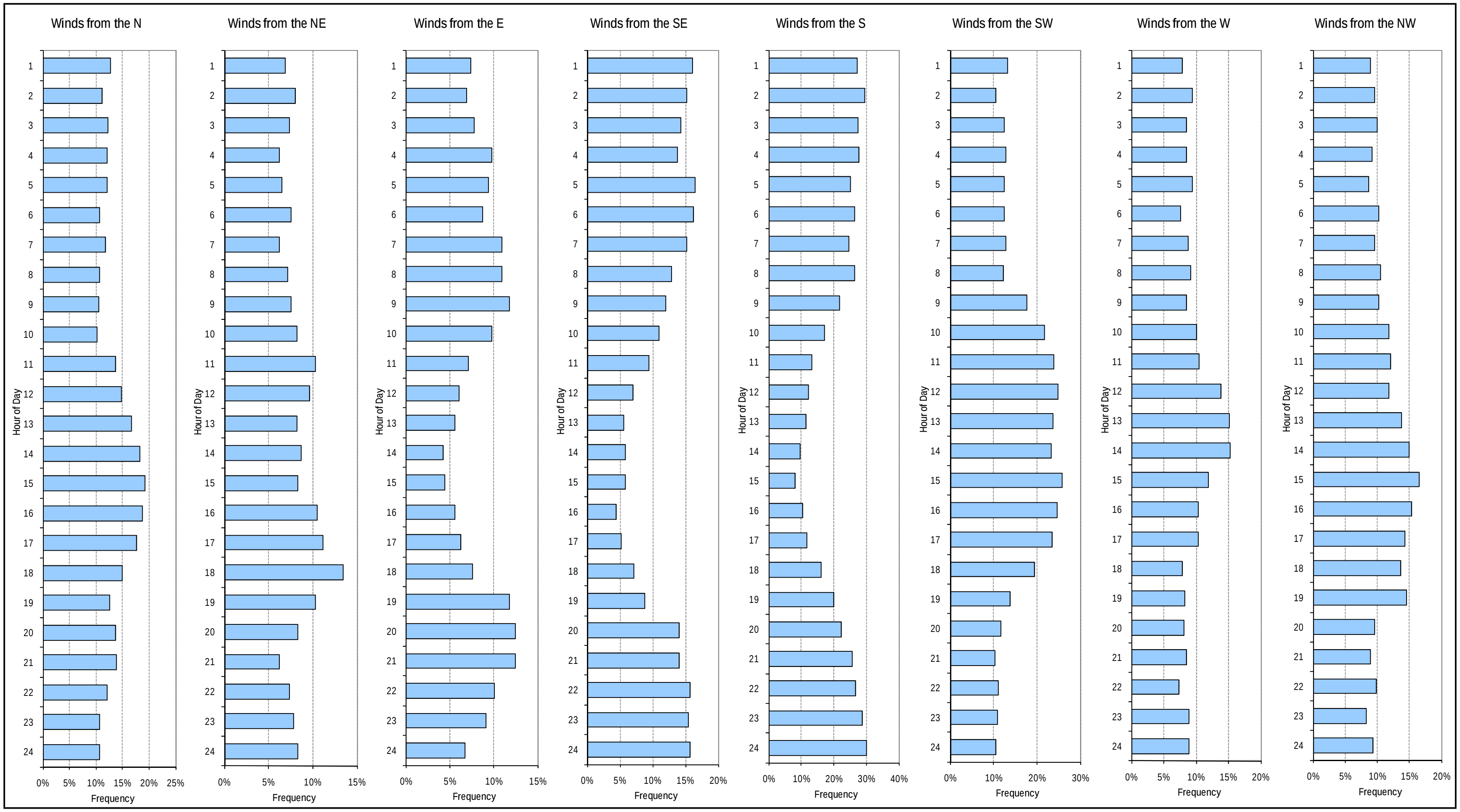


Figure C6-8: Fluctuations in Fall Wind Direction by Hour of Day for Dispersion Meteorology

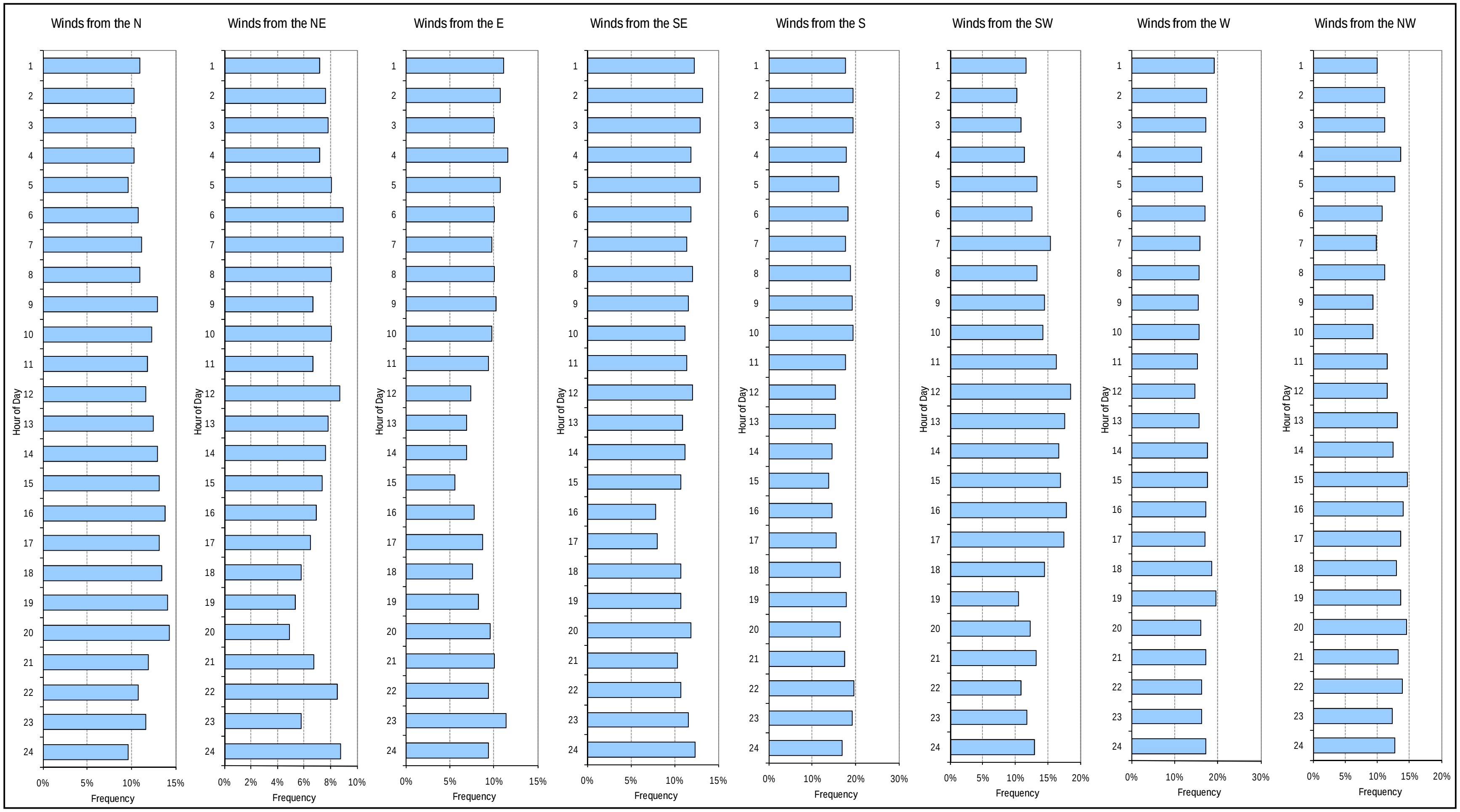


Figure C6-9: Fluctuations in Winter Wind Direction by Hour of Day for Dispersion Meteorology

C7. ATMOSPHERIC STABILITY

The stability of the atmosphere can be described as its tendency to resist or enhance vertical motion in the boundary layer. Three states of atmospheric stability are distinguished according to the vertical temperature profile or "lapse rate", namely: unstable, neutral and stable atmospheric conditions. Vertical movement is greatest under unstable atmospheric conditions, where the temperature decrease with height is greater than the adiabatic lapse rate of 0.98°C/100 m. An air parcel, which is forced to rise in an unstable atmosphere, will cool adiabatically, and hence remain warmer than the surrounding atmosphere and continue to rise. Similarly, if the parcel is forced downwards, the parcel of air will continue to fall, since it will cool faster than the atmosphere. Unstable conditions tend to enhance the vertical growth of the plume, causing an elevated plume to intersect the ground more rapidly. Unstable conditions are primarily associated with daytime heating conditions, which result in enhanced turbulence levels and enhanced dispersion. Stable conditions are primarily associated with night-time cooling conditions, which result in suppressed turbulence levels (poorer dispersion). Neutral conditions are primarily associated with higher wind speeds or overcast conditions [C6].

A summary of the daily atmospheric stability frequency for the dispersion meteorology is provided on Figure C7-1. The occurrence of unstable conditions is indicative of a low level of occurrence of local daytime solar heating making the air more buoyant and unstable (i.e. mid morning to early evening). Neutral and stable conditions are indicative of sinking air and are frequent during the late evening and night time hours when the local air mass tends to become less buoyant and more settled as solar heating is low or nonexistent (overnight hours). Further analysis of all unstable conditions reveal that low occurrence of extremely unstable condition (~5% of the time), which is indicative of strong convective activity and thunderstorms. Somewhat higher frequency of moderately unstable and slightly unstable conditions (>40% of the time, combined) is indicative of local lake-effect rain showers and snow-showers.

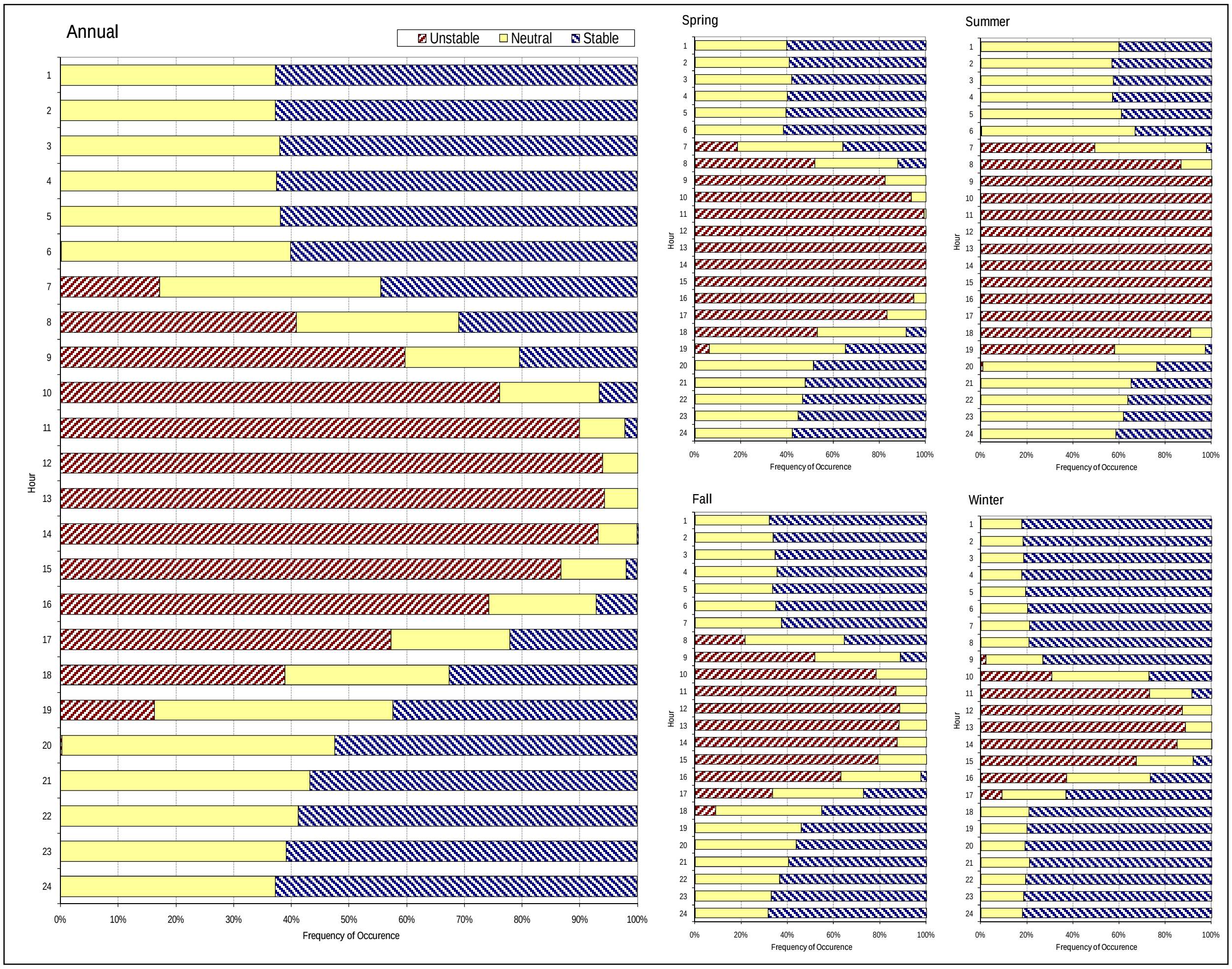


Figure C7-1: Atmospheric Stabilities for Dispersion Meteorology

C8. INVERSIONS AND MIXING HEIGHTS

C8.1 MIXING LAYER HEIGHTS

Another important parameter in the dispersion of emissions is the “mixing height”. This is the vertical extent, or height, through which a plume can be mixed in the atmosphere. The mixing heights are sustained by either convective or mechanical mixing. Convective mixing is primarily driven by surface heating; therefore convective mixing tends to occur during daytime rather than night-time hours. Mechanical mixing is primarily driven by wind-flows over uneven terrain, hence mechanical mixing is enhanced at higher wind speeds as they move over varying topography. Figure C8.1-1 shows the frequency of occurrence of daytime/night-time mixing heights for convective and mechanical mixing for the dispersion meteorology.

Analysis of the figure shows that the frequency of occurrence of convective mixing generally decreases with increasing mixing layer depth during daytime hours. This is consistent with the knowledge that convective mixing layer heights are generally lower during overcast days. The possible exception is on days with strong convective precipitation (i.e., very unstable atmospheric conditions). The average convective mixing height is approximately 650 m. Typically, convective activity associated with frontal systems and thunderstorms exhibit higher convective mixing heights, while lake-effect precipitation is characterized by lower convective mixing heights. The absence of night-time convective mixing heights (see Figure C8.1-2) is reflective of the rural nature of the land around the Bruce nuclear site. After sunrise, the mixing height continually increases during the day before drastically dropping at sunset. Night-time convective mixing depths do not occur in rural locations.

The high frequency of occurrence of low mechanical mixing heights is indicative of increased frequency of lower wind speeds during the night-time hours, an observation supported by the daytime/night-time wind-roses. The frequency of occurrence of the daytime mechanical mixing height increases from the surface to about 200 m and then decreases with altitude. This maximum at 200 m indicates the average height of the surface roughness, a measure of the variations in the height of topographical features and average wind speed.

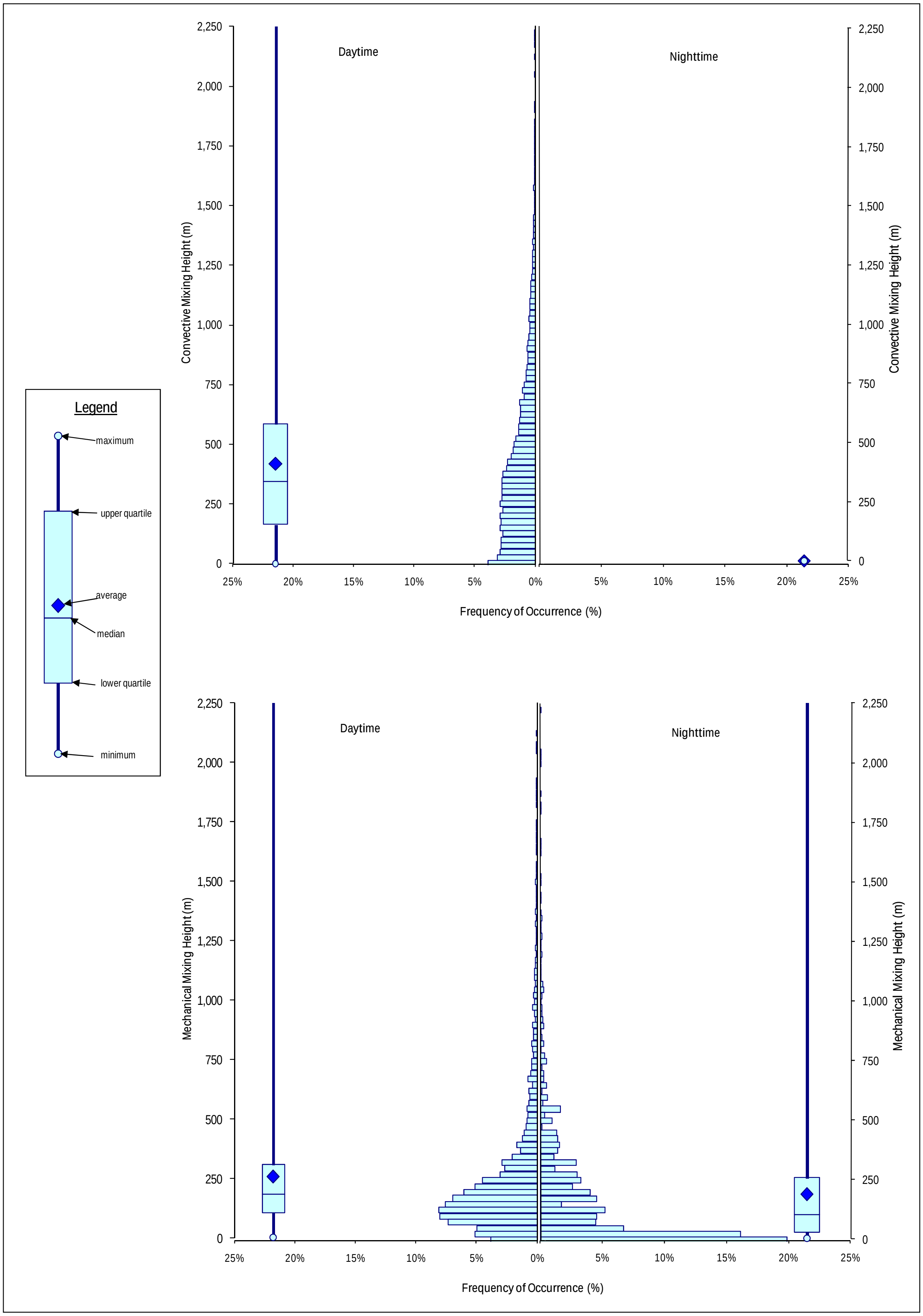


Figure C8.1-1: Mixing Heights for Dispersion Meteorology

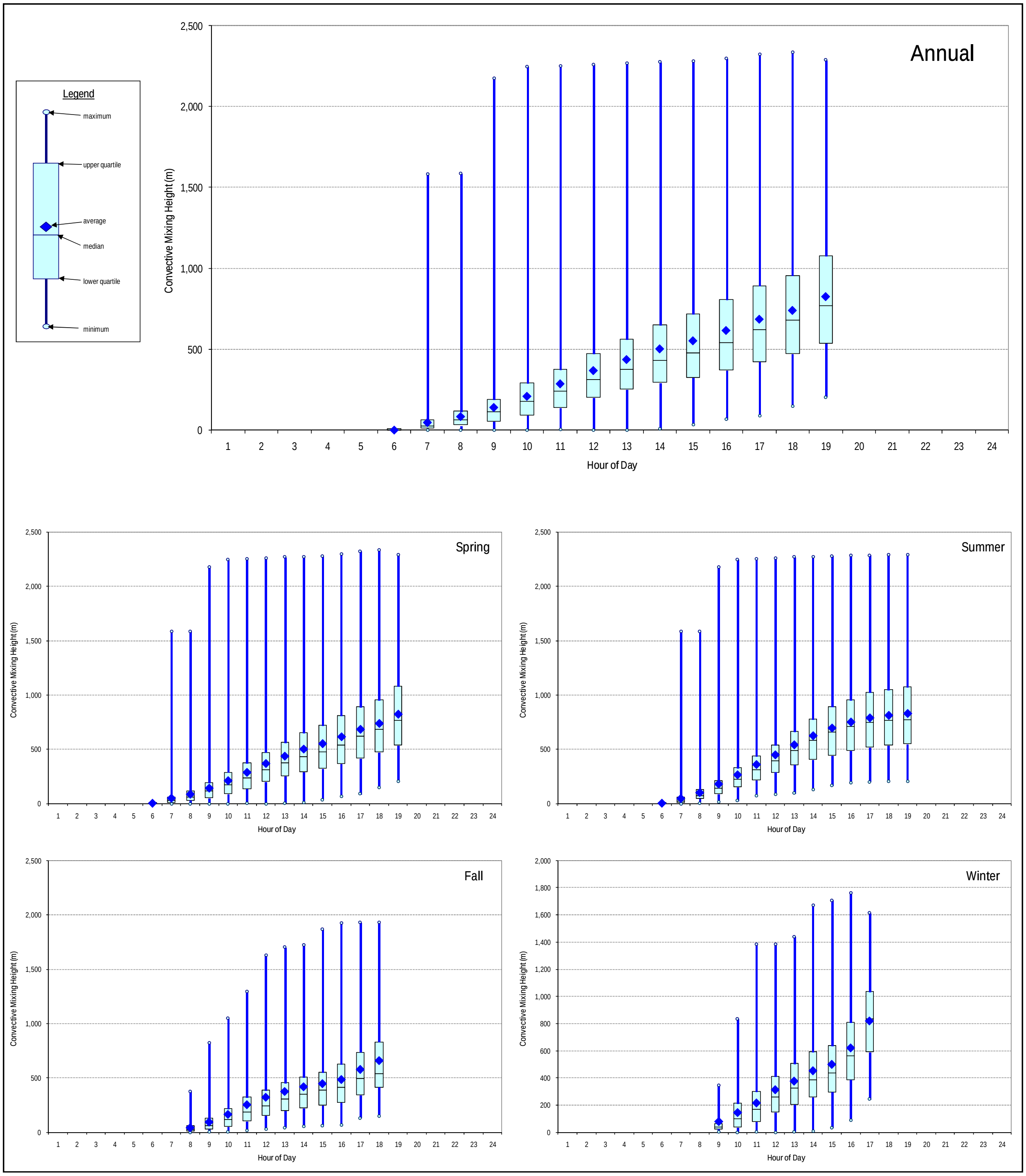


Figure C8.1-2: Hourly Mixing Height for Dispersion Meteorology

C8.2 ATMOSPHERIC INVERSIONS

Atmospheric inversions are deviations from the normal change of temperature with height. In a standard atmosphere temperature drops with height. In a typical inversion temperature falling with height reverses and the temperature begins to increase with height above the ground, creating a warm layer of air aloft. With warmer air aloft and slightly colder and heavier air below, the inversion is in place and there is no tendency for air to form upward currents and turbulence is suppressed.

Inversions can lead to pollution (e.g., smog) being trapped close to the ground, which can result in possible adverse effects on human health. Inversions can also suppress convection by acting as a lid to stop clouds from developing.

The atmosphere can develop various types of inversions, as follows.

- **Frontal Inversions**: A shallow cold or warm front can create an inversion. This is the second most common type of inversion. Both types of fronts can create inversions by advecting warmer air a few thousand feet above cooler surface air.
- **Radiation Inversions:** A cold body of water or land mass can chill the air above it. As the air chills as a result of conduction, chilling of air near the surface results in a temperature increase with height. This is common over the Great Lakes in the spring and summer months. This type of inversion is very shallow; only a few hundred metres above the ground and usually erode by mid morning.
- **Subsidence Inversion:** Strong and dominating high pressure systems promote sinking air. As air sinks it warms adiabatically. A deep high pressure system will have the greatest sinking motion in the middle levels of the atmosphere; the inversion will develop where the strongest sinking motion is taking place. With deep high pressure systems this will generally be located between 1,500 and 3,600 m above ground level. This type of inversion is the most common and the hardest to break.
- **Tropopause Inversions:** This inversion indicates the top of our atmosphere; it occurs daily and marks the transition from the lowest layer of the atmosphere (i.e., troposphere) into the stratosphere. It is usually found at 10,000 to 15,000 m above ground level.

Inversions can occur concurrently in the atmosphere, with multiple types present at one time.

Tables C8.2-1 through C8.2-4 show the various types and heights of inversions for the dispersion meteorology (2005 to 2009). These data are illustrated graphically on Figures C8.2-1 through C8.2-5. As expected, the most common inversions for the region is the subsidence inversion, which develops with large synoptic, high pressure systems that cross the Great Lakes Basin. Since the subsidence inversion is the most common, at an average height of 6,896 m above ground level, there is very little chance that it will have effect on the lower boundary layer dispersion.

Inversions that could affect the lower boundary layer dispersion are radiative inversions. However, they are the least prevalent in the region and as described above, usually erode by mid-morning.

Table C8.2-1: Annual Inversions for the Dispersion Meteorology

Parameter		Morning (12Z) Sounding [a]			Evening (00Z) Sounding [b]		
		Frontal	Radiative	Subsidence	Frontal	Radiative	Subsidence
Observed Number (2005 to 2009)		632	420	2,598	788	125	2,741
Inversion Height (m above ground)	Maximum	19,110	18,442	19,634	19,634	16,572	19,971
	75th percentile	10,441	11,065	10,363	11,009	12,331	11,296
	Median	2,779	3,844	2,934	4,181	4,419	4,683
	25th percentile	1,007	1,108	1,155	1,779	2,298	1,779
	Minimum	315	255	229	281	332	246
	Average	5,404	6,066	5,367	6,680	6,727	6,572
Inversion Depth (m)	Maximum	3,461	3,493	4,534	4,730	2,003	4,854
	75th percentile	620	690	578	772	556	903
	Median	257	285	258	293	285	325
	25th percentile	156	138	140	150	123	156
	Minimum	35	33	29	35	42	30
	Average	552	529	517	594	418	654

Notes:
a The morning (12Z) sounding corresponds to the universal morning release time of noon Greenwich Mean Time.
b The evening (00Z) sounding corresponds to the universal evening release time of midnight Greenwich Mean Time.

Table C8.2-2: Spring Inversions for the Dispersion Meteorology

Parameter		Morning (12Z) Sounding [a]			Evening (00Z) Sounding [b]		
		Frontal	Radiative	Subsidence	Frontal	Radiative	Subsidence
Observed Number (2005 to 2009)		167	138	750	165	22	647
Inversion Height (m above ground)	Maximum	19,110	18,175	19,634	18,815	16,180	19,634
	75th percentile	9,987	11,445	10,781	10,613	7,855	11,535
	Median	2,525	6,634	3,314	3,326	4,453	6,327
	25th percentile	975	1,115	1,269	1,590	3,781	2,020
	Minimum	315	366	255	349	1,889	281
	Average	5,063	6,951	5,861	6,130	6,119	7,093
Inversion Depth (m)	Maximum	3,461	2,306	3,773	2,571	1,372	4,121
	75th percentile	533	856	756	765	207	1,151
	Median	234	359	289	342	162	370
	25th percentile	148	229	156	163	114	181
	Minimum	57	53	29	40	60	35
	Average	475	602	586	582	264	735

Notes:
a The morning (12Z) sounding corresponds to the universal morning release time of noon Greenwich Mean Time.
b The evening (00Z) sounding corresponds to the universal evening release time of midnight Greenwich Mean Time.

Table C8.2-3: Summer Inversions for the Dispersion Meteorology

Parameter		Morning (12Z) Sounding [a]			Evening (00Z) Sounding [b]		
		Frontal	Radiative	Subsidence	Frontal	Radiative	Subsidence
Observed Number (2005 to 2009)		99	106	575	98	4	593
Inversion Height (m above ground)	Maximum	16,373	18,442	19,526	18,263	2,703	18,263
	75th percentile	9,969	11,253	9,837	9,210	2,217	11,002
	Median	2,253	2,703	3,012	3,216	1,732	5,073
	25th percentile	959	973	1,118	1,352	1,247	1,791
	Minimum	332	255	263	358	762	263
	Average	5,133	5,397	5,339	5,554	1,732	6,482
Inversion Depth (m)	Maximum	2,484	1,712	3,118	2,731	430	4,202
	75th percentile	1,010	644	506	470	333	803
	Median	414	229	267	309	237	354
	25th percentile	190	114	144	167	140	164
	Minimum	69	33	35	43	44	30
	Average	706	479	470	517	237	662

Notes:
a The morning (12Z) sounding corresponds to the universal morning release time of noon Greenwich Mean Time.
b The evening (00Z) sounding corresponds to the universal evening release time of midnight Greenwich Mean Time.

Table C8.2-4: Fall Inversions for the Dispersion Meteorology

Parameter		Morning (12Z) Sounding [a]			Evening (00Z) Sounding [b]		
		Frontal	Radiative	Subsidence	Frontal	Radiative	Subsidence
Observed Number (2005 to 2009)		116	97	510	219	50	708
Inversion Height (m above ground)	Maximum	17,210	18,442	18,442	18,263	16,439	19,419
	75th percentile	10,363	11,238	7,906	11,784	12,488	10,870
	Median	2,594	8,944	2,616	4,906	9,863	3,602
	25th percentile	970	1,839	1,048	1,849	1,692	1,554
	Minimum	375	418	306	281	332	349
	Average	5,703	7,666	4,651	7,409	7,905	5,910
Inversion Depth (m)	Maximum	3,065	2,348	2,781	3,323	2,003	4,854
	75th percentile	1,113	838	379	879	767	668
	Median	273	326	203	253	512	263
	25th percentile	136	171	117	164	223	134
	Minimum	35	74	35	90	43	49
	Average	610	574	412	586	547	546

Notes:

a The morning (12Z) sounding corresponds to the universal morning release time of noon Greenwich Mean Time.

b The evening (00Z) sounding corresponds to the universal evening release time of midnight Greenwich Mean Time.

Table C8.2-5: Winter Inversions for the Dispersion Meteorology

Parameter		Morning (12Z) Sounding [a]			Evening (00Z) Sounding [b]		
		Frontal	**Radiative**	**Subsidence**	**Frontal**	**Radiative**	**Subsidence**
Observed Number (2005 to 2009)		250	79	763	306	49	793
Inversion Height (m above ground)	Maximum	17,755	18,442	19,419	19,634	16,572	19,971
	75^{th} percentile	10,552	5,849	10,389	11,009	12,973	11,475
	Median	3,195	2,319	2,823	4,257	3,778	5,574
	25^{th} percentile	1,157	1,057	1,225	2,214	2,259	1,979
	Minimum	315	410	229	349	401	246
	Average	5,616	4,185	5,357	6,934	6,533	6,842
Inversion Depth (m)	Maximum	3,394	3,493	4,534	4,730	1,466	4,181
	75^{th} percentile	535	441	594	787	373	997
	Median	255	235	258	291	303	325
	25^{th} percentile	158	117	141	146	254	152
	Minimum	54	54	35	35	42	31
	Average	542	458	549	642	432	683

Notes:
a The morning (12Z) sounding corresponds to the universal morning release time of noon Greenwich Mean Time.
b The evening (00Z) sounding corresponds to the universal evening release time of midnight Greenwich Mean Time.

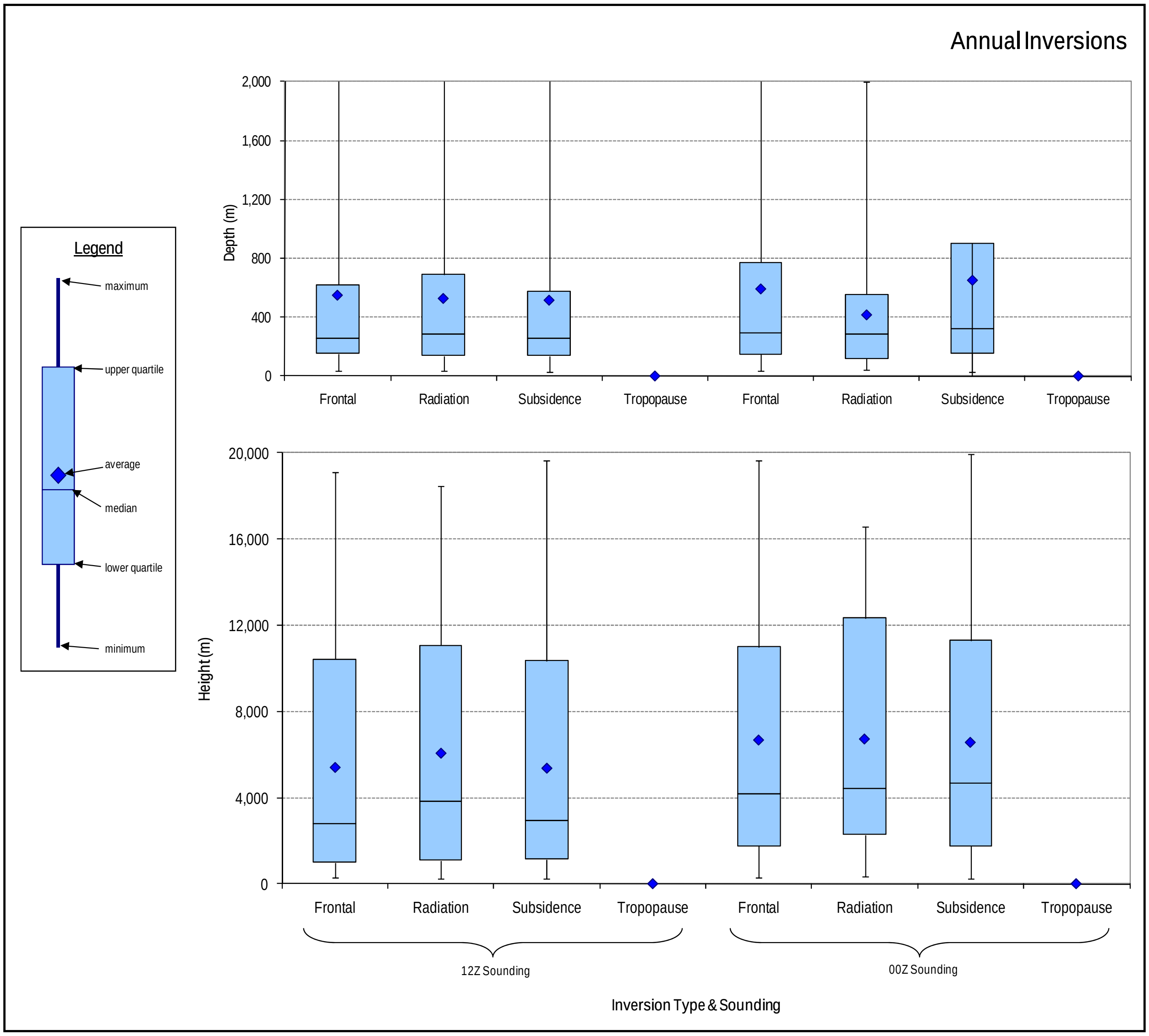


Figure C8.2-1: Annual Inversions for the Dispersion Meteorology

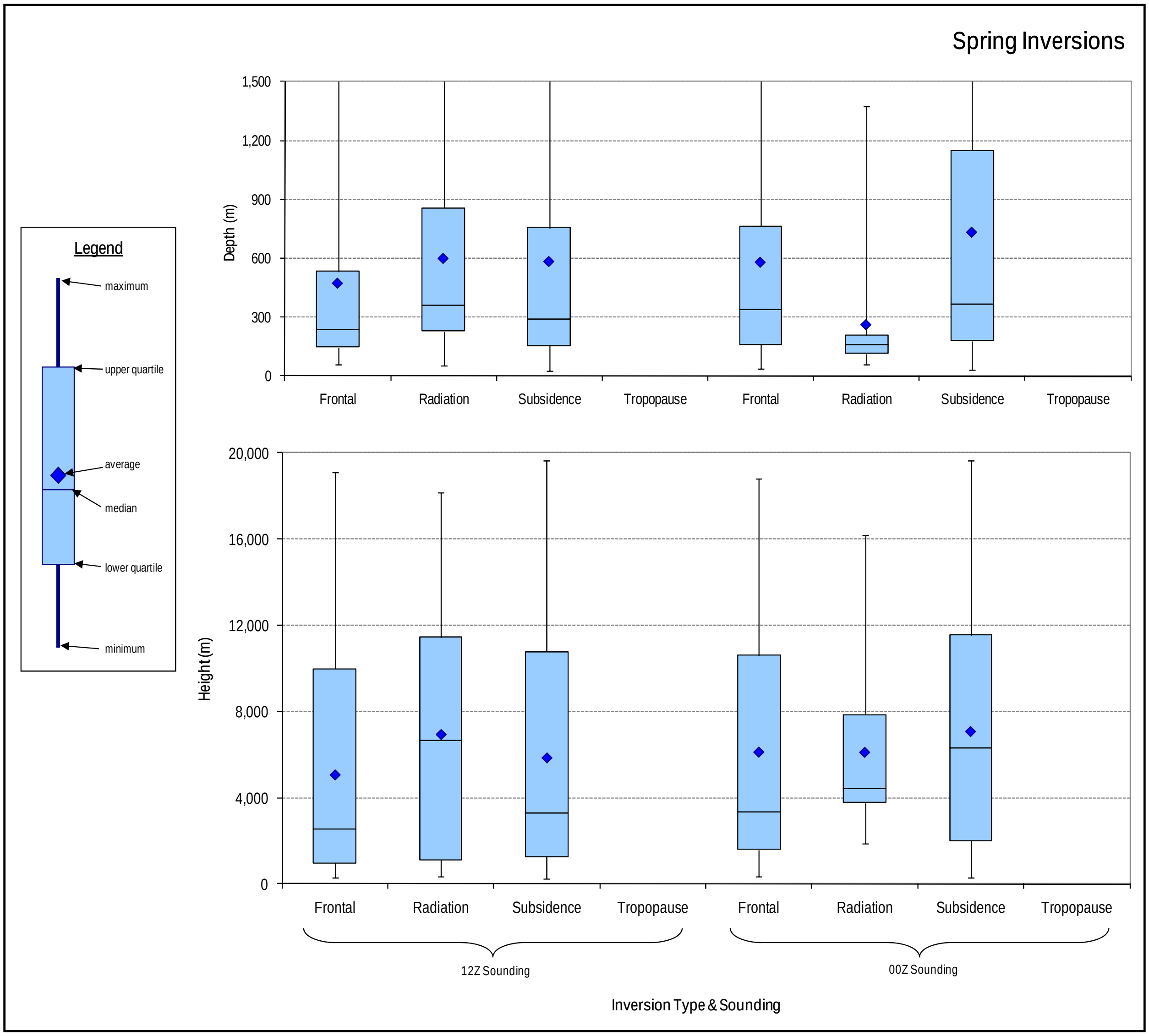


Figure C8.2-2: Spring Inversions for the Dispersion Meteorology

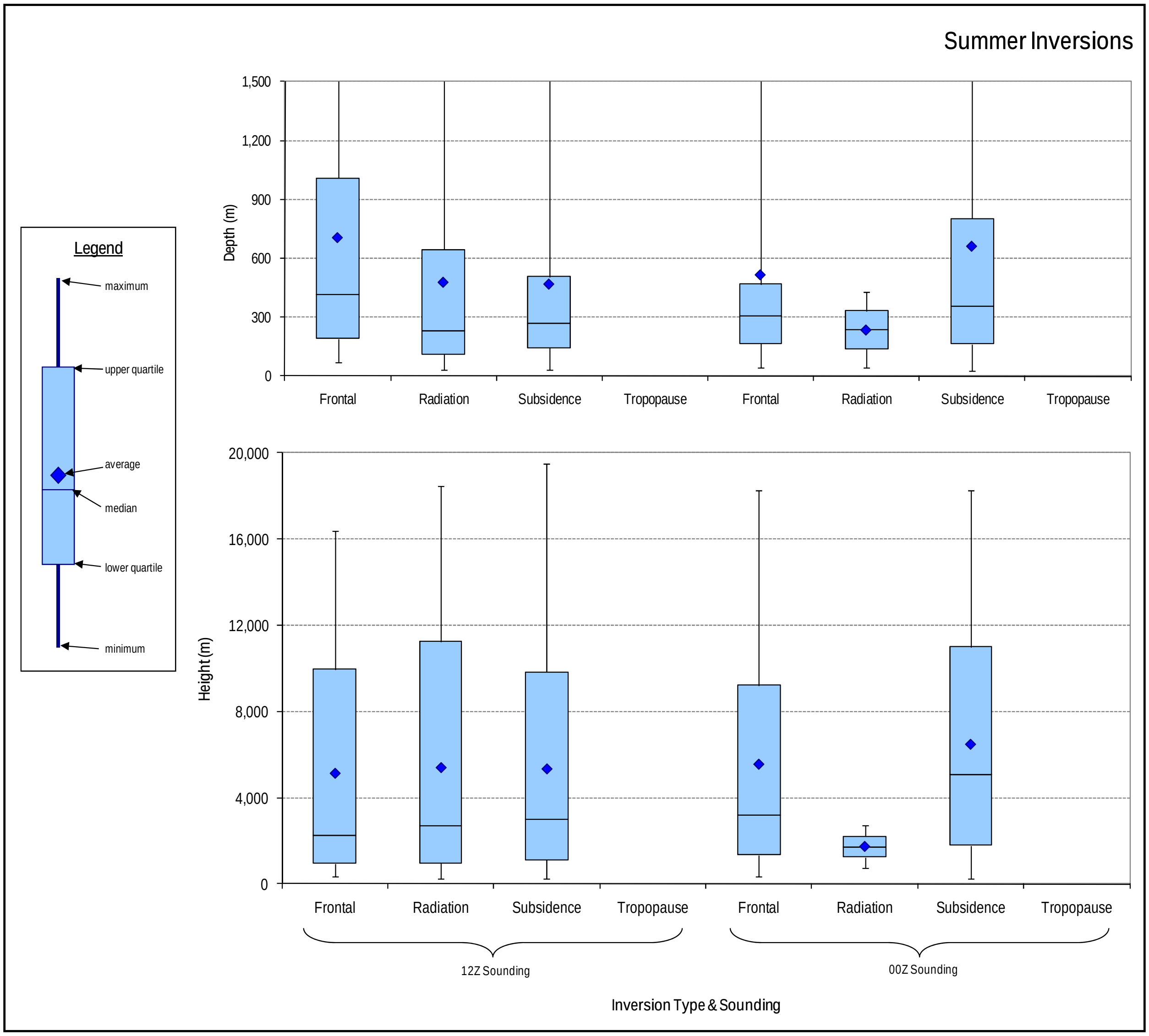


Figure C8.2-3: Summer Inversions for the Dispersion Meteorology

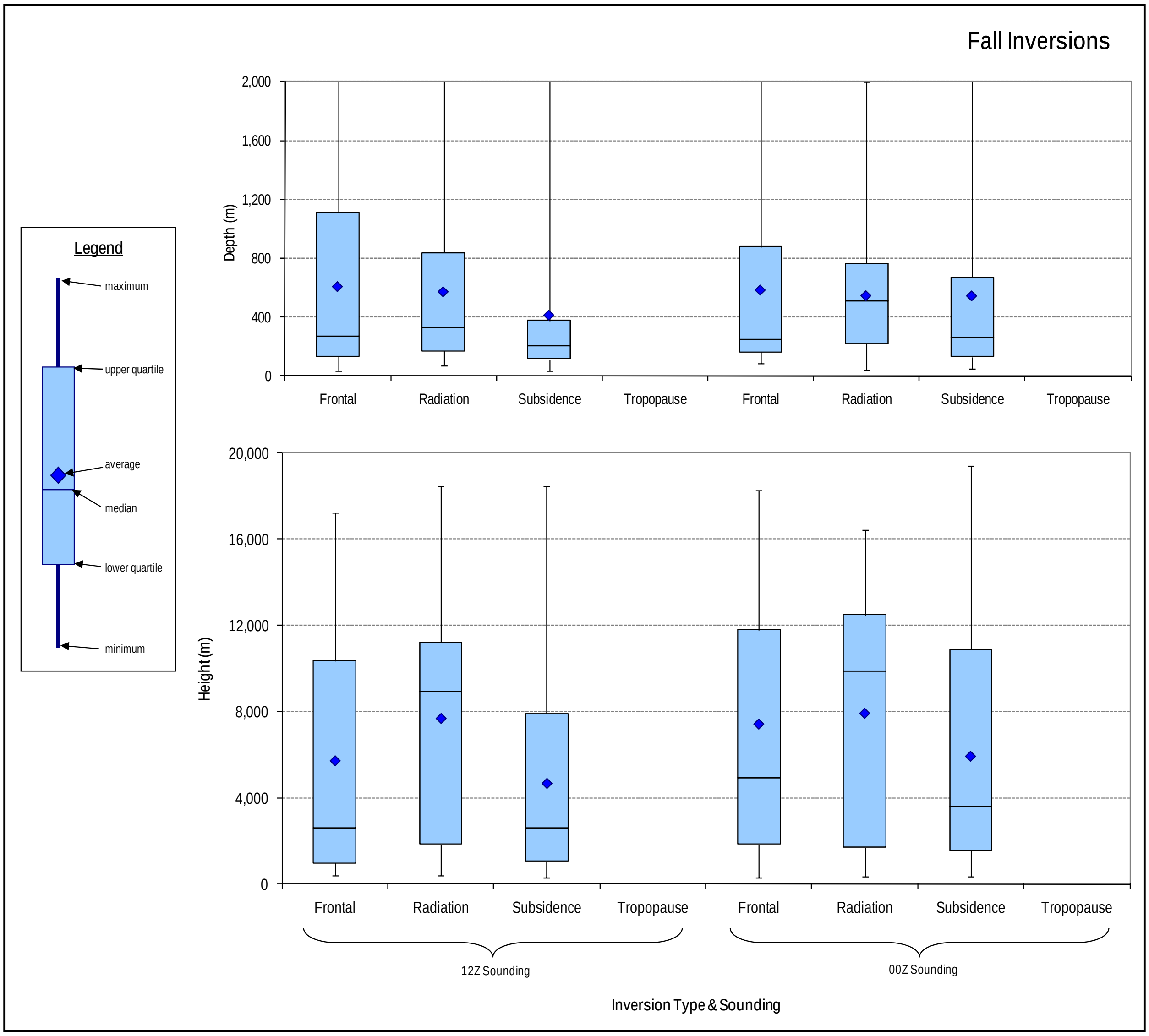


Figure C8.2-4: Fall Inversions for the Dispersion Meteorology

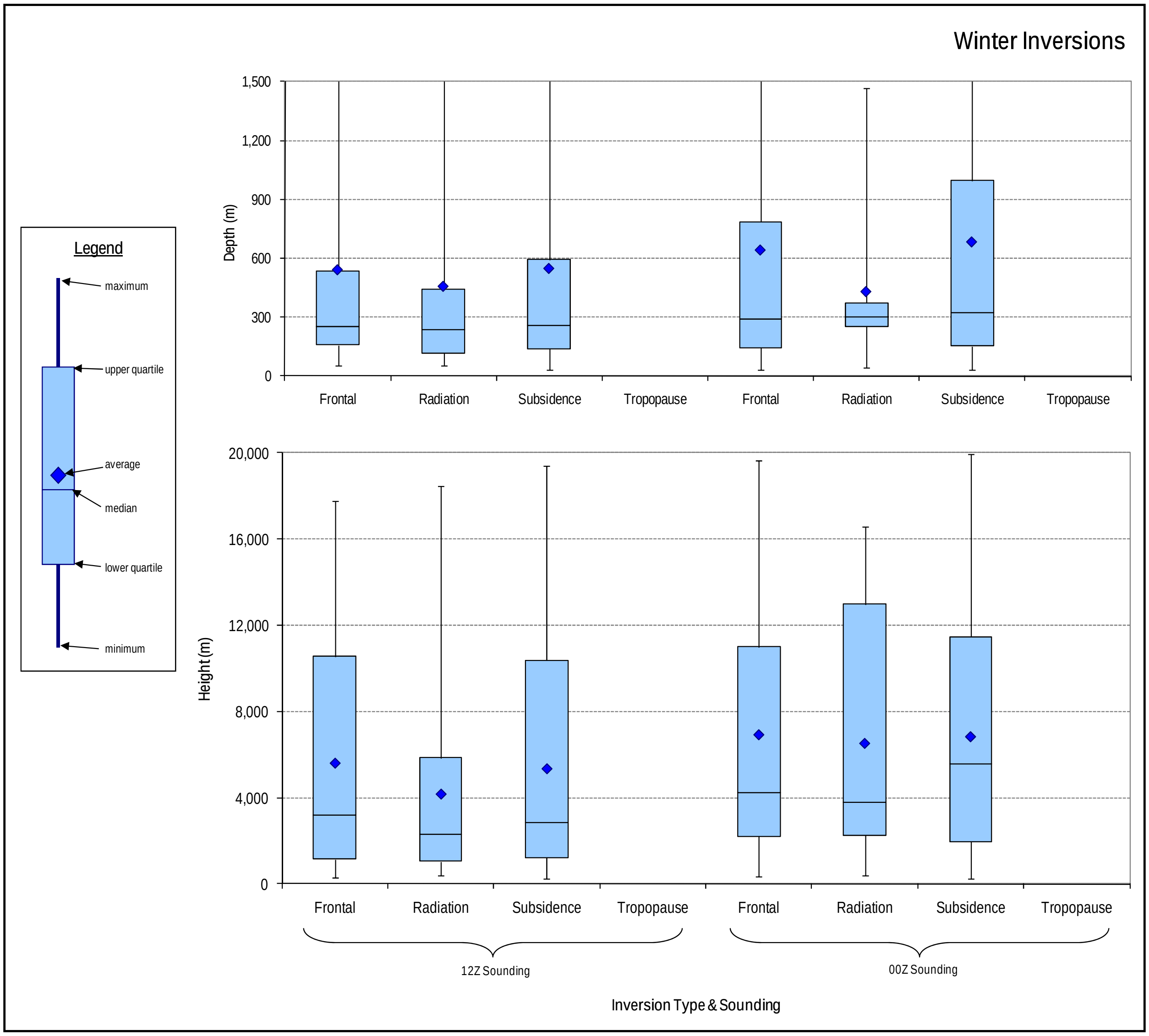


Figure C8.2-5: Winter Inversions for the Dispersion Meteorology

C8.3 LAKE BREEZE AND THERMAL INTERNAL BOUNDARY LAYER PHENOMENA

The lake breeze forms during daylight in the late spring and summer months because Great Lake waters do not warm as quickly as the surrounding land surfaces. Air cooled by contact with the cold lake waters is denser than that surrounding the lake and thus forms a cell of relatively high pressure over the lake. When the sun heats the land, the air above it warms becoming less dense. Thus, solar heating produces a wide region of lower pressure over the land. With high pressure over the lake and low pressure over land, the regional local pressure gradient pushes winds inland off the lake. This is known as the lake breeze flow (see Figure C8.3-1).

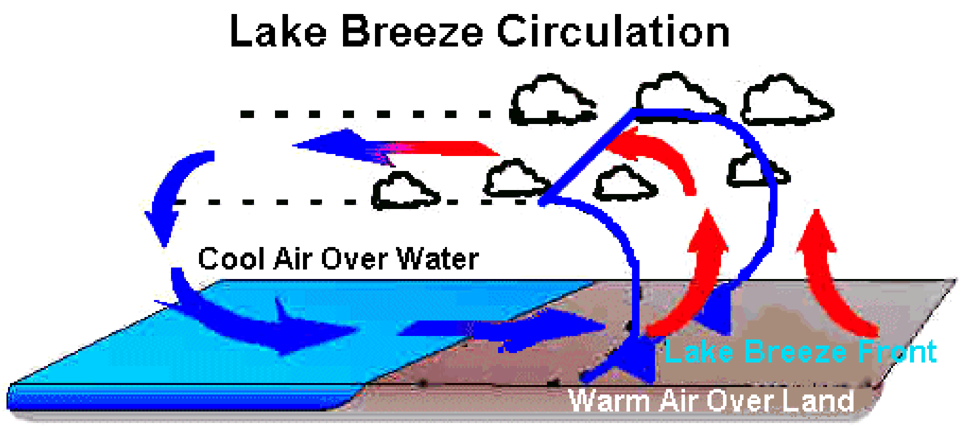


Figure C8.3-1: A Typical Lake Breeze Circulation

The lake breeze zone is quite narrow band (1 to 2 km wide) and the penetration inland depends on the temperature contrast between the land air temperature and that over the lake. Typical inland penetration is about 16 km, but at times lake breeze penetration has been recorded as far as 40 km inland.

Thermal Internal Boundary Layers (TIBLs) can be the result of the lake breeze phenomena. TIBLs form within the boundary layer when surface heat fluxes change across a border, such as the shoreline separating a lake and land. During spring and summer months, much of the incoming solar radiation will be reflected from the water. In contrast, much of the incoming solar radiation will be absorbed by the land (see Figure C8.3-2)

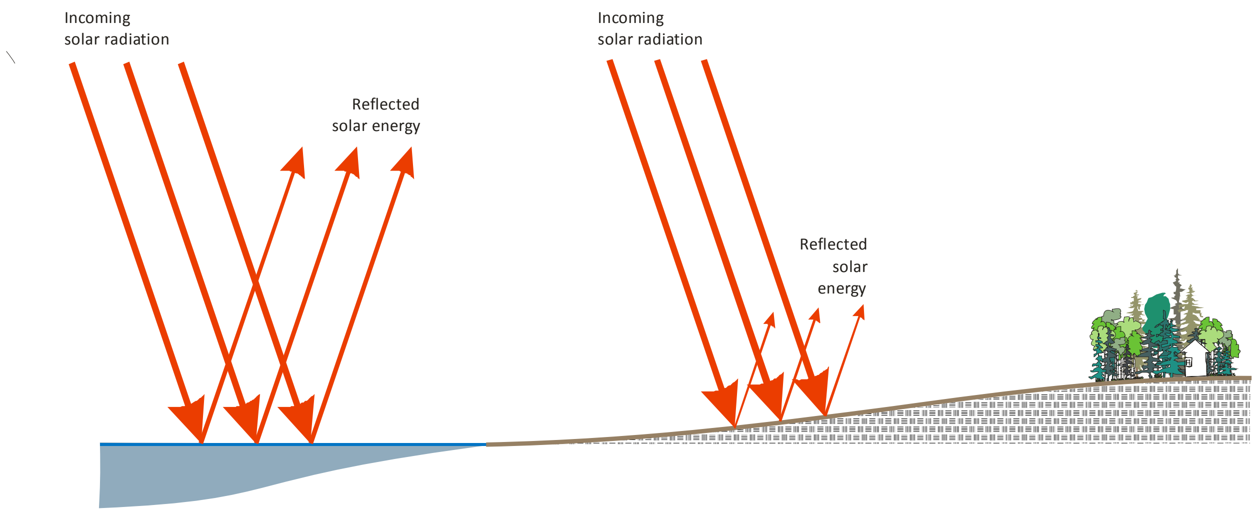


Figure C8.3-2: Solar Radiation Reflection

As a result, the air over the land is heated. This heated air will be unstable and begin to rise. This rising air tends to draw the cool stable from the water towards land. As the cool air moves towards land, the distinct, curved boundary characteristic of a TIBL forms (see Figure C8.3-3). The onshore movement of air is the "lake breeze", which has been captured in the dispersion meteorology, and thus reflected in the assessment.

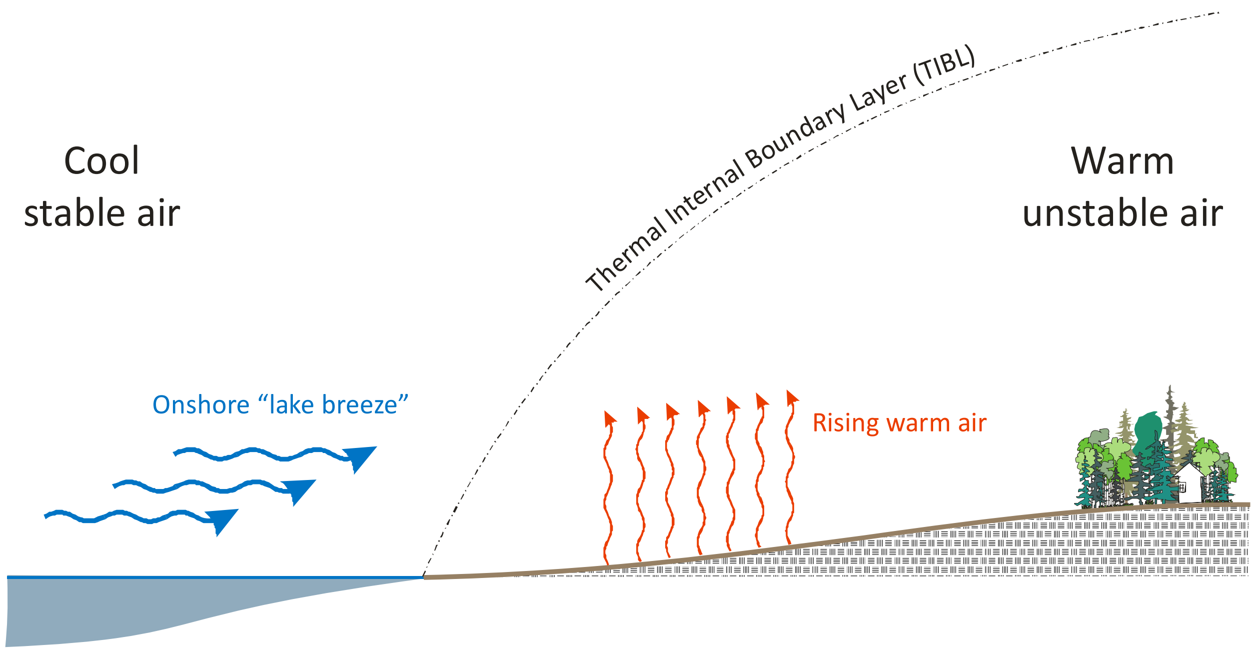


Figure C8.3-3: TIBL Boundary

While the stable air above the TIBL can act to trap emissions, much as an inversion would, this is rarely a concern with TIBLs that form at land-lake interfaces. The reason is that the conditions necessary for their formation include relatively unstable air over the land, which enhances dispersion and can result in lower ground-level concentrations from sources with relatively short stacks (see Figure C8.3-4). All of the sources associated with the DGR Project are close to the ground and would be released into the areas with enhanced dispersion.

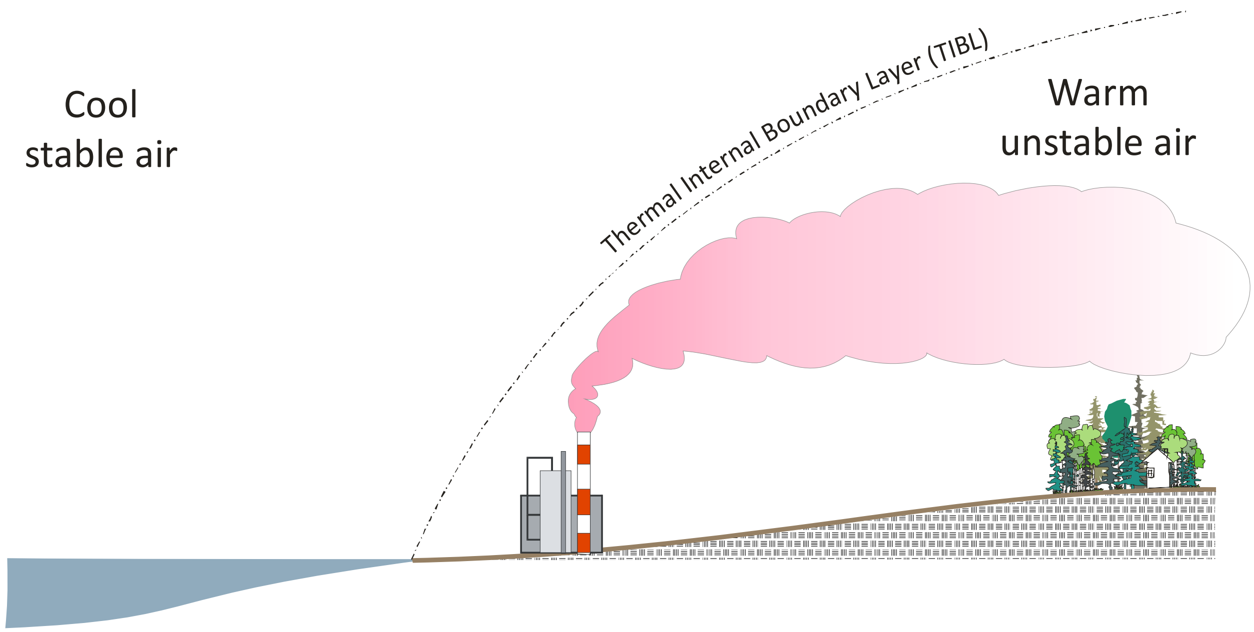


Figure C8.3-4: Air Emissions from Short Stack near TIBL

However, when a TIBL forms near very tall stacks, “shoreline fumigation” can occur. The plumes from very tall stacks (such as those present at a coal fired power plant) will be released into the stable air above the TIBL, and will move inland with the “lake breezes”. When they encounter the TIBL, the plumes are rapidly brought down to the ground (i.e., fumigated), as shown on Figure C8.3-5.

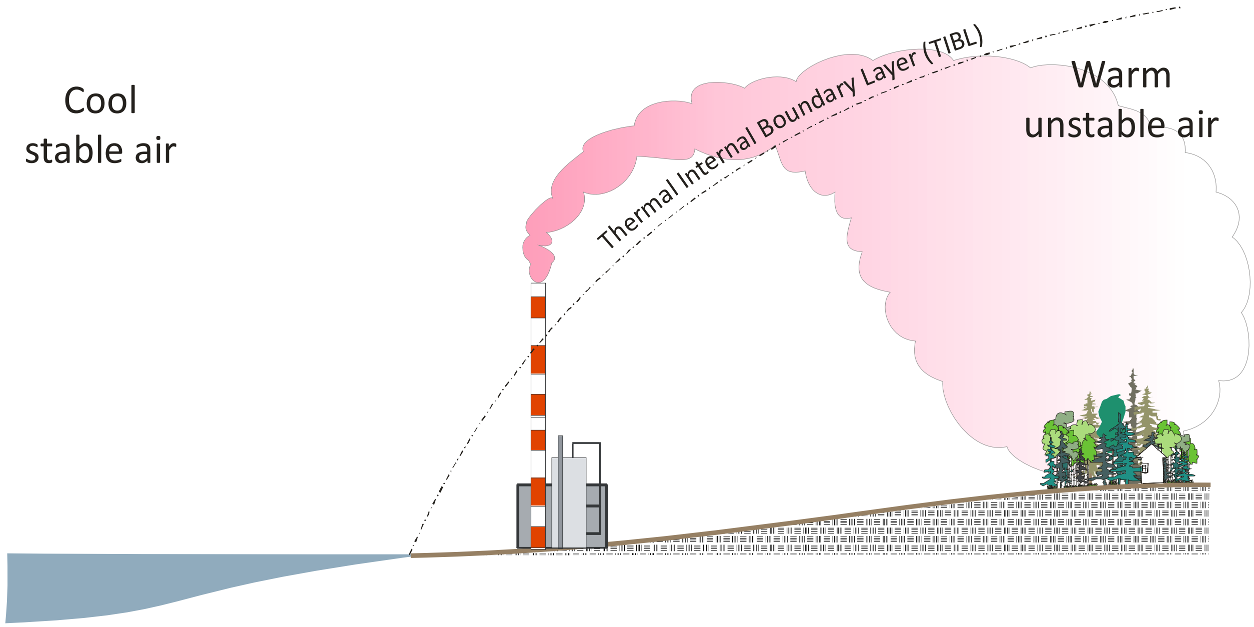


Figure C8.3-5: Air Emissions from Tall Stacks near TIBL

Because the most coal fired power plants in Ontario are situated on the shores of the Great Lakes, the issues regarding “shoreline fumigation”, “lake breezes” and Thermal Internal Boundary Layers (TIBLs) in Ontario are well researched and documented in literature. Some of the fundamental references for consideration by the reviewers should include papers by: Portelli (1978 and 1981) [C7;C8]; Venkatram (1976) [C9]; Misra (1979) [C10]; Misra and Orlock (1981) [C11]; Kerman (1981) [C12]; Kerman *et al*. (1981) [C13]; and Hoff *et al*. (1981) [C14].

Issues related to the formation of a TIBL, “lake breezes” and “shoreline fumigation” would be of particular interest if the DGR Project were a coal-fired power plant with very tall stacks. However, they are less relevant at the DGR Project site, where all of the DGR sources are close to the ground and are blow critical levels for shoreline fumigation to occur.

The dispersion conditions that would affect the ground-based and short sources at DGR are included in the dispersion meteorological data used in the modelling. The dispersion meteorological data was collected at the Bruce nuclear site, and will reflect the actual conditions occurring near the surface.

C9. ATMOSPHERIC PRESSURE

Air pressure is related to its density, which is related to the air's temperature and height above the Earth's surface. Air pressure changes with the weather. In fact, it is one of the most important factors that determine what the weather is like (e.g., how high and low pressure affects the weather). Air pressure is also called barometric pressure because barometers are used to measure it [C15]. The station pressure measurements (not corrected to Mean Sea Level) presented in Table C9-1 is the monthly average pressure for dispersion meteorology. Table C9-2 presents the monthly pressure normals for Wiarton, Ontario. The both modelled and actual station pressures are closely correlated, with the little variation (average +/- 1 kPa) month by month. Large shifts in the data were not noted in either of the tables.

Table C9-1: Monthly Pressure for Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Station Pressure (kPa)	98.9	98.8	99.0	98.8	98.8	98.7	98.8	98.9	99.1	98.9	98.9	98.9	98.9
Average Sea Level Pressure (kPa)	101.7	101.6	101.8	101.5	101.5	101.4	101.4	101.6	101.8	101.6	101.6	101.6	101.6

Table C9-2: Monthly Pressure Normals for Wiarton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Station Pressure (kPa)	98.8	99.0	98.9	98.8	98.8	98.8	98.9	99.0	99.0	99.1	98.9	98.9	98.9
Average Sea Level Pressure (kPa)	101.6	101.7	101.6	101.5	101.5	101.4	101.5	101.7	101.7	101.7	101.6	101.7	101.6

C10. SOLAR RADIATION, CLOUD COVER AND BRIGHT SUNSHINE

Tables C10-1 and C10-2 indicate the average monthly sunshine and cloud cover normals for dispersion meteorology and Wiarton, Ontario, respectively. Bright sunshine is defined as the energy required to burn a hole through the card in a recorder, called a Campbell-Stokes recorder. However, at sunrise and sunset the sun is lower in the sky and will tend to leave a scorch mark on the card, which may at the extreme end be difficult to see. The unit is designed to record the hours of bright sunshine. The hours of bright sunshine increase in July at Wiarton to a maximum of 300 hours. This is because of the increased daylight hours, as well as a decrease in cloud cover overall.

December has the least amount of bright sunshine because of the increased amount of cloud cover and fewer daylight hours [C6].

Table C10-1: Monthly Sunshine and Cloud Cover for Dispersion Meteorology

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Bright Sunshine													
Total Hours	—	—	—	—	—	—	—	—	—	—	—	—	—
Days with measurable	—	—	—	—	—	—	—	—	—	—	—	—	—
% of possible daylight hours	—	—	—	—	—	—	—	—	—	—	—	—	—
Cloud Cover													
Hours with Cloud 0 to 2 tenths	59.2	76.4	194.8	195.8	207.4	160.8	185.4	242.8	242.2	128.4	90.6	31	1,814.80
Hours with Cloud 3 to 7 tenths	83.4	108.4	143	120.6	168.4	188.6	215.2	196.2	145	127.8	98	68	1,662.60
Hours with Clouds 8 to 10 tenths	601.4	492	406.2	403.2	368	370	343	305	332.2	487.4	530.6	644.8	5,283.80

Note: Bright sunshine data were unavailable for the dispersion meteorology.

Table C10-2: Monthly Sunshine and Cloud Cover Normals for Wiarton, Ontario

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Bright Sunshine													
Total Hours	54.7	93.5	147.9	191.7	250.3	274.3	300.1	252.9	177.7	129.3	60.2	46.2	1,978.8
Days with measurable	17.3	20.6	25.2	25.9	27.8	28.5	30.4	29.7	27.0	26.0	19.1	16.6	294.1
% of possible daylight hours	19.1	31.8	40.1	47.5	54.6	58.9	63.7	58.1	47.2	37.9	20.9	16.8	41.4
Cloud Cover													
Hours with Cloud 0 to 2 tenths	72.3	109.6	198.8	210.1	250.0	236.9	259.6	251.5	207.7	163.6	75.3	61.4	2,096.8
Hours with Cloud 3 to 7 tenths	83.3	105.1	114.7	122.6	151.9	171.8	204.8	178.4	169.8	147.3	96.0	83.1	1,628.8
Hours with Clouds 8 to 10 tenths	588.5	463.0	430.5	387.3	342.0	311.2	279.7	314.2	342.5	433.0	548.7	599.5	5,040.1

C11. OTHER METEOROLOGICAL PARAMETERS

Albedo, Bowen Ratio and surface roughness length are site-specific parameters that influence air movement around a site and are dependent on the land use (urban area, farmland, woodlot, forest and swamp) of the region around the Bruce nuclear site.

- **Albedo** is a measure of the reflectivity of The Earth's surface. This is a very important parameter in meteorological dispersion modelling because it provides a measure of the amount of incident solar radiation that is absorbed by the Earth/atmosphere system. Absorbed solar radiation is one of the driving forces for local, regional, and global atmospheric dynamics. Albedo is defined as the ratio of reflected solar radiation to the total incoming solar radiation received at the surface. Model default values of albedo were used for the summer season but were altered for winter to reflect the presence of snow. Table C11-1 lists the typical albedo values [C16] used for different types of land use.
- **Bowen ratio** is the ratio of the vertical flux of sensible heat to latent heat, where sensible heat is the transfer of heat from the surface to the atmosphere via convection and latent heat is the transfer of heat required to evaporate liquid water from the surface to the atmosphere. The Bowen ratio gives a measure of the surface heat flux and how much moisture is injected into the atmosphere. Table C11-2 lists the typical values for Bowen Ratio [C16] for different types of land use.
- **Roughness length** (z_o) is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface as well as the wind speed. It is defined as the height at which the vertical wind profile is extrapolated to zero.
  Table C11-3 lists the typical values for surface roughness length [C16] for different types of land use.

Table C11-1: Albedo by Land Use

Month	Water	Deciduous Forest	Coniferous Forest	Swamp	Cultivated Land	Grassland	Urban	Desert Shrubland
January	0.2	0.5	0.35	0.3	0.6	0.6	0.35	0.45
February	0.2	0.5	0.35	0.3	0.6	0.6	0.35	0.45
March	0.12	0.12	0.12	0.12	0.14	0.18	0.14	0.3
April	0.12	0.12	0.12	0.12	0.14	0.18	0.14	0.3
May	0.12	0.12	0.12	0.12	0.14	0.18	0.14	0.3
June	0.1	0.12	0.12	0.14	0.2	0.18	0.16	0.28
July	0.1	0.12	0.12	0.14	0.2	0.18	0.16	0.28
August	0.1	0.12	0.12	0.14	0.2	0.18	0.16	0.28
September	0.14	0.12	0.12	0.16	0.18	0.2	0.18	0.28
October	0.14	0.12	0.12	0.16	0.18	0.2	0.18	0.28
November	0.14	0.12	0.12	0.16	0.18	0.2	0.18	0.28
December	0.2	0.5	0.35	0.3	0.6	0.6	0.35	0.45

Table C11-2: Bowen Ratio by Land Use

Month	Water	Deciduous Forest	Coniferous Forest	Swamp	Cultivated Land	Grassland	Urban	Desert Shrubland
January	1.5	1.5	1.5	1.5	1.5	1.5	1.5	6
February	1.5	1.5	1.5	1.5	1.5	1.5	1.5	6
March	0.1	0.7	0.7	0.1	0.3	0.4	1	3
April	0.1	0.7	0.7	0.1	0.3	0.4	1	3
May	0.1	0.7	0.7	0.1	0.3	0.4	1	3
June	0.1	0.3	0.3	0.1	0.5	0.8	2	4
July	0.1	0.3	0.3	0.1	0.5	0.8	2	4
August	0.1	0.3	0.3	0.1	0.5	0.8	2	4
September	0.1	1	0.8	0.1	0.7	1	2	6
October	0.1	1	0.8	0.1	0.7	1	2	6
November	0.1	1	0.8	0.1	0.7	1	2	6
December	1.5	1.5	1.5	1.5	1.5	1.5	1.5	6

Table C11-3: Roughness Length by Land Use

Month	Water	Deciduous Forest	Coniferous Forest	Swamp	Cultivated Land	Grassland	Urban	Desert Shrubland
January	0.0001	0.5	1.3	0.05	0.01	0.001	1	0.15
February	0.0001	0.5	1.3	0.05	0.01	0.001	1	0.15
March	0.0001	1	1.3	0.2	0.3	0.05	1	0.3
April	0.0001	1	1.3	0.2	0.3	0.05	1	0.3
May	0.0001	1	1.3	0.2	0.3	0.05	1	0.3
June	0.0001	1.3	1.3	0.2	0.2	0.1	1	0.3
July	0.0001	1.3	1.3	0.2	0.2	0.1	1	0.3
August	0.0001	1.3	1.3	0.2	0.2	0.1	1	0.3
September	0.0001	0.8	1.3	0.2	0.05	0.01	1	0.3
October	0.0001	0.8	1.3	0.2	0.05	0.01	1	0.3
November	0.0001	0.8	1.3	0.2	0.05	0.01	1	0.3
December	0.0001	0.5	1.3	0.05	0.01	0.001	1	0.15

C12. SEVERE AND UNUSUAL WEATHER

C12.1 THUNDERSTORMS

Thunderstorms represent the final stage of the growth of convective instability in a humid atmosphere. Thunderstorms can damage external structures through high winds, heavy rain and lightning. An example of severe thunderstorms were those associated with Hurricane Hazel in 1954. These severe thunderstorms had wind speeds up to 120 km/h and 18 cm of rain fall in less than 24 hours [C2]. These thunderstorms damaged transportation infrastructure, power lines, homes and other light structures.

The frequency of thunderstorm occurrence at the Bruce nuclear site is expected to be similar to that at Wiarton Airport, the location of the nearest meteorological station that records thunderstorms. For the period 1961 to 1990, Wiarton Airport averaged 28 thunderstorms per year [C17].

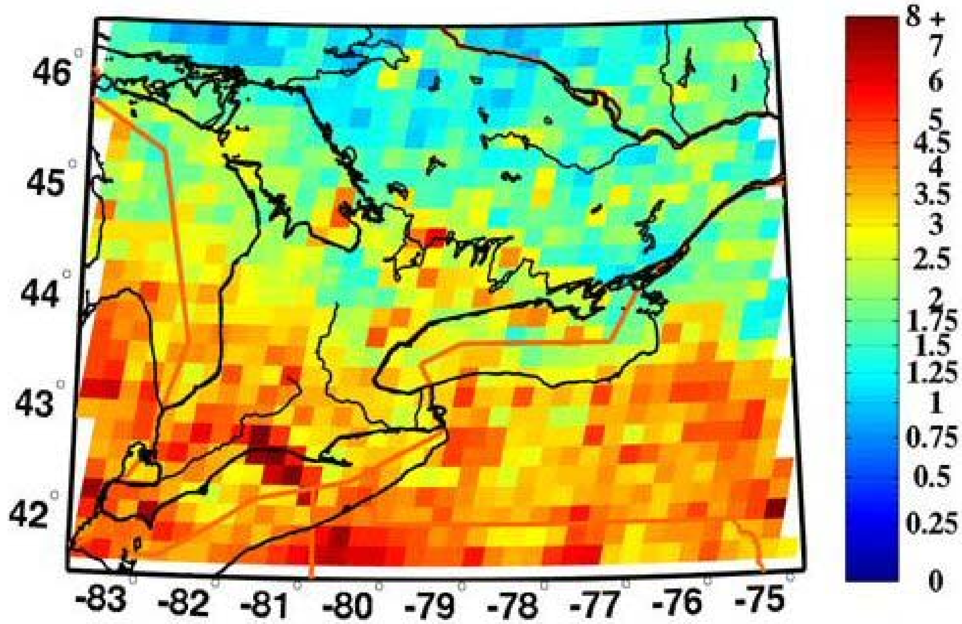
C12.3 LIGHTNING

Lightning is an atmospheric discharge of electricity, which typically occurs during thunderstorms. In the atmospheric electrical discharge, a leader of a bolt of lightning can travel at speeds of 60,000 m/s, and can reach temperatures approaching 30,000°C (54,000°F).

Lightning flashes range in Canada from about 2.0 to 2.9 million times a year, including about once every three seconds during the summer months. This is based on observations collected during the past 10 years from the Canadian lightning detection network [C18].

Lightning climatology is still young in Canada; Environment Canada installed a national lightning network in 1997-98 and began collecting data on lightning strikes throughout Canada. Even though lightning climatology is limited (1999 to 2008) Environment has developed a "flash density" map indicating the number of flashes per square kilometre per year.

As illustrated on Figure C12.3-1, extreme south-western Ontario shows a large area of lightning activity (3.0 to 5.0 flashes per square kilometre). A second maximum is located along a line from the southern tip of Georgian Bay to southeast of Barrie, also 2.5 to 4.5) flashes per square kilometre. The two highland areas in southern Ontario, Algonquin Park and the Dundalk Highlands experience lightning much less frequently than the low land areas surrounding them. The Bruce nuclear site has an average of 2.0 to 3.0 flashes per square kilometre for the period 1999 to 2008.



Source: [C18]

Figure C12.3-1: Lightning Climatology 1999 to 2008 Southern Ontario (flashes per square kilometre per year)

C12.4 HAIL STORMS

Hailstorms, associated exclusively with severe thunderstorms, are warm season phenomena; typically occurring between May and September. Hailstorms can damage external structures through high winds and the impact of falling hail. Currently, statistics on the frequency and prevalence of hail storms is not available.

C12.5 TORNADOES

Excessive atmospheric instability, rapid rates of vertical temperature change and strong shear in wind speed and wind direction are required to cause tornadoes, which are usually associated with severe thunderstorms [C5]. A tornado system may be triggered when cold air from the north meets with warm, moist air from the lower Great Lakes. The cold air undercuts the warm air and forces it up to great heights, producing convection clouds. If, at the same time, the air stream is diverging at upper levels, the warm air is drawn up even faster. This creates highly turbulent storm clouds where a tornado funnel may appear. More than one tornado may develop out of a single storm system and each funnel may travel some distance before lifting and dissipating. Tornadoes can damage external structures through high velocity winds.

Tornadoes have a random distribution and are extremely localized. A few tornadoes or near-tornadoes are reported in southern Ontario each year, but these are not as intense or damaging as tornadoes in the United States south and west of the Great Lakes [C5]. In the Regional Study Area, one to two tornadoes per 10,000 km^2 can be expected annually [C5].

C12.6 ICE STORMS

Ice storms are caused when the atmosphere is layered, with a layer of warm air above the denser cold air near the ground surface. As precipitation falls in the warm layer, rain forms. The rain then falls into the shallow cold layer and freezes. Ice storms can damage light structures such as power transmission lines through the weight of accumulated ice.

Ice storms are known to occur in eastern Ontario and Quebec, and may occur in southwestern Ontario around the Bruce nuclear site, but are likely to be less frequent. On average, Ottawa and Montreal receive freezing precipitation on 12 to 17 days a year, which generally lasts only a few hours. For the period of 1961 to 1990 freezing precipitation occurred nine days per year on average at Wiarton Airport [C17]. In January 1998, a severe ice storm occurred in eastern Ontario and Quebec. Over 90 millimetres of freezing drizzle fell during the five day storm in 1998. The January 1998 ice storm caused significant damage to transmission lines and sub-transmission systems. However, it did not damage any generating stations, because these have greater structural integrity for reasons other than resisting ice and wind loading [C19].

C12.7 FOG

The local climatology shows an average of 38 days of fog per year at the Wiarton Airport [C20]. Table C12.7-1 lists the average number of fog days per month at the Wiarton Airport. The average monthly number of days with fog varies at Wiarton Airport from a high of 5 days in both May and June to a low of 2 days in January, February, October, November and December.

Table C12.7-1: Annual Number of Days with Fog at Wiarton

Month	Number of Days with Fog
January	2
February	2
March	4
April	4
May	5
June	5
July	4
August	3
September	3
October	2
November	2
December	2
Year	**38**

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C13. REFERENCES

[C1] Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Synthesis Report.* Summary for Policy Makers.

[C2] Environment Canada. 1993. *Canadian Climate Normals Volume 3, 1951-1980.*

[C3] Ontario Ministry of the Environment. 2005. *Air Dispersion Modelling Guideline for Ontario: Version One.* PIBS#: 5165E.

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APPENDIX D: CLIMATE CHANGE

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D1. INTRODUCTION

It is widely accepted that the climate is changing, and consideration of these changes needs to be incorporated in the assessment of the effects of the DGR Project. In response to this need, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) have prepared a general guidance document for practitioners to use when incorporating climate change issues into environmental assessments [D1]. In addition, the EIS Guidelines require that the assessment includes a consideration of the likely effects of the current and future environment on the DGR Project. This includes an assessment of whether the DGR Project is sensitive to changes in climatic conditions (e.g., increased severe weather intensity) and how climate change may affect VECs in a manner such that the likely effects of the DGR Project on those VECs must be reassessed.

To facilitate this assessment, a determination of how climate has been changing and how it might change over the life of the DGR Project has been made. This appendix describes this evaluation in detail.

D2. CURRENT CLIMATE AND HISTORIC CLIMATE TRENDS

Establishing the current climatic conditions in the Project Area and describing the historic climate trends that have been observed will provide context when evaluating forecast future changes in climate. The current climate will be described using climate data from an appropriate nearby station. For the purposes of this project, the data from the station operated by the Meteorological Services of Canada Station at Wiarton was considered to be the most appropriate given the period of record and the number of parameters for which data are available.

The current climate for the Project Area will be described using climate normals, which are long-term (usually 30-year) averages of observed climate for set periods of time. The current climate normals used in Canada cover the period from 1971 through 2000.

The historic climate change is relatively straight forward, relying on changes in the long-term climate records for the region. For continuity, the historic climate trends will look at the same 30-year period used to describe the current climate (i.e., 1971 through 2000).

This assessment of current climate and historic trends will focus on temperature and precipitation, as these parameters are the most widely assessed and available. These data will be augmented with available information in situations where other climate parameters are required to support the evaluation (e.g., winds). The assessment also focuses on expected, or average, conditions as this information is consistent with the data available for future climate forecasts. Because climate models used to produce forecasts of future climate trends focus on likely average climate outcomes over large areas, they are not suitable for predicting extreme events. Extreme events, which occur on a more local scale, will be discussed qualitatively.

D2.1 CURRENT CLIMATE CONDITIONS

Current climate conditions, referred to as “climate normals” refer to arithmetic calculations based on observed climate values for a given location over a specified time period. The World Meteorological Organization recommends that climate normals be prepared at the end of every decade for the official 30-year period. For this assessment, climate normals covering the period from 1971 through 2000 will be used to characterize the current climate conditions. Climate scientists usually break the year into four seasons, determined as follows:

- Spring – March, April and May;
- Summer – June, July and August;
- Fall – September, October and November; and
- Winter – December, January and February.

Table D2.1-1 provides a summary of the annual and seasonal temperatures normals at Wiarton Airport (1971 to 2000). Table D2.1-2 provides a summary of the annual and seasonal precipitation normals at Wiarton Airport (1971 to 2000).

Table D2.1-1: Annual and Seasonal Temperature Normals for Wiarton

Parameter	Annual	Spring	Summer	Fall	Winter
Daily Average (°C)	6.1	4.5	17.4	8.3	-5.7
Daily Maximum (°C)	10.8	9.5	22.8	12.6	-1.7
Daily Minimum (°C)	1.4	-0.6	11.9	4.1	-9.6
Extreme Maximum (°C)	35.6	30.5	35.0	35.6	18.1
Extreme Minimum (°C)	-36.4	-30.7	-1.6	-18.0	-36.4
Days with Max. Temp. > 30°C	3	0	3	0	0
Days with Min. Temp. < -10°C	50	9	0	1	41

Table D2.1-2: Annual and Seasonal Precipitation Normals for Wiarton

Parameter	Annual	Spring	Summer	Fall	Winter
Rainfall (mm)	740.4	165.8	230.8	268.9	74.9
Snowfall (cm)	426.6	62.8	0.0	52.1	311.6
Precipitation (mm) [a]	1,041.3	216.8	230.8	310.9	282.8
Extreme Daily Precipitation (mm)	104.6	48.8	104.6	88.6	48.6
Days with Measurable Precipitation	183	39	32	48	64

Note:
a Rainfall (mm) and snowfall (cm) cannot be directly added to determine precipitation

D2.2 HISTORIC CLIMATE TRENDS

Traditionally, the review of changing climate would look only at past weather records to provide guidance for predicting future conditions. Historic climate trends are determined using the temperature archives observed at Wiarton over the period from 1971 through 2000. Potential trends in temperature and precipitation are evaluated by fitting a linear model to the data using the Sen's nonparametric method. The statistical significance of the observed trends is determined using the Mann-Kendall test. The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series with no seasonal cycle. The analysis uses a two-tail test to determine significance at the 90th, 95th, 99th and 99.9th percentile levels. A trend that is not determined to be significant at the 90th percentile is classified as being “not significant”. A trend that is determined to be significant at the 99.9th percentile level means that there is a 99.9 percent probability that the direction of the trend is correct.

Table D2.2-1 provides a summary of the temperature statistics for the Wiarton station covering the period from 1971 through 2000, along with the associated trends, in degrees per decade. While the annual and seasonal data all show warming trends, only the trends in the winter temperatures were shown to be statistically significant.

Table D2.2-1: Wiarton Temperature Trends, 1971 to 2000

Year	Mean Daily Temperatures [°C]				
	Annual	Winter	Spring	Summer	Fall
1971	6.3	-5.3	2.8	17.0	10.7
1972	5.0	-6.0	2.4	16.1	7.2
1973	7.1	-5.7	5.6	18.9	9.2
1974	5.8	-5.3	3.5	17.2	7.6
1975	6.7	-4.9	3.7	18.2	9.4
1976	5.1	-7.5	4.5	17.1	6.1
1977	5.6	-8.6	5.9	16.3	8.4
1978	4.9	-7.7	2.8	16.6	7.7
1979	5.6	-7.6	4.6	16.8	13.8
1980	5.2	-7.6	4.1	16.9	7.1
1981	6.0	-5.8	4.7	17.2	7.5
1982	5.9	-5.8	4.0	16.0	9.1
1983	6.7	-5.2	3.9	18.9	9.1
1984	6.4	-4.1	2.9	17.7	8.9
1985	6.1	-6.5	5.3	16.3	9.3
1986	6.5	-4.9	6.2	16.7	8.0
1987	7.8	-3.6	6.9	19.0	8.5
1988	6.5	-5.7	4.8	18.3	8.4
1989	5.5	-7.2	3.2	17.9	8.0
1990	7.2	-2.9	5.2	17.7	8.7
1991	7.5	-4.5	6.8	18.9	8.4

Table D2.2-1: Wiarton Temperature Trends, 1971 to 2000 (continued)

Year	Mean Daily Temperatures [°C]				
	Annual	Winter	Spring	Summer	Fall
1992	5.4	-4.3	3.6	14.8	7.4
1993	5.6	-6.1	3.6	17.7	6.8
1994	5.5	-8.2	3.8	16.9	9.4
1995	6.1	-5.9	4.2	18.6	7.4
1996	5.4	-5.6	2.5	17.0	7.7
1997	5.8	-5.1	2.6	17.0	8.1
1998	8.5	-1.6	7.0	18.6	9.7
1999	7.9	-3.8	6.3	18.9	9.7
2000	6.5	-5.9	6.3	16.9	8.6
Trend [°/decade]	+0.31	+0.68	+0.50	+0.26	+0.05
Significant Level	Not Statistically Significant	Statistically Significant at 90th percentile	Not Statistically Significant	Not Statistically Significant	Not Statistically Significant

The results of fitting the Sen's nonparametric method to the long-term temperature data are illustrated on Figures D2.2-1 through D2.2-5, showing the trend (the Sen's Average), the 95% and the 99% confidence intervals of the mean temperatures. The statistical significance of the observed trends using the Mann-Kendall test confirmed that only the winter data are statistically significant.

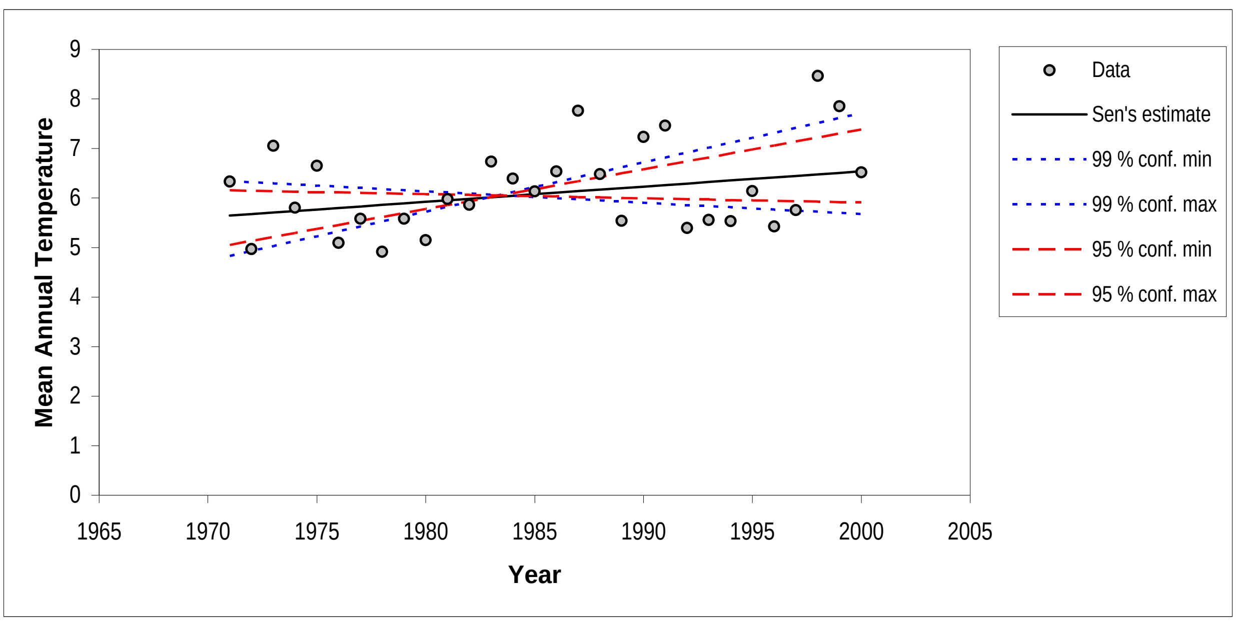

Figure D2.2-1: Wiarton Mean Annual Daily Temperatures 1971 to 2000

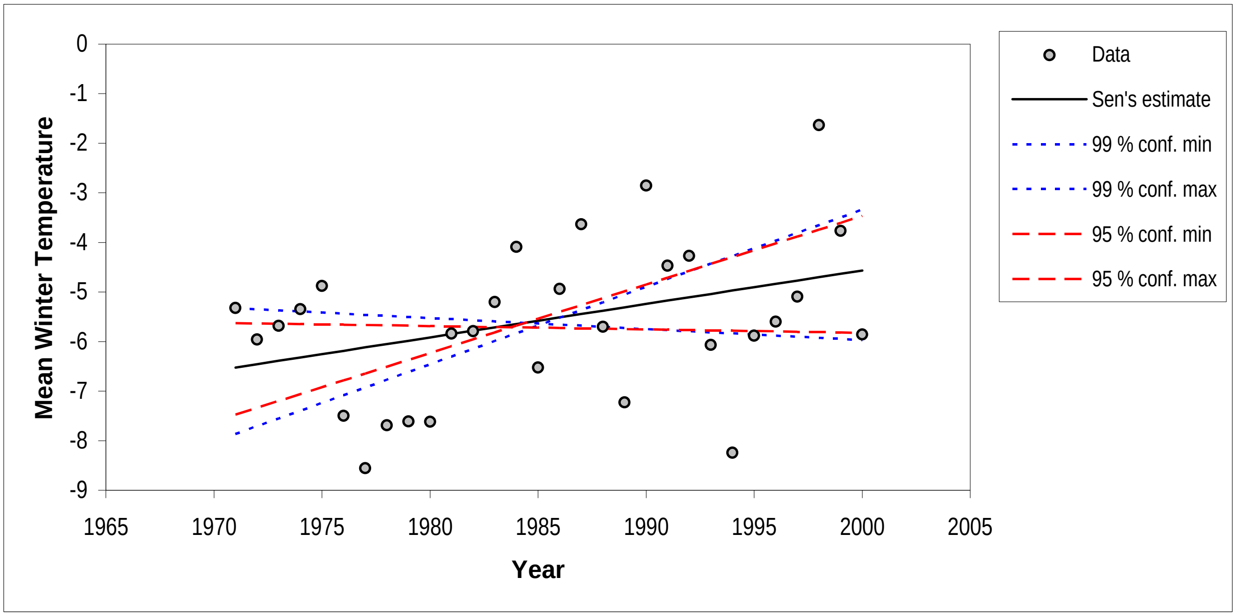

Figure D2.2-2: Wiarton Mean Winter Daily Temperatures 1971 to 2000

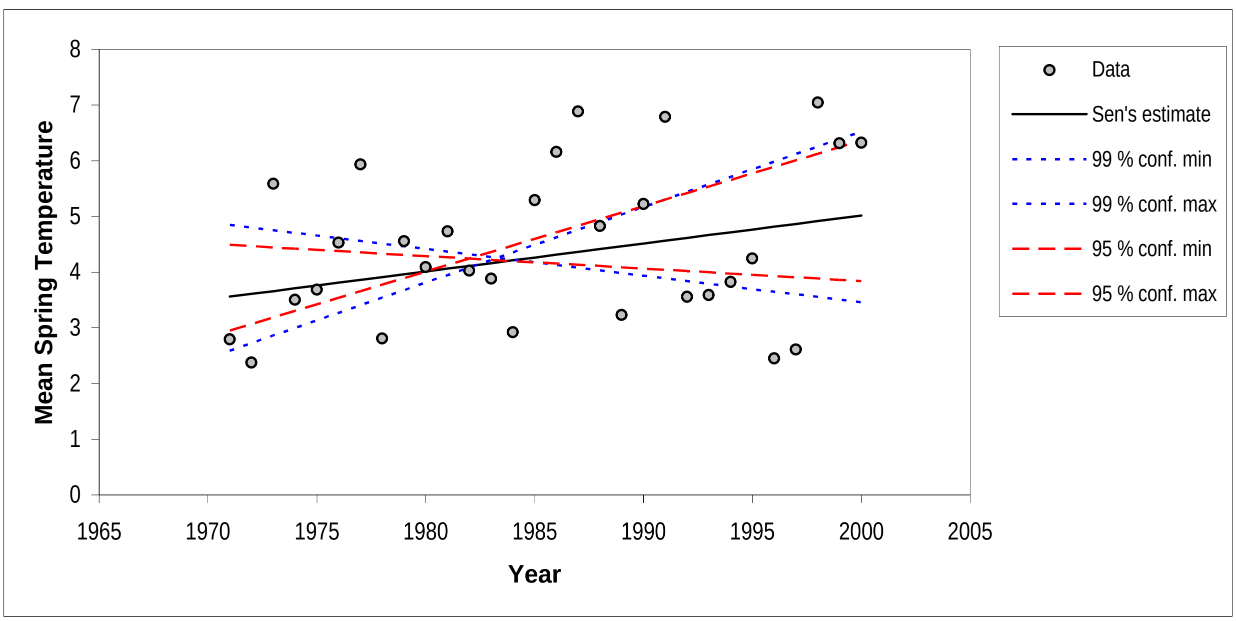

Figure D2.2-3: Wiarton Mean Spring Daily Temperatures 1971 to 2000

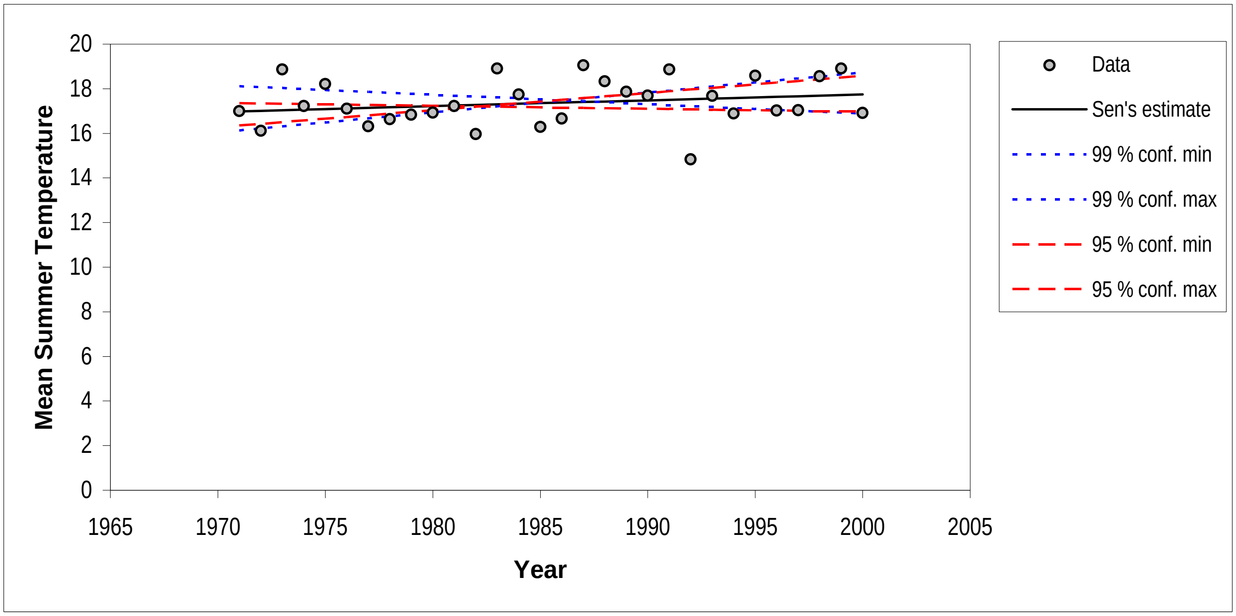

Figure D2.2-4: Wiarton Mean Summer Daily Temperatures 1971 to 2000

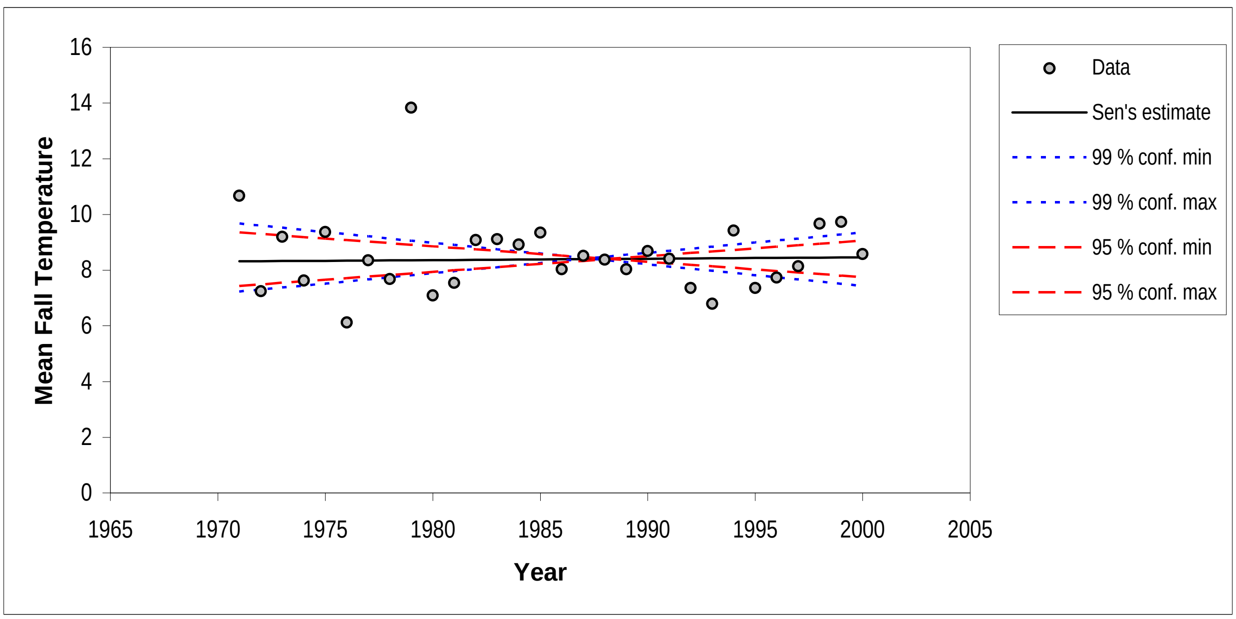

Figure D2.2-5: Wiarton Mean Fall Daily Temperatures 1971 to 2000

Table D2.2-2 provides a summary of the precipitation statistics for the Wiarton station covering the period from 1971 through 2000, along with the associated trends, in degrees per decade.

While the seasonal data show decreasing trends in the summer and increasing trends in the fall, these trends are not statistically significant.

Table D2.2-2: Wiarton Precipitation Trends, 1971 to 2000

Year	Total Precipitation [mm]				
	Annual	Winter	Spring	Summer	Fall
1971	886.9	323.1	151.4	208.0	204.4
1972	1,107.6	351.8	188.5	280.6	286.7
1973	1,104.0	220.4	287.1	289.1	307.4
1974	988.3	248.3	252.6	205.4	282.0
1975	920.3	297.4	158.6	209.2	255.1
1976	1,034.3	286.4	256.9	195.4	295.6
1977	1,177.5	403.0	144.0	288.3	342.2
1978	881.3	292.2	142.3	161.4	285.4
1979	854.0	319.8	253.7	246.9	33.6
1980	1,182.0	297.7	257.1	346.9	280.3
1981	992.1	242.1	175.7	286.0	288.3
1982	1,038.8	315.1	186.2	241.3	296.2
1983	1,153.9	295.9	364.1	128.3	365.6
1984	1,058.9	261.4	226.9	269.1	301.5
1985	1,412.6	411.1	283.6	259.0	458.9
1986	975.6	212.7	236.9	211.3	314.7
1987	967.2	179.3	141.5	258.6	387.8
1988	1,165.5	323.7	186.8	287.0	368.0
1989	858.2	228.9	180.9	109.5	338.9
1990	1,115.6	267.1	214.5	228.5	405.5
1991	1,021.5	235.0	307.3	148.9	330.3
1992	918.5	223.3	175.7	212.6	306.9
1993	990.9	265.9	203.0	220.4	301.6
1994	966.7	188.3	229.2	279.1	270.1
1995	1,109.6	263.2	226.0	214.7	405.7
1996	1,035.2	279.3	192.6	240.2	323.1
1997	1,172.4	392.4	227.4	288.4	264.2
1998	858.5	245.9	242.1	132.1	238.4
1999	1,029.5	328.5	125.0	253.1	322.9
2000	1,095.9	285.0	285.2	275.6	250.1
Trend [%/decade]	+0.13%	-4.65%	+3.23%	-0.51%	+4.41%
Significant Level	Not Statistically Significant	Not Statistically Significant	Not Statistically Significant	Not Statistically Significant	Not Statistically Significant

The results of fitting the Sen's nonparametric model to the long-term precipitation data are illustrated on Figures D2.2-6 through D2.2-10, showing the trend (the Sen's Average), the 95% and the 99% confidence intervals of the mean temperatures. The statistical significance of the observed trends using the Mann-Kendall test confirmed that decreasing trends in the summer and increasing trends in the fall are not statistically significant.

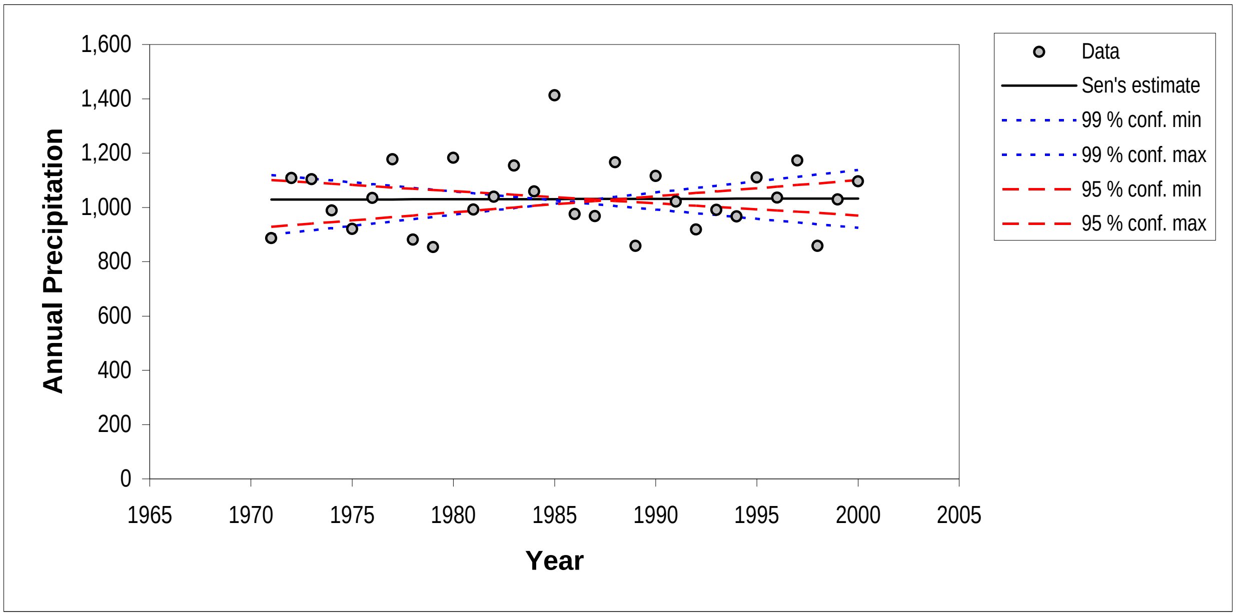

Figure D2.2-6: Wiarton Total Annual Precipitation Trends: 1971 to 2000

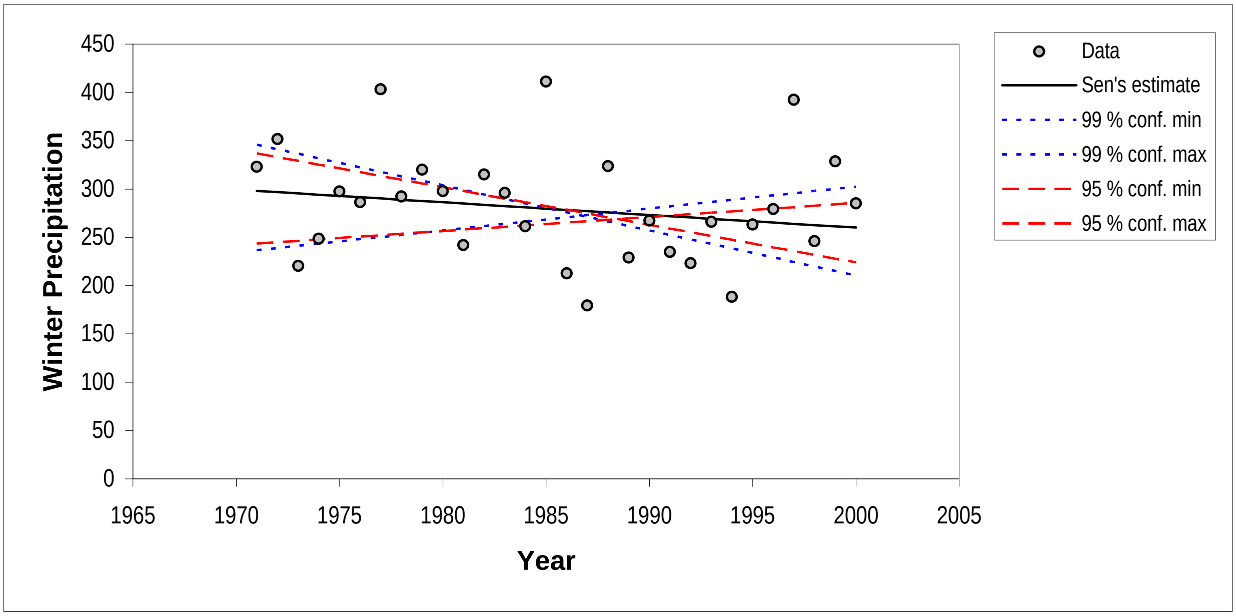

Figure D2.2-7: Wiarton Total Winter Precipitation Trends: 1971 to 2000

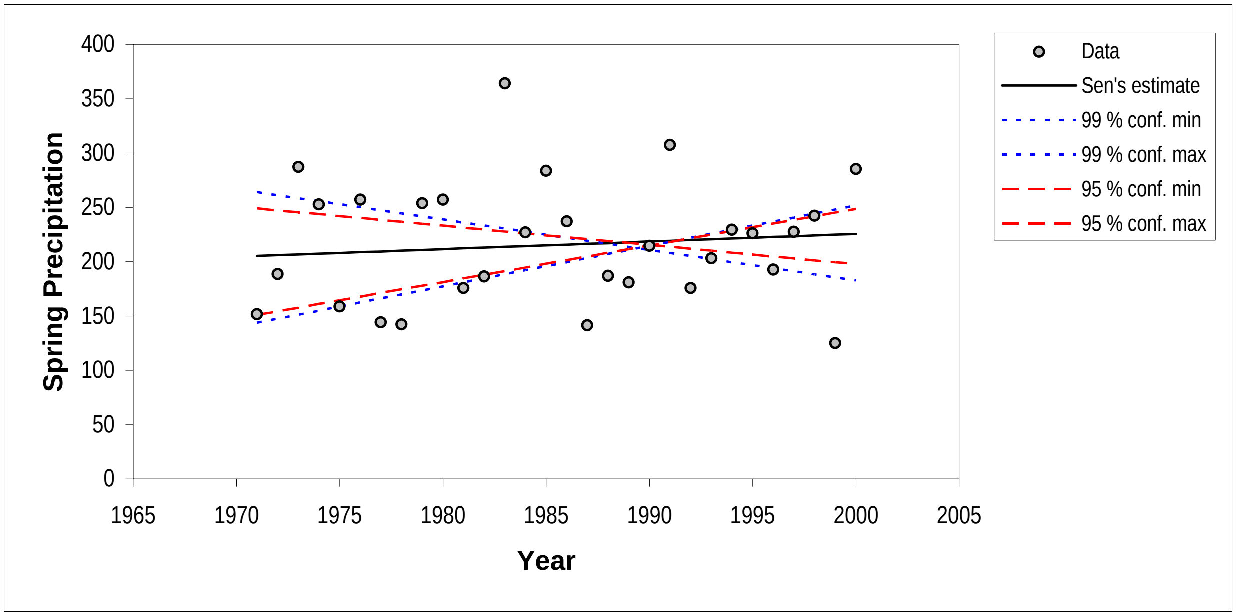

Figure D2.2-8: Wiarton Total Spring Precipitation Trends: 1971 to 2000

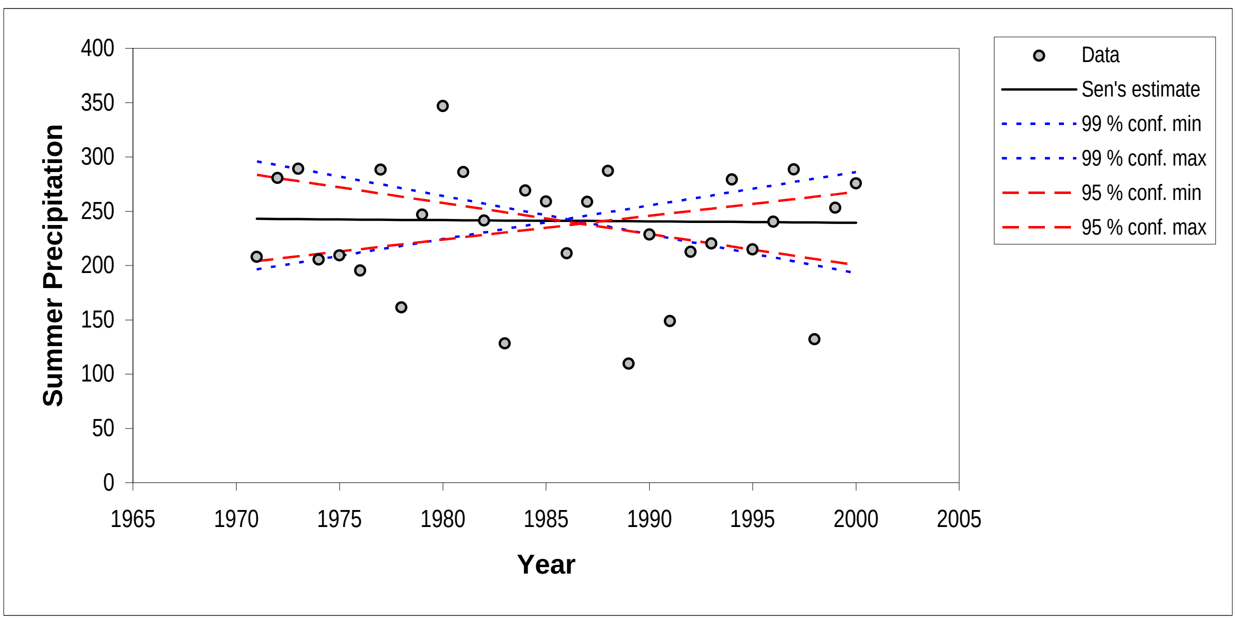

Figure D2.2-9: Wiarton Total Summer Precipitation Trends: 1971 to 2000

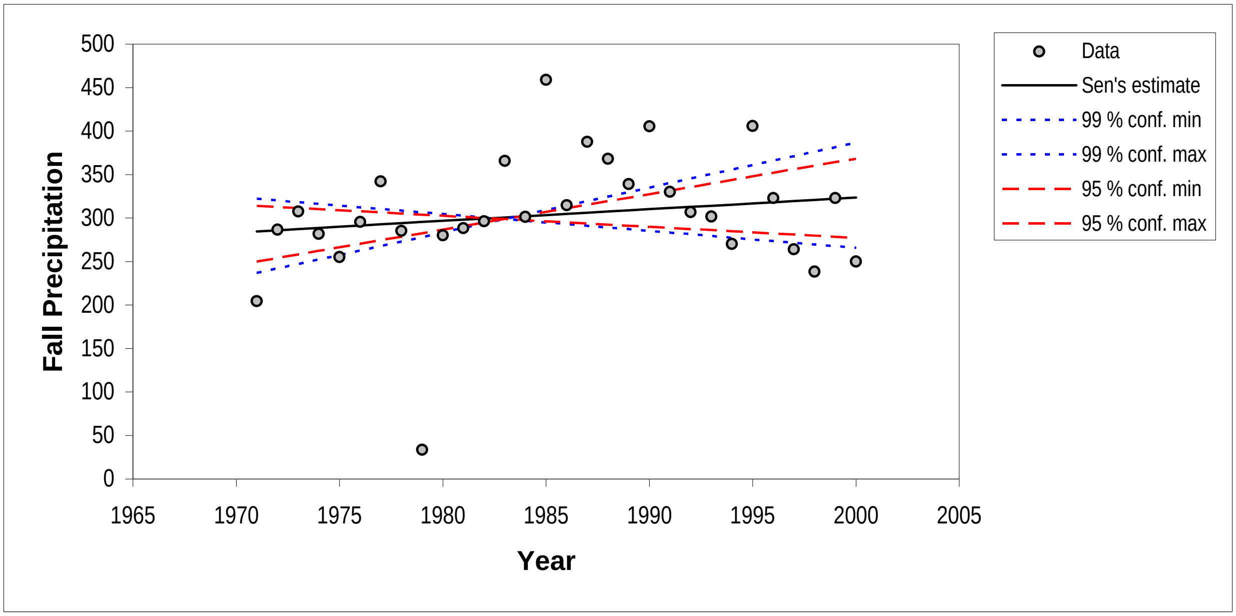

Figure D2.2-10: Wiarton Total Fall Precipitation Trends: 1971 to 2000

D2.3 FUTURE CLIMATE CHANGE

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to review international climate change data. A series of improved global climate models have been developed to respond to the concerns over future climate trends and the impact of human activities on climate, which could affect natural ecosystems and the economy.

Modelling climate is a complex process that involves the mathematical representation of global land, sea and atmosphere interactions over a long period. There is substantial uncertainty in climate change predictions. The results of global climate models are subject to many uncertainties and interpretations. This assessment uses various scenarios to partially address this concern. Since the models are susceptible to inter-decadal variability, the analysis uses the average of 30 years of data, centred on the decade of interest.

D2.3.1 Climate Forecast Models

Forecasts of future climate require the use of sophisticated mathematical computer programs called global climate models (GCMs). The IPCC (Intergovernmental Panel on Climate Change), which has been charged with providing state-of-the-art reviews of climate change science, have made use of a number of different GCMs. The seven models considered the most highly regarded and reported include the following, the main characteristics of which are shown in Table D2.3.1-1:

- Australian Commonwealth Scientific and Industrial Research Organization model (CSIRO);
- The Japanese Centre for Climate Research Studies model (CCSR);
- The German Deutsches Klimarechenzentrum model (ECHAM4);
- The United Kingdom Hadley Centre model (HADCM3);
- The United States National Centre for Atmospheric Research model (NCAR-PCM);
- The United States Geophysical Fluid Dynamic Laboratory model (GFDL); and
- The Canadian Climate Centre (CGM3) model.

For the purposes of the EA, climate change forecasts from the Canadian Climate Centre CGM3 model were chosen because it has been designed to model changing climate in the mid to upper latitudes, and in particular North America. In total, the CGM3 predictions being put forward by the IPCC for the following forecast periods were considered:

- 2011 to 2040;
- 2041 to 2070; and
- 2070 to 2100.

The forecast data from the CGM3 model are presented as the change in climate relative to the predicted 1971 to 2000 baseline predicted using the same model. This change represents the change between the 30-year average for the modelled future conditions and the predicted average for the 30-year modelled baseline period (i.e., 1971 to 2000).

Table D2.3.1-1: Widely Accepted Global Climate Models

Agency	Model	Country	Model Resolution[a] (km^2)
Commonwealth Scientific and Industrial Research Organization	CSIRO MK2	Australia	95,000
Centre for Climate System Research / National Institute for Environmental Studies	CCSR/NIES	Japan	168,000
German Deutsches Klimarechenzentrum	ECHAM4/OPYC3	Germany	41,000
Hadley Centre	HadCM3	United Kingdom	50,000
National Centre for Atmospheric Research	NCAR-PCM	United States	41,000
Geophysical Fluid Dynamics Laboratory	GFDL R30	United States	44,000
Canadian Climate Centre	CGCM2	Canada	74,000

Note:
a The model resolution represents the size of the grid cells used in the respective models.

D2.3.2 Forecast Scenarios

Global climate models require extensive inputs in order to characterize the physical and social forces that could alter climate in the future. In order to represent the wide range of the inputs possible to global climate models, the IPCC have established a series of socio-economic scenarios that help define the future levels of global GHG emissions. The IPCC [D2] identifies four general scenarios, namely ***A1***, ***B1***, ***A2*** and ***B2***.

The ***A1*** and ***A2*** scenarios represent a focus on economic growth while the ***B1*** and ***B2*** scenarios represent a shift towards more environmentally conscious solutions to growth. Both scenarios ***A1*** and ***B1*** include a shift towards global solutions while the ***A2*** and ***B2*** scenarios include growth based on regional models. Figure D2.3.2-1 provides an illustration relating the four emission scenarios.

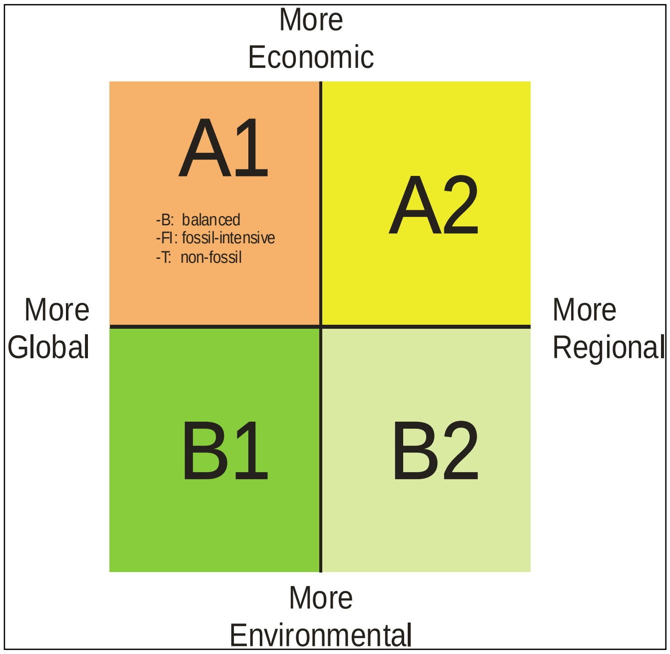

Figure D2.3.2-1: IPCC SRES Emission Scenarios

These four socio-economic scenarios have been described more fully by the IPCC in their Special Report on Emission Scenarios (SRES) [D2]. Although the IPCC has not stated which of these scenarios are most likely to occur, the ***A2*** scenario most closely reflects the current global socio-economic situation. In relation to the A2 scenario, scenarios ***A1***, ***B1*** and ***B2*** result in lower long-term GHG emissions over the next century. Of the ***A1*** scenario family, scenario ***A1FI*** yields high emissions in the first half of the 21st century as a result of increasing population and high dependence on fossil fuels for energy.

The Canadian Climate Centre has produced forecasts for the following three SRES emission scenarios put forward by the IPCC:

- Scenario A1B — The A1 family of scenarios describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. The A1 family includes three groups of scenarios that describe alternative directions in the energy system. The A1B group is distinguished by a balance across all sources of energy.
- Scenario A2 — The A2 scenario family describes a world with an underlying theme of self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is regionally oriented and per capita economic growth and technological change more fragmented and slower than for other scenarios.
- Scenario B1 — The B1 scenario describes a convergent world with the same global population that peaks in mid-century and declines thereafter (similar to the A1 scenarios). The B1 scenarios have rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

Each of these SRES scenarios corresponds with varying amounts of greenhouse gas emissions, as shown in Table D2.3.2-1. This table lists the global GHG emissions of the primary greenhouse gases (carbon dioxide, methane and nitrous oxide) in units of equivalent carbon dioxide (CO2e) emissions. The concept of carbon dioxide equivalency accounts for the greater global warming potential for methane and nitrous oxide, and allows the addition of the three compounds into a single value. The table also indicates the change in global GHG emissions for each scenario and year relative to the 2000 baseline emissions.

In addition, the CGM3 model forecasts for the following two non-SRES scenarios put forward by the IPCC in their latest round of reports were included:

- 1PTO2X — greenhouse gasses increasing from pre-industrial levels at a rate of 1% per year until the concentration has doubled, and then held constant thereafter; and
- 1PTO4X —greenhouse gasses increasing from pre-industrial levels at a rate of 1% per year until the concentration has quadrupled, and then held constant thereafter.

Neither of these scenarios are shown in Table D2.3.2-1 since there are no specific GHG emissions associated with them, rather they represent situations where the concentrations in the atmosphere of GHGs increase as described above.

Table D2.3.2-1: Global GHG Emissions Associated with SRES Scenarios

Scenario and Compound	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Scenario A1B											
fossil fuel CO_2 (Mt CO_2e/a)	6,896	9,680	12,122	14,011	14,945	16,009	15,697	15,425	14,834	13,938	13,096
other CO_2 (Mt CO_2e/a)	1,075	1,197	516	470	404	374	305	303	351	363	391
methane (Mt CO_2e/a)	6,782	7,834	8,836	9,791	9,621	9,498	8,614	7,835	7,171	6,595	6,073
nitrous oxide (Mt CO_2e/a)	2,175	2,183	2,224	2,277	2,289	2,302	2,265	2,230	2,206	2,194	2,182
TOTAL (Mt CO_2e/a)	16,927	20,894	23,698	26,550	27,259	28,183	26,882	25,793	24,561	23,089	21,742
Change relative to 2000 (%)	—	23%	40%	57%	61%	66%	59%	52%	45%	36%	28%
Scenario A2											
fossil fuel CO_2 (Mt CO_2e/a)	6,896	8,461	11,009	13,534	15,013	16,492	18,490	20,488	22,971	25,939	28,907
other CO_2 (Mt CO_2e/a)	1,075	1,116	1,246	1,189	1,061	933	665	397	247	213	179
methane (Mt CO_2e/a)	6,782	7,774	8,913	10,198	11,373	12,548	13,744	14,940	16,164	17,414	18,665
nitrous oxide (Mt CO_2e/a)	2,175	2,496	2,965	3,306	3,509	3,713	4,011	4,309	4,591	4,857	5,122
TOTAL (Mt CO_2e/a)	16,927	19,847	24,132	28,227	30,956	33,686	36,910	40,135	43,972	48,423	52,873
Change relative to 2000 (%)	—	17%	43%	67%	83%	99%	118%	137%	160%	186%	212%
Scenario B1											
fossil fuel CO_2 (Mt CO_2e/a)	6,896	8,496	9,996	11,196	12,196	11,696	10,196	8,596	7,296	6,096	5,196
other CO_2 (Mt CO_2e/a)	1,075	785	632	-90	-479	-409	-457	-421	-598	-775	-966
methane (Mt CO_2e/a)	6,782	7,328	7,916	8,084	8,000	7,538	7,181	6,803	6,152	5,585	4,955
nitrous oxide (Mt CO_2e/a)	2,175	2,330	2,516	2,547	2,578	2,578	2,392	2,299	2,175	1,989	1,772
TOTAL (Mt CO_2e/a)	16,927	18,938	21,059	21,736	22,294	21,402	19,312	17,277	15,025	12,895	10,957
Change relative to 2000 (%)	—	12%	24%	28%	32%	26%	14%	2%	-11%	-24%	-35%

Note:
— Not applicable

D2.3.3 Climate Forecasts

As noted above, the output from the CGM2 global climate model were obtained for five forecast scenarios, as well as for each of the following four time horizons:

- 1971 to 2000 (baseline);
- 2011 to 2040;
- 2041 to 2070; and
- 2070 to 2100.

Tables D2.3.3-1 and D2.3.3-2 list the annual forecasts for temperature and precipitation, respectively. These data are presented graphically on Figure D2.3.3-1. For consistency, the forecast temperature and precipitation data are presented on the basis of change per decade. The temperature forecasts are presented as degree Celsius per decade (°C/decade) and precipitation forecasts presented as percent change per decade (%/decade).

Table D2.3.3-1: Forecast Annual Temperature Trends

Scenario	1971-2000 Baseline (°C)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)
SR-A1b	8.803	10.306	+0.30	11.470	+0.33	11.005	+0.20
SR-A2	8.803	10.304	+0.30	11.379	+0.32	13.076	+0.39
SR-B1	8.803	8.803	+0.00	9.983	+0.15	11.348	+0.23
1PT04x	8.803	14.056	+1.05	14.084	+0.66	14.453	+0.51
1PT02x	8.803	10.806	+0.40	10.609	+0.23	—	—

Note:
— Forecasts not available

Table D2.3.3-2: Forecast Annual Precipitation Trends

Scenario	1971-2000 Baseline (mm)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)
SR-A1b	2.313	2.391	+0.68%	2.523	+1.13%	2.667	+1.39%
SR-A2	2.313	2.428	+0.99%	2.471	+0.85%	2.637	+1.27%
SR-B1	2.313	2.313	+0.00%	2.380	+0.36%	2.391	+0.31%
1PT04x	2.313	2.726	+3.57%	2.700	+2.09%	2.885	+2.25%
1PT02x	2.313	2.540	+1.96%	2.516	+1.10%	—	—

Note:
— Forecasts not available

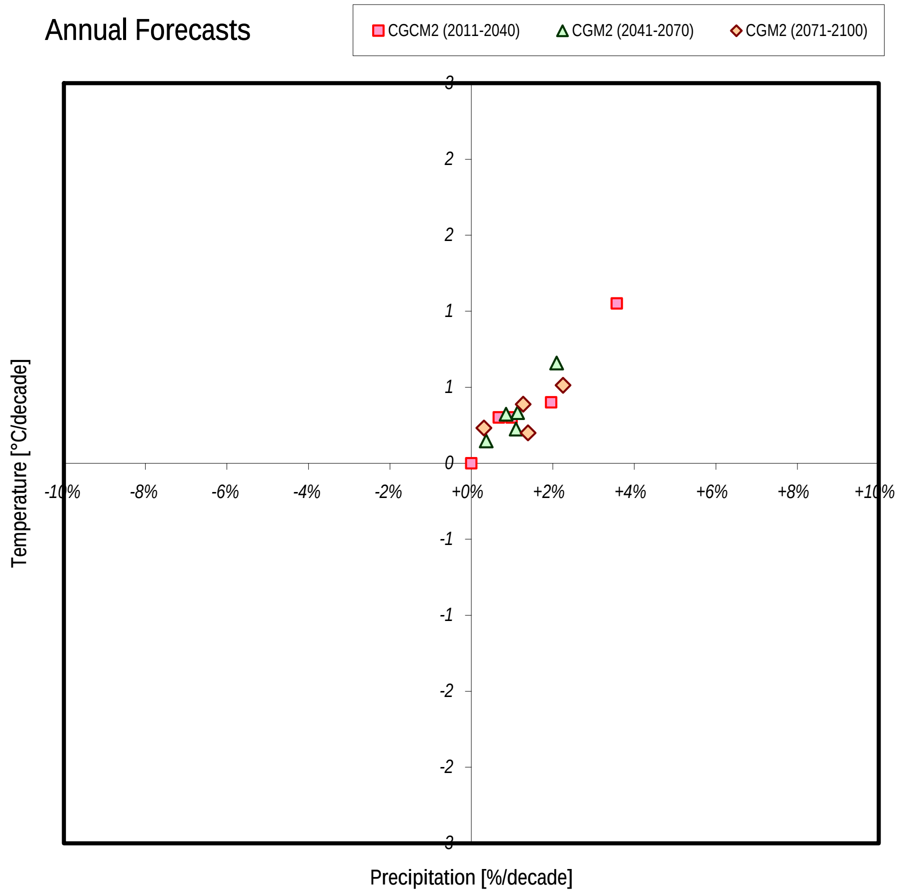

Figure D2.3.3-1: Forecast Annual Temperature and Precipitation Trends

Tables D2.3.3-3 and D2.3.3-4 list the winter forecasts for temperature and precipitation, respectively. These data are presented graphically on Figure D2.3.3-2.

Table D2.3.3-3: Forecast Winter Temperature Trends

Scenario	1971-2000 Baseline (°C)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)
SR-A1b	-0.117	1.456	+0.31	2.667	+0.35	2.171	+0.21
SR-A2	-0.117	1.322	+0.29	2.363	+0.31	3.909	+0.37
SR-B1	-0.117	-0.117	+0.00	1.150	+0.16	2.459	+0.23
1PT04x	-0.117	4.855	+0.99	4.897	+0.63	5.352	+0.50
1PT02x	-0.117	2.011	+0.43	1.715	+0.23	—	—

Note:
— Forecasts not available

Table D2.3.3-4: Forecast Winter Precipitation Trends

Scenario	1971-2000 Baseline (mm)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)
SR-A1b	2.241	2.381	+1.3%	2.691	+2.5%	2.746	+2.0%
SR-A2	2.241	2.390	+1.3%	2.592	+2.0%	2.720	+1.9%
SR-B1	2.241	2.241	+0.0%	2.193	-0.3%	2.332	+0.4%
1PT04x	2.241	3.059	+7.3%	2.794	+3.1%	3.060	+3.3%
1PT02x	2.241	2.472	+2.1%	2.564	+1.8%	—	—

Note:
— Forecasts not available

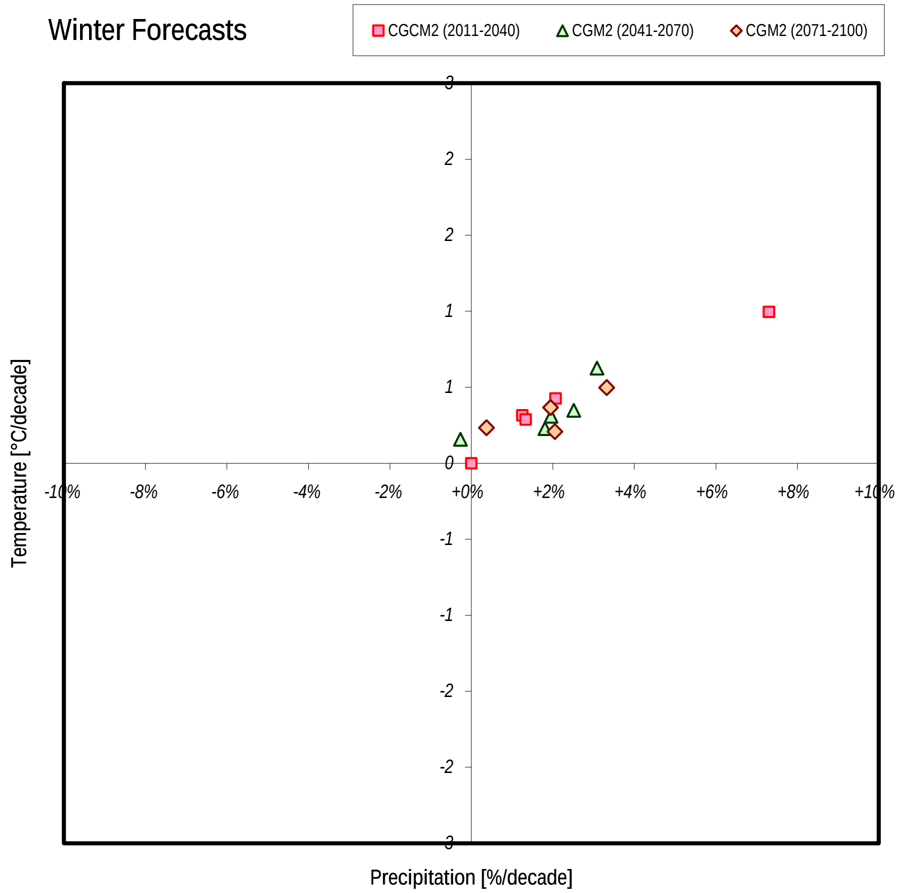

Figure D2.3.3-2: Forecast Winter Temperature and Precipitation Trends

Tables D2.3.3-5 and D2.3.3-6 list the spring forecasts for temperature and precipitation, respectively. These data are presented graphically on Figure D2.3.3-3.

Table D2.3.3-5: Forecast Spring Temperature Trends

Scenario	1971-2000 Baseline (°C)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)
SR-A1b	4.298	6.026	+0.35	7.147	+0.36	6.436	+0.19
SR-A2	4.298	6.090	+0.36	6.968	+0.33	8.781	+0.41
SR-B1	4.298	4.298	+0.00	5.439	+0.14	6.787	+0.23
1PT04x	4.298	9.748	+1.09	9.815	+0.69	10.277	+0.54
1PT02x	4.298	6.524	+0.45	6.035	+0.22	—	—

Note:
— Forecasts not available

Table D2.3.3-6: Forecast Spring Precipitation Trends

Scenario	1971-2000 Baseline (mm)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)
SR-A1b	2.547	2.722	+1.4%	2.975	+2.1%	3.074	+1.9%
SR-A2	2.547	2.890	+2.7%	2.828	+1.4%	3.272	+2.6%
SR-B1	2.547	2.547	+0.0%	2.674	+0.6%	2.674	+0.5%
1PT04x	2.547	3.234	+5.4%	3.102	+2.7%	3.683	+4.1%
1PT02x	2.547	2.996	+3.5%	2.696	+0.7%	—	—

Note:
— Forecasts not available

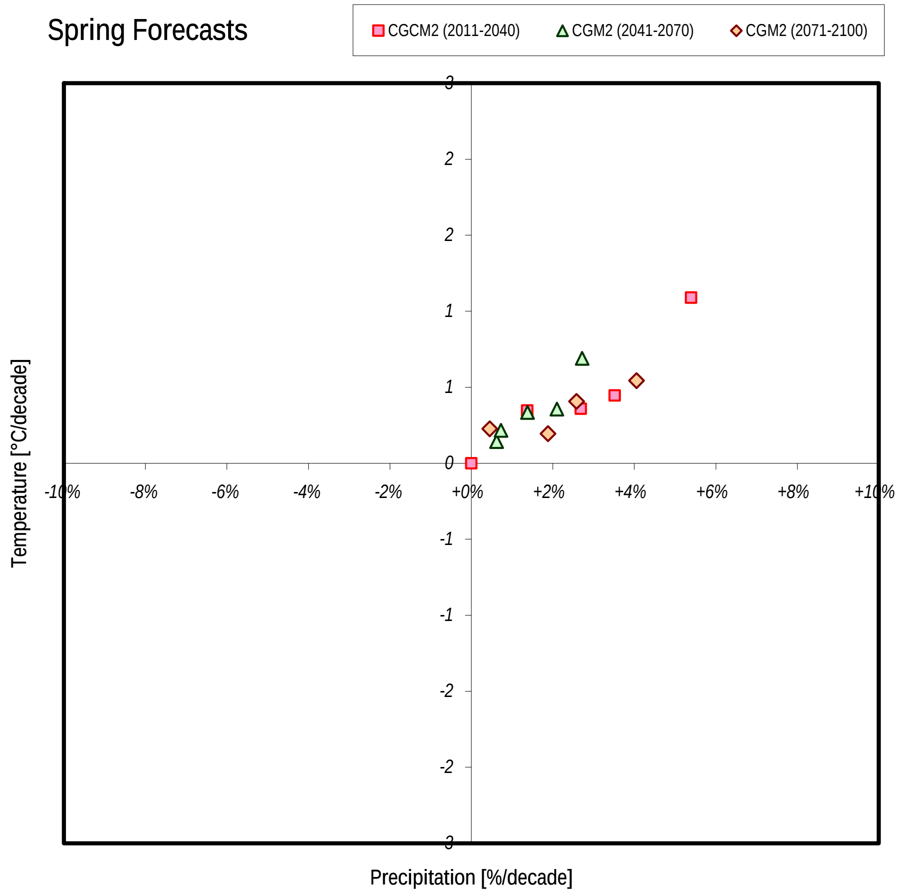

Figure D2.3.3-3: Forecast Spring Temperature and Precipitation Trends

Tables D2.3.3-7 and D2.3.3-8 list the summer forecasts for temperature and precipitation, respectively. These data are presented graphically on Figure D2.3.3-4.

Table D2.3.3-7: Forecast Summer Temperature Trends

Scenario	1971-2000 Baseline (°C)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)
SR-A1b	18.220	19.858	+0.33	20.928	+0.34	20.513	+0.21
SR-A2	18.220	19.772	+0.31	20.937	+0.34	22.690	+0.41
SR-B1	18.220	18.220	+0.00	19.540	+0.16	20.781	+0.23
1PT04x	18.220	23.727	+1.10	23.753	+0.69	23.989	+0.52
1PT02x	18.220	20.252	+0.41	19.456	+0.15	—	—

Note:
— Forecasts not available

Table D2.3.3-8: Forecast Summer Precipitation Trends

Scenario	1971-2000 Baseline (mm)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)
SR-A1b	2.130	1.940	-1.8%	1.946	-1.1%	1.970	-0.7%
SR-A2	2.130	1.936	-1.8%	1.817	-1.8%	1.890	-1.0%
SR-B1	2.130	2.130	+0.0%	1.894	-1.4%	1.873	-1.1%
1PT04x	2.130	1.768	-3.4%	2.058	-0.4%	1.987	-0.6%
1PT02x	2.130	1.996	-1.3%	1.968	-0.9%	—	—

Note:
— Forecasts not available

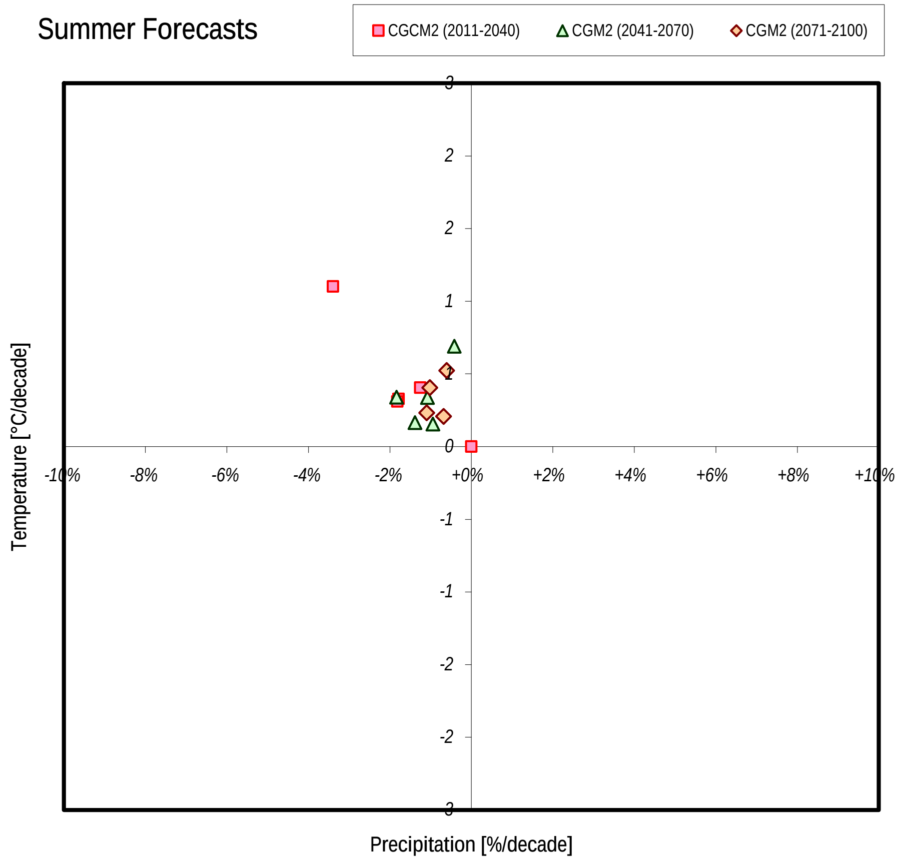

Figure D2.3.3-4: Forecast Summer Temperature and Precipitation Trends

Tables D2.3.3-9 and D2.3.3-10 list the fall forecasts for temperature and precipitation, respectively. These data are presented graphically on Figure D2.3.3-5.

Table D2.3.3-9: Forecast Fall Temperature Trends

Scenario	1971-2000 Baseline (°C)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)	Value (°C)	Trend (°C/decade)
SR-A1b	12.811	13.886	+0.21	15.138	+0.29	14.898	+0.19
SR-A2	12.811	14.030	+0.24	15.247	+0.30	16.924	+0.37
SR-B1	12.811	12.811	+0.00	13.801	+0.12	15.364	+0.23
1PT04x	12.811	17.894	+1.02	17.870	+0.63	18.194	+0.49
1PT02x	12.811	14.437	+0.33	13.815	+0.13	—	—

Note:
— Forecasts not available

Table D2.3.3-10: Forecast Fall Precipitation Trends

Scenario	1971-2000 Baseline (mm)	2011-2040 Forecast		2041-2070 Forecast		2071-2100 Forecast	
		Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)	Value (mm)	Trend (%/decade)
SR-A1b	2.335	2.522	+1.6%	2.479	+0.8%	2.877	+2.1%
SR-A2	2.335	2.495	+1.4%	2.648	+1.7%	2.666	+1.3%
SR-B1	2.335	2.335	+0.0%	2.760	+2.3%	2.685	+1.4%
1PT04x	2.335	2.842	+4.3%	2.849	+2.8%	2.809	+1.8%
1PT02x	2.335	2.697	+3.1%	2.500	+0.9%	—	—

Note:
— Forecasts not available

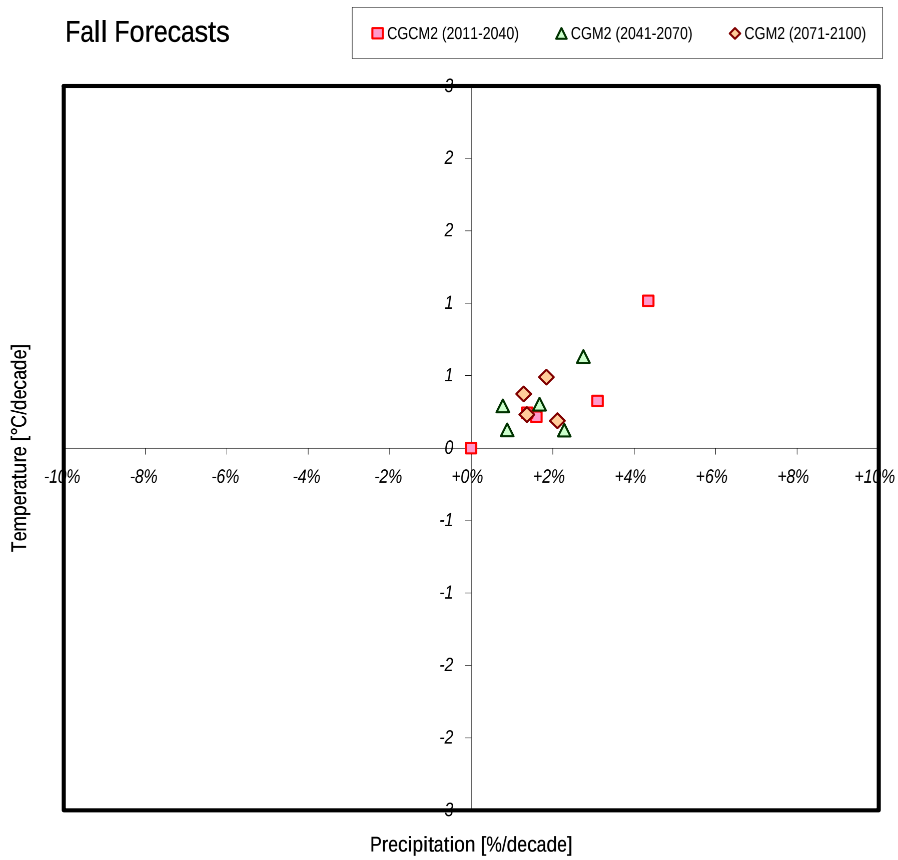

Figure D2.3.3-5: Forecast Fall Temperature and Precipitation Trends

D2.3.4 Changes in the Great Lakes Basin Resulting from IPCC Forecasts

While the global forecasts of temperature and precipitation provided through the IPCC (see Sections D2.3.4.1 and D2.3.4.2) provide an idea of changes in a broad sense, they do not focus on a particular area, nor do they indicate how those changes are likely to affect the environment itself. Within North America, a number of researchers have looked at what the IPCC climate predictions mean. The following sections summarize a review of the available literature on how the environment may change in response to the changes forecasted by the IPCC.

D2.3.4.1 Air Temperatures

The most recent IPCC data for the Canadian model forecast an annual temperature increase in the Project Area ranging from 0 to 5.25°C in 2011 to 2040 (2020’s), 0.99 to 5.28°C in 2041 to 2070 (2050’s), and 2.09 to 5.65°C in 2071 to 2100 (2080’s) (see Section D2.3.3). These forecasts are all relative to the 1971 to 2000 baseline period used in the AR4 (i.e., the fourth round of reports issued by IPCC) Synthesis Report [D3].

The IPCC forecasts [D3] are comparable to the earlier values presented in North American literature. For example, a 2005 report to the International Joint Commission [D4] indicated that mean annual air temperatures in the Great Lakes/St. Lawrence Basin would increase by 2 to 4°C by the 2050’s. Another study [D5] indicated that temperatures by the 2080’s would increase in southern and eastern Ontario by 3 to 6°C above baseline.

D2.3.4.2 Precipitation

The most recent IPCC data for the Canadian model forecast an annual increase in precipitation in the Project Area ranging from 0 to 17.6% in 2011 to 2040 (2020’s), 0.17 to 0.75% in 2041 to 2070 (2050’s), and 0.22 to 0.56% in 2071 to 2100 (2080’s) (see Section D2.3.3). These forecasts are all relative to the 1971 to 2000 baseline period used in the AR4 (i.e., the fourth round of reports issued by IPCC) Synthesis Report [D3].

While the IPCC forecasts suggest increased precipitation, the effect on available moisture may be an overall decrease because of the offsetting effect of increases in temperature. Increases in temperature could result in higher evaporation rates. Natural Resources Canada [D6] indicate that southern Canada could experience decreasing soil moisture, while a 2003 report to the International Joint Commissions [D7] predicts a decrease in expected groundwater flow for the Great Lakes, despite mixed results in their efforts to model the effects of climate change on groundwater.

The Global Climate Models (GCMs) used to produce the IPCC forecasts do not have sufficient resolution to indicate whether or not the intensity of precipitation is increasing or decreasing. Additional modelling using some “downscaling” is typically used to make such estimates. In addition, it is possible to review the past climate record to identify possible trends.
Table D2.3.4-1 provides a summary of the maximum 24-hour precipitation recorded at Wiarton, Ontario for the period from 1971 through 2000. No statistically significant trends for the total precipitation were observed (see Table D2.3.4-1), thus suggesting that there was no increase in the daily rainfall or snowfall rate over that last 30 years.

Table D2.3.4-1: Trends in Maximum Daily Precipitation for Wiarton 1971-2000

Parameter	Spring	Summer	Fall	Winter	Annual
Normal[a] Daily Maximum Precipitation (mm)	26.5	28.6	41.1	36.0	47.5
Trend (% change/decade)	-1.5%	+0.0%	+1.2%	+0.1%	+0.2%
Trend (mm/decade)	-0.38	+0.00	+0.50	+0.05	+0.07
Level of Significance	not statistically significant	not statistically significant	not statistically significant	not statistically significant	not statistically significant

Note:
a The normal daily maximum precipitation is calculated as the average of the 30 daily maximum precipitation values determined for each of the years between 1971 and 2000.

One recent paper [D8] suggested that the 20-year return period for total 24-hour rainfall could increase in intensity by 10 -20% by the 2071-2100 (2080's) forecast period.

D2.3.4.3 Lake Huron Water Levels

Although the GCM models presented by the IPCC do not provide forecasts of either lake levels or surface temperatures, efforts have been made in literature to correlate the projected changes in climate to both parameters. A recent report by Mortsch, *et al*. [D9] indicated that the annual levels for Lake Huron could change by between -0.73 to -0.98 m relative to the baseline case (1961-1990) for the 2041-2070 (i.e., 2050's) forecast period. An additional study is underway by the International Joint Commissions to examine the change in water levels on the Upper Great Lakes relative to Lake Huron. This study will include a detailed evaluation of the potential impact of climate change on water levels. However, the results of this study are not yet available.

A review of historic lake levels is important when exploring the potential effects of climate change on the levels for Lake Huron because past responses to climate give an indication as to how lake levels will respond in the future. Figure D2.3.4-1 illustrates the fluctuation in surface levels for Lake Huron for the period from 1918 through 2008. The levels in Lake Huron have shown large fluctuations from one year to the next, in the range of those indicated by Mortsch, *et al*. [D9]. The historic fluctuations appear to be the result of long-term cyclic patterns.

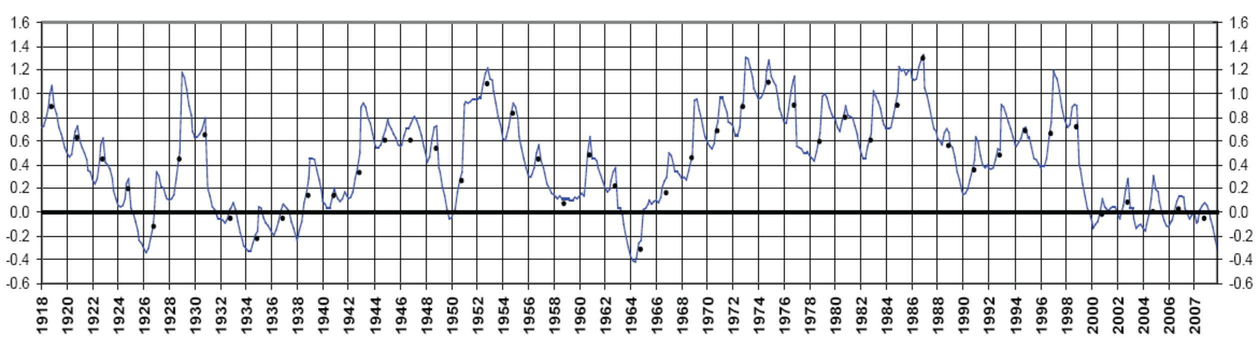

Figure D2.3.4-1: Variation in Annual Lake Huron Levels, 1918 to 2008

A recent study on the Great Lakes [D10] identified the following long-term cycles affecting the lake levels on the basis of historic beach ridge data:

- **120 to 200 year cycle:** a regular fluctuation with a period of approximately 160 years showing an increase and decrease in foreshore and dune crest elevation; and
- **33-year cycle:** a shorter hydrologic cycle in the range of 29 to 37 years (approximately 33 years) with a magnitude of approximately 0.5 to 0.6 m.

The same study [D10] identified two shorter-term cycles based on a review of lake levels. The first is a four to eight year cycle with a magnitude of about 0.4 m. The second is the one year fluctuation. It is well known that lake level varies with season as a result of the seasonal changes of precipitation and temperature (evaporation). The lake levels are higher in the summer and lower during the winter months. This is illustrated on Figure D2.3.4-2. Also included on Figure D2.3.4-2 is the most recent Lake Huron fluctuation levels from 2007 through to March 2009 period.

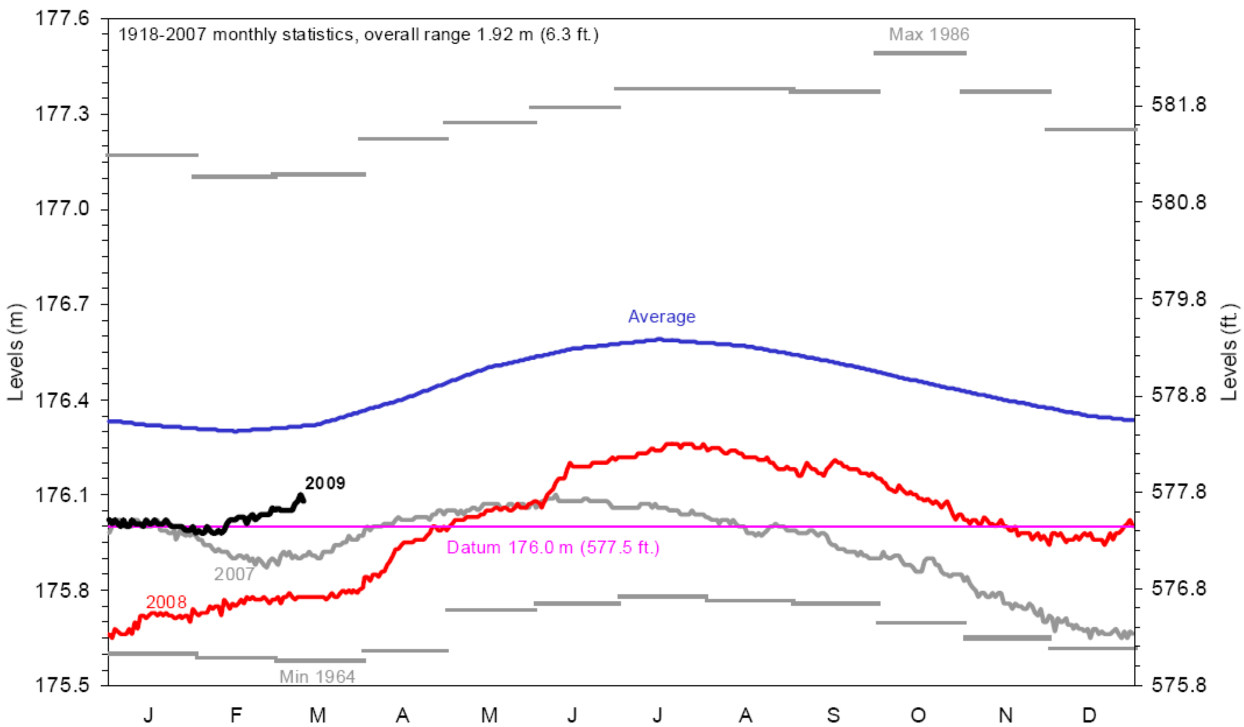

Figure D2.3.4-2: Average Variations in Monthly Lake Huron Levels, 1918 to 2007

D2.3.4.4 Extreme Weather

While there have been suggestions that the frequency and intensity of severe weather events are increasing as a result of climate change [D11], Environment Canada indicates that *"…there is not yet enough scientific evidence to show a link between increasing severe weather and a changing climate*" [D12]. There is, however, evidence that the frequency of severe weather events were increasing during the 20th century [D12]. Figure D2.3.4-3 illustrates the number of weather-related disasters recorded in Canada for each decade over the last 100 years. Environment Canada considers weather-related disasters as unusual weather events that result in the loss of property or life.

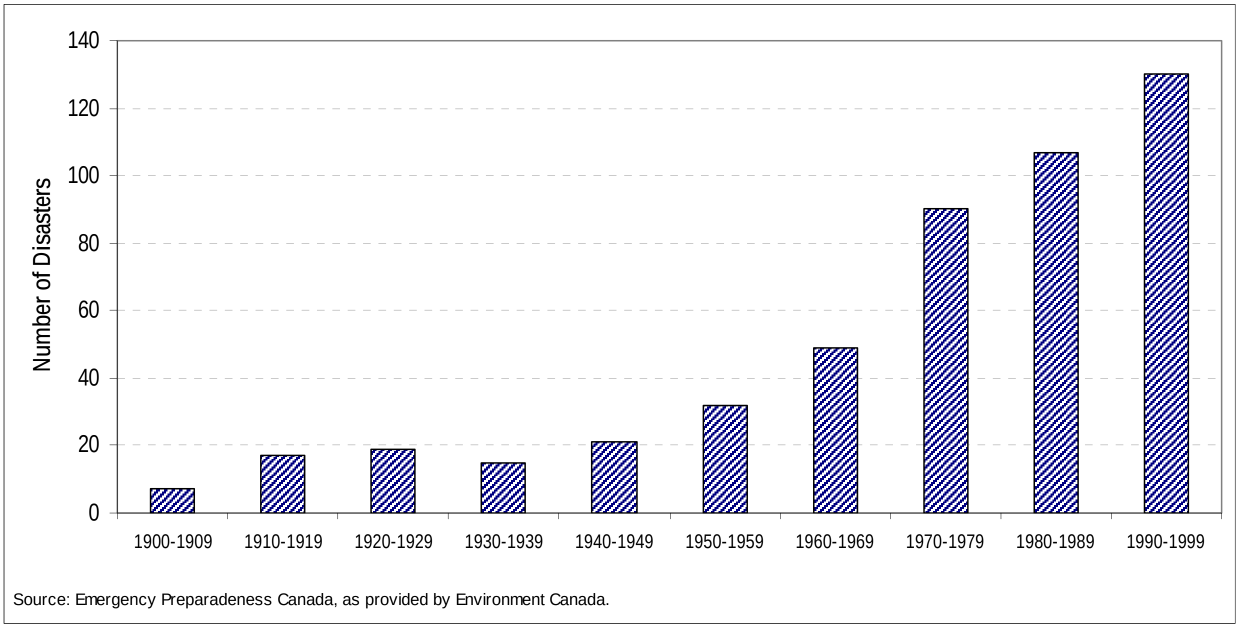

Figure D2.3.4-3: Trend in Weather Related Disasters in Canada

D3. CLIMATE TRENDS FOR USE IN ASSESSMENT

While both historic and all of the forecast information is valuable, it is not practical to evaluate the potential effects for every possible scenario. The challenge of selecting the appropriate scenarios to be evaluated was addressed by using the approach derived through multi-stakeholder consultation for evaluating climate change in environmental assessments in northern Canada [D13]. Specifically, the model forecasts were ranked on the basis of temperature and season (i.e., annual, spring, summer, fall and winter). For each of the rankings, a “low” and “high” forecast scenario was identified. In addition, the average of all forecasts was calculated.

Table D3-1 provides the seasonal and annual temperature changes for the “low” and “high” scenarios as well as the average of all scenarios. In a similar manner, Table D3-2 provides the forecast change in precipitation for both the “low” (i.e., the scenario with the lowest temperature change) and “high” (i.e., the scenario with the greatest temperature change) forecast scenarios, as well as the average of all forecasts. It is important to understand that the precipitation data is based upon the scenario derived for temperatures. Therefore, it may be that the change in precipitation for the “low” scenario is in fact bigger than the change in precipitation for the “high” scenario. The data in these tables provide a common set of information to be used by the technical disciplines in the climate change assessment. Using consistent climate forecasts in the EA will avoid confusion likely to arise if technical disciplines base their assessments of differing forecasts selected from literature.

Table D3-1: Historic and Future Temperature Trends

Season	1971-2000 Normals (°C)	1971-2000 Trend (°C/decade)	2011-2040 Forecast (°C/decade)			2041-2070 Forecast (°C/decade)			2071-2100 Forecast (°C/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	6.1	+0.31	+0.00	+0.41	+1.05	+0.15	+0.34	+0.66	+0.20	+0.33	+0.51
Spring	4.5	+0.50	+0.00	+0.45	+1.09	+0.14	+0.35	+0.69	+0.19	+0.34	+0.54
Summer	17.4	+0.26	+0.00	+0.43	+1.10	+0.15	+0.34	+0.69	+0.21	+0.34	+0.52
Fall	8.3	+0.05	+0.00	+0.36	+1.02	+0.12	+0.30	+0.63	+0.19	+0.32	+0.49
Winter	-5.7	+0.68	+0.00	+0.40	+0.99	+0.16	+0.33	+0.63	+0.21	+0.33	+0.50

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts.

Table D3-2: Historic and Future Precipitation Trends

Season	1971-2000 Normals (mm)	1971-2000 Trend (mm/decade)	2011-2040 Forecast (%/decade)			2041-2070 Forecast (%/decade)			2071-2100 Forecast (%/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	1,041.3	+0.13%	+0.00%	+1.44%	+3.57%	+0.36%	+1.11%	+2.09%	+1.39%	+1.30%	+2.25%
Spring	216.8	+3.23%	+0.00%	+2.59%	+5.39%	+0.62%	+1.51%	+2.72%	+1.88%	+2.24%	+4.05%
Summer	230.8	-0.51%	+0.00%	-1.65%	-3.40%	-0.95%	-1.13%	-0.42%	-0.68%	-0.85%	-0.61%
Fall	310.9	+4.41%	+0.00%	+2.09%	+4.35%	+2.28%	+1.67%	+2.75%	+2.11%	+1.65%	+1.85%
Winter	282.8	-4.65%	+0.00%	+2.39%	+7.30%	-0.27%	+1.82%	+3.08%	+2.05%	+1.92%	+3.32%

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts.

D4. REFERENCES

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APPENDIX E: BASELINE AIR QUALITY

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E1. INTRODUCTION

This appendix summarizes the available ambient air quality monitoring data for stations located within the Regional Study Area. This data provides an indication of the existing concentrations of the quality of the air into which the emissions from the DGR Project will be released. In addition, these data are used to determine the background air quality in the region that will be added to dispersion modelling results.

E2. DATA SOURCES

The existing air quality in the Regional Study Area is characteristic of the general air quality in South-western Ontario, and has been described using monitoring data from stations operated by the MOE. While the MOE prepares reports that summarize these data [E1;E2;E3;E4;E5;E6] these reports take several years to become available. However, the MOE recently started to make all of the hourly air quality data it collects at its stations available for use [E7]. This electronic data was obtained from the four stations nearest to the DGR Project (see Figure E2-1). The relative locations of each of the air monitoring station selected to describe the existing air quality in the Regional Study Area are summarized in Table E2-1.

Table E2-2 provides a summary of the monitoring data available from each of these stations. The table illustrates how some additional parameters have been added in recent years.

The graphs in the following sections present simplified box-and-whisker plots showing the available concentration data. The box on the figures represents the bounds of the middle 50% of the data points. The top of the box represents the 75th percentile concentration, while the bottom of the box represented the 25th percentile concentration. The line through the middle of the box represents the median, or 50th percentile concentration. The blue diamond represents the average concentration. On these figures, the whiskers extend up to the maximum, and down to the minimum concentration.

Although gaseous monitoring equipment records concentrations in units of parts per million parts (ppm) or parts per billion parts (ppb), regulatory criteria are established on the basis of micrograms per cubic metre (µg/m³). In this section, tabular monitoring results for gaseous compounds are presented in the units in which they are monitored. However, to facilitate the comparison of monitoring to criteria, graphs for gaseous compounds show axes with both ppm and µg/m³[1]. The conversion from ppm to µg/m³ is unique to each compound. In contrast, particulate monitoring equipment records concentrations in units of µg/m³. Particulate concentrations in µg/m³ cannot be converted to ppm, but are directly comparable to the criteria.

1 The µg/m³ graphs are based on a conversion at 25°C and 101.3 kPa and may differ from the AAQC. The ppm values match the AAQC values explicitly.

Table E2-1: Ambient Air Quality Monitoring Station Location Information

City	Location	Station ID	Approximate Distance from the DGR Project [km]	Direction from the DGR Project
Kitchener	Kitchener — West Ave./Homewood	26060	140	Southeast
London	London — 900 Highbury Ave.	15025	150	South-southeast
Sarnia	Sarnia — Front St./CN Tracks, Centennial Park	14064	170	South-southwest
Tiverton	Tiverton — Lot C/Concession 5, Visitor Info	18007	7	South-southeast

Table E2-2: Availability of Ambient Air Quality Data

City	Station ID	Electronic Data Availability					Periodic Data	
		NO_2	SO_2	CO	O_3	$PM_{2.5}$	SPM	PM_{10}
Kitchener	26060	2000-2002 2004-2007	2000-2003 2006	2000-2003	2000-2007	2003-2007	2000-2005	2000-2005
London	15025	2000-2007	2000-2002 2004-2007	2000-2002 2004-2007	2000-2007	2003-2007	2000-2005	2000-2005
Sarnia	14064	2000-2007	2000-2007	2000-2001	2000-2007	2003-2007	2000-2005	2000-2005
Tiverton	18007	2007	2007	NA	2000-2007	2003-2007	NA	NA

Note:
“NA” Indicates that data for the parameter were not available at that station.

0 5 10 20 30 40 50

Kilometres

LEGEND

- Ambient Air Quality Monitoring Station
- First Nations' Lands
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF AMBIENT AIR QUALITY MONITORING STATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE E2-1

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E3. OXIDES OF NITROGEN

Oxides of nitrogen (NO_X) in the atmosphere are composed primarily of two compounds: nitrogen dioxide (NO_2) and nitric oxide (NO). Emissions of NO_X occur mainly from high-temperature combustion processes. In Ontario, the transportation sector accounts for approximately 64% of the NO_X emissions [E4]. Although the majority of NO_X emissions are in the form of NO, these rapidly oxidize in the presence of hydrocarbons and sunlight to form NO_2. The NO_2 also reacts to form nitrate precursors, which contribute to the secondary formation of fine particulate matter ($PM_{2.5}$). Nitrogen dioxide (NO_2) was selected as an indicator for this assessment since it is the only oxide of nitrogen (NO_X) that has ambient criteria in Canada. Literature indicates that NO_2 can affect bronchial activity in asthmatics, and people suffering from bronchitis [E8]. There are no known effects on human health or vegetation associated with NO.

E3.1 SUMMARY OF AMBIENT NITROGEN DIOXIDE (NO_2) MONITORING RESULTS

A summary of the available 1-hour NO_2 monitoring results is presented in Table E3.1-1. Figure E3.1-1 presents a graphical summary of the 1-hour NO_2 concentrations measured at the ambient monitoring stations. As illustrated in the figure, there were no hourly readings that exceeded the ambient air quality criteria (AAQC) in Ontario of 0.200 ppm (i.e., 200 ppb).

Table E3.1-1: Ambient 1-hour NO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.000	0.002	0.006	0.010	0.012	0.016	0.039	0.071
London	0.000	0.002	0.007	0.012	0.014	0.019	0.042	0.151
Sarnia	0.000	0.002	0.006	0.011	0.014	0.019	0.039	0.156
Tiverton	0.000	0.000	0.001	0.002	0.003	0.004	0.014	0.034
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Note:
"%-ile" = percentile

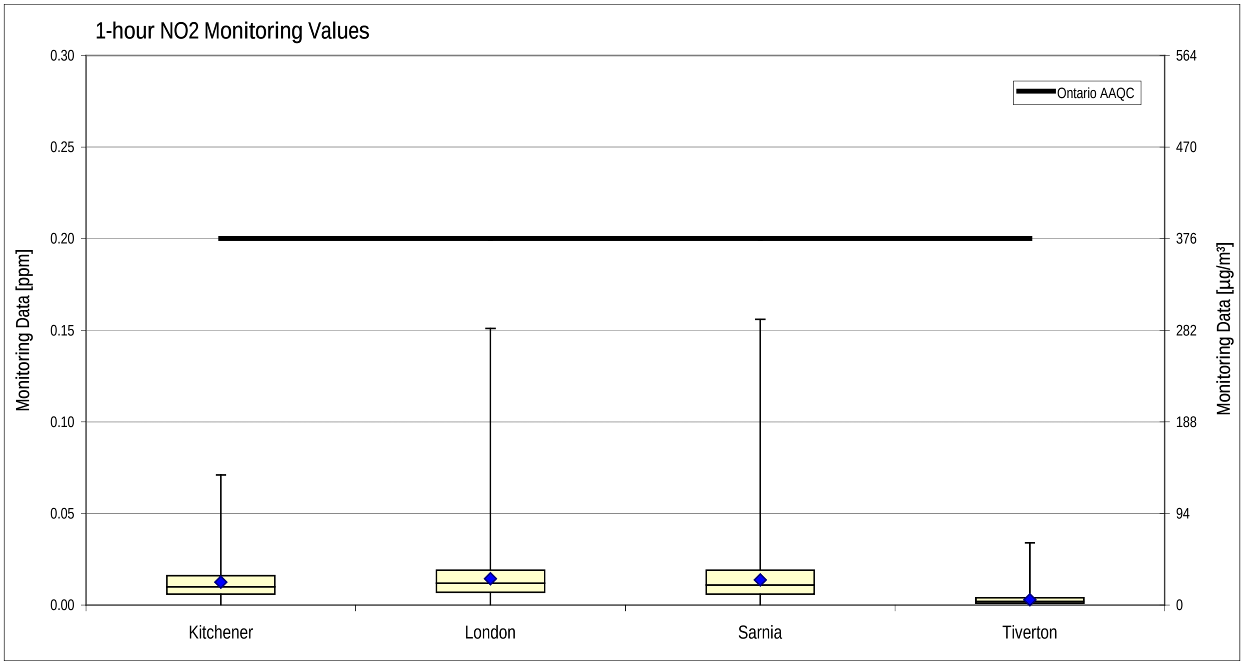

Figure E3.1-1: Ambient 1-Hour NO_2 Monitoring Results

Table E3.1-2 and Figure E3.1-2 provide summaries of the available 24-hour NO_2 concentrations measured at the ambient monitoring stations. None of the 24-hour ambient monitoring results exceed the ambient air quality criteria (AAQC) of 0.100 ppm (i.e., 100 ppb). Annual data are not reported in Ontario for NO_2. Instead, the average value of the data reported is used to represent the annual data.

Table E3.1-2: Ambient 24-hour NO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.001	0.004	0.007	0.011	0.012	0.016	0.030	0.050
London	0.002	0.004	0.009	0.013	0.014	0.018	0.034	0.059
Sarnia	0.001	0.003	0.009	0.013	0.014	0.018	0.032	0.050
Tiverton	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.014
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

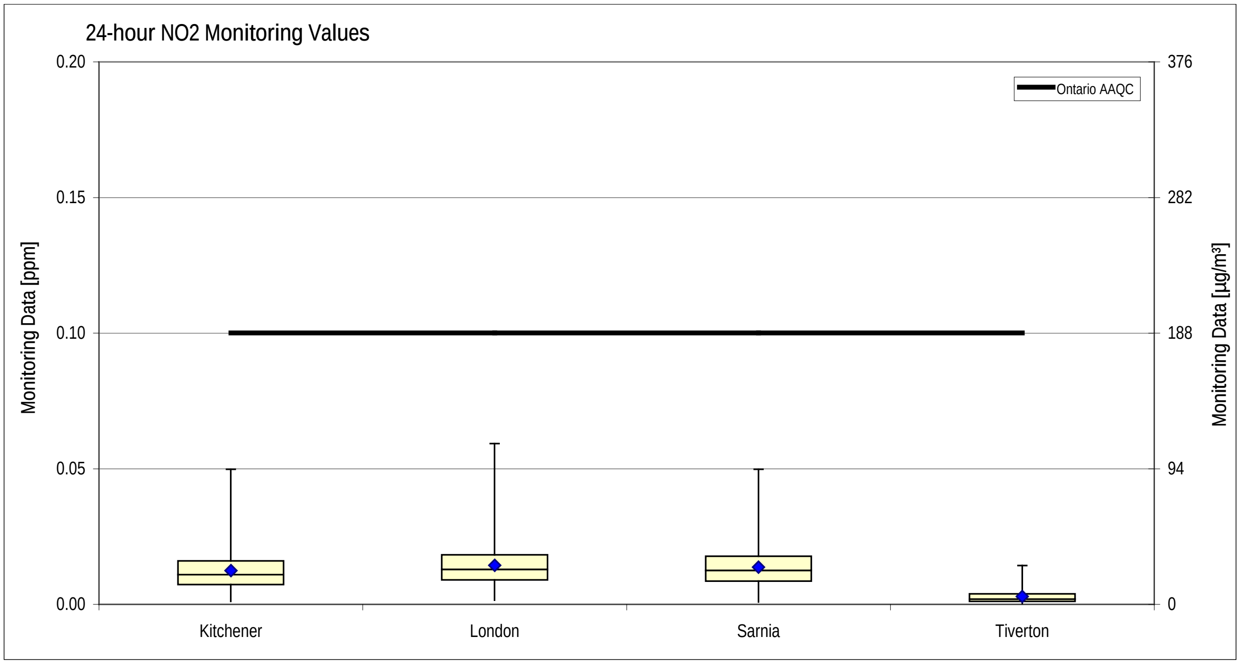

Figure E3.1-2: Ambient 24-Hour NO_2 Monitoring Results

E3.2 STATION SPECIFIC AMBIENT MONITORING RESULTS

E3.2.1 Ambient NO_2 Monitoring Results for Kitchener

Table E3.2.1-1 provides a breakdown of the hourly NO_2 concentrations recorded at the station in Kitchener. These data are illustrated on Figure E3.2.1-1. Ambient NO_2 monitoring data were not available at the station during 2003. As illustrated in the figure, measured hourly levels were well below the AAQC of 0.20 ppm in each of the monitoring years.

Table E3.2.1-1: Ambient 1-hour NO_2 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.001	0.003	0.007	0.012	0.015	0.020	0.040	0.057
2001	0.001	0.003	0.007	0.012	0.014	0.019	0.038	0.058
2002	0.000	0.002	0.006	0.010	0.012	0.016	0.034	0.052
2003	—	—	—	—	—	—	—	—
2004	0.000	0.003	0.006	0.010	0.013	0.017	0.043	0.071
2005	0.000	0.002	0.006	0.009	0.013	0.016	0.047	0.068
2006	0.000	0.002	0.005	0.008	0.011	0.014	0.036	0.062
2007	0.000	0.002	0.004	0.007	0.010	0.013	0.032	0.052
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Notes:
"%-ile" = percentile
— Data not available

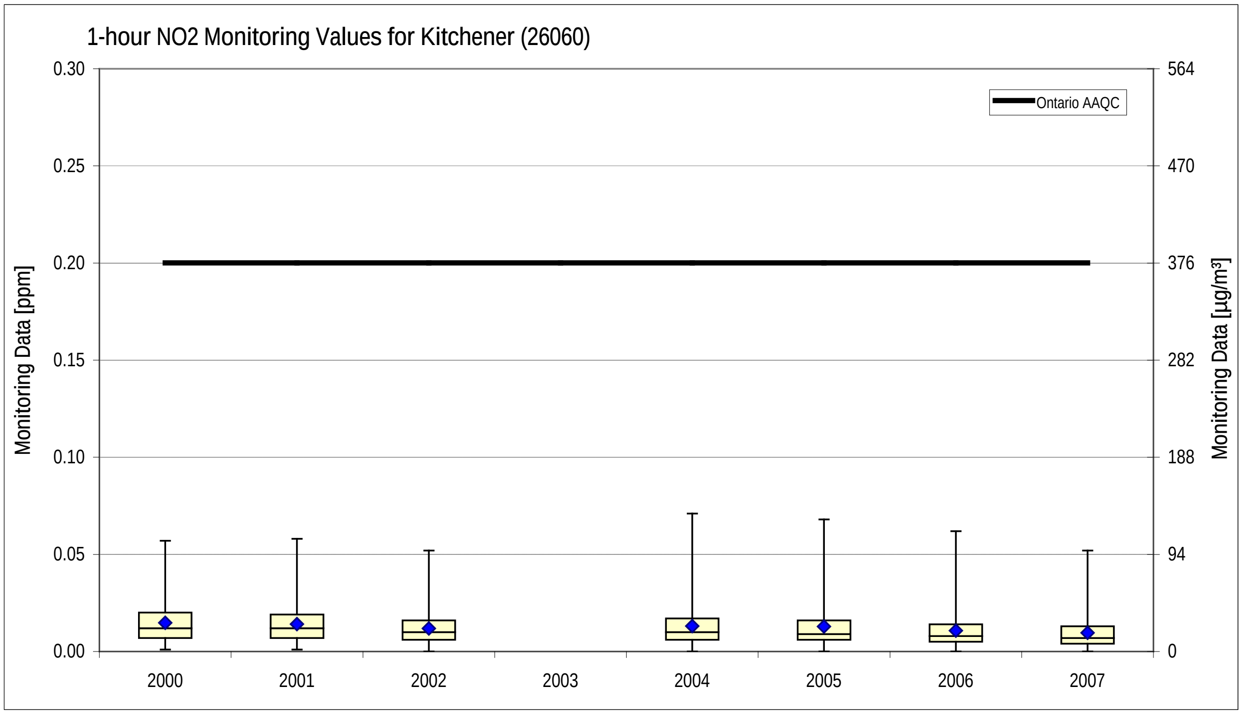

Figure E3.2.1-1: Ambient 1-Hour NO_2 Monitoring Results – Kitchener

Table E3.2.1-2 and Figure E3.2.1-2 provide breakdowns of the daily NO_2 concentrations recorded at the station in Kitchener. Ambient NO_2 monitoring data were not available at the station during 2003. The table and graph illustrate that daily NO_2 concentrations were relatively low – never exceeding half of the AAQC level of 0.10 ppm.

Table E3.2.1-2: Ambient 24-hour NO_2 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.004	0.005	0.009	0.013	0.015	0.019	0.032	0.041
2001	0.004	0.005	0.009	0.013	0.014	0.018	0.028	0.044
2002	0.001	0.004	0.008	0.011	0.012	0.016	0.026	0.032
2003	—	—	—	—	—	—	—	—
2004	0.003	0.004	0.008	0.012	0.013	0.016	0.034	0.047
2005	0.003	0.004	0.008	0.011	0.013	0.016	0.037	0.050
2006	0.002	0.003	0.006	0.009	0.011	0.014	0.025	0.036
2007	0.001	0.003	0.006	0.008	0.010	0.012	0.024	0.032
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Notes:
"%-ile" = percentile
— Data not available

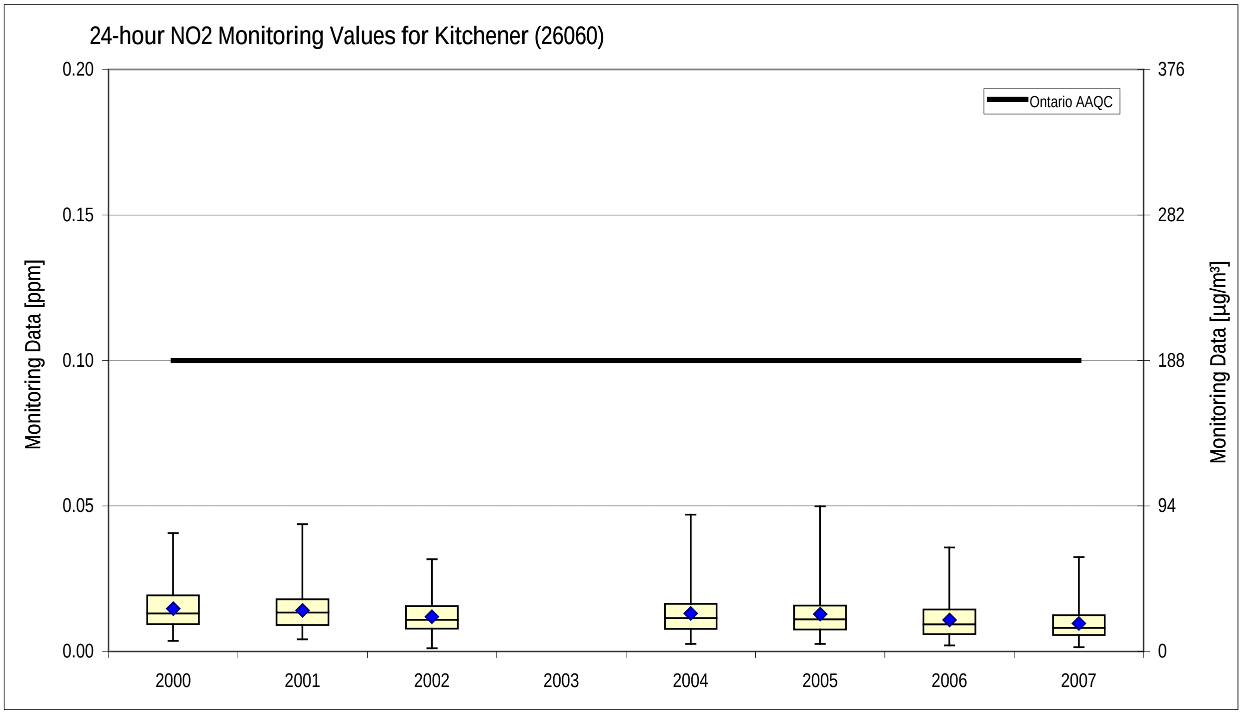

Figure E3.2.1-2: Ambient 24-Hour NO_2 Monitoring Results – Kitchener

E3.2.2 Ambient NO_2 Monitoring Results for London

Table E3.2.2-1 provides a breakdown of the hourly NO_2 concentrations recorded at the station in London. These data are illustrated on Figure E3.2.2-1. As illustrated in the figure, monitored concentrations never exceeded the AAQC limit of 0.200 ppm.

Table E3.2.2-1: Ambient 1-hour NO_2 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.001	0.003	0.009	0.015	0.017	0.024	0.047	0.088
2001	0.000	0.003	0.009	0.014	0.017	0.023	0.046	0.151
2002	0.000	0.002	0.007	0.011	0.014	0.019	0.042	0.110
2003	0.000	0.003	0.008	0.013	0.015	0.019	0.040	0.084
2004	0.000	0.003	0.007	0.011	0.014	0.018	0.039	0.073
2005	0.000	0.002	0.007	0.011	0.014	0.019	0.044	0.069
2006	0.000	0.002	0.006	0.010	0.012	0.016	0.036	0.066
2007	0.000	0.002	0.006	0.009	0.012	0.016	0.034	0.056
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Note:
“%-ile" = percentile

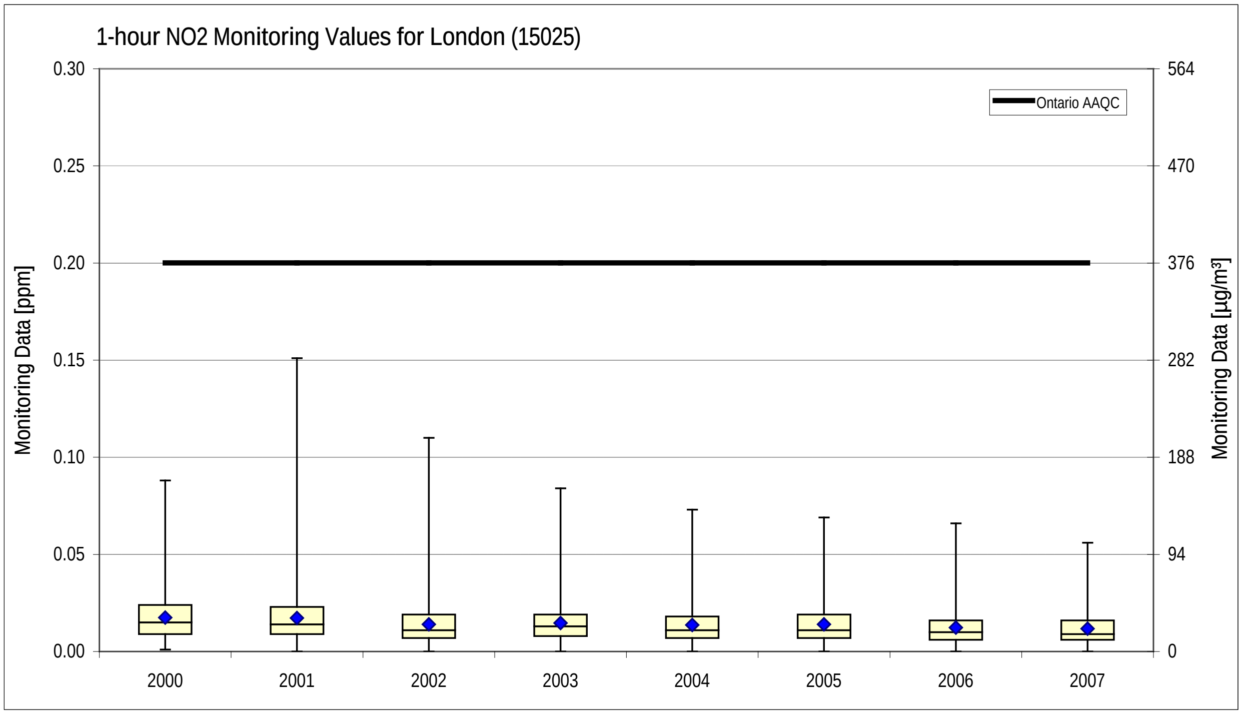

Figure E3.2.2-1: Ambient 1-Hour NO_2 Monitoring Results – London

Table E3.2.2-2 and Figure E3.2.2-2 provide breakdowns of the daily NO_2 concentrations recorded at the station in London. As the table and figure illustrate, 24-hour concentrations were always well below the AAQC of 0.100 ppm.

Table E3.2.2-2: Ambient 24-hour NO_2 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.002	0.005	0.011	0.016	0.017	0.023	0.036	0.049
2001	0.003	0.006	0.011	0.016	0.017	0.022	0.038	0.058
2002	0.002	0.004	0.009	0.013	0.014	0.018	0.034	0.059
2003	0.004	0.005	0.010	0.014	0.015	0.018	0.030	0.041
2004	0.004	0.005	0.009	0.012	0.014	0.017	0.031	0.036
2005	0.002	0.004	0.009	0.013	0.014	0.018	0.035	0.051
2006	0.002	0.004	0.008	0.011	0.012	0.016	0.028	0.032
2007	0.002	0.003	0.008	0.011	0.012	0.015	0.025	0.030
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

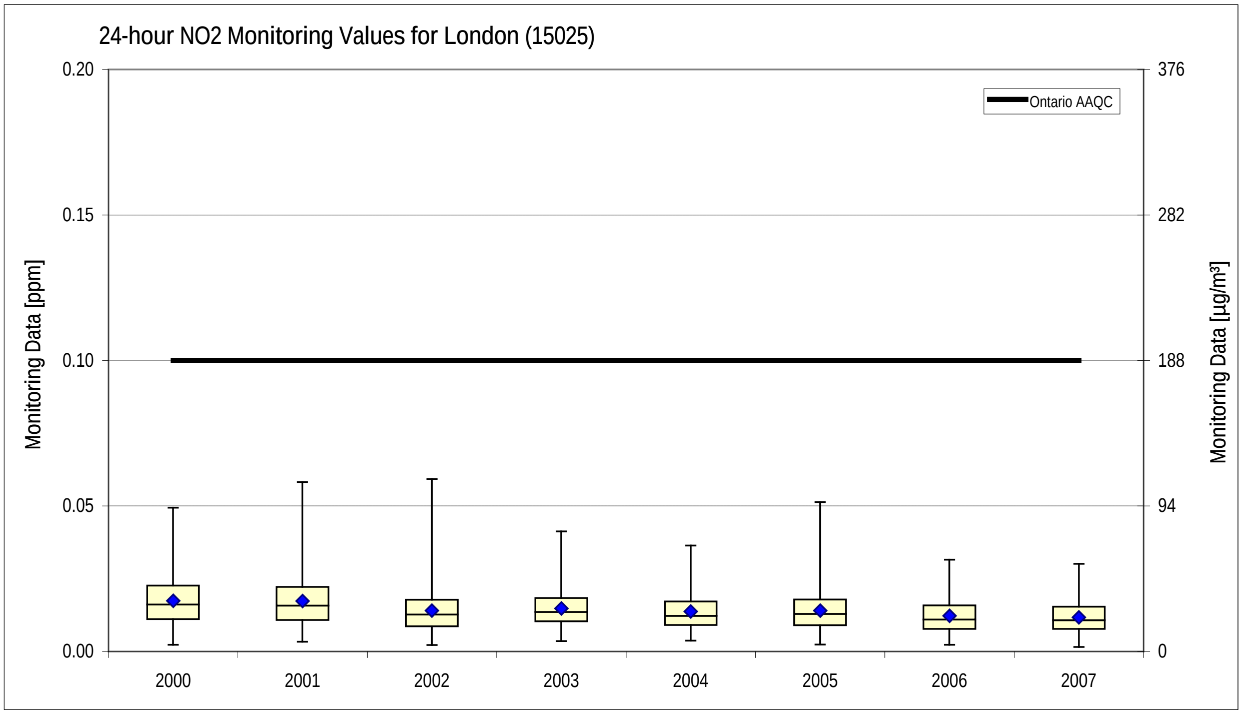

Figure E3.2.2-2: Ambient 24-Hour NO_2 Monitoring Results – London

E3.2.3 Ambient NO_2 Monitoring Results for Sarnia

Table E3.2.3-1 and Figure E3.2.3-1 provide a breakdown of the hourly NO_2 concentrations recorded at the station in Sarnia. As illustrated in the figure, monitored values never exceeded the AAQC level of 0.200 ppm, with majority of the readings being less than half of the AAQC.

Table E3.2.3-1: Ambient 1-hour NO_2 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.002	0.007	0.013	0.016	0.024	0.044	0.156
2001	0.000	0.003	0.008	0.014	0.017	0.023	0.043	0.084
2002	0.000	0.004	0.010	0.016	0.017	0.023	0.042	0.075
2003	0.000	0.003	0.006	0.011	0.013	0.017	0.038	0.070
2004	0.000	0.002	0.006	0.010	0.012	0.016	0.033	0.050
2005	0.000	0.001	0.005	0.010	0.013	0.017	0.039	0.076
2006	0.000	0.001	0.005	0.009	0.011	0.016	0.032	0.050
2007	0.000	0.001	0.005	0.009	0.011	0.016	0.033	0.058
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Note:
"%-ile" = percentile

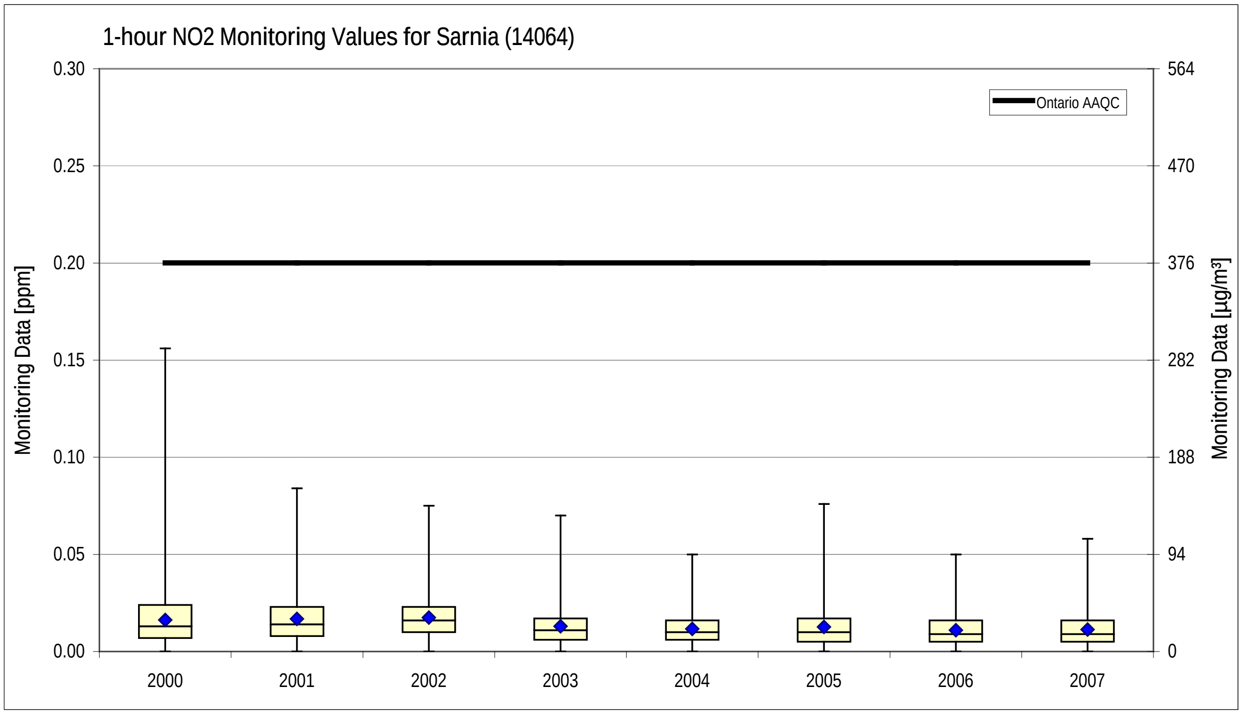

Figure E3.2.3-1: Ambient 1-Hour NO_2 Monitoring Results – Sarnia

Table E3.2.3-2 and Figure E3.2.3-2 provide breakdowns of the daily NO_2 concentrations recorded at the station in Sarnia. As illustrated in the figure, daily monitored concentrations were relatively low – never exceeding half of the AAQC level of 0.100 ppm.

Table E3.2.3-2: Ambient 24-hour NO_2 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.001	0.004	0.010	0.015	0.016	0.021	0.034	0.045
2001	0.002	0.006	0.011	0.016	0.017	0.022	0.034	0.038
2002	0.005	0.006	0.013	0.017	0.017	0.022	0.034	0.047
2003	0.003	0.005	0.008	0.012	0.013	0.016	0.032	0.043
2004	0.002	0.004	0.008	0.011	0.012	0.015	0.027	0.033
2005	0.002	0.003	0.008	0.012	0.013	0.016	0.028	0.050
2006	0.001	0.002	0.007	0.010	0.011	0.015	0.025	0.032
2007	0.001	0.002	0.007	0.011	0.011	0.015	0.024	0.033
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
“%-ile" = percentile

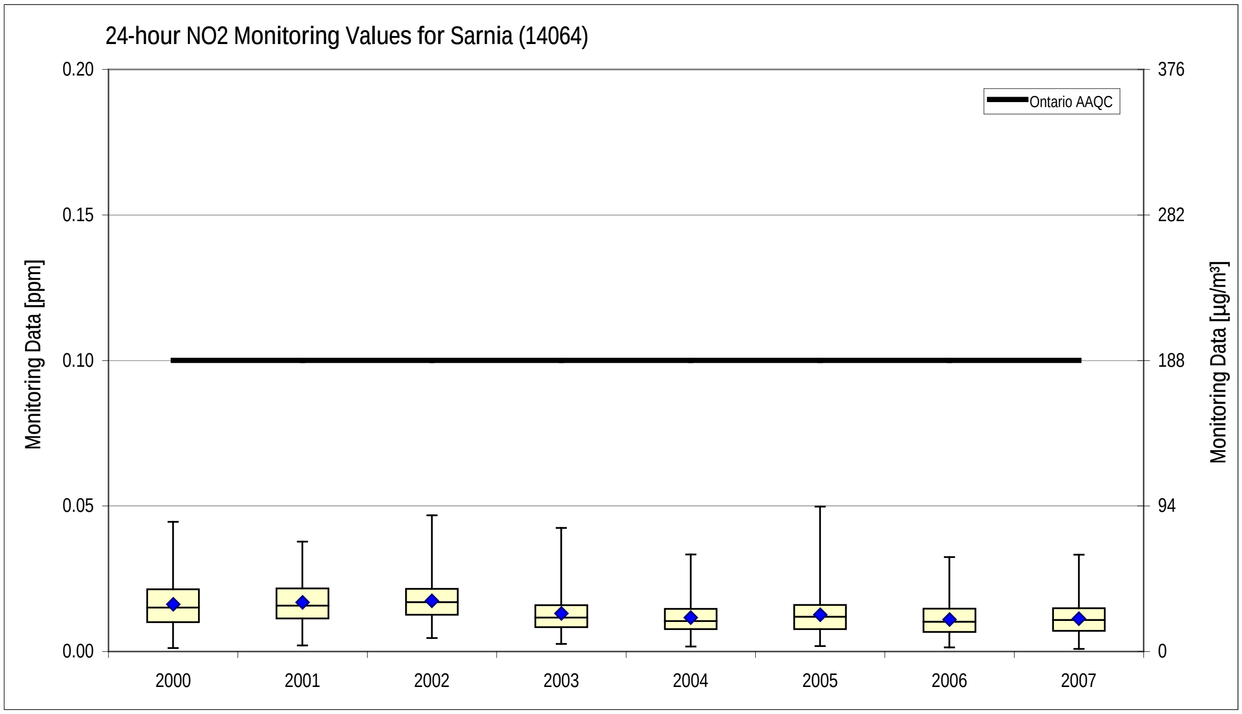

Figure E3.2.3-2: Ambient 24-Hour NO_2 Monitoring Results – Sarnia

E3.2.4 Ambient NO_2Monitoring Results for Tiverton

Table E3.2.4-1 and Figure E3.2.4-1 provide a breakdown of the hourly NO_2 concentrations recorded at the station in Tiverton. Ambient NO_2 monitoring data were only available during 2007. As illustrated in the figure, measured concentrations at this station are very low relative to the ambient air quality criteria of 0.200 ppm.

Table E3.2.4-1: Ambient 1-hour NO_2 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	0.000	0.000	0.001	0.002	0.003	0.004	0.014	0.034
AAQC (ppm)	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**	**0.200**

Notes:
"%-ile" = percentile
— Data not available

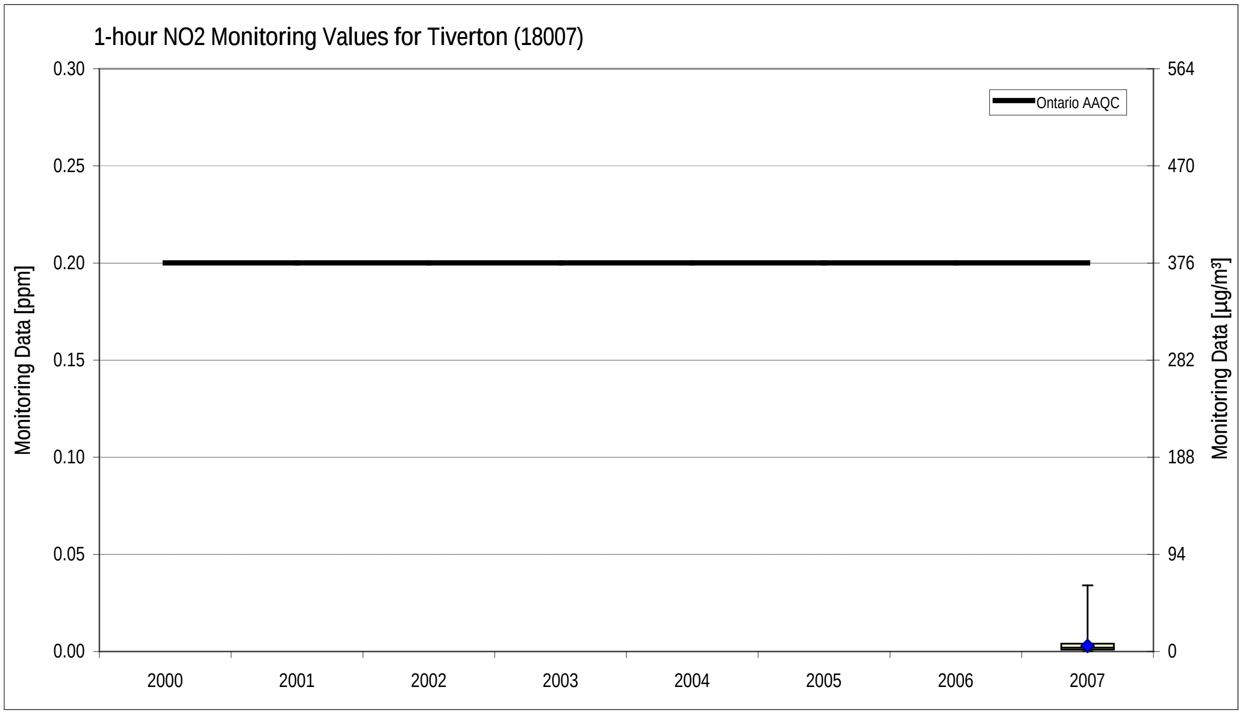

Figure E3.2.4-1: Ambient 1-Hour NO_2 Monitoring Results – Tiverton

Table E3.2.4-2 and Figure E3.2.4-2 provide breakdowns of the daily NO_2 concentrations recorded at the station in Tiverton. Ambient NO_2 monitoring data were only available during 2007. The recorded NO_2 concentrations were less than 15% of the AAQC value of 0.100 ppm.

Table E3.2.4-2: Ambient 24-hour NO_2 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.014
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Notes:
"%-ile" = percentile
— Data not available

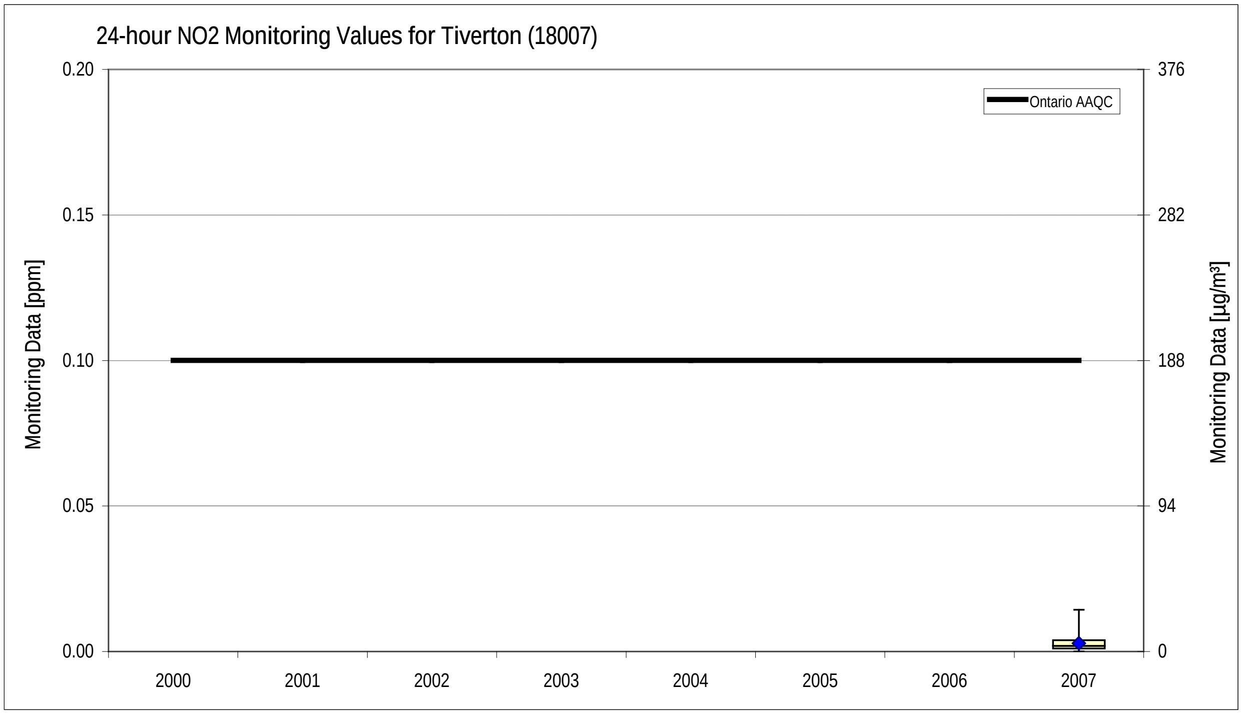

Figure E3.2.4-2: Ambient 24-Hour NO_2 Monitoring Results – Tiverton

E4. SULPHUR DIOXIDE

Sulphur dioxide (SO_2) is formed when sulphur in fuel reacts with oxygen during the combustion process. Elevated concentrations of SO_2 can have a direct effect on vegetation and, when present at sufficiently high levels can also affect respiratory function in humans. Emissions of SO_2 are a precursor to acid rain and fine particulate matter (i.e., $PM_{2.5}$). Seventy-one percent of SO_2 emissions in the province of Ontario can be attributed smelting operations and power generation [E4]. However, local SO_2 concentrations can be elevated in areas where refineries and chemical facilities are prevalent.

E4.1 SUMMARY OF AMBIENT SULPHUR DIOXIDE (SO_2) MONITORING RESULTS

A summary of the available 1-hour SO_2 monitoring results is presented in Table E4.1-1. Figure E4.1-1 presents a graphical summary of the 1-hour SO_2 concentrations measured at the ambient monitoring stations. As illustrated in the figure, there were no hourly readings that exceeded the ambient air quality criteria (AAQC) of 0.250 ppm (i.e., 250 ppb), at Kitchener, London or Tiverton. There were only two hours during the eight years of available data when the hourly concentrations in Sarnia exceeded the Ontario AAQC (one hour during each of 2001 and 2002).

Table E4.1-1: Ambient 1-hour SO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.142
London	0.000	0.000	0.001	0.002	0.003	0.003	0.011	0.039
Sarnia	0.000	0.000	0.001	0.002	0.009	0.006	0.086	0.263
Tiverton	0.000	0.000	0.000	0.001	0.001	0.002	0.009	0.026
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Note:
"%-ile" = percentile

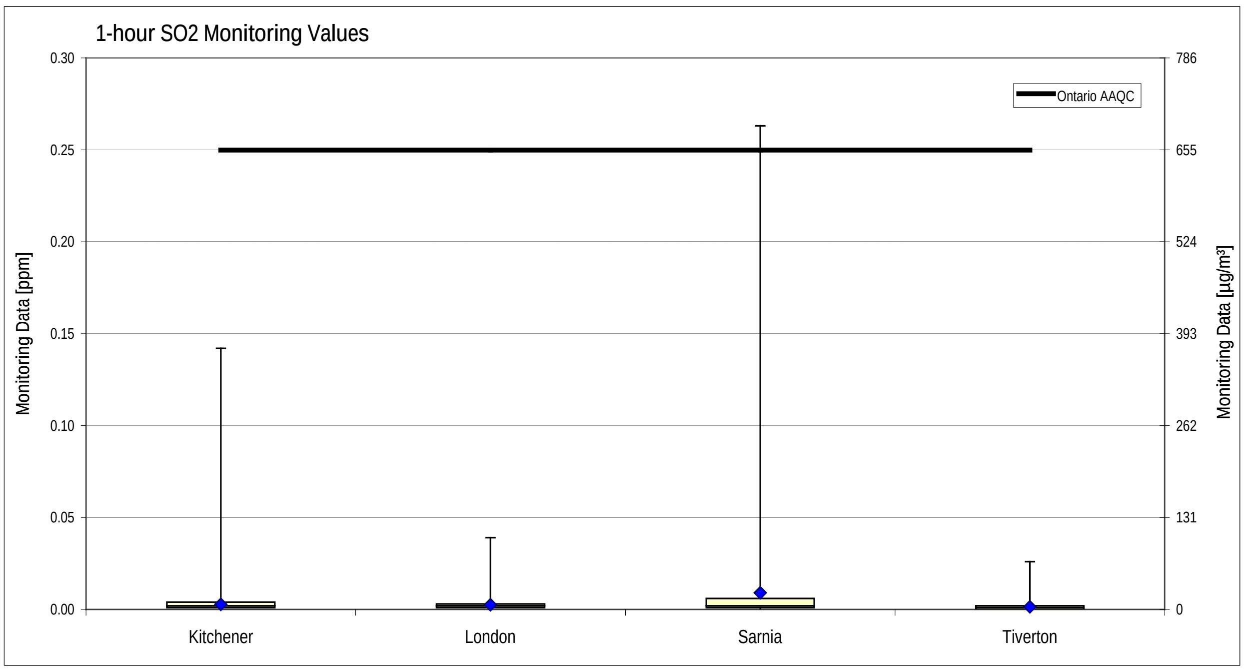

Figure E4.1-1: Ambient 1-Hour SO_2 Monitoring Results

Table E4.1-2 and Figure E4.1-2 provide summaries of the available 24-hour SO_2 concentrations measured at the ambient monitoring stations. None of the 24-hour ambient monitoring results at the Kitchener, London or Tiverton stations exceeded the daily ambient air quality criteria (AAQC) of 0.100 ppm (i.e., 100 ppb). However, there were four days during the eight years of available data when the 24-hour concentrations in Sarnia exceeded the Ontario AAQC (two days during each of 2001 and 2006).

Table E4.1-2: Ambient 24-hour SO_2 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.000	0.001	0.002	0.003	0.004	0.009	0.017
London	0.000	0.000	0.001	0.002	0.002	0.003	0.009	0.016
Sarnia	0.000	0.000	0.002	0.004	0.009	0.011	0.047	0.131
Tiverton	0.000	0.000	0.000	0.001	0.001	0.002	0.006	0.009
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

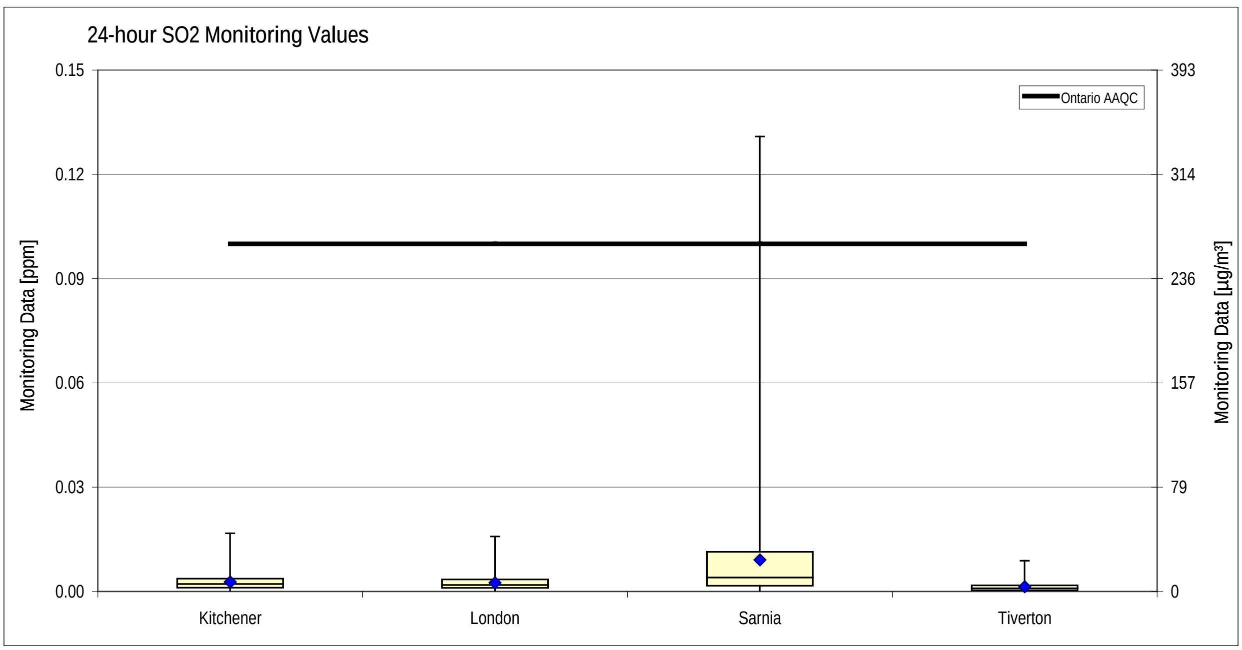

Figure E4.1-2: Ambient 24-Hour SO_2 Monitoring Results

Annual data for SO_2 are not reported in Ontario. Instead, the average value of the data reported is used to represent the annual data.

E4.2 STATION SPECIFIC AMBIENT MONITORING RESULTS

E4.2.1 Ambient Sulphur Dioxide Monitoring Results for Kitchener

Table E4.2.1-1 provides a breakdown of the hourly SO_2 concentrations recorded at the station in Kitchener. These data are illustrated on Figure E4.2.1-1. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.250 ppm. Ambient SO_2 monitoring data were not available at the station during 2004, 2005 and 2007.

Table E4.2.1-1: Ambient 1-hour SO_2 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	**2nd %-ile**	**25th %-ile**	**50th %-ile**	**Average**	**75th %-ile**	**98th %-ile**	**Maximum**
2000	0.000	0.000	0.001	0.002	0.003	0.004	0.013	0.037
2001	0.000	0.000	0.001	0.002	0.003	0.004	0.013	0.142
2002	0.000	0.000	0.001	0.002	0.003	0.004	0.011	0.032
2003	0.000	0.000	0.001	0.002	0.003	0.004	0.012	0.038
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	0.000	0.000	0.000	0.001	0.001	0.001	0.008	0.023
2007	—	—	—	—	—	—	—	—
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Notes:
"%-ile" = percentile
— Data not available

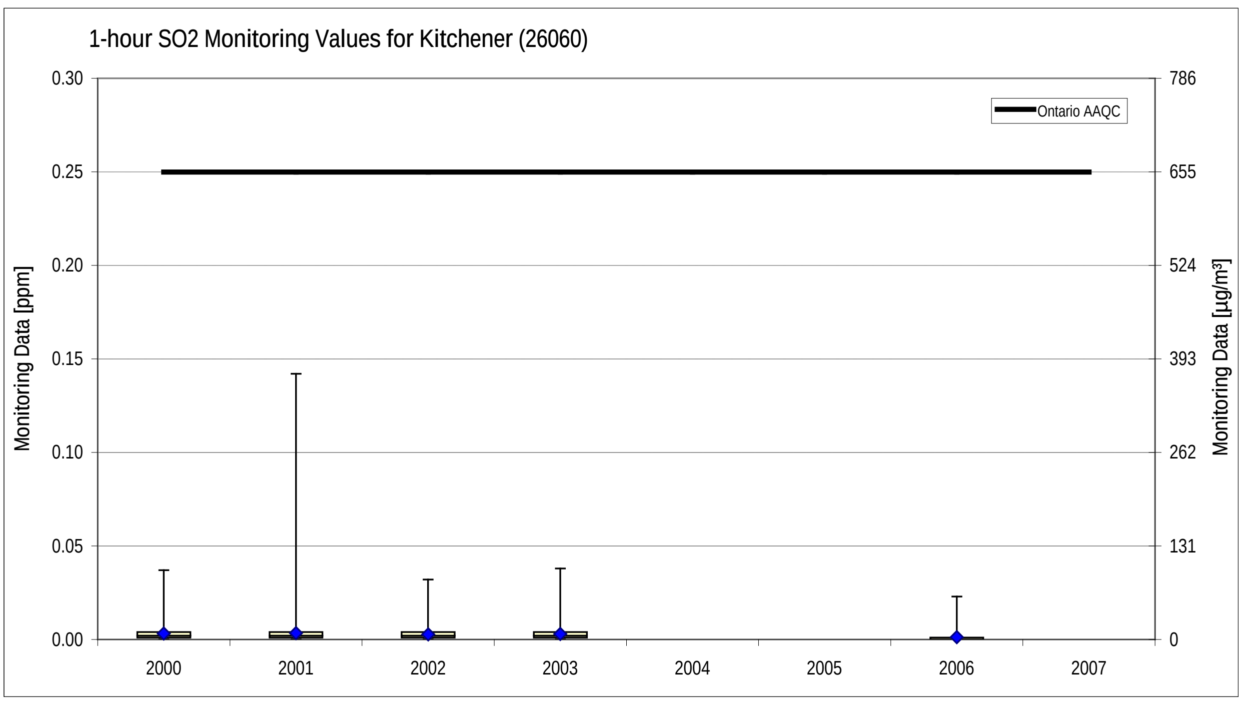

Figure E4.2.1-1: Ambient 1-Hour SO_2 Monitoring Results – Kitchener

Table E4.2.1-2 and Figure E4.2.1-2 provide breakdowns of the daily SO_2 concentrations recorded at the station in Kitchener. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.100 ppm. Ambient SO_2 monitoring data were not available at the station during 2004, 2005 and 2007.

Table E4.2.1-2: Ambient 24-hour SO_2 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.001	0.001	0.002	0.003	0.004	0.010	0.017
2001	0.000	0.000	0.002	0.003	0.003	0.004	0.010	0.015
2002	0.000	0.000	0.001	0.002	0.003	0.004	0.009	0.011
2003	0.000	0.000	0.001	0.002	0.003	0.004	0.009	0.017
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	0.000	0.000	0.000	0.001	0.001	0.002	0.006	0.007
2007	—	—	—	—	—	—	—	—
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Notes:
"%-ile" = percentile
— Data not available

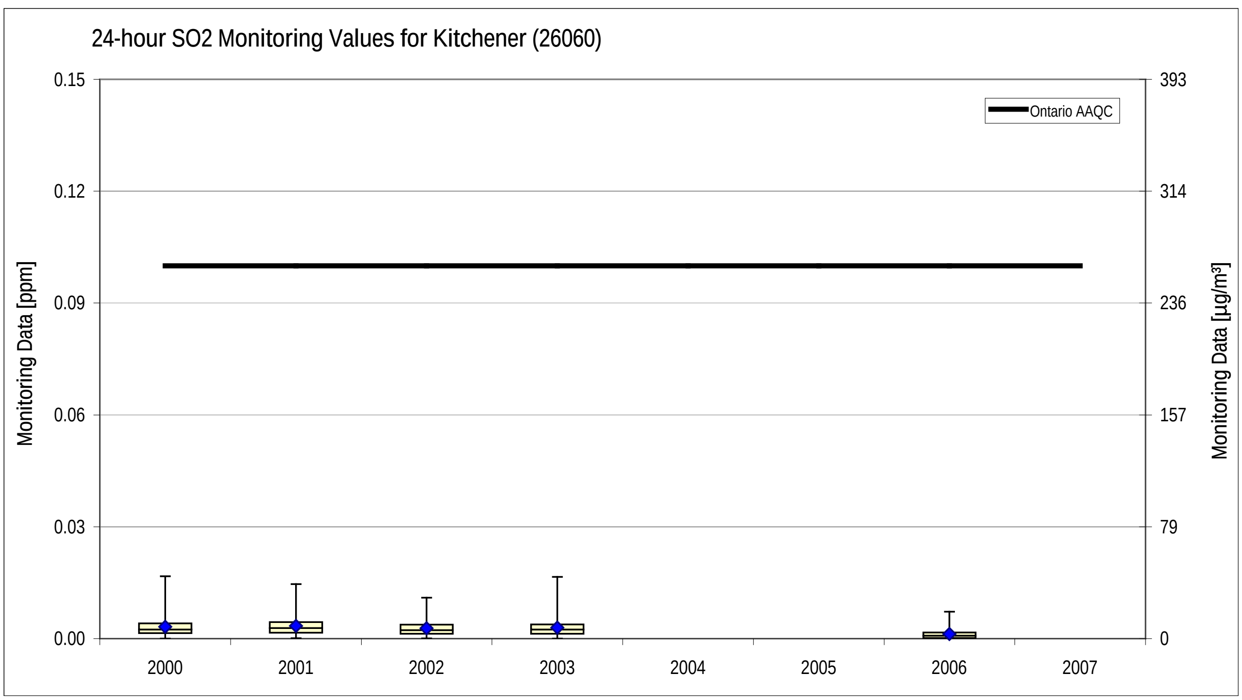

Figure E4.2.1-2: Ambient 24-Hour SO_2 Monitoring Results – Kitchener

E4.2.2 Ambient Sulphur Dioxide Monitoring Results for London

Table E4.2.2-1 provides a breakdown of the hourly SO_2 concentrations recorded at the station in London. These data are illustrated on Figure E4.2.2-1. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.250 ppm. Ambient SO_2 monitoring data were not available at the station during 2003.

Table E4.2.2-1: Ambient 1-hour SO_2 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.000	0.000	0.001	0.002	0.004	0.005	0.014	0.032
2001	0.000	0.000	0.001	0.002	0.003	0.005	0.013	0.032
2002	0.000	0.000	0.000	0.001	0.002	0.003	0.010	0.039
2003	—	—	—	—	—	—	—	—
2004	0.000	0.000	0.001	0.001	0.002	0.003	0.009	0.033
2005	0.000	0.000	0.001	0.001	0.002	0.003	0.010	0.031
2006	0.000	0.000	0.000	0.001	0.002	0.003	0.008	0.034
2007	0.000	0.000	0.001	0.001	0.002	0.002	0.009	0.024
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Notes:
"%-ile" = percentile
— Data not available

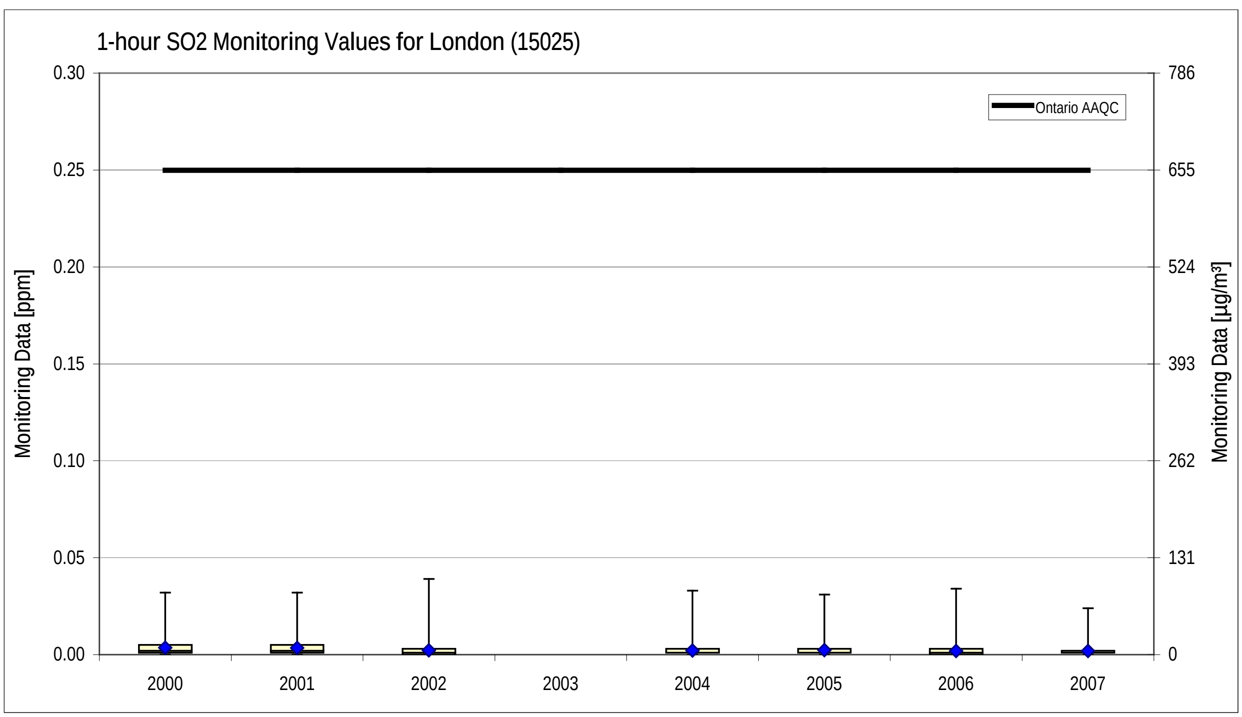

Figure E4.2.2-1: Ambient 1-Hour SO_2 Monitoring Results – London

Table E4.2.2-2 and Figure E4.2.2-2 provide breakdowns of the daily SO_2 concentrations recorded at the station in London. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.100 ppm. Ambient SO_2 monitoring data were not available at the station during 2003.

Table E4.2.2-2: Ambient 24-hour SO_2 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.000	0.001	0.003	0.004	0.005	0.011	0.016
2001	0.000	0.000	0.001	0.003	0.003	0.005	0.010	0.016
2002	0.000	0.000	0.001	0.002	0.002	0.003	0.008	0.010
2003	—	—	—	—	—	—	—	—
2004	0.000	0.001	0.001	0.002	0.002	0.003	0.006	0.015
2005	0.000	0.000	0.001	0.002	0.002	0.003	0.008	0.010
2006	0.000	0.000	0.001	0.001	0.002	0.003	0.006	0.009
2007	0.000	0.000	0.001	0.002	0.002	0.003	0.006	0.012
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Notes:
"%-ile" = percentile
— Data not available

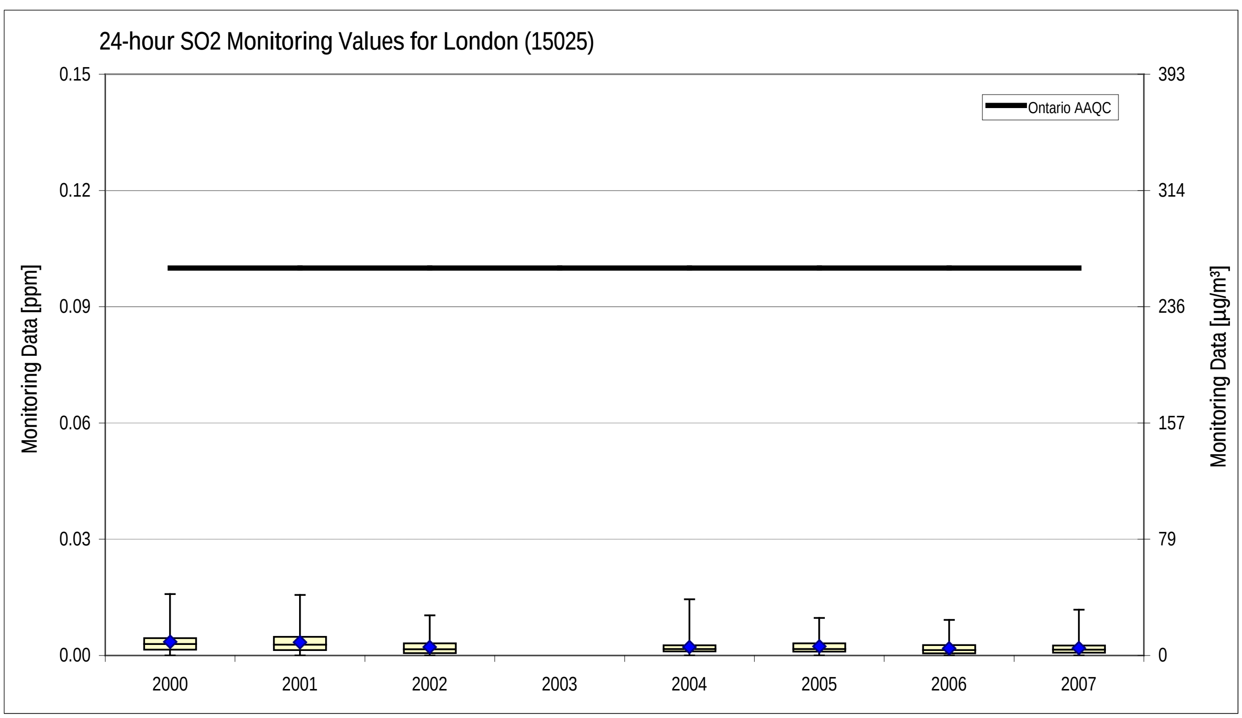

Figure E4.2.2-2: Ambient 24-Hour SO_2 Monitoring Results – London

E4.2.3 Ambient Sulphur Dioxide Monitoring Results for Sarnia

Table E4.2.3-1 provides a breakdown of the hourly SO_2 concentrations recorded at the station in Sarnia. These data are illustrated on Figure E4.2.3-1. The table and graph illustrate that the majority of the data were relatively low SO_2 levels compared to the AAQC of 0.250 ppm. However, one hour was recorded during both 2001 and 2002 in excess of the AAQC.

Table E4.2.3-1: Ambient 1-hour SO_2 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.000	0.000	0.002	0.003	0.010	0.008	0.088	0.239
2001	0.000	0.000	0.002	0.004	0.013	0.009	0.110	0.263
2002	0.000	0.000	0.001	0.003	0.010	0.007	0.097	0.254
2003	0.000	0.000	0.001	0.002	0.007	0.005	0.068	0.181
2004	0.000	0.000	0.000	0.001	0.008	0.006	0.082	0.216
2005	0.000	0.000	0.000	0.002	0.008	0.006	0.076	0.231
2006	0.000	0.000	0.001	0.002	0.008	0.006	0.078	0.243
2007	0.000	0.000	0.001	0.002	0.008	0.006	0.076	0.183
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Note:
"%-ile" = percentile

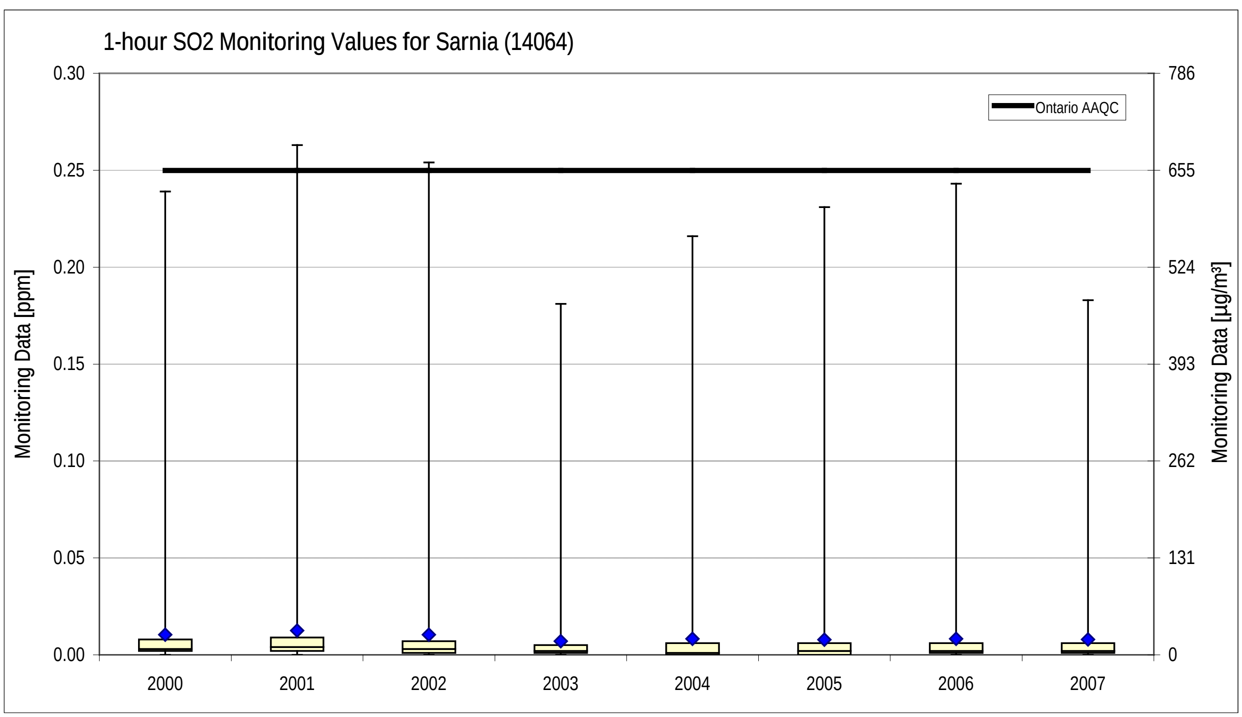

Figure E4.2.3-1: Ambient 1-Hour SO_2 Monitoring Results – Sarnia

Table E4.2.3-2 and Figure E4.2.3-2 provide breakdowns of the daily SO_2 concentrations recorded at the station in Sarnia. While the table and graph illustrate that the majority of data are well below the AAQC of 0.100 ppm, there were two days during 2001 and two days during 2006 when ambient SO_2 levels were in excess of the AAQC.

Table E4.2.3-2: Ambient 24-hour SO_2 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.001	0.003	0.005	0.010	0.012	0.054	0.078
2001	0.000	0.001	0.003	0.006	0.013	0.016	0.072	0.131
2002	0.000	0.000	0.002	0.005	0.010	0.014	0.048	0.093
2003	0.000	0.000	0.002	0.003	0.007	0.008	0.037	0.063
2004	0.000	0.000	0.001	0.003	0.008	0.010	0.043	0.075
2005	0.000	0.000	0.001	0.003	0.008	0.009	0.043	0.073
2006	0.000	0.000	0.001	0.003	0.008	0.010	0.044	0.107
2007	0.000	0.000	0.001	0.004	0.008	0.010	0.045	0.087
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Note:
"%-ile" = percentile

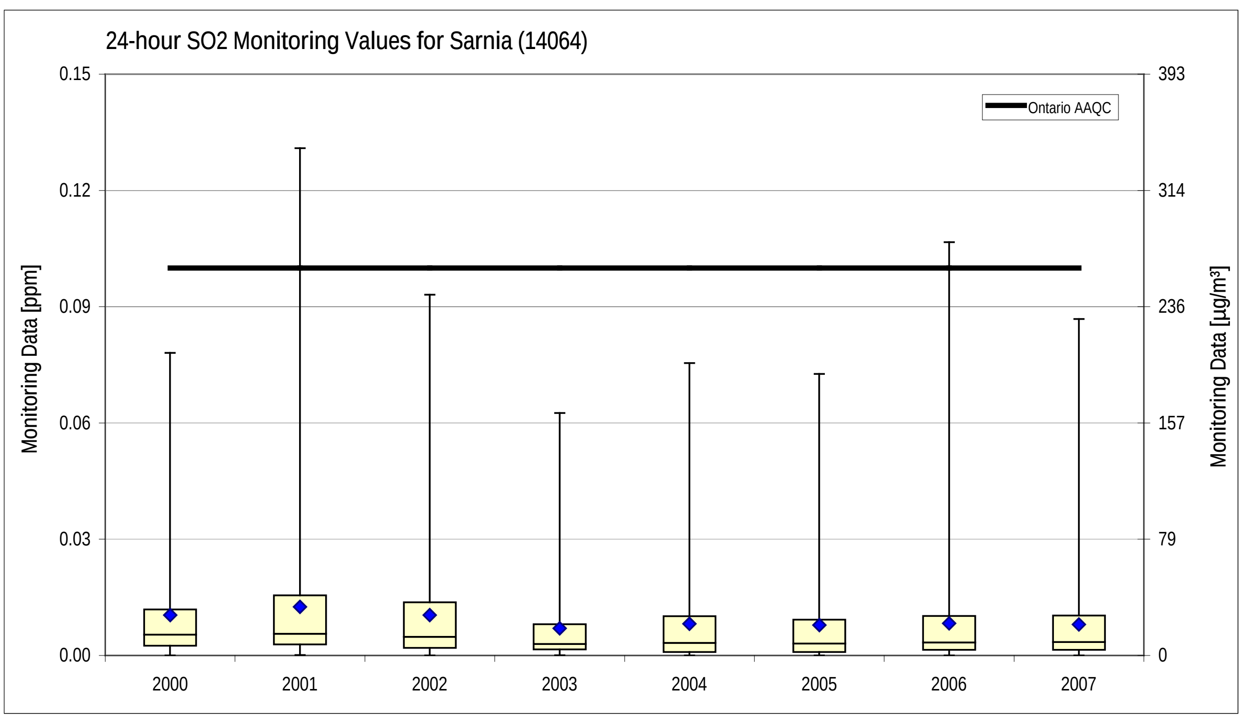

Figure E4.2.3-2: Ambient 24-Hour SO_2 Monitoring Results – Sarnia

E4.2.4 Ambient Sulphur Dioxide Monitoring Results for Tiverton

Table E4.2.4-1 provides a breakdown of the hourly SO_2 concentrations recorded at the station in Tiverton. These data are illustrated on Figure E4.2.4-1. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.250 ppm. Ambient SO_2 monitoring data were only available during 2007.

Table E4.2.4-1: Ambient 1-hour SO_2 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	0.000	0.000	0.000	0.001	0.001	0.002	0.009	0.026
AAQC (ppm)	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**	**0.250**

Notes:
"%-ile" = percentile
— Data not available

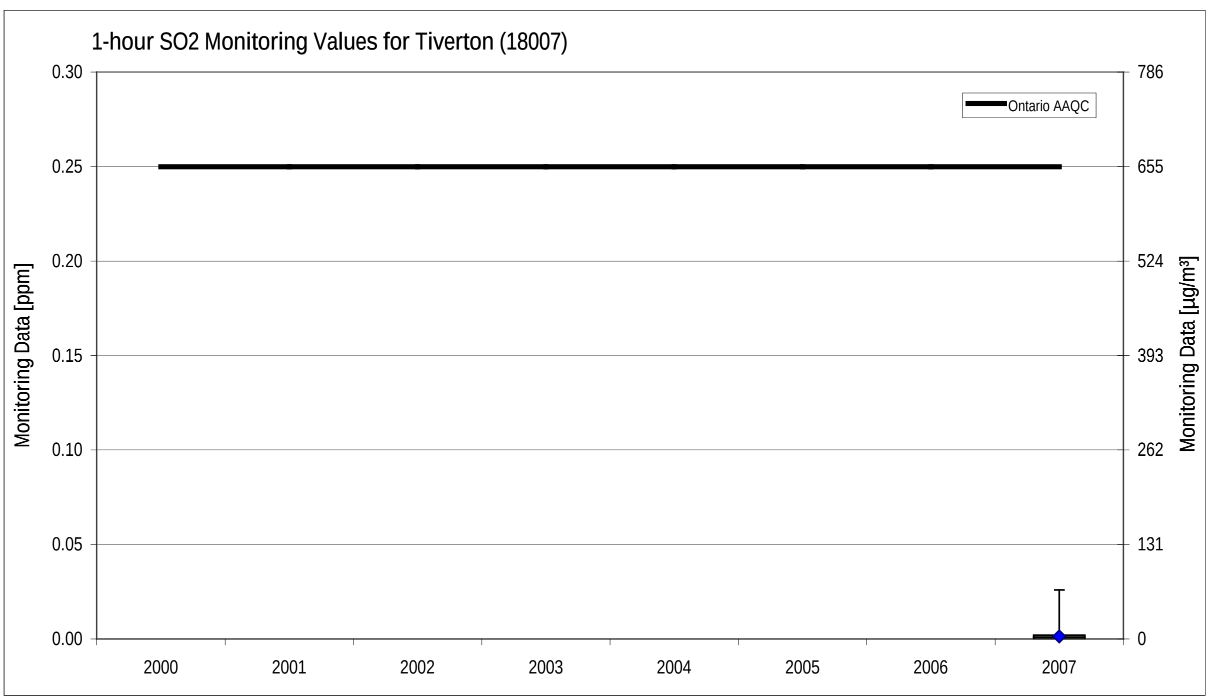

Figure E4.2.4-1: Ambient 1-Hour SO_2 Monitoring Results – Tiverton

Table E4.2.4-2 and Figure E4.2.4-2 provide breakdowns of the daily SO_2 concentrations recorded at the station in Tiverton. The table and graph illustrate the relatively low SO_2 levels recorded at the station when compared to the AAQC of 0.100 ppm. Ambient SO_2 monitoring data were only available during 2007.

Table E4.2.4-2: Ambient 24-hour SO_2 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	0.000	0.000	0.000	0.001	0.001	0.002	0.006	0.009
AAQC (ppm)	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**	**0.100**

Notes:
"%-ile" = percentile
— Data not available

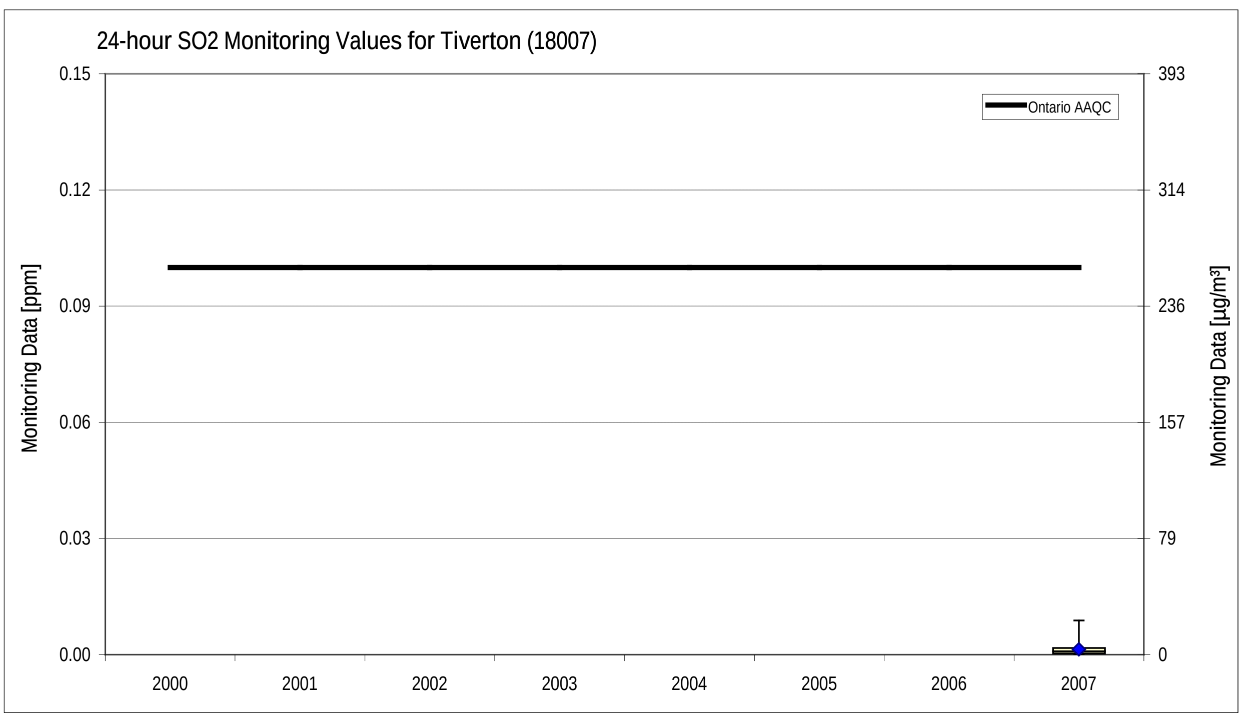

Figure E4.2.4-2: Ambient 24-Hour SO_2 Monitoring Results – Tiverton

E5. CARBON MONOXIDE

Carbon monoxide (CO) is produced primarily through the incomplete combustion of hydrocarbons. The main source of CO produced in Ontario is from the transportation sector [E4]. CO is a colourless, odourless, tasteless gas that can replace oxygen in the bloodstream, reducing the oxygen that is delivered to organs and tissues.

E5.1 AMBIENT CARBON MONOXIDE (CO) MONITORING RESULTS

A summary of the available 1-hour CO monitoring results is presented in Table E5.1-1. Figure E5.1-1 presents a graphical summary of the 1-hour CO concentrations measured at the Kitchener, London and Sarnia monitoring stations. Ambient CO data were not available at the Tiverton station. As illustrated in the figure, all of the stations with monitored data had hourly readings significantly lower than the ambient air quality criteria (AAQC) of 30 ppm.

Table E5.1-1: Ambient 1-hour CO Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.070	0.260	0.380	0.428	0.540	1.050	5.380
London	0.000	0.000	0.060	0.160	0.198	0.270	0.710	3.500
Sarnia	0.000	0.000	0.230	0.330	0.356	0.450	0.870	3.860
Tiverton	—	—	—	—	—	—	—	—
AAQC (ppm)	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**

Notes:
"%-ile" = percentile
— Data not available

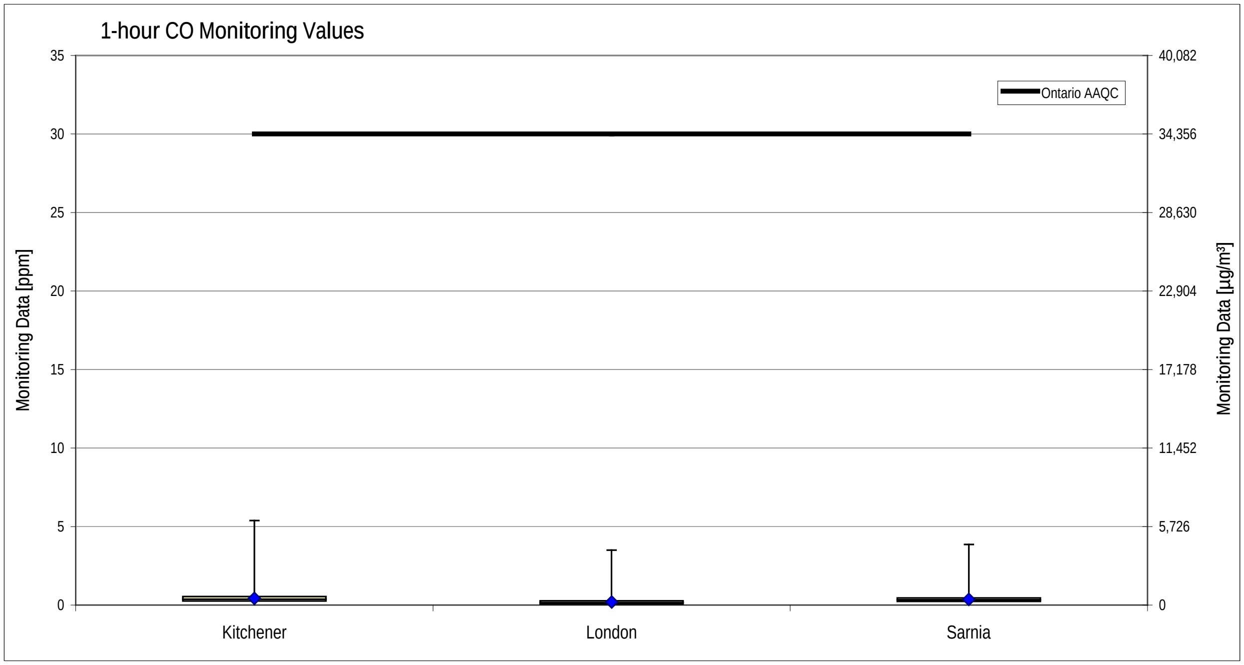

Figure E5.1-1: Ambient 1-Hour CO Monitoring Results

Table E5.1-2 and Figure E5.1-2 provide summaries of the available 8-hour CO concentrations measured at the ambient monitoring stations. No monitoring data for CO were available at the Tiverton station for the given time period. The table and graph illustrate that the recorded 8-hour CO levels at the remaining stations were well below the AAQC of 13 ppm.

Table E5.1-2: Ambient 8-hour CO Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.046	0.131	0.339	0.471	0.526	0.639	1.488	2.783
London	0.000	0.014	0.126	0.219	0.263	0.346	0.780	1.434
Sarnia	0.000	0.084	0.315	0.414	0.446	0.558	0.916	1.686
Tiverton	—	—	—	—	—	—	—	—
AAQC (ppm)	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**

Notes:
"%-ile" = percentile
— Data not available

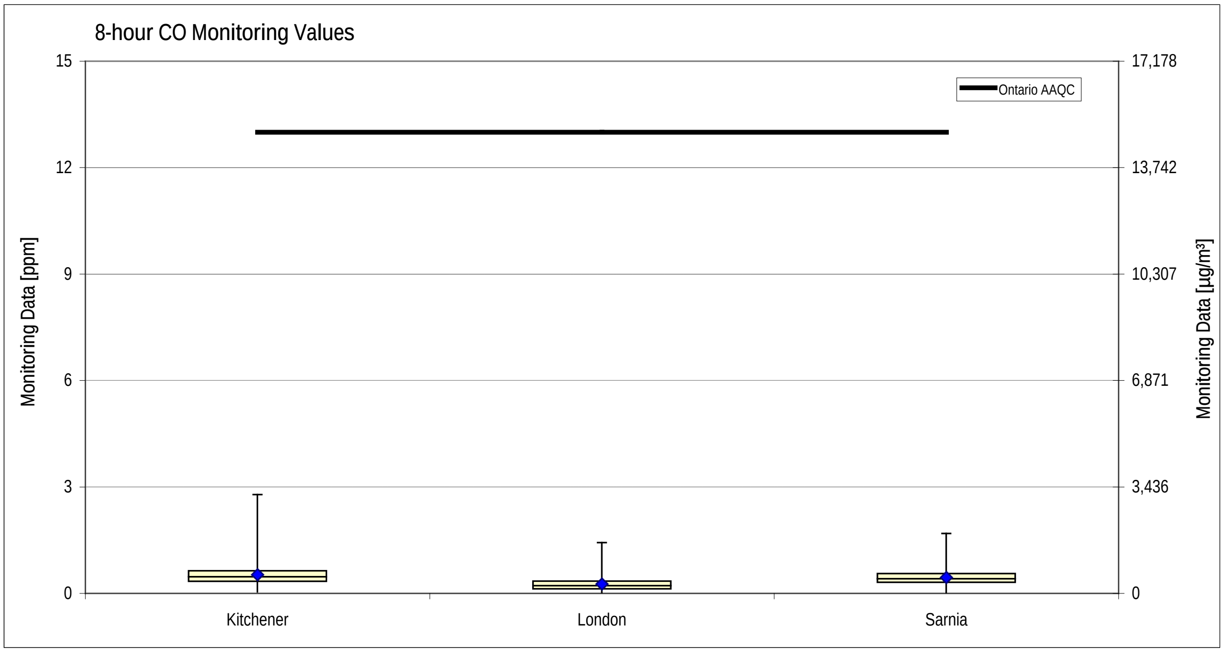

Figure E5.1-2: Ambient 8-Hour CO Monitoring Results

E5.2 STATION SPECIFIC AMBIENT MONITORING RESULTS

E5.2.1 Ambient Carbon Monoxide Monitoring Results for Kitchener

Table E5.2.1-1 provides a breakdown of the hourly CO concentrations recorded at the station in Kitchener. These data are illustrated on Figure E5.2.1-1. Ambient CO monitoring data were not available at the station between 2004 and 2007. The table and graph illustrate that in each of the monitoring years, the recorded levels were significantly lower that the ambient air quality criteria of 30 ppm.

Table E5.2.1-1: Ambient 1-hour CO Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.100	0.270	0.370	0.415	0.480	1.210	4.980
2001	0.010	0.140	0.270	0.350	0.390	0.450	0.950	5.380
2002	0.000	0.050	0.190	0.290	0.321	0.410	0.790	3.310
2003	0.000	0.060	0.390	0.570	0.558	0.700	1.160	3.940
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	—	—	—	—	—	—	—	—
AAQC (ppm)	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**

Notes:
“%-ile” = percentile
— Data not available

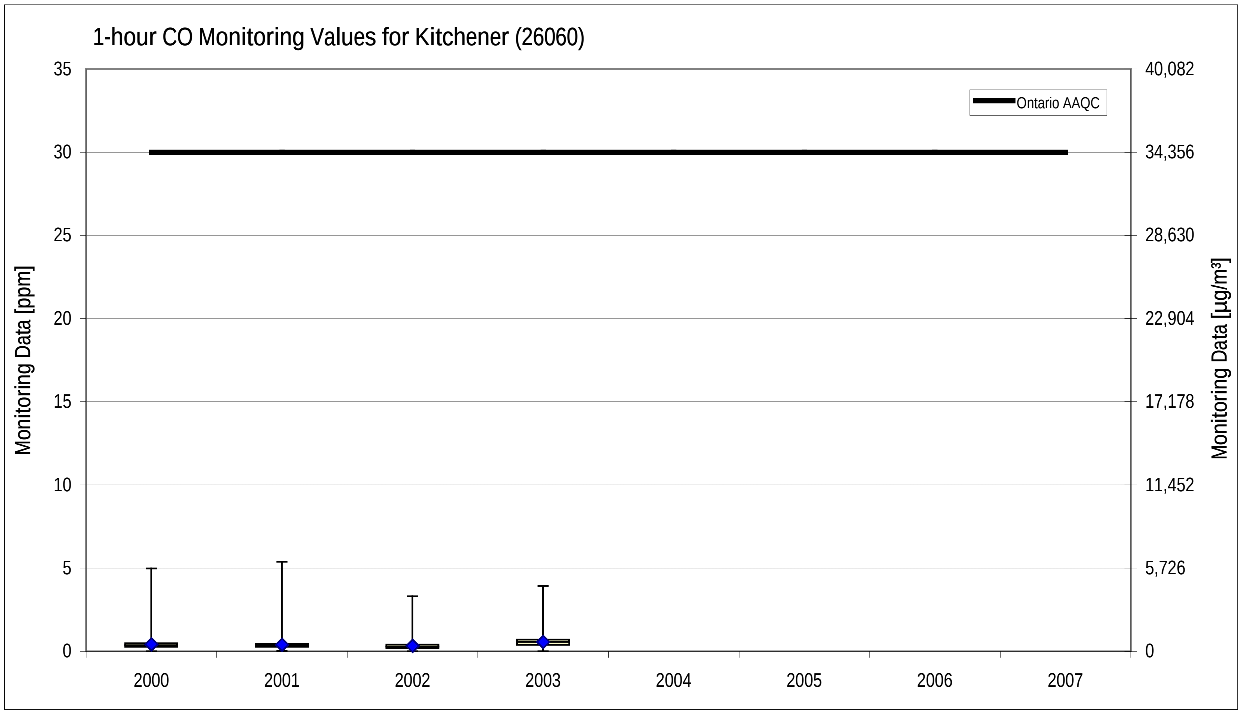

Figure E5.2.1-1: Ambient 1-Hour CO Monitoring Results – Kitchener

Table E5.2.1-2 and Figure E5.2.1-2 provide breakdowns of the 8-hour CO concentrations recorded at the station in Kitchener. Ambient CO monitoring data were not available at the station between 2004 and 2007. As illustrated in the figure, the recorded concentrations were well below the AAQC of 13 ppm in each of the monitoring years.

Table E5.2.1-2: Ambient 8-hour CO Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.070	0.189	0.349	0.468	0.536	0.582	1.654	2.783
2001	0.124	0.188	0.339	0.444	0.487	0.544	1.272	2.425
2002	0.046	0.087	0.265	0.361	0.397	0.506	0.873	1.949
2003	0.078	0.141	0.481	0.648	0.652	0.790	1.489	2.121
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	—	—	—	—	—	—	—	—
AAQC (ppm)	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**

Notes:
"%-ile" = percentile
— Data not available

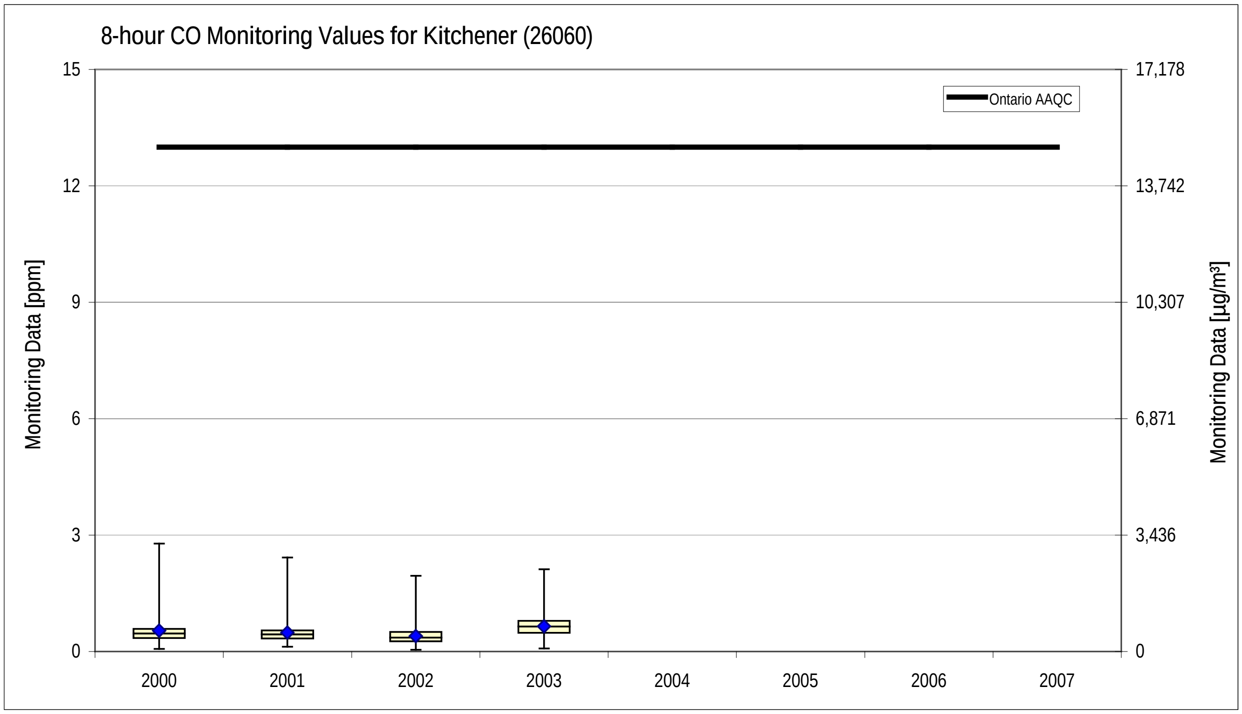

Figure E5.2.1-2: Ambient 8-Hour CO Monitoring Results – Kitchener

E5.2.2 Ambient Carbon Monoxide Monitoring Results for London

Table E5.2.2-1 provides a breakdown of the hourly CO concentrations recorded at the station in London. These data are illustrated on Figure E5.2.2-1. Ambient CO monitoring data were not available at the station during 2003. As illustrated in the figure, the concentrations in the remaining monitoring years were significantly below the AAQC of 30 ppm.

Table E5.2.2-1: Ambient 1-hour CO Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.000	0.040	0.110	0.157	0.220	0.700	2.470
2001	0.000	0.000	0.010	0.090	0.126	0.170	0.605	3.500
2002	0.000	0.000	0.010	0.080	0.115	0.160	0.510	2.270
2003	—	—	—	—	—	—	—	—
2004	0.000	0.150	0.340	0.440	0.453	0.550	0.860	2.300
2005	0.000	0.000	0.070	0.140	0.167	0.220	0.580	2.400
2006	0.000	0.000	0.110	0.180	0.187	0.240	0.470	1.830
2007	0.000	0.000	0.070	0.160	0.160	0.230	0.430	1.210
AAQC (ppm)	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**

Notes:
"%-ile" = percentile
— Data not available

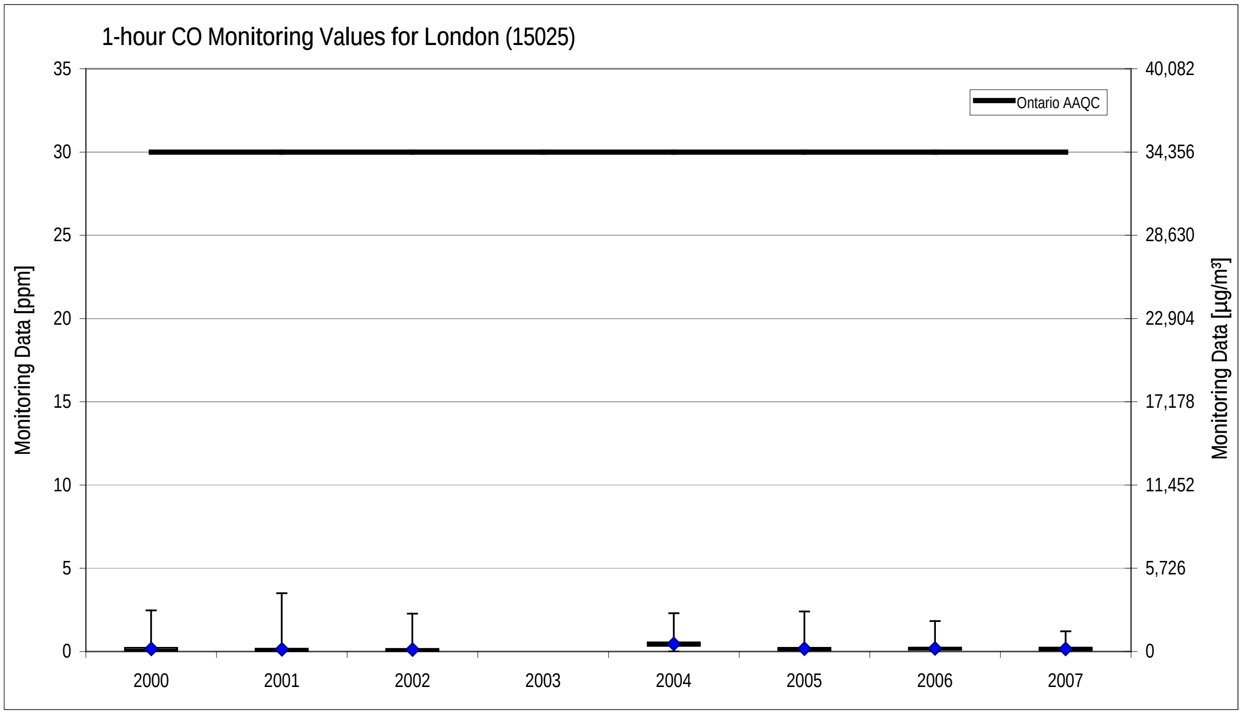

Figure E5.2.2-1: Ambient 1-Hour CO Monitoring Results – London

Table E5.2.2-2 and Figure E5.2.2-2 provide breakdowns of the 8-hour CO concentrations recorded at the station in London. Ambient CO monitoring data were not available at the station during 2003. The table and graph illustrate that the recorded 8-hour concentrations at the station were significantly below the AAQC of 13 ppm in each of the monitoring years.

Table E5.2.2-2: Ambient 8-hour CO Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.025	0.121	0.207	0.250	0.325	0.818	1.434
2001	0.000	0.007	0.100	0.171	0.207	0.257	0.741	1.383
2002	0.000	0.000	0.092	0.167	0.181	0.231	0.629	0.946
2003	—	—	—	—	—	—	—	—
2004	0.148	0.221	0.404	0.491	0.523	0.619	0.913	1.393
2005	0.006	0.026	0.126	0.203	0.224	0.282	0.663	1.241
2006	0.023	0.055	0.149	0.221	0.234	0.302	0.530	0.880
2007	0.003	0.020	0.100	0.190	0.196	0.271	0.493	0.616
AAQC (ppm)	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**

Notes:
"%-ile" = percentile
— Data not available

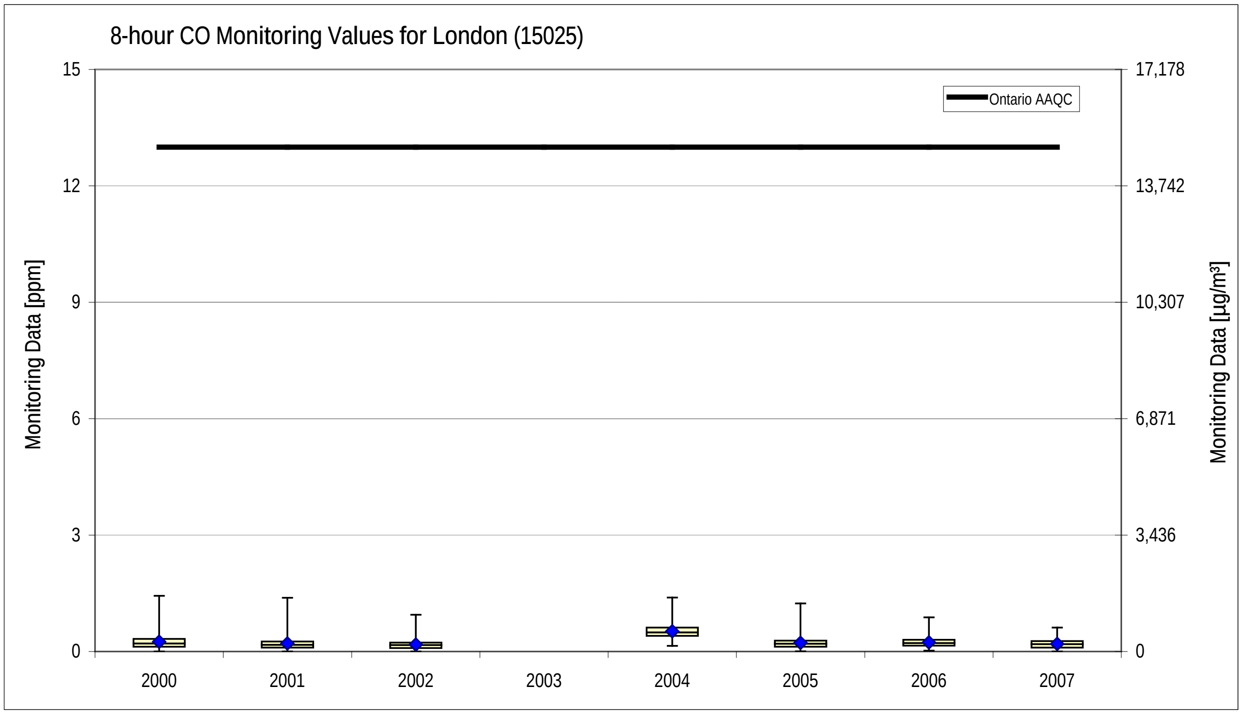

Figure E5.2.2-2: Ambient 8-Hour CO Monitoring Results – London

E5.2.3 Ambient Carbon Monoxide Monitoring Results for Sarnia

Table E5.2.3-1 provides a breakdown of the hourly CO concentrations recorded at the station in Sarnia. These data are illustrated on Figure E5.2.3-1. Ambient CO monitoring data at this station were only available in 2000 and 2001. The hourly concentrations recorded during these two years were significantly below the AAQC of 30 ppm, as illustrated in the graph.

Table E5.2.3-1: Ambient 1-hour CO Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.140	0.290	0.370	0.415	0.490	0.940	3.860
2001	0.000	0.000	0.150	0.260	0.283	0.370	0.760	2.360
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	**—**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
AAQC (ppm)	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**

Notes:
"%-ile" = percentile
— Data not available

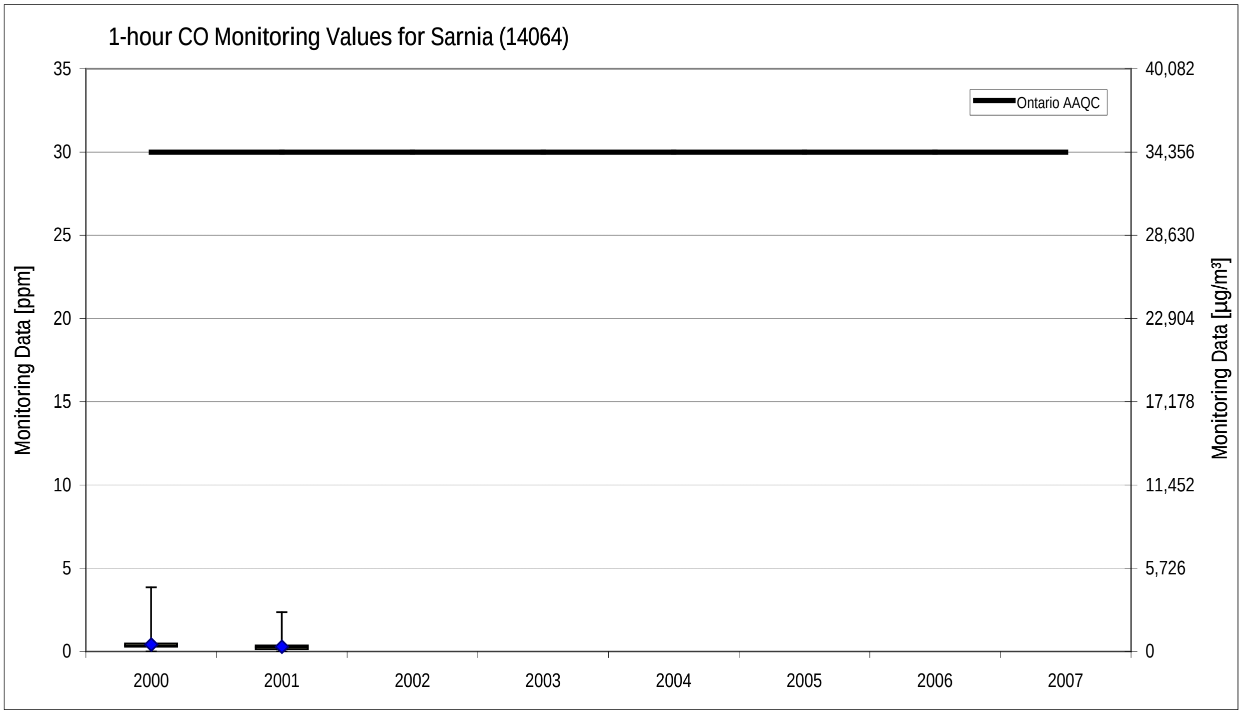

Figure E5.2.3-1: Ambient 1-Hour CO Monitoring Results – Sarnia

Table E5.2.3-2 and Figure E5.2.3-2 provide breakdowns of the 8-hour CO concentrations recorded at the station in Sarnia. Ambient CO monitoring data in this station were only available in 2000 and 2001. All of the 8-hour values recorded during this period were significantly below the AAQC of 13 ppm.

Table E5.2.3-2: Ambient 8-hour CO Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.125	0.192	0.380	0.464	0.511	0.596	0.952	1.686
2001	0.000	0.049	0.235	0.347	0.367	0.472	0.791	1.150
2002	—	—	—	—	—	—	—	—
2003	—	—	—	—	—	—	—	—
2004	—	—	—	—	—	—	—	—
2005	—	—	—	—	—	—	—	—
2006	—	—	—	—	—	—	—	—
2007	—	—	—	—	—	—	—	—
AAQC (ppm)	**13**	**13**	**13**	**13**	**13**	**13**	**13**	**13**

Notes:
"%-ile" = percentile
— Data not available

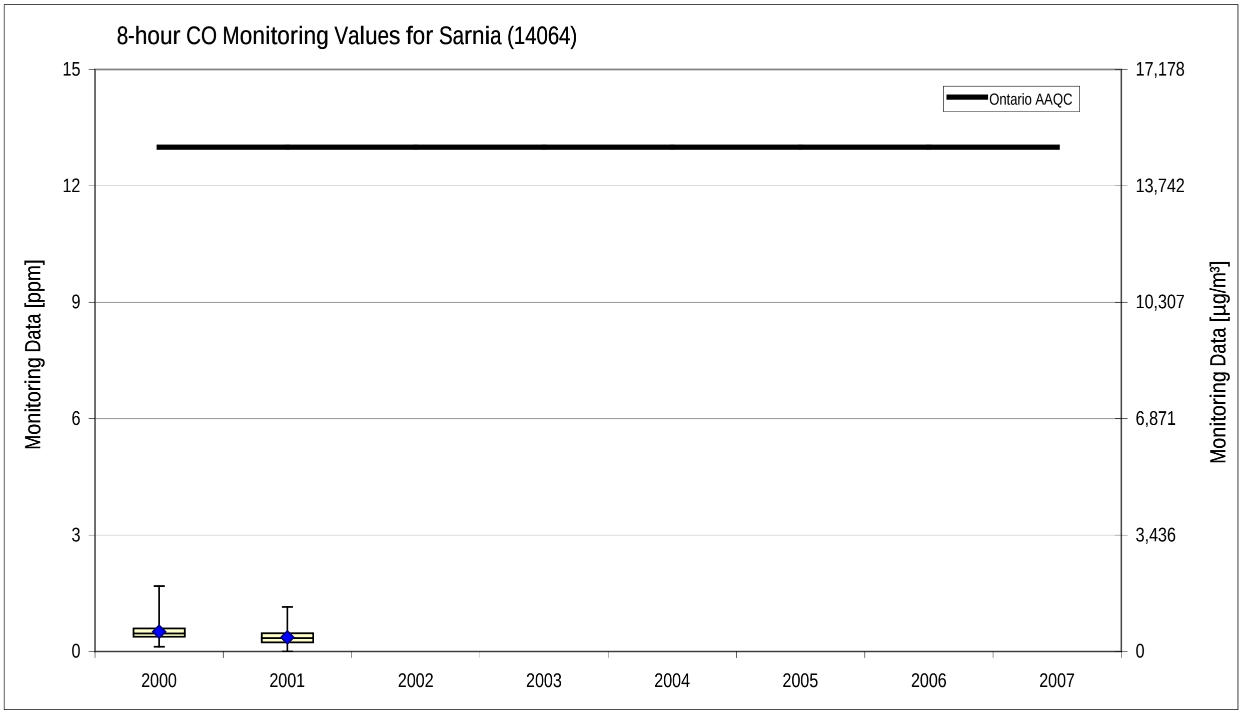

Figure E5.2.3-2: Ambient 8-Hour CO Monitoring Results – Sarnia

E6. OZONE

Ozone (O_3) is an essential part of the upper atmosphere that protects us from most of the sun's harmful ultra-violet radiation. Ozone can also be present at the earth's surface. Ground-level ozone can be attributed to three causes in Canada, namely photochemical ozone formation, stratospheric intrusion and long-range transport. The interaction of the three sources of ground-level ozone is illustrated on Figure E6-1.

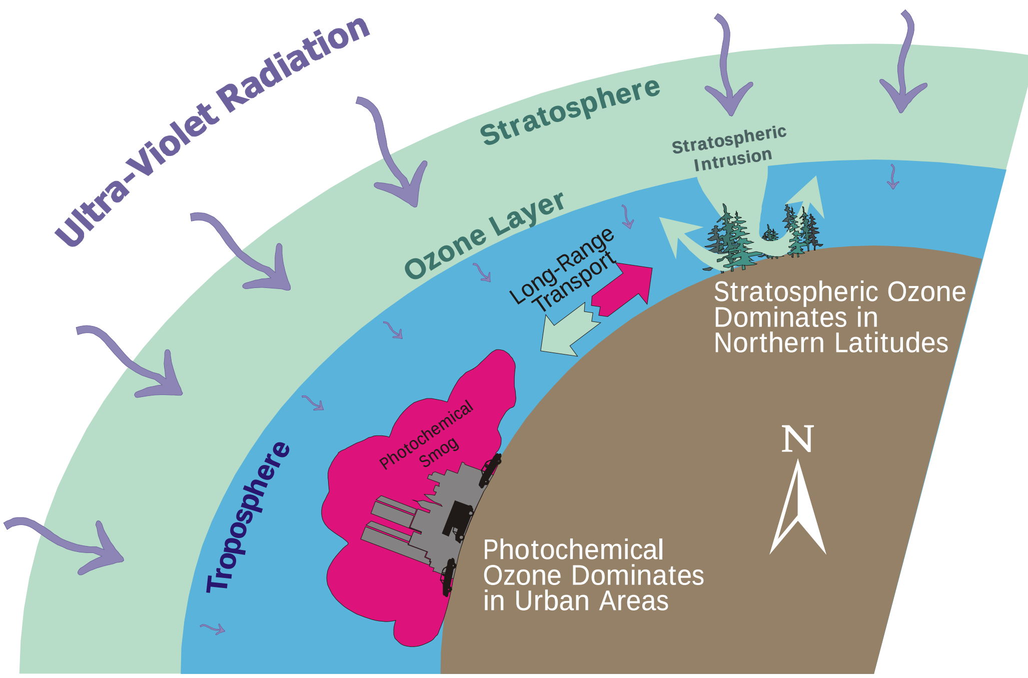

Figure E6-1: Potential Sources of Ground-Level Ozone in Canada

Photochemical ozone formation is one of the key ingredients of urban smog that is associated with large American cities, such as Los Angeles. Photochemical ozone forms when large volumes of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) are present during the right meteorological conditions. This type of ozone formation occurs during the daylight hours in the summer months when hot, sunny, stagnant conditions favour the necessary chemical reactions.

At night this photochemical ozone breaks down because sunlight, essential in the reaction, is absent. This relationship is shown in the following formulae:

$$\mathrm{VOC} + \mathrm{sunlight} + \mathrm{NO_X} \rightarrow \mathrm{O_3} \qquad \text{daytime}$$

$$O_2 + NO_2 \leftarrow O_3 + NO \qquad \text{nighttime}$$

The ozone layer is relatively close to the earth's surface in northern and central Canada. Under some conditions, this stratospheric ozone can intrude into the lower atmosphere and result in elevated ground-level ozone concentrations. This intrusion of stratospheric ozone has been identified as the key source of ground-level ozone in the rural areas of northern Canada [E9]. This is likely only a source of elevated ozone concentrations in areas of northern Ontario.

The transport of ozone over long distances occurs in several regions of Canada. In southern Ontario, photochemical ozone is frequently transported into Canada from larger cities in the United States.

The observations based on ambient ozone concentrations discussed above do not take into account changes in industrial emissions and their potential effect on ambient ozone concentrations. While increased industrial emissions are usually associated with increases in ambient concentrations, the opposite can happen with ozone. Increased emissions of oxides of nitrogen can have a “scavenging” effect on ground-level ozone, effectively reducing the average concentrations. This phenomenon is common in urban areas during the early morning and late afternoon “rush-hours”.

Figure E6-2 presents selected air quality data from a rural northern monitoring station in northern Ontario (Experimental Lakes Area) and a large urban site (Toronto – Elmcrest). The data from the Elmcrest station shows a distinct decrease in ozone levels during the early morning rush hour, while the rural station experienced a far less distinct drop at this point in the day. While it is possible to interpret this “scavenging” effect as also affecting the peak mid-day ozone levels, monitoring shows that locations with the highest NO_X scavenging also have the highest mid-day peak ozone levels. This can be explained by the time required for the photochemical reactions to occur.

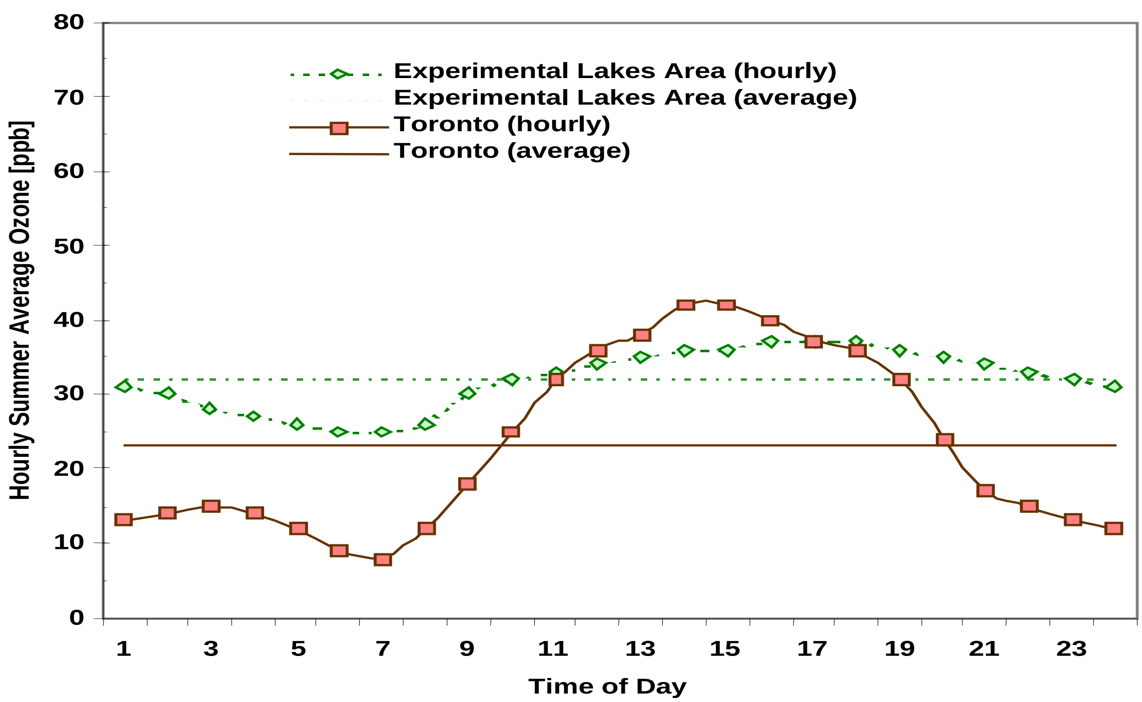

Figure E6-2: Diurnal Ozone Patterns Observed at Urban and Rural Sites

E6.1 SUMMARY OF AMBIENT OZONE (O_3) MONITORING RESULTS

A summary of the available 1-hour O_3 monitoring results is presented in Table E6.1-1. Figure E6.1-1 presents a graphical summary of the 1-hour O_3 concentrations measured at the ambient monitoring stations. As illustrated in the figure, all of the stations had hourly readings that exceeded the ambient air quality criteria (AAQC) of 0.080 ppm (i.e., 80 ppb). Table E6.1-2 lists the number of days per year (2000 through 2007) when hourly ozone exceeded the AAQC.

Table E6.1-1: Ambient 1-hour O_3 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
Kitchener	0.000	0.001	0.015	0.026	0.027	0.036	0.066	0.109
London	0.000	0.001	0.013	0.023	0.025	0.034	0.065	0.116
Sarnia	0.000	0.001	0.014	0.025	0.026	0.035	0.066	0.128
Tiverton	0.000	0.008	0.023	0.031	0.032	0.039	0.068	0.136
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

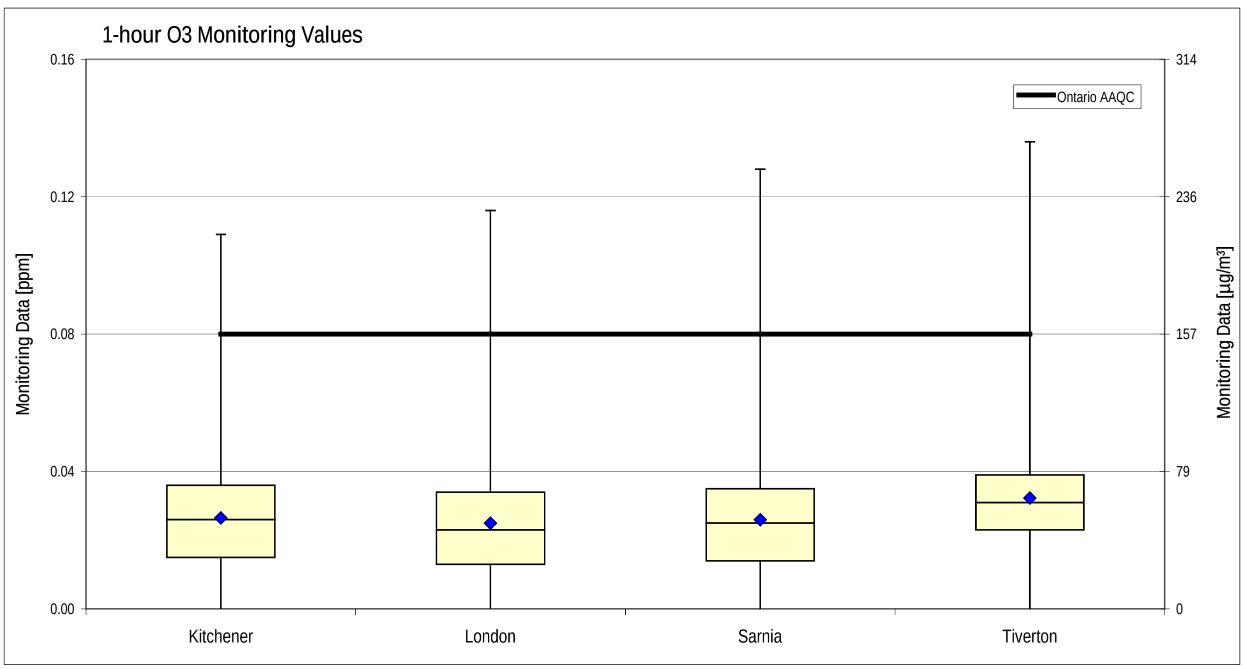

Figure E6.1-1: Ambient 1-Hour O_3 Monitoring Results

Table E6.1-2: Days per Year when 1-hour O_3 Exceeds the AAQC

City	Days per Year with 1-hour O_3 Greater than AAQC							
	2000	2001	2002	2003	2004	2005	2006	2007
Kitchener	6	16	17	11	2	9	1	8
London	5	14	21	9	2	5	1	6
Sarnia	7	18	22	9	2	21	8	19
Tiverton	8	16	20	13	3	6	4	20

As seen in the above table, the number of days when 1-hour ozone exceeds the AAQC varies from one year to the next. However, the number of days when 1-hour ozone exceeds the AAQC tend to be similar at all four stations in a given year (with the exception of 2005 at Sarnia and 2007 at Sarnia and Tiverton).

Table E6.1-3 and Figure E6.1-2 provide summaries of the available maximum 8-hour ozone concentrations measured at the ambient monitoring stations. Currently there is no 8-hour AAQC for ozone, but there is a Canada-Wide Standard [E10] that has been used for comparison to the data. Maximum 8-hour ozone concentrations at all of the stations exceeded the Canada-Wide Standard of 0.065 ppm (i.e., 65 ppb). However, compliance with the Canada-Wide Standard is based on the fourth highest 8-hour value annually, averaged over a 3-year period. Table E6.1-4 presents a summary of the 3-year compliance values.

Table E6.1-3: Ambient 8-hour O_3 Monitoring Results

City	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.002	0.009	0.026	0.035	0.036	0.045	0.075	0.104
London	0.001	0.009	0.024	0.032	0.035	0.044	0.074	0.108
Sarnia	0.000	0.008	0.025	0.034	0.036	0.044	0.077	0.113
Tiverton	0.004	0.015	0.029	0.036	0.039	0.045	0.079	0.115
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
"%-ile" = percentile

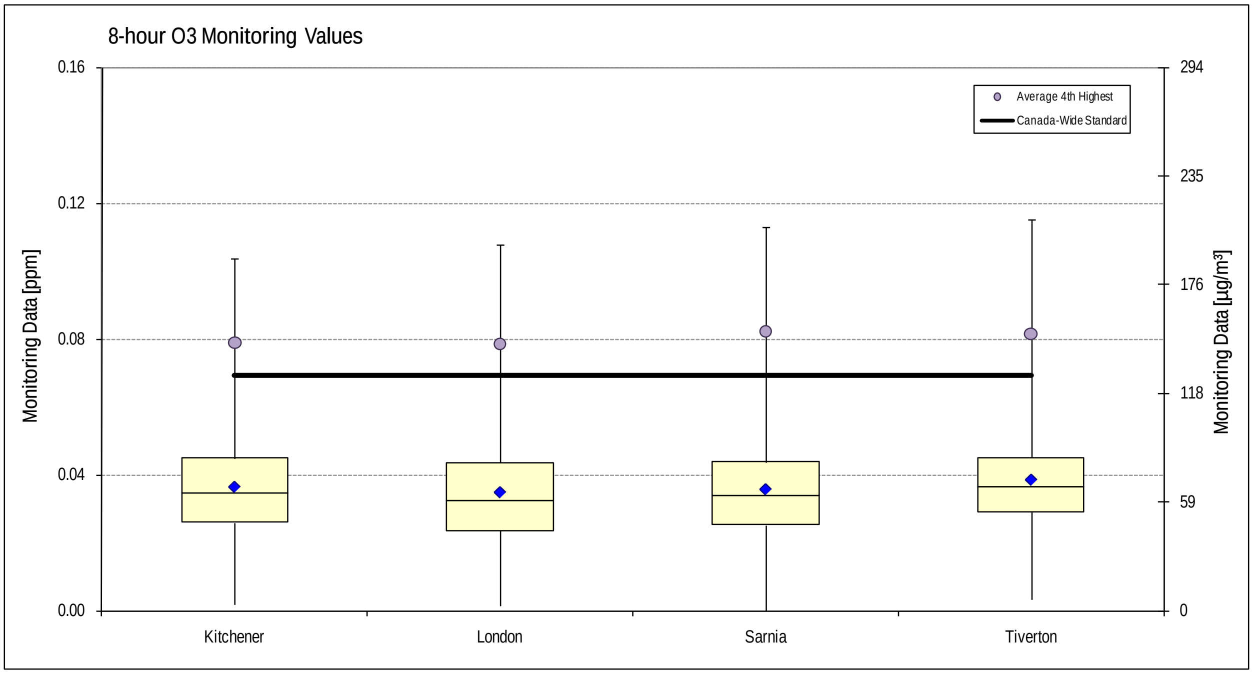

Figure E6.1-2: Ambient 8-Hour O_3 Monitoring Results

Table E6.1-4: Summary of 8-hour O_3 Monitoring Results for Comparison to the Canada-Wide Standard

City	3-year Fourth-highest 8-hour O_3 (ppm)					
	2000-2002	**2001-2003**	**2002-2004**	**2003-2005**	**2004-2006**	**2005-2007**
Kitchener	0.084	0.087	0.083	0.078	0.072	0.075
London	0.087	0.087	0.081	0.074	0.071	0.073
Sarnia	0.087	0.090	0.082	0.079	0.076	0.083
Tiverton	0.089	0.089	0.082	0.076	0.071	0.078
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

As noted in the above table, the 3-year rolling averages of the annual fourth highest 8-hour daily ozone maximum were consistent from one year to the next and across the four stations. The values were all above the Canada-Wide Standard of 0.065 ppm, since southwestern Ontario is known as an area where elevated ozone occurs, largely as a result of trans-boundary effects from the United States.

E6.2 STATION SPECIFIC AMBIENT MONITORING RESULTS

E6.2.1 Ambient Ozone Monitoring Results for Kitchener

Table E6.2.1-1 provides a breakdown of the hourly O_3 concentrations recorded at the station in Kitchener. These data are illustrated on Figure E6.2.1-1. The table and graph show that while three quarters of the data were less than half of the AAQC of 0.080 ppm, hourly readings in excess of the criteria were recorded in each of the monitoring years.

Table E6.2.1-1: Ambient 1-hour O_3 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.000	0.000	0.011	0.023	0.023	0.033	0.058	0.095
2001	0.000	0.001	0.013	0.024	0.026	0.035	0.070	0.099
2002	0.000	0.001	0.015	0.025	0.027	0.036	0.076	0.107
2003	0.000	0.002	0.016	0.027	0.028	0.038	0.068	0.109
2004	0.000	0.001	0.014	0.025	0.025	0.033	0.060	0.082
2005	0.000	0.002	0.016	0.027	0.028	0.038	0.068	0.096
2006	0.000	0.001	0.016	0.026	0.027	0.036	0.062	0.082
2007	0.001	0.002	0.018	0.028	0.029	0.037	0.067	0.095
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

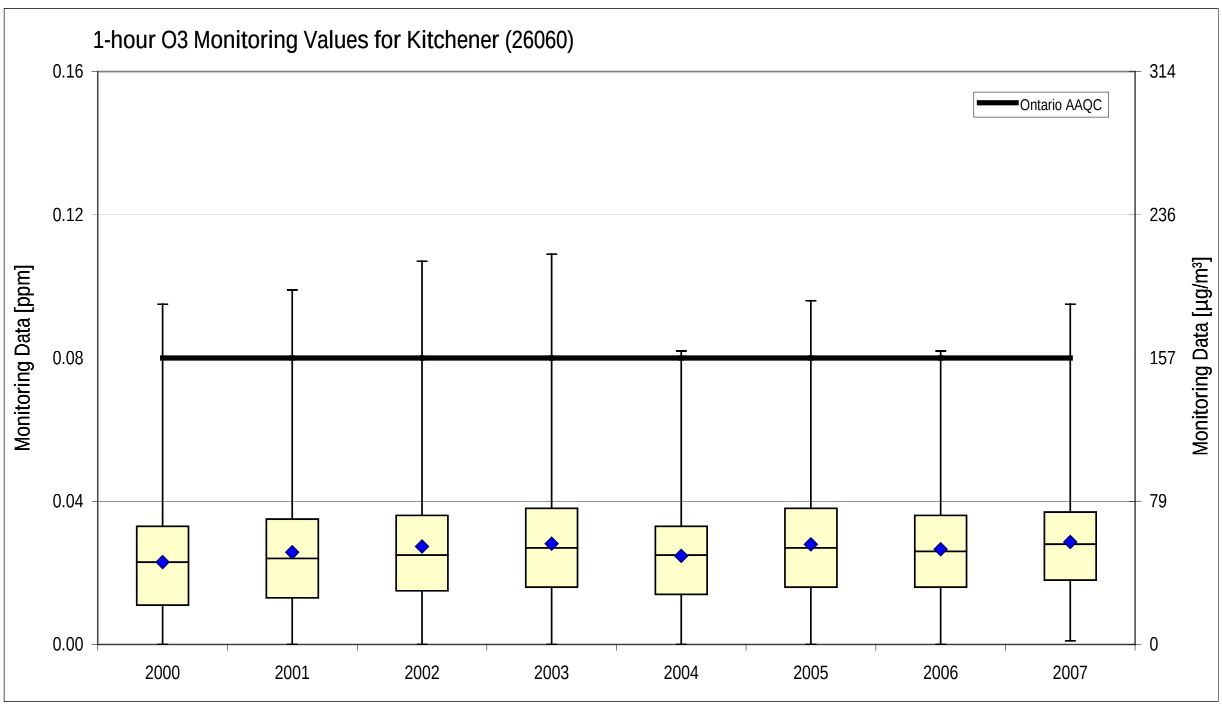

Figure E6.2.1-1: Ambient 1-Hour O_3 Monitoring Results – Kitchener

Table E6.2.1-2 and Figure E6.2.1-2 provide breakdowns of the 8-hour O_3 concentrations recorded at the station in Kitchener. The table and graph illustrate that 8-hour O_3 levels were recorded in excess of the Canada-Wide Standard of 0.065 ppm in each of the monitoring years.

Table E6.2.1-2: Ambient 8-hour O_3 Monitoring Results – Kitchener

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.002	0.007	0.024	0.032	0.033	0.042	0.069	0.084
2001	0.002	0.008	0.024	0.034	0.036	0.046	0.080	0.091
2002	0.005	0.012	0.025	0.034	0.038	0.048	0.086	0.103
2003	0.003	0.010	0.029	0.037	0.039	0.047	0.079	0.104
2004	0.005	0.009	0.026	0.032	0.034	0.041	0.066	0.076
2005	0.005	0.011	0.027	0.036	0.038	0.048	0.075	0.088
2006	0.003	0.010	0.025	0.035	0.036	0.044	0.067	0.080
2007	0.007	0.013	0.029	0.036	0.038	0.046	0.075	0.090
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
"%-ile" = percentile

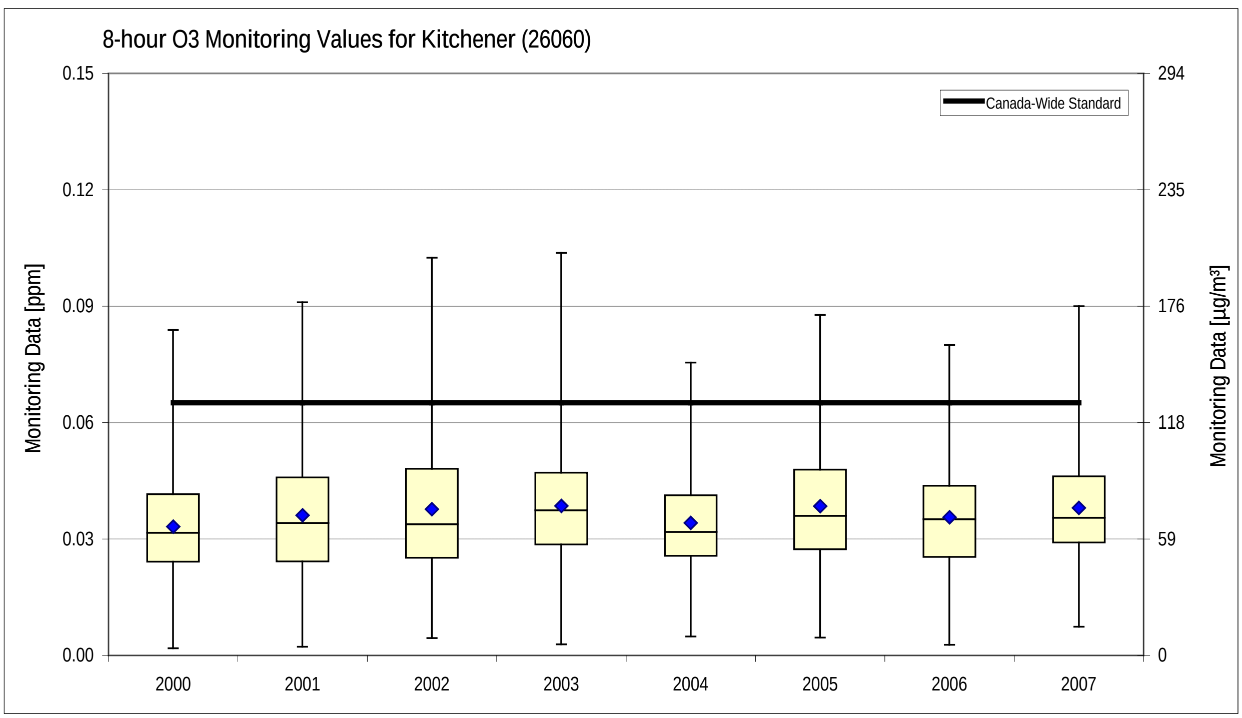

Figure E6.2.1-2: Ambient 8-Hour O_3 Monitoring Results – Kitchener

E6.2.2 Ambient Ozone Monitoring Results for London

Table E6.2.2-1 provides a breakdown of the hourly O_3 concentrations recorded at the station in London. These data are illustrated on Figure E6.2.2-1. The table and graph illustrate that the majority of the ozone observations were relatively low when compared to the AAQC; however, hourly values in excess of the criteria occurred in each monitoring year.

Table E6.2.2-1: Ambient 1-hour O_3 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.000	0.000	0.010	0.020	0.021	0.030	0.057	0.110
2001	0.000	0.000	0.012	0.022	0.024	0.033	0.069	0.104
2002	0.000	0.000	0.012	0.022	0.025	0.033	0.079	0.116
2003	0.000	0.002	0.015	0.025	0.027	0.036	0.068	0.109
2004	0.000	0.001	0.013	0.023	0.024	0.032	0.059	0.085
2005	0.000	0.001	0.015	0.024	0.026	0.035	0.067	0.093
2006	0.000	0.001	0.014	0.024	0.025	0.034	0.061	0.082
2007	0.000	0.002	0.017	0.026	0.027	0.036	0.065	0.085
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

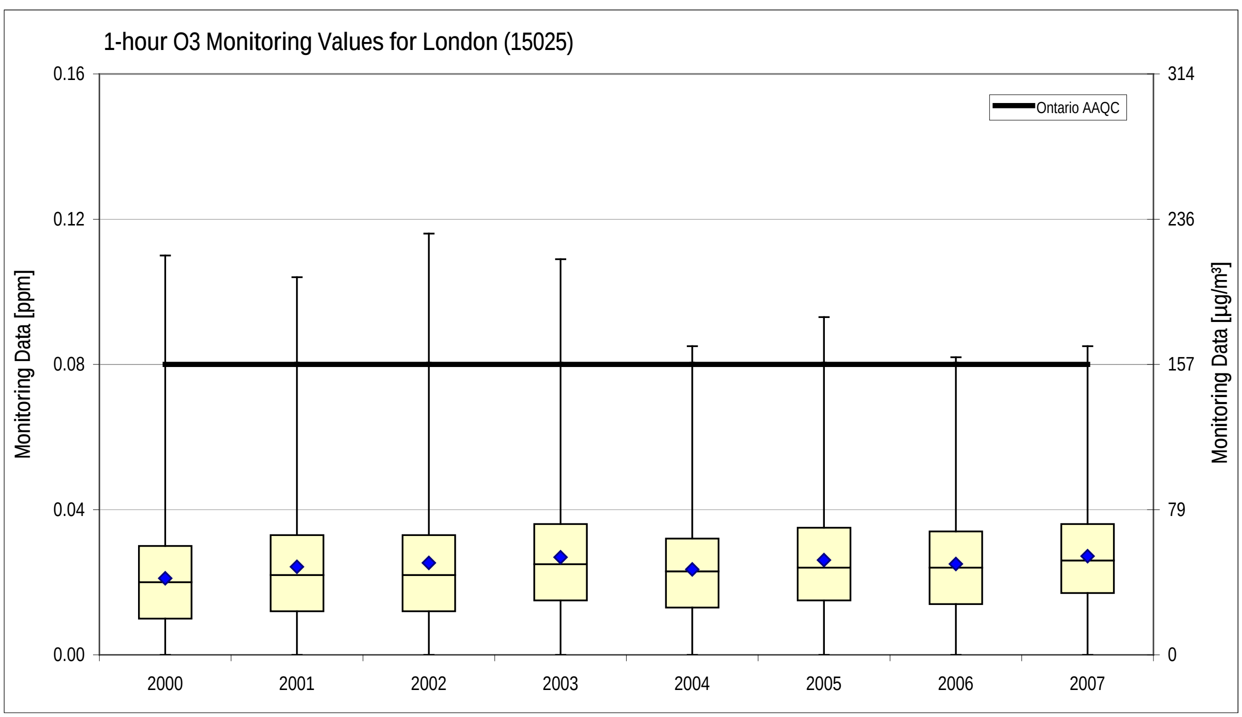

Figure E6.2.2-1: Ambient 1-Hour O_3 Monitoring Results – London

Table E6.2.2-2 and Figure E6.2.2-2 provide breakdowns of the 8-hour O_3 concentrations recorded at the station in London. The table and graph illustrate that 8-hour ozone concentrations were recorded in excess of the Canada-Wide Standard of 65 ppb in each of the monitoring years.

Table E6.2.2-2: Ambient 8-hour O_3 Monitoring Results – London

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.002	0.009	0.021	0.029	0.031	0.038	0.067	0.090
2001	0.002	0.006	0.022	0.032	0.035	0.045	0.080	0.096
2002	0.005	0.009	0.022	0.031	0.037	0.047	0.088	0.108
2003	0.005	0.010	0.027	0.036	0.037	0.047	0.076	0.104
2004	0.001	0.006	0.024	0.032	0.033	0.039	0.064	0.079
2005	0.006	0.011	0.024	0.032	0.036	0.046	0.071	0.085
2006	0.003	0.010	0.023	0.033	0.034	0.042	0.065	0.076
2007	0.004	0.013	0.026	0.035	0.037	0.045	0.072	0.082
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
"%-ile" = percentile

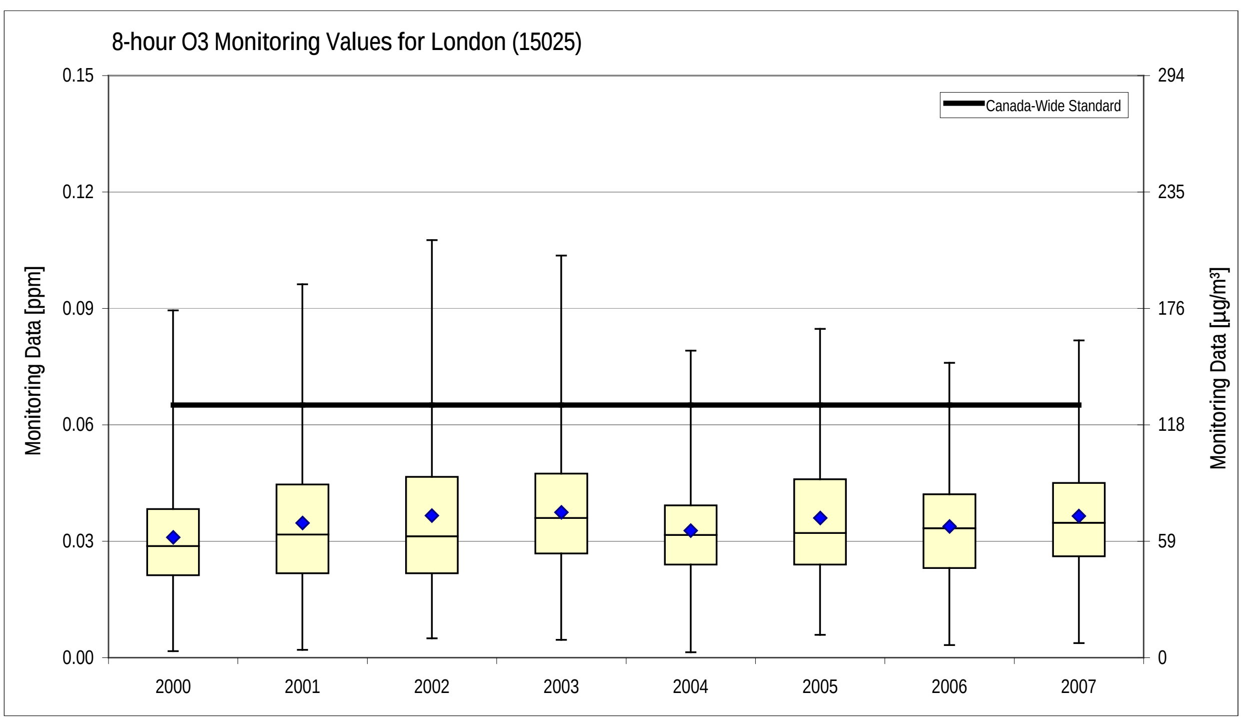

Figure E6.2.2-2: Ambient 8-Hour O_3 Monitoring Results – London

E6.2.3 Ambient Ozone Monitoring Results for Sarnia

Table E6.2.3-1 provides a breakdown of the hourly O_3 concentrations recorded at the station in Sarnia. These data are illustrated on Figure E6.2.3-1. The table and graph illustrate that while most of the readings were less than half of the AAQC of 0.080 ppm, hourly values in excess of the criteria were recorded in all eight years.

Table E6.2.3-1: Ambient 1-hour O_3 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.000	0.001	0.013	0.024	0.024	0.034	0.062	0.107
2001	0.000	0.001	0.012	0.024	0.026	0.035	0.072	0.128
2002	0.000	0.001	0.013	0.024	0.026	0.035	0.075	0.125
2003	0.000	0.002	0.015	0.024	0.025	0.032	0.061	0.110
2004	0.000	0.000	0.013	0.024	0.024	0.033	0.054	0.093
2005	0.000	0.001	0.015	0.026	0.027	0.037	0.070	0.115
2006	0.000	0.002	0.015	0.026	0.027	0.037	0.063	0.100
2007	0.000	0.002	0.018	0.028	0.029	0.037	0.068	0.106
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

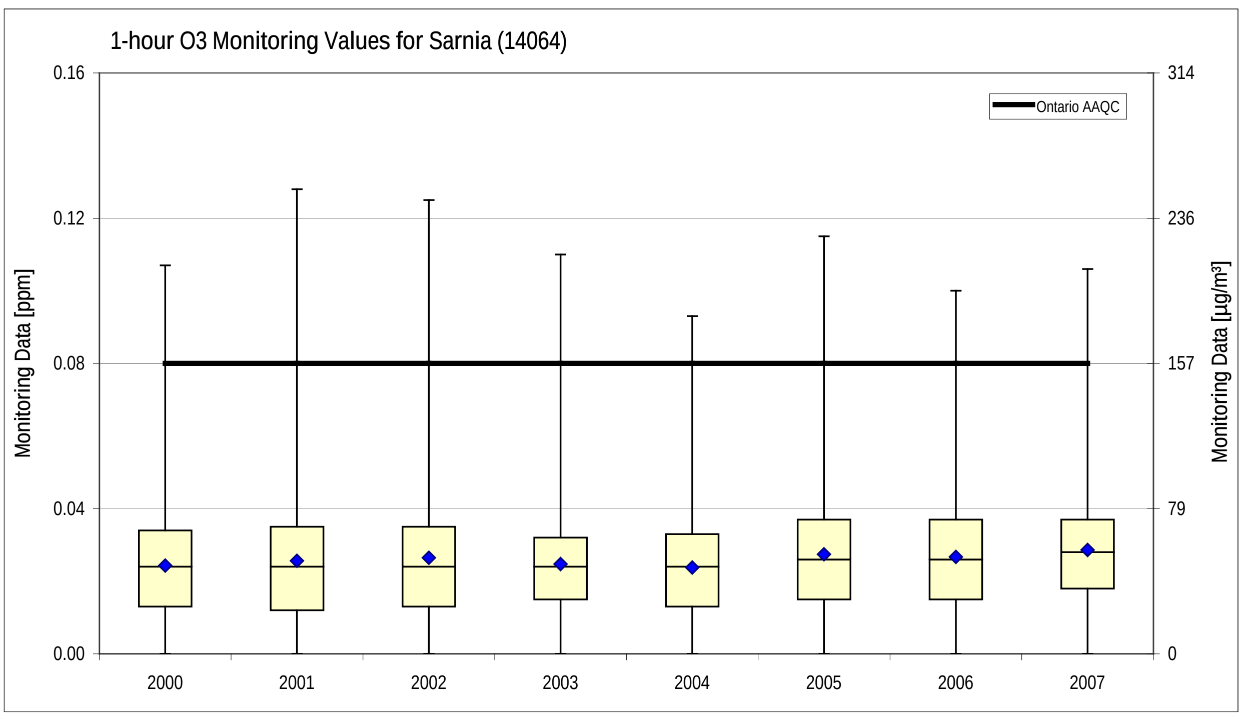

Figure E6.2.3-1: Ambient 1-Hour O_3 Monitoring Results – Sarnia

Table E6.2.3-2 and Figure E6.2.3-2 provide breakdowns of the 8-hour O_3 concentrations recorded at the station in Sarnia. There were days when the 8-hour O_3 levels exceeded the Canada-Wide Standard in each of the years with monitoring data.

Table E6.2.3-2: Ambient 8-hour O_3 Monitoring Results – Sarnia

Year	Ambient Monitoring Results (ppm)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	0.002	0.008	0.026	0.034	0.035	0.041	0.067	0.085
2001	0.003	0.005	0.024	0.033	0.036	0.046	0.086	0.104
2002	0.003	0.009	0.025	0.034	0.038	0.045	0.093	0.113
2003	0.004	0.009	0.024	0.032	0.034	0.040	0.069	0.096
2004	0.000	0.006	0.025	0.033	0.033	0.041	0.061	0.076
2005	0.004	0.011	0.026	0.035	0.038	0.048	0.079	0.099
2006	0.003	0.009	0.026	0.035	0.036	0.044	0.070	0.079
2007	0.002	0.011	0.029	0.035	0.038	0.045	0.080	0.092
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
"%-ile" = percentile

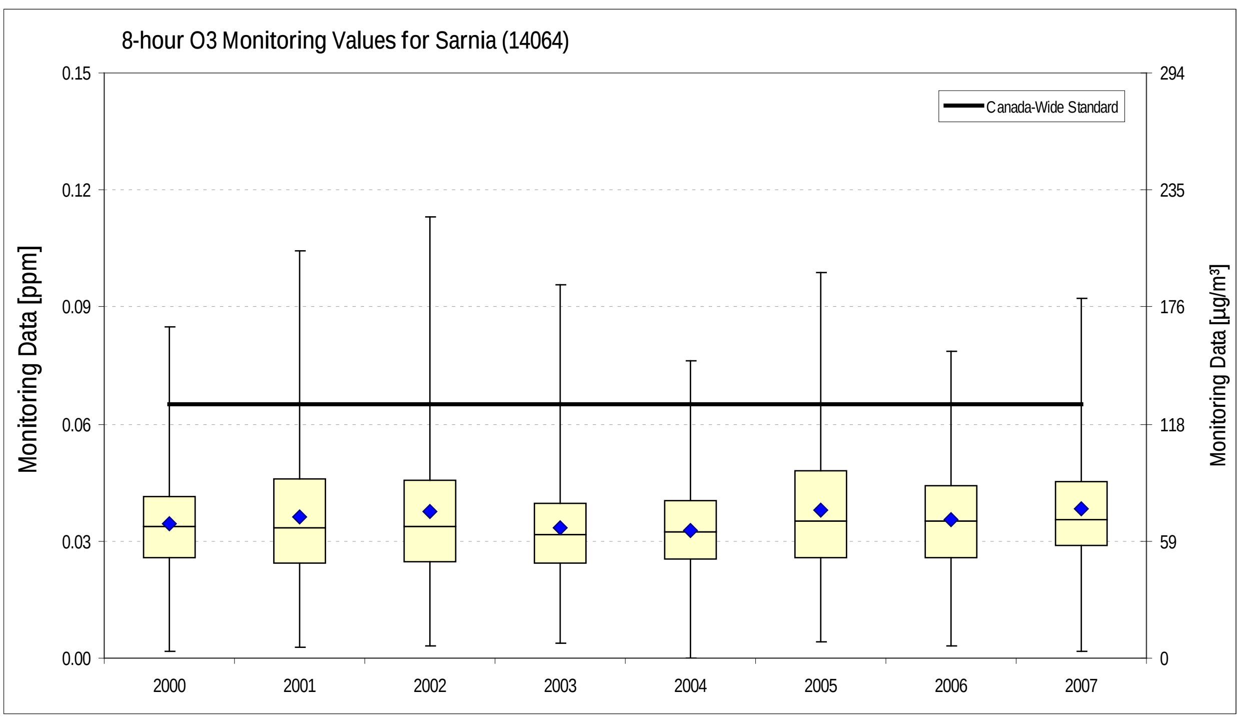

Figure E6.2.3-2: Ambient 8-Hour O_3 Monitoring Results – Sarnia

E6.2.4 Ambient Ozone Monitoring Results for Tiverton

Table E6.2.4-1 provides a breakdown of the hourly O_3 concentrations recorded at the station in Tiverton. These data are illustrated on Figure E6.2.4-1. The table and graph illustrate the hours in excess of the AAQC of 0.080 ppm occurred during each year of monitoring, despite the majority of the hourly O_3 concentrations being less than half of the criteria.

Table E6.2.4-1: Ambient 1-hour O_3 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	**2nd %-ile**	**25th %-ile**	**50th %-ile**	**Average**	**75th %-ile**	**98th %-ile**	**Maximum**
2000	0.000	0.009	0.025	0.032	0.032	0.038	0.064	0.109
2001	0.000	0.009	0.025	0.033	0.035	0.042	0.073	0.116
2002	0.002	0.011	0.025	0.032	0.035	0.040	0.080	0.136
2003	0.000	0.007	0.024	0.032	0.033	0.041	0.070	0.135
2004	0.000	0.006	0.020	0.027	0.028	0.035	0.058	0.097
2005	0.001	0.009	0.023	0.031	0.032	0.039	0.065	0.121
2006	0.000	0.007	0.019	0.027	0.029	0.038	0.060	0.091
2007	0.002	0.012	0.025	0.033	0.034	0.041	0.073	0.108
AAQC (ppm)	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**	**0.080**

Note:
"%-ile" = percentile

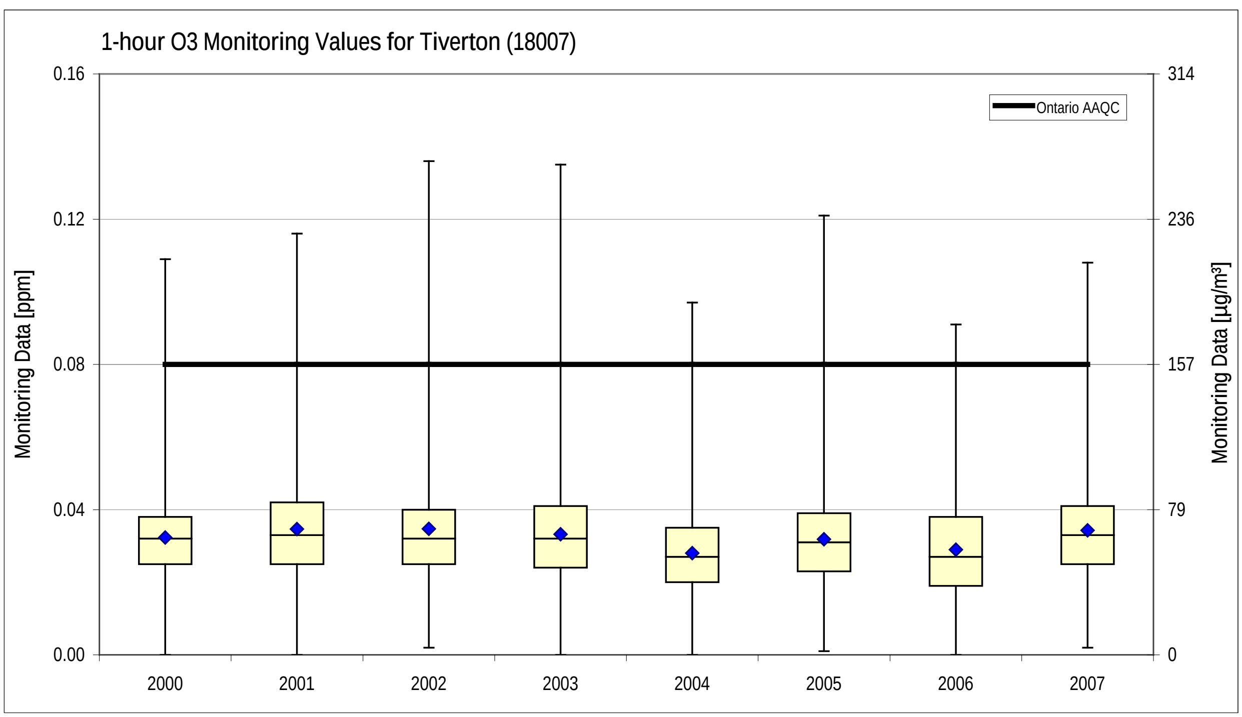

Figure E6.2.4-1: Ambient 1-Hour O_3 Monitoring Results – Tiverton

Table E6.2.4-2 and Figure E6.2.4-2 provide breakdowns of the 8-hour O_3 concentrations recorded at the station in Tiverton. The table and graph illustrate that 8-hour O_3 levels in excess of the Canada-Wide Standard were recorded at the station in each of the years with data.

Table E6.2.4-2: Ambient 8-hour O_3 Monitoring Results – Tiverton

Year	Ambient Monitoring Results (ppm)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
2000	0.009	0.017	0.031	0.037	0.039	0.043	0.069	0.086
2001	0.010	0.013	0.031	0.039	0.041	0.050	0.082	0.095
2002	0.013	0.018	0.030	0.037	0.042	0.051	0.089	0.115
2003	0.004	0.012	0.029	0.037	0.039	0.047	0.078	0.106
2004	0.004	0.014	0.027	0.034	0.034	0.041	0.062	0.084
2005	0.010	0.017	0.029	0.036	0.038	0.044	0.067	0.099
2006	0.006	0.014	0.025	0.033	0.035	0.043	0.064	0.081
2007	0.017	0.019	0.031	0.037	0.041	0.047	0.083	0.096
Canada-Wide Standard (ppm)	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**	**0.065**

Note:
“%-ile” = percentile

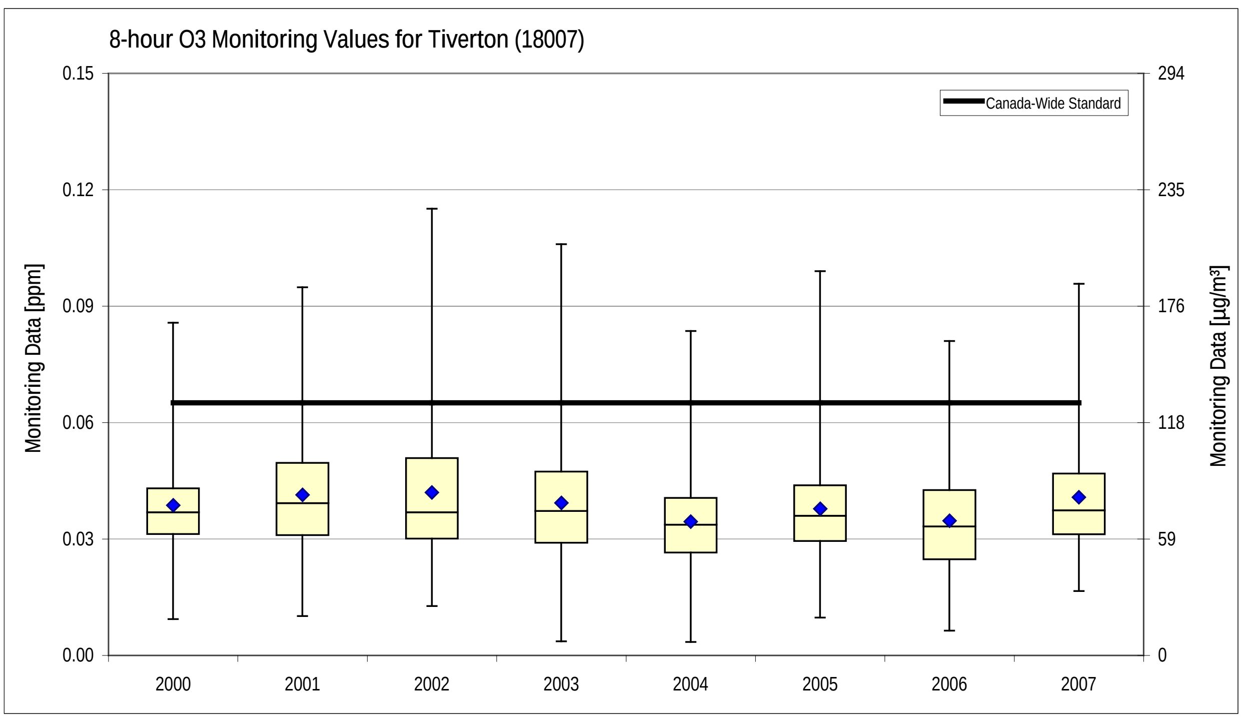

Figure E6.2.4-2: Ambient 8-Hour O_3 Monitoring Results – Tiverton

E7. FINE PARTICULATE MATTER

Airborne particulate matter in Ontario is described using three size categories. Suspended particulate matter (SPM) is the largest category and includes those airborne particles with an aerodynamic diameters less than 44 µm. The portion of the SPM with aerodynamic diameters of 10 µm, or less is referred to as PM_{10}. The PM_{10} sized particles are small enough to be inhaled into the upper respiratory tract. The fraction of the SPM and PM_{10} with an aerodynamic diameters of 2.5 µm or less is referred to and $PM_{2.5}$. The $PM_{2.5}$ sized particles are small enough to be drawn into the lungs, and are sometimes described as the respirable fraction of airborne particles. While periodic monitoring of SPM and PM_{10} is still done in Ontario, only the continuous $PM_{2.5}$ monitoring data is available electronically for review and presentation.

E7.1 SUMMARY OF AMBIENT FINE PARTICULATE MATTER ($PM_{2.5}$) MONITORING RESULTS

Figure E7.1-1 presents a graphical summary of the 24-hour $PM_{2.5}$ concentrations measured at the ambient monitoring stations. While there is no AAQC for $PM_{2.5}$, the Canada-Wide Standard [E10] has been used to compare to the data. As illustrated in the figure, all of the stations, with the exception of Tiverton, recorded 98^{th} percentile daily $PM_{2.5}$ levels that were higher than the Canada-Wide Standard level of 30 µg/m³. However, compliance with the Canada-Wide Standard is based on the 98^{th} percentile of the monitoring data, averaged over a 3-year period. Table E7.1-2 presents a summary of the 3-year rolling 98^{th} percentile $PM_{2.5}$ concentrations for comparison to the Canada-Wide Standard.

Table E7.1-1: Ambient 24-hour $PM_{2.5}$ Monitoring Results

City	Ambient Monitoring Results (µg/m³)							
	Minimum	2^{nd} %-ile	25^{th} %-ile	50^{th} %-ile	Average	75^{th} %-ile	98^{th} %-ile	Maximum
Kitchener	0.0	1.1	3.5	6.0	8.3	10.4	30.7	48.3
London	0.4	1.3	5.3	8.0	9.8	12.1	31.3	45.6
Sarnia	0.0	3.1	6.3	9.5	12.1	15.4	37.9	75.5
Tiverton	0.0	0.4	1.8	3.7	6.0	7.8	26.4	53.3
Canada-Wide Standard (µg/m³) [a]	—	—	—	—	—	—	**30**	—

Notes:
a Compliance with the Canada-Wide Standard is based on the 98^{th} percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile.
— Data not available.

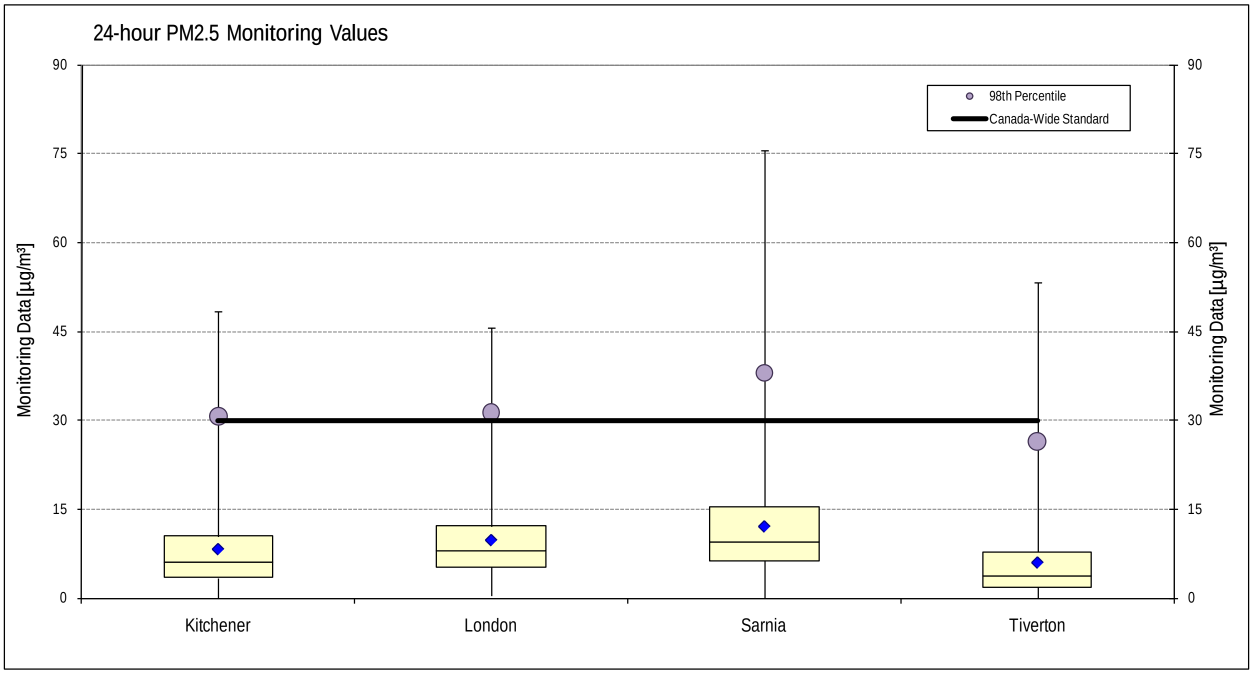

Figure E7.1-1: Ambient 24-Hour $PM_{2.5}$ Monitoring Results

Table E7.1-2: Summary of 24-hour $PM_{2.5}$ Monitoring Results for Comparison to the Canada-Wide Standard

City	3-Year 98th Percentile 24-hour $PM_{2.5}$ (µg/m³) [a]		
	2003 to 2005	2004 to 2006	2005 to 2007
Kitchener	32.0	30.1	28.9
London	34.3	31.3	27.9
Sarnia	39.9	37.1	35.8
Tiverton	28.2	25.8	24.7
Canada-Wide Standard (µg/m³) [b]	**30**	**30**	**30**

Notes:
a $PM_{2.5}$ monitoring data were available from 2003 to 2007 (see Table E2-2).
b Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile.
— Data not available.

As seen in the above table, the following describes the level of compliance with the Canada-Wide Standard for $PM_{2.5}$:

- the $PM_{2.5}$ levels in Kitchener exceeded the Canada-Wide Standard of 30 µg/m³ for each of the 3-year periods (2003 to 2005, 2004 to 2006, 2005 to 2007) for which monitoring data were available;
- the $PM_{2.5}$ levels in London exceeded the Canada-Wide Standard for the two 3-year periods (2003 to 2005 and 2004 to 2006);

- the $PM_{2.5}$ levels in Sarnia exceeded the Canada-Wide Standard of 30 µg/m³ for each of the 3-year periods (2003 to 2005, 2004 to 2006, 2005 to 2007) for which monitoring data were available; and
- the $PM_{2.5}$ levels in Tiverton met the Canada-Wide Standard of 30 µg/m³ for each of the 3-year periods (2003 to 2005, 2004 to 2006, 2005 to 2007) for which monitoring data were available.

E7.2 STATION SPECIFIC AMBIENT MONITORING RESULTS

E7.2.1 Ambient $PM_{2.5}$ Monitoring Results for Kitchener

Table E7.2.1-1 provides a breakdown of the daily $PM_{2.5}$ concentrations recorded at the station in Kitchener. These data are illustrated on Figure E7.2.1-1. Ambient $PM_{2.5}$ monitoring data were not available at the station between 2000 and 2002. The table and graph illustrate that the 98th percentile 24-hour $PM_{2.5}$ concentrations were higher than the Canada-Wide Standard levels in 2004 and 2005. However, compliance with the Canada-Wide Standard is based on the 98th percentile averaged over a three year period as discussed below.

Table E7.2.1-1: Ambient 24-hour $PM_{2.5}$ Monitoring Results – Kitchener

Year	Ambient Monitoring Results (µg/m³)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	0.208	1.033	3.646	6.083	8.109	9.958	29.008	46.917
2004	0.208	1.210	3.500	5.917	8.019	10.135	32.688	41.083
2005	0.042	1.042	3.833	6.375	9.521	12.250	34.453	48.292
2006	0.333	1.178	3.250	6.000	7.680	10.375	23.157	34.708
2007	0.625	1.220	3.333	5.750	8.016	10.167	29.073	41.333
Canada-Wide Standard (µg/m³) [a]	**—**	**—**	**—**	**—**	**—**	**—**	**30**	**—**

Notes:
a Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile.
— Data not available.

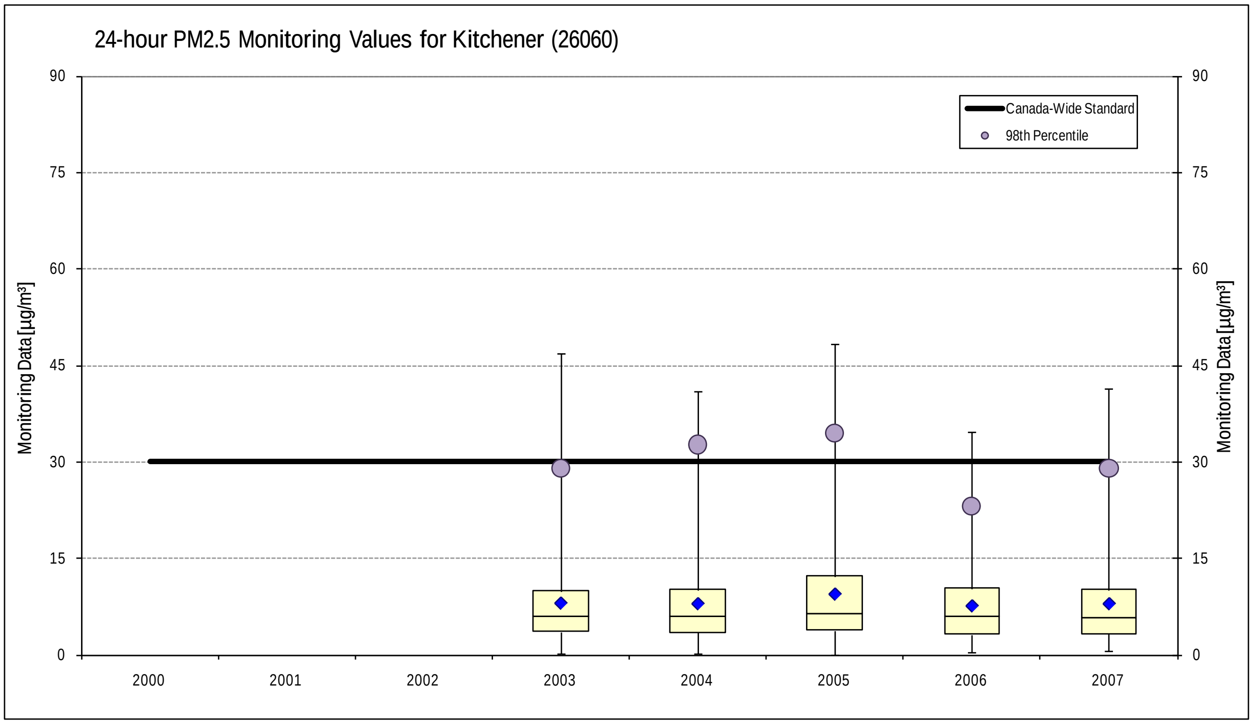

Figure E7.2.1-1: Ambient 24-Hour $PM_{2.5}$ Monitoring Results – Kitchener

Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring data, averaged over a 3-year period. On this basis, three sets of 3-year $PM_{2.5}$ levels can be calculated for the period from 2003 to 2007, for comparison to the Canada-Wide Standard of 30 µg/m³. The following describes the levels of compliance with the Canada-Wide Standard of the Kitchener $PM_{2.5}$ data:

- The 98th percentile $PM_{2.5}$ concentration for the period from 2003 to 2005 was calculated to be 32.0 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2004 to 2006 was calculated to be 30.1 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2005 to 2007 was calculated to be 28.9 µg/m³. This meets the Canada-Wide Standard of 30 µg/m³.

E7.2.2 Ambient $PM_{2.5}$ Monitoring Results for London

Table E7.2.2-1 provides a breakdown of the daily $PM_{2.5}$ concentrations recorded at the station in London. These data are illustrated on Figure E7.2.2-1. The table and graph illustrate that the 98th percentile 24-hour $PM_{2.5}$ concentrations were higher than the Canada-Wide Standard levels in 2003, 2004 and 2005. Ambient $PM_{2.5}$ monitoring data were not available at the station between 2000 and 2002.

Table E7.2.2-1: Ambient 24-hour $PM_{2.5}$ Monitoring Results – London

Year	Ambient Monitoring Results (µg/m³)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	0.875	2.398	6.611	9.479	10.951	12.958	33.473	43.250
2004	1.750	3.417	6.333	8.708	10.981	13.042	35.070	44.708
2005	1.750	3.500	6.917	9.583	11.950	14.542	34.420	45.583
2006	0.417	1.438	4.542	7.208	8.747	11.323	24.544	36.042
2007	0.583	0.739	2.696	5.000	6.499	8.333	24.645	31.708
Canada-Wide Standard (µg/m³)	**—**	**—**	**—**	**—**	**—**	**—**	**30**	**—**

Notes:
a Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile.
— Data not available.

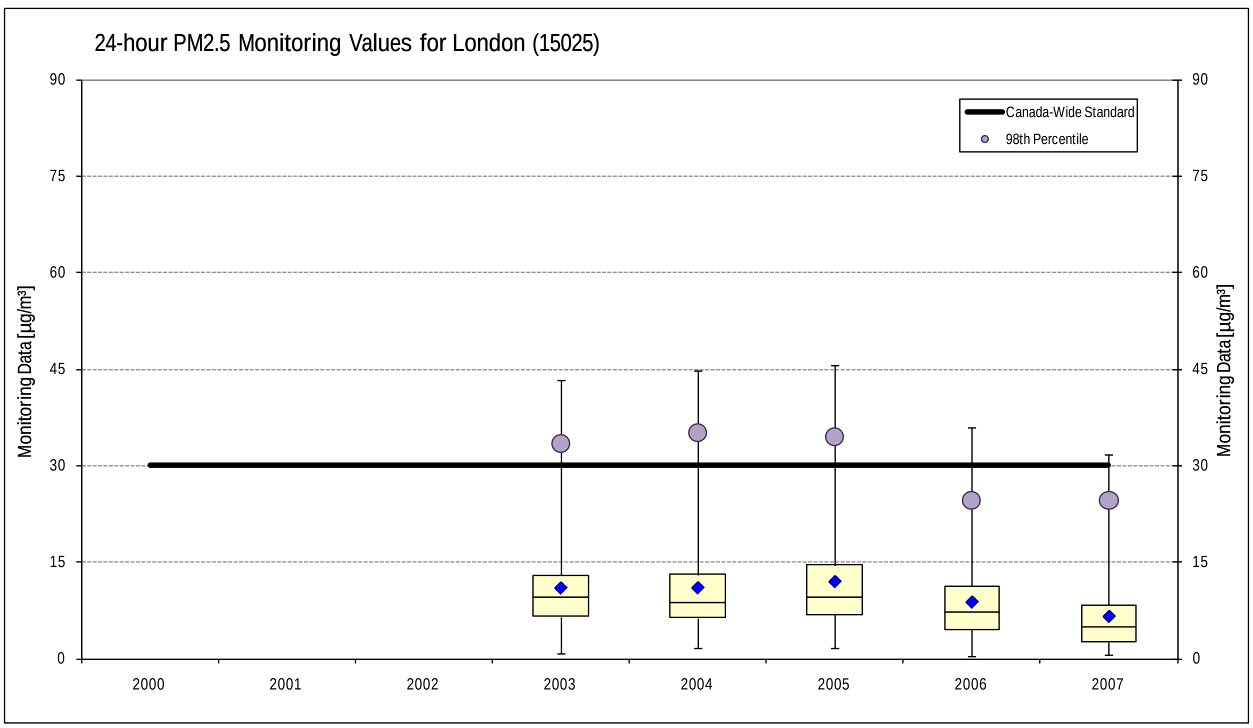

Figure E7.2.2-1: Ambient 24-Hour $PM_{2.5}$ Monitoring Results – London

Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring data, averaged over a 3-year period. On this basis, three sets of 3-year $PM_{2.5}$ levels can be calculated for the period from 2003 to 2007, for comparison to the Canada-Wide Standard of 30 µg/m³. The following describes the levels of compliance with the Canada-Wide Standard of the London $PM_{2.5}$ data:

- The 98th percentile $PM_{2.5}$ concentration for the period from 2003 to 2005 was calculated to be 34.3 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2004 to 2006 was calculated to be 31.3 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2005 to 2007 was calculated to be 27.9 µg/m³. This meets the Canada-Wide Standard of 30 µg/m³.

E7.2.3 Ambient $PM_{2.5}$ Monitoring Results for Sarnia

Table E7.2.3-1 provides a breakdown of the daily $PM_{2.5}$ concentrations recorded at the station in Sarnia. These data are illustrated on Figure E7.2.3-1. Ambient $PM_{2.5}$ monitoring data were not available at the station between 2000 and 2002. The table and graph illustrate that in each of the monitoring years, the 98th percentile daily $PM_{2.5}$ concentrations were higher than the Canada-Wide Standard levels.

Table E7.2.3-1: Ambient 24-hour $PM_{2.5}$ Monitoring Results – Sarnia

Year	Ambient Monitoring Results (µg/m³)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	1.667	2.530	6.415	9.750	12.153	15.042	38.850	75.500
2004	2.792	3.370	6.344	9.417	12.209	15.604	39.643	48.125
2005	0.000	2.470	6.250	9.583	12.800	16.458	41.268	54.292
2006	2.500	3.377	6.250	9.217	11.279	14.292	30.340	39.250
2007	2.792	3.762	6.417	9.625	12.180	15.583	35.775	46.375
Canada-Wide Standard (µg/m³)	**—**	**—**	**—**	**—**	**—**	**—**	**30**	**—**

Notes:
a Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.
"%-ile" = percentile.
— Data not available.

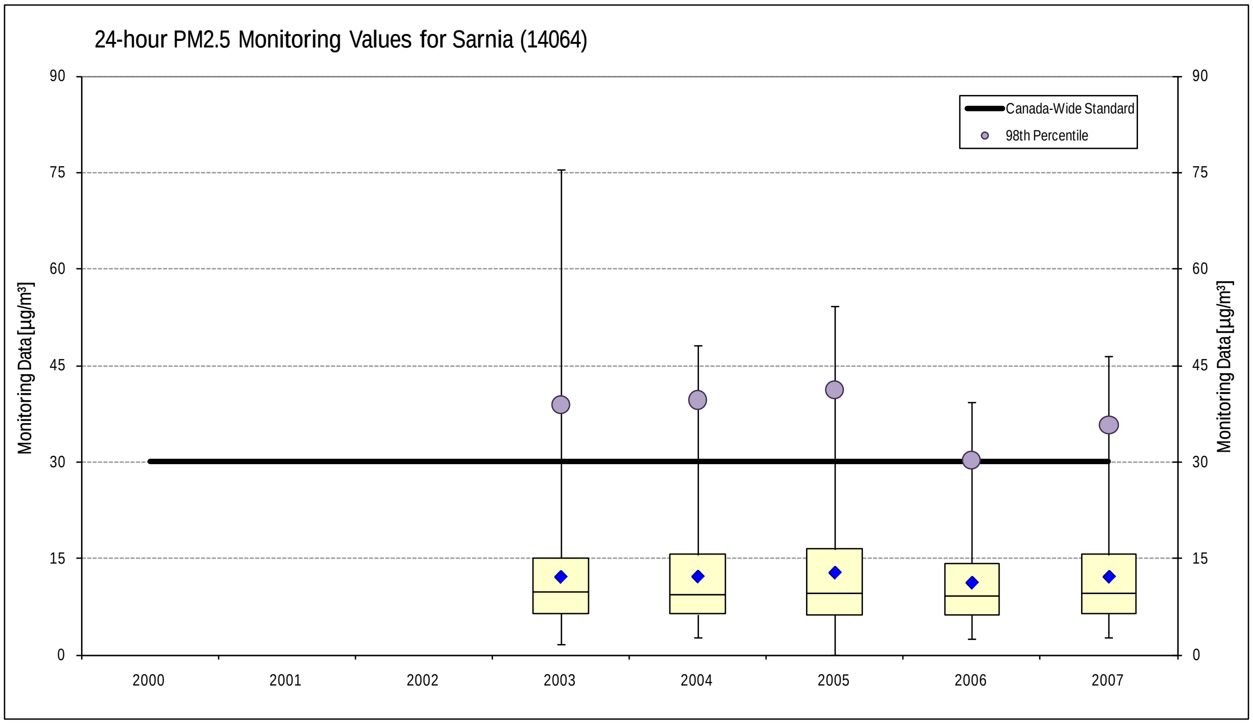

Figure E7.2.3-1: Ambient 24-Hour $PM_{2.5}$ Monitoring Results – Sarnia

Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring data, averaged over a 3-year period. On this basis, three sets of 3-year $PM_{2.5}$ levels can be calculated for the period from 2003 to 2007, for comparison to the Canada-Wide Standard. of 30 µg/m³. The following describes the levels of compliance with the Canada-Wide Standard of the Sarnia $PM_{2.5}$ data:

- The 98th percentile $PM_{2.5}$ concentration for the period from 2003 to 2005 was calculated to be 39.9 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2004 to 2006 was calculated to be 37.1 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2005 to 2007 was calculated to be 35.8 µg/m³. This exceeds the Canada-Wide Standard of 30 µg/m³.

E7.2.4 Ambient $PM_{2.5}$ Monitoring Results for Tiverton

Table E7.2.4-1 provides a breakdown of the daily $PM_{2.5}$ concentrations recorded at the station in Tiverton. These data are illustrated on Figure E7.2.4-1. Ambient $PM_{2.5}$ monitoring data were not available at the station between 2000 and 2002. The table and graph illustrate that the 98th percentile daily $PM_{2.5}$ levels were lower than the Canada-Wide Standard levels in all of the monitoring years.

Table E7.2.4-1: Ambient 24-hour $PM_{2.5}$ Monitoring Results – Tiverton

Year	Ambient Monitoring Results (µg/m³)							
	Minimum	2nd %-ile	25th %-ile	50th %-ile	Average	75th %-ile	98th %-ile	Maximum
2000	—	—	—	—	—	—	—	—
2001	—	—	—	—	—	—	—	—
2002	—	—	—	—	—	—	—	—
2003	0.458	0.713	2.426	4.563	6.475	8.083	28.300	44.053
2004	0.000	0.417	1.708	3.500	5.837	7.167	27.335	39.875
2005	0.000	0.133	1.619	3.583	6.565	8.503	28.921	53.292
2006	0.125	0.426	1.833	3.750	5.517	7.521	21.200	27.792
2007	0.000	0.440	1.708	3.250	5.624	7.500	23.878	38.667
Canada-Wide Standard (µg/m³)	**—**	**—**	**—**	**—**	**—**	**—**	**30**	**—**

Notes:

a Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.

"%-ile" = percentile.

— Data not available.

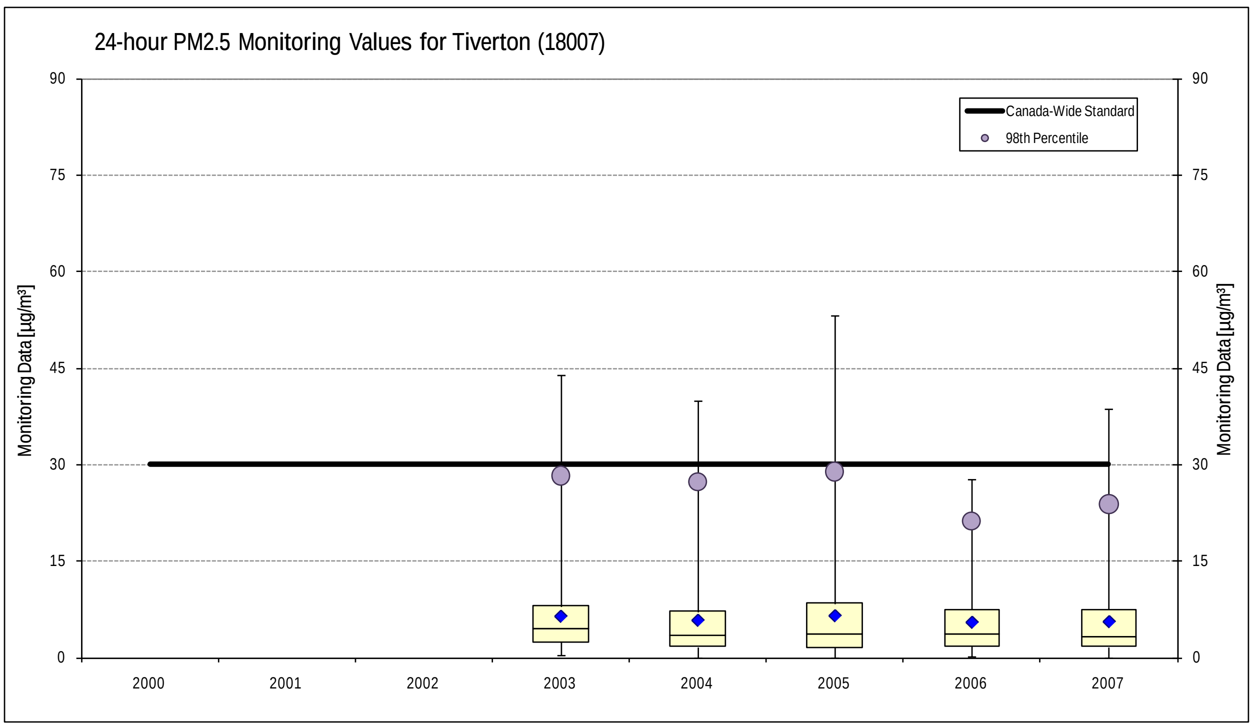

Figure E7.2.4-1: Ambient 24-Hour $PM_{2.5}$ Monitoring Results – Tiverton

Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring data, averaged over a 3-year period. On this basis, three sets of 3-year $PM_{2.5}$ levels can be calculated for the period from 2003 to 2007, for comparison to the Canada-Wide Standard of 30 µg/m³. The following describes the levels of compliance with the Canada-Wide Standard of the Tiverton PM2.5 data:

- The 98th percentile $PM_{2.5}$ concentration for the period from 2003 to 2005 was calculated to be 28.2 µg/m³. This meets the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2004 to 2006 was calculated to be 25.8 µg/m³. This meets the Canada-Wide Standard of 30 µg/m³.
- The 98th percentile $PM_{2.5}$ concentration for the period from 2005 to 2007 was calculated to be 24.7 µg/m³. This meets the Canada-Wide Standard of 30 µg/m³.

E8. BACKGROUND AIR QUALITY

Air monitoring data collected within the Regional Study Area represent the combined effect of emissions from sources near to each of the monitoring stations, as well as the effect of the emissions transported into the region. The emissions transported into the region could be considered to be the 'background air quality', which would be added to the contribution locally. Based on feedback from regulators, and expert judgement, the 90th percentile of the available monitoring data is considered a conservative estimate of background air quality [E11]. Generally, the 90th percentile concentrations from the air monitoring stations in the Regional Study Area were selected to represent background air quality.

In those cases where data are available from the station in Tiverton, the 90th percentile data from Tiverton was used to define the background concentrations. For indicators where data were not available, results from the station in London were used. Tiverton is the obvious choice, when available, given its proximity to the Bruce nuclear site and thus a closer representation of the Regional Study Area. London was selected in cases where Tiverton was not available as it was considered to be less influenced by nearby industries and transportation routes than either Kitchener or Sarnia. Air quality in Sarnia is heavily influenced by local industries and could give unrealistic estimates compared to the remote location at the Bruce nuclear site. Similarly, the monitoring station in Kitchener appears to be influenced by local traffic.

Ambient monitoring is not available to directly allow the calculation of background SPM and PM_{10} concentrations. However, background SPM and PM_{10} concentrations can be determined from the available fine particulate (i.e., $PM_{2.5}$) monitoring results. As shown on Figure E8-1, fine particulate matter (i.e., $PM_{2.5}$) is a subset of the PM_{10}, which is a subset of the SPM. Therefore, it is reasonable to assume that the ambient concentrations of SPM would be greater than the PM_{10} concentrations, which will be greater than the corresponding levels of $PM_{2.5}$.

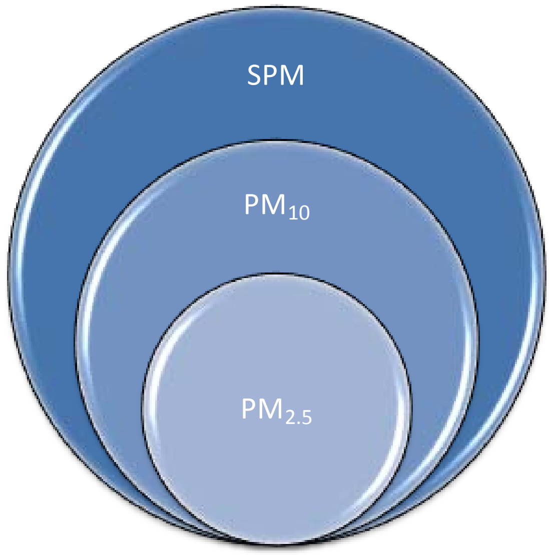

Figure E8-1: Relationship Between SPM, PM_{10} and $PM_{2.5}$

Overall, ambient levels of $PM_{2.5}$ in Canada were found to be about 50% of the PM_{10} concentrations [E12]. The ratios that apply in the Regional Study Area have been derived from the monitoring data summaries available from 1998 through 2002. Prior to 2003, the Ontario Ministry of Environment recorded concentrations of both PM_{10} and $PM_{2.5}$, but have only provided the data in a summarized format [E13;E14;E15;E2]. Since 2003, only the continuous $PM_{2.5}$ monitoring results have been recorded, and made available in both a detailed electronic [E7] and summarized format [E3;E4;E5;E6;E16]. Table E8-1 lists the 90th percentile of the continuous PM_{10} and $PM_{2.5}$ monitoring for the Tiverton, London, Kitchener and Sarnia stations for the period from 1998 through 2002, along with the corresponding $PM_{2.5}$ to PM_{10} ratios. On average, the $PM_{2.5}$ concentrations in the Regional Study Area were 60% of the PM_{10} concentrations. This ratio will be used to derive the background PM_{10} concentrations from the $PM_{2.5}$ monitoring data gathered for the period from 2003 through 2007, as detailed in Section E7.

Table E8-1: Calculated $PM_{2.5}$ to PM_{10} Ratios for the Regional Study Area

Year	Parameter	90th Percentile Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
1998	Continuous PM_{10}	—	44	—	41
	Continuous $PM_{2.5}$	23	—	37	—
	Ratio	—	—	—	—
1999	Continuous PM_{10}	—	43	—	40
	Continuous $PM_{2.5}$	—	—	26	—
	Ratio	—	—	—	—

Table E8-1: Calculated $PM_{2.5}$ to PM_{10} Ratios for the Regional Study Area (continued)

Year	Parameter	90th Percentile Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
2000	Continuous PM_{10}	—	34	—	37
	Continuous $PM_{2.5}$	22	—	21	27
	Ratio	**—**	**—**	**—**	***73%***
2001	Continuous PM_{10}	—	39	—	39
	Continuous $PM_{2.5}$	16	19	17	23
	Ratio	**—**	***49%***	**—**	***59%***
2002	Continuous PM_{10}	—	41	—	—
	Continuous $PM_{2.5}$	19	—	19	26
	Ratio	**—**	**—**	**—**	**—**

Notes:
Ratios were only calculated for those stations and years with both PM_{10} and $PM_{2.5}$ data.
— Data not available.

On average, the suspended particulate matter (SPM) concentrations (often referred to as TSP) in Canada are nearly twice the corresponding PM_{10} concentrations [E12]. The ratios that apply in the Regional Study Area have been derived from the monitoring data summaries available from 1998 through 2002, which are only available in a summarized format [E13;E14;E15;E2]. Table E8-2 lists the 90th percentile of the continuous SPM and PM_{10} monitoring for the Tiverton, London, Kitchener and Sarnia stations for the period from 1998 through 2002, along with the corresponding PM_{10} to SPM ratios. On average, the PM_{10} concentrations in the Regional Study Area were 43% of the SPM concentrations. This ratio, together with the $PM_{2.5}/PM_{10}$ ratio described previously, will be used to derive the background SPM concentrations from the $PM_{2.5}$ monitoring data gathered for the period from 2003 through 2007, as detailed in Section E7.

Table E8-2: Calculated $PM_{2.5}$ to PM_{10} Ratios for the Regional Study Area

Year	Parameter	90th Percentile Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
1998	Dis-continuous SPM	—	97.4	—	87.2
	Dis-continuous PM_{10}	—	—	—	—
	Ratio	**—**	**—**	**—**	**—**
1999	Dis-continuous SPM	—	91.1	—	—
	Dis-continuous PM_{10}	—	47.5	—	42
	Ratio	**—**	***52%***	**—**	**—**
2000	Dis-continuous SPM	—	61	—	—
	Dis-continuous PM_{10}	—	28	—	34
	Ratio	**—**	***46%***	**—**	**—**

Table E8-2: Calculated $PM_{2.5}$ to PM_{10} Ratios for the Regional Study Area (continued)

Year	Parameter	90th Percentile Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
2001	Dis-continuous SPM	—	90	—	—
	Dis-continuous PM_{10}	—	34	—	27
	Ratio	—	***38%***	—	—
2002	Dis-continuous SPM	—	76	—	—
	Dis-continuous PM_{10}	—	29	—	46
	Ratio	—	***38%***	—	—

Notes:
Rations were only calculated for those stations and years with both PM_{10} and SPM data.
— Data not available.

Table E8-3 presents the background air quality data that have been derived from the available monitoring data in the regional study area. These data will be added to the results of the dispersion modelling for notable sources located in the Local Study Area, specifically the sources at the Bruce nuclear site.

Table E8-3: Background Air Quality

Indicator	Background (µg/m³)	90th Percentile Monitored Data (µg/m³)			
		Tiverton	London	Kitchener	Sarnia
1-hour NO_2	13.2	13.2	47.0	52.7	52.7
24-hour NO_2	12.0	12.0	41.0	43.7	45.4
Annual NO_2	5.4	5.4	23.4	25.8	27.0
1-hour SO_2	10.5	10.5	15.7	55.0	15.7
24-hour SO_2	9.3	9.3	14.8	64.3	14.1
Annual SO_2	3.6	3.6	7.2	23.8	6.6
1-hour CO	816.5	—	816.5	678.5	517.5
8-hour CO	945.9	—	945.9	823.4	606.6
24-hour SPM	52.1 a	—	—	—	—
Annual SPM	23.0 a	—	—	—	—
24-hour PM_{10}	22.7 a	—	—	—	—
24-hour $PM_{2.5}$	13.6	13.6	17.4	22.8	19.1

Note:
— Data not available.

E9. REFERENCES

[E1] Ontario Ministry of the Environment (MOE). 2003. *Air Quality in Ontario, 2001 Report.* Appendix. Queen's Printer for Ontario. PIBs 4521e.

[E2] Ontario Ministry of the Environment (MOE). 2002. *Air Quality in Ontario, 2002 Report.* Appendix. Queen's Printer for Ontario. PIBs 4521e01.

[E3] Ontario Ministry of the Environment (MOE). 2004. *Air Quality in Ontario, 2003 Report.* Appendix. Queen's Printer for Ontario. PIBs 4949e.

[E4] Ontario Ministry of the Environment (MOE). 2006. *Air Quality in Ontario, 2004 Report.* Appendix. Queen's Printer for Ontario. PIBs 5383e.

[E5] Ontario Ministry of the Environment (MOE). 2006. *Air Quality in Ontario, 2005 Report.* Appendix. Queen's Printer for Ontario. PIBs6041e.

[E6] Ontario Ministry of the Environment (MOE). 2007. *Air Quality in Ontario, 2006 Report.* Appendix. Queen's Printer for Ontario. PIBs 6552e.

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[E9] Canadian Council of Ministers of the Environment (CCME). 1999. *Canadian Environmental Quality Guidelines.* Canadian Council of Ministers of the Environment.

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[E11] Canadian Environmental Assessment Agency and Canadian Nuclear Safety Commission. 2009. *Bruce Power New Nuclear Power Plant Project - Review of the Environmental Impact Statement and Application for a Licence to Prepare a Site.* Letter to Mr. Duncan Hawthorne, Bruce Power on March 11, 2009.

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[E14] Ontario Ministry of the Environment (MOE). 2000. *Air Quality in Ontario, 1999 Report.* Queen's Printer for Ontario. PIBs4159e.

[E15] Ontario Ministry of the Environment (MOE). 2000. *Air Quality in Ontario, 2000 Report.* Appendix. Queen's Printer for Ontario. PIBs 4226e.

[E16] Ontario Ministry of the Envrironment (MOE). 2008. *Air Quality in Ontario, 2007 Report.* Appendix. Queen's Printer for Ontario. PIBs 6930e.

APPENDIX F: AIR MODELLING METHODS

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F1. AIR DISPERSION MODEL

The likely environmental effects for each of the DGR Project-environment interactions involving air quality are evaluated with the aid of the AERMOD-PRIME (AERMOD) dispersion model (Version 09292). The selection of this model was based on the following capabilities:

- evaluates the various source types and compounds associated with the DGR Project;
- has a technical basis that is scientifically sound, and is in keeping with the current understanding of dispersion in the atmosphere;
- applies formulations that are clearly delineated and are subjected to rigorous independent scrutiny;
- makes predictions that are consistent with observations; and
- is recognized by provincial regulators [F1] as one suitable for use.

F1.1 AERMOD DISPERSION MODEL

The AERMOD dispersion model (Version 09292), using Bruce Power on-site meteorological data was used to evaluate the air quality effects associated with the DGR Project. The model was developed by the United States Environmental Protection Agency (U.S. EPA), and has been identified as appropriate for modelling in Ontario by the MOE [F1], and maintains consistency with the modelling completed for recent assessments at the Bruce nuclear site. The AERMOD modelling system is made up of the AERMET meteorological pre-processor, the AERMAP terrain pre-processor and the AERMOD dispersion model (see Figure F1.1-1):

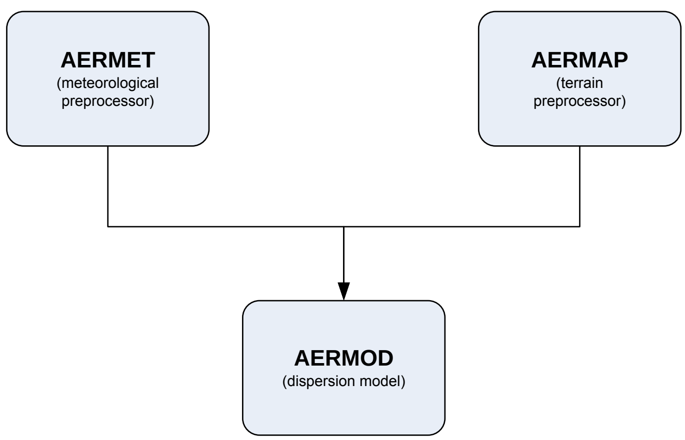

Figure F1.1-1: AERMOD Modelling System

A review of the guidelines prepared for the DGR Project highlights the need to provide information regarding the model verification and scientific defensibility, model calibration, model validation, as well as the uncertainty and sensitivity of the model. A summary of the information regarding the AERMOD dispersion model has been provided in Table F1.1-1, and is outlined in the following sections.

F1.1.1 Model Verification

The AERMOD dispersion modelling system was developed by the U.S. EPA as a replacement to the long-standing Industrial Source Complex (ISC) model, as the model recommended by the U.S. EPA for regulatory applications in the United States. This model has also been adopted in Ontario as the regulatory model recommended for permitting and regulatory applications [F1]. The model is based on Gaussian plume dispersion theory [F2] that has been used successfully for more than 30 years. However, AERMOD has incorporated a series of specific algorithms to reflect current understanding of dispersion theory [F2].

F1.1.2 Model Calibration

Regulatory dispersion models do not readily lend themselves to modification to incorporate site-specific characteristics in the equations themselves. However, the model does require meteorological data to operate. For this assessment, five-years of meteorological data were used as inputs to the AERMET pre-processor, along with information regarding site specific land use information. Finally, digital terrain data for the site and surrounding area were input to the AERMET pre-processor and used to characterize how the local topography could affect the dispersion of air contaminants.

F1.1.3 Model Validation

Part of the rigorous process used by the U.S. EPA prior to adopting AERMOD as a regulatory model [F2] was a significant verification process to confirm that the model could accurately predict ground-level concentrations when compared to monitoring data [F3;F4].

F1.1.4 Model Uncertainty and Sensitivity

Dispersion models employ assumptions that simplify the random processes associated with atmospheric motions and turbulence. While this simplification limits the model's ability to replicate individual events, the strength of the model lies in the ability to predict overall values for a given set of meteorological conditions. The process undertaken by the U.S. EPA ensured that the model predictions can be relied on as reasonable estimate of the likely concentrations. AERMOD is based on known theory, and proven to reliably produce repeatable results. To limit the uncertainty associated with emissions input to the model, conservative assumptions were made where practical (see Section F4). Finally, five-years of meteorological data were used as an input to the model to ensure the full range of possible meteorological conditions is evaluated.

Table F1.1-1: Reliability Summary for the AERMOD Dispersion Model

Model Name	Developer	Use in Assessment	Verification	Calibration	Validation	Uncertainty and Sensitivity
AERMOD (Version 09292)	United States Environmental Protection Agency	Predict air quality concentrations	AERMOD was developed to replace the long-standing ISC model as the model recommended by the U.S. EPA. AERMOD is based on Gaussian plume dispersion theory [F2] that has been used for more than 30 years. The application of specific algorithms has been updated to reflect current understanding of dispersion theory [F2].	5-years of meteorological data were used in the modelling (Appendix C). Surrounding land use input to the model pre-processor (Appendix C). Digital terrain data for the site and surrounding area input to the model.	AERMOD has been adopted by the U.S EPA as its preferred and recommended dispersion model [F3]. Prior to adoption, the U.S. EPA completed a rigorous review of the model performance [F3;F4].	AERMOD is based on known theory, and proven to reliably produce repeatable results. Uncertainty associated with emissions is managed by making conservative assumptions. Model predictions are sensitive to fluctuations in the meteorology, which can be managed by using a five-year data set. Five-years of data should include the full range of possible meteorological conditions.

F1.2 MODEL INPUTS

In order to complete the air dispersion model, a series of inputs are required. These inputs can be grouped into categories:

- dispersion meteorological data;
- terrain and receptors;
- emissions and source configurations; and
- dispersion model options.

Each of these input categories will be discussed separately in the following sections.

F2. DISPERSION METEOROLOGY

The selection of appropriate meteorological data for use in dispersion modelling is an important step in any modelling study. The selection of meteorological data needs to consider the requirements of the models selected, the availability of meteorological data and the relevance of the available data to the facility in question. The meteorological input files used by the AERMOD dispersion model are generated using the AERMET pre-processor, which is designed to be run in three stages:

1. extracts the data and assesses data quality;
2. merges the available data for 24 hour periods and writes these data to an intermediate file; and
3. reads the merged data file and develops the necessary boundary layer parameters for dispersion calculations by AERMOD.

Figure F2-1 illustrates the steps followed in processing the meteorological data for use by AERMOD. Quality assurance of the meteorological data is performed at four critical junctures before the resulting data is used by AERMOD. The AERMET pre-processor produces two meteorological data files. The first file contains boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length) as well as wind speeds, wind directions and temperature at a reference-height. The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind.

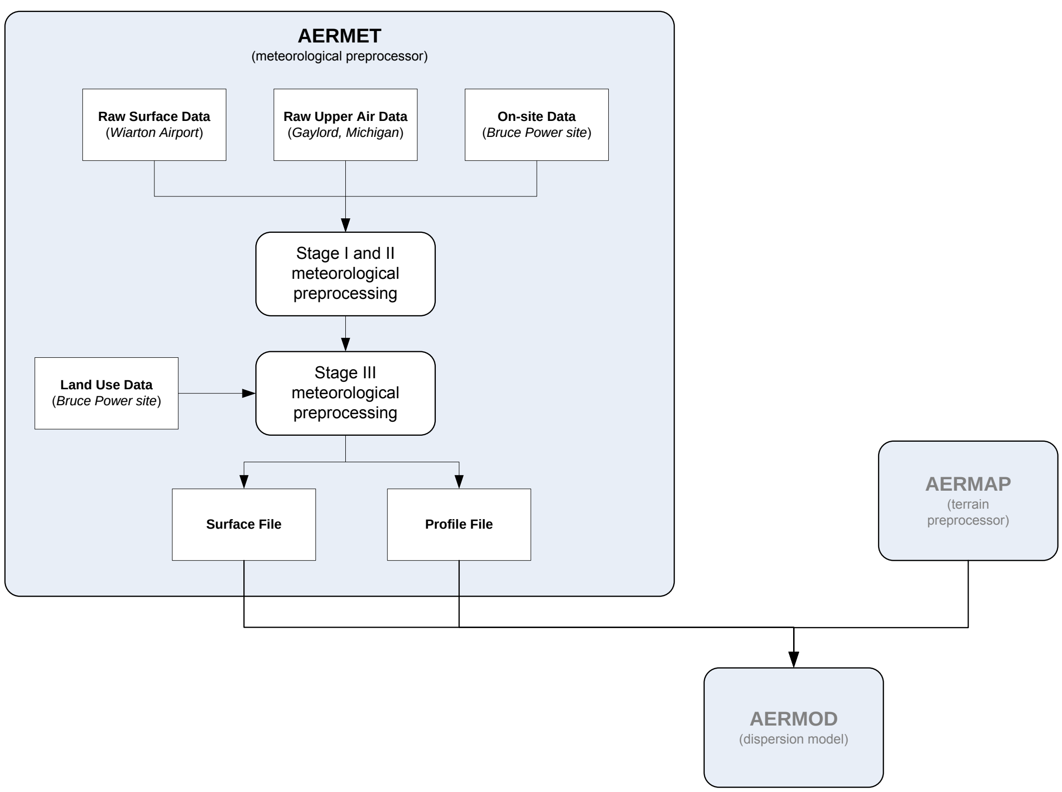

Figure F2-1: Flow Diagram for the AERMET Pre-Processor

F2.1 METEOROLOGICAL DATA SOURCES

The MOE recommends that five years of hourly data be used in the model [F1]. Hourly surface meteorological data from the Bruce nuclear site, with missing data filled in from Wiarton Airport (Station ID 6119500), for the years 2005 to 2009 were used in the assessment. Upper air data was obtained from Alpena station located in Gaylord, Michigan (Station ID 4837). The surface and upper air data are then processed through the initial stages using AERMET, as shown above. A complete discussion of the meteorological data has been included in Appendix C to this TSD.

F2.2 LAND USE DATA

Land use data collected as part of the existing studies to support the EA for the DGR Project were used as an input to the third stage of the AERMET pre-processor. The following land use categories surrounding the site were used to estimate values for albedo, Bowen Ratio and roughness length (Table F2.2-1):

Sector 1: 45°-185°

- Cultivated Land 60%;
- Water 5%; and
- Deciduous Forest 35%.

Sector 2: 185°-45°

- Water 100%.

Table F2.2-1: Land Use Characteristics by Sector

Month	Albedo	Bowen Ratio	Roughness Length (m)
Sector 1 – 45° to 185°			
January	0.545	1.500	0.181
February	0.545	1.500	0.181
March	0.545	1.500	0.181
April	0.132	0.430	0.530
May	0.132	0.430	0.530
June	0.167	0.410	0.575
July	0.167	0.410	0.575
August	0.167	0.410	0.575
September	0.157	0.775	0.310
October	0.157	0.775	0.310
November	0.157	0.775	0.310
December	0.545	1.500	0.181

Table F2.2-1: Land Use Characteristics by Sector (continued)

Month	Albedo	Bowen Ratio	Roughness Length (m)
Sector 2 – 185° to 45°			
January	0.200	1.500	0.000
February	0.200	1.500	0.000
March	0.200	1.500	0.000
April	0.120	0.100	0.000
May	0.120	0.100	0.000
June	0.100	0.100	0.000
July	0.100	0.100	0.000
August	0.100	0.100	0.000
September	0.140	0.100	0.000
October	0.140	0.100	0.000
November	0.140	0.100	0.000
December	0.200	1.500	0.000

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F3. TERRAIN AND MODEL RECEPTORS

Relying on the assumption that terrain will affect air quality concentrations at individual receptors, surrounding terrain data is required when using regulatory dispersion models, where simple to complex terrain situations apply [F5]. Terrain data are determined using the AERMAP pre-processor. AERMAP determines the base elevation for each receptor and source and then searches the terrain height and location that has the greatest influence on dispersion for each receptor [F5]. This is referred to as the hill height scale. The base elevation and hill height scale produced by AERMAP can be directly inserted into the AERMOD input file.

Figure F3-1 illustrates the steps followed in processing the terrain data using AERMAP.

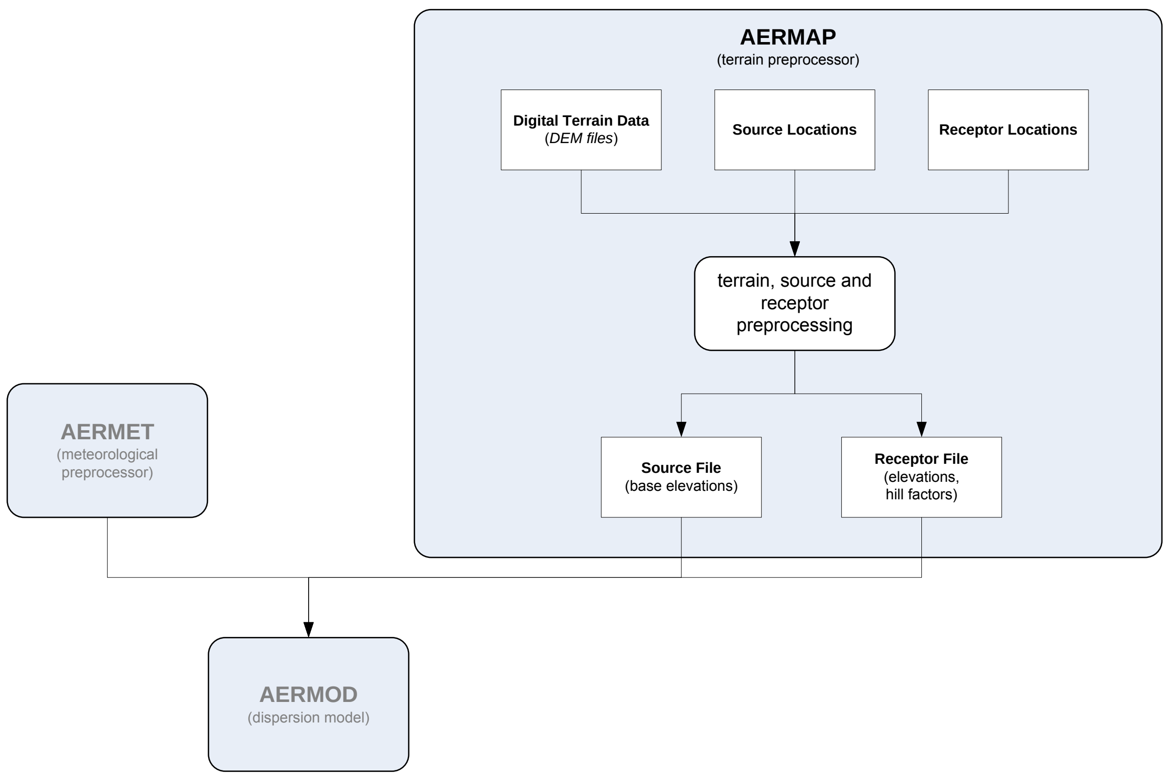


Figure F3-1: Flow Diagram for the AERMAP Pre-Processor

F3.1 DIGITAL TERRAIN DATA

Digital terrain data was obtained from the MOE [F6] (7.5 minute format). The digital terrain data is illustrated on Figure F3.1-1.

F3.1.1 Data Adjustments

AERMAP cannot distinguish between land and water. Many of the receptors modelled are located on Lake Huron and therefore, a manual adjustment to the base elevation and hill height scale factor was made. Specifically, the base elevation and hill height scale were set to 176 m for receptors located on Lake Huron. Thermal inversion boundary layers are discussed in Appendix C.

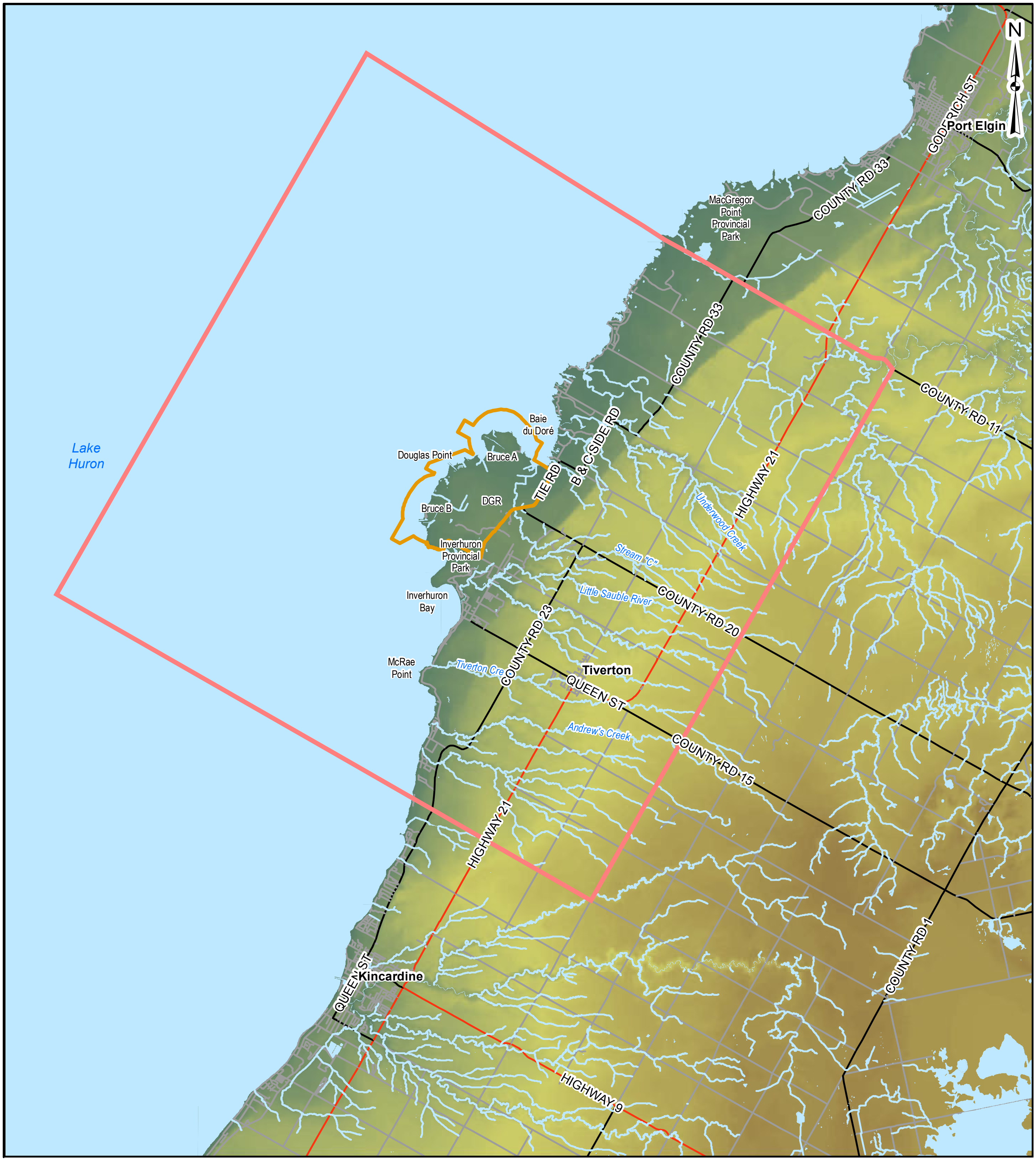
F3.2 MODEL RECEPTORS

A nested grid of receptors was developed for the assessment, as illustrated on Figure F3.2-1. Receptors were generally centered on the sources and were placed as follows:

- 100 m spacing, along the property boundary;
- 250 m spacing, within an area of 5 × 5 km;
- 500 m spacing, within an area of 10 × 10 km; and
- 1,000 m spacing, within an area of 20 × 20 km.

Ecological, human health and nuisance receptors were also considered in the assessment. The location of these receptors is shown on Figure F3.2-2.

The ecological receptors were identified by the specialists conducting the terrestrial environment assessment. These locations were identified as being ecologically sensitive in the vicinity of the site. Health receptors were sited at the nearest off-site places of residences where someone may remain for more than a day. Based on this, Inverhuron Provincial Park was included, since people camp there overnight. The nuisance receptors were placed at the nearest off-site places of residences and at Inverhuron Provincial Park.



LEGEND

- Site Study Area [1]
- Local Study Area

Elevation masl

High : 350 m

Low : 149 m

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

DIGITAL TERRAIN DATA FOR AERMAP

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE F3.1-1

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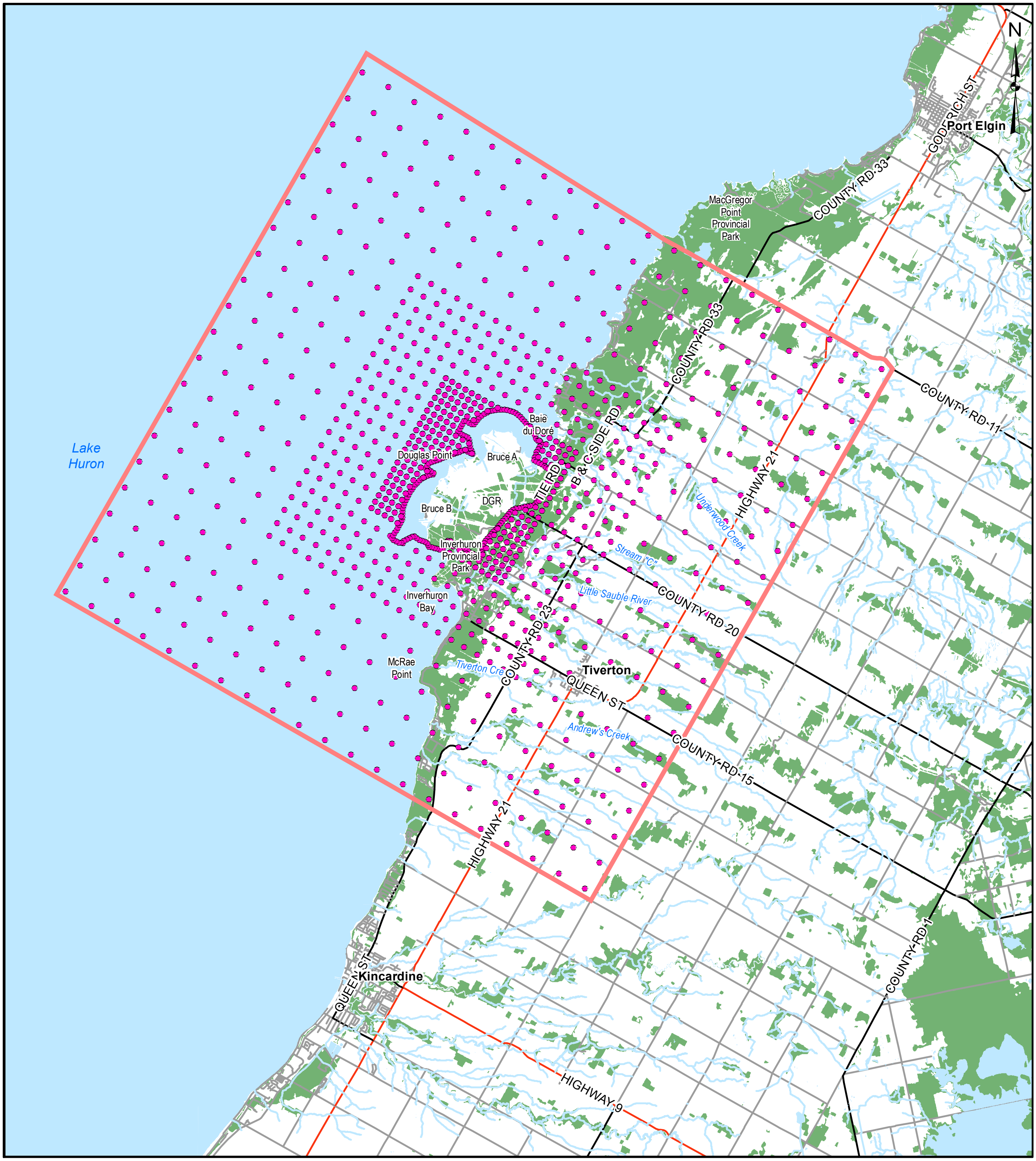

0 2 4 8 12

Kilometres

LEGEND

- Off-site Receptor
- Site Study Area [1]
- Local Study Area

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

AIR DISPERSION MODEL RECEPTORS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010	**FIGURE F3.2-1**	
REVIEW	SM	18 May. 2010		

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LEGEND

- ▲ Burial Ground Receptor
- ● Nuisance Receptor
- ■ Ecological Receptor
- ▲ Human Health Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

ECOLOGICAL, HUMAN HEALTH, BURIAL GROUND AND NUISANCE RECEPTORS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

FIGURE F3.2-2

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F4. EMISSIONS AND SOURCE CONFIGURATION

As described in Section 7 of the Atmospheric Environment TSD, air emissions were estimated for the DGR Project works and activities for which a measurable change is likely to occur. These air emissions were then used as inputs for the dispersion modelling that provided estimates of maximum ground-level concentrations resulting from the DGR Project emissions.

Emissions were calculated for two phases of the DGR Project: site preparation and construction and operations. Existing emissions were also estimated and include emissions from the stationary sources at the Bruce nuclear site, as well as the on-site vehicle movements.

The site preparation and construction phase covers the period of time during which the following DGR Project works and activities are expected to occur: site preparation and all activities associated with the construction of surface and underground facilities and installation of equipment, up until operations commence with the placement of waste. Sources of emissions at this time will include clearing and grubbing, earth-moving, building construction, shaft and emplacement room excavation, excavated material handling, installation of underground infrastructure, and on-site vehicle movements.

The operations phase covers the period during which waste is being emplaced in the DGR Project, as well as a period of monitoring prior to the start of decommissioning. Activities include receipt and on-site transfer of waste packages, underground transfer and emplacement of waste in rooms in the DGR Project, and activities necessary to support and monitor operations. Sources of emissions during operations will include all surface and underground on-site vehicle movements, and emergency diesel generator testing.

Emissions during the site preparation and construction phase and operations phase were calculated using activity and equipment specifications provided in the Project Description (see Section 4 of the EIS) and internationally accepted emission factors, most notably AP-42 [F7] and the MOBILE6.2C emissions model, as described in User's Guide to MOBILE6.1 and MOBILE6.2 [F8]. Tables F4-1 through F4-3 provide a summary of the assumptions used in the air quality assessment of the DGR Project.

Table F4-1: Existing Air Quality Emissions Assumptions

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Bruce Steam Plant Boilers (3)	4.1	tonnes fuel/boiler	3	boilers	24.0	U.S. EPA AP-42 Chapter 1.3 - Fuel Oil Combustion (9/98)
Standby Generators - Existing (A-Side, 15 MW)	15	MW output / turbine	1	turbines	4.0	U.S. EPA AP-42 Chapter 3.1 - Stationary Gas Turbines (4/00)
Standby Generators - Existing (B-Side, 15 MW)	15	MW output / turbine	1	turbines	4.0	U.S. EPA AP-42 Chapter 3.1 - Stationary Gas Turbines (4/00)
Standby Generators - Existing (B-Side, 2 MW)	2	MW output / turbine	1	turbines	2.0	U.S. EPA AP-42 Chapter 3.1 - Stationary Gas Turbines (4/00)
Vehicles - Bruce Power Employees (Main Gate) Exhaust	1.8	km / vehicle	705	vehicles per hour	3.6	MOBILE6.2C
Vehicles - Bruce Power Employees (Main Gate) Road Dust	1.8	km / vehicle	705	vehicles per hour	3.6	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)
Vehicles - Bruce Power Employees (North Gate) Exhaust	2.1	km / vehicle	705	vehicles per hour	4.3	MOBILE6.2C
Vehicles - Bruce Power Employees (North Gate) Road Dust	2.1	km / vehicle	705	vehicles per hour	4.3	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)

Table F4-1: Existing Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Vehicles - Bruce Power Employees (South Gate) Exhaust	1.8	km / vehicle	793	vehicles per hour	3.1	MOBILE6.2C
Vehicles - Bruce Power Employees (South Gate) Road Dust	1.8	km / vehicle	793	vehicles per hour	3.1	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)
Vehicles - OPG & AECL Employees (Main Gate) Exhaust	1.8	km / vehicle	54	vehicles per hour	3.6	MOBILE6.2C
Vehicles - OPG & AECL Employees (Main Gate) Road Dust	1.8	km / vehicle	54	vehicles per hour	3.6	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)
Vehicles - OPG & AECL Employees (North Gate) Exhaust	2.1	km / vehicle	54	vehicles per hour	4.2	MOBILE6.2C
Vehicles - OPG & AECL Employees (North Gate) Road Dust	2.1	km / vehicle	54	vehicles per hour	4.2	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)
Vehicles - OPG & AECL Employees (South Gate) Exhaust	1.8	km / vehicle	61	vehicles per hour	3.1	MOBILE6.2C
Vehicles - OPG & AECL Employees (South Gate) Road Dust	1.8	km / vehicle	61	vehicles per hour	3.1	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)

Table F4-1: Existing Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
WWMF - Radioactive Waste Incinerator	—	—	1	incinerator	24.0	From OPG CofA

Note:
— Not applicable

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Site Preparation and Construction of Surface Facilities						
Articulated Trucks (Cat 730) Storm Water - Exhaust	475	hp per vehicle	2	vehicles	1	U.S. EPA Emissions Standards (Tier 2)
Articulated Trucks (Cat 730) Storm Water - Paved Road Dust	5.4	km / vehicle	2	vehicles	1	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06).
Articulated Trucks (Cat 730) Storm Water - Unpaved Road Dust	1.5	km / vehicle	2	vehicles	1	U.S. EPA AP-42 Chapter 13.2.2 - Unpaved Roads (11/06)
Bulldozer (Cat D9T WH) Road Construction - Exhaust	410	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Bulldozer (Cat D9T WH) Road Construction - Fugitive	—	—	1	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Bulldozer (Cat D9T WH) Storm Water - Exhaust	410	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Bulldozer (Cat D9T WH) Storm Water - Fugitive	—	—	1	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Compactors (Cat CS-683) Road Construction - Exhaust	173	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Excavator (Cat 340D) Storm Water - Exhaust	400	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Excavator (Cat 340D) Storm Water - Fugitive	—	—	1	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Pavers (Cat BG-240C) Road Construction - Exhaust	153	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Bulldozer (Cat D9T WH) Land Clearance - Exhaust	410	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Bulldozer (Cat D9T WH) Land Clearance - Fugitive	—	—	1	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Excavator (Cat 340D) Land Clearance - Exhaust	400	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Excavator (Cat 340D) Land Clearance - Fugitive	—	—	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Feller Buncher (Cat 522) Land Clearance - Exhaust	284	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Front End Loader (Cat 988H) - Exhaust	501	hp per vehicle	3	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Front End Loader (Cat 988H) - Fugitive	—	—	3	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Motor Grader (CAT 140) - Exhaust	300	hp per vehicle	2	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Motor Grader (CAT 140) - Fugitive	—	—	2	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Articulated Trucks (Cat 730) Land Clearance - Exhaust	475	hp per vehicle	2	vehicles	1	U.S. EPA Emissions Standards (Tier 2)
Articulated Trucks (Cat 730) Land Clearance - Paved Road Dust	5.4	km / vehicle	2	vehicles	1	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06).
Articulated Trucks (Cat 730) Land Clearance - Unpaved Road Dust	1.5	km / vehicle	2	vehicles	1	U.S. EPA AP-42 Chapter 13.2.2 - Unpaved Roads (11/06)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Excavation and Construction of Underground Facilities						
Articulated Trucks (Cat 730) Re-used Material Transfer - Exhaust	475	hp per vehicle	5	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Articulated Trucks (Cat 730) Re-used Material Transfer - Unpaved Road Dust	2	km / vehicle	5	vehicles	16	U.S. EPA AP-42 Chapter 13.2.2 - Unpaved Roads (11/06)
Batch Plant	20	m^3 per hour	2	batch plant	24	U.S. EPA AP-42 Chapter 11.12 - Concrete Batching (06/06)
Blast - Dust	—	—	8	blast	0.17	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Blast - Non Combustive Explosives	0.0974	tonnes	8	blast	0.17	U.S. EPA AP-42 Chapter 13.3 - Explosives Detonation (02/80)
Bulldozer (Cat D9T WH) Waste Rock Pile Construction - Exhaust	410	hp per vehicle	2	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Explosives carrier/loader - Exhaust	73.8	hp per vehicle	4	vehicles	1	U.S. EPA Emissions Standards (Tier 2)
Front End Loader (Cat 988H) Waste Rock Pile - Exhaust	501	hp per vehicle	2	vehicles	16	U.S. EPA Emissions Standards (Tier 2)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Jumbo Atlas Copco Boomer E3 C - Exhaust	232	hp per vehicle	2	vehicles	0.2	U.S. EPA Emissions Standards (Tier 2)
Jumbo Atlas Copco Boomer E3 C - Drilling	2090	tonnes/day	4	tonnes	2	U.S. EPA AP-42 Chapter 11.19.2 - Crushed Stone Processing and Pulverized Mineral Processing (08/04)
Loader (Cat 988H) - batch plant - exhaust	501	hp per vehicle	2	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Loader (CAT R1600G - 227-4704) - (Underground Construction) - Exhaust	270	hp per vehicle	1	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Mine Trucks (CAT AD30-246-0789) (Underground Construction) - Exhaust	410	hp per vehicle	3	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Mobile Bolting Unit (Underground Construction) - Exhaust	73.755	hp per vehicle	4	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Mobile Work Stage (Underground Construction) - Exhaust	73.755	hp per vehicle	4	vehicles	12	U.S. EPA Emissions Standards (Tier 2)
Motor Grader (CAT 140) - Exhaust	300	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Motor Grader (CAT 140) - Fugitive (dust emissions)	—	—	1	vehicles	8	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Personnel Carrier (Underground Construction) - Exhaust	67.05	hp per vehicle	2	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Shotcrete Transmixer - Exhaust	170	hp per vehicle	6	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Sprayer - Exhaust	170	hp per vehicle	4	vehicles	16	U.S. EPA Emissions Standards (Tier 2)
Waste Rock Pile - Front End Loader, Bulldozer - Fugitive	—	—	2	vehicles	16	U.S. EPA AP-42 Chapter 11.9 - Western Surface Coal Mining (10/98)
Site Support Services						
Diesel Generator (3,500 kW) Back up - Construction - Exhaust	3.5	MW output / turbine	1	turbines	1	U.S. EPA Emissions Standards (Tier 2)
Workers, Payroll and Purchasing						
Heavy Vehicles - DGR Construction (Main Gate) - Paved Road Dust	2.4	km / vehicle	22	vehicles per hour	1	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)
Heavy Vehicles - DGR Construction (Main Gate) Exhaust	370	hp per vehicle	22	vehicles per hour	1	U.S. EPA Emissions Standards (Tier 2)

Table F4-2: Site Preparation and Construction Phase Air Quality Emissions Assumptions (continued)

Equipment / Process	Capacity	Capacity Unit	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Vehicles - DGR Construction and Support Workers (Main Gate) Exhaust	2.4	km / vehicle	218	vehicles per hour	2.87	MOBILE6.2C
Vehicles - DGR Construction and Support Workers (Main Gate) Road Dust	2.4	km / vehicle	218	vehicles per hour	2.87	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)

Note:
— Not applicable

Table F4-3: Operations Phase Air Quality Emissions Assumptions

Equipment / Processes	Capacity	Capacity Units	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Above Ground Transfer of Wastes						
Flat-bed transporters/tracks (Surface Operation)	370	hp per vehicle	1	vehicles	6	U.S. EPA Emissions Standards (Tier 2)
Forklifts Large (Surface Operations) - Exhaust	207.855	hp per vehicle	1	vehicles	2	U.S. EPA Emissions Standards (Tier 2)
Forklifts Small (Surface Operations)- Exhaust	93.87	hp per vehicle	1	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Underground Transfer of Waste						
Forklifts Large (Underground Operations) - Exhaust	207.855	hp per vehicle	1	vehicles	2	U.S. EPA Emissions Standards (Tier 2)

Table F4-3: Operations Phase Air Quality Emissions Assumptions (continued)

Equipment / Processes	Capacity	Capacity Units	Base Quantity	Base Quantity Units	Hours of Operation	Emission Factor / Calculation Source
Forklifts Small (Underground Operations)- Exhaust	93.87	hp per vehicle	2	vehicles	8	U.S. EPA Emissions Standards (Tier 2)
Scissor Lift (underground Operations) Exhaust	73.8	hp per vehicle	1	vehicles	2	U.S. EPA Emissions Standards (Tier 2)
Site Support Services						
Diesel Generator (3,500 kW) Back up - Operation - Exhaust	3.5	MW output / turbine	1	turbines	1	U.S. EPA Emissions Standards (Tier 2)
Workers, Payroll and Purchasing						
Vehicles - DGR Employees (Main Gate) Exhaust	2.7	km / vehicle	25	vehicles per hour	2	MOBILE6.2C
Vehicles - DGR Employees (Main Gate) Road Dust	2.7	km / vehicle	25	vehicles per hour	2	U.S. EPA AP-42 Chapter 13.2.1 - Paved Roads (11/06)

Consideration was also given to those elements incorporated into the DGR Project design, as well as the construction and operation practices that could avoid or reduce emissions. These practices and design elements are considered to be an integral component of the DGR Project and were included as part of the assessment.

F4.1.1 Sample Calculations

The following sample calculations for selected sources demonstrate how the emissions for the DGR Project were developed. The results are in units of g/s, consistent with the model inputs described in Section F4.3.

F4.1.1.1 Vehicles - DGR Construction and Support Workers (Main Gate) Road Dust

U.S. EPA AP-42 emission factors from Chapter 13.2.1 – Paved Roads (November 2006) were used to calculate the fugitive dust emissions from paved roadways. The following predictive emissions equation was used to determine the fugitive dust emission factor for paved roads:

$$E = \left(k\left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} - C\right) \times 0.25$$

where:

E = particulate emission factor (having units matching the units of k),

k = particle size multiplier for particle size range and units of interest (see Table F4.1.1-1),

sL = road surface silt loading (grams per square metre) (g/m^2),

W = average weight (tons) of the vehicles traveling the road,

C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear (see below), and

0.25 = reduction of fugitive dust emissions [F9].

Table F4.1.1-1: Particle Size Assumptions for Paved Road Dust

Size Range	k (g/VMT)	C (g/VMT)
$PM_{2.5}$	1.1	0.1617
PM_{10}	7.3	0.2119
PM_{30} (assumed to be SPM)	38	0.2119

Source: U.S. EPA AP-42 emission factors from Chapter 13.2.1 – Paved Roads (November 2006)

Sample calculation for $PM_{2.5}$ predictive emission factor:

$$E = \left(1.1\left(\frac{0.2}{2}\right)^{0.65} \times \left(\frac{2.5}{3}\right)^{1.5} - 0.1617\right) \times 0.25$$

$$E = 0.006\ g/VMT$$

Sample calculation for $PM_{2.5}$ emission rate:

$$ER = \frac{0.006\ g}{VMT} \times 2.4\ km \times \frac{218\ V}{hr} \times \frac{0.621\ M}{km} \times \frac{2.87\ hours\ of\ operation}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

$$ER = 0.000069\ g/s\ ^{*}$$

* The emission rates presented in Sections 5, 7 and 8 are in units of kg/d. To convert from g/s to kg/d, the above needs to be multiplied by a factor of 86.4. Emission rates when calculated may not result in the same number presented above due to rounding.

The emissions of PM_{10} and SPM were calculated in the same manner presented above.

F4.1.1.2 Sample Calculation: Vehicles - DGR Construction and Support Workers (Main Gate) Exhaust

The U.S. EPA MOBILE6.2C emissions model was used to calculate the exhaust (i.e., tailpipe) emissions from on-site passenger vehicles (see Table F4.1.1-2).

Table F4.1.1-2: Emission Factors for Vehicles

Compound	Emission Factor (g/mile)
NO_X	0.495
SO_2	0.007
CO	9.779
SPM	0.024
PM_{10}	0.024
$PM_{2.5}$	0.011

Sample calculation for $PM_{2.5}$ emission rate:

$$ER = \frac{0.011\ g}{VMT} \times 2.4\ km \times \frac{218\ V}{hr} \times \frac{0.621\ M}{km} \times \frac{2.87\ hours\ of\ operation}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

$$ER = 0.00012\ g/s^{*}$$

* The emission rates presented in Sections 5, 7 and 8 are in units of kg/d. To convert from g/s to kg/d, the above needs to be multiplied by a factor of 86.4. Emission rates when calculated may not result in the same number presented above due to rounding.

The emissions of the remaining indicator compounds were calculated in the same manner presented above.

F4.1.1.3 Sample Calculation: Articulated Trucks (Cat 730) Land Clearance - Exhaust

U.S. EPA Tier 2 emission standards for non-road vehicles were used to calculate the exhaust (i.e., tailpipe) emissions from all on-site heavy equipment (see Table F4.1.1-3).

Table F4.1.1-3: Emission Factors for Articulated Trucks

Compound	Emission Factor (g/hp-hr)
NO_X	2.52
SO_2	0.0050
CO	1.56
SPM	0.09
PM_{10}	0.09
$PM_{2.5}$	0.09

Sample calculation for $PM_{2.5}$ emission rate:

$$ER = \frac{0.09\ g}{hp - hr} \times \frac{475\ hp}{vehicle} \times 2\ vehicles \times \frac{1\ hours\ of\ operation}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

$$ER = 0.00099\ g/s^{*}$$

* The emission rates presented in Sections 5, 7 and 8 are in units of kg/d. To convert from g/s to kg/d, the above needs to be multiplied by a factor of 86.4. Emission rates when calculated may not result in the same number presented above due to rounding.

The emissions of the remaining indicator compounds were calculated in the same manner presented above.

F4.1.1.4 Sample Calculation: Articulated Trucks (Cat 730) Re-used Material Transfer - Unpaved Road Dust (Waste Rock Hauling)

U.S. EPA AP-42 emission factors from Chapter 13.2.2 – Unpaved Roads (November 2006) were used to calculate the fugitive dust emissions associated with hauling the waste rock. The following predictive emissions equation was used in determining the fugitive dust emission factor for paved roads:

$$E = k\left(\frac{s}{12}\right)^{a} \times \left(\frac{W}{3}\right)^{b} \times Conversion\ from\ pounds \times 0.2 \times 0.25$$

where:

E = particulate emission factor (g/VMT),

k = particle size multiplier for particle size range and units of interest (see Table F4.1.1-4),

s = surface material silt content (%),

W = mean vehicle weight (tons),

0.2 = reduction of fugitive dust through Best Management Practices, and

0.25 = reduction of fugitive dust emissions [F9].

Table F4.1.1-4: Particle Size Assumptions Unpaved Road Dust (Waste Rock Hauling)

Size Range	k (g/VMT)	a	b
$PM_{2.5}$	0.15	0.9	0.45
PM_{10}	1.5	0.9	0.45
PM_{30} (assumed to be SPM)	4.9	0.7	0.45

Sample calculation for $PM_{2.5}$ predictive emission factor:

$$E = 0.15\left(\frac{8.5}{12}\right)^{0.9} \times \left(\frac{40}{3}\right)^{0.45} \times 454\ g/lb \times 0.2 \times 0.25$$

$$E = 7.991\ g/VMT\ *$$

*Emission factor when calculated may not result in the same number presented above because of rounding.

Sample calculation for $PM_{2.5}$ emission rate:

$$ER = \frac{7.991\ g}{VMT} \times 2\ km \times \frac{2\ V}{hr} \times \frac{0.621\ M}{km} \times \frac{16\ hours\ of\ operation}{24\ hr} \times \frac{1\ hr}{3600\ s}$$

$$ER = 0.0037\ g/s^{*}$$

* The emission rates presented in Sections 5, 7 and 8 are in units of kg/d. To convert from g/s to kg/d, the above needs to be multiplied by a factor of 86.4. Emission rates when calculated may not result in the same number presented above because of rounding.

The emissions of PM_{10} and SPM were calculated in the same manner presented above.

F4.2 SITE PREPARATION AND CONSTRUCTION PHASE

The works and activities during the site preparation and construction phase will be staged over a period of approximately six years, and will not all occur at the same time. To characterize the effects of those site preparation and construction phase works and activities advanced from the second screening (see Section 7 of the Atmospheric Environment TSD) on air quality, it is necessary to identify the air emissions that could occur during selected stages through the site preparation and construction phase.

For the purposes of this assessment, the following five stages were identified:

- Stage 1: the site preparation and construction phase when emissions from the site preparation, construction of surface facilities works and excavation of the shafts activities are determined to be at their highest;
- Stage 2: the site preparation and construction phase when components of excavation and construction of underground facilities are at their highest; specifically, shaft excavation;
- Stage 3: the site preparation and construction phase when components of construction of underground facilities are at their highest; specifically, emplacement room construction;
- Stage 4: the site preparation and construction phase when components of construction of underground facilities are at their highest; specifically, installation of underground infrastructure; and
- Stage 5: the site preparation and construction phase when components of construction of underground facilities and road network construction are at their highest.

The emissions for each of the above stages were determined (see Table F4.2-1) and used to identify the bounding scenario for the site preparation and construction phase. The Stage 1, associated with site preparation works and activities, was determined to be the bounding emission case for the site preparation and construction phase.

Table F4.2-1: Site Preparation and Construction Phase Bounding Emissions

Indicator Compound [a]	Daily Emission Rate (kg/d)				
	Stage 1: Site Preparation, Construction of Surface Structures and Excavation of Shafts	**Stage 2: Excavation of Shafts**	**Stage 3: Construction of Emplacement Rooms**	**Stage 4: Installation of Underground Infrastructure**	**Stage 5: Installation of Underground Infrastructure and Road Network Construction**
NO_X	243.5	157.7	250.7	271.4	297.5
SO_2	0.5	0.3	0.5	0.5	0.6
CO	168.6	113.9	172.2	189.4	207.2
SPM	207.3	59.2	82.7	83.8	120.8
PM_{10}	49.3	18.7	26.5	27.6	35.4
$PM_{2.5}$	32.3	14.0	19.2	20.3	25.1
All [b]	**701.4**	**363.9**	**551.7**	**593.1**	**686.6**

Notes:

a Emissions of NO_X from the DGR Project includes both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b As a result of rounding, the overall emissions listed in the table do not appear to match the sum of the individual numbers. The overall emissions were calculated correctly using the individual numbers prior to rounding.

Table F4.2-2 lists the overall emissions of the bounding site preparation and construction phase emissions used as inputs to the dispersion modelling. The dispersion modelling included the combined effects of the site preparation and construction phase and existing emissions.

Table F4.2-2: Daily Site Preparation and Construction Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d)						
	Bruce Power [b]	**WWMF**	**Shafts**	**Emergency Generator**	**Vehicles [c]**	**Fugitive Dust [d]**	**Site Equipment**
NO_X	N/A	N/A	31.91	N/A	5.25	—	206.31
SO_2	N/A	N/A	0.06	N/A	0.02	—	0.41
CO	N/A	N/A	27.19	N/A	12.09	—	129.28
SPM	N/A	N/A	1.72	N/A	0.19	197.87	7.47
PM_{10}	N/A	N/A	1.70	N/A	0.19	39.91	7.47

Table F4.2-2: Daily Site Preparation and Construction Phase Emissions (continued)

Indicator Compound [a]	Daily Emission Rates (kg/d)						
	Bruce Power [b]	WWMF	Shafts	Emergency Generator	Vehicles [c]	Fugitive Dust [d]	Site Equipment
$PM_{2.5}$	N/A	N/A	1.68	N/A	0.18	22.97	7.47

Notes:

a Emissions of NO_X from the DGR Project includes both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b Bruce Power includes Bruce Power facilities, including Bruce Power vehicles travelling on-site.

c Includes tailpipe emissions from delivery vehicles and all of the OPG and DGR Project worker vehicles on-site.

d Includes all fugitive dust, including road dust, generated by on-site traffic.

— Indicates that data is not available.

N/A Indicates that emissions from these sources are not applicable for this phase of the DGR Project.

F4.3 OPERATIONS PHASE

Table F4.3-1 lists the overall emissions of the operations phase emissions used as inputs to the dispersion modelling. The dispersion modelling included the combined effects of the operations phase and existing emissions.

Table F4.3-1: Daily Operations Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d)						
	Bruce Power [b]	WWMF	Vent Raise	Emergency Generator	Vehicles [c]	Fugitive Dust [d]	Site Equipment
NO_X	N/A	N/A	5.92	19.71	0.04	—	8.87
SO_2	N/A	N/A	0.01	0.02	0.00	—	0.02
CO	N/A	N/A	4.31	12.20	0.82	—	5.78
SPM	N/A	N/A	0.33	0.70	0.00	0.13	0.37
PM_{10}	N/A	N/A	0.33	0.70	0.00	0.02	0.37
$PM_{2.5}$	N/A	N/A	0.33	0.70	0.00	0.00	0.37

Notes:

a Emissions of NO_X from the DGR Project includes both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.

b Bruce Power includes Bruce Power facilities, including Bruce Power vehicles travelling on-site.

c Includes tailpipe emissions from all of the OPG and DGR Project worker vehicles on-site.

d Includes all fugitive dust, including road dust, generated by on-site traffic.

— Indicates that data is not available/applicable.

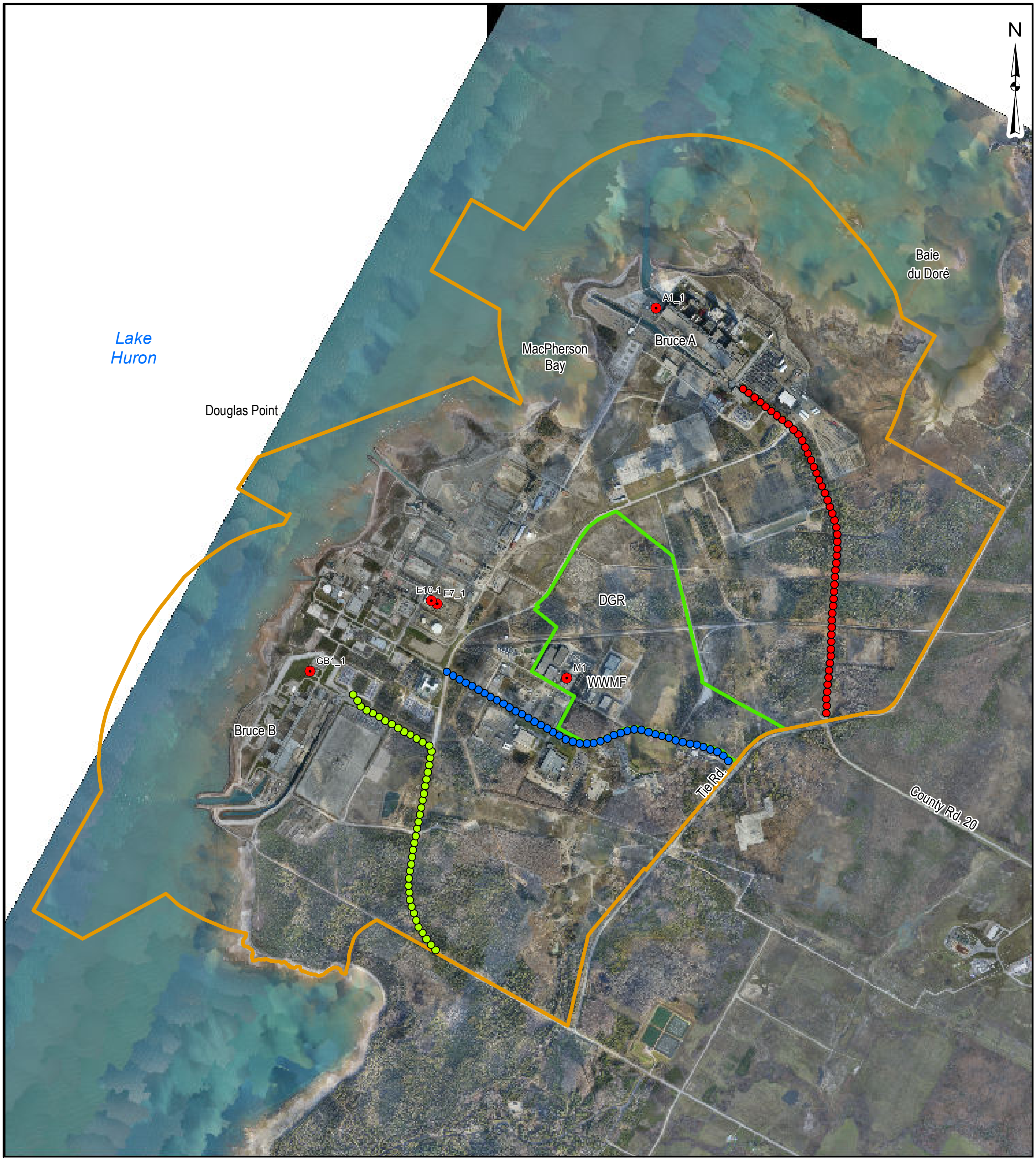
N/A Indicates that emissions from these sources are not applicable for this phase of the DGR Project.

F4.4 MODEL SOURCE TYPES

The model source types used in this assessment include: point sources, volume sources and area sources. Figures F4.4-1 through F4.4-3 illustrate the model source locations used in the assessment for existing conditions, the site preparation and construction phase and the operations phase, respectively.

F4.4.1 Point Sources

Point sources are stacks or vents. Point sources were used in all three modelling scenarios (i.e., existing, site preparation and construction phase and operations phase). The point sources include the Bruce standby generators, the Bruce Steam Plant boilers, the WWMF radioactive waste incinerator and the DGR Project ventilation shafts and vent raises. The point source model input parameters are summarized in Table F4.4.1-1.



0 0.5 1 2

Kilometres

LEGEND

- Current Source
- Main Road Source
- North Road Source
- South Road Source
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

EXISTING MODEL SOURCES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010	**FIGURE F4.4-1**	
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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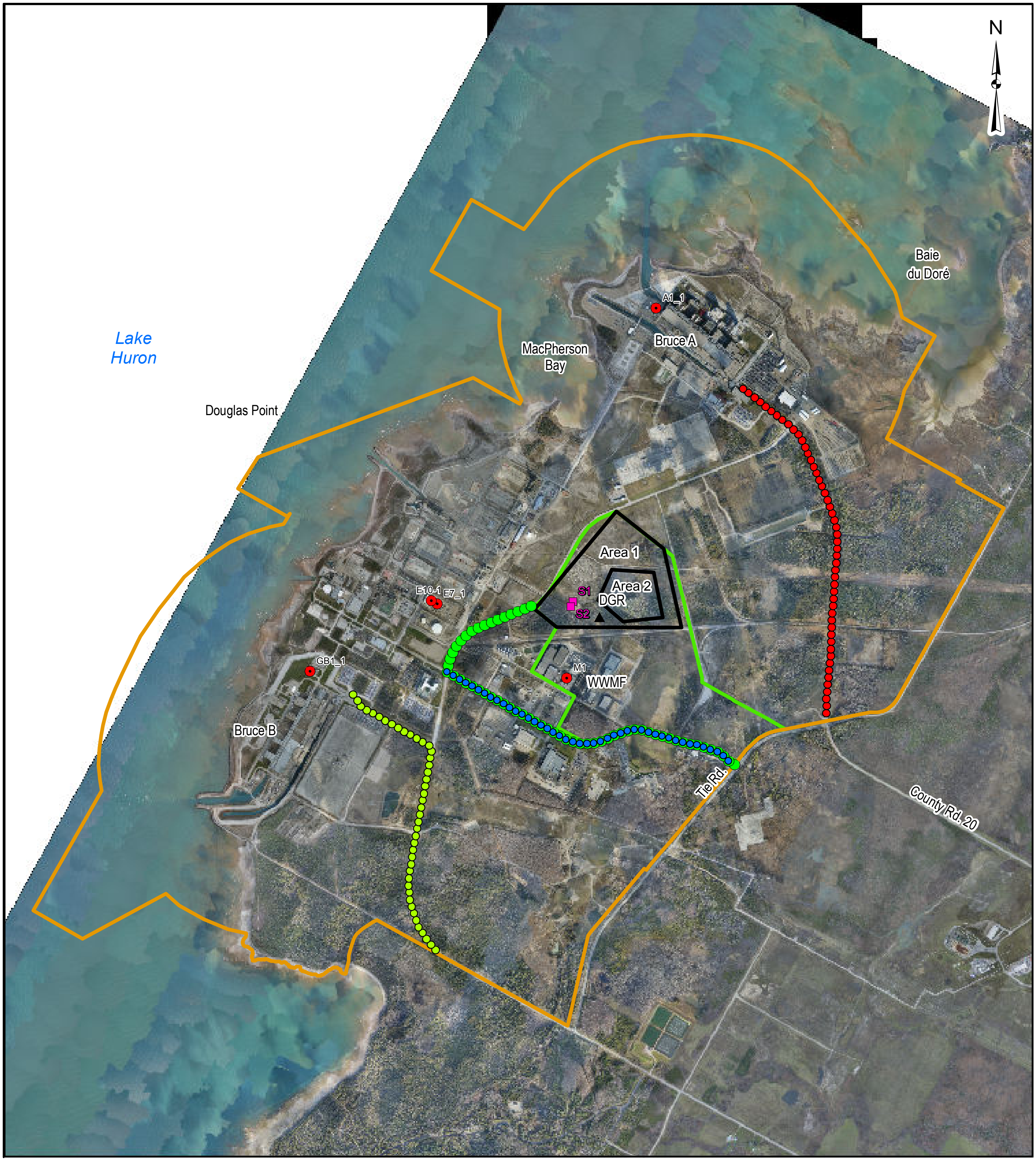

LEGEND

- Volume 1
- Point Source
- Current Source
- Main Road Source
- North Road Source
- South Road Source
- Updated Main Road Source
- Area Source
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE PREPARATION AND CONSTRUCTION PHASE MODEL SOURCES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE F4.4-2**	
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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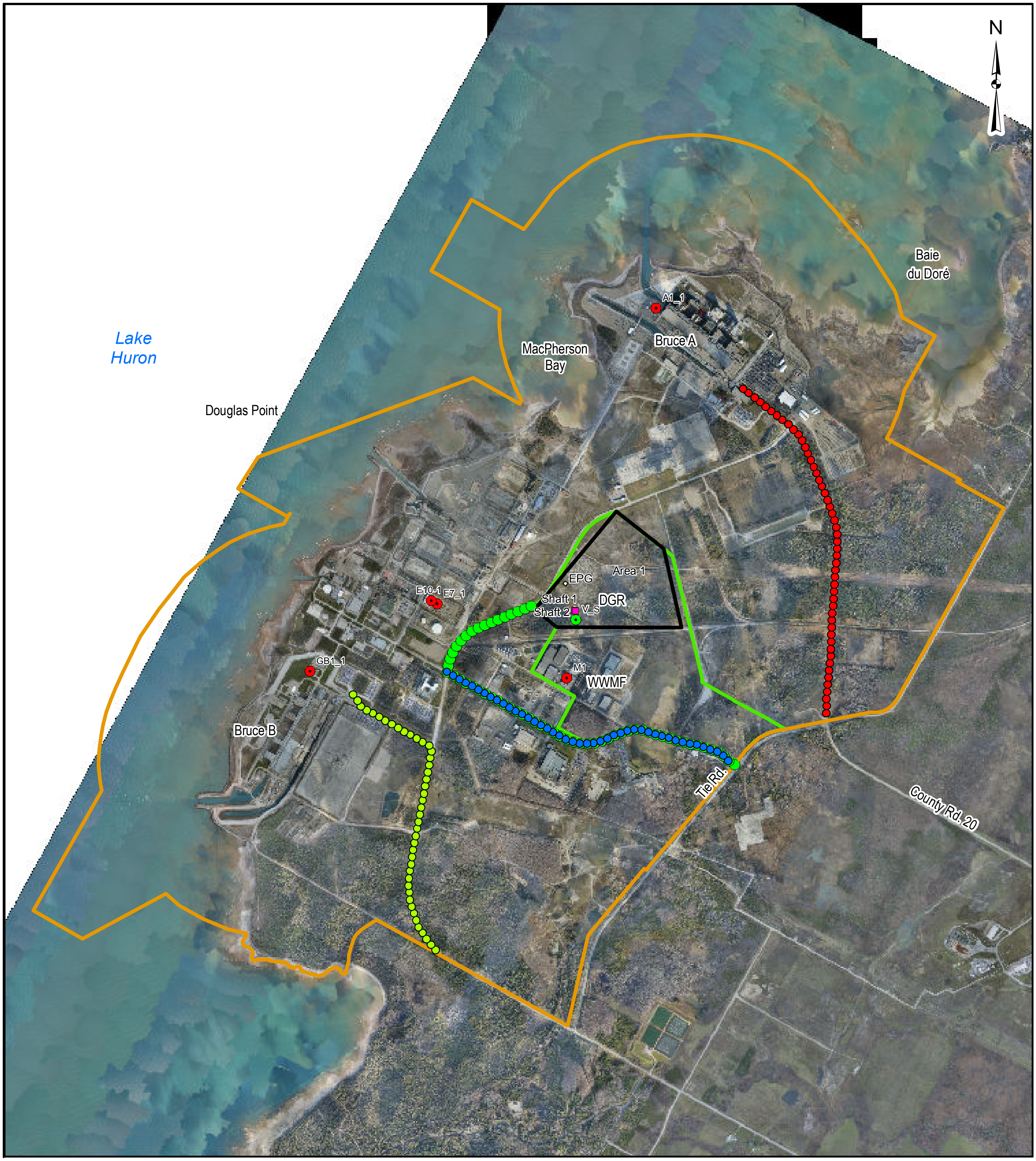

0 0.5 1 2

Kilometres

LEGEND

- Shaft Location
- Current Source
- Future Source
- Main Road Source
- North Road Source
- South Road Source
- Updated Main Road Source
- Area Source
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

OPERATIONS PHASE MODEL SOURCES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE F4.4-3**	
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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Table F4.4.1-1: Point Source Summary

Point Sources	Source ID	Height Above Grade (m)	Gas Exit Velocity (m/s)	Inner Diameter (m)	Exit Gas Temperature (°K)	X Coordinate (m)	Y Coordinate (m)	Base Elevation from AERMAP	Compound	24-hr Emission Rate (g/s)	Applicable Modelling Scenario
Standby Generators - Existing (A-Side, 15 MW)	A1_1	4.7	24.5	4.08	938	453947.00	4909869.00	179.83	NO_X	3.79E+00	Existing Site Preparation and Construction Phase Operations Phase
									SO_2	2.17E-01	
									CO	1.42E-02	
									SPM	5.16E-02	
									PM_{10}	5.16E-02	
									$PM_{2.5}$	5.16E-02	
Standby Generators - Existing (B-Side, 15 MW)	B1_1	4.7	24.5	4.08	938	452018.00	4907845.00	180.00	NO_X	3.79E+00	Existing Site Preparation and Construction Phase Operations Phase
									SO_2	2.17E-01	
									CO	1.42E-02	
									SPM	5.16E-02	
									PM_{10}	5.16E-02	
									$PM_{2.5}$	5.16E-02	
Standby Generators - Existing (B-Side, 2 MW)	E7_1	6.4	65	0.4	755	452726.10	4908219.40	186.00	NO_X	2.52E-01	Existing Site Preparation and Construction Phase Operations Phase
									SO_2	1.45E-02	
									CO	9.47E-04	
									SPM	3.44E-03	
									PM_{10}	3.44E-03	
									$PM_{2.5}$	3.44E-03	
Bruce Steam Plant Boilers (3)	E10_1	51.8	12.6	2.1	408	452693.50	4908238.00	186.00	NO_X	2.04E+01	Existing Site Preparation and Construction Phase Operations Phase
									SO_2	6.81E+01	
									CO	2.17E+00	
									SPM	5.39E+00	
									PM_{10}	4.63E+00	
									$PM_{2.5}$	3.02E+00	

Table F4.4.1-1: Point Source Summary (continued)

Point Sources	Source ID	Height Above Grade (m)	Gas Exit Velocity (m/s)	Inner Diameter (m)	Exit Gas Temperature (°K)	X Coordinate (m)	Y Coordinate (m)	Base Elevation from AERMAP	Compound	24-hr Emission Rate (g/s)	Applicable Modelling Scenario
WWMF - Radioactive Waste Incinerator	M1	21	13	0.41	1273	453448.30	4907807.20	190.00	NO_X	7.00E-02	Existing Site Preparation and Construction Phase Operations Phase
									SO_2	2.00E-02	
									CO	—	
									SPM	3.10E-03	
									PM_{10}	3.10E-03	
									$PM_{2.5}$	3.10E-03	
Sinking Shaft	S1	0	21.82	1.94	ambient	453397.00	4908235.00	187.00	NOX	1.85E-01	Site Preparation and Construction Phase
									SO_2	3.73E-04	
									CO	1.57E-01	
									SPM	9.98E-03	
									PM_{10}	9.84E-03	
									$PM_{2.5}$	9.70E-03	
Sinking Shaft	S2	0	21.82	1.94	ambient	453475.00	4908210.00	187.83	NOX	1.85E-01	Site Preparation and Construction Phase
									SO2	3.73E-04	
									CO	1.57E-01	
									SPM	9.98E-03	
									PM10	9.84E-03	
									PM2.5	9.70E-03	
Shaft/Vent Raise	SHAFT1	0.97	3.29	5.00	ambient	453494.95	4908181.78	187.97	NOX	3.43E-02	Operations Phase
									SO2	6.50E-05	
									CO	2.49E-02	
									SPM	1.93E-03	
									PM10	1.93E-03	
									PM2.5	1.93E-03	
Shaft/Vent Raise	SHAFT2	0.97	3.29	5.00	ambient	453497.80	4908179.91	188.00	NOX	3.43E-02	Operations Phase
									SO2	6.50E-05	
									CO	2.49E-02	
									SPM	1.93E-03	
									PM10	1.93E-03	
									$PM_{2.5}$	1.93E-03	

F4.4.2 Volume Sources

Volume sources are used to model releases from a variety of industrial sources that could not be classified as a stack or vent. The MOE has suggested that roads should be modelled as a series of individual volume sources creating a line that follows the road [F1]. The roads in the assessment were modelled using this volume source approach. The roads were assumed to be 20 m wide. The tailpipe emissions and road dust emissions were combined and modelled.

The roads were divided into contiguous volume sources measuring 40 by 40 m with a release height of 1.5 m. The emission rate for the entire road segment was divided amongst the volume sources. There were four road segments considered in the assessment.

Additional volume sources include the emergency power generator used in the Operations Phase, and the batch plant, used during the site preparation and construction phase. The volume sources considered in the assessment are summarized in Table F4.4.2-1.

Table F4.4.2-1: Volume Source Summary

Road Segment	Number of Volume Sources	Indicator Compound	Emission Rate Existing (g/s)	Emission Rate during the Site Preparation and Construction Phase (g/s)	Emission Rate during the Operations Phase (g/s)
North Access Road	51	NO_X	4.74E-04	4.74E-04	4.74E-04
		SO_2	6.37E-06	6.37E-06	6.37E-06
		CO	9.35E-03	9.35E-03	9.35E-03
		SPM	1.41E-03	1.41E-03	1.41E-03
		PM_{10}	2.48E-04	2.48E-04	2.48E-04
		$PM_{2.5}$	1.35E-05	1.35E-05	1.35E-05
Main Access Road	44	NO_X	3.95E-04	3.95E-04	3.95E-04
		SO_2	5.32E-06	5.32E-06	5.32E-06
		CO	7.80E-03	7.80E-03	7.80E-03
		SPM	1.27E-03	1.27E-03	1.27E-03
		PM_{10}	2.25E-04	2.25E-04	2.25E-04
		$PM_{2.5}$	1.40E-05	1.40E-05	1.40E-05
South Access Road	44	NO_X	3.89E-04	3.89E-04	3.89E-04
		SO_2	5.23E-06	5.23E-06	5.23E-06
		CO	7.68E-03	7.68E-03	7.68E-03
		SPM	1.15E-03	1.15E-03	1.15E-03
		PM_{10}	2.04E-04	2.04E-04	2.04E-04
		$PM_{2.5}$	1.11E-05	1.11E-05	1.11E-05

Table F4.3.2-1: Volume Source Summary (continued)

Road Segment	Number of Volume Sources	Indicator Compound	Emission Rate Existing (g/s)	Emission Rate during the Site Preparation and Construction Phase (g/s)	Emission Rate during the Operations Phase (g/s)
Main DGR Access Road	61	NO_X	—	4.89E-03	7.88E-06
		SO_2	—	1.07E-05	1.06E-07
		CO	—	4.70E-03	1.56E-04
		SPM	—	4.67E-04	2.53E-05
		PM_{10}	—	2.24E-04	4.49E-06
		$PM_{2.5}$	—	1.75E-04	2.80E-07
DGR Emergency Power Generator	1	NO_X	—	—	2.28E-01
		SO_2	—	—	2.78E-04
		CO	—	—	1.41E-01
		SPM	—	—	8.15E-03
		PM_{10}	—	—	8.15E-03
		$PM_{2.5}$	—	—	8.15E-03
Batch Plant	1	NO_X	—	1.17E-01	—
		SO_2	—	2.32E-04	—
		CO	—	7.24E-02	—
		SPM	—	1.36E-01	—
		PM_{10}	—	5.60E-02	—
		$PM_{2.5}$	—	5.60E-02	—

Note:
— Not applicable

F4.4.3 Area Sources

Area sources are generally used to model low level or ground releases. In general, area sources result in much higher ground level concentrations than those of volume or point sources. To remain conservative, the (construction) equipment used on the surface during site preparation, construction and operation activities was modelled as area sources. Two area sources were defined in the assessment: a 30 ha land area associated with DGR Project preparation and operation activities on the surface (AREA1) and the area associated with the waste rock pile (AREA2). The two area sources used in the model are presented in Table F4.3.3-1. The release height of the emissions in these areas was estimated to be 4 and 9 m, respectively.

Table F4.3.3-1: Area Source Summary

Area Name	Area (m^2)	Location	Indicator Compound	Emission Rate during Construction ($g/s\text{-}m^2$)
AREA1	328,888	Site Preparation and Construction Phase and Operations Phase	NO_X	3.15E-06
			SO_2	6.24E-09
			CO	2.01E-06
			SPM	2.47E-06
			PM_{10}	6.18E-07
			$PM_{2.5}$	3.19E-07
AREA2	78,679	Site Preparation and Construction Phase	NO_X	5.40E-06
			SO_2	1.07E-08
			CO	3.34E-06
			SPM	4.46E-06
			PM_{10}	8.71E-07
			$PM_{2.5}$	6.41E-07

F4.4.4 Building Downwash

AERMOD has the ability to characterize the planetary boundary layer (PBL) through both surface and mixed layer scaling. The AERMOD model constructs vertical profiles or required meteorological variables using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using the available meteorological observations.

The Plume Rise Model Enhancements (PRIME) algorithms in AERMOD include vertical wind shear calculations (important for buoyant releases from short stacks). The PRIME algorithm also allows for the wind speed deficit induced by the building to change in relation to the distance from the building. These factors improve the accuracy of predicted concentrations within building wake zones that form in the lee of buildings, as illustrated on Figure F4.4.4-1.

Building wake effects were considered in the assessment using the U.S. EPA's Building Profile Input Program (BPIP-PRIME), another pre-processor to AERMOD. The primary inputs into this pre-processor include the coordinates and heights of the buildings (shown on Figure F4.4.4-2). Data from the BPIP output can be directly inserted into the AERMOD input for use in the building wake effect calculation.

Figure F4.4.4-2 presents the building obstacles as used in the BPIP program for each phase.

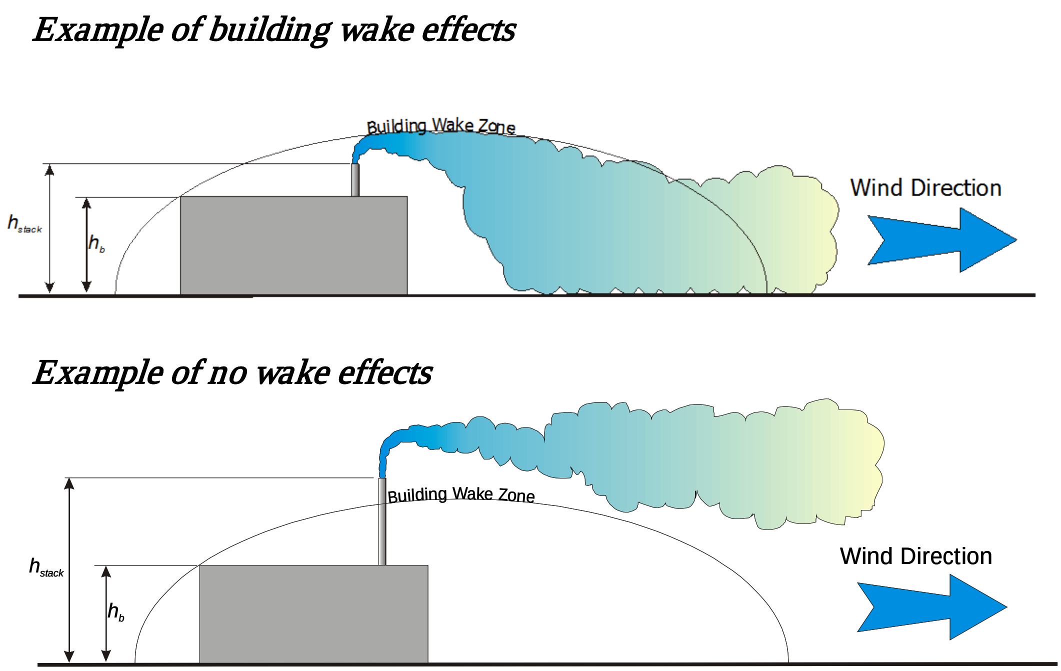

Figure F4.4.4-1: Building Wake Effects

0 0.5 1 2

Kilometres

LEGEND

- Building Obstacles
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

BUILDING OBSTACLES FOR BUILDING WAKE CALCULATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010	**FIGURE F4.4.4-2**	
CHECK	KC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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F5. MODEL OPTIONS AND RESULT PROCESSING

F5.1 OPTIONS USED IN THE AERMOD MODEL

The options used in the AERMOD model are summarized in the Table F5.1-1.

Table F5.1-1: Options Used in the AERMOD Model

Modelling Parameter	Description	Used in the Assessment?
DFAULT	Specifies that regulatory default options will be used	Yes
CONC	Specifies that concentration values will be calculated	Yes
OLM	Specifies that the non-default Ozone Limiting Method for NO_2 conversion will be used	Yes
DDPLETE	Specifies that dry deposition will be calculated	No
WDPLETE	Specifies that wet deposition will be calculated	No
FLAT	Specifies that the non-default option of assuming flat terrain will be used	No, the model will use elevated terrain as detailed in the AERMAP output
NOSTD	Specifies that the non-default option of no stack-tip downwash will be used	No
AVERTIME	Time averaging periods calculated	1-hr, 8-hr, 24-hr, and annual
URBANOPT	Allows the model to incorporate the effects of increased surface heating from an urban area on pollutant dispersion under stable atmospheric conditions	No
URBANROUGHNESS	Specifies the urban roughness length (m)	No, site specific urban roughness values were incorporated into the AERMET processing
FLAGPOLE	Specifies that receptor heights above local ground level are allowed on the receptors	No

F5.2 AVERAGING TIME CONVERSIONS

The smallest time scale that AERMOD predicts is a 1-hour average value. There are instances when criteria are based on different averaging times, and in these cases the following conversion factor, recommended by the MOE for conversion from a 1-hour averaging period to the applicable averaging period less than 1-hour could be used [F1]:

$$F = \left(\frac{t_1}{t_0}\right)^n$$

$$= \left(\frac{60}{10}\right)^{0.28}$$

$$= 1.65$$

where:

F is the factor to convert from the averaging period t_1 output from the model (MOE assumes AERMOD predicts true 60 minute averages) to the desired averaging period t_0 (assumed to be 10-minutes in the example above)

n is the exponent variable; in this case the MOE historical value of n = 0.28 is used for conversion

The assessment does not use this conversion since none of the air quality indicators have averaging periods less than 1-hour. For averaging periods greater than 1-hour, the AERMOD output was used directly.

F5.3 CONVERSION OF NO_X TO NO_2

Emissions of oxides of nitrogen (NO_X) were used as inputs to the AERMOD model. Ambient predictions of nitrogen dioxide (NO_2), one of the indicator compounds, were modelled by AERMOD using the Ozone Limiting Method (OLM) suggested by Cole and Summerhays [F10]. This method is widely accepted as being a reasonable approach that recognizes the most important mechanism for NO_X conversion, namely reactions with ozone. A non-default OLM option in the AERMOD allows that conversion of NO_X to NO_2 be modelled provided the background ozone concentration is available. The 1-hour, 24-hour and annual NO_2 concentrations were calculated using the 90th percentile of the eight-hour ground-level ozone concentrations from the Tiverton station for the years 2000 to 2008.

F6. REFERENCES

[F1] Ontario Ministry of the Environment. 2005. *Air Dispersion Modelling Guideline for Ontario: Version One.* PIBS#: 5165E.

[F2] Environmental Protection Agency (EPA). 2004. *AERMOD: Description of Model Formulation.* EPA-454/R-03-004. Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Research Triangle Park, North Carolina.

[F3] Environmental Protection Agency (EPA). 2005. *40 CRF Par 51 Revision to the Guideline on air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and other Revisions.* Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Research Triangle Park, North Carolina.

[F4] Environmental Protection Agency (EPA). 2003. *Comparison of Regulatory Design Concentrations: AERMOD vs. ISCST3, CTDMPLUS, ISC-PRIME.* Staff Report, EPA-454/R-03-002. Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division, Research Triangle Park, North Carolina.

[F5] Environmental Protection Agency (EPA). 2004. *Users Guide for the AERMOD Terrain Preprocessor (AERMAP).* EPA-454/B-03-003. Office of Air Quality Planning and Standards. Emissions, Monitoring, and Analysis Division. Research Triangle Park, North Carolina.

[F6] Ministry of the Environment (MOE). 2008. *Ontario Digital Elevation Model Data*. Accessed on May 20, 2008 from http://www.ene.gov.on.ca/envision/air/regulations/demdata/dem.html.

[F7] Environmental Protection Agency (EPA). 1995. *Compilation of Air Pollutant Emission Factors.* Volume 1: Stationary Point and Area Sources. Document AP-42 (and updates). U.S. EPA, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

[F8] Environmental Protection Agency (EPA). 2003. *User's Guide to MOBILE6.1 and MOBILE6.2.* EPA420-R-03-010. Mobile Source Emission Factor Model. Office of Transportation and Air Quality, Assessment Standards Division. Research Triangle Park, North Carolina.

[F9] Watson, J. G. and J. C. Chow. 2000. *Reconciling Urban Fugitive Dust Emissions Inventory and Ambient Source Contributions Estimates: Summary of Current Knowledge and Needed Research.* Desert Research Institute. Reno, Nevada. pp. 240.

[F10] Cole, H.S. and J.E. Summerhays. 1979. *A review of techniques available for estimating short-term NO_2 concentrations*. Journal of Air Pollution Control Association. pp. 812-817.

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APPENDIX G: NOISE MODELLING METHODS

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G1. NOISE MODELLING

The likely environmental effects of the DGR Project works on noise levels have been evaluated with the aid of the Computer Aided Noise Attenuation (CadnaA) prediction model developed by DataKustik GmbH. The selection of this model considered several capabilities:

- incorporates site specific terrain data;
- evaluates the various source types associated with the DGR Project;
- has a technical basis that is scientifically sound, and is in keeping with the current understanding of the propagation of sound in the outdoors;
- prediction program has undergone scrutiny for correct implementation of established ISO methods;
- makes predictions that are consistent with observations; and
- is recognized by provincial regulators as one suitable for use.

G1.1 CadnaA PREDICTION MODEL

The CadnaA prediction model, version 3.72.131, is a commercially available modelling program, in which one of the model algorithms are based on ISO 9613 Acoustics: Attenuation of Sound During Propagation Outdoors (International Organization of Standardization, 1993 and 1996) [G1].

The model has the ability to simulate emission sources such as roads, vessels and industrial facilities. Noise sources are characterized by entering the sound power and/or sound pressure frequency spectrum associated with each source. Other parameters such as building dimensions, frequency of use, hours of operation and enclosure attenuation ratings also define the nature of sound emissions. The prediction model takes into consideration that the sound from a stationary point noise source spreads spherically and attenuates at a rate of 6 dB per doubling of distance. The ISO 9613 prediction method is conservative, in that it assumes that all receptors are downwind from the noise source or that a moderate ground-based temperature inversion exists. In addition, ground cover and physical barriers, either natural (terrain based) or man-made and atmospheric absorption are included as determined by the DGR Project.

The EIS Guidelines require that information regarding the model verification and scientific defensibility, model calibration, model validation, as well as the uncertainty and sensitivity of the model are provided in the EIS. A summary of the information regarding the CadnaA prediction model has been provided in Table G1.1-1, and is outlined in the following sections.

Table G1.1-1: Reliability Summary for the Noise Models

Model Name	Developer	Use in Assessment	Verification	Calibration	Validation	Uncertainty and Sensitivity
CadnaA	DataKustik GmbH	Predicting noise levels associated with on-site activities, equipment and operations	• CadnaA implements the ISO standards for noise propagation outdoors • ISO 9613 • Drew *et. al.*, 2005 [G2]	CadnaA predictions were calibrated using measurements at the DGR Project site:	• CadnaA predictions are continuously validated: • Drew *et. al.*, 2005 [G2]	• ISO 9613 is based on known theory and proven to reliably produce repeatable results • CadnaA predictions of sound energy are sensitive to inputs (i.e., doubling sources will result in a doubling of acoustic energy at receptors) • Uncertainty associated with emissions is managed by making conservative assumptions (i.e. all construction equipment for certain construction works and activities operating concurrently)

G1.1.1 Model Verification

The CadnaA noise prediction model implements the ISO 9613 method, which was last published in 1996 as a prediction method for the propagation of noise outdoors. This prediction algorithm has been adopted by governing authorities globally, including the MOE in Ontario. The CadnaA prediction model has been independently validated for its implementation of the ISO standard [G2].

G1.1.2 Model Calibration

The CadnaA predictions were calibrated using noise measurements collected at the Bruce nuclear site during the 2007 and 2009 field programs. Measured site-specific noise emissions were entered into the model where available. Digital terrain data for the site and surrounding area was also entered into the prediction model to accurately predict how the local topography could affect the propagation of sound.

Noise emissions were modelled for the same locations at which field data were collected. The predicted emissions were compared to the values measured on-site to ensure the prediction model accurately predicted site specific conditions.

G1.1.3 Model Validation

The CadnaA prediction program is continually validated against known modelling results for specific inputs. In addition, this model has been independently validated for its implementation of the ISO standard [G2]. As part of the validation process, similar to the calibration process, the prediction model results were compared to known measured values within the site.

G1.1.4 Model Uncertainty and Sensitivity

The noise modelling was carried out using CadnaA, an internationally recognized model that calculates sound propagation according ISO 9613 methods and other documented standards. The model is as accurate as the inputs used; therefore the conservatism applied in emission selection was carried through, but not amplified by, the model. Also, the ISO 9613 prediction standard has an uncertainty of ±3 dB.

Conservative assumptions were made because of the uncertainty associated with predicted noise levels. For example, different construction works and activities can occur concurrently therefore it was assumed that the bounding construction year (i.e., the year that generates the highest off-site noise levels) would represent all construction.

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G2. MODEL INPUTS

In order to complete the noise prediction model and effects assessment, a series of inputs are required. These inputs can be grouped into three categories:

- sensitive receptor locations;
- terrain and imagery; and
- source location/configurations.

Each of these input categories will be discussed separately in the following sections.

G2.1 EQUIPMENT SOUND POWER LEVEL SOURCES

Emissions were determined using the Project Description (see Section 4 of the EIS) and Golder's database of measured data of similar sources. These have been summarized in Table G2.1-1. During site preparation and construction, it was assumed that equipment would run 24-hours a day.

G2.2 SENSITIVE RECEPTOR LOCATIONS

To adequately assess the effects of a project, it is required to establish the ambient conditions at sensitive receptor and ecological receptors.

G2.2.1 Land Use Data

Land use data, collected as part of the baseline studies to support this EA and the EA for the Bruce New Nuclear Power Plant Project were used as inputs to determine the nearest sensitive points of reception, human and ecological. Figure G2.2.1-1 illustrates human and ecological noise receptor locations.

In preparing a conservative assessment the noise prediction model did not include intervening trees/structures between the site and the identified receptors.

G2.2.2 Ambient Conditions

To establish the ambient noise environment for human receptors, long-term noise monitoring was completed during two extended field studies in 2005 and 2007 (approximately a week at each location) at the identified human receptor locations. The measured noise levels fluctuated throughout these periods, but in determining the ambient noise levels, the lowest one hour L_{eq} measured at each monitoring location was used to establish the ambient noise environment for the respective receptor locations. Using the lowest measured one hour L_{eq} noise levels to establish the ambient noise levels would lead to a conservative assessment.

Table G2.1-1: Summary of Equipment Sound Power Level Source References

Source Description	Octave Band Frequency (Hz)									Overall Power Level (dBA)	Reference
	31.5	63	125	250	500	1000	2000	4000	8000		
Feller Buncher (Cat 522)	107	112	113	120	107	105	105	100	95	114	Derived from Lafarge Fonthill
Tandem Trucks (assumed Peterbuilt)	96	101	111	105	100	100	99	89	86	105	Derived from MTO Equation for trucks travelling at 30 km/h
Articulated Trucks (Cat 730)	118	117	117	107	103	104	104	98	93	109	Derived from Lafarge West Paris
Compactors (Cat CS-683)	115	109	113	110	107	104	100	94	86	109	Derived from Rockfort Quarry data
Pavers (Cat BG-240C)	100	123	115	105	102	98	99	95	90	106	Derived from Rockfort Quarry data
Primary Crusher	115	119	120	114	112	111	107	101	94	115	Derived from Lafarge West Paris
Screen	111	113	109	111	107	104	103	100	97	111	Derived from Lafarge West Paris
Stackers	102	98	95	90	99	95	93	90	88	100	Derived from Lafarge West Paris
Mobile Crane (Operation - Surface)	99	108	101	101	106	99	96	91	90	106	Derived from Rockfort Quarry data
Fresh Air Raise (Propane Burner, Operation)	115	120	120	124	121	119	117	114	111	125	Derived from INCO Garson Mine
Forklifts Large (Surface Operations)	94	97	101	100	97	93	90	83	76	99	Derived from Vicwest Manufacturing Facility
Forklifts Small (Surface Operations)	94	97	101	100	97	93	90	83	76	99	Derived from Vicwest Manufacturing Facility
Flat-bed transporters/tracks (Surface Operation)	96	101	111	105	100	100	99	89	86	105	Derived from WSI
Diesel Generator (3,500 kW) Back up - Operation	102	107	107	105	112	111	112	110	103	118	Derived from Compucom using American Gas Association methods
Jumbo Atlas Copco Boomer E3 C	105	116	119	108	112	114	113	109	103	119	Derived from Dufferin Aggregates - Milton Quarry
Explosives carrier/loader	116	123	111	109	108	114	103	101	99	115	Derived from Cowal Gold Project

Table G2.1-1: Summary of Equipment Sound Power Level Source References (continued)

Source Description	Octave Band Frequency (Hz)									Overall Power Level (dBA)	Reference
	31.5	63	125	250	500	1000	2000	4000	8000		
Sprayer	105	109	115	103	102	101	100	95	87	107	Derived from Lafarge Stouffville
Loader (Cat 988H)	116	123	111	109	108	114	103	101	99	115	Derived from Cowal Gold Project
Shotcrete Transmixer	106	110	114	108	105	102	98	91	79	108	Derived from Fisher Wavy Ready Mix Plant
Motor Grader (CAT 140)	118	122	113	113	113	110	109	108	101	116	Derived from WSI
Excavator (Cat 340D)	100	97	102	99	98	97	96	88	80	102	Derived from WSI
Exhaust Fans	106	112	111	117	113	112	110	107	104	117	Derived from INCO Garson Mine
Hoist House	78	83	82	82	85	86	88	76	66	92	Derived from INCO Garson Mine
Air Compressor Plant(louvers)	108	110	112	112	111	111	110	104	97	116	Derived from INCO South Mine
Electrical Sub-Station	90	91	99	82	84	75	68	70	61	86	Derived from Inco Port Colborne
Headframe	78	83	82	82	85	86	88	76	66	92	Derived from Inco North Mine
Concrete Truck	92	99	104	105	105	95	94	89	82	104	Derived from Lafarge New Lowell
Batch Plant Concrete Truck Blower	106	110	114	108	105	102	98	91	79	108	Derived from Fisher Wavy Ready Mix Plant
Batch Plant Hopper Blower	105	97	104	101	97	100	98	91	81	104	Derived from Fisher Wavy Ready Mix Plant
Batch Plant Truck Concrete Loading	106	115	113	105	107	105	99	96	86	109	Derived from Fisher Wavy Ready Mix Plant
Batch Plant Truck Rinsing	103	115	106	103	106	105	100	94	84	109	Derived from Fisher Wavy Ready Mix Plant
Cement Storage Hopper Blower	105	97	104	101	97	100	98	91	81	104	Derived from Fisher Wavy Ready Mix Plant
Bulldozer (Cat D9T WH)	113	109	109	114	113	109	108	103	96	115	Derived from Cowal Gold Project

Note: Sound powers need to be added logarithmically. To get an overall power level in dBA, individual octave band readings have to be adjusted to account for the frequency response of humans to sound (i.e., A-weighting). For some sources, an additional 5 dBA tonal penalty will be added in the model inputs.

Spot noise measurements, including the spectral content (i.e., frequency components) at the various monitoring locations (on- and off-site) were carried out during the daytime and night-time periods to characterize the nature of existing noise levels at, and proximate to, the Site Study Area. A spot check was also completed to establish the ambient noise environment at each of the ecological points of reception (see Appendix J for results). Figure G2.2.2-1 illustrates the three locations of the long-term noise monitoring and seven locations of spot check measurements which correspond to the human and ecological receptors, respectively.

G2.3 SAMPLE CALCULATION

Noise levels are added logarithmically. Adding two identical noise sources will result in a change of noise levels of 3 dB. For example, two noise sources that generate 50 dBA each at one location will result in an overall noise level of 53 dBA, based on the following equation:

$$Oveall\ Sound\ Pressure\ Level\ (dBA) = 10\log_{10}(10^{(0.1\times 50)} + 10^{(0.1\times 50)}) = 53\ dBA$$

0 0.5 1 2

Kilometres

LEGEND

- Ecological Receptor
- Human Health Receptor
- Noise Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

NOISE RECEPTOR LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	AB	18 May. 2010		

FIGURE G2.2.1-1

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0 0.5 1 2

Kilometres

LEGEND

- ER Measurement Location
- Noise Monitoring Location
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

NOISE MEASUREMENTS LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	REV. 1
DESIGN	ASB	17 Oct. 2007	**FIGURE G2.2.2-1**	
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	AB	18 May. 2010		

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G3. TERRAIN AND IMAGERY

G3.1 DIGITAL TERRAIN DATA

Local terrain will effect the propagation of noise; therefore, local terrain data needed to be provided as an input to the noise model. The digital terrain data used in the noise predictions had coordinates that were defined in the North American Datum of 1983 (NAD83), consistent with the noise model requirements.

Digital terrain data for use in the noise model was collected and processed by Terrapoint Canada Inc. and obtained by Golder and used under licence. The data was used to provide elevations for the model source coordinates, building corner coordinates, receptor coordinates. The topographical data between sources and receptors, which is used by the CadnaA model for predicting noise propagation, was also derived from this digital terrain data. The terrain used in the model is illustrated on Figure G3.1-1; however, the contours shown on the figure were obtained by Golder and used under licence from the Ontario Ministry of Natural Resources. This was done because the digital terrain data used in the noise model was too detailed for the scale of the figure.

G3.2 SATELLITE IMAGERY

Satellite imagery was used to prepare the prediction model and assist in locating the existing and proposed equipment and operations. This imagery was also used to identify receptor locations and existing land use between the identified receptors and the site. This data was obtained from Terrapoint Canada Inc., as identified in the figures.

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0 0.5 1 2
Kilometres

LEGEND

- Ecological Receptor
- Human Health Receptor
- Noise Receptor
- Contour (5m interval)
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007. MNR NRVIS, obtained 2004.
Imagery Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCAL TOPOGRAPHY

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	AB	18 May. 2010		

FIGURE G3.1-1

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G4. SOURCE NOISE EMISSIONS

As described in Section 7 of the TSD, noise emissions were estimated for the works and activities for which a measurable change is likely to occur. These noise emissions were then used as inputs for the noise model. The noise model then predicts noise levels at receptor locations. The source noise emissions are based on sound power levels from Golder's database (see Section G2.1).

The site preparation and construction phase covers the period of time during which the following DGR Project works and activities are expected to occur: site preparation, construction of temporary and permanent structures, excavation of shafts, and workers, payroll and purchasing. The sources of emissions during operations will include operations equipment.

Site Preparation and Construction Phase

The works and activities during the site preparation and construction phase will be staged over a period of approximately six years, and are not expected to occur concurrently. Table G4-1 summarizes the equipment modelled, the number of units and the associated noise emissions for the scenario resulting in the highest noise levels at the receptors.

Table G4-1: Bounding Site Preparation and Construction Phase Noise Emissions

Source	Quantity	Overall Sound Power Level (dBA) [a]
Articulated Trucks (Cat 730) Land Clearance	2	109
Articulated Trucks (Cat 730) Re-used Material Transfer	2	109
Articulated Trucks (Cat 730) Storm Water	2	109
Batch Plant Cement Truck Blower	1	108
Batch Plant Hopper Blower	1	104
Batch Plant Truck Cement Loading	4	109
Batch Plant Truck Rinsing	4	109
Bulldozer (Cat D9T WH) Land Clearance	1	115
Bulldozer (Cat D9T WH) Road Construction	1	115
Bulldozer (Cat D9T WH) Storm Water	1	115
Bulldozer (Cat D9T WH) Waste Rock Pile Construction	1	115
Cement Storage Hopper Blower	1	104
Cement Truck	4	104
Compactors (Cat CS-683) Road Construction	1	109
Electrical Substation	1	91
Excavator (Cat 340D) Land Clearance	1	102
Excavator (Cat 340D) Storm Water	1	102

Table G4-1: Bounding Site Preparation and Construction Phase Noise Emissions (continued)

Source	Quantity	Overall Sound Power Level (dBA) [a]
Explosives Carrier/Loader	2	115
Feller Buncher (Cat 522) Land Clearance	1	114
Front End Loader (Cat 988H)	3	115
Front End Loader (Cat 988H) Waste Rock Pile	1	115
Heavy Vehicles - DGR Construction (Main Gate)	22	104
Jumbo Atlas Copco Boomer E3 C	2	119
Loader (Cat 988H) - Batch Plant	1	115
Motor Grader (CAT 140)	2	116
Pavers (Cat BG-240C) Road Construction	1	106
Shotcrete Transmixer	2	108
Sprayer	2	107
Vehicles - DGR Construction and Support Workers (Main Gate)	218	98

Notes:
The noise emissions from the construction activities were input to the CadnaA model. The results were combined with baseline noise levels to produce the ambient noise levels during the site preparation and construction phase.
a Sound powers are presented per piece of equipment.

Operations Phase

The noise emissions as summarized in Table G4-2 were used in assessing the noise levels from the operation phase of the DGR Project. The general operation of the DGR Project includes various integrated systems that were identified as part of the second screening presented in Section 7 as likely to result in measurable changes to the noise environment.

Table G4-2: Operations Phase Noise Emissions

Source	Quantity	Overall Sound Power Level (dBA) [a]
Air Compressor Plant	1	116
Diesel Generator (3,500 kW) Back-up [b]	1	118
Electrical Sub-Station	1	91
Exhaust Fans	2	117
Flat-bed Transporter/Truck	1	105
Forklifts Large	1	99
Forklifts Small	1	99
Intake Fan	1	125

Table G4-2: Operations Phase Noise Emissions (continued)

Source	Quantity	Overall Sound Power Level (dBA) [a]
Headframe [c]	2	92
Hoist House [c]	1	92
Vehicles - DGR Employees (Main Gate)	25	75

Notes:
The noise emissions from the construction activities were input to the CadnaA model. The results were combined with baseline noise levels to produce the ambient noise levels during the operations phase.
a Sound powers are presented per piece of equipment.
b Diesel generator was conservatively assumed to have a weather enclosure only.
c Sources of noise may include machinery and cabling.

In determining the noise emission levels, sound power levels from Golder’s database of similar sources were used (see Section G2). These established noise emission levels were assumed to be similar to the proposed equipment.

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G5. REFERENCES

[G1] International Organization for Standardization (ISO). 1993. *International Standard ISO 9613-1 and 9613-2: Acoustics - Attenuation of sound during propagation outdoors. Parts 1 and 2.*

[G2] Drew, Da Silva, and Decock. 2005. *Commercial Noise Models - Do They Work? A Case Study.* Presented at the Spring Noise Conference, Banff, AB.

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APPENDIX H: LIGHT ASSESSMENT

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H1. LIGHT ENVIRONMENT

As part of the assessment for the DGR Project, a light trespass assessment has been completed for selected ecological receptor locations. The purpose of these studies was to establish the existing light levels and predict the potential light trespass effects at the identified ecological receptor locations. This appendix provides an overview of light trespass, discusses its measurement and prediction, and provides existing conditions and predicted changes of light trespass levels because of construction activities and operation of the DGR. The existing light trespass measurement program was focused on determining the existing ambient light trespass levels in the environment at ecological receptors on and around the site. The desktop study was designed to predict the change in light trespass at the ecological receptors attributed to the above-ground operations of the DGR Project for both the site preparation and construction and operations phases. The desktop study has been completed in accordance with industry-standard light trespass prediction methods (i.e., Commission Internationale de l'Eclairage [CIE] publication 150:2003 [H1]).

The DGR will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site near the existing Western Waste Management Facility (WWMF). The existing light levels near the Bruce nuclear site and DGR Project attributed to existing operations consist of a mixture of dark areas with no artificial ambient light trespass to areas of low to medium ambient brightness. The maximum artificial light trespass is comparable to a very bright full moon. Seven (7) locations, labelled ER1 to ER7, were identified by the specialists completing the Terrestrial Environment TSD as being ecological receptors in the vicinity of the site. A site location plan showing the proposed location of the DGR Project and the selected ecological receptors is provided on Figure H1-1.

Using architectural drawings, preliminary lighting designs, and manufacturer's information of the proposed light sources, as well as an internal database of similar light sources, light trespass predictions of the DGR Project were completed to determine the potential night-time light trespass levels on the selected ecological receptors during both the site preparation and construction phase, as well as the operations phase. Effects during the decommissioning and abandonment phase were not specifically evaluated, but are expected to be less than, but comparable to, those during the site preparation and construction phase. To help understand the analysis made in this report, a brief discussion of light trespass, including both the physical effect and its prediction, is provided in Section H2.

H2. DESCRIPTION OF LIGHT TRESPASS

H2.1 LIGHT TRESPASS EFFECT

Light trespass is the term used to describe light that strays from its intended purpose, directly illuminating areas where it can potentially become harmful. For example, parking lot lighting that illuminates the windows of a nearby residence can be considered light trespass. Light trespass may be caused by improperly located and/or oriented fixtures, or fixtures whose light distribution is not appropriate for the task.

Light emitted from a fixture can be specified in units of "luminous intensity". Luminous intensity can be described as the amount of light per solid angle emitted in any particular direction from a source. It is specified in "candelas". The total amount of light emitted by the source (i.e., luminous flux), can be determined from the light intensity in all directions, and is measured in "lumens". A light source with a uniform intensity of 1 candela in all directions emits 4π (i.e., approximately 12.6) lumens of luminous flux.

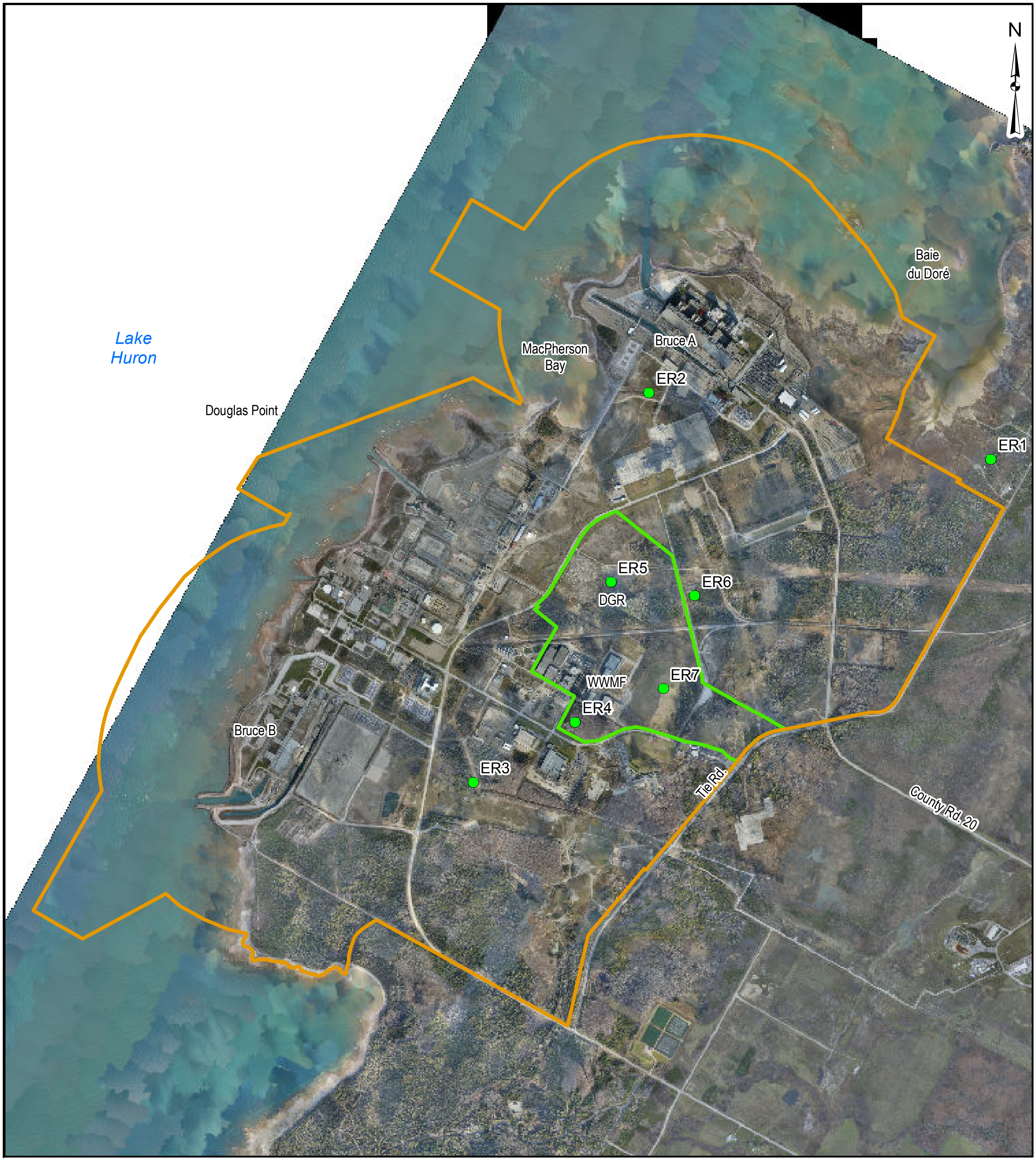
Most light sources do not have a uniform light distribution (i.e., the luminous intensity varies with a ray's direction relative to a fixture's nominal orientation). Therefore, the luminous flux received at a receptor depends on its location relative to the fixture. Typically, luminous flux is measured on a flat surface oriented towards a light source, or a group of light sources. The luminous flux received per unit area on that surface is known as the "illuminance", and is measured in "lux" (i.e., 1 lux = 1 lumen/metre^2, abbreviated as 1 lx). Some common illuminance levels are given in Table H2-1.

Table H2-1: Reference Levels of Illuminance

Example	Illuminance Level (lx)
Sun	1.2×10^5
Sunlight at ground level on a clear day	1×10^5
Average street lighting levels	3 – 10
Moonlight at ground level	0.1
60 W incandescent lamp at 1 km	6.4×10^{-5}
Sirius – brightest star	9×10^{-6}

Source: [H2]

Illuminance is the measure most commonly used to evaluate light trespass. Illuminance can be measured with a light meter (i.e., photometer), and is calculated using the luminous intensity of sources in the direction of a receptor. Predictions of light trespass attributed to the proposed light fixture installations can be compared to measured (or calculated) existing conditions, and/or light trespass limits for the specific area under investigation. Illuminance has been selected as the indicator to represent the light trespass levels for this study.



LEGEND

- Light Trespass Measurement Locations (Ecological Receptor)
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE LOCATION PLAN

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010		
REVIEW	AB	18 May. 2010		

FIGURE H1-1

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H2.2 PREDICTION

There are a number of factors that must be considered when predicting illuminance:

- the intensity of the light source in the direction of the receptor;
- the distance between the source and the receptor; and
- the angle between the receptor plane and the incoming light ray.

Rays can be completely blocked by opaque objects (barriers) such as buildings, berms, or walls. The contribution of screened sources is zero.

Real-world light sources do not have a uniform intensity distribution in all directions. The light intensity in the direction of a receptor must be calculated from the photometric data of the light source (i.e., manufacturer's specification of its intensity distribution), considering the orientation and tilt of the light source. The illuminance on a surface also decreases with the square of the distance to the source, and with the cosine of the angle that a normal to the surface makes with the incoming ray. Putting these three factors together, what is known as the cosine-corrected inverse square law is written below.

$$E = \frac{I}{D^2}(\cos\theta)$$

where:

- E = illuminance at the point of interest (lm/m^2 = lx);
- I = luminous intensity (candelas [cd]);
- D = distance to point of reception (metres); and
- θ = angle between the light ray and the normal to the surface of interest (degrees).

In addition to direct illumination by light sources, illuminance of receptors because of light reflected from building surfaces can be estimated based on the predicted light incident upon those surfaces. The luminance of a surface is given by the following equation:

$$L = rE$$

where:

- L = luminance of the surface (candelas per square metre);
- r = reflectance coefficient; and
- E = illuminance on the surface (lx).

H3. SITE DESCRIPTION

The DGR is an underground storage facility for low and intermediate level radioactive waste for the Bruce nuclear site. The DGR Project surface facilities will consist of several buildings and associated infrastructure related to the receipt, processing, and handling of waste packages, as well as rock and soil stockpiles from excavation of the repository, and a stormwater management system.

During the site preparation and construction phase of the DGR Project, portable construction lights will be used at various locations around the site, oriented towards the nearest building under construction. The facility will operate 24 hours per day, 350 days per year; therefore, security lighting will be installed throughout the site. It was assumed that all light sources would operate at all times during the night. The construction light source locations are shown on Figure H3-1, and the operations lighting and building layout are shown on Figure H3-2.

H4. LIGHT SOURCE SUMMARY

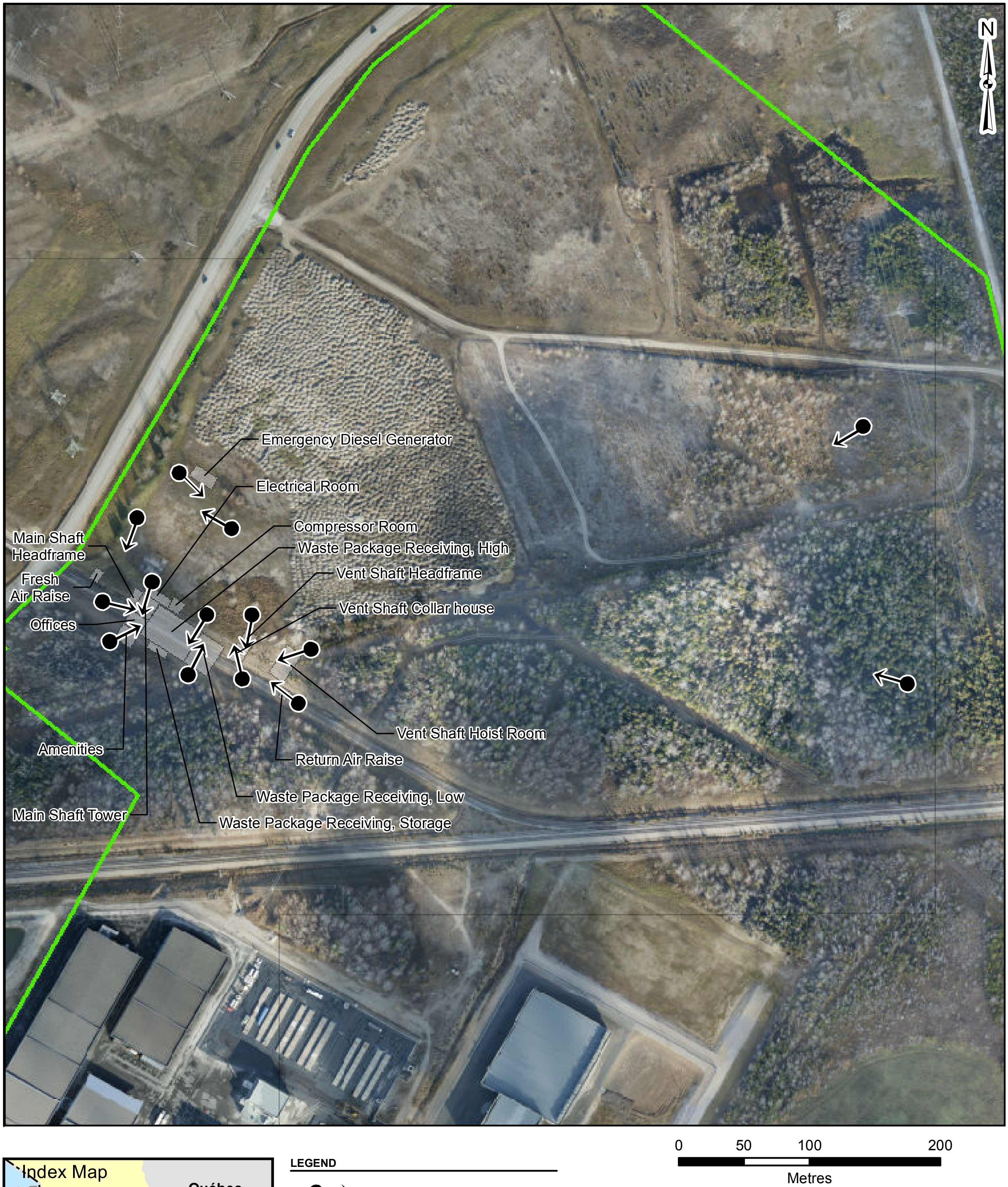
The primary light sources of concern are summarized in Table H4-1, and include the following:

- fourteen (14) 4×1000 Watt portable construction light masts;
- nine (9) 2×400 Watt pole-mounted street lights; and
- eight (8) 400 Watt wall-mounted floodlights.

The assessed light sources are summarized in Table H4-1 below. The locations of the sources are illustrated on Figures H3-1 and H3-2. Where manufacturer's data were not available for the luminaire specified in the DGR Project design, data from luminaires similar in function, design, and capacity were used. Site-specific luminaire configurations are provided in tabular format in Attachment 1.

Table H4-1: Light Source Summary

Luminaire Model Name and Description	Description	Nominal Power Per Lamp (Watts)	Luminous Output (Lumens)	IES file name
Ligman Lighting, Gandalf 10 Floodlight Asymmetrical, HST 400W, Model Number: 52034	Wall mounted floodlights	400	48,000	LM52034_REV2.IES
Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	Pole-mounted Street Lights, 2 lamps per pole	400	50,000	GMX40SXX5SF.IES
GE Lighting Systems Powr.Spot Floodlight, 1000 W MH, PSFA01M	Mast-mounted construction light, 4 lamps per mast	1,000	100,280	GE452779.IES



LEGEND

Lighting Orientation

Project Area (OPG-retained lands that encompass the DGR Project)

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE LAYOUT PLAN CONSTRUCTION LIGHTING

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE H3-1	
GIS	BC	9 Apr. 2010		
CHECK	MR	9 Apr. 2010		
REVIEW	AB	9 Apr. 2010		

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0 25 50 100

Metres

LEGEND

Lighting Orientation

Project Area (OPG-retained lands that encompass the DGR Project)

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE LAYOUT PLAN
OPERATIONS LIGHTING

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	9 Apr. 2010		
CHECK	MR	9 Apr. 2010		
REVIEW	AB	9 Apr. 2010		

FIGURE H3-2

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H5. SELECTED ECOLOGICAL RECEPTORS FOR LIGHT TRESPASS MEASUREMENTS AND PREDICTIONS

Seven locations were identified by the specialists completing the terrestrial assessment, as presented in the Terrestrial Environment TSD. These locations correspond to the locations used in the baseline noise measurement program. The measurement locations are identified in Table H5-1 and illustrated on Figure H1-1.

Table H5-1: Light Trespass Baseline Measurement Locations

Location ID	Location	Description of Receptor as Described in the Terrestrial Environment TSD	UTM Coordinates	
			Easting	Northing
ER1	Baie du Doré Provincially Significant Wetland	Marsh habitat for VEC species including common cattail, muskrat, yellow warbler, mallard, midland painted turtle, and northern leopard frog	455,811	4,909,026
ER2	Beach	Specialized habitat, potential habitat for VEC species including: mallard, midland painted turtle and bald eagle	453,906	4,909,396
ER3	Forest/adjacent to swamp	Habitat for VEC species, including: eastern white cedar, white-tailed deer, red-eyed vireo, wild turkey and yellow warbler (edge)	452,927	4,907,225
ER4	Forest	Habitat for VEC species including: eastern white cedar, white-tailed deer, red-eyed vireo, wild turkey and yellow warbler (edge)	453,495	4,907,560
ER5	Industrial barren/ adjacent to forest	Habitat for VEC species including: white-tailed deer, red-eyed vireo, wild turkey and meadow vole	453,694	4,908,341
ER6	Forest	Habitat for VEC species including: eastern white cedar, white-tailed deer, red-eyed vireo, wild turkey and yellow warbler (edge)	454,160	4,908,265
ER7	Mixed habitat – forest/cultural meadow/cultural barren	Habitat for VEC species including: eastern white cedar, white-tailed deer, red-eyed vireo, wild turkey, meadow vole, northern leopard frog, heal-all, and yellow warbler (edge)	453,986	4,907,747

H6. EXISTING LIGHT ENVIRONMENT

H6.1 STUDY METHODOLOGY

The baseline light trespass measurements were carried out using a Solar Light PMA2100 photometer, using the PMA2131 Scotopic Detector. This detector and photometer combination has a display resolution of 1 mlx. The equipment was calibrated by the manufacturer before the measurements were carried out. Additionally, field personnel checked the calibration by zeroing the photometer in the field before the measurements were carried out.

The measurements were carried out on the night of September 24, 2009. This date was chosen to provide the most accurate measurements of the artificial light sources uncontaminated by moonlight or hazy weather conditions or rain. The following conditions existed during the site visit:

- the moon was only 1/4 full;
- moonset occurred at around midnight, enabling readings uncontaminated by moonlight after that time; and
- weather conditions were clear and surfaces were dry.

The measurements were made at each ecological receptor location following best practices as per CIE publication 150:2003 [H1]. At each location, measurements were made on a vertical plane towards existing sources of light. Prior to the measurement program, the Bruce A and Bruce B Nuclear Generating Stations (Bruce A and Bruce B) and the Western Waste Management Facility (WWMF) were identified as the primary existing sources of light on-site. Other sources of light that were not identified prior to the site visit but were visible from particular receptors were also measured. When a group of sources could not be isolated and considered a point source, because of their number or their proximity to the measurement location, measurements were made in all semi-ordinate directions. Where no lights were visible, measurements were taken in the direction of Bruce A and B as well as the WWMF. Therefore, not all measurement locations have the same number of existing light measurements.

In addition, measurements were made horizontally at 1.65 m and/or 0 m above grade. Horizontal measurements can provide an indication of the cumulative effect of the light trespass from sources in all directions. Where the measurement at 1.65 m and 0 m did not differ, only one was recorded.

The minimum, maximum, and average illuminance, over a 10 second period, were recorded for every measurement location and direction. To ensure that field staff did not influence the recorded level, and to avoid shielding, personnel stood away from the detector during measurements.

H6.2 BASELINE LIGHT TRESPASS MEASUREMENT RESULTS

The following sections summarize the measurements at the ecological receptor locations.

H6.2.1 Location ER1

Light trespass levels at location ER1 are shown in Table H6.2.1-1. Measurement location ER1 is more than 1 km from Bruce A, with no nearby light sources.

Table H6.2.1-1: Illuminance Measurements at Location ER1

Light Source and Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 290°	12	17	16
Bruce B @ 250°	7	13	10
WWMF @ 245°	7	13	10
Measurement in a Horizontal Plane			
up @ 1.65 m	0	5	2
up @ 0 m	4	15	10

H6.2.2 Location ER2

Light trespass levels at location ER2 are shown in Table H6.2.2-1. Location ER2 is within 500 m of Bruce A, the associated switchyard, and other facilities with many light sources. Therefore, measurements were made in all semi-ordinate directions.

Table H6.2.2-1: Illuminance Measurements at Location ER2

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 30°	887	945	914
Bruce B @ 235°	136	158	149
WWMF @ 0°	1395	1456	1424
45°	887	945	914
90°	189	198	193
135°	309	328	319
180°	358	375	368
225°	176	189	182
270°	132	177	156
315°	912	963	937

Table H6.2.2-1: Illuminance Measurements at Location ER2 (continued)

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Horizontal Plane			
up @ 1.65 m	13	70	39
up @ 0 m	5	11	9

H6.2.3 Location ER3

Light trespass levels at location ER3 are shown in Table H6.2.3-1. Location ER3 is within a forested area, approximately 1 km from Bruce B, and more than 2 km from Bruce A. There were no visible light sources. To determine whether the low levels of existing light trespass could be attributed to the existing sky brightness, the vertical illuminance was measured in an open area a short distance from ER3.

Table H6.2.3-1: Illuminance Measurements at Location ER3

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 20°	0	0	0
Bruce B @ 280°	0	0	0
WWMF @ 60°	0	2	1
Measurements in a Horizontal Plane			
up @ 1.65 m	0	3	0
up @ 0 m	0	5	2
light trespass attributed to sky brightness	1	4	3

H6.2.4 Location ER4

Light trespass levels at location ER4 are shown in Table H6.2.4-1. As a result of the presence of sources in many directions, measurements were made in all semi-ordinate directions around the receptor. Dominant light sources were visible at approximately 40°, 75°, and 185° from north.

Table H6.2.4-1: Illuminance Measurements at Location ER4

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce B @ 265°	0	5	1
WWMF @ 30°	2	14	8
0°	N/A	N/A	2
45°	14	18	15
90°	0	14	2
135°	0	7	2
180°	14	27	22
225°	0	3	0
270°	0	3	1
315°	N/A	N/A	0
70°	16	19	18
20°	0	9	2
Measurement in a Horizontal Plane			
up @ 1.65 m	N/A	N/A	1

Note:
N/A Not applicable

H6.2.5 Location ER5

Light trespass levels at location ER5 are shown in Table H6.2.5-1. No lights were visible from Bruce B, or the WWMF. Other light sources such as those at the Heavy Water Plant were visible.

Table H6.2.5-1: Illuminance Measurements at Location ER5

Light Source and Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 30°	19	27	21
Bruce B @ 250°	1	10	4
WWMF @ 190°	0	9	4
Heavy Water Plant @ 320°	10	19	15

Table H6.2.5-1: Illuminance Measurements at Location ER5 (continued)

Light Source and Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Horizontal Plane			
up @ 1.65 m	N/A	N/A	6
up @ 0 m	2	12	7

Note:
N/A Not applicable

H6.2.6 Location ER6

Light trespass levels at location ER6 are shown in Table H6.2.6-1. No light sources were visible. The primary source of light was from sky brightness.

Table H6.2.6-1: Illuminance Measurements at Location ER6

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 340°	0	4	1
Bruce B @ 250°	0	2	0
WWMF @ 240°	N/A	N/A	0
Measurement in a Horizontal Plane			
up @ 1.65 m	0	3	1

Note:
N/A Not applicable

H6.2.7 Location ER7

Light trespass levels at location ER7 are shown in Table H6.2.7-1. Lights from the generating stations and the WWMF, as well as other construction and roadway lighting, were visible from this location.

Table H6.2.7-1: Illuminance Measurements at Location ER7

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
Measurement in a Vertical Plane			
Bruce A @ 18°	40	44	42
Bruce B @ 270°	65	69	67

Table H6.2.7-1: Illuminance Measurements at Location ER7 (continued)

Light Source And Orientation (degrees from North)	Minimum Illuminance (mlx)	Maximum Illuminance (mlx)	Average Illuminance (mlx)
WWMF @ 300°	79	84	82
Other Lights @ 110°	1	9	5

H7. PREDICTED LIGHT ENVIRONMENT

H7.1 STUDY METHODOLOGY

The change in light trespass at the ecological receptors was predicted using light trespass calculations. This calculation is specifically designed for light trespass attributed to large facilities. It uses the illuminance equations discussed in Section H2.2, source and receptor data, shielding of light rays by DGR Project structures, and interpolation of luminaire intensity distributions (based on manufacturer's IES files and the geometric configuration of the site and the receptors) to predict the cumulative illuminance at the ecological receptors. The software takes into consideration the following lighting and site configuration data:

- luminaire light intensity distributions;
- source locations in UTM coordinates;
- source elevations in metres above grade;
- source orientations in degrees from north;
- source vertical tilts in degrees from downwards;
- shielding of rays by buildings;
- reflection of operations phase light sources from building surfaces;
- receptor locations in UTM coordinates;
- receptor heights in metres above grade; and
- receptor orientations in degrees from north.

The source data listed above were determined from lighting designs provided in the DGR Project design and shown on Figure H3-1 and H3-2, manufacturer's information, and from discussion with the design team. The building specifications were determined from architectural drawings, as shown on Figure H3-2. The luminaires used at the DGR Project site are listed in Table H4-1. The manufacturer's data sheets and IES files can be found in Attachment 2. The orientations of the receptors were adjusted to determine the maximum illuminance attributed to DGR Project light sources during both the site preparation and construction phase, and the operations phase.

The following assumptions were made for the prediction of light trespass at the identified receptors:

- no light loss factor (LLF) was applied to the luminaire light intensities to ensure a conservative result;

- construction lighting and operations lighting were modelled separately - no overlapping period was considered;
- construction lights were modelled at their maximum height, 10 m above grade;
- construction lights were oriented towards the nearest building;
- construction light component lamps were oriented at ± 20° from the nominal orientation of the luminaire in degrees from north;
- construction light component lamps were tilted at ± 10° from the nominal tilt in degrees from downwards;
- no shielding because of buildings was applied in the site preparation and construction phase lighting predictions;
- pole mounted street lights were modelled at 10 m above grade;
- pole-mounted street light component lamps were oriented 90° and 270° from north for each pole;
- wall-mounted lights were modelled either 3 or 4 m above grade if above a man-door or roll-up door, respectively, or 6 m above grade if not located near a door;
- wall-mounted lights were tilted 45° from downwards;
- the reflectance coefficient, r, used to calculate illuminance at the receptors attributed to the reflection from the buildings, was assumed to be 0.5 for all building surfaces; and
- average illuminance on building surfaces were predicted in the centre of significant building walls based on operations phase light sources; these results were used to determine building surface luminance.

H7.2 RESULTS

The DGR construction and operation phases, as described in sections H3 and H4, were modelled to determine the bounding light trespass levels on the selected ecological receptors ER1 to ER7. Table H7.2-1 summarizes the predicted light levels, at the ecological receptor locations, compared to the highest measured value, for both the site preparation and construction, and operation phases. The receptor orientation is shown in degrees from north (° from N), and measured and predicted light trespass are shown in milliLux (mlx). Sample calculations are available in Attachment 3.

Table H7.2-1: Ecological Receptor Light Trespass Summary

Receptor ID	Existing		Site Preparation and Construction Phase			Operations Phase		
	Orientation (° from N)	Max Existing Level (mlx)	Orientation (° from N)	Max Predicted DGR Project-related Increase (mlx)	Max Predicted Level (mlx)	Orientation (° from N)	Max Predicted DGR Project-related Increase (mlx)	Max Predicted Level (mlx)
ER1	290	16	250	0.05	16.05	250	4	20
ER2	0	1,424	196	0	1,424	201	59	1,483
ER3	60	1	25	1	2	30	67	68
ER4	180	22	358	15	37	358	340	362
ER5	30	21	262	4	25	242	1,241	1,262
ER6	340	1	275	1	2	0	0	1
ER7	300	82	315	14	96	308	227	309

H8. REFERENCES

[H1] Commission Internationale l'Eclairage. 2003. *Guidelines on the Limitations of the Effects of Obtrusive Light from Outdoor Lighting Installations*. 150:2003.

[H2] Crawford, D. L. 2000. *Light Pollution, an Environmental Problem for Astronomy and for Mankind. Società Astronomica Italiana*. pp.11-40.

Attachment 1

Source Configurations

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Source ID	Description	UTM coordinates		Luminaire Type	IES Filename	Height Above Grade (m)	Lamp Orientation (° From N)	Lamp Tilt (° from down)
		Easting	Northing					
CL01a	Construction Lights	453423	4908336	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	155	55
CL01b	Construction Lights	453423	4908336	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	115	55
CL01c	Construction Lights	453423	4908336	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	155	35
CL01d	Construction Lights	453423	4908336	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	115	35
CL02a	Construction Lights	453463	4908294	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	320	55
CL02b	Construction Lights	453463	4908294	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	280	55
CL02c	Construction Lights	453463	4908294	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	320	35
CL02d	Construction Lights	453463	4908294	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	280	35
CL03a	Construction Lights	453444	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	232	55
CL03b	Construction Lights	453444	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	192	55
CL03c	Construction Lights	453444	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	232	35
CL03d	Construction Lights	453444	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	192	35
CL04a	Construction Lights	453479	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	211	55
CL04b	Construction Lights	453479	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	171	55
CL04c	Construction Lights	453479	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	211	35
CL04d	Construction Lights	453479	4908228	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	171	35
CL05a	Construction Lights	453523	4908202	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	272	55
CL05b	Construction Lights	453523	4908202	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	232	55
CL05c	Construction Lights	453523	4908202	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	272	35
CL05d	Construction Lights	453523	4908202	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	232	35
CL06a	Construction Lights	453514	4908160	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	328	55
CL06b	Construction Lights	453514	4908160	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	288	55
CL06c	Construction Lights	453514	4908160	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	328	35
CL06d	Construction Lights	453514	4908160	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	288	35
CL07a	Construction Lights	453471	4908179	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	7	55
CL07b	Construction Lights	453471	4908179	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	327	55
CL07c	Construction Lights	453471	4908179	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	7	35
CL07d	Construction Lights	453471	4908179	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	327	35
CL08a	Construction Lights	453430	4908182	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	47	55
CL08b	Construction Lights	453430	4908182	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	7	55
CL08c	Construction Lights	453430	4908182	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	47	35
CL08d	Construction Lights	453430	4908182	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	7	35
CL09a	Construction Lights	453370	4908207	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	83	55
CL09b	Construction Lights	453370	4908207	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	43	55
CL09c	Construction Lights	453370	4908207	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	83	35
CL09d	Construction Lights	453370	4908207	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	43	35
CL10a	Construction Lights	453364	4908238	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	124	55
CL10b	Construction Lights	453364	4908238	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	84	55
CL10c	Construction Lights	453364	4908238	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	124	35
CL10d	Construction Lights	453364	4908238	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	84	35
CL11a	Construction Lights	453402	4908253	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	217	55
CL11b	Construction Lights	453402	4908253	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	177	55
CL11c	Construction Lights	453402	4908253	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	217	35
CL11d	Construction Lights	453402	4908253	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	177	35
CL12a	Construction Lights	453391	4908302	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	220	55
CL12b	Construction Lights	453391	4908302	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	180	55

Source ID	Description	UTM coordinates		Luminaire Type	IES Filename	Height Above Grade (m)	Lamp Orientation (° From N)	Lamp Tilt (° from down)
		Easting	Northing					
CL12c	Construction Lights	453391	4908302	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	220	35
CL12d	Construction Lights	453391	4908302	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	180	35
CL13a	Construction Lights	453945	4908372	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	259	55
CL13b	Construction Lights	453945	4908372	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	219	55
CL13c	Construction Lights	453945	4908372	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	259	35
CL13d	Construction Lights	453945	4908372	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	219	35
CL14a	Construction Lights	453979	4908175	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top right	GE452779.IES	10	306	55
CL14b	Construction Lights	453979	4908175	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 top left	GE452779.IES	10	266	55
CL14c	Construction Lights	453979	4908175	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom right	GE452779.IES	10	306	35
CL14d	Construction Lights	453979	4908175	GE Powr-Spot Floodlight 1000W MH, PSFA01M***4**0, 4 bottom left	GE452779.IES	10	266	35

Source ID	Description	UTM coordinates		Luminaire Type	IES Filename	Height Above Grade (m)	Lamp Orientation (° From N)	Lamp Tilt (° from down)
		Easting	Northing					
PS01a	Pole-mounted street lights	453427	4908344	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS02a	Pole-mounted street lights	453448	4908277	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS03a	Pole-mounted street lights	453537	4908242	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS04a	Pole-mounted street lights	453536	4908139	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS05a	Pole-mounted street lights	453470	4908092	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS06a	Pole-mounted street lights	453477	4908042	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS07a	Pole-mounted street lights	453481	4907990	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS08a	Pole-mounted street lights	453382	4908166	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS09a	Pole-mounted street lights	453312	4908218	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS10a	Pole-mounted street lights	453374	4908309	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	90	0
PS01b	Pole-mounted street lights	453427	4908344	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS02b	Pole-mounted street lights	453448	4908277	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS03b	Pole-mounted street lights	453537	4908242	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS04b	Pole-mounted street lights	453536	4908139	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS05b	Pole-mounted street lights	453470	4908092	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS06b	Pole-mounted street lights	453477	4908042	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS07b	Pole-mounted street lights	453481	4907990	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS08b	Pole-mounted street lights	453382	4908166	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS09b	Pole-mounted street lights	453312	4908218	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
PS10b	Pole-mounted street lights	453374	4908309	Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS	GMX40SXX5SF.ies	10	270	0
WS01	Building-mounted floodlights	453389	4908251	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	6	354	45
WS02	Building-mounted floodlights	453436	4908220	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	4	33	45
WS03	Building-mounted floodlights	453483	4908212	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	6	85	45
WS04	Building-mounted floodlights	453505	4908179	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	6	123	45
WS05	Building-mounted floodlights	453466	4908190	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	3	213	45
WS06	Building-mounted floodlights	453446	4908184	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	4	123	45
WS07	Building-mounted floodlights	453419	4908195	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	4	213	45
WS08	Building-mounted floodlights	453379	4908237	Ligman Gandalf 10, M/N: 52034	LM52034_REV2.IES	6	303	45

Attachment 2

Manufacturer's Data

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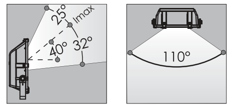
52031
(Gandalf 10)

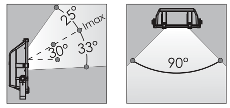
52031

HIT 250w. E40
20000 lm 11.3 kg.



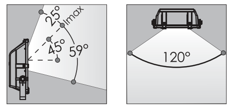
52032

HIT 400w. E40
32000 lm 13.0 kg.



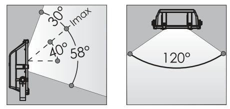
52033

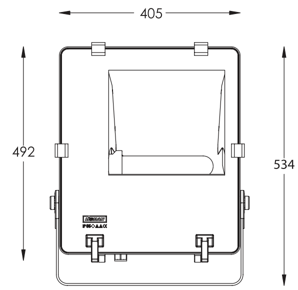
HST 250w. E40
27000 lm 11.3 kg.

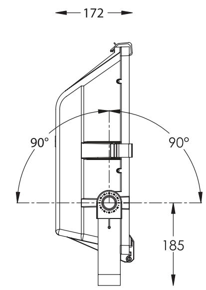


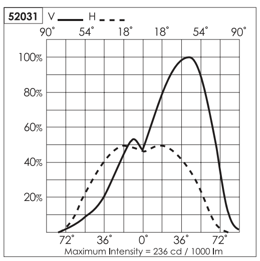
52034

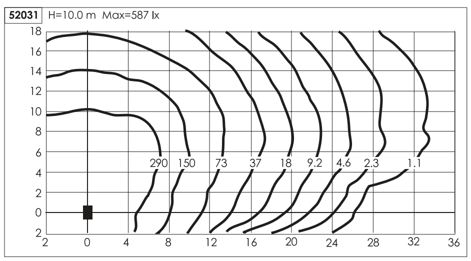
HST 400w. E40
48000 lm 13.0 kg.

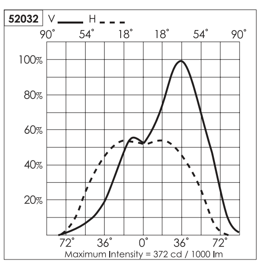


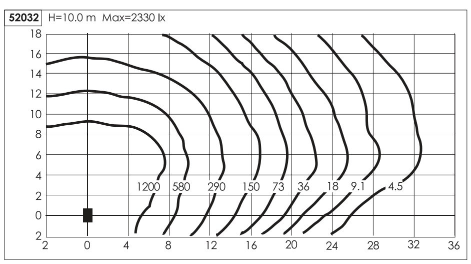












Wall-mounted Lights IES data for:

Ligman Lighting, Gandalf 10 Floodlight Asymmetrical, HST 400W, Model Number: 52034

```
IESNA:LM-63-1995
[TEST] 060204-1110
[MANUFAC] LIGMAN
[LUMCAT] 52034
[LUMINAIRE] Gandalf 10 floodlight asymmetrical
[LAMP] HST 400W / NAV-T 400W(SON-T) OSRAM
[BALLAST] VS NaHj 400 220V/ 50Hz
[OTHER] Ignitor GATA Z400 220-240V/50-60Hz
[OTHER] Vossloh Schwabe 50uf
[OTHER] Product Detail
[OTHER] Silver color cast aluminium body
[OTHER] Clear glass lens
[OTHER] Aluminium reflector asymmetrical
[OTHER] Test hole dia 0.2 m.
TILT=NONE
1  48000.0  1.000  37  19  1  2  0.235  0.260  0.000
1.0  1  440
        0.0         2.5         5.0         7.5        10.0        12.5        15.0
       17.5        20.0        22.5        25.0        27.5        30.0        32.5
       35.0        37.5        40.0        42.5        45.0        47.5        50.0
       52.5        55.0        57.5        60.0        62.5        65.0        67.5
       70.0        72.5        75.0        77.5        80.0        82.5        85.0
       87.5        90.0
        0.0        10.0        20.0        30.0        40.0        50.0        60.0
       70.0        80.0        90.0       100.0       110.0       120.0       130.0
      140.0       150.0       160.0       170.0       180.0
    11942.4     11472.0     11956.8     13070.4     12480.0     12196.8     12710.4
    13560.0     13041.6     14145.6     14731.2     15388.8     15283.2     16689.6
    16497.6     16022.4     16953.6     15998.4     16084.8     16622.4     16646.4
    16104.0     15163.2     15292.8     13934.4     13185.6     11400.0     11448.0
    10368.0     10536.0      8140.8      4814.4      3758.4      2414.4      1324.8
      604.8        62.4
    11942.4     11496.0     11380.8     12004.8     12532.8     12235.2     13238.4
    13041.6     13915.2     13617.6     14817.6     14625.6     15556.8     16296.0
    16632.0     16718.4     16646.4     16612.8     16478.4     16584.0     16459.2
    16689.6     16468.8     15830.4     14625.6     13348.8     12518.4     11860.8
    10454.4     10440.0      8937.6      5155.2      3787.2      2688.0      1444.8
      744.0        96.0
    11942.4     11764.8     12547.2     12499.2     12220.8     12811.2     12892.8
    13526.4     13872.0     14222.4     14673.6     15600.0     15873.6     16785.6
    16934.4     17524.8     17832.0     18033.6     18129.6     17846.4     17678.4
    18326.4     17587.2     17520.0     16512.0     15254.4     13953.6     13478.4
    12009.6     11304.0     10185.6      5654.4      3984.0      2803.2      1497.6
      686.4        86.4
    11942.4     12403.2     12249.6     10848.0     12451.2     13118.4     12710.4
    13152.0     13435.2     14294.4     14788.8     15379.2     16070.4     16838.4
    17203.2     17860.8     17985.6     18720.0     19104.0     18792.0     18696.0
    18259.2     17961.6     17875.2     16612.8     16022.4     14774.4     14116.8
    12537.6     10881.6      9859.2      6273.6      3552.0      2380.8      1310.4
      638.4       124.8
    11942.4     10982.4     11510.4     12758.4     11923.2     12979.2     12897.6
    13603.2     13152.0     13833.6     14102.4     14760.0     14956.8     15811.2
    16027.2     16454.4     16238.4     16641.6     16497.6     16411.2     15777.6
    15748.8     15220.8     14846.4     13958.4     13454.4     12441.6     11654.4
    10622.4      8433.6      6580.8      4704.0      3360.0      2342.4      1401.6
      936.0       595.2
    11942.4     12220.8     11683.2     12177.6     11894.4     12912.0     13008.0
```

Wall-mounted Lights IES data for:

Ligman Lighting, Gandalf 10 Floodlight Asymmetrical, HST 400W, Model Number: 52034

12619.2	13070.4	14059.2	13867.2	13992.0	13492.8	13785.6
14107.2	13564.8	13267.2	13238.4	12758.4	12129.6	11932.8
10896.0	10948.8	10430.4	10396.8	10104.0	9681.6	9288.0
8726.4	7022.4	5208.0	4089.6	3235.2	3134.4	2347.2
1800.0	1545.6					
11942.4	9849.6	12523.2	11212.8	12523.2	12532.8	11616.0
12892.8	12528.0	12739.2	13012.8	12696.0	12302.4	12259.2
11918.4	10857.6	10512.0	9998.4	9432.0	9086.4	8870.4
8956.8	8400.0	8217.6	8467.2	8457.6	7680.0	7276.8
7041.6	6105.6	5088.0	4022.4	3163.2	2937.6	2462.4
2059.2	1838.4					
11942.4	11894.4	11481.6	12451.2	11716.8	11803.2	12288.0
12878.4	12744.0	13344.0	12249.6	11808.0	11913.6	10617.6
10084.8	9182.4	8563.2	7876.8	7636.8	7089.6	7060.8
6739.2	6206.4	6072.0	6081.6	5241.6	4728.0	4540.8
3724.8	3340.8	3014.4	2625.6	2448.0	2256.0	1915.2
1564.8	1353.6					
11942.4	11563.2	11433.6	11774.4	11227.2	12129.6	12504.0
12700.8	12201.6	12604.8	11529.6	11097.6	10704.0	10128.0
9350.4	8452.8	7824.0	7521.6	6595.2	6220.8	5596.8
5500.8	4617.6	4286.4	3494.4	3153.6	2385.6	1790.4
1180.8	964.8	1046.4	1204.8	1262.4	1190.4	1176.0
1032.0	787.2					
11942.4	11683.2	12456.0	12076.8	11342.4	12057.6	12417.6
11836.8	11683.2	12120.0	12076.8	11467.2	10425.6	9768.0
8798.4	8126.4	7142.4	6916.8	6657.6	5956.8	5496.0
4704.0	4056.0	3595.2	2908.8	2304.0	1550.4	988.8
715.2	528.0	518.4	624.0	388.8	360.0	240.0
201.6	153.6					
11942.4	10584.0	12326.4	11764.8	11342.4	11673.6	11500.8
12129.6	11793.6	11361.6	11160.0	10497.6	10152.0	9043.2
8784.0	8342.4	7468.8	7017.6	6216.0	5683.2	4977.6
4305.6	3633.6	2774.4	1920.0	1392.0	816.0	523.2
388.8	336.0	393.6	412.8	427.2	403.2	364.8
350.4	384.0					
11942.4	11524.8	12340.8	11083.2	11697.6	11073.6	11880.0
11601.6	11990.4	11371.2	11064.0	10881.6	10176.0	9288.0
8736.0	8054.4	6609.6	5188.8	4132.8	2726.4	2092.8
1420.8	940.8	763.2	436.8	398.4	283.2	206.4
216.0	153.6	139.2	153.6	163.2	230.4	216.0
249.6	244.8					
11942.4	11817.6	11035.2	10876.8	11347.2	11510.4	12043.2
11779.2	11889.6	11640.0	11121.6	10464.0	9451.2	8020.8
5932.8	4483.2	3206.4	2505.6	1972.8	1488.0	1108.8
921.6	715.2	528.0	451.2	326.4	264.0	196.8
182.4	158.4	124.8	96.0	76.8	67.2	57.6
67.2	57.6					
11942.4	12264.0	11923.2	11712.0	11198.4	11553.6	11414.4
11870.4	11817.6	10915.2	9926.4	8683.2	6561.6	4972.8
4046.4	3446.4	2668.8	2260.8	1656.0	1257.6	960.0
806.4	595.2	456.0	331.2	288.0	273.6	182.4
172.8	139.2	96.0	76.8	76.8	48.0	57.6
38.4	57.6					
11942.4	11932.8	11856.0	11668.8	12081.6	11707.2	12038.4
11568.0	11577.6	9643.2	7948.8	6412.8	5179.2	4704.0
4075.2	3336.0	2750.4	2078.4	1713.6	1224.0	988.8
753.6	499.2	403.2	326.4	259.2	235.2	192.0
163.2	96.0	115.2	67.2	38.4	57.6	24.0

Wall-mounted Lights IES data for:

Ligman Lighting, Gandalf 10 Floodlight Asymmetrical, HST 400W, Model Number: 52034

19.2	9.6					
11942.4	11860.8	10171.2	11649.6	10963.2	11092.8	11596.8
12110.4	9763.2	8126.4	6648.0	5937.6	5208.0	4224.0
3715.2	2889.6	2352.0	1862.4	1464.0	1156.8	888.0
657.6	604.8	417.6	345.6	240.0	163.2	187.2
120.0	100.8	120.0	62.4	48.0	43.2	28.8
9.6	9.6					
11942.4	10444.8	11232.0	11616.0	12091.2	12086.4	10876.8
10915.2	9096.0	7516.8	5952.0	5544.0	4737.6	4358.4
3528.0	2596.8	2332.8	1622.4	1420.8	1128.0	724.8
667.2	532.8	403.2	321.6	259.2	182.4	177.6
115.2	96.0	86.4	67.2	52.8	43.2	19.2
19.2	4.8					
11942.4	11352.0	10876.8	10636.8	10896.0	11668.8	11894.4
10718.4	8409.6	6825.6	5860.8	5424.0	4723.2	3734.4
3288.0	2726.4	1929.6	1617.6	1300.8	1051.2	796.8
571.2	460.8	350.4	307.2	264.0	177.6	196.8
134.4	115.2	81.6	38.4	52.8	43.2	24.0
0.0	4.8					
11942.4	11145.6	12115.2	12278.4	11750.4	11150.4	12201.6
11006.4	8491.2	6787.2	5937.6	5184.0	4382.4	3840.0
3009.6	2481.6	1761.6	1444.8	1310.4	921.6	705.6
652.8	432.0	283.2	283.2	230.4	182.4	139.2
177.6	139.2	105.6	67.2	28.8	38.4	14.4
28.8	9.6					

Portable Construction Lights IES data for:

GE Lighting Systems Powr.Spot Floodlight, 1000 W MH, PSFA01M

```
IESNA:LM-63-2002
[TEST] 02101606 PUBLISHED CURVE CREATED
[TESTLAB] GE C&I, LIGHTING SYSTEMS
[ISSUEDATE] 10/16/2002
[MANUFAC] GE C&I, LIGHTING SYSTEMS - EAST FLAT ROCK, NC, USA
[_FILETYPE] RELATIVE
[SEARCH] FLOOD PSFA
[LUMINAIRE] POWR-SPOT
[DISTRIBUTION] 4 X 4
[LUMCAT] PSFA01M***4**0
[LAMP] 1; 1000W MH, CLEAR BT56, AXIAL
[LAMPCAT] GE MVR1000/U
[BALLAST]
[BALLASTCAT]
[OTHER] HSNG: CAST HOUSING  FABRICATED SHEET DOOR/COVER
[MORE] REFL: SEMI-SPEC SPUN ALUM
[MORE] ENCL: CLEAR SHEET GLASS
[MORE] ACSY:
[MORE] SOCKET POSITION: FIXED
[MORE] COMMENT:
[_ABSOLUTELUMENS] NA
[_LCS]
[_BUG]
[_SUPPLYVOLTAGE]
[_AVERAGEDFILES]
TILT=NONE
1 100280 100.2800 39 20 2 1 -1.6 0.0 0.0
1 1 1078
 -90 -85 -75 -65 -55 -45 -42.5 -37.5 -35 -32.5 -27.5 -25 -22.5 -17.5 -15 -12.5 -7.5 -
5 -2.5 0 2.5 5 7.5 12.5 15 17.5 22.5 25 27.5
 32.5 35 37.5 42.5 45 55 65 75 85 90
 0 2.5 5 7.5 12.5 15 17.5 22.5 25 27.5 32.5 35 37.5 42.5 45 55 65 75 85 90
 0 3 3 3 30 60 60 64 70 77 368 549 730 864 951 1038 1336 2074 2812 3344 3184 2298
1413 807 718 629 566 479 392 147 121 94 87 90 57
 3 3 3 0
 0 3 3 7 32 62 60 60 70 80 352 531 710 857 944 1031 1282 1910 2538 2956 2785 2062
1339 817 728 639 572 482 392 144 121 97 90 90 55
 7 3 3 0
 0 3 3 10 33 64 62 64 74 84 306 480 653 850 921 993 1190 1574 1958 2201 2077 1634
1190 829 737 644 569 475 380 141 120 99 90 90 54
 10 3 3 0
 0 3 3 9 33 64 64 67 77 87 261 429 596 844 899 954 1098 1239 1379 1446 1369 1205 1041
840 745 649 566 467 368 137 119 100 90 90 52
 10 3 3 0
 0 3 3 8 31 64 67 67 75 84 167 311 455 767 812 857 941 983 1024 1021 1001 949 897 750
685 619 455 358 261 127 112 97 90 88 49 10 3
 3 0
 0 3 3 7 30 64 67 67 74 80 144 254 365 641 720 798 879 906 934 931 912 866 820 705
629 552 383 298 213 117 106 95 90 87 47 10 3 3
 0
 0 3 3 6 28 62 67 67 72 77 121 198 275 516 628 740 817 830 844 840 824 783 743 660
572 485 311 238 164 107 100 94 90 86 44 9 3 3 0
 0 3 3 4 23 59 67 74 75 77 90 119 147 271 353 435 583 638 693 690 676 626 576 435 365
295 174 146 117 97 94 90 90 85 37 8 3 3 0
 0 3 3 3 20 57 65 75 76 77 87 104 121 196 251 306 425 470 516 516 502 465 427 320 269
219 142 126 109 95 94 92 87 84 33 7 3 3 0
```

Portable Construction Lights IES data for:

GE Lighting Systems Powr.Spot Floodlight, 1000 W MH, PSFA01M

0 3 3 3 18 51 64 77 77 77 84 89 94 121 149 177 268 303 338 341 328 303 278 204 174
144 110 105 100 94 94 94 84 77 30 7 3 3 0
0 3 3 3 13 39 50 67 70 74 80 82 84 90 95 100 114 119 124 127 124 122 121 114 109 104
97 95 94 90 89 87 74 64 23 7 3 3 0
0 3 3 3 10 33 44 60 65 70 77 80 82 87 90 94 104 108 112 112 110 110 109 105 103 100
95 94 92 89 85 82 65 57 20 7 3 3 0
0 3 3 3 9 28 37 54 60 67 74 77 80 84 85 87 94 97 100 97 97 97 97 97 97 97 94 92 90
87 82 77 57 49 18 6 3 3 0
0 3 3 3 8 18 23 37 45 54 67 72 77 80 82 84 87 89 90 87 87 89 90 94 94 94 90 87 84 70
65 60 44 32 13 4 3 3 0
0 3 3 3 7 13 19 31 37 44 57 64 67 74 77 80 87 90 89 87 89 90 90 88 87 85 80 77 71 59
54 46 31 23 10 3 3 3 0
0 3 3 3 3 7 9 14 17 19 24 27 28 32 33 37 44 47 47 47 45 44 44 44 44 41 36 33 30 23
20 18 13 10 7 3 3 3 0
0 0 3 3 3 7 7 7 7 7 7 7 7 7 7 8 9 10 10 10 10 10 9 8 7 7 7 7 7 7 7 7 7 7 3 3 3 0 0
0 0 3 3 3 3 3 3 3 3 3 3 4 6 7 7 7 7 5 3 5 7 7 7 7 6 4 3 3 3 3 3 3 3 3 3 3 0 0
0 0 0 3 3 3 3 3 3 3 3 3 3 3 3 3 1 0 0 0 0 0 1 3 3 3 3 3 3 3 3 3 3 3 3 3 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Powr•Spot® Floodlight

Put me in, Coach!

GE Powr•Spot® floodlight—the luminaire of choice for recreational, competitive and professional sports fields.

Versatility, corrosion-resistant finish, structural strength, integrity - Powr•Spot floodlight meets or exceeds specifications for the majority of general sports lighting applications.

From Youth League to Major League, Powr•Spot floodlight provides high quality lighting. Whether you're lighting a neighborhood tennis court, mountain ski slope, high school track, or building façade, the versatile, economical Powr•Spot floodlight is your best answer to the question, *"How are we going to light this field?"*

Do you want great features? Enclosed and filtered reflector with ALGLAS® finish? Choice of NEMA beam spreads? Built-in aiming? UL and CSA certification?

Do you want quality, superior optical performance, long life, and design flexibility? Turn to Powr•Spot—built to deliver—year after year.

GE Lighting Systems, Inc.

Powr•Spot® Floodlight

Applications

Recreational and competition sports fields at all levels. General floodlighting where the performance of reflectors of revolution are needed.

Features

- UL Listed
- CSA Certified or Listed by UL to Canadian standards.
- Suitable for wet locations.
- Die-cast aluminum housing with electrocoat gray paint finish inside and out provides high corrosion resistance and long ballast life.
- Standard zinc rich epoxy painted heavy-gauge angled steel trunnion provides structural strength and corrosion resistance, and eliminates need for cross-arm adapter. (Note: Optional straight trunnion available.)
- Large formed aluminum front access panel allows free access to ballast components and wiring so that wiring and maintenance can be done with optical in place.
- Lamp is isolated from ballast; ballast construction provides optimum heat transfer for cooler ballast operation, longer ballast life.
- Ballast access panel facilitates condensation draining which eliminates the need for "weep holes" in pole mounted units.
- Built-in cable and strain relief bushing withstands rough handling in field and eliminates the need for additional materials or accessories.
- Enclosed, gasketed and filtered reflector with ALGLAS® finish provides high corrosion resistance, superior optical performance and excellent lumen maintenance.
- Choice of heavy-duty (with heavy-gauge aluminum outer optical housing) or general purpose (NEMA) construction to fit a wide range of applications.
- Field convertible glare reduction is available which is an inexpensive solution to on-site glare problems.
- Choice of NEMA Types 1, 2, 3, 4, 5 or 6 beam spreads for maximum design flexibility.
- Built-in two-element rifle aiming sight, and aiming degree marker with re-aiming stop, makes the Powr•Spot easy to aim during daylight hours while on the ground, and can be maintained with optical in place.
- Remote ballast system available.
- Mogul base socket (E39 standard) means accurate lamp seating, and resists back-out due to vibration.
- Available with position oriented sockets for use with minimum tilt factor lamps.
- GE-designed and fabricated system provides single-vendor responsibility.
- Five-year fixture failure warranty assures highest quality construction and trouble-free performance.

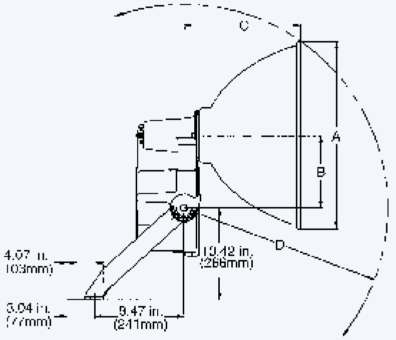
PSFA	51	M	0	A	2	3	HD0	P
Product ID. XXXX	Wattage XX	Light Source X	Voltage X	Ballast Type X	Trunnion Type X	NEMA Type Beam Spread Horiz x Vert X	Optical Reflector XXX	OPTIONS XXX
PSFA = Standard Powr•Spot Floodlight all opticals	**40**= 400 **75**= 750 **01**= 1000 **51**= 1500 **61**= 1650* *NOTE: Aiming restriction horizontal ±60°	**S** =HPS **M**=MH Standard: Lamp not included.	<u>60 Hz</u> **0** =120/208/240/277 Multivolt **1** =120 **2** =208 **3** =240 **4** =277 **5** =480 **D** =347 **T** =220 <u>50 Hz</u> **6** =220 **Y** =240	See Ballast and Photometric Selection Table **A** = Autoreg	**1** = Straight **2** = Angled **3** = Long (for SportStar™)	Select NEMA Type from Ballast and Photometric Selection Table. Example: **3** = 3X3	See Dimensions, and Ballast and Photometric Selection Table. **HD0**=Heavy Duty 20-in. (508mm) Diameter **GP0** =General Purpose 20-in. (508mm) diameter **HD2**=Heavy Duty 22-in. (559mm) diameter **GP2** =General Purpose 22-in. (559mm) diameter	**F**=Fusing (Not available with multivolt) **P**=Prewired with 6 ft (2M) #14/3

UL SP or cUL — The catalog numbers, options and modifications on this page are UL Listed unless otherwise noted.

Powr•Spot® Floodlight

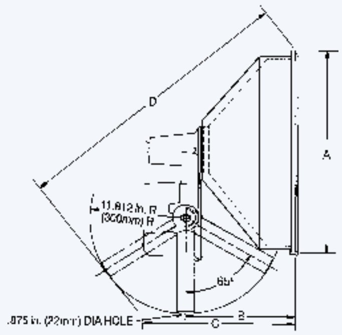
Dimensions

Optical	A Dia.	B	C	D
22-inch	23.000	7.969	12.625	23.050
559mm	584	203	321	586
20-inch	20.700	7.969	12.531	22.250
508mm	526	203	318	565



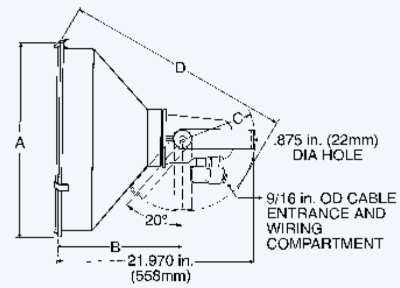
Angled Trunnion

Optical	A Dia.	B	C	D
22-inch	23.000	12.438	17.875	34.312
559mm	584	316	454	872
20-inch	20.700	12.575	18.000	31.312
508mm	526	319	457	795



Straight Trunnion

Optical	A Dia.	B	C Radius	D Min.
22-inch	23.000	13.000	9.000	26.500
559mm	584	330	229	673
20-inch	21.000	13.000	9.000	26.000
508mm	533	330	229	660



Remote Socket Holder

Wattage	Light Source	Ordering Number	Maximum Separation Optical and Ballast
400	HPS	**PSFC40S**	10 ft (3 M)
750	HPS	**PSFC75S**	10 ft (3 M)
400	MH	**PSFC40M**	Note*
1000/1500/1650	MH	**PSFC95M**	Note*

NOTE: *No limitation except voltage drop in the cable must not exceed five volts.
See "Components By Example" on page 117 for Reflector/Optical Ordering Logic.

Ballast and Photometric Selection Table

All light sources are clear unless otherwise indicated.

			Reflectors Listed by Diameter, Photometric Curve Number 35-XXXXXX, and Actual Beam Angle in degrees. NEMA Type Beam Spread (Horizontal X Vertical)					
			22-in. (559mm) Diameter		20-in. (508mm) Diameter			
Wattage	Light Source	Ballast Type All Voltages***	**1** = 1X1	**2** = 2X2	**3** = 3X3	**4** = 4X4	**5** = 5X5	**6** = 6X6
400	HPS	A	175663 (12X12.5)	175664 (20X20)	177613 (38X34)	179262 (51X47)	177464 (61X57)	177463 (80X72)
750**	HPS	A	N/A	179186 (19X20)	N/A	178177 (67X64)	178178 (77X76)	178179 (110X107)
1000	HPS	A	N/A	N/A	N/A	N/A	177610 (75X79)	N/A
400	MH	A	175951 (13X12)	175952 (27X27)	177468 (33X29)	179677 (60X48)	N/A	177466 (84X84)
1000	MH	A	N/A	176947 (25X25)*	450595 (45X41)	450522 (64X59)	450576 (104X89)	450527 (109X104)
1500***	MH	A	N/A	176947 (25X25)*	450598 (46X43)	179014	177461 (86X84)	177460 (111X109)
1650***	MH	A	N/A	176947 (25X25)*	450586 (53X49)	450577 (68X61)	450579 (106X96)	450561 (115X107)

NOTES: N/A = Not Available.
*Premium high performance 22-in. (559mm) NEMA Type 2 optical available – contact factory for photometric data.
**Multivolt not available.
***347 volts not available in multivolt 1500 or 1650 watt ratings.
For facade and indirect lighting applications with 1500 watt or greater, GELS recommends utilizing wire guard accessory WG-PSFO or WG-PSFHD2.

Data

Approximate Net Weight– 45-55 lbs(17-21 kgs)

Effective Projected Area – 22-in. (559mm) 3.0* sq ft max (0.28* sq M max)
–20 in. (508mm) 2.7 sq ft max (0.25 sq M max)

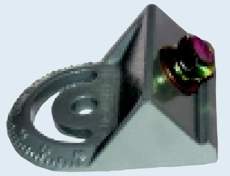
*When aimed 30° down

References

See GE Lighting Systems Product Catalog for *Component Ordering Number Logic, Explanation of Options and Other Terms Used,* and *Pole Selection.* See Catalog supplements for *Photometric Curves* and *Guide Form Specifications.*

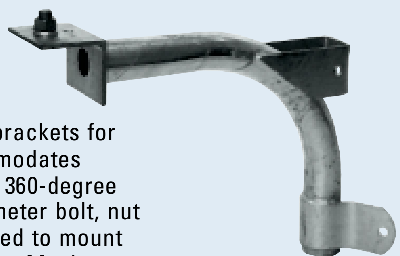
Powr•Spot® Floodlight Accessories

Cross Arm Adapter



- **CAA-001** — For 35-degree trunnion mounting with degree scale for preset aiming and 180-degree adjustment. (Not needed with angled trunnion version Powr•Spot)

Floodlight Bracket



- **FBSUWH19.5X2GV**
- **FBSUWH31.5X2GV**
- **FBSUWH48.5X2GV**

Galvanized steel upsweep brackets for vertical wood pole. Accommodates trunnion mounting with full 360-degree adjustment. A 3/4-inch diameter bolt, nut and lock washer are included to mount floodlight trunnion on flange. Maximum weight allowed is 90 lbs (41 kgs).

Spill Light and Glare Reduction System

- **EVGC-PS0** — External Visor only.
- **INGC-PS0** — Internal Louver only.
- **INGC-PS2** — Internal Louver only for 22-inch (559mm) optical (also known as "Bradley Louver").
- **IVGC-SP0** — Internal Louver and External Visor.

Polycarbonate Vandal Shield

- **LVS-PSFHD2 (400 watt maximum)** — NEMA 2, for use with 400-watt Heavy Duty 22-inch (559mm) optical only. Both vandal shield and top and side visor cannot be used at the same time.
- **LVS-PSF0 (400 watt maximum)** — For 20-inch (508mm) Heavy Duty and General Purpose opticals, all beam spreads, 400 watt maximum. Cannot use with Top and Side Visor (**TSVAL-PSF0**) or External Glare control Louvers (**EGCL-PS0N34, EGCL-PS0N56**).

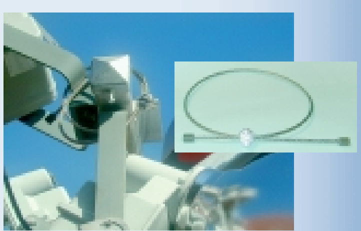
Mounting Bracket (for PE)

- **MB-PECTL** — With locking-type receptacle for use with photoelectric control (remove bracket to use with conduit).

Pole Top Adapter

- **PTADB-002** — Dark bronze, for 3-inch (76mm) OD pipe.
- **PTAGR-002** — Gray, for 3-inch (76mm) OD pipe.

Safety Cable



- **OSC-ULTS** — 4 feet (1.2 meters)
- **OSC-ULTS001** — 6 feet (1.8 meters)

Slipfitter Adapter

- **SFADB-001** — Dark bronze, cast aluminum slipfitter for 30-degree mounting of trunnion on 1-1/2 to 2-1/2 inch pipe (1.9 to 2.875 inch OD [48 to 73mm OD])*
- **SFAGR-001** — Gray, cast aluminum slipfitter for 30-degree mounting of trunnion on 1-1/2 to 2-1/2 inch pipe (1.9 to 2.875 inch OD [48 to 73mm OD])*

*Note: Use Pole Top Adapter (above) with angled trunnion version Powr•Spot

Wire Guard

- **WG-PSF0** — Fits 20-inch (508mm) Heavy Duty or General Purpose (Not Shown)
- **WG-PSFHD2** — Fits 22-inch (559mm) Heavy Duty or General Purpose (Not Shown)

The GE Five-Year Fixture Failure Warranty

The GE Five-Year Fixture Failure Warranty is a limited warranty which guarantees to you, the Purchaser for resale or for use in business, that the factory-installed electrical system (consisting of a core and coil ballast, ignitor, capacitor, socket, terminal board, photoelectric receptacle and wiring) inside GE HID lighting fixtures will be free from defects in material and workmanship for five (5) years from the date of manufacture, or five (5) years from the date the fixtures are shipped from the GE factory, whichever period you can substantiate. (Products bear a date code from which date of manufacture can be determined.) If any GE HID fixture fails to meet this warranty, GE will ship either a repaired or replacement part F.O.B. its factory. GE makes no warranty to those defined as consumers in the Magnuson-Moss Federal Trade Commission. For a copy of the complete warranty, contact GE Lighting Systems, Inc., Hendersonville, NC 28793-4506.

GE Lighting Systems, Inc.

PO Box 4506 Hendersonville, NC 28793-4506
www.ge-lightingsystems.com
(828) 693-2000 (828) 693-2112 FAX

LSP-1054F — 3/00(3M)GELS

Pole-Mounted Street Lights IES data for:
Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS

```
IESNA:LM-63-1995
[DATE]01/20/03
[TEST]ITL53279
[MANUFAC]COOPER LIGHTING - STREETWORKS
[LUMCAT]GMX40SXX5SF
[LUMINAIRE]400W HPS TYPE V AREA
[LAMP]400-WATT HPS CLEAR E-18
[_REFLECTOR]PREMIUM SEGMENTED REFLECTOR
[_REFRACTOR]CLEAR FLAT GLASS
[_SOCKETPOS]HORIZONTAL
[_LAMPLUMENS]50000
TILT=NONE
1 50000 1 37 21 1 1 1.026 1.0052 0
1 1 400
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30 32.5 35 37.5 40 42.5 45 47.5 50
 52.5 55 57.5 60 62.5 65 67.5 70 72.5 75 77.5 80 82.5 85 87.5 90
0 5 15 25 35 45 55 65 75 85 90 95 105 115 125 135 145 155 165 175 180
7331 7395 7358 7256 7108 6960 6830 6719 6627 6627 6719 7006 7228 6950 6627 6284
 5979 6062 6849 7959 8459 8931 7969 7682 6923 6821 7737 8959 8968 6775 3730
 1684 713 315 130 9 0
7331 7372 7344 7237 7099 6950 6812 6696 6599 6590 6677 6937 7094 6863 6585 6261
 5969 6043 6839 7816 8478 9037 7885 7913 6821 6576 7131 7742 8089 6441 3707
 1615 694 310 125 9 0
7331 7330 7325 7242 7117 6969 6826 6705 6599 6548 6580 6687 6664 6497 6409 6298
 6113 6108 6728 7279 8186 8556 7751 8260 7376 6927 7672 8459 8764 7325 4484
 2110 842 324 130 9 0
7331 7298 7302 7279 7186 7052 6881 6738 6627 6525 6548 6566 6400 6275 6229 6256
 6247 6215 6534 6622 7376 7223 7298 8380 7723 7783 8769 8769 9389 8880 6182
 3373 1055 338 139 9 0
7331 7298 7302 7321 7288 7186 7020 6858 6724 6631 6631 6562 6386 6261 6196 6205
 6247 6340 6349 6594 7274 6377 7663 8635 7140 7330 8542 7825 9968 8709 5914
 3272 1161 305 120 9 0
7331 7279 7293 7348 7376 7335 7210 7052 6895 6775 6710 6608 6465 6358 6307 6293
 6321 6418 6418 6645 6631 6627 7520 7936 7811 8505 8778 10000 11032 10046 7733
 4188 1606 333 130 9 0
7331 7270 7270 7330 7409 7427 7409 7302 7145 6978 6849 6724 6594 6506 6451 6423
 6418 6418 6474 6418 7307 6756 7163 9843 9329 9042 9838 10171 10088 8732 6363
 4040 1902 278 111 9 0
7331 7265 7242 7307 7367 7422 7432 7418 7344 7196 7034 6881 6738 6636 6562 6543
 6562 6585 6654 6756 7089 6890 7793 9204 8158 8390 9491 9875 9301 7547 5909
 3586 1805 342 125 9 0
7331 7261 7228 7265 7307 7316 7335 7325 7284 7210 7112 7006 6872 6751 6677 6640
 6677 6802 6964 7464 7626 7589 8783 8968 8519 8561 9084 10227 8908 7270 4646
 2827 1365 333 120 9 0
7331 7265 7223 7242 7242 7205 7177 7168 7136 7089 7062 7006 6909 6821 6756 6705
 6710 6798 7025 7270 7534 7631 8218 8700 8130 7626 7770 7871 6701 4308 2814
 1920 801 273 111 9 0
7331 7274 7219 7247 7237 7191 7163 7154 7108 7080 7034 6997 6904 6821 6765 6728
 6719 6765 6987 7154 7358 7487 7913 8154 7663 7089 7173 7459 6784 4387 3110
 2027 888 268 102 9 0
7331 7265 7223 7242 7242 7205 7177 7168 7136 7089 7062 7006 6909 6821 6756 6705
 6710 6798 7025 7270 7534 7631 8218 8700 8130 7626 7770 7871 6701 4308 2814
 1920 801 273 111 9 0
7331 7261 7228 7265 7307 7316 7335 7325 7284 7210 7112 7006 6872 6751 6677 6640
 6677 6802 6964 7464 7626 7589 8783 8968 8519 8561 9084 10227 8908 7270 4646
 2827 1365 333 120 9 0
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Pole-Mounted Street Lights IES data for:

Cooper Lighting Streetworks, Galleria Square GMA40S 400W HPS

7331 7265 7242 7307 7367 7422 7432 7418 7344 7196 7034 6881 6738 6636 6562 6543
6562 6585 6654 6756 7089 6890 7793 9204 8158 8390 9491 9875 9301 7547 5909
3586 1805 342 125 9 0
7331 7270 7270 7330 7409 7427 7409 7302 7145 6978 6849 6724 6594 6506 6451 6423
6418 6418 6474 6418 7307 6756 7163 9843 9329 9042 9838 10171 10088 8732 6363
4040 1902 278 111 9 0
7331 7279 7293 7348 7376 7335 7210 7052 6895 6775 6710 6608 6465 6358 6307 6293
6321 6418 6418 6645 6631 6627 7520 7936 7811 8505 8778 10000 11032 10046 7733
4188 1606 333 130 9 0
7331 7298 7302 7321 7288 7186 7020 6858 6724 6631 6631 6562 6386 6261 6196 6205
6247 6340 6349 6594 7274 6377 7663 8635 7140 7330 8542 7825 9968 8709 5914
3272 1161 305 120 9 0
7331 7298 7302 7279 7186 7052 6881 6738 6627 6525 6548 6566 6400 6275 6229 6256
6247 6215 6534 6622 7376 7223 7298 8380 7723 7783 8769 8769 9389 8880 6182
3373 1055 338 139 9 0
7331 7330 7325 7242 7117 6969 6826 6705 6599 6548 6580 6687 6664 6497 6409 6298
6113 6108 6728 7279 8186 8556 7751 8260 7376 6927 7672 8459 8764 7325 4484
2110 842 324 130 9 0
7331 7372 7344 7237 7099 6950 6812 6696 6599 6590 6677 6937 7094 6863 6585 6261
5969 6043 6839 7816 8478 9037 7885 7913 6821 6576 7131 7742 8089 6441 3707
1615 694 310 125 9 0
7331 7395 7358 7256 7108 6960 6830 6719 6627 6627 6719 7006 7228 6950 6627 6284
5979 6062 6849 7959 8459 8931 7969 7682 6923 6821 7737 8959 8968 6775 3730
1684 713 315 130 9 0

STREETWORKS® energy solutions

DESCRIPTION

The Galleria Area Light achieves superior light distribution by utilizing a seamless reflector system, making it the optimum choice for almost any small or medium area lighting application. U.L. listed for wet locations. CSA Certified.

Catalog #		Type
Project		
Comments		Date
Prepared by		

GS/GM/GL
GALLERIA SQUARE

100 - 1000W
Pulse Start Metal Halide
High Pressure Sodium
Metal Halide

ARCHITECTURAL AREA LUMINAIRE

SPECIFICATION FEATURES

A ... Housing
Formed aluminum housing with stamped reveal has interior-welded seams for structural integrity. Optional NEMA twistlock photocontrol. ANSI wattage/source label.

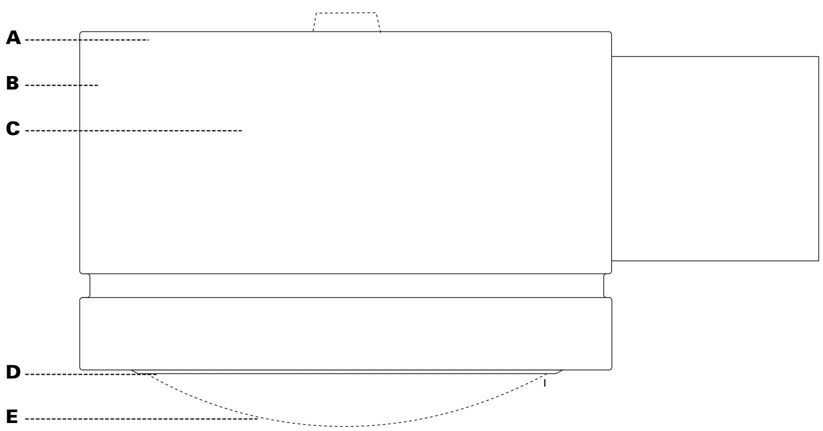
B ... Ballast
Ballast is hard-mounted to housing interior for cooler operation. Optional removable ballast tray.

C ... Reflector
Spun and stamped aluminum reflector in vertical lamp units, or hydroformed anodized aluminum reflector in horizontal lamp units.

D ... Door
Formed aluminum door has heavy-duty hinges, captive retaining screws and is finished in polyester powder coat. (Spider mount unit has steel door.)

E ... Lens
Convex tempered glass lens. Tempered flat glass available.

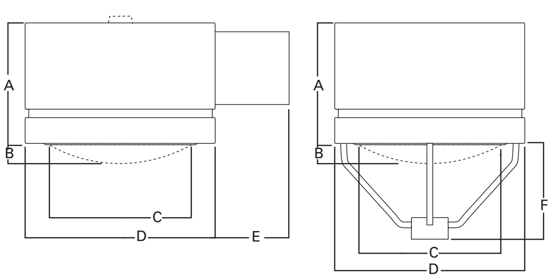
Finish
Standard polyester powder coat finish in bronze. For more color options see optional colors or consult your Streetworks representative for more information.



DARK SKY COMPLIANT FCO Full Cutoff

NOTE: In all flat glass configurations only.

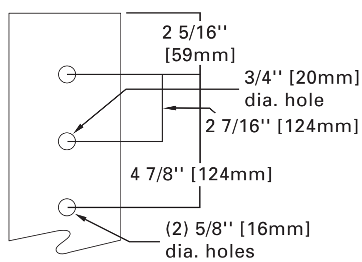
DIMENSIONS



NOTE: Top cap used on GM with 1000W flat glass vertically lamped optics only.

Fixture	A	B	C	D	E	F
GS (in.)	9 1/4	1 1/2	12 7/8	15 5/8	6 or 9	3 1/4
(mm)	235	38	327	397	152 or 229	337
GM (in.)	11	3 1/2	19 1/4	21 3/4	6 or 14	15 or 16
(mm)	279	89	480	552	152 or 356	381 or 406
GL (in.)	14 1/2	4 1/4	25 7/8	27	6 or 14	18 3/4 or 19 3/4
(mm)	368	108	657	686	152 or 356	476 or 502

DRILLING PATTERN



WATTAGES
GS 100-175
GM 175-1000
GL 400-1000

SHIPPING DATA
Approximate Net Weight:
GS 36 lbs. (16 kgs.)
GM 79 lbs. (36 kgs.)
GL 88 lbs. (40 kgs.)

ISO SYSTEMS CERTIFIED

ORDERING INFORMATION

Sample Number: GMA25SWWAR

Product Family
- **GS**=Galleria Square Small
- **GM**=Galleria Square Medium
- **GL**=Galleria Large Square

Mounting Method
- **A**= Arm Mount
- **B**= Spider Mount (2 2/8" - 3" O.D. Tenon)
- **C**= Spider Mount (3 1/2" O.D. Tenon)

Lamp Wattage [1]
Pulse Start Metal Halide
- **10**= 100W
- **15**= 150W
- **17**= 175W
- **25**= 250W
- **32**= 320W
- **35**= 350W
- **40**=400W
- **75**=750W[2]
- **91**=1000W[3]

High Pressure Sodium
- **10**=100W
- **15**=150W
- **25**=250W
- **40**=400W
- **91**=1000W

M (Probe Start) [4]
- **17**=175W
- **25**=250W
- **40**=400W
- **91**=1000W

Lamp Type [1]
- **P**=Pulse Start Metal Halide
- **S**=High Pressure Sodium
- **M**= Metal Halide

Ballast Type [1]
- **C**= CWI
- **H**= Reac. /HPF
- **K**= 10KV CWA
- **N**= Hi.Reac./NPF
- **P**= Hi. Reac./HPF
- **R**= Hi.Reac./NPF
- **W**= CWA
- **M**= Mag. Reg.

Voltage [1]
- **2**=120V
- **0**=208V
- **4**=240V
- **7**= 277V
- **8**= 480V
- **9**= 347V
- **W**= Multi-Tap wired 120V
- **G**= 120/240 wired 240V
- **V**= Multi-Tap wired 240V
- **N**= Multi-Tap wired 277V

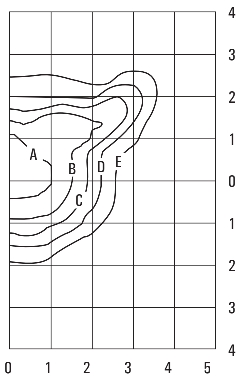
Distribution
- **1D**= Type I MCO
- **2D**= Type II MCO
- **3D**= Type III MCO
- **2S**= Type II MCO[5]
- **3S**=Type III MCO[5]
- **4S**=Type IV_MCO[5]
- **5S**=Type V MCO[5]
- **FT**=Forward Throw
- **AR**=Area Round
- **AS**=Area Square
- **3V**=Type III Vertical
- **RW**=Rectangular Wide
- **SL**=Spill Light[6] Eliminator

Options
- **1**=Single Fuse (120, 277 or 347V)
- **2**=Double Fuse, (208, 240, or 480V)
- **4**=Internal NEMA Photocontrol Receptacle
- **WH**= White
- **BK**= Black
- **BZ**= Bronze
- **AP**= Grey
- **DP**= Dark Platinum
- **GM**= Graphite Metallic
- **AIR**= Arm Included for Round Pole
- **AIS**= Arm included for Square Pole
- **H**= Plug-In Starter Receptacle[6]
- **T**= Removable Tray
- **CSR**= Color Reveal Stripe Red
- **CSB**= Color Reveal Stripe Blue
- **CSY**= Color Reveal Stripe Yellow
- **CSG**= Color Reveal Stripe Green
- **CSD**=Color Reveal Stripe Gold
- **CSS**=Color Reveal Stripe Silver
- **CSW**=Color Reveal Stripe White
- **F**=Flat Glass
- **B**=House Side Shield

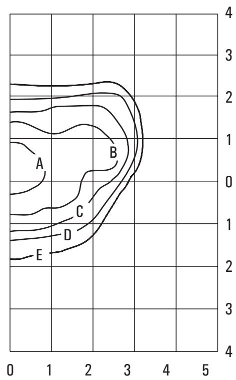
Accessories
- **MA1004**=14" Arm for Square Pole (Medium and Large Housing Only)[7]
- **MA1005**=6" Arm for Square Pole (Medium and Large Housing Only)
- **MA1007**= 14" Arm for Round Pole (Medium and Large Housing Only)[7]
- **MA1008**= 6" Arm for Round Pole (Medium and Large Housing Only)
- **MA1021**= 6" Arm for Square Pole (Small Housing Only)
- **MA1022**= 6" Arm for Round Pole (Small Housing Only)
- **MA1023**= 9" Arm for Square Pole (Small Housing Only)[7]
- **MA1024**= 9" Arm for Round Pole (Small Housing Only)[7]
- **MA1006**= Direct Mounting Kit for Square Pole
- **MA1009**= Direct Mounting Kit for Round Pole
- **WH**= White
- **BK**= Black
- **AP**= Grey
- **__**= Bronze
- **DP**= Dark Platinum
- **GM**=Graphite Metallic
- **GSMEXTHS**=Medium External House Side Shield (Specify Color)
- **GSLEXTHS**=Large External House Side Shield (Specify Color)
- **MA1060**=House Side Shield for GS - Field Installed
- **MA1061**=House Side Shield for GM - Field Installed
- **MA1062**=House Side Shield for GL - Field Installed
- **OA1209**=TufGuard Vandal Shield for GS
- **OA1210**=TufGuard Vandal Shield for GM
- **MA1207**=Mast Arm Adapter
- **MA1029**=Wall Bracket
- **OA1066**=Pipe Adapter

Notes:
1. Refer to the technical section for lamp/ballast voltage compatibility.
2. Pulse Start Metal Halide vertical mount only. Medium-based lamp for GS housing. Mogul-base on GM and GL housings.
3. 1000W GM with flat glass required BT-37 lamp and is not available in AS, RW, 3V distributions.
4. Probe Start Metal Halide available for non-US markets only (175-400W).
5. Requires reduced envelope lamps for 400 and 1000W MH. Not available in 1000 Watt HPS. Not Available in GL.
6. Not available in 1000W.
7. Required for mounting fixtures at 90 degree increments.

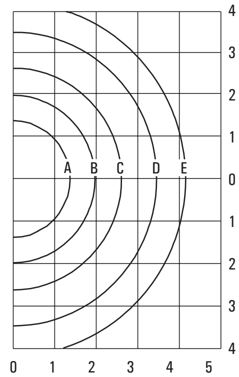
PHOTOMETRICS (Complete IES files available at www.cooperlighting.com)



GSA17M3DF.IES
175-Watt MH
14,000-Lumen Clear Lamp
Type III Flat Glass



GMA40S3DF.IES
400-Watt HPS
50,000-Lumen Clear Lamp
Type III Flat Glass

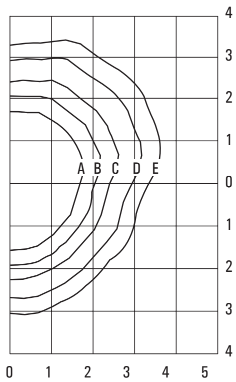


GMA91MARS.IES
1000-Watt MH
110,000-Lumen Clear Lamp
Area Round Sag Glass

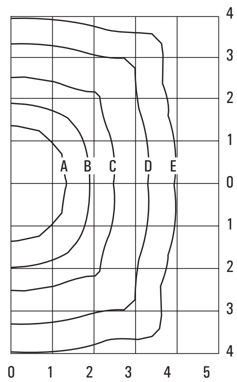
FOOTCANDLE TABLE

Select mounting height and read across for footcandle values of each isofootcandle line. Distance in units of mounting height.

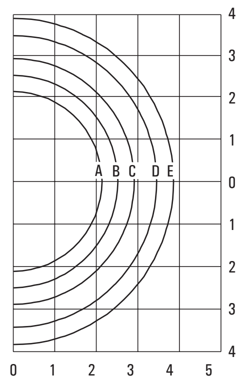
Mounting Height	Footcandle Values for Isofootcandle Lines A	B	C	D	E
GSA17M3DF.IES					
10'	11.25	4.50	2.25	1.16	0.45
15'	**5.00**	**2.00**	**1.00**	**0.50**	**0.25**
20'	2.80	1.12	0.56	0.28	0.19
GMA40S3DF.IES					
30'	**2.00**	**1.00**	**0.50**	**0.25**	**0.10**
35'	1.46	0.73	0.37	0.18	0.07
40'	1.12	0.56	0.28	0.14	0.06
GMA91MARS.IES					
30'	3.50	2.00	1.00	0.50	0.20
35'	2.60	0.73	0.37	0.18	0.07
40'	**2.00**	**1.00**	**0.50**	**0.20**	**0.10**



GMA91M3VF.IES
1000-Watt MH
110,000-Lumen Clear Lamp
Type III Vertical Flat Glass



GMA91MASS.IES
1000-Watt MH
110,000-Lumen Clear Lamp
Area Square Sag Glass



GMA91MARF.IES
1000-Watt MH
110,000-Lumen Clear Lamp
Area Round Flat Glass

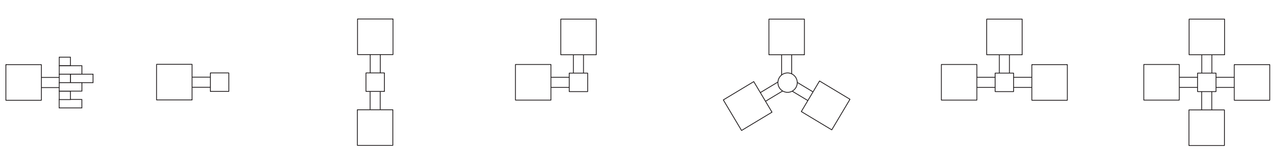
FOOTCANDLE TABLE

Select mounting height and read across for footcandle values of each isofootcandle line. Distance in units of mounting height.

Mounting Height	Footcandle Values for Isofootcandle Lines A	B	C	D	E
GMA91M3VF.IES / GMA91MASS.IES					
30'	3.50	2.00	1.00	0.50	0.20
35'	2.60	0.73	0.37	0.18	0.07
40'	**2.00**	**1.00**	**0.50**	**0.20**	**0.10**
GMA91MARF.IES					
30'	**2.00**	**1.00**	**0.50**	**0.25**	**0.10**
35'	1.46	0.73	0.37	0.18	0.07
40'	1.12	0.56	0.28	0.14	0.06

MOUNTING CONFIGURATIONS

Wall Mount | Arm Mount Single | Arm Mount 2 @ 180° | Arm Mount 2 @ 90° | Arm Mount 3 @ 120° (Round Pole Only) | Arm Mount 3 @ 90° | Arm Mount 4 @ 90°



E.P.A. TABLE

	DRILL PATTERN	SINGLE [W/Arm where applicable]	2 @ 180°	2 @ 90°	3 @ 90°	3 @ 120°	4 @ 90°
GSA [Arm Mount]	"M"	1.7	3.4	3.4	4.6	4.6	5.2
GMB [Spider Mount]	2 3/8" or 3"	1.04	n/a	n/a	n/a	n/a	n/a
GMA [Arm Mount]	"M"[1]	2.9	5.8	6.8	9.2	9.2	10.4
GMB [Spider Mount]	3"	2.22	n/a	n/a	n/a	n/a	n/a
GLA [Arm Mount]	"M"[1]	4.4	8.8	9.8	13.7	13.7	15.6
GLC [Spider Mount]	3" or 3 1/2"	3.7	n/a	n/a	n/a	n/a	n/a

NOTE: 1 Assumes 14" arm for 90° and 120° mounting configurations, 6" for all else.

Attachment 3

Sample Inputs and Outputs
Receptor ER4
Operations Phase

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Receptor Data

Receptor ID	UTM Coordinates		Height (m)	Orientation (° from N)	Tilt (° up from horizontal)	Direct Illuminance (lx)	Reflectance Illumination (lx)	Total Illuminance (lx)
	Easting	Northing						
ER4	453495	4907560	1.65	358	0	0.34	0.0042	0.34

Barrier Data

Barrier Name	Barrier Type	Barrier End-point UTM Coordinates (m)				Height (m)
		Start Point		End Point		
		Easting	Northing	Easting	Northing	
Bldg_Amenities	Building	453380	4908222	453372	4908211	3
Bldg_Amenities	Building	453372	4908211	453385	4908203	3
Bldg_Amenities	Building	453385	4908203	453392	4908214	3
Bldg_CollarHouse	Building	453467	4908208	453459	4908196	5
Bldg_CollarHouse	Building	453459	4908196	453468	4908190	5
Bldg_CollarHouse	Building	453468	4908190	453476	4908203	5
Bldg_CompressorRoom	Building	453422	4908228	453427	4908237	5.5
Bldg_CompressorRoom	Building	453427	4908237	453419	4908242	5.5
Bldg_ElecRoom	Building	453395	4908246	453399	4908252	5.5
Bldg_ElecRoom	Building	453399	4908252	453417	4908240	5.5
Bldg_HeadframeTop	Building	453381	4908236	453399	4908224	62.5
Bldg_HeadframeTop	Building	453399	4908224	453407	4908238	62.5
Bldg_HeadframeTop	Building	453407	4908238	453389	4908250	62.5
Bldg_HeadframeTop	Building	453389	4908250	453381	4908236	62.5
Bldg_HoistHouse	Building	453491	4908185	453505	4908206	11.5
Bldg_HoistHouse	Building	453505	4908206	453516	4908199	11.5
Bldg_HoistHouse	Building	453516	4908199	453503	4908177	11.5
Bldg_HoistHouse	Building	453503	4908177	453491	4908185	11.5
Bldg_Offices	Building	453386	4908233	453380	4908222	3
Bldg_VentShaft	Building	453468	4908208	453473	4908218	43
Bldg_VentShaft	Building	453473	4908218	453482	4908212	43
Bldg_VentShaft	Building	453482	4908212	453476	4908203	43
Bldg_WastePackageLower	Building	453440	4908215	453457	4908204	16
Bldg_WastePackageLower	Building	453457	4908204	453443	4908182	16
Bldg_WastePackageLower	Building	453443	4908182	453426	4908193	16
Bldg_WastePackageStorage	Building	453400	4908209	453397	4908204	3
Bldg_WastePackageStorage	Building	453397	4908204	453412	4908195	3
Bldg_WastePackageStorage	Building	453412	4908195	453415	4908199	3
Bldg_WastePackageUpper	Building	453407	4908237	453441	4908216	20
Bldg_WastePackageUpper	Building	453441	4908216	453426	4908192	20
Bldg_WastePackageUpper	Building	453426	4908192	453392	4908214	20

Barrier Data

Barrier Name	Barrier Type	Barrier End-point UTM Coordinates (m)				Height (m)
		Start Point		End Point		
		Easting	Northing	Easting	Northing	
Bldg_ExhaustFans	Building	453497	4908166	453502	4908174	3
Bldg_ExhaustFans	Building	453502	4908174	453508	4908170	3
Bldg_ExhaustFans	Building	453508	4908170	453503	4908162	3
Bldg_ExhaustFans	Building	453503	4908162	453497	4908166	3
Bldg_IntakeFans	Building	453360	4908266	453366	4908262	3
Bldg_IntakeFans	Building	453366	4908262	453360	4908253	3
Bldg_IntakeFans	Building	453360	4908253	453354	4908257	3
Bldg_IntakeFans	Building	453354	4908257	453360	4908266	3
Bldg_MainShaftTower	Building	453386	4908233	453395	4908246	62.5
Bldg_MainShaftTower	Building	453395	4908246	453408	4908238	62.5
Bldg_MainShaftTower	Building	453408	4908238	453399	4908224	62.5
Bldg_MainShaftTower	Building	453399	4908224	453386	4908233	62.5
Bldg_Amenities	Building	453392	4908214	453380	4908222	3
Bldg_CollarHouse	Building	453476	4908203	453467	4908208	5
Bldg_CompressorRoom	Building	453419	4908242	453413	4908234	5.5
Bldg_CompressorRoom	Building	453413	4908234	453422	4908228	5.5
Bldg_ElecRoom	Building	453417	4908240	453413	4908234	5.5
Bldg_ElecRoom	Building	453413	4908234	453395	4908246	5.5
Bldg_GenSet	Building	453435	4908343	453452	4908333	0
Bldg_GenSet	Building	453452	4908333	453447	4908324	0
Bldg_GenSet	Building	453447	4908324	453430	4908335	0
Bldg_GenSet	Building	453430	4908335	453435	4908343	0
Bldg_Offices	Building	453380	4908222	453392	4908214	3
Bldg_Offices	Building	453392	4908214	453399	4908224	3
Bldg_Offices	Building	453399	4908224	453386	4908233	3
Bldg_VentShaft	Building	453476	4908203	453468	4908208	43
Bldg_WastePackageLower	Building	453426	4908193	453440	4908215	16
Bldg_WastePackageStorage	Building	453415	4908199	453400	4908209	3
Bldg_WastePackageUpper	Building	453392	4908214	453407	4908237	20
Waste_RockPile	Rock Pile	453688	4908267	453737	4908367	15
Waste_RockPile	Rock Pile	453737	4908367	453792	4908384	15
Waste_RockPile	Rock Pile	453792	4908384	453866	4908370	15
Waste_RockPile	Rock Pile	453866	4908370	453906	4908346	15
Waste_RockPile	Rock Pile	453906	4908346	453940	4908187	15
Waste_RockPile	Rock Pile	453940	4908187	453931	4908163	15
Waste_RockPile	Rock Pile	453931	4908163	453857	4908161	15
Waste_RockPile	Rock Pile	453857	4908161	453786	4908161	15

Barrier Data

Barrier Name	Barrier Type	Barrier End-point UTM Coordinates (m)				Height (m)
		Start Point		End Point		
		Easting	Northing	Easting	Northing	
Waste_RockPile	Rock Pile	453786	4908161	453764	4908168	15
Waste_RockPile	Rock Pile	453764	4908168	453688	4908226	15
Waste_RockPile	Rock Pile	453688	4908226	453684	4908249	15
Waste_RockPile	Rock Pile	453684	4908249	453688	4908267	15

Illuminance

Source Number	Direct Illuminance (lx)
PS01a	0.0E+00
PS02a	0.0E+00
PS03a	1.6E-02
PS04a	2.2E-02
PS05a	2.0E-02
PS06a	3.2E-02
PS07a	4.3E-02
PS08a	2.2E-04
PS09a	2.9E-05
PS10a	0.0E+00
PS01b	0.0E+00
PS02b	0.0E+00
PS03b	2.6E-03
PS04b	3.9E-03
PS05b	2.6E-02
PS06b	3.1E-02
PS07b	4.0E-02
PS08b	1.9E-02
PS09b	1.5E-02
PS10b	0.0E+00
WS01	0.0E+00
WS02	0.0E+00
WS03	5.0E-04
WS04	1.4E-02
WS05	3.2E-02
WS06	1.9E-02
WS07	2.6E-02
WS08	1.1E-04

Reflection Data

Surface Name	Orientation (° from N.)	Surface End-point UTM Coordinates (m)				Height (m)	Illuminance of Surface (lx)	Reflectivity Coefficient	Receptor Illuminance (lx)
		Start Point		End Point					
		Easting	Northing	Easting	Northing				
Bldg_Amenities	303	453380	4908222	453372	4908211	3	2.41	0.5	0.0E+00
Bldg_Amenities	213	453372	4908211	453385	4908203	3	7.40	0.5	2.1E-04
Bldg_Amenities	123	453385	4908203	453392	4908214	3	3.33	0.5	7.7E-05
Bldg_CollarHouse	303	453467	4908208	453459	4908196	5	3.08	0.5	0.0E+00
Bldg_CollarHouse	213	453459	4908196	453468	4908190	5	14.51	0.5	4.9E-04
Bldg_CollarHouse	123	453468	4908190	453476	4908203	5	1.62	0.5	6.8E-05
Bldg_CompressorRoom	123	453422	4908228	453427	4908237	5.5	6.50	0.5	1.9E-04
Bldg_CompressorRoom	33	453427	4908237	453419	4908242	5.5	5.27	0.5	0.0E+00
Bldg_ElecRoom	303	453395	4908246	453399	4908252	5.5	5.69	0.5	0.0E+00
Bldg_ElecRoom	33	453399	4908252	453417	4908240	5.5	5.27	0.5	0.0E+00
Bldg_HeadframeTop	213	453381	4908236	453399	4908224	62.5	1.76	0.5	1.4E-03
Bldg_HeadframeTop	123	453399	4908224	453407	4908238	62.5	1.76	0.5	9.8E-04
Bldg_HeadframeTop	33	453407	4908238	453389	4908250	62.5	1.76	0.5	0.0E+00
Bldg_HeadframeTop	303	453389	4908250	453381	4908236	62.5	1.76	0.5	0.0E+00
Bldg_HoistHouse	303	453491	4908185	453505	4908206	11.5	14.77	0.5	0.0E+00
Bldg_HoistHouse	33	453505	4908206	453516	4908199	11.5	3.61	0.5	0.0E+00
Bldg_HoistHouse	123	453516	4908199	453503	4908177	11.5	2.37	0.5	4.1E-04
Bldg_HoistHouse	213	453503	4908177	453491	4908185	11.5	4.57	0.5	4.3E-04
Bldg_Offices	303	453386	4908233	453380	4908222	3	2.41	0.5	0.0E+00
Bldg_VentShaft	303	453468	4908208	453473	4908218	43	2.99	0.5	0.0E+00
Bldg_VentShaft	33	453473	4908218	453482	4908212	43	2.45	0.5	0.0E+00
Bldg_VentShaft	123	453482	4908212	453476	4908203	43	2.02	0.5	5.1E-04
Bldg_WastePackageLower	33	453440	4908215	453457	4908204	16	3.07	0.5	0.0E+00
Bldg_WastePackageLower	123	453457	4908204	453443	4908182	16	9.37	0.5	2.4E-03
Bldg_WastePackageLower	213	453443	4908182	453426	4908193	16	3.77	0.5	7.3E-04
Bldg_WastePackageStorage	303	453400	4908209	453397	4908204	3	3.77	0.5	0.0E+00
Bldg_WastePackageStorage	213	453397	4908204	453412	4908195	3	3.77	0.5	0.0E+00
Bldg_WastePackageStorage	123	453412	4908195	453415	4908199	3	3.77	0.5	0.0E+00
Bldg_WastePackageUpper	33	453407	4908237	453441	4908216	20	4.17	0.5	2.1E-03
Bldg_WastePackageUpper	123	453441	4908216	453426	4908192	20	9.37	0.5	2.7E-03
Bldg_WastePackageUpper	213	453426	4908192	453392	4908214	20	4.10	0.5	1.7E-03

APPENDIX I: VIBRATIONS ASSESSMENT

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I1. VIBRATIONS ASSESSMENT

The following ground vibration impact assessment forms part of the Atmospheric Environment TSD in support of the construction of a Deep Geologic Repository (DGR) at the Bruce nuclear site, in the Municipality of Kincardine, for the Nuclear Waste Management Organization (NWMO) on behalf of Ontario Power Generation (OPG). This impact assessment specifically assesses the peak ground vibration levels that could be generated from the site as a result of controlled blasting operations necessary for the excavation of shafts and an underground storage facility. This ground vibration impact assessment describes the following:

- summarizes the extent to which controlled blasting would be required during the site preparation and construction phase;
- reviews existing provincial and federal guidelines for the assessment of environmental effects from blasting;
- reviews potential sensitive receptors around the DGR Project site;
- predicts potential ground vibration levels generated from the controlled blasting operations; and
- provides recommendations for the control of ground vibration effects.

I2. METHODS

The following steps were used to assess the effects of energy released from the DGR Project in the form of ground vibrations from blasting operations:

- identify key sensitive receptors within and around the DGR site that may be affected by the ground vibrations;
- predict how the blasting activities will affect the key receptors using numerical models and empirical data;
- determine the potential vibration effects from the DGR Project by applying the established assessment measures to the predicted effects on the key indicators; and
- identify suitable mitigation and/or monitoring for any impacts.

The vibration assessment describes the effects of ground vibrations from rock blasting operations at the DGR site.

I3. BEDROCK EXCAVATION OPERATIONS

Figure I3-1 shows the Project Area and the locations of the receptors within the Bruce nuclear site. Bedrock excavation by means of controlled blasting is anticipated for a main access shaft, a ventilation shaft and the underground repository, the locations of which are shown on Figure I3-2. The main shaft would be excavated to a diameter of 7.85 m and a nominal depth of 720 m. The ventilation shaft would be excavated to a diameter of 6.2 m and a nominal depth of 745 m. The underground repository would consist of a number of parallel rooms excavated at a nominal depth of 680 m below ground surface with each room measuring about 8.6 m × 7.0 m in cross section.

Controlled blasting operations for shaft sinking and underground development would consist of 4 m rounds blasting four times per day for a daily production of approximately 2,090 tonnes.

Explosives would consist primarily of ANFO (ammonium nitrate and fuel oil), while emulsion blends would be used in wet holes. As a result of the more confined blasting associated with shaft sinking and horizontal underground development, the explosive weights are expected to range between about 1.4 to 2.0 kg/m³. Explosive weights per blast hole would vary between about 10 and 20 kg depending on the diameter of the blast hole being used.

The bedrock surface is situated approximately 10 to 20 m below ground surface. The bedrock to be excavated for the shafts would consist of an initial sequence of sub-horizontally interbedded dolostone and shale followed by a shale sequence and finally an argillaceous limestone. The underground repository rooms would be excavated within the sub-horizontally bedded argillaceous limestone. A more detailed description of the general overburden and bedrock conditions within the Project Area can be found in the Preliminary Safety Report [I1].

I4. GROUND VIBRATION GUIDELINES

Ground vibration guidelines or regulations typically established for blasting sites to prevent damage to adjacent facilities or structures generally range from 12.5 mm/s (rounded up to 13 mm/s on Figure I4-1) to 50 mm/s, depending on the dominant frequency of the ground vibration [I2;I3]. Exceeding these levels does not in itself imply that damage would or has occurred but only increases the potential that damage might occur. Ground vibration limits for stronger materials, such as concrete, may be set as high as 150 to 200 mm/s, while peak ground vibration levels of 300 to 600 mm/s are required to create micro-cracks or open existing discontinuities in bedrock [I4]. While the ground vibration velocity is considered the best indicator of the damage potential from ground vibrations, the frequency of the vibration must also be considered. Figure I4-1 shows a frequency based safe level blasting criteria produced by the U.S. Bureau of Mines, which is based on comprehensive studies carried out over a 40-year period [I5]. The results of these studies are used by many U.S. and Canadian jurisdictions to define blasting limit values.

0 0.5 1 2

Kilometres

LEGEND

- Ecological Receptor
- Human Health Receptor
- Noise Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

RECEPTORS IN THE SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	19 May. 2010		
CHECK	MR	19 May. 2010		
REVIEW	AB	19 May. 2010		

FIGURE I3-1

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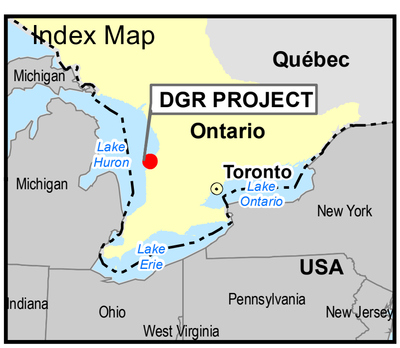

LEGEND

- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Stormwater Management System
- Soils and Rock Stockpiles

REFERENCE

Base Data Provided by 4DM, Nov 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

0 125 250 500
Metres

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

RECEPTORS IN THE PROJECT AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	AB	16 Mar. 2010	**FIGURE I3-2**	
GIS	BC	22 Apr. 2010		
CHECK	KC	22 Apr. 2010		
REVIEW	AB	22 Apr. 2010		

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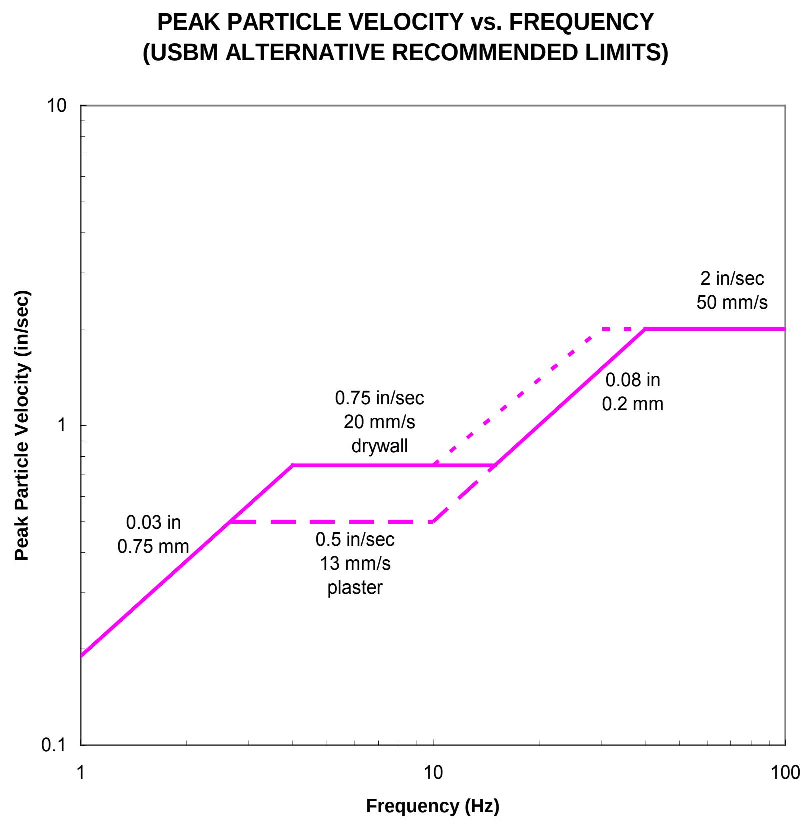

Source: [I2]
Notes:

a The Curve above is the 'Siskind Curve' developed by David Siskind from the U.S Bureau of Mines in 1980 (USBM). Another modified curve was adopted by the Office of Surface Mine (OSM) in 1983 which is the small dotted line (between 11 to 30 Hz).

b USBM RI 8507 (solid and large dashed line)
OSM Regulations (small dashed line)

Figure I4-1: U.S. Bureau of Mines Safe Blasting Ground Vibration Criteria

Ontario Provincial Standard Specification (OPSS) 120 [I6] entitled "General Specification for the Use of Explosives" provides maximum peak particle velocity ground vibration limits for structures and pipelines, as well as fresh concrete and grout, as outlined in Table I4-1.

Table I4-1: OPSS 120 Maximum Peak Particle Velocity Values

Element	Frequency (Hz)	PPV (mm/s)
Structures and pipelines	<40 >40	20 50
Concrete and grout <72 hours from placement	NA	10

OPSS 120 [I6] also provides a comprehensive list of requirements for blast design and submission requirements by the blasting contractor including but not limited to details on pre-blast surveys, test blast protocols and details on equipment and materials.

Ground and air vibration effects produced at private structures adjacent to surface or underground mining operations are subject to guidelines contained in Noise Pollution Control (NPC) publication 119 of the Model Municipal Noise Control By-Law, dated August, 1978 [I3], published by the Ontario Ministry of Environment. Under conditions where monitoring of the blasting operations is routinely carried out the ground and air vibration guideline limits at the nearest structure off the quarry or mine property are 12.5 mm/s and 128 dBL, respectively. NPC 119 [I3] tends to be more restrictive with ground vibration limits as it takes into account the annoyance of ground vibrations from blasting attributed to the length of time a quarry or mine may be in operation compared to a construction project. Quarry and mine blast ground vibrations can also have lower dominant frequencies compared to smaller construction blast vibrations and thus tend to become more noticeable to the occupants of adjacent structures. It is expected that the blasting required for the underground facilities for the DGR Project would produce ground vibrations with characteristics similar to mine blasts (i.e., lower dominant frequencies compared to surface construction blasts).

Fisheries and Oceans Canada (DFO) has established a set of guidelines for the use of explosives in or near Canadian fisheries waters [I7]. These guidelines set out that “No explosive may be used that produces or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during egg incubation”. Under conditions where these guidelines could not be met the proponent would be required to prepare a mitigative plan outlining additional procedures for protecting fish and their habitat. It is worth noting that this guideline limit only applies during spawning season and only at spawning beds. The DFO guidelines also set out an underwater overpressure limit of 100 kPa at fish habitat. The underwater overpressure limit only tends to become a measurable indicator when blasting or explosives are used within the water body itself. No blasting is expected to occur in any body of water on or around the DGR Project site.

For the purposes of the assessment, a peak particle velocity ground vibration limit of 13 mm/s has been assumed at receptors of concern within the Bruce nuclear site, including the Project Area. These receptors are discussed in Section I5.

I5. GROUND VIBRATION RECEPTOR LOCATIONS

A ground vibration receptor is a location where measurements or predictions of vibration levels are made.

Ground vibration intensity decays with distance from its source, regardless of its initial magnitude, as a result of geometric spreading and natural damping. The closest receptors to the vibration source would therefore generally experience or be exposed to the highest vibration levels and therefore could be considered to be at greatest risk. The impacts ground vibrations have on a particular receptor are determined by the magnitude of the vibration, its dominant frequency, the receptors construction and its overall condition.

Sensitive receptors have been identified within the Project Area as well as within and outside the Bruce Nuclear site. The minimum distances between the identified sensitive receptor and the closest shaft and the underground facility has also been identified. The distances quoted to the underground facility include both the horizontal and vertical components. All distances are approximate.

The following sensitive physical receptors to ground vibrations produced by controlled blasting operations have been identified and are shown on Figures I3-1 and I3-2: and summarized in Table I5-1.

Table I5-1: Physical Receptors Sensitive to Ground Vibrations

Sensitive Receptor	Minimum Distance to Shaft (m)	Minimum Distance to Underground Facility (m)	Vibration Limit (mm/s)
Hydro One substation	550	900	OPG – 13
Bruce B transformers and switchyards	1,200	1,200	OPG – 13
WWMF propane storage tanks	300	650	OPG – 13
Bruce Power office building	800	900	OPG – 13
Bruce nuclear site security entrance building (Main gate)	1,100	725	OPG – 13
WWMF dry storage facility	300	650	OPG – 13
Bruce A transformers and switchyards	700	900	OPG – 13
CO_2 storage facility @ WWMF	225	650	OPG – 13

The following ecological receptors, as shown on Figure I3-1 and summarized in Table I5-2, have been identified by the terrestrial environment specialists and are described in the Terrestrial Environment TSD.

Table I5-2: Ecological Receptors Sensitive to Ground Vibrations

Sensitive Receptor	Minimum Distance to Shaft (m)	Minimum Distance to Underground Facility (m)	Vibration Limit (mm/s)
ER1, Baie du Doré Provincially Significant Wetland, northeast of Bruce nuclear site	2,600	2,500	—
ER2, beach north of Project Area	1,250	1,400	DFO – 13 at spawning bed
ER3, forest southwest of Project Area	1,100	1,050	—
ER4, forest within Project Area	700	700	—
ER5, industrial barren within Project Area	225	650	—

Table I5-2: Ecological Receptors Sensitive to Ground Vibrations (continued)

Sensitive Receptor	Minimum Distance to Shaft (m)	Minimum Distance to Underground Facility (m)	Vibration Limit (mm/s)
ER6, forest northeast of Project Area	750	725	—
ER7, forest/meadow within Project Area	700	700	—
Shoreline of Lake Huron west of the Project Area	1,000	1,200	DFO – 13 at spawning bed
South Railway Ditch bisecting Project Area and Bruce nuclear site	150	650	DFO – 13 at spawning bed

Note:
— Not applicable.

Residential receptors have also been identified outside the Bruce nuclear site as shown on Figure I3-1 and summarized in Table I5-3.

Table I5-3: Residential Receptors Sensitive to Ground Vibrations

Sensitive Receptor	Minimum Distance to Shaft (m)	Minimum Distance to Underground Facility (m)	Vibration Limit
R1, residence south of Bruce nuclear site	3,000	2,850	NPC 119, 12.5 mm/s, 128 dBL
R2, residence on Baie du Doré north of Bruce nuclear site	2,600	2,500	NPC 119, 12.5 mm/s, 128 dBL
R3, residence on shore of Lake Huron south of Bruce nuclear site	3,200	3,100	NPC 119, 12.5 mm/s, 128 dBL

The closest receptors to the shaft excavations would be the CO_2 storage facility, the WWWF dry storage and propane storage locations, ER5 and the South Railway Ditch at distances of 150 to 300 m. The South Railway Ditch can be excluded as a sensitive receptor in the event that there are no spawning beds identified or blasting does not occur within the upper portions of the shafts during the spawning season should spawning depressions be identified. The closest sensitive receptors to the underground facility would be the same as those for the shaft except the minimum distance would increase to 650 m.

I6. PREDICTION OF PEAK GROUND VIBRATION LEVELS

The rate at which the ground vibration effects decay from the site are dependent upon site specifics, such as depth of overburden and type and characteristics of the bedrock. Predictive modelling of ground vibrations from blasting and construction operations utilize cube root Scaled Distance equations, which incorporate both the distance and input energy or explosive weight per delay parameters. Scaled Distance equations can be expressed as:

$$PPV = K\left(\frac{D}{W^{0.33}}\right)^{-e}$$

PPV = peak ground vibration level (mm/s)
K & e = site specific constants
D = distance between blast and receptor (m)
W = maximum explosive weight per delay period (kg)

Blast vibration Scaled Distance equations were estimated for a specific site using blast data based on the Bruce B tunnel excavation (Lukajic, B and Dupak, D.D., 1985).

Prediction of maximum ground vibrations can be calculated based on the following upper bound equation for typical blast data [I8], which takes into account differing rock conditions and blast procedures. The Scaled Distance equation developed from the blasting operations for the Bruce B excavation site based on a 95% confidence interval regression line was:

$$PPV = 2438\left(\frac{D}{W^{0.33}}\right)^{-1.65}$$

PPV = peak particle velocity (mm/s)
D = as defined above
W = as defined above

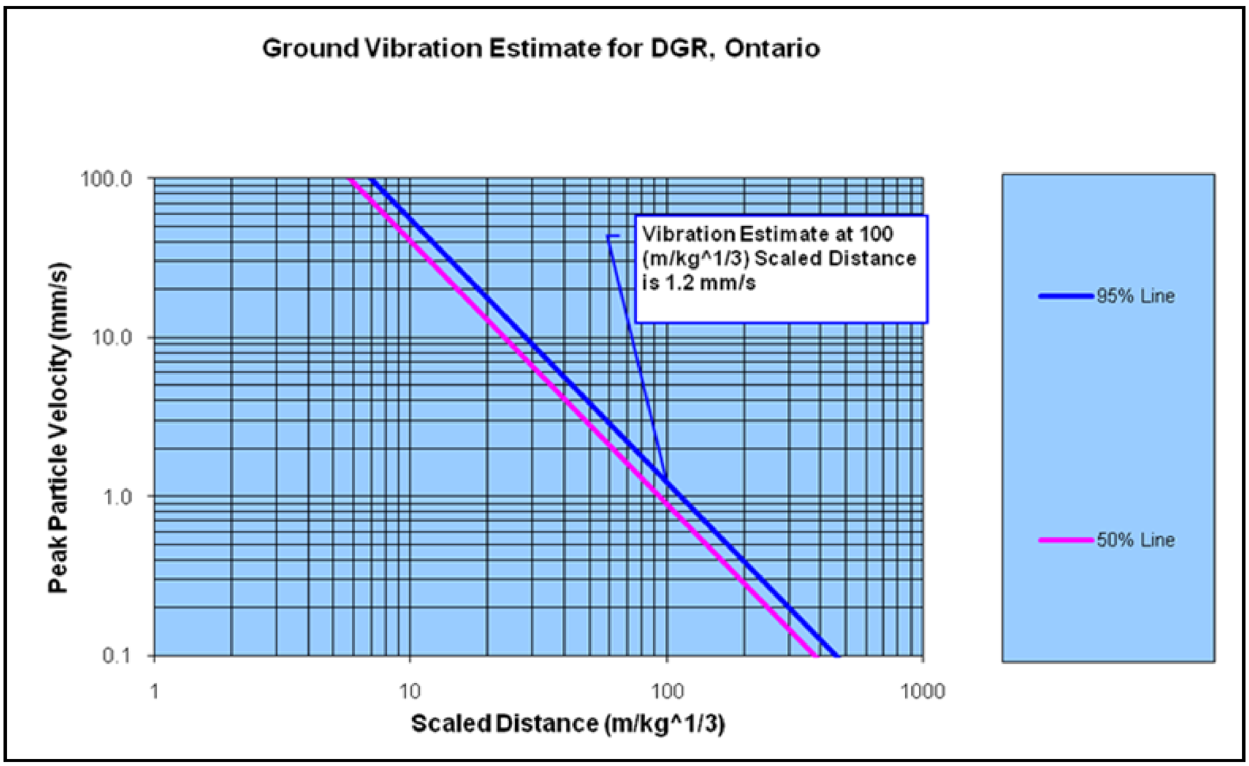

Figure I6-1: Vibration Scaled Distance Estimate Based on Bruce B Tunnel Excavation

Charge weights per delay have a direct effect on the peak particle velocity. Working on the assumption of a maximum vibration limit of 13 mm/s allows the calculation of theoretical maximum charge weights. For a receptor at 150 m away from the blast source, the maximum charge weight per delay would be 250 kg to maintain the 13 mm/s vibration limit. On Figure I6-1 above for a scaled distance of $(100\ m/kg)^{1/3}$ (532 m receptor distance and 150 kg charge weight per delay) the estimated peak particle velocity is 1.2 mm/s.

These theoretical maximum allowable explosive weights should easily be met considering they are greater than the maximum explosive weight per blast hole, as discussed in Section I3. While 112 kg per delay would be reasonable for shaft sinking, the maximum explosive weight per delay period for an entire development round would not be expected to exceed about 150 kg.

Table I6-1 summarizes the predicted maximum ground vibration levels that could be experienced at each of the sensitive receptors identified in Section I5, assuming maximum explosive weights of 112 and 150 kg per delay period during shaft sinking and underground development respectively.

Table I6-1: Predicted Peak Ground Vibration Levels

Receptor	Maximum Ground Vibration During Shaft Sinking (mm/s)	Maximum Ground Vibration During Underground Development (mm/s)
Hydro One substation	1.0	0.5
Bruce B transformers and switchyards	0.3	0.3
WWMF propane storage tanks	2.7	0.9
Bruce Power office building	0.5	0.5
Bruce nuclear site security entrance building (Main gate)	0.3	0.7
WWMF dry storage facility	2.7	0.9
Bruce A transformers and switchyards	0.5	0.5
CO_2 storage facility @ WWMF	4.3	0.9
ER1, Baie du Doré Provincially Significant Wetland, northeast of Bruce nuclear site	<0.3	<0.3
ER2, beach north of Project Area	0.3	<0.3
ER3, forest southwest of Project Area	0.3	0.4
ER4, forest within Project Area	0.7	0.8
ER5, industrial barren within Project Area	4.3	0.9
ER6, forest northeast of Project Area	0.6	0.7
ER7, forest/meadow within Project Area	0.7	0.8
Shoreline of Lake Huron west of the Project Area	0.4	0.3

Table I6-1: Predicted Peak Ground Vibration Levels (continued)

Receptor	Maximum Ground Vibration During Shaft Sinking (mm/s)	Maximum Ground Vibration During Underground Development (mm/s)
South Railway Ditch bisecting Project Area and Bruce nuclear site at closest point (150 m)	8.4	0.9
R1, residence south of Bruce nuclear site	<0.3	<0.3
R2, residence on Baie du Doré north of Bruce nuclear site	<0.3	<0.3
R3, residence on shore of Lake Huron south of Bruce nuclear site	<0.3	<0.3

The ground vibration estimate for a charge weight of 100 kg per delay at a receptor located 1,000 m away is 0.34 mm/s as shown on Figure I6-2.

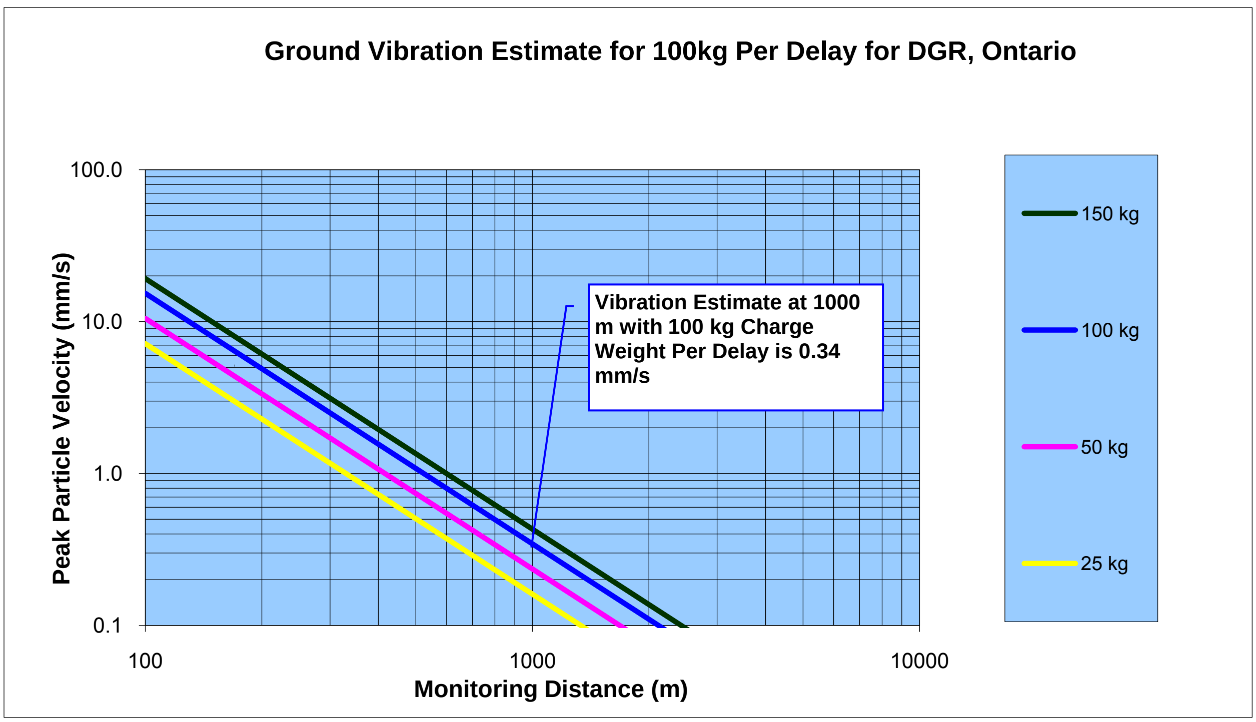

Figure I6-2: Ground Vibration Estimate Curve for 100 Kg Per Delay for the DGR Site

The ground vibration estimate for a charge weight of 150 kg per delay at a receptor located 1,000 m away is 0.43 mm/s as shown in Figure I6-3.

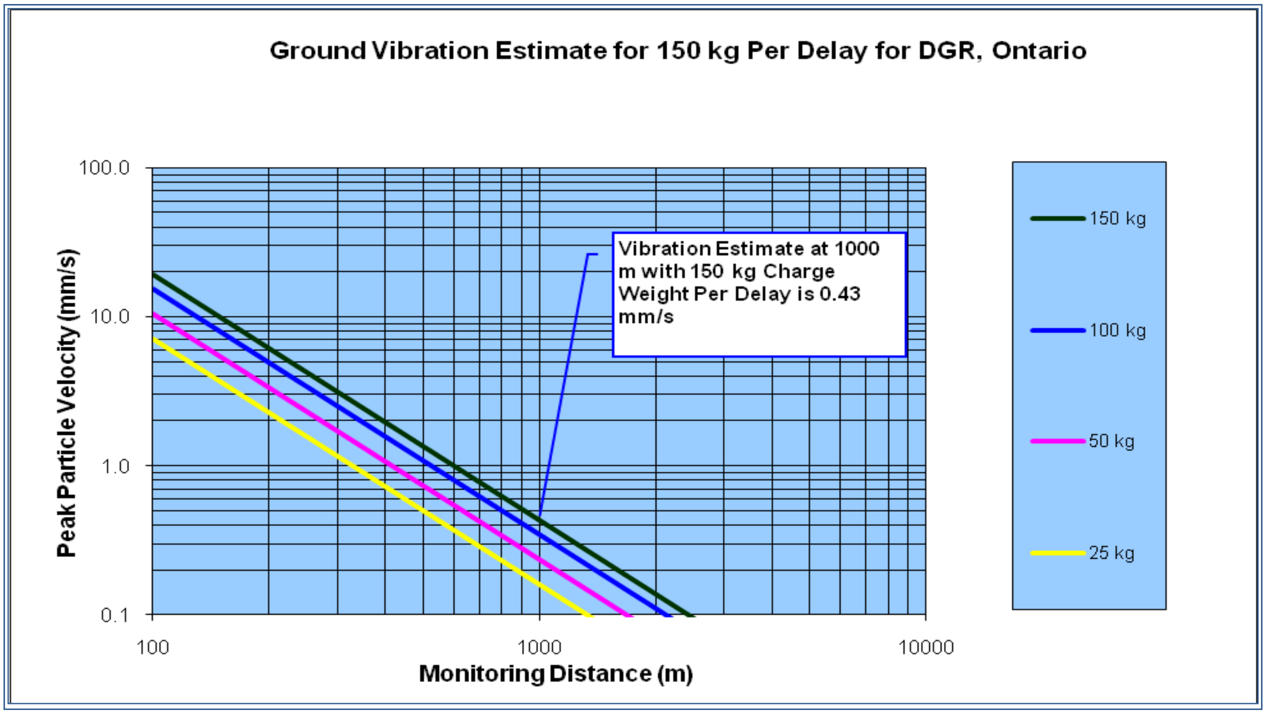

Figure I6-3: Ground Vibration Estimate Curve for 150 Kg Per Delay for the DGR Site

I7. PREDICTION OF AIR VIBRATION LEVELS

Air vibrations, or airblast, is a pressure wave traveling through the air produced by the direct action of the explosive on air or the indirect action of a confining material subjected to explosive loading. Air vibrations from surface blasting operations consist primarily of acoustic energy below 20 Hz, where human hearing is less acute [I5], while noise is that portion of the spectrum of the air vibration lying within the audible range from 20 to 20000 Hz. It is the lower frequency component (below 20 Hz) of air vibration, which is less audible, that is of interest as it is often the source of secondary rattling and shaking within a structure. For the purposes of this report, air vibration is measured as decibels in the Linear or Unweighted mode (dBL).

Air vibrations attenuate from a blast site at a slower rate than with ground vibrations. The distribution of air vibration energy from a blast is also influenced by the current weather conditions during the blast. For example, wind can increase down-wind levels by 10 to 15 dBL [I9]. Low cloud ceilings and temperature inversions also contribute to air vibrations propagating further than would typically be the case. Other factors influencing air vibration distribution from a blast include the length of collar and type of stemming material, differences in explosive types and variations in burden distance.

The rate at which air vibrations decay or attenuate from a blast site can be expressed by the Scaled Distance, which is defined as:

$$SD = \frac{D}{\sqrt[3]{W}}$$

where:

SD = Scaled Distance

D = distance (m) between the blast and receptor

W = maximum weight of explosive (kg) detonated per delay period

Depending on the degree of confinement of the explosive, predicted maximum air vibrations would fall within the bounds of the following two equations [I8]:

$P = 20\log_{10}[(SD)^{-1.1}] + 170.75$ (based on an average burial of explosives)

$P = 20\log_{10}[0.1(SD)^{-1.1}] + 170.75$ (based on explosive burial designed for air vibration suppression)

where:

P = peak air pressure (dBL)

SD = Scaled Distance ($ft/lb^{0.33}$)

Based on experience working at dozens of surface mines and quarries, the air vibration levels from the DGR Project site are expected to fall within the limits of these two equations. An average between these two equations is included in Table I7-1, which represents the air vibration levels predicted for this site.

Table I7-1 summarizes the predicted peak air vibration levels that could be experienced at each of the sensitive receptors assuming maximum explosive weights of 112 and 150 kg per delay period during shaft sinking and underground development respectively.

Table I7-1: Predicted Peak Air Vibration Levels

Receptor	Peak Air Vibration During Shaft Sinking (dBL)	Peak Air Vibration During Underground Development (dBL)
Hydro One substation	111	107
Bruce B transformers and switchyards	103	104
WWMF propane storage tanks	116	110
Bruce Power office building	107	107

Table I7-1: Predicted Peak Air Vibration Levels (continued)

Receptor	Peak Air Vibration During Shaft Sinking (dBL)	Peak Air Vibration During Underground Development (dBL)
Bruce nuclear site security entrance building (Main gate)	104	109
WWMF dry storage facility	116	110
Bruce A transformers and switchyards	108	107
CO_2 storage facility @ WWMF	119	110
ER1, Baie du Doré Provincially Significant Wetland, northeast of Bruce nuclear site	96	97
ER2, beach north of Project Area	103	103
ER3, forest southwest of Project Area	104	105
ER4, forest within Project Area	108	109
ER5, industrial barren within Project Area	119	110
ER6, forest northeast of Project Area	108	109
ER7, forest/meadow within Project Area	108	109
Shoreline of Lake Huron west of the Project Area	105	104
South Railway Ditch bisecting Project Area and Bruce nuclear site at closest point (150 m)	123	110
R1, residence south of Bruce nuclear site	94	96
R2, residence on Baie du Doré north of Bruce nuclear site	96	97
R3, residence on shore of Lake Huron south of Bruce nuclear site	94	95

Working on the assumption of a maximum air vibration limit of 128 dBL allows the calculation of theoretical maximum charge weights. For a receptor at 150 m away from the blast source, the maximum charge weight per delay would be 530 kg to maintain the 128 dBL air vibration limit. As the total weight of explosive for an entire development round would not exceed about 400 kg, the maximum explosive weight per delay period would not be expected to exceed about 150 kg.

I8. CONCLUSIONS

Based on the modelling of ground vibration (Section I6), all predictions at the defined receptors (Section I5) meet the applicable limits described in Section I4. For air vibrations, all the predictions presented in Section I7 meet the maximum air vibration limit of 128 dBL. Although there will be no effects with respect to vibration criteria, vibration can have an indirect effect on ecological receptors. These effects are assessed in the Aquatic and Terrestrial Environment TSDs.

I9. FOLLOW-UP RECOMMENDATIONS

It is understood that as a minimum blasting preparation, design and implementation would take place in accordance with the appropriate requirements, for example NPC 119 [I3]. In addition, the following actions are recommended:

- The initial series of regular production blasts shall be monitored at varying distances from each blast to characterize the site specific ground vibration attenuation rates. This would entail establishing monitoring stations between the blast site and adjacent receptors during the initial series of shaft blasts. The site specific attenuation data developed during this monitoring period should then be used to better define ground vibration effects at the closest sensitive receptors.
- Subsequent routine monitoring of all blasting operations should be carried out in the vicinity of the closest receptors to the proposed blasting operations. As extraction continues within the shaft and underground development, the actual monitoring locations should be routinely and regularly reviewed so that the closest receptors are always being monitored for ground vibration effects.
- A communication program should be implemented to keep neighbours informed of the status of activity. During blasting near surface, blasting should take place during daylight hours.

I9. REFERENCES

[I1] Ontario Power Generation (OPG). 2011. *Deep Geologic Repository for Low and Intermediate Level Waste - Preliminary Safety Report*. 00216-REP-01320-355682 R000.

[I2] Siskind, D. E., Stagg, M. S. 2000. *Blast Vibration Damage Assessment Study and Report.* Prepared for the Miami-Dade County Blasting Task Force.

[I3] Ministry of Environment, 1978. *Model Municipal Noise Control By-Law*. Final Report.

[I4] Keil, L. D., Burgess, A. S., Nielson, N. M., and A. Koropatrick. 1977. *Blast Vibration Monitoring of Rock Excavation*. Canadian Geotechnical Journal, Volume 14.

[I5] Siskind, D. E., Stagg, M. S., Kopp, J. W., and C.H. Dowding. 1980. *Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting*, U.S.B.M. Report RI8507.

[I6] Ontario Provincial Standard Specification. 2008. *General Specification for the Use of Explosives*. Metric OPSS 120.

[I7] Wright, D. G., and G.E. Hopky. 1998. *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters.* Canadian Technical Report of Fisheries and Aquatic Sciences 2107. Fisheries and Oceans Canada.

[I8] International Society of Explosives Engineers (ISEE). 1998. *Blaster's Handbook*, 17th Edition.

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APPENDIX J: PREDICTIONS USED BY OTHER TSDS AND DISCIPLINES

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J1. PREDICTIONS USED BY OTHER TSDS AND DISCIPLINES

In addition to the indicator predictions used for assessing the effects of the DGR Project on the atmospheric environment VECs (i.e., air quality and noise levels), air quality and noise level predictions were also made for a range of indicators and at selected ecological and human receptors used for assessing the indirect effects of changes in air quality and noise levels on other VECs. This appendix summarizes those predictions. The potential effects are assessed in the Terrestrial Environment TSD, Socio-economic Environment TSD and Aboriginal Interests TSD, and the human health assessment in the EIS.

J1.1 AIR QUALITY

Air quality predictions at selected receptors (see Figure J1.1-1) were determined with the aid of the AERMOD dispersion model (Version 07026), as described in Section 5.1.3 of the Atmospheric Environmental TSD.

J1.1.1 Ecological Receptor Predictions

Ecological receptors can also experience an adverse effect as a result of changes in air quality associated with the DGR Project. This would be an indirect effect on ecological receptors, which would be assessed in the appropriate TSD (i.e., Terrestrial Environment TSD). These ecological receptors were identified by the specialists conducting the terrestrial environment assessment (see Figure J1.1-1).

Table J1.1.1-1 provides a summary of the air quality predictions at ecological receptors for all phases of the DGR Project, and includes the background air quality concentrations, as described in Appendix E.

Table J1.1.1-1: Air Quality Predictions at Ecological Receptors

Indicator	Maximum Existing Concentrations (µg/m³)	Maximum Site Preparation and Construction Phase Concentrations (µg/m³)	Maximum Operations Phase Concentrations (µg/m³)
1-hour NO_2	81.6	499.5	184.0
24-hour NO_2	22.9	154.1	96.8
Annual NO_2	7.1	32.6	11.1
1-hour SO_2	133.9	133.9	133.9
24-hour SO_2	40.5	40.6	40.5
Annual SO_2	5.7	5.8	5.8
24-hour SPM	63.3	182.5	63.5
Annual SPM	25.0	46.5	25.1

Note:
The above numbers do not include predications at ER5 (currently industrial barren) where the waste rock management area is to be located.

J1.1.2 Human Health Receptor Predictions

Changes in air quality as a result of emissions from the DGR Project have the potential to affect human health. This would be an indirect effect on human health. The direct and indirect effects of the DGR Project on human health are presented in the EIS itself because it is affected by a number of different disciplines.

The EIS Guidelines require a discussion of the potential health effects associated with the emissions from the DGR Project, including both criteria compounds and compounds emitted from activities such as fossil fuel combustion and explosives use. A review of the DGR Project works and activities was used to identify compounds that could be emitted from the DGR Project that may have an effect on human health. This target compound list includes the following:

- carbon monoxide (CO);
- nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2);
- fine particulates (i.e., PM_{10} and $PM_{2.5}$);
- volatile organic compounds including:
  - acetaldehyde;
  - acetone;
  - acrolein;
  - benzene;
  - ethylbenzene;
  - formaldehyde;
  - toluene; and
  - xylenes.
- carcinogenic polycyclic aromatic hydrocarbons (PAHs);
- non-carcinogenic PAHs
- naphthalene
- selected metals, including:
  - aluminum;
  - cadmium;
  - chromium;
  - lead; and
  - zinc.

Concentrations of the above compounds were calculated at selected health receptors and used to determine concentrations for existing conditions for the site preparation and construction phase, and for the operations phase. Concentrations during the decommissioning phase were assumed to be similar, or less than, during construction. These health receptors were identified by the specialists conducting the health assessment (see Figure J1.1-1).

Attachment 1 provides a summary of the air quality predictions at the human health receptors for all phases of the DGR Project. The concentrations include the background air quality concentrations, as presented in Appendix E, using the methods described in Appendix F.

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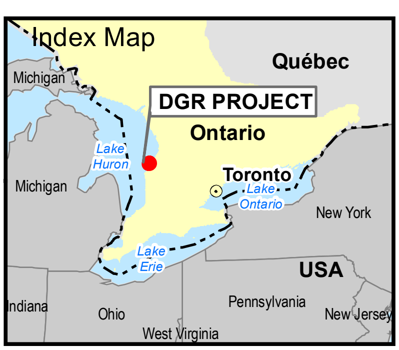
Kilometres



LEGEND

- ▲ Burial Ground Receptor
- ● Nuisance Receptor
- ■ Ecological Receptor
- ▲ Human Health Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF NON-VEC RECEPTORS FOR AIR QUALITY PREDICTIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE J1.1-1**	
GIS	BC	18 May. 2010		
CHECK	BC	18 May. 2010		
REVIEW	SM	18 May. 2010		

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J1.1.3 Nuisance Receptor Predictions

Changes in air quality, specifically particulate (dust), have the potential to affect aesthetic quality, which is an indirect effect on socio-economic environment VECs. This indirect effect is assessed in the Socio-economic Environment TSD. These nuisance receptors were identified by the specialists conducting the assessment, and the reason for their selection is set out in Section 5.1.1.1 of the Socio-economic Environment TSD.

Table J1.1.3-1 provides a summary of the air quality predictions at nuisance receptors for all phases of the DGR Project and includes the background air quality concentrations, as described in Appendix E.

Table J1.1.3-1: Maximum Air Quality Predictions at Nuisance Receptors

Indicator Compound	Maximum Existing Concentration (μg/m³)	Maximum Site Preparation and Construction Phase Concentration (μg/m³)	Maximum Operations Phase Concentration (μg/m³)
24-hour SPM	58.0	168.0	58.5

J1.1.4 Aboriginal Receptor Predictions

Changes in air quality, specifically particulate (dust), also have the potential to affect aesthetic quality during the traditional use of lands and resources, which is an indirect effect on Aboriginal interests VECs. This indirect effect is assessed in the Aboriginal Interests TSD. The additional nuisance receptor, namely the Aboriginal burial ground, was identified by the specialists conducting the assessment, and the reason for their selection is set out in Section 4.3.1.2 of the Aboriginal Interests TSD.

Table J1.1.4-1 provides a summary of the air quality predictions at the Aboriginal burial ground within the Bruce nuclear site for all phases of the DGR Project. The predictions include the background air quality, as described in Appendix E.

Table J1.1.4-1: Maximum Air Quality Predictions at the Burial Ground

Indicator Compound	Maximum Existing Concentration (μg/m³)	Maximum Site Preparation and Construction Phase Concentration (μg/m³)	Maximum Operations Phase Concentration (μg/m³)
24-hour SPM	58.7	155.8	59.0

J1.1.5 Airborne Deposition of Nitrates

Although the DGR Project will not release any water to Stream C, it is possible that compounds emitted from the DGR Project can be transmitted and deposited in Stream C catchment area. Feedback from regulators has identified the potential for residual nitrates in the blasting agents to be deposited either directly to Stream C or to the lands that drain to Stream C. In order to evaluate this potential, the air dispersion model was used to predict the deposition of dust and particulate to the Stream C watershed. The conservative assumption was then made that all of the dust emitted during the site preparation and construction phase would have a nitrate concentration equivalent to the amount of residual nitrates released from the excavation of the shaft, divided by the amount of rock excavated from the shaft. This is conservative since dust emissions will result from a number of activities at the site in addition to those associated with the excavation material (e.g., particulate emitted during the clearing of the site). The results have been presented in Table J1.1.5-1, and show deposition in both the upstream (the section of the catchment upstream of Tie Road), and downstream catchments of Stream C.

Table J1.1.5-1: Nitrate Deposition for Stream C Catchment Area

Stream C Catchment Area	Upstream Catchment	Downstream Catchment
Average Dust Deposition ($mg/m^2 \times a$)	814	1,754
Fraction of Nitrate in Excavated Rock (%)	0.002%	0.002%
Average Nitrate Deposition ($mg/m^2 \times a$)	0.014	0.029
Catchment Area (ha)	841	201
Total Nitrate Deposition (mg/a)	114,312	58,958

Note:
The fraction of nitrate in the waste rock is based on calculations assuming 5% of the ANFO or emulsion explosives used remain in the rock. In addition, all of the nitrogen remaining in the rock has been assumed in the form of NO_3.

J1.2 NOISE LEVELS

Noise levels predictions at selected receptors (see Figure J1.2-1) were determined with the aid of the CadnaA noise model, as described in Section 8.1.1.2 of the Atmospheric Environment TSD.

J1.2.1 Ecological Receptor Predictions

Ecological receptors can also experience adverse effects as a result of changes in noise levels associated with emissions from the DGR Project. This would be an indirect effect on ecological receptors, which would be assessed in the appropriate TSD (i.e., the Terrestrial Environment TSD). These ecological receptors were identified by specialists conducting the terrestrial environment assessment (see Figure J1.2-1).

Un-weighted noise levels, described as dB_{lin}, were considered to be more appropriate for evaluating effects on ecological receptors than A-weighted levels (dBA), which are used in describing human response to noise. The un-weighted noise levels represent the actual acoustic energy in the atmosphere, and are considered to be an unbiased representation of how ecological receptors react to noise levels in the environment.

Table J1.2.1-1 provides a summary of the noise level predictions at ecological receptors for the DGR Project.

0 0.5 1 2
Kilometres

LEGEND

- Ecological Receptor
- Human Health Receptor
- Noise Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

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PROJECT

ATMOSPHERIC ENVIRONMENT
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCATION OF NON-VEC RECEPTORS FOR NOISE PREDICTIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	18 May. 2010		
CHECK	KC	18 May. 2010	**FIGURE J1.2-1**	
REVIEW	AB	18 May. 2010		

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Table J1.2.1-1: Noise Level Predictions at Ecological Receptors

Receptor	Existing Noise Levels (dB_{lin})	Predicted Ambient Noise Levels during Site Preparation and Construction Phase (dB_{lin})	Predicted Ambient Noise Levels during Operations Phase (dB_{lin})
ER1	68	69	68
ER2	71	72	71
ER3	61	71	64
ER4	65	85	68
ER5	67	80	73
ER6	67	73	69
ER7	70	74	71

J1.2.2 Human Health Receptor Predictions

Changes in the noise levels have the potential to affect human health, which would be an indirect effect on human health. The direct and indirect effects of the DGR Project on human health are presented in the EIS itself because it is affected by a number of different disciplines. These health receptors were identified by the specialists conducting the health assessment.

The predicted noise levels at health receptors can be compared to the existing conditions and Health Canada criteria. Health Canada has published a draft national guideline for evaluating health impacts of noise [J1]. This guideline considers the following:

- characteristics of the noise level;
- construction noise impacts based on increased levels of annoyance in the population;
- operational noise impacts based on increased levels of annoyance in the population;
- impact on special land uses such as schools, hospitals and seniors' residences; and
- sleep disturbance impacts.

The Health Canada approach deals with increases in predicted noise levels over the existing conditions for the daytime (L_d) and nighttime (L_n) equivalent noise levels, as well as a whole day equivalent noise level descriptor (L_{eq24}). In addition, impulsive and tonal characteristics of source noise are accounted for because they can increase potential effects. The following two measures are included in the Health Canada document:

- The percentage of the exposed population that could be "highly annoyed" by increased noise levels caused by projects (%HA), which is described by the following formula:

$$HA = \frac{100}{1 + exp[10.4 - 1.32 \times \log(10^{0.1 \times L_{eq24}} + 3.375 \times 10^{0.1 \times L_n})]}$$

where:
L_{eq24} = the 24-hour equivalent noise level calculated according to ISO1996-1:05 [J2]; and
L_n = the nighttime average sound level according to ISO1996-1:05 [J2].

- The specific impact, or impulse noise, indicator (HCII), which is defined as follows:

$$HCII = 10 \times \log(10^{0.1 \times L_{eq24}}) + 3.375 \times 10^{0.1 \times L_n}$$

where:
L_{eq24} = the 24-hour equivalent noise level calculated according to ISO1996-1:05 [J2]; and
L_n = the nighttime average sound level according to ISO1996-1:05 [J2].

Table J1.2.2-1 provides a summary of the predictions for the human health receptor locations for the %HA measure. A value of 6.5%HA is considered by Health Canada to have the potential for adverse effects on human health.

Table J1.2.2-1: Noise Level Predictions at Human Health Receptors (%HA)

Receptor	Ambient %HA	Existing %HA	DGR Project-related Change Relative to Existing (%)
Site Preparation and Construction Phase			
R1 – Albert Street	1.6	1.5	0.1
R2 – Baie du Doré	2.6	2.1	0.5
R3 – Inverhuron Provincial Park	2.2	2.1	0.1
Operations Phase			
R1 – Albert Street	6.0	1.5	4.5
R2 – Baie du Doré	8.3	2.1	6.2
R3 – Inverhuron Provincial Park	7.7	2.1	5.6

Table J1.2.2-2 provides a summary of the predictions for human receptors for the HCII measure. The exceedance of 75 dBA is considered by Health Canada to have the potential for adverse effects on human health.

Table J1.2.2-2: Noise Level Predictions at Human Health Receptors (HCII)

Receptor	Baseline HCII (dBA)	Predicted Ambient HCII during Site Preparation and Construction Phase (dBA)	Predicted Ambient HCII during Operations Phase (dBA)
R1 – Albert Road	47	48	58
R2 – Baie du Doré	50	51	61
R3 – Inverhuron Provincial Park	50	50	60

J1.2.3 Nuisance Receptor Predictions

Changes in noise levels have the potential to affect local receptors, which is an indirect effect on socio-economic environment VECs. This indirect effect is assessed in the Socio-economic Environment TSD. These nuisance receptors were identified by the specialists conducting the assessment, and the reason for their selection is set out in the Socio-economic Environment TSD.

Table J1.2.3-1 provides a summary of the noise level predictions at nuisance receptors for the DGR Project. As described in Section 8.1 of the Atmospheric Environment TSD a change in noise levels ≤3 dB would be hardly perceptible.

Table J1.2.3-1: Noise Level Predictions at Nuisance Receptors

Receptor	Existing Noise Levels (dBA)	Site Preparation and Construction Phase		Operations Phase	
		Predicted Ambient Noise Levels (dBA)	Predicted Change (dB)	Predicted Ambient Noise Levels (dBA)	Predicted Change (dB)
R1 – Albert Road	36	38	+2	38	+2
R2 – Baie du Doré	37	42	+5	40	+3
R3 – Inverhuron Provincial Park	35	37	+2	37	+2

J2. REFERENCES

[J1] Health Canada. 2005. *Noise Impact Assessment Orientation Document for Projects Triggering CEAA*. Draft Version.

[J2] International Organization for Standardization (ISO). 1993. *International Standard ISO 9613-1 and 9613-2: Acoustics - Attenuation of sound during propagation outdoors*. Parts 1 and 2.

Attachment 1

Air Quality Predictions at Human Health Receptors

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Table 1: Air Quality Predictions at HH1

Compound	Existing (µg/m³)						Site Preparation and Construction Phase (µg/m³)						Operations Phase (µg/m³)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	9.6E+01	1.4E+01	4.7E+00	2.3E+00	5.1E-01	1.2E+00	5.2E+02	2.7E+01	8.9E+00	3.9E+00	8.5E-01	2.6E+00	1.9E+02	1.7E+01	5.4E+00	2.7E+00	5.8E-01	1.4E+00
8-hour CO	3.0E+01	1.0E+01	6.8E+00	3.2E+00	9.7E-01	1.2E+00	1.4E+02	2.8E+01	1.4E+01	6.0E+00	1.6E+00	2.6E+00	5.1E+01	1.4E+01	7.9E+00	3.8E+00	1.1E+00	1.4E+00
1-hour NO_2	5.3E+01	7.3E+00	3.5E+00	9.8E-01	6.8E-02	5.6E-01	4.0E+02	1.8E+01	6.6E+00	3.4E+00	5.3E-01	2.3E+00	2.1E+02	9.0E+00	4.4E+00	1.4E+00	1.7E-01	9.0E-01
24-hour NO_2	6.3E+00	3.2E+00	2.4E+00	1.8E+00	8.1E-01	5.6E-01	5.1E+01	1.6E+01	1.2E+01	7.5E+00	2.4E+00	2.3E+00	1.8E+01	5.4E+00	4.0E+00	2.6E+00	1.2E+00	9.0E-01
Annual NO_2	6.1E-01	6.1E-01	6.1E-01	6.1E-01	6.1E-01	5.6E-01	2.5E+00	2.5E+00	2.4E+00	2.4E+00	2.4E+00	2.3E+00	9.6E-01	9.6E-01	9.6E-01	9.6E-01	9.4E-01	9.0E-01
24-hour PM_{10}	1.2E+00	6.0E-01	4.4E-01	3.0E-01	1.2E-01	9.9E-02	1.1E+01	3.4E+00	2.4E+00	1.2E+00	3.6E-01	4.4E-01	1.4E+00	6.3E-01	4.8E-01	3.4E-01	1.5E-01	1.1E-01
24-hour $PM_{2.5}$	7.2E-01	3.5E-01	2.5E-01	1.5E-01	4.5E-02	4.7E-02	7.4E+00	2.2E+00	1.5E+00	8.1E-01	2.2E-01	2.8E-01	9.0E-01	3.9E-01	2.9E-01	2.0E-01	7.0E-02	6.1E-02
1-hour SO_2	1.7E+02	1.6E+01	2.9E+00	3.3E-01	7.2E-02	9.5E-01	1.7E+02	1.6E+01	2.9E+00	3.6E-01	7.4E-02	9.5E-01	1.7E+02	1.6E+01	2.9E+00	3.4E-01	7.3E-02	9.5E-01
24-hour SO_2	1.6E+01	7.6E+00	5.3E+00	3.3E+00	8.2E-01	9.5E-01	1.6E+01	7.6E+00	5.3E+00	3.3E+00	8.2E-01	9.5E-01	1.6E+01	7.6E+00	5.3E+00	3.3E+00	8.2E-01	9.5E-01
Annual SO_2	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.9E-01	9.5E-01	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.9E-01	9.5E-01	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.9E-01	9.5E-01
1-hour Acetaldehyde	1.5E+01	2.1E+00	9.7E-01	2.7E-01	1.9E-02	1.6E-01	2.0E+01	2.5E+00	1.2E+00	3.9E-01	3.1E-02	2.1E-01	1.5E+01	2.2E+00	1.1E+00	3.0E-01	2.2E-02	1.7E-01
1-hour Acetone	7.9E+00	1.1E+00	5.1E-01	1.4E-01	9.8E-03	8.3E-02	1.1E+01	1.3E+00	6.4E-01	2.0E-01	1.6E-02	1.1E-01	7.9E+00	1.1E+00	5.6E-01	1.6E-01	1.2E-02	8.8E-02
1-hour Acrolein	1.2E+00	1.7E-01	7.9E-02	2.2E-02	1.5E-03	1.3E-02	1.6E+00	2.0E-01	9.9E-02	3.2E-02	2.5E-03	1.7E-02	1.2E+00	1.8E-01	8.6E-02	2.4E-02	1.8E-03	1.4E-02
1-hour Benzene	9.8E-01	1.4E-01	6.4E-02	1.8E-02	1.2E-03	1.0E-02	1.3E+00	1.6E-01	7.9E-02	2.5E-02	2.0E-03	1.4E-02	9.8E-01	1.4E-01	6.9E-02	1.9E-02	1.4E-03	1.1E-02
1-hour Ethylbenzene	1.7E-01	2.3E-02	1.1E-02	3.0E-03	2.1E-04	1.8E-03	2.2E-01	2.8E-02	1.4E-02	4.4E-03	3.4E-04	2.4E-03	1.7E-01	2.4E-02	1.2E-02	3.3E-03	2.5E-04	1.9E-03
1-hour Formaldehyde	8.0E+00	1.1E+00	5.2E-01	1.4E-01	9.9E-03	8.4E-02	1.1E+01	1.3E+00	6.5E-01	2.1E-01	1.6E-02	1.1E-01	8.0E+00	1.2E+00	5.6E-01	1.6E-01	1.2E-02	8.9E-02
1-hour Toluene	1.4E+00	2.0E-01	9.2E-02	2.6E-02	1.8E-03	1.5E-02	1.9E+00	2.4E-01	1.2E-01	3.7E-02	2.9E-03	2.0E-02	1.4E+00	2.1E-01	1.0E-01	2.8E-02	2.1E-03	1.6E-02
1-hour Xylenes	1.1E+00	1.6E-01	7.3E-02	2.0E-02	1.4E-03	1.2E-02	1.5E+00	1.9E-01	9.2E-02	2.9E-02	2.3E-03	1.6E-02	1.1E+00	1.6E-01	8.0E-02	2.2E-02	1.7E-03	1.3E-02
1-hour Carcinogenic PAHs	9.9E-05	9.4E-06	1.9E-06	3.1E-07	4.5E-08	5.7E-07	2.3E-04	1.3E-05	5.4E-06	1.4E-06	1.8E-07	1.2E-06	9.9E-05	1.0E-05	2.9E-06	4.6E-07	7.4E-08	6.9E-07
1-hour Non-carcinogenic PAHs	6.2E-03	5.9E-04	1.2E-04	2.0E-05	2.8E-06	3.6E-05	1.5E-02	8.4E-04	3.4E-04	8.9E-05	1.2E-05	7.6E-05	6.2E-03	6.5E-04	1.8E-04	2.9E-05	4.6E-06	4.3E-05
1-hour Naphthalene	3.1E-03	2.9E-04	5.8E-05	9.7E-06	1.4E-06	1.8E-05	7.2E-03	4.1E-04	1.7E-04	4.4E-05	5.7E-06	3.7E-05	3.1E-03	3.2E-04	8.9E-05	1.4E-05	2.3E-06	2.1E-05
1-hour Aluminum	9.3E-03	8.8E-04	1.8E-04	2.9E-05	4.3E-06	5.4E-05	2.2E-02	1.3E-03	5.1E-04	1.3E-04	1.7E-05	1.1E-04	9.3E-03	9.8E-04	2.7E-04	4.3E-05	6.9E-06	6.5E-05
1-hour Cadmium	7.0E-03	6.6E-04	1.3E-04	2.2E-05	3.2E-06	4.0E-05	1.6E-02	9.5E-04	3.8E-04	1.0E-04	1.3E-05	8.6E-05	7.0E-03	7.3E-04	2.0E-04	3.2E-05	5.2E-06	4.8E-05
1-hour Chromium	1.2E-03	1.1E-04	2.2E-05	3.7E-06	5.3E-07	6.7E-06	2.7E-03	1.6E-04	6.4E-05	1.7E-05	2.2E-06	1.4E-05	1.2E-03	1.2E-04	3.4E-05	5.4E-06	8.7E-07	8.1E-06
1-hour Lead	1.2E-03	1.1E-04	2.2E-05	3.7E-06	5.3E-07	6.7E-06	2.7E-03	1.6E-04	6.4E-05	1.7E-05	2.2E-06	1.4E-05	1.2E-03	1.2E-04	3.4E-05	5.4E-06	8.7E-07	8.1E-06
1-hour Zinc	8.1E-03	7.7E-04	1.6E-04	2.6E-05	3.7E-06	4.7E-05	1.9E-02	1.1E-03	4.5E-04	1.2E-04	1.5E-05	1.0E-04	8.1E-03	8.5E-04	2.4E-04	3.8E-05	6.1E-06	5.7E-05

Note: Location of the human health receptors are shown on Figure J1.1-1.

Table 2: Air Quality Predictions at HH2

Compound	Existing (µg/m³)						Site Preparation and Construction Phase (µg/m³)						Operations Phase (µg/m³)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	2.0E+02	2.9E+01	9.5E+00	4.3E+00	1.1E+00	2.5E+00	1.0E+03	3.9E+01	1.4E+01	7.1E+00	1.5E+00	3.9E+00	2.1E+02	3.1E+01	1.0E+01	4.9E+00	1.2E+00	2.7E+00
8-hour CO	7.8E+01	2.3E+01	1.3E+01	6.3E+00	2.0E+00	2.5E+00	1.4E+02	3.8E+01	1.8E+01	9.4E+00	2.9E+00	3.9E+00	8.0E+01	2.5E+01	1.4E+01	6.9E+00	2.2E+00	2.7E+00
1-hour NO_2	6.8E+01	8.2E+00	3.7E+00	1.2E+00	1.4E-01	6.5E-01	5.4E+02	2.0E+01	9.0E+00	3.8E+00	6.2E-01	2.4E+00	1.8E+02	9.8E+00	4.9E+00	2.0E+00	3.3E-01	9.7E-01
24-hour NO_2	6.7E+00	3.5E+00	2.6E+00	1.8E+00	9.1E-01	6.5E-01	3.7E+01	1.7E+01	9.8E+00	6.7E+00	2.5E+00	2.4E+00	1.2E+01	5.1E+00	3.8E+00	2.5E+00	1.3E+00	9.7E-01
Annual NO_2	7.3E-01	7.2E-01	7.1E-01	7.0E-01	6.5E-01	6.5E-01	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.5E+00	2.4E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.9E-01	9.7E-01
24-hour PM_{10}	1.6E+00	6.8E-01	5.0E-01	3.3E-01	1.7E-01	1.3E-01	8.9E+00	4.5E+00	2.5E+00	1.3E+00	4.3E-01	5.1E-01	1.7E+00	7.1E-01	5.5E-01	3.7E-01	1.9E-01	1.4E-01
24-hour $PM_{2.5}$	6.2E-01	3.3E-01	2.1E-01	1.3E-01	4.1E-02	4.5E-02	5.5E+00	2.8E+00	1.5E+00	7.6E-01	2.3E-01	3.0E-01	8.1E-01	4.0E-01	2.4E-01	1.7E-01	6.4E-02	5.8E-02
1-hour SO_2	2.2E+02	1.4E+01	1.8E+00	3.3E-01	7.9E-02	8.6E-01	2.2E+02	1.4E+01	1.8E+00	3.5E-01	8.2E-02	8.6E-01	2.2E+02	1.4E+01	1.8E+00	3.3E-01	7.9E-02	8.6E-01
24-hour SO_2	1.3E+01	7.2E+00	4.4E+00	2.8E+00	6.6E-01	8.6E-01	1.3E+01	7.2E+00	4.5E+00	2.8E+00	6.7E-01	8.6E-01	1.3E+01	7.2E+00	4.4E+00	2.8E+00	6.6E-01	8.6E-01
Annual SO_2	9.6E-01	9.5E-01	9.5E-01	9.4E-01	9.1E-01	8.6E-01	9.6E-01	9.6E-01	9.5E-01	9.4E-01	9.1E-01	8.6E-01	9.6E-01	9.6E-01	9.5E-01	9.4E-01	9.1E-01	8.6E-01
1-hour Acetaldehyde	1.9E+01	2.3E+00	1.0E+00	3.2E-01	3.8E-02	1.8E-01	3.5E+01	2.7E+00	1.3E+00	4.2E-01	5.3E-02	2.4E-01	2.0E+01	2.4E+00	1.1E+00	3.3E-01	4.1E-02	1.9E-01
1-hour Acetone	1.0E+01	1.2E+00	5.4E-01	1.7E-01	2.0E-02	9.5E-02	1.9E+01	1.4E+00	6.9E-01	2.2E-01	2.8E-02	1.2E-01	1.0E+01	1.3E+00	5.6E-01	1.8E-01	2.2E-02	9.9E-02
1-hour Acrolein	1.6E+00	1.9E-01	8.3E-02	2.6E-02	3.1E-03	1.5E-02	2.9E+00	2.2E-01	1.1E-01	3.4E-02	4.3E-03	1.9E-02	1.6E+00	1.9E-01	8.6E-02	2.7E-02	3.4E-03	1.5E-02
1-hour Benzene	1.3E+00	1.5E-01	6.7E-02	2.1E-02	2.5E-03	1.2E-02	2.3E+00	1.8E-01	8.6E-02	2.7E-02	3.5E-03	1.5E-02	1.3E+00	1.6E-01	6.9E-02	2.2E-02	2.7E-03	1.2E-02
1-hour Ethylbenzene	2.2E-01	2.6E-02	1.2E-02	3.6E-03	4.3E-04	2.0E-03	4.0E-01	3.0E-02	1.5E-02	4.7E-03	6.0E-04	2.6E-03	2.2E-01	2.7E-02	1.2E-02	3.7E-03	4.7E-04	2.1E-03
1-hour Formaldehyde	1.0E+01	1.2E+00	5.5E-01	1.7E-01	2.0E-02	9.6E-02	1.9E+01	1.4E+00	7.0E-01	2.2E-01	2.8E-02	1.3E-01	1.1E+01	1.3E+00	5.6E-01	1.8E-01	2.2E-02	1.0E-01
1-hour Toluene	1.8E+00	2.2E-01	9.8E-02	3.0E-02	3.7E-03	1.7E-02	3.3E+00	2.6E-01	1.3E-01	4.0E-02	5.1E-03	2.2E-02	1.9E+00	2.3E-01	1.0E-01	3.2E-02	3.9E-03	1.8E-02
1-hour Xylenes	1.5E+00	1.7E-01	7.8E-02	2.4E-02	2.9E-03	1.4E-02	2.7E+00	2.0E-01	9.9E-02	3.2E-02	4.0E-03	1.8E-02	1.5E+00	1.8E-01	8.0E-02	2.5E-02	3.1E-03	1.4E-02
1-hour Carcinogenic PAHs	1.3E-04	8.3E-06	1.4E-06	2.8E-07	4.9E-08	5.2E-07	4.5E-04	1.3E-05	4.6E-06	1.3E-06	2.2E-07	1.2E-06	1.3E-04	9.4E-06	2.2E-06	5.2E-07	1.0E-07	6.3E-07
1-hour Non-carcinogenic PAHs	8.0E-03	5.2E-04	9.0E-05	1.7E-05	3.1E-06	3.2E-05	2.8E-02	8.4E-04	2.9E-04	8.0E-05	1.4E-05	7.4E-05	8.2E-03	5.9E-04	1.4E-04	3.2E-05	6.3E-06	3.9E-05
1-hour Naphthalene	3.9E-03	2.6E-04	4.4E-05	8.5E-06	1.5E-06	1.6E-05	1.4E-02	4.1E-04	1.4E-04	3.9E-05	6.7E-06	3.6E-05	4.0E-03	2.9E-04	6.8E-05	1.6E-05	3.1E-06	1.9E-05
1-hour Aluminum	1.2E-02	7.8E-04	1.4E-04	2.6E-05	4.6E-06	4.9E-05	4.2E-02	1.3E-03	4.3E-04	1.2E-04	2.0E-05	1.1E-04	1.2E-02	8.9E-04	2.1E-04	4.9E-05	9.4E-06	5.9E-05
1-hour Cadmium	8.9E-03	5.8E-04	1.0E-04	1.9E-05	3.5E-06	3.6E-05	3.2E-02	9.4E-04	3.3E-04	9.0E-05	1.5E-05	8.3E-05	9.2E-03	6.7E-04	1.6E-04	3.6E-05	7.0E-06	4.4E-05
1-hour Chromium	1.5E-03	9.7E-05	1.7E-05	3.2E-06	5.8E-07	6.1E-06	5.3E-03	1.6E-04	5.4E-05	1.5E-05	2.6E-06	1.4E-05	1.5E-03	1.1E-04	2.6E-05	6.1E-06	1.2E-06	7.4E-06
1-hour Lead	1.5E-03	9.7E-05	1.7E-05	3.2E-06	5.8E-07	6.1E-06	5.3E-03	1.6E-04	5.4E-05	1.5E-05	2.6E-06	1.4E-05	1.5E-03	1.1E-04	2.6E-05	6.1E-06	1.2E-06	7.4E-06
1-hour Zinc	1.0E-02	6.8E-04	1.2E-04	2.3E-05	4.0E-06	4.3E-05	3.7E-02	1.1E-03	3.8E-04	1.0E-04	1.8E-05	9.7E-05	1.1E-02	7.8E-04	1.8E-04	4.3E-05	8.2E-06	5.2E-05

Note: Location of the human health receptors are shown on Figure J1.1-1.

Table 3: Air Quality Predictions at HH3

Compound	Existing (µg/m³)						Site Preparation and Construction Phase (µg/m³)						Operations Phase (µg/m³)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	3.6E+01	2.1E+00	1.0E+00	4.7E-01	2.5E-02	1.9E-01	2.3E+02	5.6E+00	1.9E+00	7.3E-01	3.9E-02	4.4E-01	5.2E+01	2.6E+00	1.2E+00	5.4E-01	2.8E-02	2.3E-01
8-hour CO	4.5E+00	1.7E+00	1.1E+00	6.4E-01	1.4E-01	1.9E-01	2.9E+01	4.5E+00	2.6E+00	1.3E+00	1.9E-01	4.4E-01	6.5E+00	2.0E+00	1.3E+00	7.7E-01	1.5E-01	2.3E-01
1-hour NO_2	5.1E+01	5.8E+00	1.9E+00	3.7E-01	4.1E-02	3.9E-01	2.7E+02	1.0E+01	4.6E+00	7.6E-01	5.5E-02	7.3E-01	7.1E+01	6.3E+00	2.4E+00	5.0E-01	4.9E-02	4.4E-01
24-hour NO_2	7.5E+00	2.4E+00	1.7E+00	1.2E+00	5.1E-01	3.9E-01	1.2E+01	4.7E+00	3.5E+00	2.4E+00	9.3E-01	7.3E-01	8.0E+00	2.6E+00	1.9E+00	1.4E+00	6.0E-01	4.4E-01
Annual NO_2	4.6E-01	4.6E-01	4.5E-01	4.5E-01	4.4E-01	3.9E-01	8.7E-01	8.6E-01	8.6E-01	8.4E-01	8.1E-01	7.3E-01	5.2E-01	5.1E-01	5.1E-01	5.1E-01	5.0E-01	4.4E-01
24-hour PM_{10}	1.5E+00	3.8E-01	2.6E-01	1.6E-01	4.4E-02	5.1E-02	3.1E+00	8.9E-01	6.3E-01	4.3E-01	1.1E-01	1.2E-01	1.5E+00	3.9E-01	2.7E-01	1.6E-01	4.8E-02	5.3E-02
24-hour $PM_{2.5}$	9.6E-01	2.4E-01	1.7E-01	9.9E-02	2.5E-02	3.2E-02	2.1E+00	5.8E-01	4.1E-01	2.7E-01	7.1E-02	7.8E-02	9.8E-01	2.5E-01	1.7E-01	1.1E-01	3.0E-02	3.4E-02
1-hour SO_2	1.6E+02	9.8E+00	1.1E+00	2.4E-01	5.5E-02	6.6E-01	1.6E+02	9.8E+00	1.1E+00	2.4E-01	5.6E-02	6.6E-01	1.6E+02	9.8E+00	1.1E+00	2.4E-01	5.5E-02	6.6E-01
24-hour SO_2	2.1E+01	5.3E+00	3.6E+00	2.1E+00	4.5E-01	6.6E-01	2.1E+01	5.3E+00	3.6E+00	2.1E+00	4.5E-01	6.6E-01	2.1E+01	5.3E+00	3.6E+00	2.1E+00	4.5E-01	6.6E-01
Annual SO_2	8.7E-01	8.6E-01	8.3E-01	8.0E-01	6.9E-01	6.6E-01	8.7E-01	8.6E-01	8.3E-01	8.0E-01	6.9E-01	6.6E-01	8.7E-01	8.6E-01	8.3E-01	8.0E-01	6.9E-01	6.6E-01
1-hour Acetaldehyde	1.5E+01	1.6E+00	5.5E-01	1.0E-01	1.1E-02	1.1E-01	1.5E+01	1.7E+00	6.5E-01	1.5E-01	1.2E-02	1.2E-01	1.5E+01	1.6E+00	5.5E-01	1.1E-01	1.2E-02	1.1E-01
1-hour Acetone	7.6E+00	8.6E-01	2.9E-01	5.4E-02	6.0E-03	5.8E-02	7.8E+00	8.8E-01	3.4E-01	7.8E-02	6.5E-03	6.3E-02	7.6E+00	8.6E-01	2.9E-01	6.0E-02	6.2E-03	5.9E-02
1-hour Acrolein	1.2E+00	1.3E-01	4.4E-02	8.4E-03	9.3E-04	9.0E-03	1.2E+00	1.4E-01	5.3E-02	1.2E-02	1.0E-03	9.7E-03	1.2E+00	1.3E-01	4.5E-02	9.2E-03	9.6E-04	9.1E-03
1-hour Benzene	9.5E-01	1.1E-01	3.6E-02	6.8E-03	7.5E-04	7.2E-03	9.7E-01	1.1E-01	4.3E-02	9.7E-03	8.1E-04	7.8E-03	9.5E-01	1.1E-01	3.6E-02	7.4E-03	7.7E-04	7.3E-03
1-hour Ethylbenzene	1.6E-01	1.8E-02	6.1E-03	1.2E-03	1.3E-04	1.2E-03	1.7E-01	1.9E-02	7.4E-03	1.7E-03	1.4E-04	1.3E-03	1.6E-01	1.8E-02	6.2E-03	1.3E-03	1.3E-04	1.3E-03
1-hour Formaldehyde	7.7E+00	8.7E-01	2.9E-01	5.5E-02	6.1E-03	5.9E-02	7.9E+00	9.0E-01	3.5E-01	7.9E-02	6.6E-03	6.4E-02	7.8E+00	8.8E-01	3.0E-01	6.0E-02	6.3E-03	5.9E-02
1-hour Toluene	1.4E+00	1.6E-01	5.2E-02	9.8E-03	1.1E-03	1.0E-02	1.4E+00	1.6E-01	6.2E-02	1.4E-02	1.2E-03	1.1E-02	1.4E+00	1.6E-01	5.3E-02	1.1E-02	1.1E-03	1.1E-02
1-hour Xylenes	1.1E+00	1.2E-01	4.1E-02	7.8E-03	8.7E-04	8.3E-03	1.1E+00	1.3E-01	4.9E-02	1.1E-02	9.4E-04	9.0E-03	1.1E+00	1.2E-01	4.2E-02	8.6E-03	8.9E-04	8.4E-03
1-hour Carcinogenic PAHs	9.5E-05	5.7E-06	9.3E-07	1.9E-07	3.4E-08	4.0E-07	1.1E-04	7.7E-06	1.9E-06	3.1E-07	4.1E-08	5.1E-07	9.6E-05	5.9E-06	1.1E-06	2.3E-07	3.7E-08	4.1E-07
1-hour Non-carcinogenic PAHs	6.0E-03	3.6E-04	5.8E-05	1.2E-05	2.1E-06	2.5E-05	7.0E-03	4.8E-04	1.2E-04	1.9E-05	2.5E-06	3.2E-05	6.0E-03	3.7E-04	6.8E-05	1.4E-05	2.3E-06	2.6E-05
1-hour Naphthalene	2.9E-03	1.8E-04	2.9E-05	5.8E-06	1.1E-06	1.2E-05	3.4E-03	2.4E-04	6.0E-05	9.6E-06	1.2E-06	1.6E-05	2.9E-03	1.8E-04	3.4E-05	7.1E-06	1.1E-06	1.3E-05
1-hour Aluminum	9.0E-03	5.4E-04	8.7E-05	1.8E-05	3.2E-06	3.7E-05	1.1E-02	7.2E-04	1.8E-04	2.9E-05	3.8E-06	4.8E-05	9.0E-03	5.5E-04	1.0E-04	2.2E-05	3.5E-06	3.9E-05
1-hour Cadmium	6.7E-03	4.0E-04	6.5E-05	1.3E-05	2.4E-06	2.8E-05	7.9E-03	5.4E-04	1.4E-04	2.2E-05	2.9E-06	3.6E-05	6.7E-03	4.1E-04	7.7E-05	1.6E-05	2.6E-06	2.9E-05
1-hour Chromium	1.1E-03	6.7E-05	1.1E-05	2.2E-06	4.0E-07	4.7E-06	1.3E-03	9.0E-05	2.3E-05	3.6E-06	4.8E-07	6.0E-06	1.1E-03	6.9E-05	1.3E-05	2.7E-06	4.3E-07	4.9E-06
1-hour Lead	1.1E-03	6.7E-05	1.1E-05	2.2E-06	4.0E-07	4.7E-06	1.3E-03	9.0E-05	2.3E-05	3.6E-06	4.8E-07	6.0E-06	1.1E-03	6.9E-05	1.3E-05	2.7E-06	4.3E-07	4.9E-06
1-hour Zinc	7.8E-03	4.7E-04	7.6E-05	1.5E-05	2.8E-06	3.3E-05	9.2E-03	6.3E-04	1.6E-04	2.6E-05	3.3E-06	4.2E-05	7.9E-03	4.8E-04	9.0E-05	1.9E-05	3.0E-06	3.4E-05

Note: Location of the human health receptors are shown on Figure J1.1-1.

Table 4: Air Quality Predictions at HH4

Compound	Existing (µg/m³)						Site Preparation and Construction Phase (µg/m³)						Operations Phase (µg/m³)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	2.6E+02	1.4E+01	6.1E+00	1.8E+00	3.9E-01	1.7E+00	7.4E+02	2.4E+01	9.0E+00	2.6E+00	5.6E-01	3.3E+00	2.6E+02	1.6E+01	6.9E+00	2.0E+00	4.4E-01	1.9E+00
8-hour CO	8.9E+01	1.8E+01	8.8E+00	3.8E+00	9.3E-01	1.7E+00	2.8E+02	3.9E+01	1.7E+01	5.6E+00	1.4E+00	3.3E+00	1.1E+02	2.0E+01	9.9E+00	4.2E+00	1.0E+00	1.9E+00
1-hour NO_2	5.5E+01	7.4E+00	3.1E+00	6.9E-01	7.2E-02	5.3E-01	4.5E+02	1.8E+01	6.6E+00	3.3E+00	4.5E-01	2.5E+00	1.8E+02	9.2E+00	4.2E+00	1.5E+00	2.0E-01	9.0E-01
24-hour NO_2	7.1E+00	3.1E+00	2.3E+00	1.7E+00	7.4E-01	5.3E-01	7.2E+01	2.1E+01	1.2E+01	7.5E+00	1.9E+00	2.5E+00	2.0E+01	6.1E+00	4.0E+00	2.5E+00	1.1E+00	9.0E-01
Annual NO_2	6.0E-01	6.0E-01	5.9E-01	5.7E-01	5.3E-01	5.3E-01	3.6E+00	3.6E+00	3.5E+00	3.3E+00	2.7E+00	2.5E+00	1.2E+00	1.2E+00	1.2E+00	1.1E+00	9.6E-01	9.0E-01
24-hour PM_{10}	1.3E+00	6.5E-01	4.5E-01	3.1E-01	1.3E-01	1.0E-01	2.5E+01	5.1E+00	3.3E+00	1.4E+00	2.8E-01	5.4E-01	1.6E+00	7.9E-01	5.3E-01	3.7E-01	1.4E-01	1.2E-01
24-hour $PM_{2.5}$	6.9E-01	2.9E-01	2.0E-01	1.5E-01	3.9E-02	4.2E-02	1.5E+01	3.2E+00	2.1E+00	8.5E-01	1.7E-01	3.3E-01	8.8E-01	4.1E-01	2.7E-01	1.8E-01	5.9E-02	5.7E-02
1-hour SO_2	1.7E+02	1.5E+01	1.7E+00	2.9E-01	7.7E-02	8.3E-01	1.7E+02	1.5E+01	1.7E+00	3.2E-01	8.1E-02	8.4E-01	1.7E+02	1.5E+01	1.7E+00	3.0E-01	7.8E-02	8.4E-01
24-hour SO_2	1.5E+01	6.2E+00	4.4E+00	3.1E+00	6.6E-01	8.3E-01	1.5E+01	6.2E+00	4.4E+00	3.1E+00	6.7E-01	8.4E-01	1.5E+01	6.2E+00	4.4E+00	3.1E+00	6.6E-01	8.4E-01
Annual SO_2	9.7E-01	9.6E-01	9.5E-01	9.3E-01	8.8E-01	8.3E-01	9.7E-01	9.7E-01	9.5E-01	9.4E-01	8.8E-01	8.4E-01	9.7E-01	9.6E-01	9.5E-01	9.3E-01	8.8E-01	8.4E-01
1-hour Acetaldehyde	1.6E+01	2.1E+00	8.6E-01	1.9E-01	2.0E-02	1.5E-01	2.5E+01	2.6E+00	1.2E+00	2.7E-01	3.3E-02	2.1E-01	1.6E+01	2.2E+00	9.5E-01	2.1E-01	2.4E-02	1.6E-01
1-hour Acetone	8.2E+00	1.1E+00	4.5E-01	1.0E-01	1.0E-02	7.8E-02	1.3E+01	1.4E+00	6.2E-01	1.4E-01	1.7E-02	1.1E-01	8.2E+00	1.2E+00	5.0E-01	1.1E-01	1.2E-02	8.3E-02
1-hour Acrolein	1.3E+00	1.7E-01	7.0E-02	1.6E-02	1.6E-03	1.2E-02	2.0E+00	2.1E-01	9.6E-02	2.2E-02	2.7E-03	1.7E-02	1.3E+00	1.8E-01	7.8E-02	1.7E-02	1.9E-03	1.3E-02
1-hour Benzene	1.0E+00	1.4E-01	5.6E-02	1.3E-02	1.3E-03	9.7E-03	1.6E+00	1.7E-01	7.7E-02	1.8E-02	2.1E-03	1.4E-02	1.0E+00	1.4E-01	6.3E-02	1.4E-02	1.5E-03	1.0E-02
1-hour Ethylbenzene	1.7E-01	2.3E-02	9.6E-03	2.2E-03	2.2E-04	1.7E-03	2.8E-01	3.0E-02	1.3E-02	3.1E-03	3.7E-04	2.4E-03	1.7E-01	2.5E-02	1.1E-02	2.4E-03	2.7E-04	1.8E-03
1-hour Formaldehyde	8.3E+00	1.1E+00	4.6E-01	1.0E-01	1.1E-02	7.9E-02	1.3E+01	1.4E+00	6.3E-01	1.5E-01	1.7E-02	1.1E-01	8.3E+00	1.2E+00	5.1E-01	1.1E-01	1.3E-02	8.4E-02
1-hour Toluene	1.5E+00	2.0E-01	8.1E-02	1.8E-02	1.9E-03	1.4E-02	2.3E+00	2.5E-01	1.1E-01	2.6E-02	3.1E-03	2.0E-02	1.5E+00	2.1E-01	9.1E-02	2.0E-02	2.2E-03	1.5E-02
1-hour Xylenes	1.2E+00	1.6E-01	6.5E-02	1.5E-02	1.5E-03	1.1E-02	1.9E+00	2.0E-01	8.9E-02	2.1E-02	2.5E-03	1.6E-02	1.2E+00	1.7E-01	7.2E-02	1.6E-02	1.8E-03	1.2E-02
1-hour Carcinogenic PAHs	1.0E-04	8.7E-06	1.3E-06	2.2E-07	4.8E-08	5.0E-07	3.1E-04	1.4E-05	4.3E-06	1.1E-06	1.7E-07	1.3E-06	1.0E-04	1.0E-05	2.2E-06	4.1E-07	8.1E-08	6.3E-07
1-hour Non-carcinogenic PAHs	6.4E-03	5.4E-04	8.4E-05	1.4E-05	3.0E-06	3.1E-05	2.0E-02	8.6E-04	2.7E-04	7.0E-05	1.0E-05	7.9E-05	6.4E-03	6.4E-04	1.4E-04	2.6E-05	5.1E-06	4.0E-05
1-hour Naphthalene	3.1E-03	2.7E-04	4.1E-05	6.9E-06	1.5E-06	1.5E-05	9.6E-03	4.2E-04	1.3E-04	3.5E-05	5.2E-06	3.9E-05	3.1E-03	3.2E-04	6.6E-05	1.3E-05	2.5E-06	1.9E-05
1-hour Aluminum	9.5E-03	8.1E-04	1.3E-04	2.1E-05	4.5E-06	4.7E-05	2.9E-02	1.3E-03	4.1E-04	1.1E-04	1.6E-05	1.2E-04	9.5E-03	9.6E-04	2.0E-04	3.9E-05	7.6E-06	5.9E-05
1-hour Cadmium	7.1E-03	6.1E-04	9.4E-05	1.6E-05	3.4E-06	3.5E-05	2.2E-02	9.7E-04	3.0E-04	7.9E-05	1.2E-05	8.9E-05	7.1E-03	7.2E-04	1.5E-04	2.9E-05	5.7E-06	4.4E-05
1-hour Chromium	1.2E-03	1.0E-04	1.6E-05	2.6E-06	5.7E-07	5.9E-06	3.7E-03	1.6E-04	5.1E-05	1.3E-05	2.0E-06	1.5E-05	1.2E-03	1.2E-04	2.5E-05	4.9E-06	9.5E-07	7.4E-06
1-hour Lead	1.2E-03	1.0E-04	1.6E-05	2.6E-06	5.7E-07	5.9E-06	3.7E-03	1.6E-04	5.1E-05	1.3E-05	2.0E-06	1.5E-05	1.2E-03	1.2E-04	2.5E-05	4.9E-06	9.5E-07	7.4E-06
1-hour Zinc	8.3E-03	7.1E-04	1.1E-04	1.8E-05	4.0E-06	4.1E-05	2.6E-02	1.1E-03	3.6E-04	9.2E-05	1.4E-05	1.0E-04	8.3E-03	8.4E-04	1.8E-04	3.4E-05	6.6E-06	5.2E-05

Note: Location of the human health receptors are shown on Figure J1.1-1.

Table 5: Air Quality Predictions at HH5

Compound	Existing (µg/m³)						Site Preparation and Construction Phase (µg/m³)						Operations Phase (µg/m³)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	6.1E+01	2.1E+00	8.9E-01	4.3E-01	5.9E-02	3.4E-01	3.4E+02	4.7E+00	1.6E+00	6.3E-01	9.1E-02	7.9E-01	9.2E+01	2.5E+00	9.8E-01	4.7E-01	6.9E-02	4.0E-01
8-hour CO	1.8E+01	4.2E+00	1.8E+00	6.1E-01	2.0E-01	3.4E-01	5.9E+01	9.7E+00	3.6E+00	1.1E+00	3.2E-01	7.9E-01	2.1E+01	4.8E+00	2.1E+00	7.2E-01	2.3E-01	4.0E-01
1-hour NO_2	2.9E+01	4.4E+00	1.4E+00	1.8E-01	2.1E-02	2.8E-01	2.7E+02	8.2E+00	2.8E+00	5.1E-01	8.3E-02	9.0E-01	6.2E+01	5.4E+00	1.9E+00	3.3E-01	4.6E-02	3.8E-01
24-hour NO_2	4.1E+00	1.9E+00	1.4E+00	9.3E-01	3.3E-01	2.8E-01	1.9E+01	7.3E+00	4.6E+00	2.6E+00	8.0E-01	9.0E-01	4.8E+00	2.4E+00	1.7E+00	1.2E+00	4.6E-01	3.8E-01
Annual NO_2	3.0E-01	3.0E-01	3.0E-01	3.0E-01	2.8E-01	2.8E-01	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	9.0E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01	4.0E-01	3.8E-01
24-hour PM_{10}	7.5E-01	3.7E-01	2.6E-01	1.8E-01	6.4E-02	5.3E-02	5.9E+00	1.6E+00	9.4E-01	5.0E-01	1.5E-01	1.9E-01	7.6E-01	3.8E-01	2.7E-01	1.9E-01	7.2E-02	5.7E-02
24-hour $PM_{2.5}$	4.8E-01	2.3E-01	1.6E-01	1.0E-01	2.8E-02	3.0E-02	3.7E+00	9.8E-01	6.0E-01	3.2E-01	9.7E-02	1.2E-01	4.9E-01	2.3E-01	1.7E-01	1.1E-01	3.8E-02	3.4E-02
1-hour SO_2	8.2E+01	1.1E+01	2.2E+00	2.1E-01	3.4E-02	6.5E-01	8.2E+01	1.1E+01	2.2E+00	2.2E-01	3.5E-02	6.5E-01	8.2E+01	1.1E+01	2.2E+00	2.1E-01	3.5E-02	6.5E-01
24-hour SO_2	1.1E+01	5.0E+00	3.5E+00	2.3E+00	6.0E-01	6.5E-01	1.1E+01	5.0E+00	3.5E+00	2.3E+00	6.0E-01	6.5E-01	1.1E+01	5.0E+00	3.5E+00	2.3E+00	6.0E-01	6.5E-01
Annual SO_2	7.5E-01	7.4E-01	7.4E-01	7.2E-01	6.7E-01	6.5E-01	7.5E-01	7.4E-01	7.4E-01	7.2E-01	6.8E-01	6.5E-01	7.5E-01	7.4E-01	7.4E-01	7.2E-01	6.8E-01	6.5E-01
1-hour Acetaldehyde	8.1E+00	1.2E+00	4.1E-01	4.9E-02	6.0E-03	7.9E-02	1.2E+01	1.5E+00	5.2E-01	5.4E-02	7.5E-03	9.7E-02	8.1E+00	1.3E+00	4.3E-01	5.0E-02	6.5E-03	8.2E-02
1-hour Acetone	4.3E+00	6.5E-01	2.1E-01	2.6E-02	3.2E-03	4.2E-02	6.4E+00	7.7E-01	2.8E-01	2.8E-02	4.0E-03	5.1E-02	4.3E+00	6.7E-01	2.3E-01	2.6E-02	3.4E-03	4.3E-02
1-hour Acrolein	6.6E-01	1.0E-01	3.3E-02	4.0E-03	4.9E-04	6.4E-03	1.0E+00	1.2E-01	4.3E-02	4.4E-03	6.1E-04	7.9E-03	6.6E-01	1.0E-01	3.5E-02	4.1E-03	5.3E-04	6.6E-03
1-hour Benzene	5.3E-01	8.1E-02	2.7E-02	3.2E-03	3.9E-04	5.2E-03	8.0E-01	9.6E-02	3.4E-02	3.5E-03	4.9E-04	6.4E-03	5.3E-01	8.3E-02	2.8E-02	3.3E-03	4.3E-04	5.3E-03
1-hour Ethylbenzene	9.1E-02	1.4E-02	4.6E-03	5.5E-04	6.8E-05	8.9E-04	1.4E-01	1.7E-02	5.9E-03	6.0E-04	8.5E-05	1.1E-03	9.1E-02	1.4E-02	4.9E-03	5.6E-04	7.3E-05	9.2E-04
1-hour Formaldehyde	4.3E+00	6.6E-01	2.2E-01	2.6E-02	3.2E-03	4.2E-02	6.5E+00	7.8E-01	2.8E-01	2.9E-02	4.0E-03	5.2E-02	4.3E+00	6.8E-01	2.3E-01	2.7E-02	3.5E-03	4.4E-02
1-hour Toluene	7.7E-01	1.2E-01	3.9E-02	4.7E-03	5.7E-04	7.5E-03	1.2E+00	1.4E-01	5.0E-02	5.1E-03	7.2E-04	9.3E-03	7.7E-01	1.2E-01	4.1E-02	4.8E-03	6.2E-04	7.8E-03
1-hour Xylenes	6.1E-01	9.4E-02	3.1E-02	3.7E-03	4.6E-04	6.0E-03	9.3E-01	1.1E-01	4.0E-02	4.1E-03	5.7E-04	7.3E-03	6.1E-01	9.6E-02	3.3E-02	3.8E-03	4.9E-04	6.2E-03
1-hour Carcinogenic PAHs	4.8E-05	6.2E-06	1.3E-06	1.4E-07	2.0E-08	3.8E-07	1.4E-04	8.2E-06	2.5E-06	2.7E-07	4.0E-08	5.9E-07	4.8E-05	6.5E-06	1.7E-06	1.7E-07	2.9E-08	4.1E-07
1-hour Non-carcinogenic PAHs	3.0E-03	3.9E-04	8.2E-05	8.8E-06	1.3E-06	2.4E-05	8.8E-03	5.1E-04	1.6E-04	1.7E-05	2.5E-06	3.7E-05	3.0E-03	4.1E-04	1.1E-04	1.1E-05	1.8E-06	2.6E-05
1-hour Naphthalene	1.5E-03	1.9E-04	4.0E-05	4.3E-06	6.2E-07	1.2E-05	4.3E-03	2.5E-04	7.7E-05	8.4E-06	1.2E-06	1.8E-05	1.5E-03	2.0E-04	5.2E-05	5.4E-06	9.1E-07	1.3E-05
1-hour Aluminum	4.5E-03	5.8E-04	1.2E-04	1.3E-05	1.9E-06	3.6E-05	1.3E-02	7.7E-04	2.4E-04	2.6E-05	3.8E-06	5.6E-05	4.5E-03	6.2E-04	1.6E-04	1.6E-05	2.8E-06	3.9E-05
1-hour Cadmium	3.4E-03	4.4E-04	9.2E-05	9.9E-06	1.4E-06	2.7E-05	9.9E-03	5.8E-04	1.8E-04	1.9E-05	2.8E-06	4.2E-05	3.4E-03	4.6E-04	1.2E-04	1.2E-05	2.1E-06	2.9E-05
1-hour Chromium	5.6E-04	7.3E-05	1.5E-05	1.6E-06	2.4E-07	4.5E-06	1.7E-03	9.6E-05	2.9E-05	3.2E-06	4.7E-07	7.0E-06	5.6E-04	7.7E-05	2.0E-05	2.0E-06	3.5E-07	4.8E-06
1-hour Lead	5.6E-04	7.3E-05	1.5E-05	1.6E-06	2.4E-07	4.5E-06	1.7E-03	9.6E-05	2.9E-05	3.2E-06	4.7E-07	7.0E-06	5.6E-04	7.7E-05	2.0E-05	2.0E-06	3.5E-07	4.8E-06
1-hour Zinc	3.9E-03	5.1E-04	1.1E-04	1.2E-05	1.7E-06	3.1E-05	1.2E-02	6.7E-04	2.1E-04	2.2E-05	3.3E-06	4.9E-05	3.9E-03	5.4E-04	1.4E-04	1.4E-05	2.4E-06	3.4E-05

Note: Location of the human health receptors are shown on Figure J1.1-1.

Table 6: Air Quality Predictions at HH6

Compound	Existing (µg/m^3)						Site Preparation and Construction Phase (µg/m^3)						Operations Phase (µg/m^3)					
	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average	Maximum	98th percentile	95th percentile	90th percentile	75th percentile	Average
1-hour CO	1.7E+02	4.5E+01	2.2E+01	1.6E+01	2.7E+00	4.8E+00	1.1E+03	9.2E+01	3.7E+01	2.4E+01	3.9E+00	9.4E+00	3.3E+02	5.5E+01	2.5E+01	1.8E+01	2.9E+00	5.4E+00
8-hour CO	8.7E+01	3.0E+01	2.2E+01	1.5E+01	5.4E+00	4.8E+00	2.7E+02	8.0E+01	4.2E+01	2.5E+01	8.7E+00	9.4E+00	9.3E+01	3.6E+01	2.5E+01	1.7E+01	6.1E+00	5.4E+00
1-hour NO_2	6.0E+01	1.3E+01	5.6E+00	1.9E+00	4.0E-01	1.0E+00	5.1E+02	5.6E+01	1.9E+01	1.2E+01	2.6E+00	6.0E+00	3.2E+02	1.7E+01	8.7E+00	3.9E+00	8.4E-01	2.0E+00
24-hour NO_2	9.5E+00	5.2E+00	3.9E+00	2.8E+00	1.4E+00	1.0E+00	7.8E+01	3.9E+01	2.6E+01	1.7E+01	6.8E+00	6.0E+00	2.8E+01	1.3E+01	7.9E+00	5.2E+00	2.4E+00	2.0E+00
Annual NO_2	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.1E+00	1.0E+00	8.1E+00	8.0E+00	7.7E+00	7.4E+00	6.4E+00	6.0E+00	2.4E+00	2.4E+00	2.4E+00	2.3E+00	2.1E+00	2.0E+00
24-hour PM_{10}	2.2E+00	1.2E+00	9.1E-01	6.6E-01	3.4E-01	2.5E-01	2.3E+01	1.0E+01	6.5E+00	3.7E+00	1.1E+00	1.3E+00	2.6E+00	1.4E+00	1.1E+00	7.6E-01	4.0E-01	2.9E-01
24-hour $PM_{2.5}$	1.3E+00	6.4E-01	4.4E-01	3.0E-01	8.4E-02	8.8E-02	1.5E+01	6.4E+00	4.1E+00	2.3E+00	6.2E-01	7.9E-01	1.5E+00	8.3E-01	6.2E-01	4.0E-01	1.5E-01	1.3E-01
1-hour SO_2	1.9E+02	3.7E+01	4.4E+00	4.8E-01	1.3E-01	1.7E+00	1.9E+02	3.7E+01	4.4E+00	5.2E-01	1.4E-01	1.7E+00	1.9E+02	3.7E+01	4.4E+00	4.8E-01	1.3E-01	1.7E+00
24-hour SO_2	2.8E+01	1.4E+01	9.4E+00	6.4E+00	1.5E+00	1.7E+00	2.8E+01	1.4E+01	9.5E+00	6.4E+00	1.5E+00	1.7E+00	2.8E+01	1.4E+01	9.4E+00	6.4E+00	1.5E+00	1.7E+00
Annual SO_2	2.0E+00	2.0E+00	1.9E+00	1.9E+00	1.8E+00	1.7E+00	2.0E+00	2.0E+00	1.9E+00	1.9E+00	1.8E+00	1.7E+00	2.0E+00	2.0E+00	1.9E+00	1.9E+00	1.8E+00	1.7E+00
1-hour Acetaldehyde	1.7E+01	3.8E+00	1.5E+00	5.1E-01	1.1E-01	2.8E-01	4.0E+01	4.8E+00	2.5E+00	8.9E-01	1.9E-01	4.5E-01	1.7E+01	4.0E+00	1.7E+00	5.5E-01	1.2E-01	3.1E-01
1-hour Acetone	8.9E+00	2.0E+00	8.1E-01	2.7E-01	5.7E-02	1.5E-01	2.1E+01	2.5E+00	1.3E+00	4.7E-01	9.9E-02	2.4E-01	8.9E+00	2.1E+00	9.0E-01	2.9E-01	6.1E-02	1.6E-01
1-hour Acrolein	1.4E+00	3.1E-01	1.3E-01	4.2E-02	8.8E-03	2.3E-02	3.3E+00	3.9E-01	2.1E-01	7.2E-02	1.5E-02	3.7E-02	1.4E+00	3.2E-01	1.4E-01	4.4E-02	9.4E-03	2.5E-02
1-hour Benzene	1.1E+00	2.5E-01	1.0E-01	3.4E-02	7.1E-03	1.8E-02	2.6E+00	3.1E-01	1.7E-01	5.8E-02	1.2E-02	3.0E-02	1.1E+00	2.6E-01	1.1E-01	3.6E-02	7.6E-03	2.0E-02
1-hour Ethylbenzene	1.9E-01	4.3E-02	1.7E-02	5.7E-03	1.2E-03	3.1E-03	4.5E-01	5.4E-02	2.9E-02	1.0E-02	2.1E-03	5.1E-03	1.9E-01	4.5E-02	1.9E-02	6.1E-03	1.3E-03	3.5E-03
1-hour Formaldehyde	9.0E+00	2.0E+00	8.2E-01	2.7E-01	5.8E-02	1.5E-01	2.1E+01	2.5E+00	1.4E+00	4.7E-01	1.0E-01	2.4E-01	9.0E+00	2.1E+00	9.2E-01	2.9E-01	6.2E-02	1.6E-01
1-hour Toluene	1.6E+00	3.6E-01	1.5E-01	4.9E-02	1.0E-02	2.7E-02	3.8E+00	4.5E-01	2.4E-01	8.4E-02	1.8E-02	4.3E-02	1.6E+00	3.8E-01	1.6E-01	5.2E-02	1.1E-02	2.9E-02
1-hour Xylenes	1.3E+00	2.9E-01	1.2E-01	3.9E-02	8.2E-03	2.1E-02	3.0E+00	3.6E-01	1.9E-01	6.7E-02	1.4E-02	3.4E-02	1.3E+00	3.0E-01	1.3E-01	4.1E-02	8.7E-03	2.3E-02
1-hour Carcinogenic PAHs	1.1E-04	2.1E-05	2.9E-06	4.0E-07	8.6E-08	1.0E-06	5.1E-04	3.1E-05	1.5E-05	4.7E-06	8.1E-07	3.1E-06	1.4E-04	2.4E-05	6.3E-06	1.1E-06	2.2E-07	1.4E-06
1-hour Non-carcinogenic PAHs	7.0E-03	1.3E-03	1.8E-04	2.5E-05	5.4E-06	6.4E-05	3.2E-02	2.0E-03	9.5E-04	3.0E-04	5.1E-05	1.9E-04	8.7E-03	1.5E-03	3.9E-04	7.0E-05	1.4E-05	8.6E-05
1-hour Naphthalene	3.5E-03	6.6E-04	9.0E-05	1.2E-05	2.6E-06	3.2E-05	1.6E-02	9.6E-04	4.7E-04	1.5E-04	2.5E-05	9.5E-05	4.3E-03	7.4E-04	1.9E-04	3.4E-05	6.7E-06	4.2E-05
1-hour Aluminum	1.1E-02	2.0E-03	2.8E-04	3.7E-05	8.1E-06	9.7E-05	4.8E-02	2.9E-03	1.4E-03	4.5E-04	7.6E-05	2.9E-04	1.3E-02	2.3E-03	5.9E-04	1.1E-04	2.0E-05	1.3E-04
1-hour Cadmium	7.9E-03	1.5E-03	2.1E-04	2.8E-05	6.1E-06	7.2E-05	3.6E-02	2.2E-03	1.1E-03	3.3E-04	5.7E-05	2.2E-04	9.7E-03	1.7E-03	4.4E-04	7.9E-05	1.5E-05	9.7E-05
1-hour Chromium	1.3E-03	2.5E-04	3.4E-05	4.7E-06	1.0E-06	1.2E-05	5.9E-03	3.7E-04	1.8E-04	5.6E-05	9.5E-06	3.6E-05	1.6E-03	2.8E-04	7.4E-05	1.3E-05	2.5E-06	1.6E-05
1-hour Lead	1.3E-03	2.5E-04	3.4E-05	4.7E-06	1.0E-06	1.2E-05	5.9E-03	3.7E-04	1.8E-04	5.6E-05	9.5E-06	3.6E-05	1.6E-03	2.8E-04	7.4E-05	1.3E-05	2.5E-06	1.6E-05
1-hour Zinc	9.2E-03	1.8E-03	2.4E-04	3.3E-05	7.1E-06	8.4E-05	4.2E-02	2.6E-03	1.3E-03	3.9E-04	6.7E-05	2.5E-04	1.1E-02	2.0E-03	5.2E-04	9.2E-05	1.8E-05	1.1E-04

Note: Location of the human health receptors are shown on Figure J1.1-1.