OPG's DEEP GEOLOGIC

REPOSITORY

FOR LOW & INTERMEDIATE LEVEL WASTE

Hydrology and Surface Water Quality Technical Support Document

March 2011

Prepared by: Golder Associates Ltd.

NWMO DGR-TR-2011-04

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NWMO DGR-TR-2011-04

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EXECUTIVE SUMMARY

ES.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'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 Receipt 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 the 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. As such, these boundaries become the study areas adopted for the EA. Four study areas were selected for the assessment of hydrology and surface water quality: the Regional Study Area, Local Study Area, Site Study Area and Project Area. The Project Area, although not specified in the DGR Project 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).

ES.3 VALUED ECOSYSTEM COMPONENTS

While all components of the environment are important, it is neither practical 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., total suspended solids as an indicator for surface water quality). Each indicator requires specific ‘measures’ that can be quantified and assessed (e.g., concentration of total suspended solids in surface water). 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 hydrology and surface water quality:

- surface water quantity and flow; and
- surface water quality.

ES.4 RESULTS

Project-environment interactions are identified and assessed for potential measurable changes. Measurable changes in surface water quantity and flow, and surface water quality in the on-site drainage network are identified as a result of the DGR Project. These identified measurable changes are assessed to determine whether they are adverse. The following residual adverse effects are identified after taking mitigation measures into consideration for the surface water quantity and flow VEC:

- Decrease in flow in the North Railway Ditch associated with operations of the stormwater management pond. This residual adverse effect was assessed to be not significant because of the low magnitude and geographic extent (i.e., limited to the Project Area).
- Increase in flow in the drainage ditch under Interconnecting Road associated with site preparation and construction of the stormwater management system and the shaft sump pumping. This residual adverse effects was assessed to be not significant because of the low geographic extent and low timing and duration (i.e., limited to the Site Study Area and the relatively short construction period).
- Increase in flow in the drainage ditch under Interconnecting Road during the operations phase associated with operations of the stormwater management pond and pumping of underground water. This residual adverse effect was assessed to be not significant because of the low geographic extent (i.e., limited to the Site Study Area).

In addition, the following other conclusions are made regarding hydrology and surface water quality:

- no residual adverse effects were identified for surface water quality, provided the discharge from the stormwater management system meets certificate of approval discharge criteria;
- the environment is not expected to adversely affect the DGR Project, with regards to surface water quantity and flow (e.g., flooding); and
- climate change is not expected to alter the conclusions reached with regards to the effects of the DGR Project on surface water quantity and flow.

Therefore, no significant adverse effects are identified for hydrology and surface water quality 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.

The follow-up monitoring proposed for hydrology and surface water quality recommends monitoring surface water quality during the site preparation and construction, and operations phases at the DGR Project site discharge point (Interconnecting Road beyond the stormwater management pond). The program objectives are to characterize site runoff and to ensure site discharge meets certificate of approval discharge criteria.

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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 an 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 or operated nuclear generating stations, in a DGR at the Bruce nuclear site in the Municipality of Kincardine, Ontario. The project location 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 licences.

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 DGR 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 Regulations. 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, a copy of which is included in the EIS as Appendix A, were finalized on January 26, 2009. 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 DGR Project EIS 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 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 assessed 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 the assessment 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. Additionally, Chapter 7 of the Preliminary Safety Report presents the preliminary derived release limits to surface water for the DGR.

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 Hydrology and Surface Water Quality TSD evaluates the non-radiological effects of the site preparation and construction, operations and decommissioning of the DGR Project on hydrology and surface water quality. 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.

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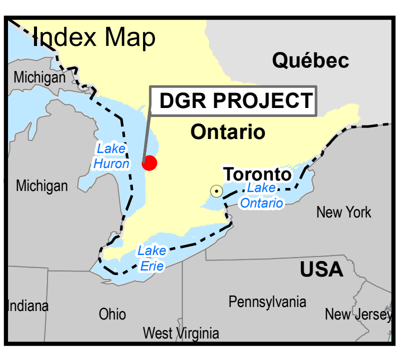

0 5 10 20 30 40 50

Kilometres

LEGEND

- ONRoads
- 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

HYDROLOGY AND SURFACE WATER QUALITY 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	14 Apr. 2010		
CHECK	BC	14 Apr. 2010		
REVIEW	MAR	14 Apr. 2010		

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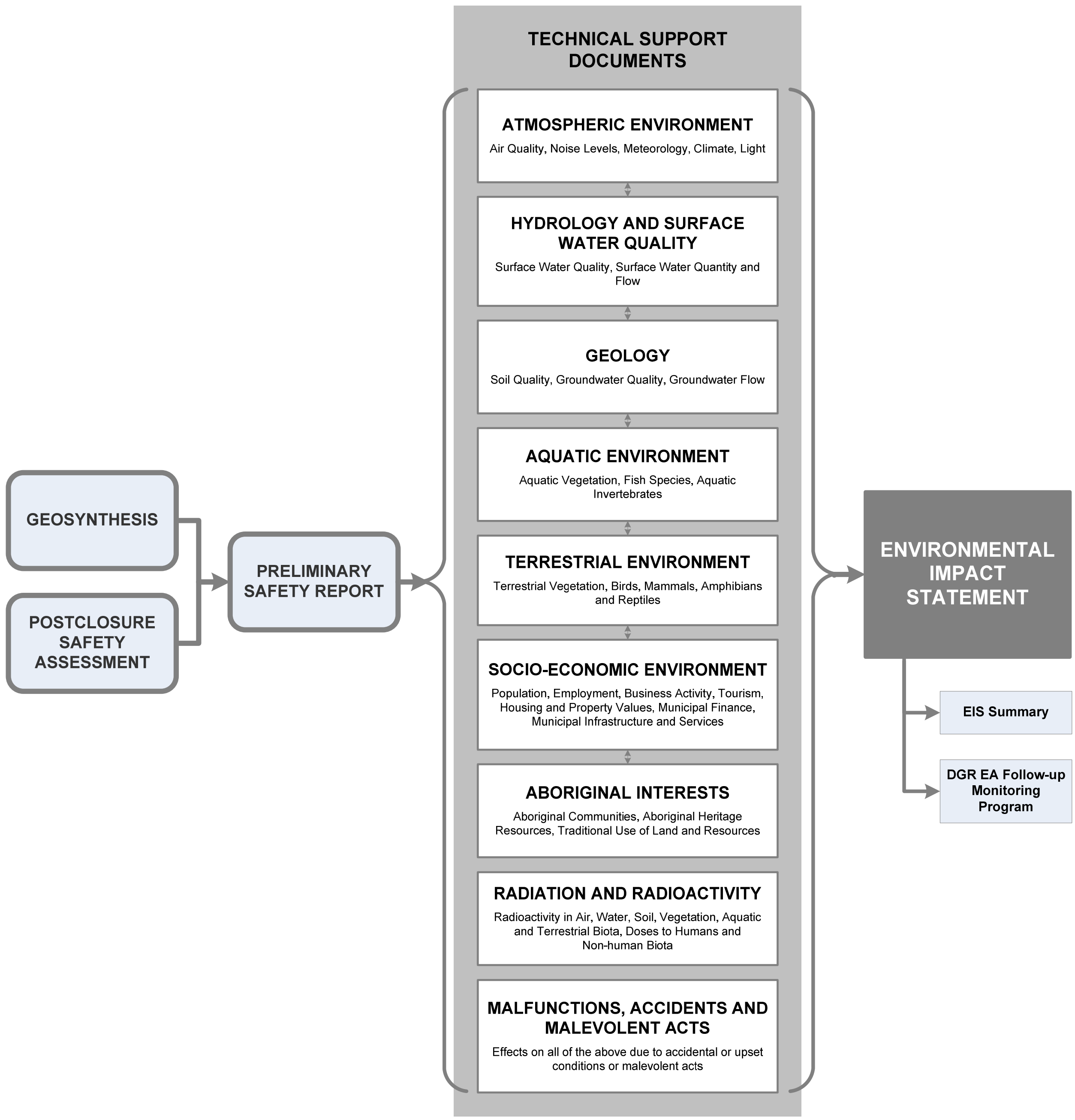

Figure 1.2-1: Organization of EA Documentation

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2. APPROACH

2.1 GENERAL SUMMARY OF EA APPROACH

The approach used for assessing the DGR Project, and documented in the 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 DGR 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 assessed 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, irreversibility, and ecological and social context 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. Hydrology and surface water quality 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 surface water quantity and flow may affect surface water quality).

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., changes in drainage areas during site preparation can affect the VEC surface water quantity and flow). An indirect interaction occurs when the VEC is affected by a change in another VEC (e.g., changes in the air quality [VEC in the Atmospheric Environment TSD] could affect the surface water quality VEC through the deposition of dust to surface water). These interactions are identified in Section 6, and evaluated in Sections 7 and 8, as appropriate.

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 hydrology and surface water quality VECs and where the indirect effects are evaluated. Other TSDs use predictions from the Hydrology and Surface Water Quality TSD. This includes the Socio-economic Environment, Terrestrial Environment, Aquatic Environment and Geology TSD. Multi-feature VECs are evaluated in Section 7 in 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.

[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".

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 hydrology and surface water quality is provided at the end of the assessment section (Section 8.4.1).

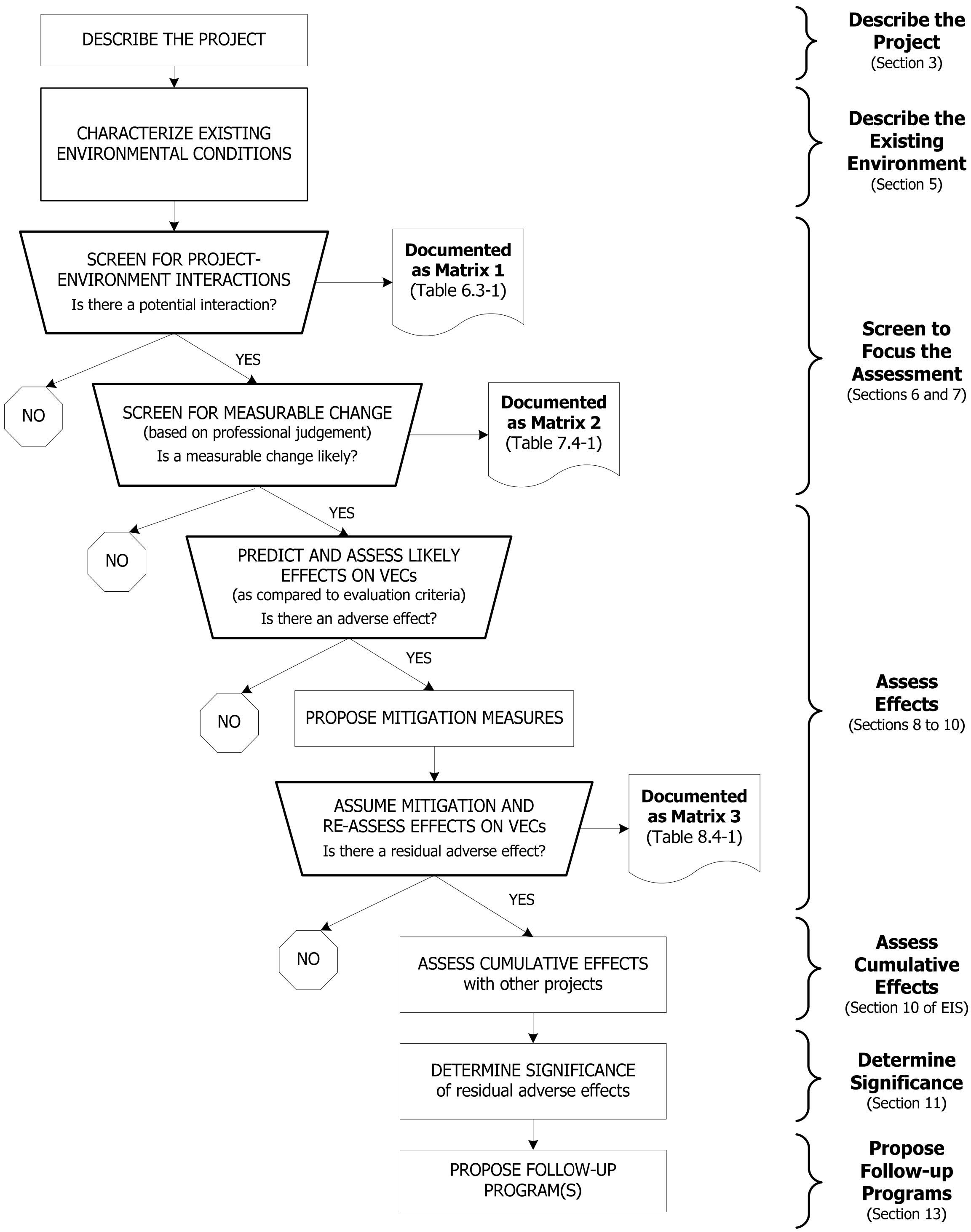

Figure 2.1-1: Methodology for Assessment of Effects

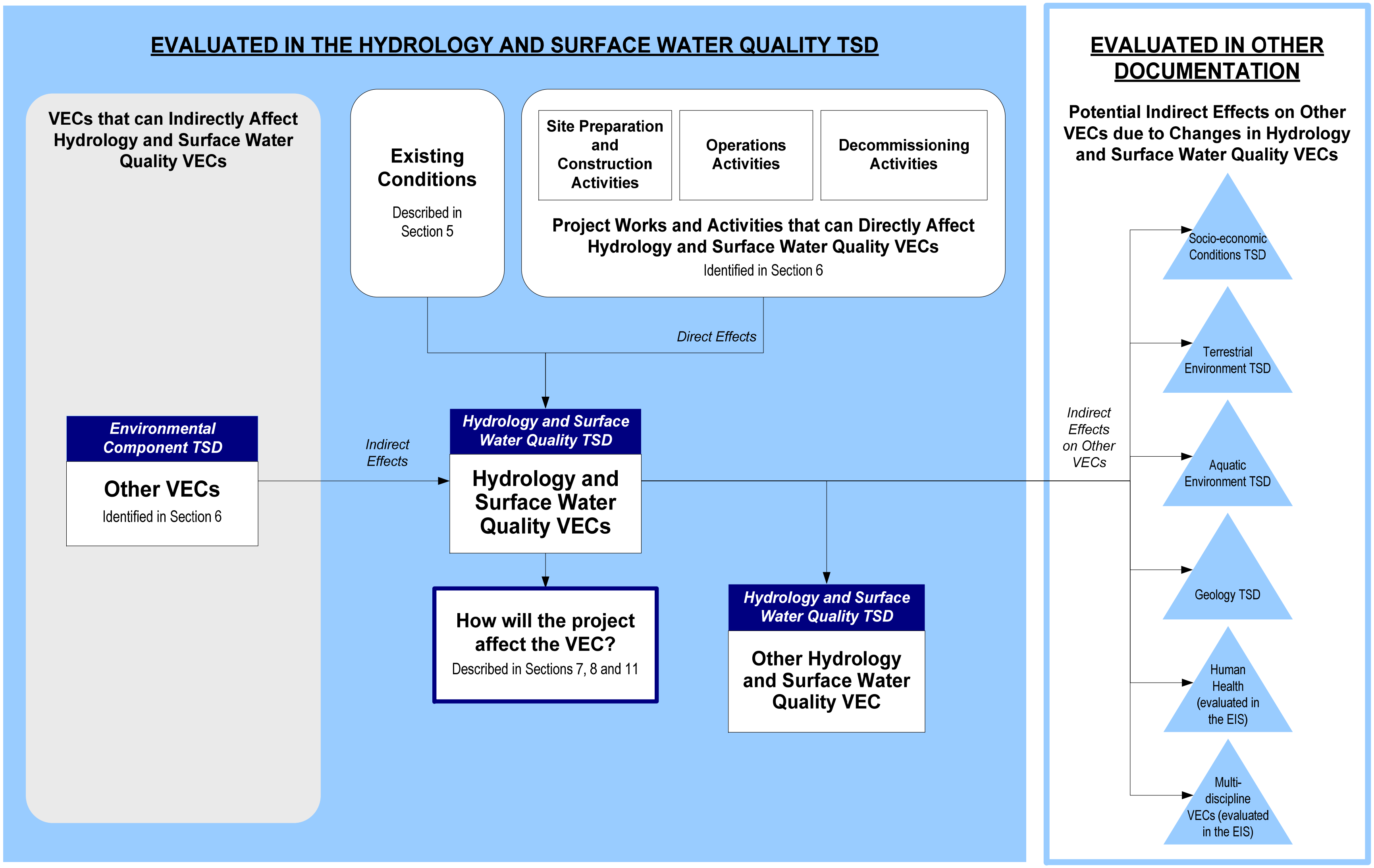

Figure 2.1-2: Information Flow Diagram for the Hydrology and Surface Water Quality VECs

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 Aboriginal 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 with regards to 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 local Aboriginal communities.

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 hydrology and surface water quality 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, 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, 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 about 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 of up to three hundred years.

These timeframes are intended to be sufficiently flexible to capture the effects of the DGR Project. The assessment of hydrology and surface water quality focuses on the first three phases as there are no activities during the abandonment and long-term performance phase that could interact with the hydrology and surface water 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. As such, these boundaries become the study areas adopted for the EA.

The DGR Project EIS Guidelines (included as Appendix A of the EIS) 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. Generic study areas for the EA are presented in the EIS. As described in the following sections, these have been modified for the Hydrology and Surface Water Quality TSD.

Four study areas were selected for the assessment of hydrology and surface water quality: 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 (Figure 2.4.2-1) for hydrology and surface water quality includes the lands bound by regional watersheds and extend 4 km offshore. The northern and southern limits have been selected to include municipal Water Supply Plant (WSP) intakes at Southampton and Kincardine. Consistent with the EIS Guidelines, this is the area within which there is the potential for cumulative or wider-spread effects.

2.4.2.2 Local Study Area

The Local Study Area (Figure 2.4.2-2) for hydrology and surface water quality corresponds to the Stream C and Underwood Creek watersheds for the on-land (non-lake) portion. The Local Study Area also extends approximately 2 km offshore into Lake Huron, from MacGregor Point Provincial Park in the north to McRae Point in the south. Consistent with the EIS Guidelines, this is the area outside of the Site Study Area with a reasonable potential for direct hydrology and surface water quality effects.

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 for the generating stations on land and over water, as defined in the DGR Project EIS Guidelines. The Site Study Area includes the nearshore waters of Lake Huron, including MacPherson Bay (small embayment immediately south of Bruce A and Baie du Doré), which receive the surface water runoff from catchment areas draining water from portions of the DGR Project Area. The Site Study Area also includes the lower section of the Stream C watershed, which drains the remainder of the DGR Project Area.

2.4.2.4 Project Area

The Project Area (see 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. The Project Area was the particular area of focus for the hydrology and surface water quality assessment. The Project Area includes a network of drainage ditches, including the North and South Railway Ditches, which drain to the larger catchment areas in the Site Study Area.

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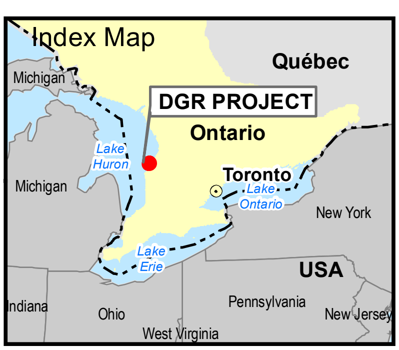

LEGEND

- Municipal Water Supply
- 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

HYDROLOGY AND SURFACE WATER QUALITY
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		
GIS	ASB	14 Apr. 2010	**FIGURE 2.4.2-1**	
CHECK	AB	14 Apr. 2010		
REVIEW	MAR	14 Apr. 2010		

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0 1 2 4 6

Kilometres

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.

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PROJECT

HYDROLOGY AND SURFACE WATER QUALITY TECHNICAL SUPPORT DOCUMENT

TITLE

LOCAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	10 Apr. 2010		
CHECK	AB	10 Apr. 2010		
REVIEW	MAR	10 Apr. 2010		

FIGURE 2.4.2-2

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LEGEND

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

0 0.5 1 2

Kilometres

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

HYDROLOGY AND SURFACE WATER QUALITY
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	**FIGURE 2.4.2-3**	
GIS	BC	22 Apr. 2010		
CHECK	AB	22 Apr. 2010		
REVIEW	MAR	22 Apr. 2010		

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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 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 (LLW) 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 DGR 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 (i.e., the DGR Project) on the hydrology and surface water quality 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 system will maintain critical equipment 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 drainage ditch 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 the 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 services area in which offices, a workshop, wash bay, refuge stations, lunch rooms 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 approximately 250 m. End walls may be erected once the rooms are filled.

The emplacement rooms will all be aligned with the assumed direction (east-north-east) 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.

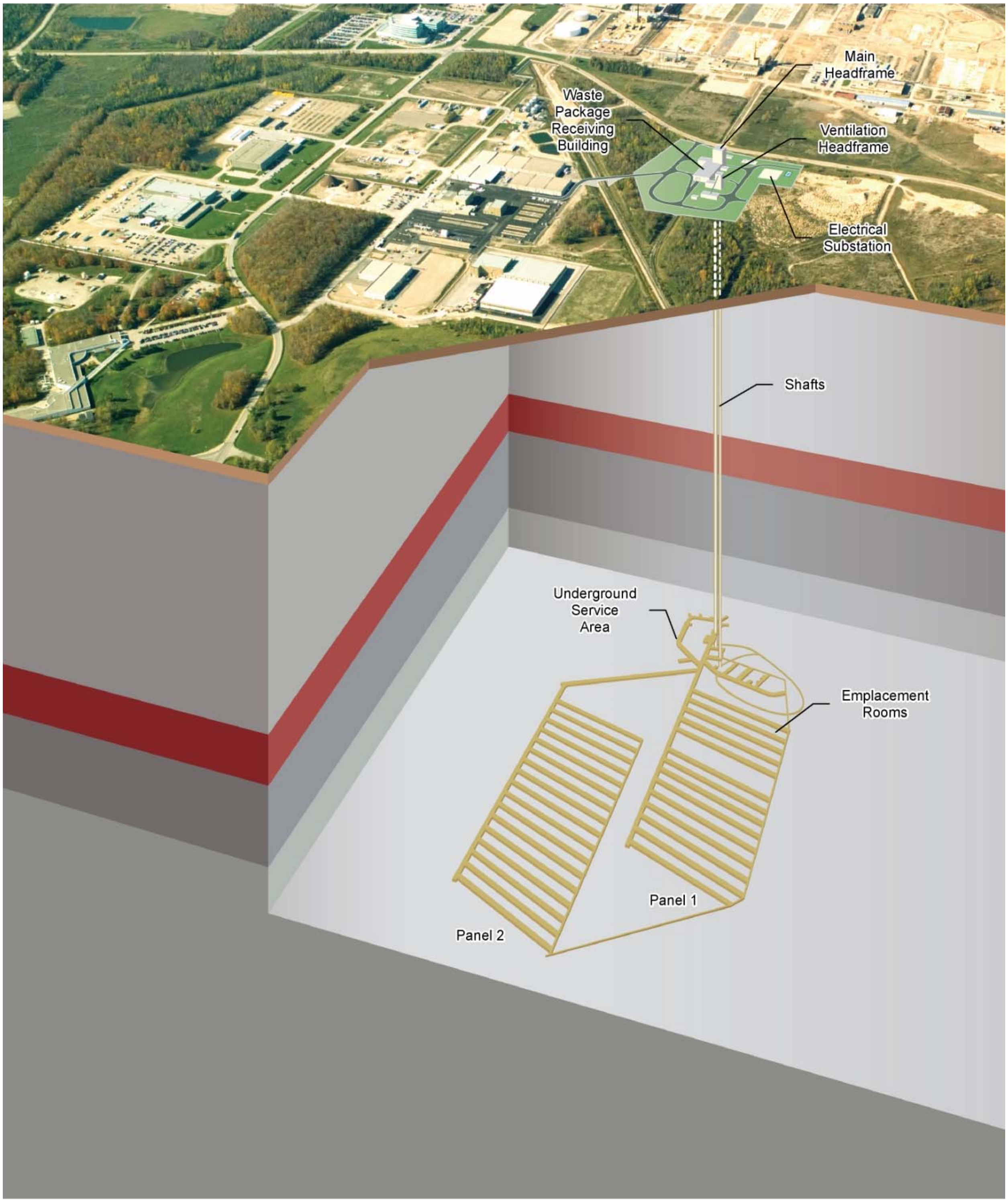

Figure 3.1-1: Schematic of DGR Project

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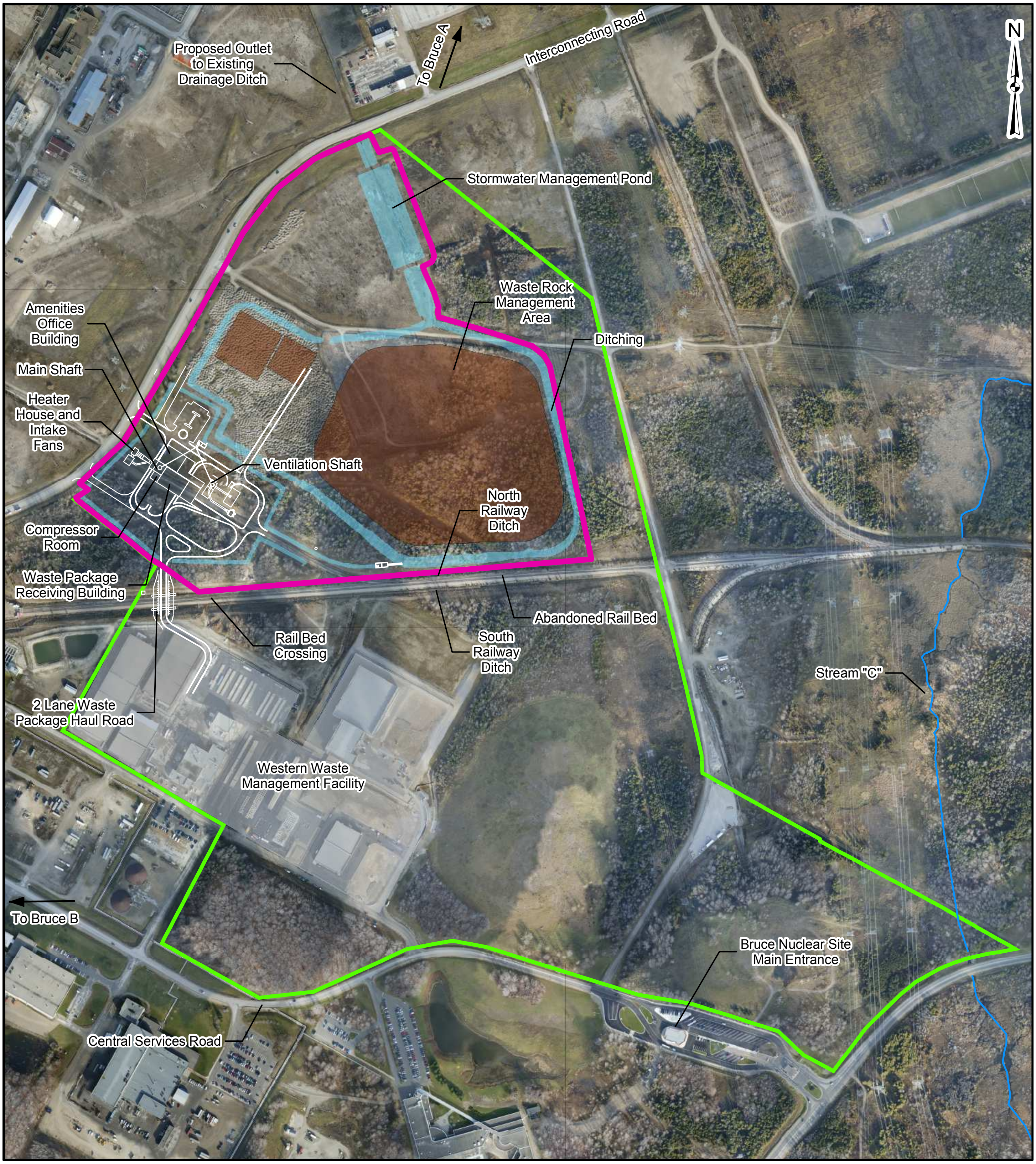

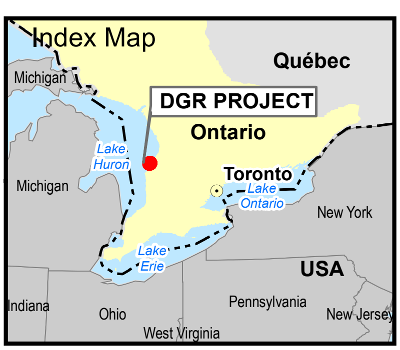

LEGEND

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

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

HYDROLOGY AND SURFACE WATER QUALITY TECHNICAL SUPPORT DOCUMENT

TITLE

LAYOUT OF DGR SURFACE INFRASTRUCTURE

Golder Associates
Mississauga, Ontario

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		

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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 individually valued component of the environment or a collection of components that represent one aspect of the environment (e.g., surface water quality).

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., surface water quality);
- an individual wildlife species (e.g., mallard duck, lake whitefish 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., suspended solids as an indicator for surface water quality). Each indicator requires specific 'measures' that can be quantified and assessed (e.g., increase in suspended solids concentrations).

The 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 houses, 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 with regards to 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 hydrology and surface water quality: surface water quantity and flow, and surface water quality. These two VECs were selected to be representative of hydrology and surface water quality because they are important to the ecosystem and members of the public. They are also 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 Hydrology and Surface Water Quality

VEC	Rationale for Selection	Indicators	Measures
Surface Water Quantity and Flow	• Maintaining natural flows in local streams during specific times is critical to various life stages of sensitive species	• Seasonal stream flow	• Changes in seasonal stream flow
Surface Water Quality	• Water quality is critical for sensitive aquatic species, recreational use and aesthetics	• Total suspended solids • Nutrients • Metals • Temperature • Salinity • pH	• Concentrations of indicator compounds • Changes in temperature

Note:
This TSD considers only potential effects of the DGR Project on surface water quality associated with conventional (i.e., non-radiological) parameters. The potential effects of radioactivity on surface water quality are considered in the Radiation and Radioactivity TSD. In addition, overall effects of the DGR Project on Lake Huron are considered in the EIS.

The following sections identify and justify the selection of VECs for assessing the effects of the DGR Project on hydrology and surface water quality.

4.1 VALUED ECOSYSTEM COMPONENTS

4.1.1 Surface Water Quantity and Flow

Changes to surface water flow and quantity can alter the habitat for sensitive species in rivers and streams. Many species rely on specific flow velocities and water depths for their various life stages (e.g., spawning). Maintaining typical seasonal and annual flows, including variations, will maintain the habitats in and around the stream.

Changes in the flow regime of a stream can also change the erosion and deposition of sediments within the stream, which in turn can alter the habitat in and around the stream. Maintaining a deposition/erosion balance that is consistent with the existing conditions within the stream will ensure that the habitat conditions remain the same.

4.1.2 Surface Water Quality

Specific water quality parameters are critical for the various life stages of sensitive aquatic species. Changes in parameters such as suspended sediment concentration (i.e., water clarity), nutrients, metals, salinity and temperature can negatively affect the growth and development of these species. Therefore, maintaining water quality at a specific location within the natural variability will increase the probability that a sensitive species will maintain the existing population.

Water quality is also a valuable aspect with regards to human uses. A body of water with poor water quality (e.g., odours, poor water clarity, algal blooms) will not likely be aesthetically attractive for recreational use or domestic consumption.

4.2 INDICATORS

4.2.1 Surface Water Quantity and Flow

The indicator selected for the surface water quantity and flow VEC is seasonal flow. Seasonal flow was selected since it reflects the time period that is consistent with changes to the conditions and habitat within a stream. Daily flow variations caused by precipitation events are not likely to change the conditions in a water body provided that the long-term conditions are consistent with existing conditions. Annual flow conditions are not the most useful indicator since they do not consider seasonal effects (e.g., spring runoff) that are critical to some species. It should be recognized that there is a natural, non-trivial amount of variation in seasonal flow from year to year that must be considered.

4.2.2 Surface Water Quality

The indicators selected for the surface water quality VEC were total suspended solids, metals concentrations, nutrients and temperature. The rationale for the selection of each indicator is discussed below.

Total suspended solids (TSS) is generally a measure of water clarity, the amount of particulates and the degree of erosion in the area. Many cold water species (e.g., trout) can only tolerate high TSS concentrations for short periods of time. As TSS concentrations increase, the amount of light that penetrates into the water decreases. A decrease in light can affect plant growth and the health of benthic organisms.

The amount of nutrients (nitrogen, phosphorous and ammonia) in a water body controls the growth of algae and aquatic plants. In Ontario, the growth of algae and aquatic plants is generally limited by the amount of phosphorous. Increases in algae and aquatic plants can degrade habitat, change the sediment quality, decrease dissolved oxygen levels (decay of algae/plant material) and make the water aesthetically displeasing. Nitrogen, while not as important to plant growth as phosphorous, is important for the DGR Project given that there may be residual ammonia in the waste rock piles from the use of explosives (e.g., ANFO). Of specific interest is un-ionized ammonia.

While most species can tolerate low concentrations of metals in the water, increasing the concentration of some metals (e.g., mercury, copper) can lead to increased toxicity (acute or chronic). The metals chosen as indicators for water quality are aluminum, boron, cobalt, copper, iron, thallium, vanadium and zinc. During the baseline water quality monitoring in 2007 and 2009, copper, iron and zinc exceeded the respective Provincial Water Quality Objective (PWQO) [9] on at least one occasion. In addition, leachate tests indicated that aluminum, boron, cobalt, thallium, and vanadium concentrations in the waste rock pile runoff could potentially exceed of the PWQOs [10]. The surface water quality monitoring results are discussed further in Section 5.5.2 and are provided in Appendix E.

Salinity, measured as specific conductivity, is also included as an indicator. Total dissolved solids (TDS) is a measure of the total inorganic and organic ions present in water. It measures a variety of parameters, including metals, dissolved limestone and salt. In surface water samples, high TDS is typically an indication of high salinity. Increases in salinity can indicate an increase in other parameters that are not measured or are usually below the detection limit.

The measurement of pH is also included since most aquatic organisms require a suitable pH (e.g., 6.5 to 8.5 as specified in the PWQO) [9]. Additionally, pH is required to calculate un-ionized ammonia [9].

Water temperature is a key feature when assessing the aquatic habitat within a stream. Not only does water temperature regulate biological activity (e.g., plant growth, decay), some species are sensitive to changes to water temperature during specific life stages (e.g., spawning, egg incubation). Temperature is also required for the calculation of un-ionized ammonia [9].

4.3 MEASURES

4.3.1 Surface Water Quantity and Flow

The measure used to evaluate the effects of the DGR Project on the surface water quantity and flow will be the changes in seasonal stream flow relative to the existing conditions. The baseline conditions are established in Section 5.

4.3.2 Surface Water Quality

The measure used to evaluate the effects of the DGR Project on the surface water quality will be changes in concentrations of the indicator compounds (i.e., TSS, nutrients and metals) and changes in temperature.

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

This section provides a description of the existing environmental conditions in the study area for the hydrology and surface water quality components of the EIS. For the purposes of this TSD, “existing conditions” are defined as those generally present at the site and may reflect the cumulative 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.

5.1 EXISTING ENVIRONMENT METHODS

The description of the existing environment focuses on VECs identified in Section 4. Information is presented for the study area with emphasis placed on the areal extents most likely to be affected by the DGR Project. The description of the existing environment for hydrology and surface water quality presents:

- a compilation and review of existing information; and
- details and results of the field programs undertaken to update existing information and fill data gaps.

The hydrology and surface water quality component of the study uses the Regional, Local and Site Study Areas and Project Area (defined in Section 2.4.2) to characterize the existing conditions. The Project Area is the portion of the Bruce nuclear site that is being considered for the DGR Project. The Project Area specifically includes the WWMF because of its proximity to the DGR Project and shared drainage pathways. The nearshore areas of Baie du Doré and the small embayment immediately south of MacPherson Point are included in the Site Study Area. For convenience, the Project Area and the Site Study Area are discussed together.

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 hydrology and surface water quality are explained in the following sections.

5.1.1 Sources of Existing Data

The following sources of information were used in the characterization of the existing environment.

5.1.1.1 Surface Water Quantity and Flow

The characterization of the existing water quantity and flow conditions in the Site Study Area is based on the following reports and studies:

- Interim Stormwater Management Plan for Zone K [11];
- Bruce A Nuclear Division - Storm Water Control Study [12]; and
- Surface Water Resources Technical Support Document, Bruce A Refurbishment for Life Extension and Continued Operations Project [13].

5.1.1.2 Surface Water Quality

The characterization of the existing water quality conditions in the Site Study Area is based on the following reports and studies:

- Western Waste Management Facility Integrated EA Follow-up Program [14];
- Low Level Storage Buildings 9, 10 & 11 Environmental Assessment Study Report [15];
- Interim Stormwater Management Plan for Zone K [11];
- Bruce A Nuclear Division - Storm Water Control Study [12]; and
- Results of Storm Water Monitoring Program, Bruce Power Site, Tiverton, Ontario [16].

5.1.2 Field Studies

Field studies were completed in this EA process to support the description of the existing conditions. Specific studies measured:

- surface water flow;
- surface water quality;
- sediment quality; and
- geomorphic conditions in Stream C.

For ease of discussion, the methods for each of the studies are described with the results in Sections 5.4 and 5.5, as appropriate. Detailed surface water quality sampling results are presented in Appendix E. Detailed sediment sampling results are presented in Appendix F.

5.2 TRADITIONAL KNOWLEDGE AND ABORIGINAL SHARING

As described in the Aboriginal Interests TSD, the local Aboriginal communities have historically identified a number of issues relating to the Bruce nuclear site, which would apply to the DGR Project. Those issues that relate to hydrology and surface water quality include:

- traditional lands, waters, and resources, a fundamental part of Aboriginal culture, identity and economy, and essential to the sustainability of the Aboriginal communities;
- treaty rights in the waters surrounding the Bruce Peninsula, including fishing rights and lake bed;
- long-term use of lands and waters, including use of traditional territory for hunting, gathering and fishing;
- the traditional fisheries of Lake Huron and Georgian Bay and their importance to the cultural and economic health of the First Nation communities;
- Lake Huron water quality; and
- effects of future lake water levels and climate change.

The description of the existing hydrology and surface water quality includes discussion of water quality in Lake Huron and other streams and ditches in the Site Study Area (Section 5.5) so that the above-listed concerns may be assessed in the EA.

5.3 OVERVIEW OF KEY FEATURES

This section provides a brief overview of the key surface water features that are associated with this assessment. The intent of this section is to provide the reader with an introduction to the key features and how they relate to each other. Detailed descriptions of these key features are provided in the following sections. Key features are shown on Figure 5.3-1.

The Bruce nuclear site is primarily drained by a network of constructed ditches and drains that have been divided into several drainage areas (Section 5.4.3). The DGR Project site is mostly located within the MacPherson Bay South Drainage Area and drains into MacPherson Bay (Section 5.4.2) via an un-named ditch (Section 5.4.3.1).

A small portion of the DGR Project site currently drains to the east via the North Railway Ditch (Section 5.4.3.2). The North and South Railway Ditches flow adjacent to an abandoned rail bed toward Stream C (Section 5.4.4). Stream C is a diverted tributary of the Little Sauble River that passes through the eastern portion of the Bruce nuclear site. Stream C provides drainage for the Stream C Drainage Area and ultimately drains into Baie du Doré located to the northeast of the Bruce nuclear site.

Both MacPherson Bay and Baie du Doré are shallow embayments of Lake Huron (Section 5.4.1).

Figure 5.3-1: Key Features of the Bruce Nuclear Site

5.4 HYDROLOGY

5.4.1 Lake Huron

Lake Huron is the major water body near the Bruce nuclear site. The lake is the second largest of the Great Lakes, with a surface area of approximately 60,000 km^2 and a shoreline length of approximately 6,200 km. The surface of Lake Huron is approximately 176 m above sea level. The average depth is 59 m, while the maximum depth is 229 m at a location near Sault Ste. Marie. The maximum depth near the study area is approximately 180 m. Approximately 40% of Lake Huron's waters are less than or equal to 40 m deep, and are located in the shallows of Georgian Bay and the North Channel in the north, Saginaw Bay in the south and a narrow band along the entire perimeter of the lake.

The Great Lakes water levels have fluctuated throughout their history. Levels of Lakes Michigan and Huron, for example, reached record highs in both 1886 and 1986. Lakes Michigan and Huron's record low water levels coincided with climatic events such as the Dust Bowl of the 1930s, a multi-continental severe drought in 1964 (which is the record low for the two lakes), and the most recent El Niño of 1997, which was the strongest on record [17].

Although there are extensive networks of small rivers and creeks feeding into Lake Huron in the Local Study Area (Figure 2.4.2-2), there are no major rivers in the Site Study Area. There are two small east to west drainage courses entering the lake adjacent to the Bruce nuclear site: Underwood Creek empties into the Baie du Doré to the north; and the Little Sauble River, which forms the southern boundary of Inverhuron Provincial Park, empties into Inverhuron Bay to the south. In addition, there is a small stream, Stream C (see Section 5.4.4), that enters the Baie du Doré through the Bruce nuclear site and a number of on-site drainage features (see Section 5.4.3) that are directed to Lake Huron.

To the west and northwest, Lake Huron stretches uninterrupted for approximately 128 km. The nearest land across the lake is Port Hope, Michigan, USA, approximately 98 km southwest of the Bruce nuclear site.

On Lake Huron, ice normally begins to form in harbours and shallow-water areas in early December with ice fields and concentrated brash forming in early January. The central part of Lake Huron normally does not freeze over in winter, but drifting patches of thin ice may be present from early February until mid-March. Annual Maximum Ice Coverage (AMIC) ranges from 45 to 79% [18]. The shallow areas of the lake (less than 40 m deep) typically have extensive ice cover every winter.

In general, water depths in the nearshore zone of the lake range from 6 to 20 m, except in Baie du Doré where depths do not exceed 5 m. Bedrock substrate predominates in the shallow areas of the open shoreline, grading to a mixture of pebble, cobble and boulder at the 7 to 12 m depths. Extensive marsh areas are located along the shore of Baie du Doré.

Nearshore currents in Lake Huron have been measured during the ice-free period since the early 1970s. Current direction in the Regional Study Area is predominantly parallel to the shoreline with a northeastern direction being the most common. Currents to the southwest also occur but on a less frequent basis [13].

Municipal, commercial and recreational uses of Lake Huron in the Regional Study Area of the Bruce nuclear site include drinking water intakes, disposal of treated municipal waste water, commercial and recreational fishing, recreational boating, and swimming [15]. The towns of Southampton and Kincardine have municipal water supply plants (WSPs) that obtain water from Lake Huron, and water pollution control plants (WPCPs) that discharge treated wastewater to Lake Huron. The modestly warmer waters originating from the cooling water discharges from the Bruce nuclear generating stations provide year round sport fishing opportunities. The Baie du Doré wetland adjacent to the Bruce nuclear site and northeast of the Project Area provides habitat suitable for fish spawning and rearing.

Recreational uses of Lake Huron are frequent in the areas of MacGregor Point Provincial Park, Brucedale Conservation Area and Inverhuron Provincial Park, as well as other public beaches along the shore. Recreational uses of Lake Huron are discussed in the Socio-economic Environment TSD. Most of the rural population within the Regional Study Area obtains its water from private or communal wells. Private and communal wells and groundwater conditions are discussed in the Geology TSD. Many inland cottages have water wells and septic tanks, although some lakefront properties may have direct intakes from the lake. One business at the Bruce ECO-Industrial Park, located just east of the Bruce nuclear site, obtains its drinking water, which is treated prior to distribution, from the lake at an intake located along the shore of the Bruce nuclear site.

5.4.2 MacPherson Bay

MacPherson Bay is a small bay of Lake Huron located immediately south of the Bruce A nuclear generating station and is bounded by MacPherson Point to the north and Douglas Point to the south. MacPherson Bay is approximately 1,000 m wide where it meets the main body of Lake Huron and is approximately 600 m long. MacPherson Bay is generally shallow with depths less than 1 m. The maximum depth is approximately 3 m at the outer edges of the bay [19]. The bottom is characterized as either sand, cobble or bedrock [20].

MacPherson Bay receives direct runoff from the Bruce nuclear site, specifically from the MacPherson Bay North and South Drainage Areas shown on Figure 5.4.2-1. Runoff from the proposed DGR Project is expected to be discharged into MacPherson Bay via the un-named drainage ditch described in Section 5.4.3.1.

5.4.3 Surface Runoff and Drainage

Large portions of the inland Regional Study Area east of the Bruce nuclear site are within the Saugeen River Watershed, which drains into Lake Huron at Southampton approximately 30 km north of the Bruce nuclear site. Most of the land is developed for livestock and cash crop farming. Areas not developed for agriculture are generally either forested or consist of small rural communities. Surface water runoff in the Local Study Area generally drains directly to Lake Huron via small local watersheds.

The Bruce nuclear site is located within two small local watersheds (Stream C and MacPherson Bay, discussed in detail in Sections 5.4.4 and 5.4.2, respectively) bounded by the Underwood Creek watershed to the north and the Little Sauble River watershed to the south as shown on Figure 5.4.3-1. The Bruce nuclear site has an extensive drainage system consisting of catch basins, manholes, open ditches and culverts. All of the drainage is directed to Lake Huron via several outfalls and natural drainage features. Natural drainage enters the Bruce nuclear site via Stream C, a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s. Based on previous EA studies, drainage on the site has been geographically divided into sub-catchments as shown on Figure 5.4.2-1 [16]. Where available, the flow directions are also shown on Figure 5.4.2-1.

Historically, the Bruce nuclear site was divided into 15 small catchment areas (A through O), representing individual stormwater management zones, as shown on Figure 5.4.3-2. The relationship between the larger drainage areas and the catchment areas is shown on Figure 5.4.2-1. The historic catchment areas are shown on Figure 5.4.3-2 and are summarized in Table 5.4.3-1. Many of the historic studies on-site are reported in terms of these catchment areas.

A review of the Interim Stormwater Management Plan for Zone K [11] indicates that the DGR Project is located primarily within Catchment K, though a small portion of the DGR Project site along Interconnecting Road falls within Catchment J. Catchment K drains to Lake Huron via Catchment Areas J and L (south of MacPherson Point) and to Baie du Doré via the North and South Railway Ditches and Stream C.

As part of the field program (see Section 5.5.2.1), a site visit was conducted to verify the site drainage and identify any standing water. The existing drainage conditions shown on Figure 5.4.3-2 were updated from previous mapping to reflect minor differences identified during the site visit (e.g., some of the drainage ditches along Interconnecting Road at the north-eastern portion of Catchment K were found to drain in different directions than shown previously). These catchments consist largely of vacant land and electrical switchyards.

Table 5.4.3-1: Relationship between Drainage Areas and Catchment Areas at the Bruce Nuclear Site

Drainage Area [a]	Historic Catchment Area [b]
Bruce A	M, N, O
Bruce B	B, C, D
Bruce B North	E
Bruce B South	A
Douglas Point	H, G, F
Douglas Point North	I
MacPherson North	L, part of K
MacPherson South	J, part of K
Stream C	part of K

Notes:
a Refer to Figure 5.4.2-1 for drainage areas.
b Historic catchment areas are defined in [12].

0 0.25 0.5 1 1.5

Kilometres

LEGEND

- Little Sauble and Stream C Watershed Divide
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- Approximate Catchment Boundary
- Drainage Outfall
- Plant Discharge Channels

Drainage Area	Historic Catchment Area [12]
Bruce A	M, N, O
Bruce B	B, C, D
Bruce B North	E
Bruce B South	A
Douglas Point	H, G, F
Douglas Point North	I
MacPherson North	L, part of K
MacPherson South	J, part of K
Stream C	part of K

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

HYDROLOGY AND SURFACE WATER QUALITY
TECHNICAL SUPPORT DOCUMENT

TITLE

SITE DRAINAGE AREAS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE 5.4.2-1	
GIS	BC	28 Apr. 2010		
CHECK	KC	28 Apr. 2010		
REVIEW	AB	28 Apr. 2010		

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LEGEND

- Watershed Boundary
- Local Site Drainage
- 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

HYDROLOGY AND SURFACE WATER QUALITY
TECHNICAL SUPPORT DOCUMENT

TITLE

LOCAL DRAINAGE AREAS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 5.4.3-1**	
GIS	BC	19 Apr. 2010		
CHECK	KC	19 Apr. 2010		
REVIEW	AB	19 Apr. 2010		

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LEGEND

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

Catchment Areas

- Catchment A
- Catchment B
- Catchment C
- Catchment D
- Catchment E
- Catchment F
- Catchment G
- Catchment H
- Catchment I
- Catchment J
- Catchment K
- Catchment Division between K1 & K2
- Catchment L
- Catchment M
- Catchment N
- Catchment O

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 andwithin 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

0 125 250 500 750
Metres

PROJECT
HYDROLOGY AND SURFACE WATER QUALITY TECHNICAL SUPPORT DOCUMENT

TITLE
HISTORIC SITE DRAINAGE AREAS

Golder Associates
Mississauga, Ontario

PROJECT No.06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	03 Aug. 2006		
GIS	BC	12 Oct. 2010		
CHECK	KC	12 Oct. 2010		
REVIEW	AB	12 Oct. 2010		

FIGURE 5.4.3-2

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Catchment K is generally flat with an average slope of 0.006 m/m and is drained by a system of ditches along roadways and rail beds [13]. With the exception of the South Railway Ditch and Stream C, the drainage ditches in Catchment K are expected to be dry the majority of the time with flow occurring only during and following periods of significant rain or snowmelt. During the sampling events, there was not enough depth or velocity to measure flow at locations in Catchment K. The proposed DGR Project location primarily consists of open grassed areas and light brush cover. Some construction debris exists, and there are few impervious surfaces (i.e., paved areas) in Catchment K.

Catchments J and L are small, relatively flat drainage areas located between Interconnecting Road and Lake Huron just south of MacPherson Point. Drainage of these areas is through a series of catch basins, sewers and roadside ditches. These catchments include mostly vacant land and electrical switch yards. The southern section of Catchment J also drains part of the lands of the decommissioned heavy water plant.

The existing drainage areas and estimated flows in the portion of the Project Area where the surface facilities of the DGR will be located are summarized in Table 5.4.3-2. Three flows are presented for each of four assessment points (A to D). The flows include the mean annual discharge (total annual discharge volume averaged over the year), the 1:2 year peak flow (flow with a 50% probability of exceedance in any year) and 1:100 year peak flow (flow with a 1% probability of exceedance in any year). Mean annual discharge was determined by multiplying the recorded mean annual precipitation at the Environment Canada Meteorological station at Wiarton (1,041.3 mm) times the catchment drainage area multiplied by an assumed runoff coefficient based on the drainage basin characteristics. Peak flows are as reported in the Interim Stormwater Management Plan [11]. A sample calculation for deriving the average annual flow is provided in Appendix G.

Table 5.4.3-2: Drainage Areas and Flows in the DGR Surface Footprint

Flow Assessment Point		Existing Drainage (ha)	Average Annual Flow (L/s) [a]	1:2 Year Peak Flow (L/s) [b]	1:100 Year Peak Flow (L/s) [b]
A	Stream C at point of discharge from the Bruce nuclear site (North Access Road)	1,042.4	144.6	2,090	3,760
B	South Railway Ditch at Stream C	43.4	6.0	170	600
C	North Railway Ditch at Stream C	26.1	3.6	60	350
D	Drainage Ditch at Point of Discharge from DGR Project site (Interconnecting Road)	41.3	5.7	N/A	N/A

Notes:

a Based on mean annual precipitation at Wiarton (1,041.3 mm) and assumed runoff coefficient of 0.42 for all the assessed drainage areas.

b Reported in August 2000 ‘Interim Stormwater Management Plan – Zone K’ [11].

5.4.3.1 Un-named Drainage Ditch

Runoff from the proposed DGR Project site will be conveyed directly to MacPherson Bay via an existing un-named drainage ditch (Figure 5.3-1). Under the existing conditions, the ditch drains the portion of the MacPherson Bay South Drainage Area to the southeast of Interconnecting Road. Immediately upstream of Interconnecting Road the ditch is more appropriately described as a swale (a shallow sloped, grass lined ditch). The ditch is approximately 1.5 m deep near the road. Further upstream, the ditch is barely distinguishable from the surrounding flat terrain. Most of the ditch bottom is either grass lined or filled with cattails. The section immediately downstream of Interconnecting Road has been lined with cobbles, presumably to reduce erosion during large rainfall events.

The ditch conveys flow under Interconnecting Road via three culverts (each approximately 600 mm in diameter). These culverts are currently partially blocked with sediment and aquatic plants.

Downstream of Interconnecting Road, the ditch follows a straight path towards MacPherson Bay. For the most part, this section of the ditch is also a grassy swale with some cattail filled areas. The depth of the ditch gradually increases as it nears MacPherson Bay.

5.4.3.2 North and South Railway Ditches

Both the North and South Railway Ditches flow eastward towards Stream C adjacent to an abandoned rail bed. The North and South Railway Ditches were likely constructed during the initial development of the Bruce nuclear site in the 1960s.

The South Railway Ditch is straight with a channel width of approximately 5 m at the top of the bank throughout the reaches within the Project Area as shown on Figure 5.4.2-1. Historical investigations of the ditch documented a wetted channel width of 3 m and a mean water depth of 0.15 m [21]. The channel is choked with thick stands of cattail in some places, which serves to reduce water velocity. Flowing water was not observed during the September 11, 2009 water sampling event. There are also open channel sections that appear to have been subjected to clean-out/dredging in the past. The banks are covered with a mix of grasses, trees and shrubs.

The North Railway Ditch (see Figure 5.4.2-1) is similar in size to the South Railway Ditch and is also filled with thick stands of cattails. The North Railway Ditch is usually dry and only conveys water after large rainfall events.

5.4.4 Stream C

Stream C is located to the east, largely outside of the Project Area (see Figure 5.4.4-1). Stream C transects the southeast corner of the Project Area. As described in Section 5.3, it is a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s. It is the largest stream entering Baie du Doré.

Stream C enters the Bruce nuclear site via a culvert under Tie Road. The culvert is located approximately 300 m east of the main security gate. Downstream of Tie Road, Stream C flows north through a broad flood plain for approximately 700 m before passing under the abandoned rail bed via a large culvert. Stream C passes through a small pond immediately downstream of the culvert before meandering towards the confluence with the roadside ditch at the North Access Road. Stream C then flows north alongside the road for approximately 250 m before turning eastward under the North Access Road via a large culvert. Stream C then continues to the northeast for approximately 1,000 m before draining into the southeast portion of Baie du Doré.

The following sections provide a more detailed geomorphic assessment of Stream C.

5.4.4.1 Geomorphic Assessment of Stream C

A field reconnaissance was undertaken for a portion of Stream C on September 11, 2009, as part of the baseline characterization. The purpose of the reconnaissance was to characterize existing channel conditions to support a screening level geomorphic assessment and identify areas of potential concern with regards to erosion and deposition (if any).

Visual inspections (via walkovers) were conducted along the following reaches of Stream C (shown on Figure 5.4.4-2):

- upstream of the abandoned rail bed for approximately 250 m; and
- downstream of the abandoned rail bed to the confluence with the roadside ditch at the North Access Road.

The following sections provide general observations regarding the screening level geomorphic assessment of Stream C. Brief assessments of the roadside ditch and Stream C downstream of the site boundary are also provided based on a general visual inspection.

Upstream of Abandoned Rail Bed

The section of Stream C located immediately upstream of the abandoned rail bed drains to the north (see Figure 5.4.4-1) and was generally characterized by a single to multiple thread channel with a marked meandering pattern and limited bed form morphology.

The surrounding floodplain area was broad and well vegetated with mostly grasses and herbs. Secondary or ‘high flow’ channels were observed in places, likely demonstrating historic flooding and a strong hydraulic connection between the stream and floodplain. A marsh/wetland feature was noted along the eastern side of the floodplain with an approximate area of 2 ha. A hydro corridor runs along the western side of the floodplain.

The bankfull width of the main channel was estimated at approximately 2.5 to 3.5 m. The channel bed was typically incised below the floodplain by roughly 0.25 to 0.75 m. Channel geometry was largely trapezoidal with low to moderate bank angles (25° to 50°).

Bed substrate was dominated by soft/loose organics with fines intermixed and instances of cobble to boulder sized materials. Large woody debris was relatively limited. Bank materials were predominated by silty clay to silty sand loam. In general, the banks were heavily vegetated with grasses and herbs.

Depositional features (i.e., areas where sediments accumulate) were typically observed on the inside of meander bends; however, some instances of mid-channel or lobate sediment bars were noted. Minor bank erosion (mostly undercut) was noted on the outside and apex of several meanders.

Downstream of Abandoned Rail Bed to Confluence with Roadside Ditch

Stream C is directed beneath the abandoned rail bed via a corrugated steel pipe and then discharges or drains to a small pond with an approximate area of 0.1 ha (see Figure 5.4.4-1). From there, flows are directed to a well-defined channel that is generally characterized by relatively low sinuosity (or a negligible meandering pattern) and modest riffle-pool sequences or transitional runs. The floodplain was broad and well vegetated; predominated by grasses and shrubs with some forest cover, particularly along the right overbank area (i.e., east and south of the channel).

The stream flows to the north for approximately 225 m, and then abruptly turns, and drains to the east for roughly 300 m (flanked to the north by a utilities corridor) before it joins the roadside ditch where it is again directed to the north. The observed channel pattern suggests historic re-alignment (i.e., straightening). Stream C is a former tributary of the Little Sauble River, diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s.

The bankfull width of the channel varies from approximately 3.5 to 5.5 m. The channel bed was typically incised below the floodplain by roughly 0.5 to 1.25 m. The channel geometry was noted as trapezoidal to rectangular with moderate to high bank angles (55° to 80°).

Bed materials are predominated by silt and sand with cobble to boulder sized material. The larger substrate represents an armour layer at the channel bed. Bank substrate was composed of silty clay to silty sand loam (with clay). The banks were generally well vegetated with grasses, particularly along the section of stream oriented north-south.

Depositional features were typically observed along channel margins; however, more extensive sediment accumulation (mostly organics) was noted along a section of channel from approximately 125 to 175 m downstream of the rail bed. In general, observed bank erosion (i.e., scour and/or undercut) was relatively minor and largely limited to the section of stream oriented east-west. However, notable bank scour and possible bank slump was identified along the section of channel located immediately downstream of the small pond mentioned above (shown on Figure 5.4.4-1). The channel at this location was characterized by two sweeping meander bends over a distance of approximately 50 m. Bank erosion was observed on the outside of the respective meanders; vertically from toe to near top of bank and laterally for approximately 5 to 10 m.

Roadside Ditch

Stream C drains along the west side of the North Access Road for approximately 250 m via a roadside ditch that was approximately 3 to 4 m wide and trapezoidal in shape. The banks of the roadside channel were generally well vegetated with mostly grasses and herbs.

0 125 250 500
Metres

LEGEND

- Stream
- Ditch and Flow Direction
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

ELC Group

- Marsh
- Swamp

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

HYDROLOGY AND SURFACE WATER QUALITY
TECHNICAL SUPPORT DOCUMENT

TITLE

AQUATIC FEATURES ON THE SITE

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 5.4.4-1**	
GIS	BC	22 Apr. 2010		
CHECK	AB	22 Apr. 2010		
REVIEW	MAR	22 Apr. 2010		

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0 0.5 1 2

Kilometres

LEGEND

- Geomorphic Assessment
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- Water and Sediment Sample Location
- Flow Assessment Point

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

HYDROLOGY AND SURFACE WATER QUALITY
TECHNICAL SUPPORT DOCUMENT

TITLE

SURFACE WATER SAMPLING LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	23 Apr. 2010		
CHECK	KC	23 Apr. 2010		
REVIEW	AB	23 Apr. 2010		

FIGURE 5.4.4-2

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Stream C Downstream of North Access Road

At the end of the roadside channel, Stream C turns to the northeast and passes under the North Access Road via a large culvert. The banks of the channel immediately downstream of the road were generally well vegetated with mostly grasses and herbs. The bed form along this reach was relatively muted. Stream C ultimately drains to Lake Huron approximately 1 km downstream (i.e., to the north) of the road crossing.

5.5 SURFACE WATER QUALITY

This section discusses the conventional (i.e., non-radioactive) chemical characteristics of surface water quality. Radioactivity in surface water is discussed in the Radiation and Radioactivity TSD.

5.5.1 Water Quality in Lake Huron and Embayments

The conventional chemical characteristics of Lake Huron are presented because the lake will ultimately be the receiving water body for any potential releases from the DGR Project.

Lake Huron water quality within the Local Study Area has been characterized during previous sampling programs conducted by OPG and others. Sampling results from several of these studies are summarized in the following section. Nearshore samples were also collected in MacPherson Bay in 2007 and 2009 as a part of the field studies associated with this EA (see Figure 5.4.4-2). Sample results from the 2007 and 2009 field studies are presented in Appendix E. A description of the sampling program is provided in Section 5.5.2.1. Sampling results from historic studies and the 2007 and 2009 field studies were used to establish the baseline water quality for the portion of Lake Huron that falls within the Local Study Area. These are summarized in Table 5.5.1-1. The information presented in this section includes information available in the source documents. Some information (e.g., sample locations, sample frequency, total number of samples) was not available for all studies.

The University of Toronto Great Lakes Institute (UTGLI) carried out a pre-operational study on water quality as part of the Douglas Point Project from 1959 to 1960. Ontario Hydro carried out a pre-operational study for Bruce A from April 1969 to March 1970. During the latter study, Bruce A was under construction and Douglas Point Nuclear Generating Station was operational. The results of these two studies are summarized in the EA for the proposed Bruce B development [22]. Phosphate and nitrate levels in Lake Huron were found to be lower than those found in the lower Great Lakes [22]. Samples for both programs were taken offshore near to the Bruce nuclear site. The EA for the Bruce B development [22] also predicted an increase in Total Dissolved Solids as a result of urbanization of the Lake Huron basin. A summary of results obtained from both the UTGLI and Ontario Hydro studies is included in Table 5.5.1-1.

As part of monitoring (by Ontario Hydro) of the potential effects resulting from the operation of the Bruce nuclear site (the program was initiated in conjunction with the development of Bruce A), Lake Huron surface water quality was monitored at five locations between 1973 and 1981 [23]. Sampling locations included the Bruce A intake, forebay and discharge; Gunn Point, located approximately 5 km south of Bruce A; and Sandy Bay, located approximately 7.5 km north of Bruce A (features shown on Figure 2.4.2-2). Several parameters were analyzed, including, but not limited to nitrogen, phosphorus, dissolved solids, chlorophyll, calcium and silica. The range of parameter concentrations measured throughout the study from all sample locations is provided in Table 5.5.1-1. Little variation was observed spatially or temporally. These results are consistent with those reported for Lake Huron by other authors [22], and are below the PWQOs [23].

A lake water sampling program in the Local Study Areas was conducted in June 2001 for the Bruce A Units 3 & 4 Restart EA [24]. The Lake Huron water sample presented in Table 5.5.1-1 was taken approximately 1 km offshore and 1 km southwest of Bruce B. Results were generally similar to those measured during previous background lake water quality studies [22;23]. Water quality results for the background lake water sample met the PWQO [9], Ontario Drinking Water Objectives [25] and Canadian Environmental Quality Guidelines [26] for all of the parameters analyzed. No background water quality issues (i.e., exceedance of PWQOs) were identified, with the exception of PCBs in and near the Bruce A outfall channel. A full discussion of the results obtained during the 2001 sampling program, including observed PCB legacy issues, has been included in the Bruce A Units 3 & 4 Restart EA Surface Water Resources Technical Support Document [24].

Previous water quality sampling results [22;23;24] were generally similar to those collected in MacPherson Bay (SW6) during the 2007 and 2009 surface water sampling program. When compared to the earlier results, the water quality in MacPherson Bay was similar to samples taken further offshore in terms of dissolved solids, pH, conductivity, suspended solids, hardness and un-ionized ammonia. However, higher concentrations of iron, calcium, sodium and potassium were observed in MacPherson Bay compared to the historic Lake Huron results. Two of the samples collected in 2007 at SW6 showed total iron concentrations higher than the previous studies, and were above the PWQO for iron (300 µg/L).

Table 5.5.1-1: Summary of Lake Huron Water Quality Sampling Results

Parameter	Sampling Programs					Guidelines		
	U of T Study 1959/1960 [22] [d]	Ontario Hydro 1969/ 1970 [22] [d]	Ontario Hydro 1973-81 [23] [e]	2001 EA Study (Lake Huron Location) [24] [f]	2007 & 2009 Surface Water Sampling (SW6)	Provincial Water Quality Objectives [9]	Ontario Drinking Water Objectives [25]	Canadian Environmental Quality Guidelines [26]
Turbidity (NTU)	1.0-2.5	0.1-1.0	1.1	—	—	—	5	5
pH	7.5-8.45	7.9-8.4	8.1	8.1	7.4-8.2	6.5-8.5	6.5-8.5	6.5-8.5
Specific Cond. at 25°C (micromhos/cm)	183-218	202-210	185	204	210-244	—	—	—
Chloride (mg/L)	4.9-6.0	5.0-8.0	—	7.7	—	—	250 [b]	<250
Sulphate (mg/L)	5.9-13.5	12-15	—	15.8	—	—	500 [b]	<500
Iron (mg/L)	0[g]-0.22	0.08	—	<0.03	<0.5[h]-0.54	0.3	—	<0.3
Calcium (mg/L)	26-29.6	25-28	26.2	27.1	26-93	—	—	—
Magnesium (mg/L)	6.7-8.4	6.9-9.0	7.0	7.25	7.7-24	—	—	—
Sodium (mg/L)	3.0-4.5	2.8-4.0	—	3.9	4.5-140	—	200 [b]	<200
Potassium (mg/L)	0.8-1.8	0.9-1.3	—	0.9	0.9-1.8	—	—	—
Dissolved Solids (mg/L)	112-134	116-131	121	90	121-160	—	500 [b]	<500
Suspended Solids (mg/L)	—	—	2.0	5	<10-35	—	—	—
Total Hardness (mg/L)	94-106	93-104	—	—	94-110	—	80-100 [c]	—

Table 5.5.1-1: Summary of Lake Huron Water Quality Sampling Results (continued)

Parameter	Sampling Programs					Guidelines		
	U of T Study 1959/1960 [22] [d]	Ontario Hydro 1969/ 1970 [22] [d]	Ontario Hydro 1973-81 [23] [e]	2001 EA Study (Lake Huron Location) [24] [f]	2007 & 2009 Surface Water Sampling (SW6)	Provincial Water Quality Objectives [9]	Ontario Drinking Water Objectives [25]	Canadian Environmental Quality Guidelines [26]
Oxygen Consumed (mg/L)	0.6-1.9	0.5-1.3	—	0.8	—	—	—	—
Silica (mg/L)	—	0.6-1.9	1.4	0.55	—	—	—	—
Nitrate (mg/L)	—	0.2-0.5	1.1	0.4	—	—	10	13
Free Ammonia (mg/L)	—	0.01-0.06	—	<0.03	<0.002-0.006	0.02	—	—
Total Phosphorus (µg/L)	—	—	13.6	10	—	0.02 [a]	—	—
Total Phosphate (mg/L)	—	<0.1	—	<1	—	—	—	—

Notes:
a Interim PWQO.
b Aesthetic objective.
c Operational guideline.
d Original reference only provides range of the observed data but does not provide raw data, number of samples or sample locations.
e Reported average of three samples collected between 1979 and 1981 and an undisclosed number of samples between 1973 and 1975.
f Results based on one sample (June 27, 2001) collected 1 km south of Bruce B.
g No method detection limit was reported.
h MDL is greater than the PWQO.
— Parameter not analyzed/reported.

5.5.2 Water Quality in Surface Drainage Features in Site Study Area

The characterization of the existing water quality conditions in the Site Study Area was based on results of a number of existing studies, as described in Section 5.1.1.2, and the results of a surface sampling program conducted as part of this EA. This sampling program is described in Section 5.5.2.1. Sampling locations are shown on Figure 5.4.4-2.

Water quality characteristics are discussed for five categories: total suspended solids (TSS), nutrients, temperature, metals and organic contaminants. The characteristics are discussed in Sections 5.5.2.2 through 5.5.2.6, below. The sections include a summary of the sampling results for the 2007 and 2009 studies. A complete list of sampling results from the 2007 and 2009 field programs is provided in Appendix E. Lake Huron water quality is discussed separately in Section 5.5.1. Sediment quality is discussed in Section 5.5.2.7.

Where appropriate, results from the sampling programs are compared with the Provincial Water Quality Objective (PWQO) [9] and the Canadian Council of Ministers of the Environment (CCME) Guidelines [26]. This comparison is provided solely to reflect water quality relative to existing accepted benchmarks. In general, the PWQOs provided more stringent criteria than the CCME Guidelines and therefore most of the discussions below reference the PWQO criteria instead of the CCME Guidelines. Method detection limits were below the relevant criteria values for all analyzed parameters with the exception of iron in the 2007 and 2009 sampling programs.

5.5.2.1 Surface Water Quality Sampling Program

Water samples were collected at six locations (Figure 5.4.4-2) in the Site Study Area over six sampling events to characterize the existing water quality. All samples were analyzed for a variety of non-radioactive parameters. Results are provided in Appendix E. Radiological water quality is discussed in the Radiation and Radioactivity TSD.

Three surface water quality sampling events were completed in 2007 at, and near, the proposed DGR Project Area. The sampling events were completed on May 3, June 14 and October 12, 2007 and samples were collected at six locations during each event. The sampling program was repeated in 2009 with water quality samples collected on May 25, September 11 and October 27, 2009. Table 5.1.2-1 provides a brief description of the sampling locations used in the 2007 and 2009 programs.

Table 5.5.2-1: 2007 and 2009 Water Quality Sampling Locations

Location	Description
SW1	Stream C entering Bruce nuclear site (South Side of Tie Road)
SW2	Stream C exiting Bruce nuclear site (West Side of Road)
SW3	South Railway Ditch Near WWMF
SW4	South Railway Ditch East of WWMF
SW5	Drainage Culvert under Interconnecting Road (North Side of Road)
SW6	MacPherson Bay

Note: Sampling locations are shown on Figure 5.4.4-2.

Samples were taken in the same locations throughout the program with the following exceptions:

- SW2 was moved to the west side of the road to avoid debris and improve access during the second and third sampling events (June 14, 2007 and October 12, 2007);
- during the second and third sampling events (June 14, 2007 and October 12, 2007) water samples at SW5 were collected on the south side of the road since the north side was dry; and
- on September 11, 2009, water quality samples were not collected at SW3, SW4 and SW5 because of dry conditions (i.e., no water present).

5.5.2.2 Total Suspended Solids

Total suspended solids (TSS) is a measure of the amount of particulate material present in a water sample. TSS concentrations vary widely with location and can increase significantly during and after rainfall events. Prolonged high TSS concentrations are generally considered to have a negative impact on aquatic life.

TSS analysis was completed on samples collected at the WWMF in 2004 as part of the WWMF Integrated EA Follow-up Program [14]. The seven sampling locations were within the Site Study Area and generally within the South Railway Ditch with an additional three control stations (one at Goderich and two in the Little Sauble River). Samples were collected in June 2004. The analytical results for TSS concentrations in the Site Study Area samples ranged from <2 to 20 mg/L. TSS concentrations in the Goderich and Little Sauble River samples ranged from 5.5 to 284 mg/L.

Stormwater monitoring was conducted during 1996 as part of the Interim Storm Water Monitoring Plan [11]. Results showed that the TSS concentrations were considerably higher during spring runoff and rainfall events. During these events, the TSS concentrations ranged from 22 to 775 mg/L. Further details on sample locations and frequencies are not available.

The Bruce A Storm Water Study [12] measured TSS concentrations in Stream C, which ranged from 5 to 50 mg/L upstream of the Bruce nuclear site and 4 to 22 mg/L at the point where Stream C leaves the Bruce nuclear site. The same study reported that the TSS concentrations entering Lake Huron from Catchments J and L ranged from <2 to 84 mg/L in 1996. Subsequent sampling in 2003 reported TSS concentrations in Catchment L ranging from 2 to 5 mg/L [16].

In the 2007 DGR Project EA sampling program, all the samples had TSS concentrations below the method detection limit of 10 mg/L with the exception of SW3 and SW5 on July 14, 2007 and SW3 on October 12, 2007. These samples had TSS concentrations of 18, 19 and 51 mg/L, respectively. Given the abnormally dry conditions that prevailed throughout 2007, all samples collected during the 2007 sampling program are representative of dry weather conditions.

In the 2009 sampling program for the DGR Project EA, most of the samples had TSS concentrations below the detection limit of 10 mg/L. Exceptions ranged from 24 to 90 mg/L in samples collected at SW3, SW4, SW5 and SW6 on either May 25, 2009 or October 27, 2009. Both the May 25, 2009 and October 27, 2009 sampling events occurred after periods of rain (i.e., rained within the previous 24 hours) and are indicative of wet weather conditions.

5.5.2.3 Nutrients

Nutrient concentrations of total phosphorous and nitrogen (ammonia, nitrate, Total Kjeldahl Nitrogen [TKN]) are generally used to assess the potential for effects on macrophyte and algae growth. Excessive nutrients can cause nuisance growth of macrophytes and algae that can impact water quality and aquatic organisms.

Nutrient analysis was available for the South Railway Ditch samples collected in 2003 and 2004 [14]. These results showed that the nutrient concentrations in the South Railway Ditch samples were consistent with the samples collected at the control sites described in 5.5.1.

The un-ionized ammonia concentrations measured in 2003 and 2004 ranged from 0.02 to 0.03 mg/L in samples collected from the South Railway Ditch [14] and exceeded the PWQO for un-ionized ammonia of 0.02 mg/L. In 2007 and 2009, the measured un-ionized ammonia concentrations ranged from <0.002 to 0.013 mg/L, and were consistently below the PWQO.

The total phosphorus concentrations measured in 2003 and 2004 ranged from 20 to 100 µg/L in the South Railway Ditch [14] and most samples exceeded the PWQO for total phosphorus of 20 µg/L (i.e., the level to avoid nuisance growth of algae). In 2007 and 2009, the measured total phosphorus concentrations ranged from <2 to 28 µg/L.

The Bruce A Storm Water Study measured phosphorous concentrations in samples collected from the Catchment L discharge to Lake Huron to be less than 50 µg/L in 1996 [12] and 2003 [16].

5.5.2.4 Water Temperature

Water temperature for surface water features in the Site Study Area was not documented prior to the surface water quality sampling in 2007 and 2009. Water temperatures were recorded at the six locations on the six different sampling dates. The water temperature at the sampling locations is provided in Appendix E and is presented in Table 5.5.2-2.

The water temperatures ranged from 9.1ºC on October 27, 2009 at SW2 and SW5 to 23ºC on June 14, 2007 at SW5. In general, the water temperatures at all the locations correlated reasonably well with the average daily air temperature at the site, as would be expected in cases of shallow, slow moving water and shallow nearshore embayments.

Table 5.5.2-2: Summary of Water Temperature Data

Date	Average Daily Air Temperature	SW1 Stream C – Upstream	SW2 Stream C – Downstream	SW3 South Railway Ditch – West	SW4 South Railway Ditch – East	SW5 Drain Under Inter – connecting Road	SW6 Macpherson Bay
May 3, 2007	8.9°C	16.8ºC	13.0ºC	12.6ºC	13.2ºC	13.2ºC	14.4ºC
June 14, 2007	20.6°C	20.6ºC	20.1ºC	20.5ºC	21.4ºC	23.0ºC	19.1ºC
October 12, 2007	8.3°C	12.7ºC	11.0ºC	11.0ºC	10.0ºC	11.1ºC	12.8ºC
May 25, 2009	10.5°C	14.8ºC	16.4ºC	13.3ºC	14.0ºC	12.3ºC	18.1ºC
September 11, 2009	16.2°C	15.9ºC	18.3ºC	—	—	—	20.3ºC
October 27, 2009	9.4°C	12.0ºC	9.1ºC	11.4ºC	10.8ºC	9.1ºC	11.1ºC

Note: On May 25, 2009, SW3, SW4 and SW5 were dry and temperature was not recorded. Sampling locations shown on Figure 5.4.4-2.

5.5.2.5 Metals

The presence of metals in water samples can be the result of natural background conditions or can be an indication of contamination from industrial sources. Metals concentrations higher than the relevant PWQO [9] or other criteria (such as the CCME Guidelines [26]) may indicate an impact to the aquatic environment.

Water samples collected in the South Railway Ditch in 2003 and 2004 [14] showed exceedances of the respective PWQO for cadmium, cobalt, copper, iron, selenium and zinc. Exceedances of these parameters were also observed for the control samples collected at Goderich and in the Little Sauble River.

Water samples collected in 1996 during stormwater monitoring were analyzed for iron, copper and zinc [12]. Samples exceeded the PWQO for iron during two of six events, and exceeded the PWQO for copper during one event. No exceedances of the PWQO for zinc were reported. Stormwater sampling collected from catchment L during the in 2001 and 2003 sampling programs [16] exceeded the PWQO for zinc.

In general, the 2007 and 2009 analytical results showed low concentrations of metals, though some exceedances of the PWQO were noted. The samples collected in the South Railway Ditch (SW3 and SW4) typically had higher concentrations, while the lowest concentrations were recorded in MacPherson Bay (SW6).

The following exceedances of the PWQO were noted:

- The sample collected at SW5 on June 14, 2007 exceeded the PWQO for copper (5 µg/L).
- Samples collected at SW1, SW3, SW4, SW5 and SW6 in 2007 and 2009 exceeded the PWQO for iron (300 µg/L).
- Samples collected at SW3, SW4, SW5 and SW6 on May 3, 2007 exceeded the PWQO for zinc (20 µg/L). The samples collected at SW3 and SW5 on July 14, 2007 and the sample collected at SW3 on October 12, 2007 also exceeded the PWQO for zinc.
- In 2009, samples collected at SW3, SW4 and SW5 on May 24, 2009 exceeded the PWQO for zinc. Samples also exceeded the PWQO at SW3 and SW4 on October 27, 2009.

Detectable concentrations of aluminum were also noted at all of the sampling locations in 2007 and 2009. Surface water samples were not filtered; therefore, the results cannot be compared to the PWQO of 75 µg/L, which applies to clay free samples only. Detectable concentrations of aluminum are typically found in unfiltered samples taken in areas with clay present in the watershed soils.

5.5.2.6 Organic Contaminants

Organic contaminants refer to parameters such as chlorinated solvents and petroleum products. These contaminants are generally the result of industrial releases but some parameters such as oil and grease can occur naturally.

The presence of the Spent Solvent Treatment Facility (SSTF), the Waste Chemical Transfer Facility (WCTF) and an abandoned oil unloading facility near the Project Area (shown on Figure 5.4.4-1) suggests that there is a potential for the presence of organic contaminants in the Site Study Area [21].

Limited information regarding organic contaminants is available for the Site Study Area. During stormwater monitoring in 1996 [12], 2001 and 2003 [16], stormwater samples were analyzed for oil and grease and PCBs. The PCB concentrations were consistently less than the method detection limits in 1996 [12], 2001 and 2003 [16]. The oil and grease concentrations were generally below the method detection limits, though some samples had concentrations as high as 13 mg/L[11;12;16].

In 2007 and 2009, all concentrations of volatile organic compounds (VOCs) in the samples collected were below the method detection limit. There were no exceedances of the PWQO for VOCs. The results were generally less than the method detection limit (0.5 mg/L) for oil and grease; however, four samples had concentrations ranging from 0.5 to 2.1 mg/L.

5.5.2.7 Sediment Quality

During the collection of water quality samples on September 11, 2009 (see Section 5.5.2.1), bottom sediment samples were collected for analysis at all the locations listed in Table 5.5.2-1 and shown on Figure 5.4.4-2. Unless major changes occur within a stream, changes in sediment quality (if any) are expected to occur slowly over time. It is therefore considered appropriate to use one sampling event to define the existing conditions. The sediment sample analytical results are provided in Appendix F.

Analytical results were compared to both the CCME Sediment Guidelines [26] and the Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards – Table 1 [27]. The following points outline some of the general findings of the sediment sampling and analysis:

- Exceedances of the CCME sediment criteria for copper and zinc were reported in samples SW3, SW4 and SW5. Exceedances of the criteria for arsenic, cadmium and nickel were also reported in sample SW3.
- No exceedances of metals criteria were reported in sample SW1, SW2 and SW6.
- Concentrations for PCBs and BTEX were consistently below the method detection limits in all samples.
- Petroleum Hydrocarbons (PHC) concentrations were generally below the detection limits with some exceptions. In samples SW1, SW3, SW4 and SW5 the reported concentrations of F3 (C_{16} to C_{34} hydrocarbons) PHC ranged from 13 to 720 µg/g. Additionally, an F4 (C_{34} to C_{50} hydrocarbons) PHC concentration of 460 µg/g was reported at SW3 (South Railway Ditch – West).

The WWMF Integrated EA Follow-Up Program [14] reported exceedances of CCME and MOE sediment criteria, where available, in the sediment for cadmium, copper, manganese, nickel and zinc for the samples collected in the South Railway Ditch. These occurrences are consistent with the data collected in 2009.

5.6 SUMMARY OF EXISTING ENVIRONMENT

Table 5.6-1 provides a summary of the existing hydrology and surface water quality by VEC.

Table 5.6-1: Summary of Existing Hydrology and Surface Water Quality

VEC	Existing Environment
Surface Water Quantity and Flow	• The North Railway Ditch (Project Area) at Stream C has a drainage area of 26.1 ha. The South Railway Ditch at Stream C has a drainage area of 43.4 ha. The North Railway Ditch is usually dry while the South Railway Ditch generally has a low flow. Both are filled with aquatic plants (primarily cattails). • Stream C (Site Study Area) is a perennial stream and has a drainage area of 1,042.4 ha. Outside of the Bruce nuclear site, it is generally an agricultural watershed. Areas within the Bruce nuclear site drain into Stream C via constructed drainage ditches. • The drainage area tributary to MacPherson Bay (Site Study Area) is 41.3 ha. Drainage is via constructed ditches that only have measurable flows during storm events. During dry periods the flow is stagnant or there is no water present.

Surface Water Quality	• Total suspended solids concentrations ranged from <10 mg/L [a] to over 750 mg/L during storm events (Site Study Area and Project Area).
	• Metal concentrations were generally below the relevant PWQO in samples collected from the Site Study Area:
	    • total aluminium ranged between 25 and 330 µg/L in Stream C (Site Study Area) and 13 and 150 µg/L in the South Railway Ditch (Project Area);
	    • total copper ranged from <1 to 2 µg/L in both Stream C and the South Railway Ditch;
	    • total iron ranged between 58 and 680 µg/L in Stream C and <50 and 790 µg/L in the South Railway Ditch; and
	    • total zinc ranged from <5 to 11 µg/L in Stream C and 6 and 72 µg/L in the South Railway Ditch.
	• Total phosphorous concentrations in the South Railway Ditch (Project Area) ranged from 20 to 100 µg/L which exceed the PWQO for phosphorous (20 µg/L to avoid growth of nuisance plants).
	• Water temperature correlated reasonably well with the average daily air temperature in the Site Study Area and Project Area.

Note:
a Numbers reported as "<" are below the method detection limit.

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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 hydrology and surface water quality 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 were screened to determine those with the potential to interact with the hydrology and surface water quality VECs. The screening was conducted based on the general description of the existing environmental conditions. This allowed the EA to focus on issues of key importance where potential interactions between the DGR Project and hydrology and surface water quality 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. This screening is conducted by VEC for site preparation and construction, operations, and decommissioning phases of the DGR Project.

Hydrology and surface water quality VECs interact with the DGR Project directly (e.g., change in drainage area) and indirectly (e.g., effects on surface water quality attributed to changes in groundwater quality [a VEC in the Geology TSD]). Both direct and indirect interactions are carried forward through this assessment. 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 was 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 hydrology and surface water quality VECs. As shown in the Basis for 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. Some of the other TSDs (e.g., the Aquatic Environment TSD) use predictions identified in the Hydrology and Surface Water Quality TSD, as illustrated on Figure 2.1-2.

6.2.1 Direct Interactions

6.2.1.1 Site Preparation

Surface Water Quantity and Flow

During site preparation, it is expected that site drainage that is currently flowing into the Stream C watershed will be diverted into the MacPherson Bay drainage area. Therefore, site preparation is expected to have a direct interaction with stream flow and is carried forward to the second screening.

Surface Water Quality

During site preparation, construction activities may contribute to an increased sediment load into the drainage ditches. Therefore, site preparation is expected to have a direct interaction with surface water quality and is carried forward to the second screening.

6.2.1.2 Construction of Surface Facilities

Surface Water Quantity and Flow

During the construction of surface facilities, including the crossing over the abandoned rail bed, it is expected that site drainage that is currently flowing into the Stream C watershed will be diverted into the MacPherson Bay drainage area. In addition, dewatering may be required for excavation of foundations of some surface facilities. Therefore, construction of surface facilities is expected to have a direct interaction with stream flow and is carried forward to the second screening.

Surface Water Quality

During the construction of surface facilities, including the crossing over the abandoned rail bed, activities may contribute to an increased sediment load into the drainage ditches. Therefore, the construction of surface facilities is expected to have a direct interaction with surface water quality and is carried forward to the second screening.

6.2.1.3 Excavation and Construction of Underground Facilities

Surface Water Quantity and Flow

During the excavation and construction of underground facilities, dewatering may increase flows in adjacent drainage ditches. Therefore, excavation and construction of underground facilities is expected to have a direct interaction with stream flow and is carried forward to the second screening.

Surface Water Quality

During the excavation and construction of underground facilities, dewatering and placement of material in the waste rock piles may release water with an alternate chemistry into adjacent drainage ditches. Particular parameters of concern include suspended solids, saline groundwater and residual explosives (i.e., ANFO). Therefore, excavation and construction of underground facilities is expected to have a direct interaction with surface water quality and is carried forward to the second screening.

6.2.1.4 Above-ground Transfer of Waste

Surface Water Quantity and Flow

The movement of waste above ground is not expected to interact with surface water quantity and flow, and therefore, is not carried forward to the second screening.

Surface Water Quality

During the above-ground movement of waste, it is possible that vehicle traffic could lead to increased sediment loads to the adjacent drainage ditches. Therefore, the above-ground movement of waste is carried forward to the second screening.

6.2.1.5 Underground Transfer of Waste

Surface Water Quantity and Flow

The underground movement of waste is not expected to interact with surface water quantity and flow, and therefore, is not carried forward to the second screening.

Surface Water Quality

The underground movement of waste is not expected to interact with surface water quality, and therefore, is not carried forward to the second screening.

6.2.1.6 Decommissioning of the DGR Project

Surface Water Quantity and Flow

Construction activities during the decommissioning of the DGR Project could potentially alter drainage patterns in the area and subsequently affect surface water quantity and flow. It also includes the decommissioning of the on-site drainage system and the stormwater management pond. Activities that could potentially change drainage patterns may include the construction of temporary roads, grading of the site once the buildings are removed and excavations. Although these interactions are likely negligible the interaction is still possible. Therefore, the decommissioning of the DGR Project has been carried forward to the second screening.

Surface Water Quality

Construction activities during the decommissioning of the DGR Project could potentially alter sediment loads to drainage ditches in the area and subsequently affect surface water quality. Therefore, the decommissioning of the DGR Project has been carried forward to the second screening.

6.2.1.7 Abandonment of the DGR Facility

Surface Water Quantity and Flow

The abandonment activities may include removal of access controls. These activities are likely to be minor in nature and are not expected to interact with surface water quantity and flow.

Surface Water Quality

The abandonment activities may include removal of access controls. These activities are likely to be minor in nature and are not expected to interact with surface water quality.

6.2.1.8 Presence of the DGR Project

Surface Water Quantity and Flow

Presence of the DGR Project is associated with the perceptions and views and vistas of the project. Therefore, there is no potential interaction with surface water quantity and flow.

Surface Water Quality

Presence of the DGR Project is associated with the perceptions and views and vistas of the project. Therefore, there is no potential interaction with surface water quality.

6.2.1.9 Waste Management

Surface Water Quantity and Flow

Waste management represents all activities required to manage waste during the DGR Project, including waste rock, conventional waste and management of radiological waste produced as a result of operating the DGR. No liquid waste streams will be discharged to any surface water bodies. Waste management is not expected to interact with surface water quantity and flow (i.e., does not affect drainage patterns or divert water flows) and, therefore, is not carried forward to the second screening.

Surface Water Quality

Runoff from the waste rock piles could potentially interact with water quality in drainage ditches. Collection, storage and disposal of water from underground sumps, and of wastewater from above- and below- ground facilities is also addressed under support and monitoring of the DGR life cycle (Section 6.2.1.10). Therefore, the potential interaction between the waste management activity (i.e., the waste rock pile) and surface water quality is carried forward to the second screening.

6.2.1.10 Support and Monitoring of DGR Life Cycle

Surface Water Quantity and Flow

Support and monitoring of the DGR life cycle includes the collection, storage and disposal of water from underground sumps, and of wastewater from above- and below- ground facilities. It also includes the operations of the surface drainage in a stormwater management system throughout the project life. This includes discharge from the stormwater management system to the environment, therefore there is a potential interaction with surface water quantity and flow, and this activity is carried forward to the second screening.

Surface Water Quality

Support and monitoring of DGR life cycle includes the collection, storage and disposal of water from underground sumps, and of wastewater from above- and below- ground facilities. It also includes the operations of the stormwater management system throughout the project life. This activity includes discharges from the stormwater management system to the environment, therefore there is a potential interaction with surface water quality, and this activity is carried forward to the second screening.

6.2.1.11 Workers, Payroll and Purchasing

Surface Water Quantity and Flow

Workers, payroll and purchasing includes all workers required during each phase to implement the DGR Project, including spending, deliveries and workers travelling to and from the site. Workers, payroll and purchasing is not expected to interact with surface water quantity and flow (i.e., does not affect drainage patterns or divert water flow), and therefore, is not carried forward to the second screening.

Surface Water Quality

As part of workers, payroll and purchasing, increased vehicle traffic may contribute to an increased sediment load into the drainage ditches. Therefore, the workers, payroll and purchasing is expected to have a direct interaction with surface water quality and is carried forward to the second screening.

6.2.2 Indirect Interactions

6.2.2.1 Changes in Air Quality

Surface Water Quantity and Flow

There are no expected indirect interactions with surface water quantity and flow as a result of changes in air quality.

Surface Water Quality

Construction activities during site preparation could potentially contribute to increased suspended sediment concentrations caused by deposition of dust on the water surface. Additionally, the deposited dust could include residues from the blasting agents. As a result, changes in air quality could cause indirect interactions with surface water quality.

6.2.2.2 Changes in Noise Levels

Surface Water Quantity and Flow

There are no expected indirect interactions with surface water quantity and flow as a result of changes in noise levels.

Surface Water Quality

There are no expected indirect interactions with surface water quality because of changes in noise levels.

6.2.2.3 Changes in Surface Water Quantity and Flow

Surface Water Quantity and Flow

Surface water quantity and flow cannot interact with itself.

Surface Water Quality

Changes in surface water quantity and flow could affect water quality through concentration or dilution of parameters. Changes in drainage area and the associated changes in flow could potentially change water temperature in the local drainage features. As a result, changes in surface water quantity and flow could cause an indirect interaction with surface water quality.

6.2.2.4 Changes in Surface Water Quality

Surface Water Quantity and Flow

Changes in surface water quality will not have an interaction with the surface water quantity or flow.

Surface Water Quality

Surface water quality cannot interact with itself.

6.2.2.5 Changes in Soil Quality

Surface Water Quantity and Flow

There are no expected indirect interactions with surface water quantity and flow as a result of the changes in soil quality.

Surface Water Quality

Potential changes in soil quality could indirectly interact with surface water quality through two pathways. Soil particles could run off through stormwater and could be re-suspended and deposited as dust on the water surface. This interaction is advanced to the second screening.

6.2.2.6 Changes in Groundwater Quality

Surface Water Quantity and Flow

There are no expected indirect interactions with surface water quantity and flow as a result of the changes in groundwater quality.

Surface Water Quality

Potential changes in groundwater quality could indirectly interact with surface water quality through groundwater discharge to surface water bodies. As a result, changes in the groundwater quality could cause an indirect effect to surface water quality.

6.2.2.7 Changes in Groundwater Flow

Surface Water Quantity and Flow

Changes in the groundwater level could potentially change the rate of groundwater discharge to Stream C (e.g., the shaft sinking may cause dewatering of the upper 150 m of bedrock depending on how effective grouting and the permanent liner will be with regards to limiting inflows). As a result, changes in the groundwater level could cause an indirect interaction with surface water quantity and flow.

Surface Water Quality

Changes in the groundwater level could potentially change the rate of groundwater discharge to Stream C and subsequently change the surface water quality. As a result, changes in the groundwater level could cause an indirect interaction with surface water quality.

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 project-environment interactions involving VECs. These interactions are advanced to Section 7 for a second screening to determine those interactions that may result in a measurable change to hydrology and surface water quality.

Following the screening of potential 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 will be carried forward for further assessment.

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

Project Work and Activity	Surface Water Quantity and Flow			Surface Water Quality		
	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	•	•	•	•	•	•
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 effect 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 that could interact with hydrology and surface water quality. The abandonment of the DGR facility work and activity occurs immediately following decommissioning 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

Table 6.3-2: Advancement of Hydrology and Surface Water Quality VECs

VEC	Retained?	Rationale
Surface Water Quantity and Flow	Yes	There are several potential direct and indirect interactions
Surface Water Quality	Yes	There are several potential direct and indirect 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 hydrology and surface water quality 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, a judgement is made using qualitative and quantitative information, as available.

For the purposes of surface water quantity and flow, a measurable change in flow in any stream would be a change to the drainage area of the stream or any direct addition or abstraction of flow from the stream. For changes in surface water quality, a measurable change is considered if the change in any water quality parameters is beyond the background variability of the receiving water body. The ranges of water quality indicator concentrations for each receiving water body are presented in Section 5.5.

For potential indirect changes, a measurable change is considered possible if there is a likely adverse effect identified for another VEC (e.g., there could be a measurable change in surface water quantity and flow if there is a likely adverse effect on groundwater flow [a VEC in the Geology TSD]).

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 7.4).

7.2 SURFACE WATER QUANTITY AND FLOW

7.2.1 Direct Changes

7.2.1.1 Diversion of Flow from Stream C Watershed to MacPherson Bay

The diversion of flow from the Stream C watershed to MacPherson Bay was identified as a direct potential effect as a result of the following project works and activities:

- site preparation (Section 6.2.1.1);
- construction of surface facilities (Section 6.2.1.2);
- decommissioning of the DGR facility (Section 6.2.1.6); and
- support and monitoring of DGR life cycle (Section 6.2.1.10).

The first three works and activities share the same effect (i.e., same changes in drainage area), and the effects are examined in the second screening collectively. All changes in drainage will be directed to the operation of the stormwater management system considered in the support and monitoring of the DGR life cycle work and activity.

The change in drainage areas is the direct result of diverting flow to MacPherson Bay that currently drains to the North Railway Ditch and subsequently to Stream C. Figure 7.2.1-1 shows the area from which drainage will be diverted away from the Stream C watershed as a result of the DGR Project. The total diverted drainage area is 8.2 ha. The changes in drainage areas are considered at four locations:

A. Stream C;
B. South Railway Ditch at Stream C;
C. North Railway Ditch at Stream C; and
D. drainage ditch at discharge from the Project Area (at Interconnecting Road).

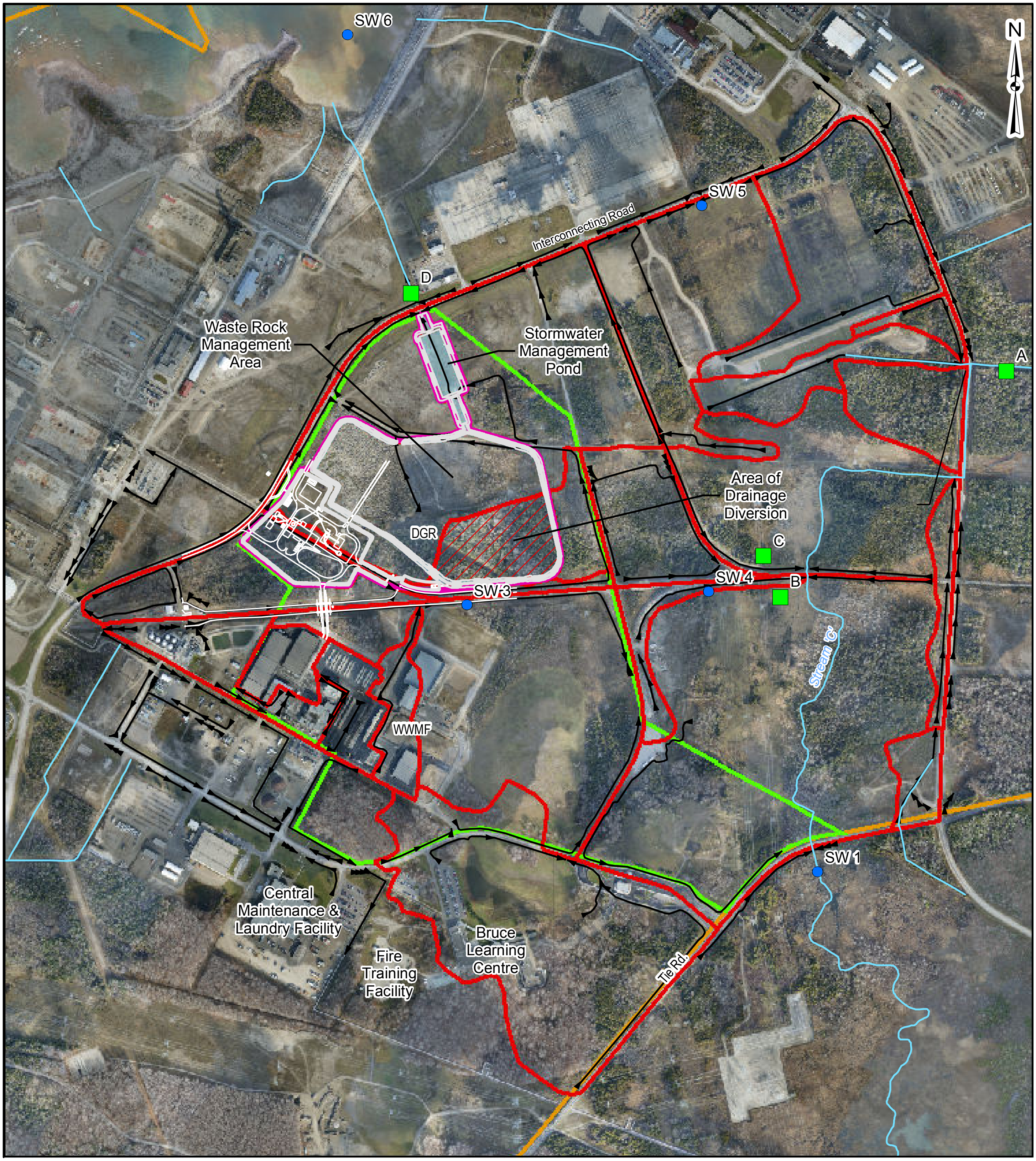
The changes in drainage areas are presented in Table 7.2.1-1.

Table 7.2.1-1: Summary of Measurable Changes to Drainage Areas

Flow Assessment Point [a]		Existing Drainage (ha)	Proposed Drainage (ha)	Change (ha)	Measurable Change
A	Stream C (at discharge from Bruce nuclear site – North Access Road) [b]	1,042.4	1034.2	-8.2	**Yes**
B	South Railway Ditch at Stream C	43.4	43.4	0	No
C	North Railway Ditch at Stream C	26.1	17.9	-8.2	**Yes**
D	Drainage ditch from DGR Project site (Interconnecting Road)	41.3	49.5	+8.2	**Yes**

Notes:
a Flow assessment locations are shown on Figure 5.4.4-2.
b Drainage area A includes both drainage areas B and C and represents the cumulative effect on Stream C.

Based on the above analysis, the effects of the DGR Project (i.e., the single diversion of drainage area) on surface water quantity and flow are likely to be measurable in Stream C at point of discharge from Bruce nuclear site, in the North Railway Ditch and in the drainage ditch at Interconnecting Road. Therefore, only these measurable changes are carried forward to the effects assessment in Section 8. As the changes in drainage area are captured in the continued operation of the stormwater management system, only the support and monitoring of the DGR life cycle work and activity is advanced for assessment.



LEGEND

- Flow Assessment Point
- Water Sample Location
- Ditch
- Operations Layout
- Stream
- Ditch and Flow Direction
- DrainageDiversion
- Footprint
- Stormwater Management System
- Catchments
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

0 125 250 500

Metres

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

HYDROLOGY AND SURFACE WATER QUALITY TECHNICAL SUPPORT DOCUMENT

TITLE

DIVERTED DRAINAGE

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE 7.2.1-1	
GIS	BC	22 Apr. 2010		
CHECK	AB	22 Apr. 2010		
REVIEW	MAR	22 Apr. 2010		

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7.2.1.2 Excavation Water Discharge

As identified in Section 6.2.1.3, the discharge of water during excavation and construction of underground facilities (i.e., excavation dewatering) could potentially increase flow in the drainage ditch between the DGR Project site and MacPherson Bay. Dewatering during excavation of foundations for surface facilities may also be required; however, it is likely that the volumes will be small and less than those considered during shaft excavation.

The maximum total flow that could be experienced from dewatering during shaft excavation is 5.3 L/s during construction. For purposes of the assessment, it was conservatively assumed that the maximum design dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construction.

The water discharged during excavation will be discharged into the drainage ditches of the stormwater management system, and then directed towards MacPherson Bay through the drainage ditch system. Therefore, the effect of excavation water discharge on surface water quantity and flow is carried forward to the assessment in Section 8 (support and monitoring of DGR life cycle activity).

7.2.1.3 Sump Water Pumping

As identified in Section 6.2.1.10, water pumped from the shaft sumps during operations may have an effect on the quantity of stream flow. The maximum sump pumping design flows are 2.3 L/s during operations. However, the DGR will be designed with the objective of operating largely as a dry facility with only relatively small amounts of water collecting in the shaft sumps. These may result in measurable change to stream flow. Therefore, the effect of sump water pumping is carried forward to the assessment in Section 8 (support and monitoring of DGR life cycle activity).

7.2.2 Indirect Changes

7.2.2.1 Changes in Groundwater Flow

In Section 6.2.2, it was identified that the excavation and construction of the underground facilities could indirectly affect stream flow by changing the groundwater level and discharge rate to the streams. Analysis completed in the Geology TSD indicates that the change in groundwater level caused by the excavation and construction of the underground facilities would not be measurable at any of the streams, ditches and wetlands in the Site Study Area. Consequently, there cannot be a measurable change in water quantity and flow in the streams and ditches. Therefore, a change in groundwater flow is not carried forward to the assessment as an indirect effect to surface water quantity and flow.

7.3 SURFACE WATER QUALITY

7.3.1 Direct Changes

7.3.1.1 Discharge of Stormwater from the DGR Project Site

The discharge of stormwater during the site preparation and construction, operation and decommissioning of the DGR Project were all identified as having the potential to directly interact with surface water quality in the North and South Railway Ditches and the drainage ditch to Lake Huron. These effects are the result of the following project works and activities:

- site preparation (Section 6.2.1.1);
- construction of surface facilities (Section 6.2.1.2);
- excavation and construction of underground facilities (Section 6.2.1.3);
- above ground transfer of wastes (Section 6.2.1.4);
- decommissioning of the DGR Project (Section 6.2.1.6);
- waste management (Section 6.2.1.9);
- support and monitoring of DGR life cycle (Section 6.2.1.10); and
- workers, payroll and purchasing (Section 6.2.1.11).

All of these works and activities share the same effect (i.e., changes in the quality of runoff directed to the stormwater management system), and all changes in water quality are captured at one endpoint at the stormwater management pond (support and monitoring of DGR life cycle). Therefore, only this work and activity is considered further in the second screening. Potential effects include increased suspended solids, hydrocarbons and road salt from construction activities and vehicle traffic, and changes in water chemistry caused by runoff from the waste rock piles.

The amount of suspended sediment resulting from construction activities is influenced by factors such as weather conditions, site conditions, construction practices and the effectiveness of sediment control measures. Without mitigation it is likely that increased sediment contributions will have a measurable effect on water quality.

Similarly, the constituents of the runoff from the waste rock piles are influenced by factors such as rock composition, particle size, weather conditions and cover material. The runoff could cause a measurable change in water quality.

As noted in Section 6.2.1.3, specific parameters of concern include salinity, explosives and metals in the waste rock piles. Each of these parameters is discussed further in the following sections.

Explosives

Some explosives, specifically emulsion and ammonium nitrate/fuel oil (ANFO), will be used during the construction of the underground works. Typically a portion of the explosives used will not detonate and will contribute to small amounts of ammonia, nitrate and fuel oil in the runoff from the waste rock piles.

Since the expected concentrations of ammonia, nitrate and oil and hydrocarbons (from fuel oil) may cause a measurable change in the quality of run-off, the potential changes in concentrations of undetonated explosives is carried forward to the effects assessment in Section 8 (support and monitoring of DGR life cycle).

Metals and Salinity

The natural weathering of the waste rock may contribute various amounts of trace metals and salt to the runoff from the Waste Rock Management Area. Although these contributions are expected to be small, in keeping with a precautionary approach, a measurable change is assumed and carried forward to the effects assessment in Section 8 (support and monitoring of DGR life cycle activity).

Water Temperature

Discharges from the stormwater management system could potentially change the temperature of receiving water bodies if the water entering the system is of a notably different temperature than that exiting the system. As the stormwater management system will largely handle surface runoff, it is not expected to cause a direct measurable change in temperature. Potential measurable changes in temperature through changes in surface water quantity and flow are considered in Section 7.3.2.2.

7.3.2 Indirect Changes

7.3.2.1 Changes in Air Quality

In Section 6.2.2.1, it was identified that there was a potential interaction with surface water quality in Stream C as a result of the deposition of dust from the construction of the DGR facility. This effect includes potential increases in total suspended solids and residual nitrates from the use of explosives. Appendix J, Section J1.1.5 of the Atmospheric Environment TSD provides conservative estimates of the annual average deposition rates of dust and nitrate as the result of construction. The deposition rates were provided for two sub-catchments of Stream C, upstream of Tie Road (e.g., outside the Bruce nuclear site boundary) and downstream of Tie Road (e.g. inside the Bruce nuclear site boundary). The deposition rates are provided in Table 7.3.2-1.

Table 7.3.2-1: Nitrate Deposition for Stream C Catchment Area during Site Preparation and Construction Phase

Stream C Catchment Area	Upstream Catchment	Downstream Catchment
Drainage Area (ha)	840.8	201.2
Average Dust Deposition (mg/m²/yr)	814	1,754
Average Nitrate Deposition (mg/m²/yr)	0.0136	0.0293
Total Nitrate Deposition (g/d)	0.313	0.162

Although the changes in dust and nitrate deposition are expected to be small, in keeping with a precautionary approach, a measurable change is assumed and carried forward to the effects assessment in Section 8. There are not expected to be measurable contributions to nitrate deposition during the operations and decommissioning phases.

7.3.2.2 Changes in Surface Water Quantity and Flow

Changes in surface water quantity and flow could potentially affect water quality. As described in Section 7.2.1, there is a likely measurable change in flow in the North Railway Ditch (decreased flow), the drainage ditch at point of discharge from the DGR Project site (increased flow), and Stream C at the point of discharge from Bruce nuclear site (decreased flow). Therefore, this indirect change to surface water quality is forwarded for consideration in Section 8.

Water Temperature

Changes in drainage area and the associated changes in flow could indirectly change the water temperatures in the local drainage features. For this portion of the assessment, a measurable change in average annual temperature is a change in a water body temperature greater than the reported accuracy of the instruments used during the field program (i.e., ±0.5ºC).

The measured water temperature data (see Table 5.5.2-2) generally indicates a reasonable correlation between ambient air temperatures and water temperatures, however, water temperatures differences between the on site drainage ditches, MacPherson Bay and Stream C are apparent.

The maximum recorded difference in water temperature between Stream C (SW2) and the South Railway Ditch (SW4) was 2.4ºC during the field monitoring program carried out in 2007 and 2009. This occurred on May 25, 2009 when the temperatures in Stream C and the South Railway Ditch were 16.4ºC and 14.0ºC, respectively. Although temperature measurements are not available for the North Railway Ditch, it is assumed that they would generally be similar to the South Railway Ditch. It follows then, that the difference in water temperature between the North Railway Ditch and Stream C could also be as much as 2.4ºC. Consequently, a change in the volumes of water from these ditches contributing to Stream C could potentially change the temperature in Stream C.

According to Table 7.2.1-1, the change (reduction) in drainage area contributing to Stream C due to the proposed diversion of flow from the North Railway Ditch is approximately 0.8% (i.e., less than 1%). Therefore, assuming that change in flow volume is roughly proportional to change in drainage area and for a temperature differential of 2.4ºC, the potential impact on temperatures in Stream C downstream of the point of diversion would be 0.02ºC (i.e., 0.8%×2.4ºC). As this is much less than the ±0.5ºC measurement criterion proposed above, it follows that there should be no measurable change in the water temperature in Stream C as a result of the proposed drainage area diversion.

From Table 7.2.1-1, the increased flow discharging (via existing ditches) to MacPherson Bay is approximately 20% due to the proposed drainage area diversion. From Table 5.5.2-2 the temperature differential between MacPherson Bay (SW6) and the various ditches can be as much as 5–6ºC, though most of the time the temperature differences between these water bodies are within ±2ºC. Given the usually small differential in temperature and the extremely large volume of water in MacPherson Bay (compared to the relatively small additional volumes being discharged via the drainage ditches), no measurable increase in the average water temperature of the bay is expected.

As there are no expected measurable changes in water temperature as a result of the DGR Project, effects on water temperature are not considered further.

7.3.2.3 Changes in Soil Quality

Changes in soil quality could affect water quality through runoff or deposition. As discussed in the Geology TSD, no measurable changes in soil quality are expected. Therefore, this indirect interaction is not considered further.

7.3.2.4 Changes in Groundwater Quality

In Section 6.2.2.6, it was identified that the DGR Project could indirectly affect stream water quality by changing the groundwater quality. Analysis completed in the Geology TSD indicates that the change in groundwater quality resulting from the DGR Project would not be measurable at any of the streams and ditches in the Site Study Area. Consequently, there cannot be a measurable change in water quality in the streams and ditches. Therefore, a change in groundwater quality is not carried forward for assessment.

7.3.2.5 Changes in Groundwater Flow

In Section 6.2.2.7, it was identified that changes in the groundwater level and thus, the discharge rate to the streams, could affect surface water quality. Analysis completed in the Geology TSD indicates that there would be no adverse effect on groundwater levels caused by the excavation and construction of the underground facilities at any of the streams and ditches in the Site Study Area. Consequently, there cannot be a measurable change in water quality in the streams and ditches attributed to changes in groundwater flow. Therefore, a change in groundwater level is not carried forward for further assessment.

7.4 SUMMARY OF THE SECOND SCREENING

Table 7.4-1 provides a summary of the second screening for the DGR Project. Squares (■) on this matrix represent likely project-environment interactions resulting in a measurable change in VECs. These interactions are advanced to Section 8 for a third screening to determine those interactions that may result in a likely effect on hydrology and surface water quality VECs.

Table 7.4-1: Matrix 2 – Summary of the Second Screening for Measurable Change on VECs

Project Work and Activity	Surface Water Quantity and Flow			Surface Water Quality		
	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 effect 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 that could interact with hydrology and surface water quality VECs. The abandonment of the DGR facility work and activity occurs immediately following decommissioning 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 7.4-2, all of the VECs proposed in Table 4-1 will be carried forward for further assessment.

Table 7.4-2: Advancement of Hydrology and Surface Water Quality VECs

VEC	Retained?	Rationale
Surface Water Quantity and Flow	Yes	There is a direct measurable change during the support and monitoring of DGR life cycle.
Surface Water Quality	Yes	There is a direct measurable change during the support and monitoring of DGR life cycle. There is an indirect measurable change as a result of a change in surface water quantity and flow.

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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 hydrology and surface water quality VECs that could reasonably be expected as a result of the DGR Project.

8.1 ASSESSMENT METHODS

8.1.1 Identify Likely Environmental Effects

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.

Changes to the surface water quantity and flow are calculated based on changes to the drainage areas (e.g., flow diverted from one catchment to another). Consistent with standard industry practice, the changes in flow were calculated as being directly proportional to the changes in drainage areas (i.e., for the purposes of this assessment, it is assumed that there is a direct correlation to contributing drainage area). Direct flow increases (i.e., sump water) were also considered. An adverse effect on surface water quantity and flow is considered to be one that could be detected by using standard stream flow measurement techniques. This is considered to be a change in flow beyond ±15% [28]. This is conservative; increases in flow beyond 15% may, in fact, be beneficial under certain circumstances (i.e., increased water availability during drought conditions). Changes in flow that are less than ±15% are lower than the typical accuracy of in-stream flow measurements. The rationale for developing this criterion is described fully in Appendix C.

With regard to surface water quality, if the DGR Project results in the concentration of any of the indicator compounds in the stormwater management system discharge exceeding the criteria presented in Appendix D, adverse effects on water quality are likely. The range of existing concentrations of indicator compounds is provided in Section 5.5.

If a likely environmental effect is identified, the effect is assessed as 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 the matrix, but are not considered further in this TSD. The results of the assessment are recorded in Matrix 3 (Section 8.4).

8.1.2 Consider Mitigation Measures

When the assessment of effects indicates that an adverse effect on one of the hydrology and surface water quality 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 likely 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 '◆' on Matrix 3 (Section 8.4). Residual adverse effects are advanced to Section 11 for an assessment of significance.

8.2 SURFACE WATER QUANTITY AND FLOW

8.2.1 Linkage Analysis

The evaluation of the effects of the DGR Project on the surface water quantity and flow VEC used changes in the stream flow to measure direct and indirect project effects. Measurable changes in the three separate catchments were identified as a result of one drainage diversion, namely:

- the catchment draining to Stream C;
- the catchment draining to the North Railway Ditch; and
- the catchment draining to the drainage ditch (Interconnecting Road), and ultimately to MacPherson Bay.

The operation of the stormwater management system, which includes the discharge from underground shaft sump pumping system, is included as part of the support and monitoring of the DGR life cycle work and activity. The operation of the stormwater management system has been identified as resulting in a measurable change on the surface water quantity and flow VEC during the site preparation and construction, operations, and decommissioning phases of the project.

No indirect effects were identified that could measurably affect the surface water quantity and flow VEC.

Changes in surface water quantity and flow were identified as resulting in measurable indirect changes to the surface water quality VEC, which is evaluated in Section 8.3. Changes in surface water quantity and flow also have the potential to affect the aquatic environment and the terrestrial environment. These potential effects are evaluated in Section 8 of the respective Aquatic and Terrestrial Environment TSDs.

8.2.2 In-design Mitigation

Some effects on surface water quantity and flow have been avoided or reduced through items inherent in the project design (i.e., in-design mitigation). The surface drainage ditches and stormwater, which collectively from the stormwater management system are inherent in the project design and are accounted for during the assessment of adverse effects. All stormwater runoff from the DGR Project site and the Waste Rock Management Area will be collected in drainage ditches and directed to the stormwater management system.

The shaft liner is designed to minimize the amount of groundwater seepage into the shaft. The dewatering system will be designed based on a steady-state leakage of 0.63 L/s in each shaft.

In the event that one of the liners begins to leak more than this amount, the dewatering system will have sufficient capacity to handle an additional volume on a temporary basis until grouting or other repair work can be performed in order to reduce this inflow below the design volume. During the operations phase, the DGR is designed with the objective to operate as a dry facility, with little to no seepage through the shaft lining. This will reduce the ultimate volume of water discharged to the stormwater management system; however, the assessment conservatively assumes the maximum constant flow rate is sustained.

8.2.3 Direct Effects

The change in flows (increase or decrease) to three catchment areas (Stream C, the North Railway Ditch and the drainage ditch from the DGR Project site) as a result of redirecting drainage to MacPherson Bay is a direct measurable change that was determined in the second screening (Section 7.2.1.1). Changes to the surface water quantity and flow are calculated based on changes to the drainage areas (e.g., flow diverted from one catchment to another). The changes in flow are calculated by pro-rating the flows by changes in drainage areas. As well, additional flows resulting from shaft pumping during construction and operations contribute to the direct change in flow in the outlet ditch from the site (at Interconnecting Road).

The assessment of effects on surface water quantity and flow is summarized in Table 8.2.3-1.

The decrease in drainage area for Stream C is calculated to be -0.8% and is below the adverse effect criteria (i.e., >±15% change) and this location is not considered further in the assessment. The decrease in the drainage area and thus flow to the North Railway Ditch is 31%. The increase in drainage flow to the drainage ditch (the point of discharge from the Project Area) is 20%. Based on the criteria presented in Section 8.1.1 these changes are above the adverse effect criteria (i.e., >±15% change). As a result, an adverse effect on surface water quantity and flow resulting from the diversion of flow from these drainage areas is likely.

In addition to the redirected drainage area flows, an increase in the average annual flow rate (calculated in Section 5.4.3) to the drainage ditch at Interconnecting Road will also result from dewatering of the shaft excavation during construction and shaft sump pumping during operations. The maximum total flow rate of pumped water that could be experienced is 5.3 L/s[2] during construction [4]. The dewatering discharge could increase the average annual flow in the drainage ditch under Interconnecting Road by approximately 93% during construction. When combined with the increase in flow associated with the diverted drainage areas (i.e., +20%), the average flow could increase by approximately 114%. This increase exceeds the adverse effect criteria of ±15%.

The maximum sump water pumping flows that could be experienced is 2.3 L/s[3] during operations. This flow is 40% of the estimated average annual flow in the outlet ditch for existing conditions (i.e., 5.7 L/s) and is expected to cause a measurable increase in flow. When combined with the increase in flow associated with the diverted drainage areas (i.e., +20%), the average flow in the drainage ditch could increase by approximately 61% during operations. This increase exceeds the adverse effect criteria of ±15%.

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2 For purposes of the assessment, it was conservatively assumed that the maximum dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construct.

3 The peak flow includes an allowance for a temporary inflow attributed to a leak in the shaft lining. In reality, the liner will be designed with the objective of little to no seepage through the shaft lining.

Table 8.2.3-1: Likely Adverse Effects on Surface Water Quantity and Flow

Flow Assessment Point	Location	Existing Drainage Area (ha)	Existing Flow (L/s) [a]	Proposed Drainage Area (ha)	Proposed Flow (L/s)			Total Change (%)	Adverse Effect?
					From Drainage Area [a]	From Shaft Sump Pumping	Total		
A	Stream C (at point of discharge from Bruce nuclear site – North Access Road)	1,042.4	144.6	1,034.2	143.4	0	143.4	-0.8%	No
C	North Railway Ditch at Stream C	26.1	3.6	17.9	2.5	0	2.5	-31%	**Yes**
D	Drainage Ditch at point of discharge from DGR Project Site (Interconnecting Road)	41.3	5.7	49.5	6.9	5.3 [b]	12.2	+114%	**Yes**
					6.9	2.3 [c]	9.2	+61%	**Yes**

Notes:

a Annual Average Flow from Table 5.4.3-2 as calculated using the drainage area, precipitation and runoff coefficients (see Appendix G for sample calculation).

b For purposes of the assessment, it was conservatively assumed that the maximum dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construct.

c The peak flow includes an allowance for a temporary inflow attributed to a leak in the shaft lining. In reality, the liner will be designed with the objective of little to no seepage through the shaft lining.

8.2.3.1 Verification

This section provides a brief verification of the flow change estimates presented above. The methodology used to estimate the changes in flow assume that flow is linearly proportional to drainage area and does not consider the differences in runoff coefficients attributable to land use and types.

The typical runoff coefficient for Stream C was estimated from the average annual flow for the Pine River (data provided in Appendix C) and an annual average rainfall of 1,041.3 mm at Wiarton (see Section 10.1 for a summary of climate normals). The runoff coefficient for Stream C and the Pine River, which are both primarily agricultural, was estimated to be 0.42 (e.g., 42% of the precipitation that falls in the watershed is discharged as streamflow). In contrast, the area draining into the North Railway Ditch and to Interconnecting Road can be described as undeveloped and would be expected to have a runoff coefficient in the order of 0.30 [29].

The limitations of the flow estimates at each of the prediction locations (see Table 8.2.3-1) can be summarized as follows:

- **Stream C at point of Discharge from Bruce nuclear site**: Since the likely specific runoff coefficient (0.30) for the diverted area is smaller than the “typical” runoff coefficient estimated for of the entire Stream C watershed (0.42), then the actual contribution of flow from the diverted area to Stream C would be lower than the amount assumed in the assessment (Table 8.2.3-1) where changes in flow were determined strictly on the basis of drainage area added or removed. It then follows that the reduction in flow calculated using runoff coefficients would be less than the flow reduction calculated by pro-rating drainage areas. Therefore, the estimated reduction of flow based on drainage area reduction for Stream C represents the upper limit of the expected change and provides a conservative estimate.
- **North Railway Ditch at Stream C**: Since the land use, topography and soil conditions are fairly consistent across the North Railway Ditch drainage no differences in the runoff coefficient are expected. Thus, the approach using drainage area proportionality provides a reasonable estimate of change in flow.
- **Drainage ditch under Interconnecting Road**: Since the land use, topography and soil conditions are fairly consistent across this drainage area and the diverted area there are no differences in the runoff coefficient expected. Thus, the approach using drainage area alone provides a reasonable estimate of change in flow.

In general, the results presented in Table 8.2.3-1 provide a reasonable estimate of the changes in flow expected to occur as a result of the project.

8.2.4 Indirect Effects

No likely indirect changes in surface water quantity and flow were carried forward from the second screening.

8.2.5 Additional Mitigation Measures

For the drainage ditch under Interconnecting Road, the channel capacity should be evaluated during detailed design to ensure that the ditch can properly convey the expected flows from the stormwater management pond. However, no credit has been taken in the assessment for this. Therefore, the effect is advanced for further consideration.

8.2.6 Residual Adverse Effects

Based on the analysis, there is a residual adverse effect associated with the operation of the stormwater management pond on surface water quantity and flow. This residual adverse effect is advanced to Section 11 for an evaluation of significance.

8.3 SURFACE WATER QUALITY

8.3.1 Linkage Analysis

The evaluation of the effects of the DGR Project on the surface water quality VEC used changes in the concentrations of indicator compounds and changes in temperature to measure direct and indirect project-related changes. The assessment considered the following indicators:

- total suspended solids;
- nutrients;
- metals;
- temperature;
- pH; and
- salinity.

The operation of the stormwater management pond, which is included as part of the support and monitoring of the DGR life cycle work and activity, was identified as having a measurable change on the surface quality VEC during all phases of the project.

Changes to the surface water quantity and flow VEC were also identified as having a likely measurable change on the surface water quality VEC (see Section 8.2).

Changes in surface water quality also have the potential to affect the aquatic, terrestrial, socio-economic environments, Aboriginal interests and human health. These potential indirect effects are evaluated in Section 8 of the respective Aquatic Environment, Terrestrial Environment, Socio-economic Environment, Aboriginal Interests TSDs, and Appendix C (Human Health Assessment) of the EIS.

8.3.2 In-design Mitigation

The DGR Project design includes the construction and operation of a stormwater management system. All stormwater runoff from the DGR Project site and the Waste Rock Management Area will be collected in drainage ditches that flow into a stormwater management pond.

A system of water sampling and testing is proposed to confirm that all water released from the DGR Project site via the stormwater management pond has concentration levels below certificate of approval discharge criteria. Two stormceptors are located in the shaft services facility area, designed to mitigate for oil and grease and suspended sediments, prior to discharge to the stormwater pond. The stormwater pond is designed to settle out suspended solids and provide sufficient storage during storm events. A normally open manual control gate will control the discharge of water from the management pond. The gate will be closed if water samples from the pond show contaminant levels above certificate of approval discharge criteria.

Discharges from the stormwater management system will be directed to the drainage ditch along the Interconnecting Road and ultimately to McPherson Bay. No releases from the site will be directed to the North or South Railway Ditch, or the Stream C watershed.

8.3.3 Direct Effects

All releases from the DGR Project and surface runoff (up to the design storm event) will be captured in the stormwater management pond. It is anticipated that run-off from the waste rock pile will contain fines from both exposed rock during construction and operation of the DGR Project, and soil, during storage on-site. Water from the stormwater management system will be discharged via a controlled outlet to the existing drainage ditch along the Interconnecting Road, which drains north towards Lake Huron. Rock excavates will contain a number of elements that can be leached over time from the WRMA. It is likely that the concentrations in the run-off from the waste rock management area will be the highest during the first few years of placement on surface.

8.3.3.1 Trace Metals

Runoff from the waste rock piles is expected to contain trace concentrations of metals, the concentrations of which were estimated using a short-term leachate test [10]. The results for pH, sulphate and those dissolved metals where testing indicated the potential for elevated concentrations are presented, along with the appropriate PWQO, in Table 8.3.3-1. It should be noted that the concentrations of these metals are those that are expected in the runoff from the WRMA, not the concentrations that will be discharged to the environment. It is understood that there will be other flows from the site discharging into the pond, including groundwater that is captured during the excavation and pumped to the surface and surface runoff.

The results from short-term leach testing do indicate a potential for some metals to leach at concentrations above the PWQOs and two samples had leachate pH values greater than the PWQO range. However, the short-term test conditions are not considered to be representative of weathering and other processes likely to occur in the field over time. The natural processes affecting the material (e.g., dilution, sorption, etc.) are likely to result in lower concentrations of leached metals than was observed in the short-term leach testing.

8.3.3.2 Salinity

Table 8.3.3-2 provides the salinity related parameters that were found during the short term leachate tests [10] and chloride concentrations ranging from below 5.5 to 2,000 mg/L in the leachate.

Table 8.3.3-1: Water Quality Results for Short-term Leachate Tests

Sample		pH	Sulphate (mg/L)	Dissolved Metals (mg/L)[a,c]					
				Aluminum	Boron	Cobalt	Copper[d]	Thallium	Vanadium
Criteria (PWQO)		6.5-8.5	—	0.075[b]	0.2	0.0009	0.001	0.0003	0.006
Unit 1	DGR-4 (114.35)	**8.73**	21	<0.01	0.0692	0.000032	0.0007	<0.00002	**0.016**
	DGR-4 (157.25)	**8.8**	210	0.06	0.0389	0.000055	<0.0005	<0.00002	0.00198
	DGR-3 (318.87)	7.41	1700	0.05	**0.334**	0.000716	0.0008	0.00004	0.00007
	DGR-4 (393.49)	7.59	230	0.01	**1.32**	0.000728	0.0022	0.00029	0.00059
	DGR-3 (471.73)	7.34	390	<0.01	**1.39**	0.000316	0.0013	0.00006	0.00053
Unit 2	DGR-4 (479.25)	7.27	23	<0.01	**1.62**	0.000302	0.0011	0.00005	0.00026
	DGR-3 (589.63)	7.56	88	0.03	**0.944**	**0.00106**	0.0008	**0.00039**	0.00015
	DGR-3 (589.81)	7.6	130	<0.01	**0.633**	0.000807	0.0007	**0.00038**	0.00012
	DGR-3 (647.39)	7.33	78	0.01	**1.4**	**0.00104**	0.0011	**0.00037**	0.00015
	DGR-4 (658.6)	7.78	27	0.06	**0.542**	0.00011	<0.0005	0.00007	0.00114
Unit 3	DGR-2 (660.14)	7.71	49	0.07	**0.292**	0.00004	<0.0005	0.00003	0.00083
	DGR-4 (667.31)	7.75	18	**0.08**	**0.287**	0.000029	0.0006	0.00003	0.00086
	DGR-4 (671.43)	7.71	17	0.04	**0.368**	0.000056	<0.0005	0.00004	0.00081
	DGR-3 (671.51)	7.8	21	0.01	**0.471**	0.000089	<0.0005	0.00005	0.0008
	DGR-4 (675.34)	7.77	18	**0.08**	**0.249**	0.000058	<0.0005	0.00003	0.00083
	DGR-2 (675.88)	7.75	25	0.04	**0.407**	0.000091	<0.0005	0.00004	0.00089
	DGR-3 (676.42)	7.63	20	0.03	**0.546**	0.000098	0.0006	0.00005	0.0008
	DGR-3 (677.82)	7.76	20	0.07	**0.269**	0.000034	<0.0005	0.00003	0.00083
	DGR-2 (679.24)	7.67	24	**0.08**	0.198	0.000044	<0.0005	0.00003	0.00043

Table 8.3.3-1 Water Quality Results for Short-term Leachate Tests (continued)

Sample		pH	Sulphate (mg/L)	Dissolved Metals (mg/L)[a,c]					
				Aluminum	Boron	Cobalt	Copper[d]	Thallium	Vanadium
Unit 3 (cont.)	DGR-3 (680.21)	7.69	19	**0.08**	**0.338**	0.00001	<0.0005	0.00003	0.00103
	DGR-3 (696.76)	7.63	34	0.04	**0.543**	0.000139	<0.0005	0.00011	0.00085
	DGR-4 (682.58)	7.62	27	0.03	**0.605**	0.000235	0.0005	0.00009	0.00051
	DGR-4 (680.68)	7.68	25	0.07	**0.293**	0.000096	<0.0005	0.00006	0.00082
	DGR-3 (388.62)	7.65	24	0.03	**0.538**	0.000205	0.0006	0.00007	0.00079

Notes:
a Dissolved concentrations are generated in the geochemical testing and are compared to the criteria which are representative of total concentrations.
b Based on pH values > 6.5 and < 9.0, in clay free samples [9].
c Values bold are greater than the reported PWQO [9].
d Based on Interim PWQO for copper of 0.001 mg/L for samples with a hardness of 20 mg/L as $CaCO_3$ or lower [9].
— Not applicable
Source: [10]

Table 8.3.3-2: Salinity Related Water Quality Results for Short-term Leachate Tests

Sample		Chloride (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Conductivity (µS/cm)	Salinity (PSU[a])
Unit 1	DGR-4 (114.35)	16	11	3	13	8	201	0.001
	DGR-4 (157.25)	5.5	29	1	35	1	515	0.0011
	DGR-3 (318.87)	320	622	10	29	181	3350	0.023
	DGR-4 (393.49)	2,200	496	94	160	434	6250	0.037
	DGR-3 (471.73)	1,500	450	173	73	281	4710	0.029
Unit 2	DGR-4 (479.25)	1,800	443	202	68	328	5150	0.031
	DGR-3 (589.63)	1,400	295	129	45	419	4280	0.027

Table 8.3.3-2: Salinity Related Water Quality Results for Short-term Leachate Tests (continued)

Sample		Chloride (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Conductivity (µS/cm)	Salinity (PSU[a])
	DGR-3 (589.81)	1,400	218	80	38	486	4120	0.27
Unit 2 (cont'd)	DGR-3 (647.39)	1,700	378	191	48	392	4800	0.03
	DGR-4 (658.6)	180	37	37	8	69	736	0.012
Unit 3	DGR-2 (660.14)	190	54	23	13	59	759	0.012
	DGR-4 (667.31)	210	48	25	13	65	760	0.012
	DGR-4 (671.43)	250	57	29	14	76	882	0.013
	DGR-3 (671.51)	270	52	33	13	78	934	0.013
	DGR-4 (675.34)	180	41	20	11	51	653	0.011
	DGR-2 (675.88)	300	59	37	17	89	1040	0.013
	DGR-3 (676.42)	370	73	44	18	99	1250	0.014
	DGR-3 (677.82)	170	38	21	10	53	643	0.012
	DGR-2 (679.24)	160	37	17	9	44	604	0.012
	DGR-3 (680.21)	220	45	25	12	61	802	0.012
	DGR-3 (696.76)	190	43	24	9	55	719	0.014
	DGR-4 (682.58)	430	79	50	19	122	1440	0.015
	DGR-4 (680.68)	410	78	48	20	118	1400	0.012
	DGR-3 (388.62)	350	70	46	14	98	1230	0.015

Notes:
a Salinity expressed in Practical Salinity Units (PSU) which is expressed as an equivalent Potassium Chloride (KCl) concentration.
Source: [10]

While there are no specific water quality criteria for salinity, road salts have been identified by Environment Canada as a priority substance [30]. In the road salt assessment report [30], the effects of sodium chloride, potassium chloride, magnesium chloride and calcium chloride are assessed in terms of chloride concentration. The assessment suggests that the Critical Toxicity Value (CTV) for chloride varies from 400 to 1,500 mg/L depending on the organisms being considered.

The higher chloride values (i.e., >400 mg/L) are largely associated with the shallow and intermediate bedrock. Waste rock from these reaches represents only a small portion of the waste rock to be managed on-site (0.6 ha, or 2% of the DGR Project site). In addition, this waste rock is expected to be used in berms, which would be covered, or if left in stockpiles on site for more than one year they will be covered, and therefore, concentrations will likely decrease following this time. Therefore there are no likely adverse associated with salinity.

8.3.3.3 Nutrients

Blasting during the excavation of the DGR may result in an explosives residue on the waste materials stored at surface. Estimates of the residual explosives in the waste rock piles may have concentrations as high as 18 mg/L (as N) for ammonia and 18 mg/L (as N) for nitrate. Under the expected conditions (e.g., 25ºC and pH of 8.5), the un-ionized ammonia concentration is expected to be approximately 2.7 mg/L [10]. This value is greater than the PWQO for un-ionized ammonia of 0.02 mg/L [9]. This runoff will be captured in the stormwater management system where it will not be released unless it meets the certificate of approval discharge criteria.

8.3.3.4 Summary

Ultimately the quality of the water in the stormwater management pond will depend on the quality of other flows to the pond including groundwater pumped to surface and stormwater run-off. It is expected that some type of treatment for one or more parameters may be required in order for the final effluent to meet the applicable criteria. The project design (see Section 4 of the EIS) provides for water treatment. Provided that the certificate of approval discharge criteria are met, there are no adverse effects on surface water quality expected from the DGR Project.

8.3.4 Indirect Effects

8.3.4.1 Changes in Air Quality

In Section 7.3.2.1, a potential effect on surface water quality in Stream C was identified as a result of the deposition of dust from the construction of the DGR facility. This effect includes potential increases in total suspended solids and residual nitrates from the use of explosives. The deposition rates were provided for two sub-catchments of Stream C, upstream of Tie Road (e.g., outside the Bruce nuclear site boundary) and downstream of Tie Road (e.g. inside the Bruce nuclear site boundary).

Table 8.3.4-1 provides a summary of the atmospheric deposition rates and the estimated changes in Stream C water quality. The potential increase in total suspended solids and nitrate were calculated by multiplying the deposition rate by the catchment area and dividing by the annual average flow on a daily basis (e.g., all rates and flows converted to a daily value, see Appendix G). The results for total suspended solids are expressed in mg/L, while the results for nitrate are expressed in µg/L. This results in overly conservative estimates since the method does not account for the removal of suspended solids or nitrate by vegetation or infiltration through the soil. The results are summed for the two catchment areas to provide the worst case condition that would be expected (e.g., at the mouth where Stream C drains into Baie du Doré).

Table 8.3.4-1: Estimated Effects on Suspended Solids and Nitrate Concentration in Surface Water Due to Atmospheric Deposition during Construction

Stream C Catchment Areas	Upstream Catchment	Downstream Catchment	Total Catchment
Drainage Area (ha)	840.8	201.2	1,042
Average Annual Flow (L/s)	115	142	—
Annual Flow (m^3/d)	9,900	12,269	—
Total Suspended Solids			
Average Dust Deposition (mg/m^2/yr) [a]	814	1,754	—
Total Dust Deposition (g/d)	18,750	9,671	—
Average TSS Increase (mg/L)	1.89	0.79	2.68
Nitrate			
Average Nitrate Deposition (mg/m^2/yr) [a]	0.0136	0.0293	—
Total Nitrate Deposition (g/d)	0.313	0.162	0.475
Average Nitrate Increase (µg/L)	0.032	0.013	0.045

Notes:
Sample calculations are provided in Appendix G, Section G1.3.
a Deposition rates from Appendix J, Table J1.1.5-1 of the Atmospheric Environment TSD.

Total Suspended Solids

As shown in Table 8.3.4-1, the total increase in total suspended solids is expected to be approximately 2.7 mg/L. This increase is expected to be trivial since it is less than the method detection limit for suspended solids of 10 mg/L (as shown in Appendix E).

Nitrate

As shown in Table 8.3.4-1, the total increase in nitrate is expected to be less than 0.05 µg/L. This increase is expected to be trivial since it is less than 0.1% of the reported nitrate concentrations in Lake Huron (see Table 5.5.1-1). The increase is well below the Ontario Drinking Water Objective for nitrate[4] of 10 mg/L [25]. In addition, the total daily deposition of nitrate to the Stream C watershed (0.48 g/day) is approximately 25% of the total daily nitrogen production of a herring gull, which is reported to be 1.819 g/day [31].

Therefore, no adverse effects on water quality are likely from changes in air quality.

4 It should be noted that the Ontario Drinking Water Objective for nitrate is used for comparison as the PWQOs [9] do not provide numeric criteria for nitrate. In addition the increase is well below the interim Canadian Environmental Quality Guideline [26] of 13 mg/L for protection of aquatic life (freshwater).

8.3.4.2 Changes in Surface Water Quantity and Flow

A measurable indirect change to water quality as a result of a measurable change in surface water quantity and flow in the North Railway Ditch and Stream C was identified in Section 7.3.2.2. Since runoff to the North Railway Ditch is the primary source of indicators in surface water, a decrease in runoff will reduce both the loading to the North Railway Ditch, and subsequently Stream C, as well as the water available to dilute the indicator concentrations. These are expected to balance each other. Therefore, no adverse effects on water quality are likely from indirect effects.

8.3.5 Additional Mitigation Measures

As described in Section 8.3.2, the preliminary design for the DGR Project stormwater management system provides for water treatment, including a stormwater management system and water treatment units (stormceptors). The system will control the release of water from the site up to the design storm capacity.

The discharge from the stormwater management system will also be subject to discharge criteria stipulated in the Certificate of Approval for Industrial Sewage Works (Section 53 of the *Ontario Water Resources Act*). The criteria in the Certificate of Approval will be determined during the approval process and may differ from those values presented in Appendix D.

8.3.6 Residual Adverse Effects

Discharge from the pond is expected to meet the discharge criteria; therefore, no residual adverse effects on surface water quality are expected from the DGR Project.

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 project-environment interactions resulting in a residual adverse effect on a VEC. These interactions are advanced to Section 11 for a consideration of significance. In this case, a residual adverse effect was identified for surface water quantity and flow.

8.4.1 Application of a Precautionary Approach in the Assessment

With regard to the Hydrology and Surface Water Quality TSD, conservatism has been built into the assessment. The following points outline the conservatism used in the assessment.

- The change in flow for Stream C and the North Railway Ditch was estimated assuming that the runoff coefficients for the entire watershed and the diverted areas are identical. As discussed in Section 8.2.3.1, the runoff coefficient for the diverted areas is likely lower than the greater watershed. As a result, the contribution from the diverted area would be smaller and the corresponding reduction in flow is expected to be lower.
- The estimated flows from dewatering during excavation and operations are the maximum flows used to size the pumps. The typical flows are expected to be lower.
- The predicted runoff water quality does not account for any dilution from precipitation or decrease in concentrations with time, and thus is expected to be conservative.

- The assessment attached equal importance to effects on man-made ditches even though natural streams are generally perceived to be more environmentally sensitive.

8.4.2 Application of Traditional Knowledge in the Assessment

Lake Huron water quality is known to be important to the Aboriginal communities and was considered in the effects assessment through the selection of VECs. No other Aboriginal input was available relative to the hydrology and surface water quality for use in the assessment.

8.4.3 Cumulative Effects

Effects of the DGR Project have the potential act cumulatively with those of other projects. The EIS Guidelines require that the EA consider 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.

Three residual adverse effects were identified during the assessment, namely, decrease in flow in the North Railway Ditch associated with operations of the stormwater management system, increase in flow in the drainage ditch under Interconnecting Road associated with both the site preparation and construction of the stormwater management system and the shaft sump pumping, and operations of the stormwater management pond and pumping of underground water. The cumulative effect of these residual adverse effects on Hydrology and Surface Water Quality with past, present and reasonably foreseeable future projects is presented in Section 10 of the EIS.

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

Project Work and Activity	Surface Water Quantity and Flow			Surface Water Quality		
	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 effect 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 which could interact with the hydrology and surface water quality VECs. 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

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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. First, 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 is evaluated based on past experience at the site and professional judgement of the study team. In this TSD, the assessment of effects of the environment on the DGR Project focuses on those conditions associated with hydrology and surface water quality (e.g., flooding). 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.

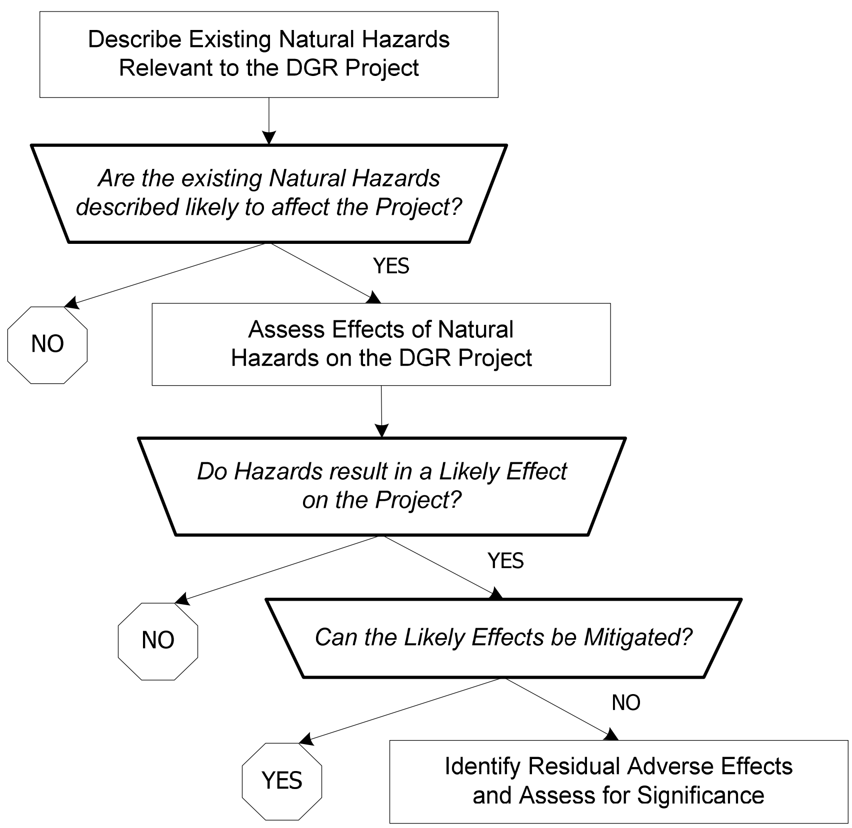

Figure 9.1-1: Method to Effects of the Environment on the DGR Project

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 HYDROLOGY AND SURFACE WATER QUALITY ENVIRONMENT ON THE DGR PROJECT

Rising lake levels and/or surface flooding may affect the DGR Project. The DGR will be located, designed, constructed and operated so as to minimize the probability of flooding prior to abandonment and, should flooding occur, its impact on operations. The DGR Project site is located about 1 km from Lake Huron about 7 m above the current lake water level. Thus it is unlikely that rising lake levels will cause flooding at the DGR Project site during its operating life.

The DGR Project site will be graded and the site will have ditching so that stormwater will freely flow away from all DGR surface structures and to minimize risk of flooding these surface structures. However, to eliminate the possibility of any flood water flowing into the underground repository during its operating life, the top elevation of two shaft collars and any other entry point to the underground repository will be set higher than the maximum possible flood level attributed to a postulated Probable Maximum Precipitation (PMP) event for the Bruce nuclear site.

9.2.1 Coastal Flooding

The assessment for potential coastal flooding considered maximum lake water level, storm surge, seiche, wind wave and wave uprush that could affect the DGR operational area inland of the Lake Huron shoreline. Further information is provided in the Maximum Flood Hazard Assessment [32].

The 500-year maximum instantaneous Lake Huron water level is predicted to be 178.6 m IGLD [32]. In 80 years of record the maximum observed water-level was approximately 177.8 m IGLD in 1986. The planned elevation of the operation areas of the DGR Project site is expected to be approximately 186 masl. Thus the freeboard above static lake levels for extreme events is at least 7 m and the risk of coastal flooding of the DGR Project site as a result of high lake levels is extremely small.

The predicted maximum storm surge (of 1.3 m) resulting from a passing severe Alberta Clipper storm would likely last for time scales of minutes to one or several hours and would not affect the DGR Project site [32]. The wave flooding model (seiche and wind wave) showed significant wave height amounts of up to 6 m within 100 m from the shoreline. This translated into some ‘wetting’ of the northern tip of the DGR Project Area; however, maximum wave flooding would not affect the operational area of the DGR to the southwest with regards to the hydrology and surface water quality.

Maximum estimated elevation of wave uprushes is 180.5 m IGLD [32]. However, because of the location of the DGR facility approximately 1 km from the shoreline, the likelihood that the DGR Project Area will experience the wave run-ups is extremely low. Any water that would overtop existing near-shore perimeter works would temporarily collect on these works then eventually drain back to the lake.

Tsunamis are long period gravity waves generated by seismic disturbances of the sea bottom or shore, or landslides resulting in a sudden displacement of the water surface with the resulting wave energy spreading outwards across the ocean or lake at high speed. Tsunami occurrences in Canada are rare, with the Pacific coast at greatest risk due to the high occurrence of earthquake and landslide activity. No probable or definite tsunamis have been recorded for Lake Huron [32].

9.2.2 Surface Flooding

The assessment for potential surface flooding considered the maximum riverine flood hazard assessment and the assessment of flood hazard due to direct rainfall. Further information can be found in the Maximum Flood Hazard Assessment [32].

In terms of the assessment of the maximum riverine flood hazard, two conclusions were derived for probable maximum flood (PMF) and probable maximum precipitation (PMP).

- The computed Little Sauble River PMF floodplain does not extend into the DGR Project site. Further, transfer of flood water from the Little Sauble River to Stream C during a PMP/PMF event is not anticipated given the topography that separates the watercourses.
- The computed Stream C PMF floodplain does not extend into the DGR Project site. The spill area identified on the upstream side of the North Access Road flowing in the direction of Interconnecting Road is not anticipated to represent a flood risk to the DGR Project site as the spill elevation (approximately 181.3 m) at the spill discharge location is well below currently planned elevations of the operational areas of the DGR Project site (i.e., 186 m).

As a result, the riverine flood potential resulting from a PMP/PMF event will not impact the DGR Project site given currently planned elevations of the DGR operational areas and existing topography.

A PMP event occurring across the DGR Project site has the potential to generate flood levels in excess of the DGR Project site preliminary design elevation of 186 m. This flood risk is mitigated through engineered features.

9.3 SUMMARY

Taking into account the detailed engineering studies identified above to adequately address the potential coastal and surface floods, no residual adverse effects of the environment on the DGR Project with regards to hydrology and surface water quality are expected.

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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 [2], and their effects on the DGR Project are described in the EIS (Section 9).

The requirement of the DGR Project EIS Guidelines (included as Appendix A to the EIS) 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? and
- How will the DGR Project affect climate change (e.g., contribution to climate change by the emission of greenhouse gasses)?

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. The Atmospheric Environment TSD 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

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. Refer to Appendix D of the Atmospheric Environment TSD for the 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%

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. Refer to Appendix D of the Atmospheric Environment TSD 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.

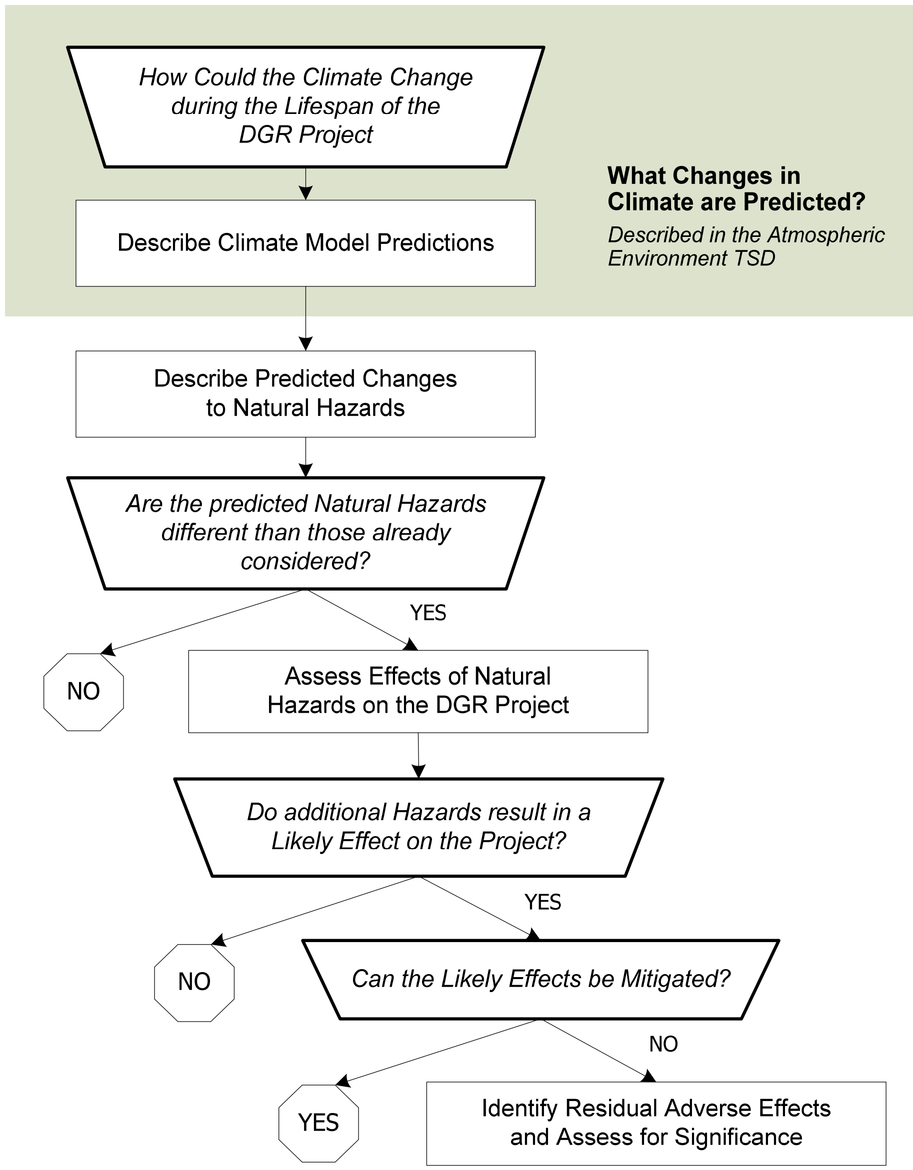

Figure 10.2.1-1: Method to Assess Effects of the Future Environment on the DGR Project

Once the future environment is established (Section 10.1), 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 Future Hydrology and Surface Water Quality on the DGR Project

As discussed in Section 9, the probability of flooding (from the lake) is low for the DGR Project because of its elevation and distance from the lake and potential surface flooding (from Stream C) will be mitigated with proper engineering design.

During the site preparation and construction phase and operations phase, an increase in the flood potential attributed to climate change is unlikely. In terms of coastal flooding the potential is, in fact, likely to be reduced in the future according to studies reported in the literature that predict Lake Huron levels to drop by between -0.73 to -0.98 m relative to the baseline case (1961 to 1990) for the 2041 to 2070 forecast period (see Section D2.3.4 of Appendix D of the Atmospheric Environment TSD). With respect to on-land flooding, predicted increased precipitation in all but the summer season for the three forecast periods shown in Table 10.1-2, suggest an increased possibility of flooding associated with spring snowmelt/rainfall runoff events affecting both Stream C and the DGR Project site stormwater management system. If these trends are realized, it stands to reason that increased precipitation through the winter months (December to February) would result in greater snowpack depths, which combined with higher soil moisture conditions in the fall and higher precipitation in the spring months (March to May) would produce more severe spring runoff events in the future. However, these potential impacts can be mitigated with proper engineering design, as described in Section 9.

In the longer term, there may also be an increased potential for flooding attributed to possible increases in the frequency and intensity of precipitation (see Section D2.3.4 of Appendix D of the Atmospheric Environment TSD). However, when the DGR is decommissioned, the shafts will be sealed and flooding will no longer have an effect.

Based on the above, there are no effects on the DGR Project as the result of a future hydrology and surface water quality environment.

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.

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.

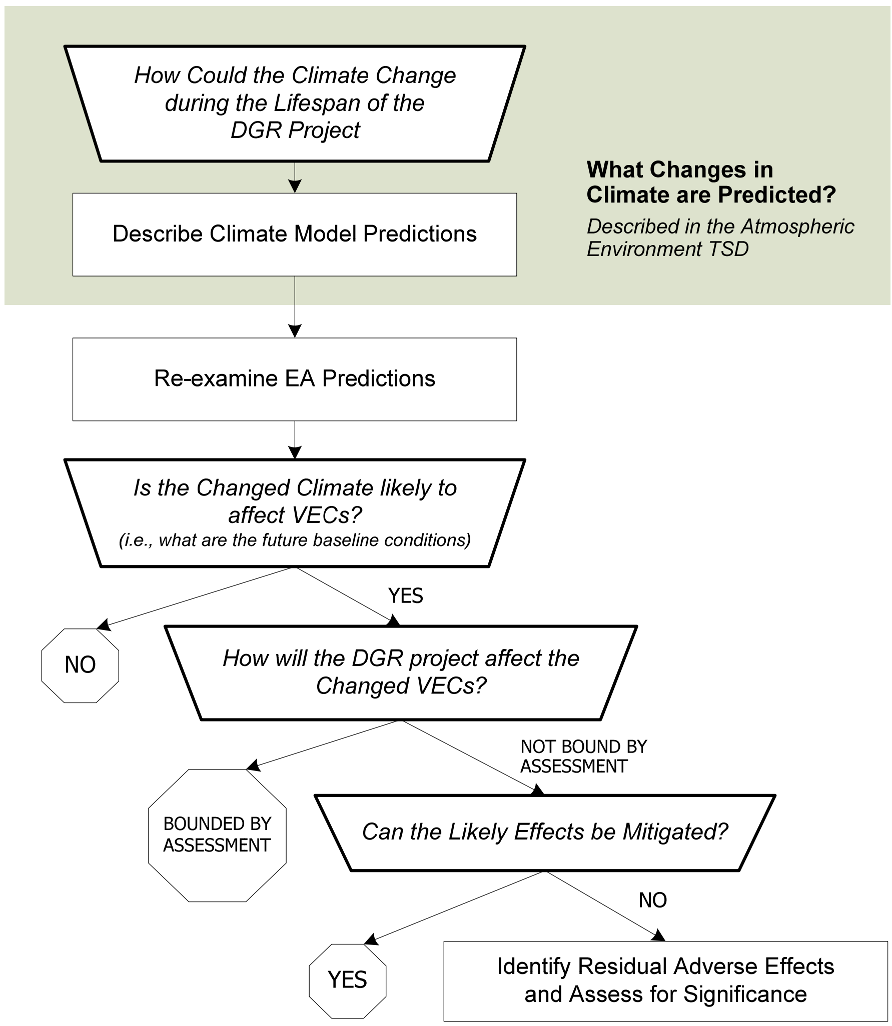

Figure 10.3.1-1: Method to Assess Effects of the DGR Project on the Future Environment

10.3.2 Assessment of the DGR Project on the Future Hydrology and Surface Water Quality VECs

Change in air temperature (i.e., affecting evapotranspiration rates and precipitation) could potentially change the flow in area streams and the amount of runoff from the DGR Project. An increase in annual precipitation as predicted in Table 10.1-2 would increase the potential amount of runoff from the DGR Project. An increase in air temperature as predicted in Table 10.1-1 would increase the rate of evaporation, thus reducing runoff, primarily in the summer months and diminishing the effect of increased precipitation on an annual basis. From Table 10.1-2, the projected future increase in annual precipitation for the highest forecast scenario over the time period from 2011 to 2100 is shown in Table 10.3.2-1. Also shown is the estimated change in runoff attributable to the increased precipitation, based on a conservative runoff coefficient of 0.5 and ignoring the potential reduction in runoff due to increase temperatures and evapotranspiration rates.

Table 10.3.2-1: Projected Increase in Annual Precipitation and Runoff

Time Period	Annual Precipitation Increase (%/decade)	Annual Precipitation Increase for Time Period (%)	Estimated Change in Runoff (%)
2011 to 2040	3.57	10.71	5.36
2041 to 2070	2.09	6.27	3.14
2071 to 2100	2.25	6.75	3.38
Total Period	N/A	23.73	11.88

Note:
N/A Not applicable

From Table 10.3.2-1, the estimated maximum change in streamflow (runoff) is approximately 12% (by the end of the century) based on the most conservative climate change forecast, a conservative runoff coefficient and ignoring the effects of increased temperatures. Since this potential change is <15% (i.e., less than the adopted criteria for reliable flow measurement), adverse effects on Stream C or the DGR Project site drainage ditches are not anticipated (see Appendix C and Section 11.1).

Changes in surface water quality could result from the effects of climate change: for example, increased volumes of runoff could potentially increase turbidity levels or decrease the overall concentration of contaminants in the runoff through dilution. However, since the change in runoff is not expected to be measurable, no adverse changes to water quality are expected.

Table 10.3.2-2 summarizes the potential effects of climate change on hydrology and surface water quality VECs, and describes whether these changes could affect the conclusions of the assessments presented for assessment of direct effects in Section 8.

Table 10.3.2-2: Effects of Climate Change on Hydrology and Surface Water Quality VECs

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Surface Water Quantity and Flow	Changes in temperatures and precipitation have the potential to affect streamflows (runoff).	Increases in runoff resulting from increased precipitation are partially mitigated by increased evaporation resulting from increased air temperature. Maximum estimated changes in flow are within the accuracy limits of standard flow measurement equipment and are predicted to be non-adverse (i.e., changes would be <15%) through to year 2011.	None
Surface Water Quality	Changes in temperature and precipitation could change the streamflows (runoff), which could indirectly affect water quality.	Changes in water quality would only result from changes in runoff. Since no measurable change in runoff is predicted, no measurable changes in water quality are expected.	None

10.4 EFFECTS OF THE DGR PROJECT ON CLIMATE CHANGE

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, which considers the direct and indirect changes as a result of the DGR Project is not relevant with regards to hydrology and surface water quality, and is described in the Atmospheric Environment TSD.

10.5 SUMMARY

No effects of climate change related to hydrology and surface water quality are advanced to Section 11 for an evaluation of significance.

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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 hydrology and surface water quality VECs. An assessment of the cumulative effects associated with the DGR Project is addressed in Section 10 of the EIS.

11.1 ASSESSMENT METHODS

If residual adverse effects are identified in the assessment (Sections 8 through 10), they are assessed to determine if the residual adverse effect is significant. Significance is rated using criteria applicable to hydrology and surface water quality. 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 11.1-2.		
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 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 effect)	**Low**	**Medium**	**High**
	Conditions or phenomena causing the effect occur infrequently (i.e., several times per year)	Conditions or phenomena causing the effect occur at regular, although infrequent intervals (i.e., several times per month)	Conditions or phenomena causing the effect occur at regular and frequent intervals (i.e., daily or continuously)
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)

The criteria used to evaluate magnitude are specific to each of the VECs under consideration. The following sections summarize the effects level definitions for magnitude for the hydrology and surface water quality VECs. Only non-negligible (i.e., measurable) effects are carried forward for an assessment of significance.

Table 11.1-2: Effects Levels for Assigning Magnitude

Indicator Criteria	Effects Level Definition		
	Low	Medium	High
Surface Water Quantity and Flow	15% to 50% change [a] (increase or decrease)	50% to 100% increase or 50% to 75% decrease [a]	> 100% increase or > 75% decrease [a]

Note:
a Change measured as percent change from mean annual flow.

Changes to surface water quality and flow are measured against the magnitude criteria identified in Table 11.1-2. The rationale for the development of the flow criteria is provided in detail in Appendix C of this report. The following points outline the rationale for the flow criteria:

- Changes in flow that are lower than the typical accuracy of in-stream flow measurements (±15%) are considered not adverse.
- Changes in streamflow compared to the natural variation in average annual flow (estimated to be ±50% for Stream C) was considered representative of the transition from low to medium to high level effects
- If a change is measurable but the change is no more than the variation in average annual streamflow (i.e., 50%) then the effect is considered to have a low magnitude effect.
- If the change is greater than the variability in average annual streamflow but no more than twice the variability (i.e., 100% increase or 75% decrease), then the effect is considered to have a medium magnitude effect.
- If the change is greater than twice the estimated variability in average annual flows (i.e., greater than 100% increase or 75% decrease), then the effect is considered to have a high magnitude of effect.

It should be noted that the above criteria was developed specifically for application to natural streams (i.e., Stream C). Application of the criteria to man-made drainage ditches, which in general are environmentally less sensitive than natural streams, is believed to be conservative.

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. Firstly, magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the VEC being affected is considered to determine the overall significance of the effect.

[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.

This decision tree is specific to hydrology and surface water quality and the effects level criteria defined in Tables 11.1-1 and 11.1-2. Some of the guiding principles are:

- all effects within the natural variability of the receiving water body (i.e., low magnitude) would result in a low environmental consequence and would not be considered significant;
- generally, if the effects that are limited to the Site Study Area (i.e., low extent) or are evident only during the site preparation and construction phase (i.e., low timing and duration) result in a low environmental consequence and would not be considered significant; and
- effects with a high magnitude and extent would result in a high environmental consequence and may be considered significant.

A 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.

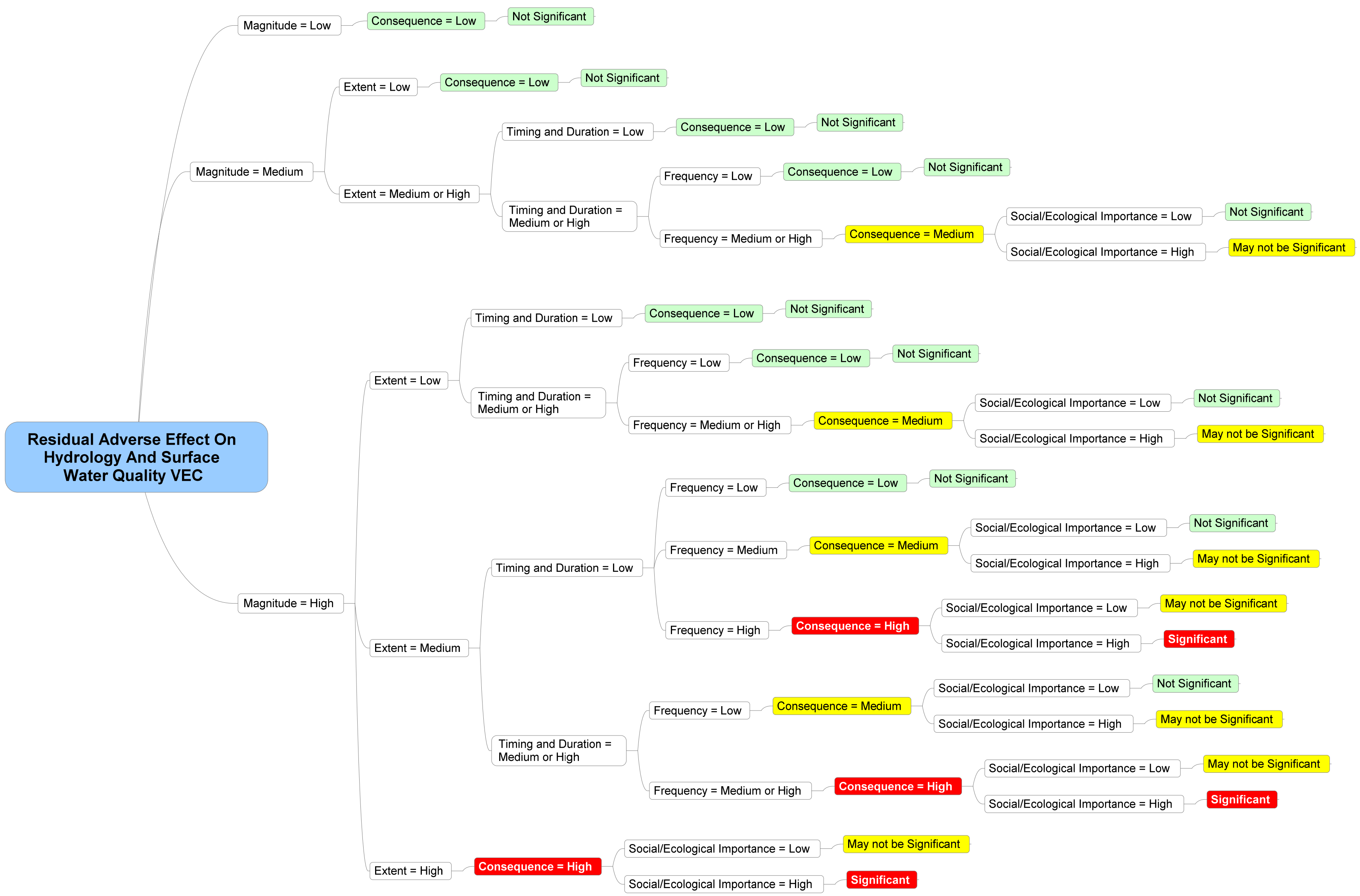

Figure 11.1-1: Determination of Significance of Residual Adverse Effects

11.2 SIGNIFICANCE OF RESIDUAL ADVERSE EFFECTS

As described in Section 8, three residual adverse effects of the DGR Project on hydrology and surface water quality VECs were identified:

- 31% reduction in surface water quantity and flow in the North Railway Ditch upstream of Stream C attributed to reduction in drainage area from the construction of the stormwater management system;
- 114% increase during the site preparation and construction phase in surface quantity and flow in the drainage ditch at Interconnecting Road attributed to increase in drainage area from the construction of the stormwater management system and the shaft sump pumping; and
- 61% increase during the operation phase in surface quantity and flow in the drainage ditch at Interconnecting Road attributed to increase in drainage area from the construction and operation of the stormwater management system and the shaft sump pumping.

As shown in Table 11.1-2, and based on the decision flow shown on Figure 11.1-1, the reduction in flow to the North Railway Ditch was assessed as not significant because of the low magnitude. Even though the magnitude level was assessed as high, the increase in flow at the Interconnecting Road during site preparation and construction was assessed to be not significant because of the low geographic extent and the low timing and duration.

The increase in flow at the Interconnecting Road during operations was assessed to be not significant because of the medium magnitude and low geographic extent. These effects are expected to have a high duration because the operation of the system will continue through both the operations and decommissioning phases. However, the frequency is expected to be medium because the effect will only be observed during certain times (i.e., high flow events caused by summer storm or snowmelt runoff).

All changes in flow are not expected to be measurable in Lake Huron beyond the point of discharge.

Table 11.2-1: Summary of Residual Adverse Effects and Significance Levels

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Surface Water Quantity and Flow						
Decreased Flow in North Railway Ditch	Low • 15% to 50% change in flow (decrease)	Low • Effect is limited to the Site Study Area	High • Effect extends beyond the operations phase	Medium • Conditions causing the effect occur several times per month	Medium • Effect is reversible with time (i.e., the drainage system will be removed prior to abandoning the DGR)	**Not significant**
Increased Flow in drainage ditch at Interconnecting Road (during site preparation and construction)	High • >100% increase	Low • Effect is limited to the Site Study Area	Low • Effect occurs during the site preparation and construction phase	Medium • Conditions causing the effect occur several times per month	Medium • Effect is reversible with time	**Not significant**
Increased Flow in drainage ditch at Interconnecting Road (during operations)	Medium • 50 to 100% increase	Low • Effect is limited to the Site Study Area	Medium • Effect occurs during the operations phase	Medium • Conditions causing the effect occur several times per month	Medium • Effect is reversible with time	**Not significant**

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 and non-renewable resources” as a VEC. 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 are 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*”.

Potential project-environment interactions identified in the screening matrices were reviewed to determine the likelihood of interactions between the DGR Project and resource sustainability and availability. For the purpose of this assessment, the likely residual adverse effects of the DGR Project’s physical works and activities on the environment were not considered as having the potential to adversely affect the sustainability of associated resources (i.e., local and regional water resources).

12.2 LIKELY EFFECTS

Therefore, the DGR Project is not expected to have any effects on renewable and non-renewable resources with regards to hydrology and surface water quality.

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13. PRELIMINARY FOLLOW-UP PROGRAM

The DGR Project EIS 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 so doing, 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 hydrology and surface water quality assessment. The recommendations identify the general timeframe for follow-up and monitoring (site preparation and construction, operations, decommissioning and/or abandonment and long-term performance phase). The preliminary follow-up monitoring program has been prepared and is submitted along with the EIS.

Table 13.1-1: Potential Follow-up Monitoring for the Hydrology and Surface Water Quality

VEC	Phase	Program Objective	Suggested Frequency and Location of Monitoring
Water Quality	• Site preparation and construction • Operations (1 year)[a]	Confirm site discharge meets certificate of approval discharge criteria	Project Area discharge point (Interconnecting Road) – quarterly, when flowing
		Confirm effectiveness of water treatment	Project Area discharge point (Interconnecting Road) – quarterly, when flowing

Note:

a Monitoring of the discharge will continue through operations under the conventional regulatory monitoring requirements program, as described in the DGR EA Follow-up Monitoring Program.

13.2 PERMITTING REQUIREMENTS

It is expected that the DGR Project will be subject to a number of additional permitting requirements. Those permits related to the hydrology and surface water quality include, but may not be limited to:

- Under Section 53 of the Ontario *Water Resources Act*, a Certificate of Approval Industrial Sewage Works would be required for the construction and operation of the stormwater management system.

14. CONCLUSIONS

Based on the assessment provided in this TSD, the following conclusions are provided;

- A residual adverse effect on surface water quantity and flow is predicted to be caused by measurable decreases in stream flow in the North Railway Ditch and increases in the drainage ditch to Lake Huron. The environmental consequence of these effects is considered to be low and the residual adverse effect is assessed as not significant.
- No residual adverse effects to surface water quality are expected as a result of the site preparation and construction, operations, decommissioning or abandonment and long-term performance phases of the DGR Project provided that suitable stormwater treatment is implemented.
- Climate change is not expected to have any effect on the conclusions reached regarding the effects of the DGR Project on surface water quantity and flow or surface water quality.
- The environment is not expected to have any adverse effects on the DGR Project.
- The DGR Project is not expected to have any effects on renewable and non-renewable resources with regards to hydrology and surface water quality.

Therefore, no significant adverse effects are identified for hydrology and surface water quality VECs.

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APPENDIX A: LIST OF ACRONYMS, UNITS AND TERMS

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LIST OF ACRONYMS

Acronym	Descriptive Term
AMIC	Annual Maximum Ice Coverage
ANFO	Ammonium Nitrate/Fuel Oil
BTEX	Benzene, toluene, ethylbenzene, xylenes
$CaCO_3$	Calcium Carbonate
CEAA	Canadian Environmental Assessment Act
CCME	Canadian Council of Ministers of the Environment
CNSC	Canadian Nuclear Safety Commission
CofA	Certificate of Approval
DGR	Deep Geologic Repository
EA	Environmental Assessment
EIS	Environmental Impact Statement
IGLD	International Great Lakes Datum
ILW	Intermediate Level Waste
L&ILW	Low and Intermediate Level Waste
LLW	Low level waste
MOE	Ministry of the Environment
NaCl	Sodium Chloride
NWMO	Nuclear Waste Management Organization
OPG	Ontario Power Generation Inc.
PCBs	Polychlorinated Biphenyls
PHC	Petroleum hydrocarbons
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PWQO	Provincial Water Quality Objectives
QA/QC	Quality Assurance/Quality Control
RA	Responsible Authority
SSTF	Spent Solvent Treatment Facility
TKN	Total Kjeldahl Nitrogen
TSD	Technical Support Document
TSS	Total Suspended Solids
VEC	Valued Ecosystem Component

LIST OF ACRONYMS (continued)

Acronym	Descriptive Term
VOC	Volatile Organic Compound
WCTF	Waste Chemical Transfer Facility
WPCP	Water Pollution Control Plant
WPRB	Waste Package Receiving Building
WSP	Water Supply Plant
WWMF	Western Waste Management Facility

LIST OF UNITS

Symbol	Units
%	Percent
°C	Degrees Celsius
g/d	Grams per Day
g/L	Grams per Litre
ha	Hectares
km	Kilometres
km^2	Square Kilometres
L/s	Litres per Second
m	Metres
m^3	Cubic Metres
m/m	Metre per Metre
masl	Metres above sea level
mbgs	Metres below ground surface
micromhos/cm	Micromhos per Centimetre
µg/L	Micrograms per Litre
$µg/m^3$	Microgram per Cubic Metre
mg/L	Milligrams per Litre
$mg/m^2/yr$	Milligrams per Square Metre per Year
mm	Millimetres
NTU	Nephelometric Turbidity Unit
pH	A measure of the acidity or alkalinity of a solution. The pH scale spans 0 to 14, with 0 representing a strongly acidic solution, 7 representing a neutral solution, and 14 representing a strongly basic (alkaline) solution.
s	Seconds

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.

Abstraction – the process of taking water from any source, either temporarily or permanently.

As-disposed waste – the volume of space the L&ILW waste occupies when placed in the DGR.

Bruce nuclear site – The 932 ha (9.32 km^2) 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. T he Agency works to provide Canadians with high-quality environmental assessments that contribute to informed decision making, in support of sustainable development.

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.

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).

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

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.

Safety Report – A key licensing document which provides an overview of the facility design and operations, summarizes the integrated results of individual safety assessments, and demonstrates that a facility can be constructed, operated, or continue to be operated, without undue risk to health and safety of the workers and the public, and the environment.

Preliminary Safety Report (PSR) is the Safety Report submitted to CNSC in support of an application for a Site Preparation/Construction Licence.

Final Safety Report (FSR) is the Safety Report submitted to CNSC in support of an application for a Licence to Operate.

Shaft – A vertical or near-vertical excavated passageway that connects the surface with an underground workplace or connects two or more underground workplaces at different elevations.

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 – The waste material, the container, and any external barriers (e.g. shielding material), as prepared in accordance with requirements for handling, transfer and emplacement in the repository. It is a discrete unit that can be individually identified and handled at the repository facility.

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.

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

Project Works and Activities	Description
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.
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.

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

Project Works and Activities	Description
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.
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: RATIONALE FOR FLOW CRITERIA

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C1. INTRODUCTION

Ontario Power Generation (OPG) has proposed to develop a Deep Geologic Repository (DGR) in the Municipality of Kincardine, Ontario. The project will encompass an approximate area of 30 ha which includes the buildings, construction laydown areas, waste rock disposal areas and storage areas. The area proposed for development is currently partially drained by the Stream C watershed. During the development of the DGR project, a portion of the flow to Stream C will be diverted to drain directly to MacPhersons Bay via a series of ditches.

In order to complete the environmental assessment (EA) process, criteria are required to measure the magnitude (level of effect) of changes to the flow regime in Stream C and its tributaries. This appendix provides the rationale for the effect levels used in the main body of this report. Criteria are required for determining low, medium and high levels of effects.

C2. DEVELOPMENT OF CRITERIA

Criteria for changes to stream flow were developed, taking into consideration the ability to measure streamflow in natural channels, the natural variation in stream flow and the possible effects of flow increases or decreases on channel hydraulic and geomorphic characteristics, as well as aquatic habitat and biota. An understanding of the natural streamflow variability with respect to Stream C is also required to assess the environmental impacts (of changes to Stream C) on the proposed DGR project.

C2.1 AVAILABLE STREAM FLOW DATA

Since there are no historical flow records available for Stream C, flow records for adjacent gauges were collected to determine the pattern and variability of flows. It is generally understood that no two rivers are exactly alike, but a general relationship can be developed between drainage area, temporal variability and stream flow of gauged and ungauged streams in the same geographic area.

The Water Survey of Canada (WSC) hydrometric database (HYDAT) [C1] provides the stream flow data which is used in the variability analysis. The locations of WSC gauges in the local area are shown on Figure C2.1-1. The four gauges used in the analysis are Pine River at Lurgan (02FD001), Teeswater River near Paisley (02FC015), North Saugeen River near Paisley (02FC013) and Saugeen River near Port Elgin (02FC001). The duration of historical flow data of the above gauges along with the drainage areas and monthly stream flows are provided in Table C2.1-1.

From the average monthly flows shown in Table C2.1-1, the unit flows ($m^3/s/km^2$) of all four gauges are similar and therefore a general relationship can be inferred for Stream C from the other gauging stations. Also, the average monthly flows and flow variability can be pro-rated on a drainage area basis for Stream C from the available historical flows.

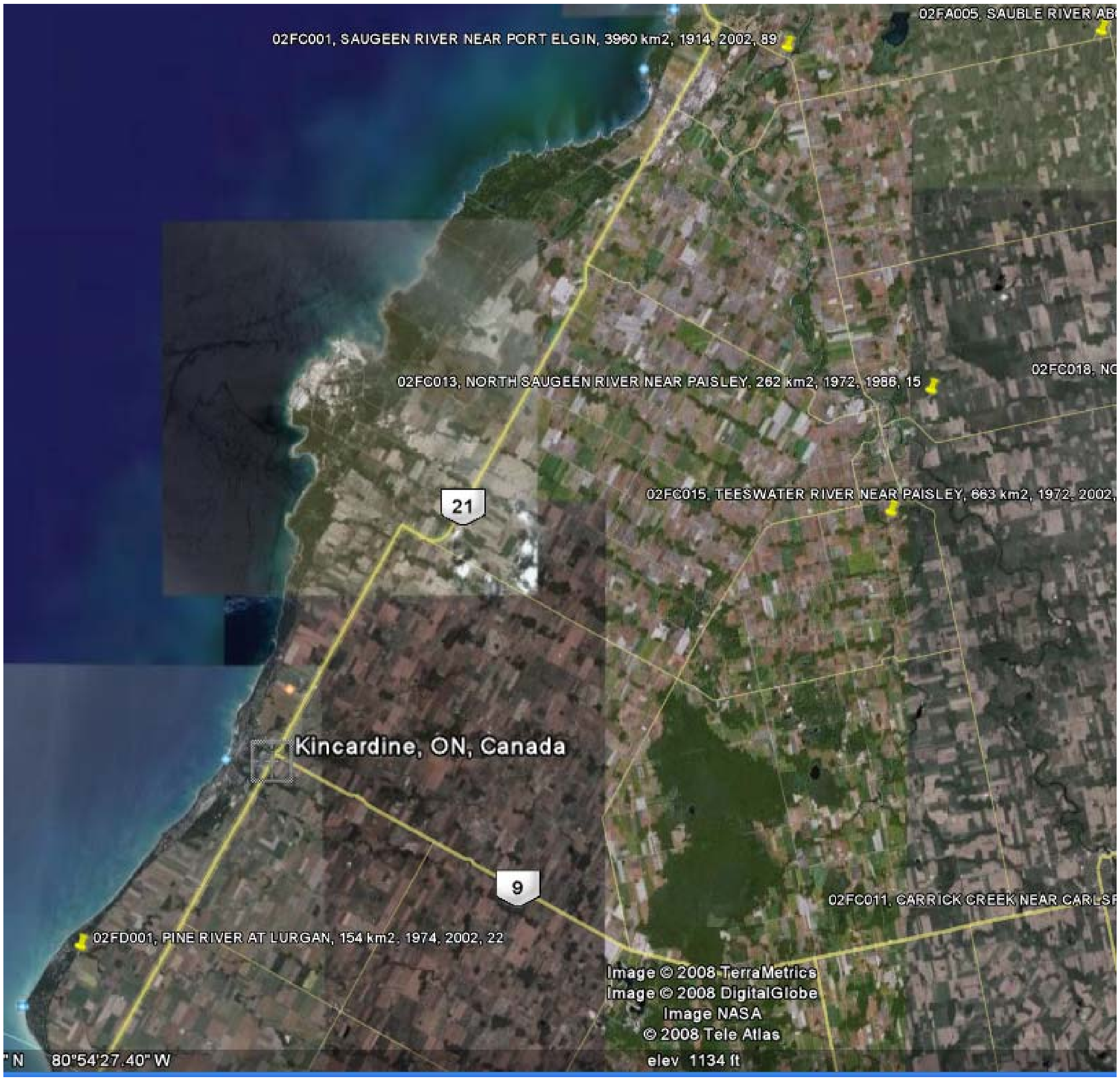

Figure C2.1-1: Location of WSC Stream Gauges used for Flow Variability Analysis

Table C2.1-1: Average Monthly Flows

Location	**Pine River at Lurgan**		**Teeswater River near Paisley**		**North Saugeen River near Paisley**		**Saugeen River near Port Elgin**	
Gauge No.	02FD001		02FC015		02FC013		02FC001	
Drainage Area (km^2)	154		663		262		3960	
Data Duration	1974-2002		1972-2002		1972-1986		1914-2005	
Month	**Average**		**Average**		**Average**		**Average**	
	(m^3/s)	**($m^3/s/km^2$)**	**(m^3/s)**	**($m^3/s/km^2$)**	**(m^3/s)**	**($m^3/s/km^2$)**	**(m^3/s)**	**($m^3/s/km^2$)**
Jan	2.13	0.014	13.2	0.020	3.78	0.014	58.2	0.015
Feb	3.04	0.020	12.6	0.019	4.55	0.017	58.5	0.015
Mar	7.00	0.045	27.8	0.042	8.82	0.034	128	0.032
Apr	3.13	0.020	25.5	0.038	9.68	0.037	145	0.037
May	1.08	0.007	9.54	0.014	5.49	0.021	61.2	0.015
Jun	0.506	0.003	4.91	0.007	3.48	0.013	33.4	0.008
Jul	0.210	0.001	2.78	0.004	2.48	0.009	23.8	0.006
Aug	0.211	0.001	2.67	0.004	2.24	0.009	17.5	0.004
Sep	0.959	0.006	3.87	0.006	2.79	0.011	20.4	0.005
Oct	1.12	0.007	5.43	0.008	2.88	0.011	30.7	0.008
Nov	2.45	0.016	10.4	0.016	3.89	0.015	50.0	0.013
Dec	2.96	0.019	12.5	0.019	4.51	0.017	57.8	0.015
Annual	2.07	0.013	10.9	0.016	4.56	0.017	56.9	0.014

Note:
Data obtained from Water Survey of Canada [C1].

C2.2 EFFECT LEVEL CRITERIA

For the EA process, four flow change criteria are needed (measurable, low effect, medium effect and high effect). The proposed criteria are summarized as follows:

- For a change to be considered to have an effect, it must be measurable (i.e., detectable by using standard streamflow measurement techniques). For stream flow, a measurable effect may be caused by a change in the drainage area that contributes runoff to the stream or any direct addition or abstraction of flow from the stream.
- If a change is measureable but within the natural variation in average annual stream flow then the effect is considered to have a low magnitude of effect.
- If the change is greater than the variability in average annual streamflow but less than twice the variability, then the effect is considered to have a medium magnitude of effect.
- If the change is greater than twice the variability in average annual flows, then the effect is considered to have a high magnitude of effect.

Each of the threshold criteria (e.g., criteria separating medium and high) is developed in the following sections. It should be noted that, although seasonal flow variations are presented and discussed, they were not directly considered in the development of the effects level criteria since changes to average annual flows are generally accepted as the best indicator of longer term effects on the stream channel such as average hydraulic properties and geomorphology. Daily flow variations were not considered since they are the result of individual precipitation events (i.e., weather related) and do not represent long term variation in flow due to climatic factors.

C2.2.1 Measurement Criteria

Flow in small streams, creeks and ditches is typically measured with a metering device (flow metre) that records the average flow velocity in individual columns of water across the channel, known as the area-velocity approach. Typically, the accuracy of these measurements is ±15% if the measurement procedure is used consistently [C2]. For the purposes of this EA, it is assumed that the area-velocity approach would be used to measure flows and that a change of less than 15% from the existing mean annual flow could not be measured. This change can either be an increase or a decrease.

C2.2.2 Low to Medium Effect Threshold Criteria

Variation in annual flow is the result of variation in annual climatic conditions, the most important of which are precipitation and temperature, which affects rates of evapotranspiration in the drainage basin. These variations occur naturally and the habitat and biota in a particular stream can tolerate these variations. If the predicted change in flow is less than the natural variation in annual flow then the expected level of effect is considered to be low. If the change is greater than the natural variation, then the expected level of effect is considered to be medium.

Table C2.2.2-1 summarizes the variation in annual flow for the four gauged locations in the area of the DGR project. For the smallest watershed (Pine River), which is closest in size to Stream C, the annual flows are typically within 50% of the long term average. Therefore it is proposed that a change in flow of 50% or more would be representative of a medium level of effect. This change can either be an increase or decrease.

C2.2.3 Medium to High Effect Threshold Criteria

As discussed above, flows greater than the variation in the average annual flow are considered to have a medium effect on the hydraulic and geomorphic characteristics of Stream C. However, if the changed flow regime (increase or decrease) is too far beyond the natural variation in average annual flow, it is expected that these changes would noticeably affect both the hydraulic (i.e., flow depth, width, velocity) and geomorphic (i.e., alignment, bottom substrate, erosion and deposition processes) characteristics of the stream channel over a period of time Affects on aquatic habitat and biota are also more likely.

The effects on Stream C are considered high for changes to the flow regime that result in flow increases that are twice (2 times) the natural variation, which based on the preceding analysis of Pine River flows is assumed to be ±50% of the average annual flow. Therefore, the high effects criterion for increased flows is a change greater than 2 times 50% (i.e., a 100% increase in average annual flow). Similarly, the effect on Stream C is considered to be high for changes to the flow regime that result in decreased flows that are twice the natural variability (i.e., a 75% decrease in average annual flow).

Table C2.2.2-1: Observed Variation in Annual Stream Flow

Location	**Pine River at Lungan**		**Teeswater River near Paisley**		**North Saugeen River near Paisley**		**Saugeen River near Port Elgin**	
Gauge No.	02FD001		02FC015		02FC013		02FC001	
Drainage Area (km^2)	154		663		262		3960	
Year	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**
1972	—	—	10.2	-8%	4.31	-5%	55.6	-1%
1973	—	—	9.33	-16%	4.40	-3%	56.2	0%
1974	1.72	-18%	9.04	-18%	4.51	-1%	57.5	2%
1975	2.17	3%	11.4	3%	4.74	4%	61.2	9%
1976	1.99	-5%	12.7	15%	4.62	1%	68.4	22%
1977	2.67	27%	12.6	14%	4.74	4%	69.4	23%
1978	1.37	-35%	8.56	-23%	3.50	-23%	48.2	-14%
1979	2.18	4%	12.2	10%	5.29	16%	69.7	24%
1980	1.96	-7%	9.68	-13%	4.97	9%	60.1	7%
1981	2.19	4%	10.6	-4%	4.50	-1%	60.1	7%
1982	2.72	30%	12.4	12%	4.69	3%	67.1	19%

Table C2.2.2-1: Observed Variation in Annual Stream Flow (continued)

Location	Pine River at Lungan		Teeswater River near Paisley		North Saugeen River near Paisley		Saugeen River near Port Elgin	
Gauge No.	02FD001		02FC015		02FC013		02FC001	
Drainage Area (km^2)	154		663		262		3960	
Year	Average (m^3/s)	% Change vs Long Term Average	Average (m^3/s)	% Change vs Long Term Average	Average (m^3/s)	% Change vs Long Term Average	Average (m^3/s)	% Change vs Long Term Average
1983	1.53	-27%	8.36	-24%	3.83	-16%	50.2	-11%
1984	2.26	8%	10.9	-2%	4.29	-6%	59.2	5%
1985	2.65	26%	13.8	25%	5.40	19%	75.7	35%
1986	3.10	48%	13.7	24%	—	—	76.5	36%
1987	1.79	-15%	8.98	-19%	—	—	46.3	-18%
1988	2.11	0%	9.71	-12%	—	—	50.1	-11%
1989	0.995	-53%	7.22	-35%	—	—	41.3	-27%
1990	2.60	24%	11.7	6%	—	—	65.9	17%
1991	1.97	-6%	11.1	0%	—	—	60.3	7%
1992	2.58	23%	12.7	15%	—	—	66.5	18%
1993	1.45	-31%	9.60	-13%	—	—	56.4	0%
1994	—	—	10.2	-8%	—	—	53.0	-6%
1995	—	—	10.1	-9%	—	—	54.0	-4%
1996	—	—	15.9	44%	—	—	79.5	41%
1997	—	—	15.1	36%	—	—	76.2	36%
1998	—	—	—	—	—	—	44.4	-21%
1999	—	—	—	—	—	—	33.0	-41%
2000	—	—	—	—	—	—	62.0	10%
2001	—	—	—	—	—	—	78.5	40%
2002	—	—	—	—	—	—	54.3	-3%
2003	—	—	—	—	—	—	58.4	4%
2004	—	—	—	—	—	—	69.9	24%
2005	—	—	—	—	—	—	55.6	-1%

Table C2.2.2-1: Observed Variation in Annual Stream Flow (continued)

Location	Pine River at Lungan		Teeswater River near Paisley		North Saugeen River near Paisley		Saugeen River near Port Elgin	
Gauge No.	02FD001		02FC015		02FC013		02FC001	
Drainage Area (km^2)	154		663		262		3960	
Year	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**	**Average (m^3/s)**	**% Change vs Long Term Average**
Long Term Average	2.10	0%	11.1	0%	4.56	0%	56.2	0%
Maximum	3.10	48%	15.9	44%	4.50	19%	79.5	41%
Minimum	0.995	-53%	7.22	-35%	3.50	-23%	33.0	-41%

Note:
Data obtained from Water Survey of Canada [C1].

C2.2.4 Seasonal Variation in Flow

In general, seasonal variation in flow is greater than the variation in annual flow. The average pattern of seasonal variation in stream flow is known as the seasonal hydrograph or stream flow regime. The streams discharging to Lake Huron surrounding the Project site exhibit the *nival regime* (e.g., the snow melt dominates flow regime). Table C2.2.3-1 shows the typical seasonal flow variation for four gauging stations in the vicinity of the DGR project. Typically the spring runoff flows are three to ten times higher than the summer low flows. The largest differences are evident in the smallest watershed (Pine River). Since Stream C has a smaller watershed (9 km^2) than the Pine River, it is possible that the difference between summer and spring flows (for Stream C) could also be as much or even greater than by a factor of ten.

Table C2.2.3-1: Observed Seasonal Variation in Stream Flow

Location		Pine River at Lungan			Teeswater River near Paisley			North Saugeen River near Paisley			Saugeen River near Port Elgin		
Gauge No.		02FD001			02FC015			02FC013			02FC001		
Drainage Area (km^2)		154			663			262			3,960		
Season	Month	Monthly Average (m^3/s)	Seasonal		Monthly Average (m^3/s)	Seasonal		Monthly Average (m^3/s)	Seasonal		Monthly Average (m^3/s)	Seasonal	
			Average	% Annual		Average	% Annual		Average	% Annual		Average	% Annual
Winter	Dec	2.96	2.71	10.9%	12.5	12.77	9.7%	4.51	4.28	7.8%	57.8	58.17	8.5%
	Jan	2.13			13.2			3.78			58.2		
	Feb	3.04			12.6			4.55			58.5		
Spring	Mar	7.00	3.74	15.1%	27.8	20.95	16.0%	8.82	8.00	14.6%	128	111.40	16.3%
	Apr	3.13			25.5			9.68			145		
	May	1.08			9.54			5.49			61.2		
Summer	Jun	0.506	0.31	1.2%	4.91	3.45	2.6%	3.48	2.73	5.0%	33.4	24.90	3.6%
	Jul	0.210			2.78			2.48			23.8		
	Aug	0.211			2.67			2.24			17.5		
Fall	Sep	0.959	1.51	6.1%	3.87	6.57	5.0%	2.79	3.19	5.8%	20.4	33.70	4.9%
	Oct	1.12			5.43			2.88			30.7		
	Nov	2.45			10.4			3.89			50.0		
	Annual	24.8			131			54.6			685		

Note:
Data obtained from Water Survey of Canada [C1].

C3. REFERENCES

[C1] Environment Canada. 2006. *Surface Water and Sediment Data*. National Water Data Archive (HYDAT). Water Survey of Canada. Environment Canada.

[C2] United States Department of the Interior. 2001. *Water Measurement Manual*. Water Resources Research Laboratory. United States Department of the Interior Bureau of Reclamation.

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APPENDIX D: SUMMARY OF WATER QUALITY CRITERIA

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Appendix D – Summary of Water Quality Criteria

Parameter	Units	PWQO[1]	Interim PWQO[1]	CEQG: Recreational [8]	CEQG: Aquatic Life [9]
General Chemistry					
Alkalinity	mg/L ($CaCO_3$)	≤ 25 % decrease from natural conditions	—	—	—
Ammonia, Total	mg/L	0.02[14]	—	—	1.37-2.2
Nitrite	mg/L	—	—	—	0.06
Nitrate	mg/L	—	—	—	Narrative[26]
Pathogen Indicators for Fresh Waters: Total Coliforms (*Escherichia coli* + fecal coliforms)	counts/ 100 mL	100 *E.coli*/100 mL[10]	—	*2000 E.coli*/L[10,11]	—
Oil and Grease		See note 13	—	—	—
pH	N/A	6.5-8.5	—	5.0-9.0[12]	6.5-9.0
Phosphorus, Total	mg/L	—	0.010[22]	—	—
Temperature	ºC	Maximum absolute of 30ºC Maximum increase of 10ºC	—	—	—
Total Dissolved Solids	mg/L	—	—	—	—
Total Suspended Solids	mg/L	—	—	—	Narrative[23]
Turbidity	NTU	≤ 10 % change from natural Secchi disk reading	—	Narrative[25]	Narrative[24]
Metals					
Aluminum (filtered)	mg/L	—	See notes 6 & 7 below table	—	—
Aluminum	mg/L	—	0.075[7]	—	0.005-0.100[15]

Appendix D – Summary of Water Quality Criteria (continued)

Parameter	Units	PWQO[1]	Interim PWQO[1]	CEQG: Recreational [8]	CEQG: Aquatic Life [9]
Antimony	mg/L	—	0.02	—	—
Arsenic	mg/L	0.1	0.005	—	0.005
Barium	mg/L	—	—	—	—
Boron	mg/L	—	0.2	—	—
Cadmium	mg/L	0.0002	0.0001[3]	—	0.000017[16]
Cesium	mg/L	50[21]	—	—	—
Chromium, Total	mg/L	—	—	—	—
Chromium (VI)[2,29]	mg/L	0.001	—	—	0.001
Chromium (III)[2,29]	mg/L	0.0089	—	—	0.0089
Cobalt	mg/L	0.0009	—	—	—
Copper	mg/L	0.005	0.001[3]	—	0.002-0.004[17]
Iron	mg/L	0.3	—	—	0.300
Lead	mg/L	0.005[4]	0.001[3]	—	0.001-0.007[18]
Manganese	mg/L	—	—	—	—
Mercury (filtered)	mg/L	0.0002	—	—	0.0001
Molybdenum	mg/L	—	0.04	—	0.073[19]
Nickel	mg/L	0.025	—	—	0.025-0.15[20]
Phosphorus	mg/L	—	0.01[22]	—	—
Selenium	mg/L	0.1	—	—	0.001
Silver	mg/L	0.0001	—	—	0.0001
Sodium	mg/L	—	—	—	—

Appendix D – Summary of Water Quality Criteria (continued)

Parameter	Units	PWQO[1]	Interim PWQO[1]	CEQG: Recreational [8]	CEQG: Aquatic Life [9]
Thallium	mg/L	—	0.0003	—	0.0008
Tungsten	mg/L	—	0.03	—	—
Uranium	mg/L	—	0.005	—	—
Vanadium	mg/L	—	0.006	—	—
Zinc	mg/L	0.03	0.02	—	0.03
Zirconium	mg/L	—	0.004	—	—

Notes:

1 PWQO and Interim PWQO guidelines provided by MOE [9].

2 Cr(III) and Cr(VI) to be analyzed at lab only if Total Chromium is detected above 10 ppb.

3 PWQO is dependent on hardness (as $CaCO_3$) of water sample; most conservative PWQO is presented in this table.

4 PWQO is dependent on alkalinity (as $CaCO_3$) of water sample; most conservative PWQO is presented in this table.

5 Filtered metals samples are to be collected only at the PNGS-A lake water and liquid effluent sampling locations; filtered metal samples are not to be collected at the PNGS-B lake water sampling locations.

6 A filtered aluminum sample will be prepared from the unpreserved general chemical sample in compliance with PWQO procedures.

7 Interim PWQO for Aluminum (filtered) is described as follows:
- At pH 4.5 to 5.5 the Interim PWQO is 15 µg/L based on inorganic monomeric aluminum measured in clay free samples*;
- At pH >5.5 to 6.5, no condition should be permitted which would increase the acid soluble inorganic aluminum concentration in clay-free samples to more than 10% above natural background concentrations for waters representative of that geological area of the Province that are unaffected by man-made inputs; and
- At pH >6.5 to 9.0, the Interim PWQO is 75 µg/L based on total aluminum measured in clay-free samples*.

* If natural background aluminum concentrations in water bodies unaffected by man-made inputs are greater that the numerical Interim PWQO (above), no condition is permitted that would increase the aluminum concentration in clay-free samples by more than 10% of the natural background level.

8 Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines: Recreational Water Quality Guidelines and Aesthetics (Chapter 3).

9 Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines: Canadian Water Quality Guideline (CWQG) for the Protection of Aquatic Life (Chapter 4).

10 When experience has shown that greater than 90 percent of the fecal coliforms are E. coli, either fecal coliform or E. coli may be determined. When less than 90 percent of the fecal coliforms are E. coli, only E. coli may be determined.

11 Geometric mean of at least 5 samples taken during a period not to exceed 30 days.

12 If the water has a very low buffering capacity, pH values from 5.0 to 9.0 should be acceptable.

13 Oil or petrochemicals should not be present in concentrations that:
- can be detected as a visible film, sheen, or discolouration on the surface;
- can be detected by odour;
- can form deposits on shorelines and bottom sediments that are detectable by sight or odour.

14 Ammonia guideline: Expressed as μg/L unionized ammonia. Guideline for un-ionized ammonia is temperature and pH dependent.
15 Aluminum guideline: 5μg/L at pH < 6.5; 100 μg/L at pH ≥ 6.5.
16 Interim guideline; Cadmium guideline = $10^{[0.86[\log(hardness)]-3.2]}$
17 Copper guideline = 2 μg/L at [$CaCO_3$] = 0-120 mg/L
= 3 μg/L at [$CaCO_3$] = 120-180 mg/L
= 4 μg/L at [$CaCO_3$] > 180 mg/L
18 Lead guideline = 1 μg/L at [$CaCO_3$] = 0-60 mg/L
= 2 μg/L at [$CaCO_3$] = 60-120 mg/L
= 4 μg/L at [$CaCO_3$] = 120-180 mg/L
= 7 μg/L at [$CaCO_3$] > 180 mg/L
19 Interim guideline.
20 Nickel guideline = 25 μg/L at [$CaCO_3$] = 0-60 mg/L
= 65 μg/L at [$CaCO_3$] = 60-120 mg/L
= 110 μg/L at [$CaCO_3$] = 120-180 mg/L
= 150 μg/L at [$CaCO_3$] > 180 mg/L
21 Cesium-137.
22 A high level of protection against aesthetic deterioration for ice-free period – this should apply to all lakes naturally below this value. To avoid nuisance concentrations of algae in lakes, average total P for the ice-free period should not be > 20 μg/L.
23 Suspended sediments: (CEQG, Aquatic Life):
- Clear Flow: Maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d).
- High Flow: Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is > 250 mg/L.

24 Turbidity (CEQG, Aquatic Life):
- Clear Flow: Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for longer term exposures (e.g., 30-d period).
- High Flow or Turbid Waters: Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is > 250 mg/L.

25 Turbidity of water should not be increased more than 5.0 NTU over natural turbidity when turbidity is low (<50 NTU).
26 Concentrations that stimulate excessive weed growth should be avoided.
27 PCBs will only be sampled over the existing DNGS outfall diffuser at 5 of the 10 stations in this zone. This will be performed as a spot-check to determine if PCBs are present in the cooling water discharges from the diffuser.
28 The MDL for PCBs is greater than the PWQO. It is unknown if this is a limitation of the analytical equipment or method of analysis. However, the MDL for PCBs as required under MISA is 0.05 μg/L [MOE, 1999] which agrees with the MDL cited by the OPG approved analytical laboratory (i.e., Kinectrics). While this MDL is greater than the PWQO, the MOE Lab Services Branch provides a MDL which is also greater than the PWQO (i.e., 0.02 μg/L).
29 The MDLs for Chromium III and VI are greater than the associated PWQOs. It is unknown if this is a limitation of the analytical equipment or methods of analysis. However, the MDL for Chromium VI as required under MISA is 0.01 mg/L [MOE, 1999] which agrees with the MDLs cited by the OPG approved analytical laboratory (i.e., Kinectrics) for Chromium III and VI.
30 Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines: Community Water Supplies (Chapter 2).
31 AO = Aesthetic Objective.
32 IMAC = Interim Maximum Acceptable Concentration; MAC = Maximum Acceptable Concentration.
33 Trihalomethanes = chloroform, bromodichloromethane, dibro modichloromethane, bromoform.

APPENDIX E: 2007 AND 2009 SURFACE WATER SAMPLING RESULTS

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Appendix E
2007 and 2009 Surface Water Sampling Results

Parameter	Units	PWQO	MDL	SW1 Stream C - Upstream						SW2 Stream C - Downstream								
				3-May-07	14-Jun-07	12-Oct-07	25-May-09	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	14-Jun-07	12-Oct-07	25-May-09	25-May-09 (Dup)	11-Sep-09	11-Sep-09 (Dup)	27-Oct-09
FIELD OBSERVATIONS																		
Conductivity	umho/cm	-		560	490	750	460	580	530	550	490		670	480		540		600
pH		*6.5 to 8.5*		7.68	7.93	7.68	7.87	7.70	7.13	8.05	8.57		8.31	8.33		8.34		7.50
Temperature	C	-		16.8	26.6	12.7	14.8	15.9	12.0	13.0	20.1		11.0	16.4		18.3		9.1
General Chemistry																		
Total Ammonia-N	mg/L	-	0.05	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Un-Ionized Ammonia	mg/L	*0.02*	calculated	<0.003	0.012	<0.002	<0.002	<0.001	<0.001	<0.002	0.010	0.013	<0.002	<0.003	<0.001	<0.004	<0.004	<0.001
Total Phosphorous	mg/L	*0.02*		-	-	-	-	0.023	0.015	-	-	-	-	-	-	0.016	0.018	<0.002
Total Chemical Oxygen Demand (COD	mg/L	-	4	12	20	20	12	13	<4	11	14	14	29	13	13	14	13	<4
Conductivity	µmho/cm	-	1 / 2	528	514	597	494	559	559	530	529	530	599	512	512	529	531	611
Total Dissolved Solids	mg/L	-	1	324	322	331	320	370	375	297	342	330	332	320	325	355	357	405
Hardness (CaCO3)	mg/L	-	1	240	270	320	240	280	270	240	270	260	280	240	240	270	270	270
Total Organic Carbon (TOC)	mg/L	-	0.1	4.6	7.5	6.8	4.2	4.8	4.4	4.8	5.9	6	5.2	4.5	4.4	4.6	4.7	4.7
pH	pH	*6.5 to 8.5*		8.3	8.3	8.3	8.1	8.0	8	8.3	8.4	8.5	8.4	8.3	8.3	8.4	8.4	8.2
Total Suspended Solids	mg/L	-	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Alkalinity (Total as CaCO3)	mg/L	-	1	255	255	285	243	280	266	240	245	247	255	238	240	264	261	263
Total Oil & Grease	mg/L	-	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
METALS																		
Total Aluminum (Al)	µg/L	*75*[a]	5	25	54	31	40	31	87	35	69	330	33	56	64	80	85	68
Total Antimony (Sb)	µg/L	*20*	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	µg/L	*5*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Barium (Ba)	µg/L	-	5	16	15	17	15	16	18	14	14	14	15	14	14	14	14	17
Total Beryllium (Be)	µg/L	*1100*	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Bismuth (Bi)	µg/L	-	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Boron (B)	µg/L	*200*	10	15	29	20	14	20	14	17	21	20	22	14	14	10	10	21
Total Cadmium (Cd)	µg/L	*0.5*	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Calcium (Ca)	µg/L	-	200	69000	70000	83000	70000	76000	83000	68000	72000	72000	74000	70000	67000	70000	70000	83000
Total Cesium (Cs)	µg/L	-	2 / 50	<50	<50	<50	-	-	<2	<50	<50	<50	<50	-	-	-	-	<2
Total Chromium (Cr)	µg/L	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chromium (VI)	µg/L	*1*	0.5 / 5	<5	<5	<5	<0.5	<0.5	<0.5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium (+3)	µg/L	*8.9*	5	<5	<5	<5	-	<5	<5	<5	<5	<5	<5	-	-	<5	<5	<5
Dissolved Chromium (Cr)	µg/L	-	5	-	<5	-	-	<5	<5	-	<5	<5	-	-	-	<5	<5	<5
Total Cobalt (Co)	µg/L	*0.9*	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	µg/L	*5*	1	<1	<1	<1	2	<1	<1	<1	2	1	1	2	2	2	2	<1
Total Iron (Fe)	µg/L	*300*	50 / 100	280	680	430	690	300	610	58	140	270	<100	300	280	200	200	<100
Total Lead (Pb)	µg/L	*5 / 25*	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Lithium (Li)	µg/L	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Magnesium (Mg)	µg/L	-	50	24000	25000	28000	24000	24000	24000	21000	23000	23000	23000	22000	22000	22000	22000	23000
Total Manganese (Mn)	µg/L	-	2	25	100	110	40	73	87	10	15	25	7	22	21	21	21	15
Total Mercury (Hg)	µg/L	-	0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Molybdenum (Mo)	µg/L	*40*	1	<1	<1	<1	<1	<1	<1	<1	5	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	µg/L	*25*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Potassium (K)	µg/L	-	200	2300	1400	2800	1900	900	-	1900	1700	1700	2300	1800	1800	1200	1200	-
Total Selenium (Se)	µg/L	*100*	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Silicon (Si)	µg/L	-	50	320	2400	5300	1100	-	-	1200	2000	2100	3600	1500	1400	-	-	-
Total Silver (Ag)	µg/L	*0.1*	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Sodium (Na)	µg/L	-	100	13000	13000	14000	12000	10000	11000	18000	17000	17000	26000	16000	15000	12000	12000	24000
Total Strontium (Sr)	µg/L	-	1	200	210	240	200	220	210	270	230	230	360	230	230	210	210	430
Total Tellurium (Te)	µg/L	-	1	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	-	-	-
Total Thallium (Tl)	µg/L	*0.3*	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Thorium (Th)	µg/L	-	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Tin (Sn)	µg/L	-	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Titanium (Ti)	µg/L	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Tungsten (W)	µg/L	*30*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Uranium (U)	µg/L	-	0.1	0.6	0.3	0.3	0.4	0.3	0.4	0.8	0.7	0.8	0.6	0.6	0.6	0.5	0.5	1
Total Vanadium (V)	µg/L	*6*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<5	<5	<1
Total Zinc (Zn)	µg/L	*20*	5	<5	7	<5	7	<5	<5	7	11	9	<5	9	7	<1	<1	<5
Total Zirconium (Zr)	µg/L	*4*	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Parameter	SW3 South Railway Ditch - West					SW4 South Railway Ditch - East					
	3-May-07	14-Jun-07	12-Oct-07	25-May-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	12-Oct-07 (Dup)	25-May-09	27-Oct-09
FIELD OBSERVATIONS											
Conductivity	1680	1470	540	1760	1330	1220	1130	740		1250	1150
pH	7.38	7.55	7.37	7.93	7.23	7.67	7.76	7.61		7.60	7.23
Temperature	12.6	20.5	11.0	13.3	11.4	13.2	21.4	10.0		14.0	10.8
General Chemistry											
Total Ammonia-N	<0.05	0.14	<0.05	<0.05	<0.05	<0.05	0.14	<0.05	<0.05	<0.05	<0.05
Un-Ionized Ammonia	<0.001	0.009	<0.001	<0.0005	<0.001	<0.002	0.009	<0.001	<0.001	<0.0003	<0.002
Total Phosphorous	-	-	-	-	0.028	-	-	-	-	-	0.003
Total Chemical Oxygen Demand (COD	12	23	14	15	15	11	20	14	18	22	5
Conductivity	1680	1500	474	1820	1350	1170	1150	672	676	1310	1220
Total Dissolved Solids	1020	880	278	1150	885	716	684	371	362	830	800
Hardness (CaCO3)	280	310	130	270	200	320	290	200	190	280	280
Total Organic Carbon (TOC)	3.9	7.8	6.1	3.9	4.6	6.5	6.8	6.1	7.7	6.1	4.4
pH	8.1	8.2	8.1	7.6	7.9	8.3	8.2	8.2	8.2	7.4	8.2
Total Suspended Solids	<10	18	51	<10	24	<10	<10	<10	<10	56	90
Alkalinity (Total as CaCO3)	236	236	95	240	179	320	241	149	144	267	241
Total Oil & Grease	<0.5	1.1	<0.5	<0.5	2.1	<0.5	0.5	<0.5	<0.5	<0.5	<0.5
METALS											
Total Aluminum (Al)	13	99	150	40	110	52	15	69	19	120	38
Total Antimony (Sb)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Barium (Ba)	39	44	21	41	33	34	14	13	13	35	26
Total Beryllium (Be)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Bismuth (Bi)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Boron (B)	25	31	20	17	18	47	17	22	22	44	32
Total Cadmium (Cd)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Calcium (Ca)	84000	83000	40000	89000	67000	94000	27000	55000	54000	87000	84000
Total Cesium (Cs)	<50	<50	<50	-	<4	<50	<50	<50	<50	-	<4
Total Chromium (Cr)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chromium (VI)	<5	<5	<5	<0.5	<0.5	<5	<5	<5	<5	<0.5	<0.5
Chromium (+3)	<5	<5	<5	-	<5	<5	<5	<5	<5	-	<5
Dissolved Chromium (Cr)	-	<5	-	-	<5	-	<5	-	-	-	<5
Total Cobalt (Co)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	2	2	2	3	3	2	<1	1	1	4	1
Total Iron (Fe)	53	750	790	250	740	170	<50	340	150	640	<100
Total Lead (Pb)	<0.5	<0.5	0.6	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Lithium (Li)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Magnesium (Mg)	21000	24000	9400	22000	14000	29000	8800	13000	13000	27000	21000
Total Manganese (Mn)	27	230	200	45	140	39	<2	35	14	140	56
Total Mercury (Hg)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Molybdenum (Mo)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	2	3	2	3	<1	<1	<1	2	<1	2	<1
Total Potassium (K)	2500	2400	1000	1900	-	2600	1000	1200	1100	2200	-
Total Selenium (Se)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Silicon (Si)	720	2700	1600	760	-	1300	590	1900	1900	1700	-
Total Silver (Ag)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Sodium (Na)	230000	200000	51000	280000	200000	120000	4900	69000	72000	180000	150000
Total Strontium (Sr)	1800	1900	620	1900	1300	2000	180	930	900	2000	1800
Total Tellurium (Te)	<1	<1	<1	<1	-	<1	<1	<1	<1	<1	-
Total Thallium (Tl)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Thorium (Th)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Tin (Sn)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Titanium (Ti)	<5	<5	5	<5	<5	<5	<5	<5	<5	<5	<5
Total Tungsten (W)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Uranium (U)	0.8	0.6	0.1	0.7	0.7	0.9	0.2	0.3	0.3	0.7	0.7
Total Vanadium (V)	<1	2	2	<1	2	<1	<1	<1	<1	<1	<1
Total Zinc (Zn)	72	69	54	75	58	26	6	15	6	38	12
Total Zirconium (Zr)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Parameter	Units	PWQO	MDL	SW1 Stream C - Upstream						SW2 Stream C - Downstream									SW3 South Railway Ditch - West					SW4 South Railway Ditch - East					
				3-May-07	14-Jun-07	12-Oct-07	25-May-09	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	14-Jun-07	12-Oct-07	25-May-09	25-May-09 (Dup)	11-Sep-09	11-Sep-09 (Dup)	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	25-May-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	12-Oct-07 (Dup)	25-May-09	27-Oct-09
VOLATILES																													
Acetone (2-Propanone)	µg/L	-	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzene	µg/L	*100*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Bromodichloromethane	µg/L	*200*	0.1 / 0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
Bromoform	µg/L	*60*	0.2 / 1	<0.2	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.2	<1
Bromomethane	µg/L	*0.9*	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	-	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Chlorobenzene	µg/L	*15*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Chloroform	µg/L	-	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Dibromochloromethane	µg/L	-	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
1,2-Dichlorobenzene	µg/L	*2.5*	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
1,3-Dichlorobenzene	µg/L	*2.5*	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
1,4-Dichlorobenzene	µg/L	*4*	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
1,1-Dichloroethane	µg/L	*200*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
1,2-Dichloroethane	µg/L	*100*	0.1 / 0.2 / 0.5	<0.1	<0.1	<0.1	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.5
1,1-Dichloroethylene	µg/L	*40*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
cis-1,2-Dichloroethylene	µg/L	*200*	0.1 / 0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
trans-1,2-Dichloroethylene	µg/L	*200*	0.1 / 0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
1,2-Dichloropropane	µg/L	*0.7*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
cis-1,3-Dichloropropene	µg/L	-	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
trans-1,3-Dichloropropene	µg/L	-	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
Ethylbenzene	µg/L	*8*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Ethylene Dibromide	µg/L	*5*	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
Methylene Chloride(Dichloromethane)	µg/L	*100*	0.5 / 2	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<2
Methyl Isobutyl Ketone	µg/L	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Methyl Ethyl Ketone (2-Butanone)	µg/L	*400*	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Methyl t-butyl ether (MTBE)	µg/L	*200*	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
Styrene	µg/L	*4*	0.1 / 0.2 / 0.5	<0.1	<0.1	<0.1	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.5
1,1,1,2-Tetrachloroethane	µg/L	*20*	0.1 / 0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
1,1,2,2-Tetrachloroethane	µg/L	*70*	0.1 / 0.2 / 0.5	<0.1	<0.2	<0.2	<0.2	<0.2	<0.5	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.1	<0.2	<0.2	<0.2	<0.5	<0.1	<0.2	<0.2	<0.2	<0.2	<0.5
Tetrachloroethylene	µg/L	*50*	0.1 / 0.2	<0.1	<0.2	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.2	<0.1	<0.2	<0.1	<0.2	<0.2	<0.2	<0.1	<0.2
Toluene	µg/L	*0.8*	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1,1,1-Trichloroethane	µg/L	*10*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
1,1,2-Trichloroethane	µg/L	*800*	0.2 / 0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5
Trichloroethylene	µg/L	*20*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Vinyl Chloride	µg/L	*600*	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
p+m-Xylene	µg/L	-	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
o-Xylene	µg/L	*40*	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Xylene (Total)	µg/L	-	0.1 / 0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2

Notes: Shaded cells indicate PWQO exceedances.
a) At pH >6.5 to 9, based on total aluminum measured in clay-free samples.

Appendix E
2007 and 2009 Surface Water Sampling Results

Parameter	Units	PWQO	MDL	SW5 Drain Under Interconnecting Road							SW6 MacPherson Bay							TRIP BLANKS					FIELD BLANKS				
				3-May-07	3-May-07 (Dup)	14-Jun-07	12-Oct-07	25-May-09	27-Oct-09	27-Oct-09 (Dup)	3-May-07	3-May-07 (Dup)	14-Jun-07	12-Oct-07	25-May-09	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	11-Sep-09	27-Oct-09
FIELD OBSERVATIONS																											
Conductivity	umho/cm	-		680		610	2670	620	600		230		200	296	210	210	200	-	-	-	-	-	-	-	-	-	-
pH		*6.5 to 8.5*		7.66		7.61	8.36	7.34	7.50		8.36		8.84	8.68	7.89	8.36	7.47	-	-	-	-	-	-	-	-	-	-
Temperature	C	-		13.2		23.0	11.1	12.3	9.1		14.4		19.1	12.8	18.1	20.3	11.1	-	-	-	-	-	-	-	-	-	-
General Chemistry																											
Total Ammonia-N	mg/L	-	0.05	<0.05	<0.05	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	-	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	0.09	<0.05	<0.05	<0.05
Un-Ionized Ammonia	mg/L	*0.02*	calculated	<0.002	<0.001	0.011	<0.003	<0.001	<0.001	<0.001	<0.002	-	0.006	<0.002	<0.001	<0.002	<0.0003	-	-	-	-	-	-	-	-	-	-
Total Phosphorous	mg/L	*0.02*		-	-	-	-	-	<0.002	0.008	-	-	-	-	-	0.007	<0.002	-	-	-	<0.002	<0.002	-	-	-	0.003	<0.002
Total Chemical Oxygen Demand (COD	mg/L	-	4	12	20	18	38	10	8	<4	5	-	<4	4	8	5	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Conductivity	µmho/cm	-	1 / 2	722	735	599	2520	662	682	561	219	-	217	222	244	210	217	<2	<2	<2	<1	1	<2	<2	<2	<1	<1
Total Dissolved Solids	mg/L	-	1	416	404	380	1180	420	450	370	121	-	125	124	160	137	140	<1	<1	<1	<10	<10	<1	<1	<1	<10	<10
Hardness (CaCO3)	mg/L	-	1	280	280	320	390	290	270	280	94	-	100	110	110	97	96	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Total Organic Carbon (TOC)	mg/L	-	0.1	6.7	-	6	13.8	3.3	4.8	4.4	1.9	-	1.9	1.8	2.1	2.0	1.7	0.2	<0.1	<0.1	<0.2	<0.2	0.1	<0.1	0.3	<0.2	<0.2
pH	pH	*6.5 to 8.5*		8.3	8.3	8.3	8.5	7.9	8.1	8.2	8.2	-	8.2	8.3	7.5	8.0	7.4	5.6	5.9	6.3	5.4	6.8	6.8	7.0	6.0	5.9	5.7
Total Suspended Solids	mg/L	-	10	<10	<10	19	<10	10	<10	41	<10	-	<10	<10	35	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Alkalinity (Total as CaCO3)	mg/L	-	1	285	283	306	378	291	255	264	84	-	82	84	90	81	85	3	1	<1	<1	2	2	2	<1	<1	<1
Total Oil & Grease	mg/L	-	0.5	<0.5	-	1.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
METALS																											
Total Aluminum (Al)	µg/L	-	5	68	-	200	59	25	57	44	110	27	65	50	130	160	29	<5	5	<5	<5	6	5	6	5	<5	9
Total Antimony (Sb)	µg/L	*20*	0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Arsenic (As)	µg/L	*5*	1	<1	-	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Barium (Ba)	µg/L	-	5	24	-	25	36	19	23	17	27	14	32	15	17	14	14	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Beryllium (Be)	µg/L	*1100*	0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Bismuth (Bi)	µg/L	-	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Boron (B)	µg/L	*200*	10	20	-	29	36	16	16	14	22	18	42	19	14	10	16	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Cadmium (Cd)	µg/L	*0.5*	0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Calcium (Ca)	µg/L	-	200	89000	-	100000	120000	96000	82000	80000	93000	28000	77000	32000	36000	26000	29000	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
Total Cesium (Cs)	µg/L	-	2 / 50	<50	-	<50	<50	-	<2	<2	<50	<50	<50	<50	-	-	<2	<50	<50	<50	-	<2	<50	<50	<50	-	<2
Total Chromium (Cr)	µg/L	-	5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chromium (VI)	µg/L	*1*	0.5 / 5	<5	-	<5	<5	<0.5	<0.5	<0.5	<5	<5	<5	<5	<0.5	<0.5	<0.5	<5	<5	<5	<5	<0.5	<5	<5	<5	<5	<0.5
Chromium (+3)	µg/L	*8.9*	5	<5	-	<5	<5	-	<5	<5	<5	<5	<5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dissolved Chromium (Cr)	µg/L	-	5	-	-	<5	-	-	<5	<5	-	-	<5	-	-	<5	<5	-	<5	-	<5	<5	-	<5	-	<5	<5
Total Cobalt (Co)	µg/L	*0.9*	0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Copper (Cu)	µg/L	*5*	1	2	-	6	5	3	2	<1	3	<1	<1	<1	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Iron (Fe)	µg/L	*300*	50 / 100	270	-	1900	460	180	<100	370	540	<50	400	<100	280	<100	<100	<50	<50	<100	<100	<100	<50	<50	<100	<100	<100
Total Lead (Pb)	µg/L	*5 / 25*	0.5	0.6	-	1.1	0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Lithium (Li)	µg/L	-	5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Magnesium (Mg)	µg/L	-	50	20000	-	19000	24000	18000	15000	25000	21000	8400	24000	9000	11000	7700	8400	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Total Manganese (Mn)	µg/L	-	2	49	-	67	18	33	8	65	67	<2	54	4	12	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Mercury (Hg)	µg/L	-	0.1	<0.1	-	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Molybdenum (Mo)	µg/L	*40*	1	<1	-	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Nickel (Ni)	µg/L	*25*	1	<1	-	<1	2	<1	1	<1	1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Potassium (K)	µg/L	-	200	1500	-	2100	2700	1600	-	-	1700	1200	1800	1000	1100	900	-	<200	<200	<200	<200	-	<200	<200	<200	<200	-
Total Selenium (Se)	µg/L	*100*	2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Silicon (Si)	µg/L	-	50	620	-	3900	7900	2900	-	-	1000	350	2000	770	500	-	-	<50	<50	<50	-	-	<50	<50	<50	-	-
Total Silver (Ag)	µg/L	*0.1*	0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Sodium (Na)	µg/L	-	100	44000	-	13000	450000	29000	30000	11000	43000	5000	140000	5000	6200	4500	4700	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Total Strontium (Sr)	µg/L	-	1	700	-	540	990	490	590	210	730	150	1700	150	370	120	120	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Tellurium (Te)	µg/L	-	1	<1	-	<1	<1	<1	-	-	<1	<1	<1	<1	<1	-	-	<1	<1	<1	-	-	<1	<1	<1	-	-
Total Thallium (Tl)	µg/L	*0.3*	0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Thorium (Th)	µg/L	-	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Tin (Sn)	µg/L	-	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Titanium (Ti)	µg/L	-	5	<5	-	8	<5	<5	<5	<5	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Tungsten (W)	µg/L	*30*	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Uranium (U)	µg/L	-	0.1	0.7	-	0.6	1.7	0.6	1.1	0.5	0.7	0.2	0.5	0.2	0.4	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Vanadium (V)	µg/L	*6*	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Zinc (Zn)	µg/L	*20*	5	85	-	42	59	67	26	<5	110	7	16	<5	9	<5	<5	<5	5	8	<5	<5	<5	<5	<5	<5	<5
Total Zirconium (Zr)	µg/L	*4*	1	<1	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Parameter	Units	PWQO	MDL	SW5 Drain Under Interconnecting Road							SW6 MacPherson Bay							TRIP BLANKS					FIELD BLANKS				
				3-May-07	3-May-07 (Dup)	14-Jun-07	12-Oct-07	25-May-09	27-Oct-09	27-Oct-09 (Dup)	3-May-07	3-May-07 (Dup)	14-Jun-07	12-Oct-07	25-May-09	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	11-Sep-09	27-Oct-09	3-May-07	14-Jun-07	12-Oct-07	11-Sep-09	27-Oct-09
VOLATILES																											
Acetone (2-Propanone)	µg/L	-	10	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzene	µg/L	*100*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Bromodichloromethane	µg/L	*200*	0.1 / 0.5	<0.1	-	<0.1	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	1.1	<0.5
Bromoform	µg/L	*60*	0.2 / 1	<0.2	-	<0.2	<0.2	<0.2	<1	<1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<1
Bromomethane	µg/L	*0.9*	0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	-	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Chlorobenzene	µg/L	*15*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Chloroform	µg/L	-	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	5.4	<0.2
Dibromochloromethane	µg/L	-	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	0.3	<0.5
1,2-Dichlorobenzene	µg/L	*2.5*	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
1,3-Dichlorobenzene	µg/L	*2.5*	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
1,4-Dichlorobenzene	µg/L	*4*	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
1,1-Dichloroethane	µg/L	*200*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
1,2-Dichloroethane	µg/L	*100*	0.1 / 0.2 / 0.5	<0.1	-	<0.1	<0.1	<0.2	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5
1,1-Dichloroethylene	µg/L	*40*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
cis-1,2-Dichloroethylene	µg/L	*200*	0.1 / 0.5	<0.1	-	<0.1	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5
trans-1,2-Dichloroethylene	µg/L	*200*	0.1 / 0.5	<0.1	-	<0.1	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5
1,2-Dichloropropane	µg/L	*0.7*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
cis-1,3-Dichloropropene	µg/L	-	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
trans-1,3-Dichloropropene	µg/L	-	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
Ethylbenzene	µg/L	*8*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Ethylene Dibromide	µg/L	*5*	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
Methylene Chloride(Dichloromethane)	µg/L	*100*	0.5 / 2	<0.5	-	<0.5	<0.5	<0.5	<2	<2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	<2
Methyl Isobutyl Ketone	µg/L	-	5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Methyl Ethyl Ketone (2-Butanone)	µg/L	*400*	5	<5	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Methyl t-butyl ether (MTBE)	µg/L	*200*	0.2	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
Styrene	µg/L	*4*	0.1 / 0.2 / 0.5	<0.1	-	<0.1	<0.1	<0.2	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5	<0.1	<0.1	<0.1	<0.2	<0.5
1,1,1,2-Tetrachloroethane	µg/L	*20*	0.1 / 0.5	<0.1	-	<0.1	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5
1,1,2,2-Tetrachloroethane	µg/L	*70*	0.1 / 0.2 / 0.5	<0.1	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	<0.5	<0.1	<0.2	<0.2	<0.2	<0.5	<0.1	<0.2	<0.2	<0.2	<0.5
Tetrachloroethylene	µg/L	*50*	0.1 / 0.2	<0.1	-	<0.1	<0.2	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	<0.1	<0.2	<0.1	<0.2	<0.2	<0.1	<0.2
Toluene	µg/L	*0.8*	0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1,1,1-Trichloroethane	µg/L	*10*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
1,1,2-Trichloroethane	µg/L	*800*	0.2 / 0.5	<0.2	-	<0.2	<0.2	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5
Trichloroethylene	µg/L	*20*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Vinyl Chloride	µg/L	*600*	0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
p+m-Xylene	µg/L	-	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
o-Xylene	µg/L	*40*	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2
Xylene (Total)	µg/L	-	0.1 / 0.2	<0.1	-	<0.1	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.2

Note: 1) Shaded cells indicate PWQO exceedances.

APPENDIX F: 2009 SEDIMENT SAMPLING RESULTS

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Appendix F
2009 Sediment Sampling Results

Parameter	Units	CCME [1]	SGWS Table 1 [2]	MDL	SW1 Stream C - Upstream		SW2 Stream C - Downstream		SW3 South Railway Ditch - West	SW4 South Railway Ditch - East	SW5 Drain Under Interconnecting Road	SW6 MacPherson Bay	TRIP BLANK
					11-Sep-09	11-Sep-09 (Lab Dup)	11-Sep-09	11-Sep-09 (Dup)	11-Sep-09	11-Sep-09	11-Sep-09	11-Sep-09	11-Sep-09
GENERAL													
Total Organic Carbon	mg/kg			500	470000		35000	42000	290000	68000	47000	32000	<500
Moisture	%			0.2	17		17	16	85	29	15	15	<0.2
METALS													
Aluminum (Al)	µg/g			50	2600		1600	1600	4400	3600	2500	1100	
Antimony (Sb)	µg/g			0.2	<0.2		<0.2	<0.2	0.9	<0.2	<0.2	<0.2	
Arsenic (As)	µg/g	5.9	6	1	2		<1	<1	**7**	2	1	<1	
Barium (Ba)	µg/g			0.5	28		7.9	8.1	57	28	13	4.6	
Beryllium (Be)	µg/g			0.2	<0.2		<0.2	<0.2	0.2	<0.2	<0.2	<0.2	
Bismuth (Bi)	µg/g			1	<1		<1	<1	<1	<1	<1	<1	
Boron (B)	µg/g			5	<5		<5	5	7	6	<5	<5	
Cadmium (Cd)	µg/g	0.6	0.6	0.1	0.1		<0.1	<0.1	**7.5**	0.4	0.2	<0.1	
Calcium (Ca)	µg/g			50	100000		100000	150000	33000	110000	120000	89000	
Chromium (Cr)	µg/g	37.3	26	1	6		7	6	12	9	12	6	
Cobalt (Co)	µg/g		50	0.1	2.1		1.5	1.6	8.1	3.3	2.2	1.3	
Copper (Cu)	µg/g	35.7	16	0.5	7.2		7.1	9.9	**110**	24	17	16	
Iron (Fe)	µg/g			50	10000		5400	5200	16000	11000	8600	5000	
Lead (Pb)	µg/g	35	31	1	4		3	3	24	8	13	1	
Magnesium (Mg)	µg/g			50	28000		36000	46000	15000	35000	40000	32000	
Manganese (Mn)	µg/g			1	930		230	290	1300	720	250	170	
Molybdenum (Mo)	µg/g			0.5	<0.5		<0.5	<0.5	2.8	<0.5	<0.5	<0.5	
Nickel (Ni)	µg/g		16	0.5	3.7		3.4	3.3	28	8.4	7.1	2.5	
Phosphorus (P)	µg/g			50	530		310	270	610	510	280	300	
Potassium (K)	µg/g			200	260		210	260	830	540	320	<200	
Selenium (Se)	µg/g			0.5	0.7		0.5	<0.5	2.1	0.7	<0.5	<0.5	
Silver (Ag)	µg/g		0.5	0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Sodium (Na)	µg/g			100	110		130	130	2100	340	190	<100	
Strontium (Sr)	µg/g			1	120		78	100	190	160	100	66	
Thallium (Tl)	µg/g			0.05	<0.05		<0.05	<0.05	0.16	<0.05	<0.05	<0.05	
Tin (Sn)	µg/g			5	<5		<5	<5	<5	<5	<5	<5	
Uranium (U)	µg/g			0.05	0.31		0.36	0.43	1.9	0.52	0.35	0.29	
Vanadium (V)	µg/g			5	7		8	7	48	13	13	8	
Zinc (Zn)	µg/g	123	120	5	22		28	18	**2200**	**290**	**200**	14	
POLYCHLORINATED BIPHENYLS (PCBs)													
Aroclor 1262	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1016	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1221	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1232	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1242	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1248	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1254	µg/g	0.06		0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1260	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Aroclor 1268	µg/g			0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
Total PCB	µg/g	0.0341	0.07	0.01	<0.01		<0.01	<0.01	<0.06	<0.01	<0.01	<0.01	<0.01
HYDROCARBONS													
Benzene	µg/g			0.02	<0.02	<0.02	<0.02	<0.02	<0.2	<0.02	<0.02	<0.02	<0.02
Toluene	µg/g			0.02	<0.02	<0.02	<0.02	<0.02	<0.2	<0.02	<0.02	<0.02	<0.02
Ethylbenzene	µg/g			0.02	<0.02	<0.02	<0.02	<0.02	<0.2	<0.02	<0.02	<0.02	<0.02
o-Xylene	µg/g			0.02	<0.02	<0.02	<0.02	<0.02	<0.2	<0.02	<0.02	<0.02	<0.02
p+m-Xylene	µg/g			0.04	<0.04	<0.04	<0.04	<0.04	<0.4	<0.04	<0.04	<0.04	<0.04
Total Xylenes	µg/g			0.04	<0.04	<0.04	<0.04	<0.04	<0.4	<0.04	<0.04	<0.04	<0.04
F1 (C6-C10)	µg/g			10 or 100	<10	<10	<10	<10	<100	<10	<10	<10	<10
F1 (C6-C10) - BTEX	µg/g			10 or 100	<10	<10	<10	<10	<100	<10	<10	<10	<10
F2 (C10-C16 Hydrocarbons)	µg/g			10 or 100	<10	<10	<10	<10	<100	<10	<10	<10	<10
F3 (C16-C34 Hydrocarbons)	µg/g			10 or 100	25	41	<10	<10	720	25	13	<10	<10
F4 (C34-C50 Hydrocarbons)	µg/g			10 or 100	<10	<10	<10	<10	460	<10	<10	<10	<10

Notes:
1. CCME (Canadian Council of Ministers of the Environment) - Canadian Sediment Quality Guidelines for the Protection of Aquatic Life; exceedances bolded.
2. SGWS (Soil, Ground Water and Sediment Standards) - Table 1: Full Depth Background Site Conditions Standards (for Sediment); exceedances shaded.

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APPENDIX G: SAMPLE CALCULATIONS

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CONTENTS

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G1. SAMPLE CALCULATIONS

G1.1 CATCHMENT ANNUAL FLOW CALCULATION

Existing flows at assessment points used in the DGR Project assessment of changes in surface water quantity and flow were calculated using catchment areas, mean annual precipitation at the Wiarton Airport and assumed runoff coefficients (Section 5.4.3 of the Hydrology and Surface Water Quality TSD) using the standard formula:

$$Q = cPA$$

Where:

Q is the flow rate to be estimated at the point of interest (L/s);
c is the runoff coefficient;
P is the annual rainfall amount (mm); and
A is catchment area (m^2).

The Average Annual Flow (Q) of Stream C at point of discharge from the Bruce nuclear site (North Access Road) is calculated then, as follows:

$$\mathrm{Q} = 0.42 \times \frac{1{,}041.3\ \mathrm{mm}}{\mathrm{yr}} \times 1{,}042.4\ \mathrm{ha} \times \frac{10{,}000\ \mathrm{m^2}}{\mathrm{ha}} \times \frac{1\mathrm{m}}{1{,}000\ \mathrm{mm}} \times \frac{1{,}000\ L}{m^3} \times \frac{1\ hr}{3{,}600\ s} \times \frac{1\ d}{24\ hr} \times \frac{1\ yr}{365\ d}$$
$$= 144.6\ L/s$$

Where:

c = 0.42 (the annual runoff coefficient derived from local streamflow records (Table C2.1-1);
P = 1,041.3 mm/yr (mean annual precipitation at Wiarton); and
A = 1,042.4 ha.

G1.2 CHANGE IN FLOW CALCULATION

The changes in flow are calculated by pro-rating the flows by changes in drainage areas, and adding additional flows, if necessary. Sample calculation for the Average Annual Flow (Q) of Stream C at point of discharge from the Bruce nuclear site (North Access Road):

$Q_2 = Q_1 \times A_2/A_1$

Where:

Q_2 is changed flow L/s;
Q_1 is existing flow in L/s;
A_2 is changed drainage area in ha; and

A_1 is existing drainage area in ha.

$$Q = \frac{144.6\ L}{s} \times \frac{1{,}034.2\ ha}{1042.4\ ha} = 143.4\ L/s$$

G1.3 NITRATE CONCENTRATION INCREASE

Average nitrate increase for Stream C of the increase are calculated as follows:

$$\frac{114.58\ L}{s} \times \frac{86{,}400\ s}{day} \times \frac{m^3}{1{,}000 L} = 9{,}900 m^3/day$$

$$\frac{0.014\ mgN}{m^2 yr} \times \frac{10{,}000\ m^2}{ha} \times 840.8\ ha \times \frac{yr}{365\ days} \times \frac{g}{1{,}000\ mg} = 0.313\ gN/day$$

$$\frac{0.313\ gN}{day} \times \frac{day}{9{,}900\ m^3} \times \frac{m^3}{1{,}000\ L} \times \frac{1{,}000\ mg}{g} = 0.032 \mu gN/L$$