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PREDICTIVE EFFECTS ASSESSMENT FOR THE WESTERN WASTE MANAGEMENT FACILITY EXPANSION PROJECT

Predictive Effects Assessment for the Western Waste Management Facility Expansion Project

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Accepted by: Susan Rapin
Director Environmental Services
Environment

PREDICTIVE EFFECTS ASSESSMENT FOR THE WESTERN WASTE MANAGEMENT FACILITY EXPANSION PROJECT

Submitted to:

Ontario Power Generation Inc.

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Prepared by:

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EXECUTIVE SUMMARY

Ontario Power Generation (OPG) is proposing to expand the Western Waste Management Facility (WWMF) for the storage of used fuel, low and intermediate waste (L&ILW), and for waste processing. The WWMF expansion project will consist of site preparation, construction, operation and maintenance of the following facilities:

- Four Used Fuel Dry Storage Buildings (UFDSBs), which will be built in addition to the four existing UFDSBs;
- Four L&ILW storage buildings (any combination of Low Level Storage Building (LLSB), Retube Component Storage Building (RCSB) and Steam Generator Storage Building (SGSB));
- One Waste Sorting Building (WSB);
- One Large Object Processing Building (LOPB); and,
- Repurposing an existing LLSB or using one of the new LLSBs for staging and overpacking of L&ILW.

The licensing process for the WWMF expansion project requires that OPG makes adequate provision for the protection of the environment and human health and safety. This includes identification, quantification, characterization, and prevention or mitigation of effects resulting from the proposed WWMF expansion project. To support these requirements, a Predictive Effects Assessment (PEA) was conducted and the results, including Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (EcoRA), are summarized below. The PEA is equivalent to the predictive Environmental Risk Assessment (ERA) defined in Canadian Standards Association (CSA) N288.6-12 *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*, as an ERA that attempts to estimate the effects of a contaminant or stressor on an existing environment, resulting from a new facility or process, prior to its release into the environment.

<u>Human Health Risk Assessment</u>

The HHRA evaluated the impact on human health of radiological and non-radiological contaminants in different media, as well as physical stressors, resulting from the WWMF expansion project.

For radiological emissions, it was estimated that the highest potential dose to a member of the public from the Project is 0.25 µSv/y. Taking into account the operation of the existing nuclear facilities at the Bruce nuclear site, the dose to a member of the public remains less than 5 µSv/y. This is less than 0.5% of the regulatory limit for a member of the public of 1 mSv/y, or 1000 µSv/y. Therefore, it was concluded that there are no adverse radiological effects to the public.

For non-radiological emissions, of all the environmental media considered (including the atmospheric environment [air quality and noise], surface water, sediment, soil, and groundwater), the only non-radiological contaminant which was estimated to exceed the assessment criteria was airborne particulates at the Bruce nuclear site boundary, during the construction period only. However, the concentrations were estimated based on conservative assumptions and the adverse effect was immediately reversible with cessation of emission-generating activities. In addition, the frequency of occurrence was low. For example, the exceedances of Ambient Air Quality Criteria (AAQC) at the Bruce nuclear site boundary occurred less than 1% of the time while construction activities are taking place. Furthermore, the concentrations of these indicators at all specific human receptor locations, which are further afield than the Bruce nuclear site boundary, were below the AAQC values. Therefore, it was concluded that there are likely no adverse effects to human health due to the elevated airborne particulate concentrations.

Noise was the only physical stressor considered for the purposes of the HHRA, consistent with CSA N288.6-12. The noise levels were modelled for the nearest human noise receptors during the site preparation and construction phases, and during the operation and maintenance phase of the Project. During the site preparation and construction phases, the increased noise levels were not considered to have an adverse effect on human health as the increase from each Project phase was less than the 5 dB above baseline noise level criterion. During the operation and maintenance phase, the modelled noise levels were well below the NPC-300 criteria. Therefore, it was concluded that there are likely no adverse effects to human health due to increased noise.

Ecological Risk Assessment

The EcoRA evaluated radiological and non-radiological contaminants in different media, as well as physical stressors resulting from the Project.

The effects from radiological emissions from the WWMF were determined for indicator species across all trophic levels. The total radiological doses received by the indicator species, taking into account the existing conditions and the emissions from the Project, were estimated to be in the range of 0.53 µGy/h to 3.57 µGy/h, which are well below the benchmark values given in CSA N288.6-12. Therefore, it was concluded that there are likely no adverse radiological effects to the ecological receptors.

Through the ecological risk characterization, it was determined there are no adverse effects to air quality, soil and groundwater. It was anticipated that there would be likely no adverse effects from predicted air emissions since the levels are below screening levels and/or are short in duration. No adverse effects are expected from exposure to soil contaminants as the Project is not expected to release contaminants to soil. For groundwater there was no direct pathway to receptors and therefore there were no adverse effects due to the Project; there is potentially a reduction in recharge to the aquifers but this effect is negligible on a regional scale.

The largest changes to surface water quantity were expected in the South Railway Ditch in the event that drainage from all expansion areas was directed to the South Railway Ditch. However, no adverse effect to the biological integrity of the aquatic systems within the South Railway Ditch was expected. Changes in surface water quality as a result of increased total suspended solid (TSS) loading during the site preparation and construction phases were expected to have no likely adverse effect to aquatic receptors. There were likely no adverse effects to aquatic receptors from any other surface water contaminants. Under the case where all surface run-off is directed to the South Railway Ditch through a stormwater management facility, a small increase in water temperature in the South Railway Ditch water was predicted. However, this is based on a conservative estimate prior to in-design mitigation and is not expected to constitute an adverse effect to the aquatic environment, Valued Ecosystem Components (VECs) or indicators. Overall, no adverse effect to the biological integrity of the aquatic systems within the South Railway Ditch was expected.

Quantitative analysis shows that the Project is unlikely to represent a noise disturbance beyond tolerance on species currently occurring within the vicinity of the WWMF. It was concluded that there are likely no adverse effects on ecological receptors from changes in noise levels that may arise from the Project.

A qualitative assessment was performed to determine the adverse effects associated with lighting, road kill, and bird strikes resulting from the Project. No likely adverse effects were identified for these physical stressors.

The ecological risk characterization on VECs and associated receptors concluded that there was no adverse effect on aquatic receptors from loss of habitat, and the potential adverse effects due to the loss of habitat on Eastern White Cedar, the Wetland Complex, Eastern Wood-Pewee, and Little Brown Myotis were acceptable. The adverse effects identified for Butternut trees were acceptable if the identified mitigation measures are implemented.

Mitigation measures and environmental monitoring program

Mitigation measures to minimize the potential environmental impacts of the Project on human and ecological receptors were identified for the following disciplines:

- Air Quality: Implementation of dust management plan;
- Noise: Implementation of Good Industry Management Practices;
- Surface Water: Application of a standard Stormwater Management Facility design and application of appropriate erosion and sediment control measures during construction activities;
- Soil: Implementation of a soil management plan and the utilization of silt fences;
- Groundwater: Various measures in relation to minimizing risk to groundwater across the expansion areas, including appropriate location and design of buildings, maintaining the present hydraulic function of the silt till aquitard, limiting the stormwater infiltration in areas with recharge windows or thin silt till above the bedrock, and installation of low permeability barriers; and,
- Terrestrial environment: Various measures to minimize the impacts on terrestrial species and habitat, such as development of a compact WWMF expansion site, erection of exclusionary fencing, revegetation, avoiding vegetation clearing during the breeding bird season, and compensation offsets as per *O.Reg. 242/08* for removal of category 2 Butternuts.

The following environmental monitoring program requirements have been identified:

- Air quality: Monitoring of PM_{10} during construction;
- Soil: Soil monitoring as set out in the Soil Management Plan;

- Surface water and sediment: monitoring of TSS during Site Preparation and Construction as per Ministry of Environment and Climate Change (MOECC) requirements for the Stormwater Environmental Compliance Approval. Stormwater monitoring during Operations and Maintenance; and,
- Radiation and radioactivity: Monitoring of ambient dose rate along the expanded fence line during the operation and maintenance.

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1.0 INTRODUCTION

Ontario Power Generation (OPG) is proposing to expand the Western Waste Management Facility (WWMF) for the storage of used fuel, low and intermediate waste (L&ILW), and for waste processing. The WWMF expansion project, also called the "Project", will consist of site preparation, construction, operation and maintenance of the following facilities:

- Four Used Fuel Dry Storage Buildings (UFDSBs) 5 to 8[1];
- Four L&ILW storage buildings (any combination of Low Level Storage Building (LLSB), Retube Component Storage Building (RCSB) and Steam Generator Storage Building (SGSB));
- One Waste Sorting Building (WSB);
- One Large Object Processing Building (LOPB); and,
- Repurposing an existing LLSB or using one of the new LLSBs for staging and overpacking of L&ILW.

The licensing process for the WWMF expansion project requires that OPG makes adequate provision for the protection of the environment and human health and safety. This includes identification, quantification, characterization, and prevention or mitigation of effects resulting from the proposed WWMF expansion project. To support these requirements, a Predictive Effects Assessment (PEA) was conducted for the WWMF expansion project.

This document presents the results of the PEA for the proposed WWMF expansion project. In this report, the PEA is equivalent to a predictive Environmental Risk Assessment (ERA) which is defined in the Canadian Standards Association (CSA) N288.6-12 [1] as an ERA that attempts to estimate the effects of a contaminant or stressor on an existing environment, resulting from a new facility or process, prior to its release into the environment.

The PEA described herein has been developed with the current knowledge and information available at this time. The assumptions, results, mitigations and environmental monitoring included, in some cases, are based on existing legislation (e.g., Migratory Birds Convention Act), Good Industry Management Practices and professional judgement. It should be noted that in addition to meeting all regulatory requirements, applicable municipal, provincial and federal permits and approvals (e.g., Ministry of Environment and Climate Change (MOECC) Environmental Compliance Approvals (ECA)) will be obtained through the detailed design and approvals process that will further guide Project completion.

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[1] These are four new UFDSBs proposed to be built, in addition to four existing UFDSBs 1 to 4.

2.0 OBJECTIVES AND SCOPE

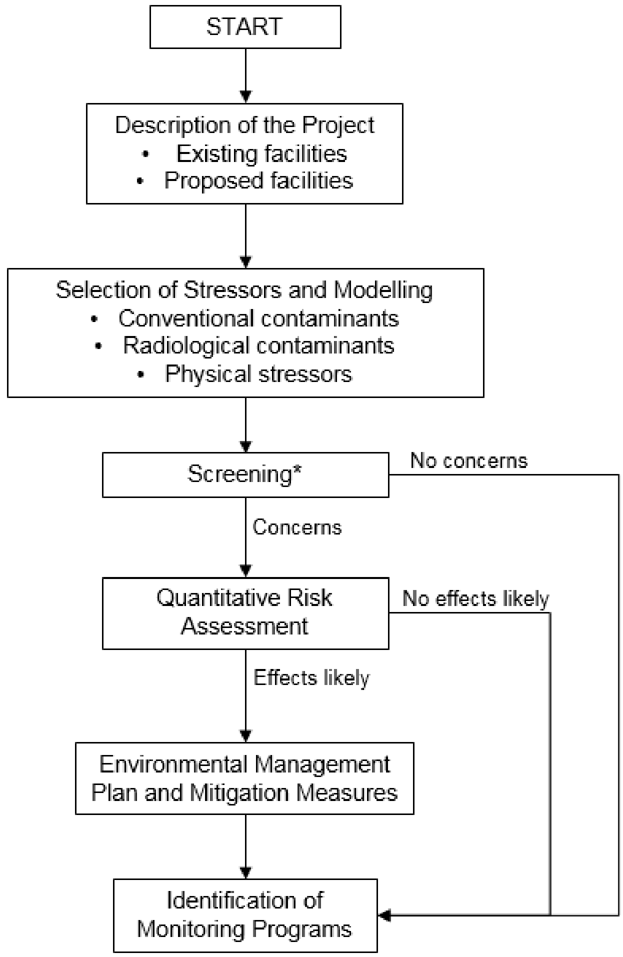
The objective of this assessment is to predict the potential adverse environmental effects (alternatively referred to as "effects") associated with the site preparation, construction, operation and maintenance of the WWMF expansion project. The potential effects during the following phases of the Project were assessed:

- Site preparation;
- Construction of UFDSBs 5 to 8;
- Construction of four L&ILW storage buildings which will be a combination of LLSBs, RCSBs, and SGSBs;
- Construction of one WSB;
- Construction of one LOPB;
- Repurposing an existing LLSB or using one of the new LLSBs for staging and overpacking of L&ILW; and,
- Operation and maintenance of these facilities.

Mitigation measures, if required based on the PEA, are identified. Any potential Environmental Monitoring Programs (EMPs) required are recommended.

3.0 STRUCTURE OF THE PREDICTIVE EFFECTS ASSESSMENT

The PEA is carried out in accordance with CSA N288.6-12 [1]. The progression through the assessment is illustrated at a high level for both the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (EcoRA) in Figure 3-1.



* The potential radiological effects on human and non-human biota were not screened; i.e., all potential radiological effects were assessed quantitatively.

Figure 3-1: PEA Progression through Tiers of Assessment

This report is structured as follows:

1. Description of the Project;
2. Determination of potential contamination and physical stressors resulting from the Project;
3. HHRA;
4. EcoRA;
5. Environmental management plan and mitigation measures;
6. Identification of EMPs; and,
7. Conclusions.

4.0 DESCRIPTION OF THE WWMF EXPANSION PROJECT

4.1 Overview

4.1.1 WWMF

The WWMF is within the Bruce nuclear site, which is located on the east shore of Lake Huron, approximately 18 km north of Kincardine and 17 km southwest of Port Elgin, Ontario, Canada (Figure 4-1).

The WWMF covers an area of 19 hectares within the OPG-retained lands and is a Class 1B nuclear facility for the management of L&ILW and used fuel. The WWMF facilities currently consist of the L&ILW management area and the used fuel management area. The WWMF is classified as a 1B facility as it is for the processing and interim storage of nuclear substances generated at OPG owned or operated nuclear facilities [2]. Used fuel refers to the uranium dioxide fuel bundles which have been removed from a reactor, have been stored in an irradiated fuel bay for at least 10 years, and have been loaded into a Dry Storage Container (DSC) and transferred to the designated facility for interim dry storage. DSCs are vacuum dried and contain no liquid. L&ILW consists of Low Level Waste (LLW) and Intermediate Level Waste (ILW). LLW is waste having a dose rate less than 10 mSv/h at 30 cm. ILW is waste having a dose rate greater than or equal to 10 mSv/h at 30 cm; all alpha emitting waste that is not used fuel waste, LLW or high thermal spent cobalt waste; or all filters and ion exchange columns with long half-life radionuclides, and reactor core components and bulk ion exchange resins.

The L&ILW management area is enclosed by a fence. The area consists of various structures primarily used for storage and processing of L&ILW from Pickering Nuclear Generating Station (NGS), Darlington NGS and Bruce Power's NGSs. The facilities that currently exist at the L&ILW management area are as follows:

- LLSBs #1 to #14: The LLSBs are warehouse-like buildings. The LLSB structural design utilizes prefabricated, pre-stressed concrete. Shielding is provided as required to limit radiation fields. LLSBs provide storage for Type 1 and Type 2 LLW[2], which consist of items such as lightly contaminated small metal objects and parts, incinerator ash, insulation, solidified liquids, and desiccant. The LLW is placed in varying types of containers that are stacked in the LLSBs.
- SGSB #1: The SGSB structural design utilizes prefabricated, pre-stressed concrete. Shielding is provided as required to limit radiation fields. The SGSB provides storage space for up to 24 steam generators.
- RCSB #1: The RCSB structural design utilizes prefabricated, pre-stressed concrete. It provides storage capacity for retube component waste containers

[2] Type 1 solid wastes are those with a contact dose rate less than or equal to 2 mSv/h. Type 2 solid wastes are those with a contact dose rate less than or equal to 0.15 Sv/h but greater than 2 mSv/h. Type 3 solid wastes are those with a contact dose rate greater than 0.15 Sv/h. Note that the dose rates refer to the state before any volume reduction is performed.

from the refurbishment of reactor units. Additional suitably packaged L&ILW from reactor refurbishment or operation may also be stored in the building.

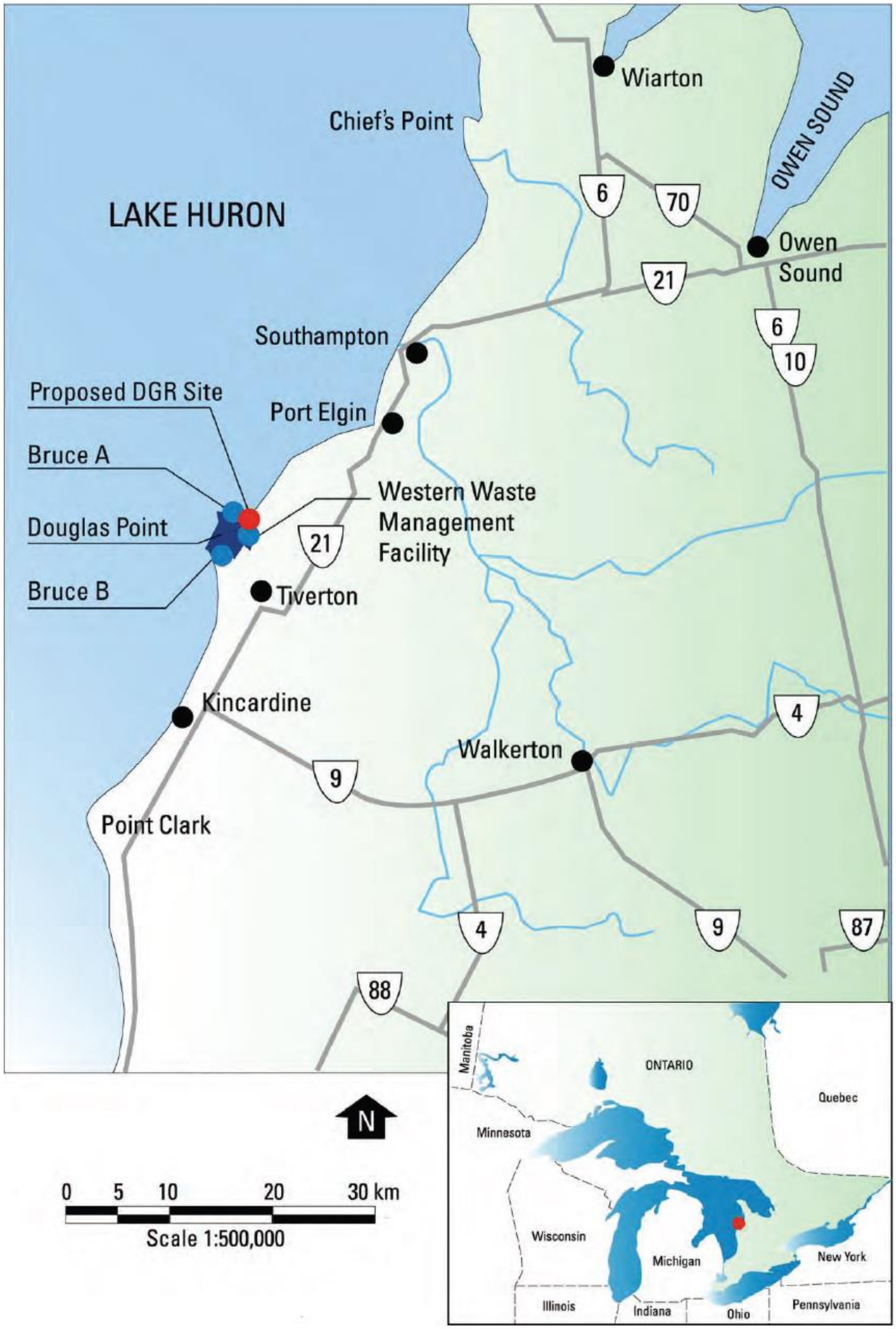


Figure 4-1: Bruce Nuclear Site [3]

- Waste Volume Reduction Building (WVRB): The WVRB provides for the management of LLW, such as waste receiving and handling, compaction, and incineration prior to storage. The WVRB houses an incinerator unit and a compactor unit designed for processing LLW. The WVRB also incorporates a truck unloading area, electrical and control rooms, and other service areas that support the waste processing function of the facility.
- Transportation Package Maintenance Building (TPMB): The TPMB houses a main shop area for the maintenance and decontamination of transportation packaging used for the transfer of radioactive materials between generating stations and waste management sites. The building also houses an active ventilation room, a smaller machine shop to service equipment for other portions of the WWMF, a control maintenance workshop with workstation areas for performing ongoing maintenance work, as well as a mechanical/electrical room, test room, vestibule, and washroom.
- Quadricells, In-ground Containers (ICs), trenches, and tile holes: These structures were built to store a variety of solid radioactive wastes. Quadricells are above-ground facilities with reinforced concrete modules consisting of two independent envelopes with a monitored interspace, designed to hold Type 3 wastes, such as spent ILW resin. In-ground trenches provide storage capacity for Type 1 and 2 radioactive wastes. Tile holes, which are vertical and cylindrical below-ground storage structures, are an early design for the storage of Type 3 wastes. They can be used for any wastes with dimensions compatible with the tile holes. The ICs provide storage capacity for Type 2 and Type 3 radioactive wastes, including waste heat exchangers (IC-HXs).
- Amenities Building: This building provides entry space, office space, locker and shower facilities, and lunchroom facilities for the WWMF staff.

The used fuel management area has additional security protection and is located northeast of the L&ILW storage area. It currently consists of the DSC processing building and four UFDSBs where used fuel is stored. The DSC processing building provides a facility for the receipt, inspection, and preparation for use of empty DSCs, seal welding of loaded DSCs, and office space for personnel. Each DSC storage building is designed to house a maximum of 500 DSCs.

The layout of the existing waste storage facilities at the WWMF is shown in Figure 4-2.

1. LLSBs
2. In-ground Storage Structure (trenches, tile holes, ICs, IC-HXs)
3. SGSB (3-1) and RCSB (3-2)
4. Used Fuel Processing Building (4-1) and UFDSBs 1 to 4 (4-2)
5. WVRB and Amenities Buildings
6. TPMB
7. Quadricells

Figure 4-2: Layout of the Existing Waste Management Facilities at WWMF

It should be noted that OPG has previously obtained Environmental Assessment (EA) approval [4] to build and operate facilities within the existing WWMF fence line for the storage and management of refurbishment waste. Some of these facilities, such as the SGSB and RCSB as shown in Figure 4-2, have been constructed and commissioned. The following facilities will be built in future as needed:

- Seven Storage Buildings for L&ILW;
- Additional (30) IC-HXs; and,
- Additional (270) IC-18s (18 m^3 in-ground containers).

4.1.2 Other Facilities within Bruce Nuclear Site

There are other facilities within the Bruce nuclear site, as shown in Figure 4-3. A brief description of these facilities is provided below.

4.1.2.1 Bruce Nuclear Generating Stations

Bruce Power operates Bruce NGS A (Bruce A) and Bruce NGS B (Bruce B), each housing four CANDU® reactors. All of these units are currently operational and produce a total of ~6,200 megawatts of electricity for the Ontario grid.

Bruce A is located on the north-west corner of the Bruce nuclear site, about 2.5 km to the north-east of Douglas Point, while Bruce B is located at the south-west corner, about 0.8 km to the south of Douglas Point.

The Bruce A section includes part of a 914 m exclusion zone surrounding the Bruce A powerhouse structure and the associated Lake Huron water lots. These portions are controlled by Bruce Power. Similarly, the Bruce B section includes part of a 914 m exclusion zone extending from the Bruce B powerhouse structure to the northern part of Inverhuron Park. The park is owned by OPG and leased to the Ministry of Natural Resources and Forestry. The four units of Bruce A were originally put into service in 1977 and the four Bruce B units were put into service in 1987 [5][3].

There are several support facilities located on the site, including the Bruce Steam Plant, the Central Maintenance and Laundry Facility, the Bruce Learning Centre (including the fire training facility), garages, warehouses, workshops, a sewage processing plant and various administrative buildings.

4.1.2.2 Douglas Point Waste Management Facility

The Douglas Point Waste Management Facility is owned by Canadian Nuclear Laboratories. The facility consists of a permanently shut down, partially decommissioned prototype 200-megawatt CANDU® reactor and associated structures and ancillaries. This facility is presently in the long term "Storage with Surveillance" phase of a decommissioning program.

4.1.2.3 Hydro One Facilities

Hydro One owns and operates a number of assets within the Bruce nuclear site. These include, but are not limited to, office and workshops for maintenance, switchyards at Bruce A / Bruce B, switching stations, transformer stations, and the transmission corridors.

4.1.2.4 Radioactive Waste Operation Site 1

The Radioactive Waste Operation Site 1 (listed as RWOS1 in Figure 4-3) was established to manage the L&ILW from the Douglas Point and Pickering A Nuclear Generating Stations. The site is comprised of a number of in-ground waste storage structures containing solid L&ILW. In the 1990s and early 2000s a portion of the waste was removed from some in-ground structures (trenches) and some in-ground structures (tile holes) were removed in their entirety; the associated waste was relocated to the WWMF. The site has not received waste since 1976 and the remaining storage structures remain in a caretaking mode.

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[3] This reference was an enclosure to the DGR EA submission document [6].

Figure 4-3: Facilities at the Bruce Nuclear Site[4,5]

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[4] Note: AECL is now Canadian Nuclear Laboratories.
[5] The boundaries of the OPG-retained land have changed. The land surrounding the Bruce Heavy Water Plant (shown in green, to the northwest of Interconnecting Road) is no longer included in the OPG-retained land.

4.1.2.5 Spent Solvent Treatment Facility (SSTF)

The SSTF was established in the 1990s to store and process boiler cleaning waste (spent solvent) consisting of EDTA and metals such as copper, iron, zinc and nickel. The SSTF has not accepted spent solvent since 2003 and remains in a caretaking mode. The majority of the spent solvent stored at the SSTF, with the exception of a limited volume in the heels of the storage tanks, has been disposed of offsite at an approved disposal facility.

4.1.2.6 Deep Geologic Repository

A Deep Geologic Repository (DGR) has been proposed to be built within the OPG-retained land. The DGR will be comprised of two shafts, a number of underground emplacement rooms, and support facilities. The DGR will be used for the long-term management of L&ILW currently managed in the WWMF, and other L&ILW to be generated from OPG-owned NGSs.

4.2 Need for the Project

Currently, used fuel from Bruce A and Bruce B, along with the operational L&ILW from Bruce Power and OPG, are stored at the WWMF. Consistent with the past development of the WWMF, the construction of specific buildings/structures will occur on an "as needed" basis, with new facilities being built as required to meet storage and processing needs.

For business planning purposes, OPG has forecasted the expansion requirements based on continued operation, refurbishment and end of life assumptions for the NGSs. Furthermore, it is assumed that the DGR for the disposal of L&ILW will be in service in 2026 and the UFDSBs at the WWMF are intended to provide interim storage until a DGR for the long term management of used fuel is operational.

Based on the expansion forecast to meet the storage and processing needs of the nuclear facilities, additional buildings are required to manage the used fuel and the radioactive waste to be generated in the future. However, there is insufficient land space in the current licensed area to accommodate all of the additional buildings. Accordingly, OPG is proposing to expand the WWMF to accommodate some or all of the additional buildings for the storage of used fuel, L&ILW, and for waste processing. For planning purposes, the proposed in-service dates for the buildings to be constructed under the Project are shown in Table 4-1. The potential WWMF expansion areas are illustrated in Figure 4-4, bounded by the dark blue lines.

Table 4-1: Approximate In-service Plan for the Project

Facilities	In-service dates
UFDSB #5	2019
UFDSB #6	2019
WSB	2020
LOPB	2024
L&ILW storage building #1 (RWSB #3)*	2025
L&ILW storage building #2 (LLSB #20)*	2027

Facilities	In-service dates
L&ILW storage building #3 (RWSB #4)*	2028
L&ILW storage building #4 (SGSB #3)*	2028
UFDSB #7	2028
UFDSB #8	2033

* For the purpose of the PEA, L&ILW storage building could be a LLSB, SGSB or RCSB.

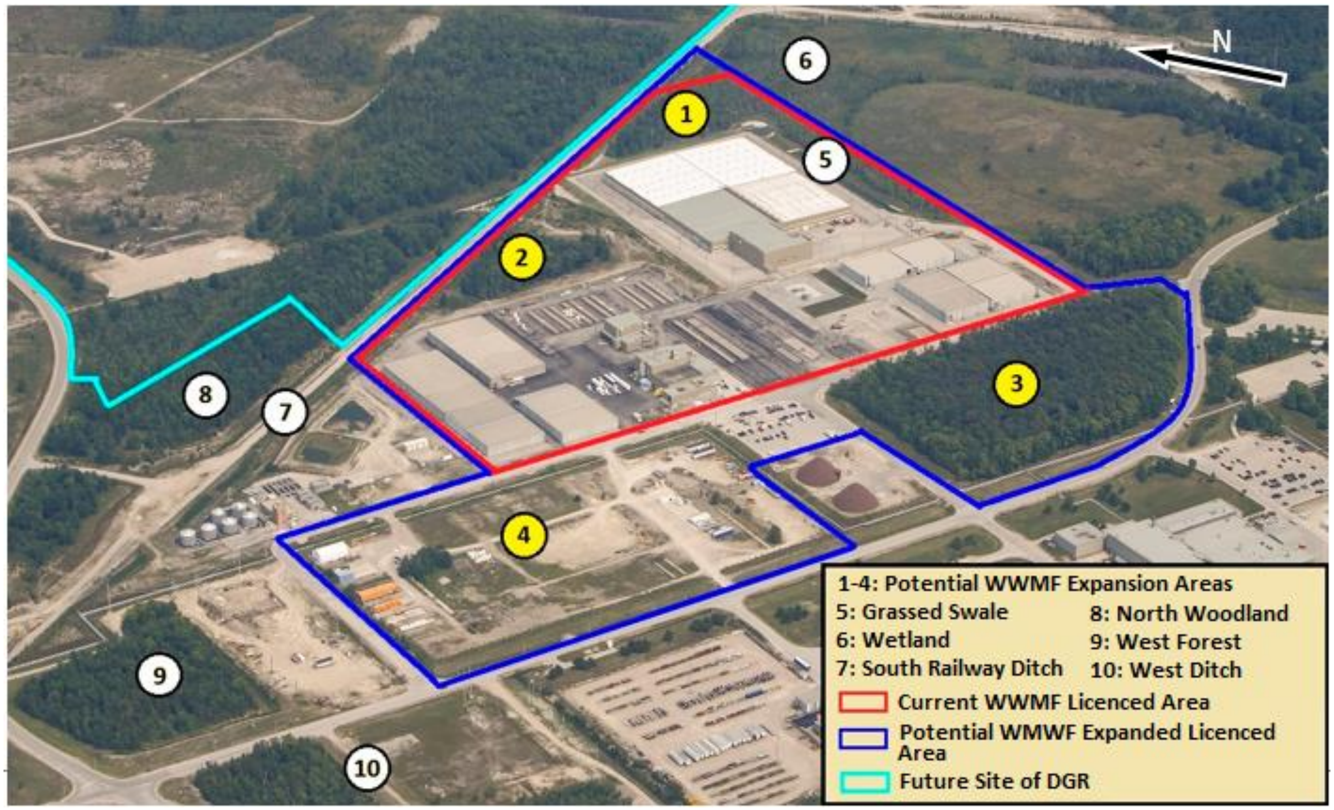

Figure 4-4: Location of the WWMF Expansion

4.3 Description of the Project

As discussed in Section 1, the Project will involve the site preparation, construction, and operation and maintenance of four UFDSBs, four L&ILW Storage Buildings, one LOPB, and one WSB. A brief description of the major Project activities and these buildings is provided below.

4.3.1 Major Project Activities

The major activities associated with the Project are:

- Site preparation phase: this phase includes all activities associated with developing the "WWMF Expansion areas", also referred to as "area" or "areas" within this report, prior to construction of new facilities.

- Construction phase: this phase includes construction of all structures and facilities for the WWMF Expansion Project up until operations commence with the processing and placement of waste in the new facilities. It is likely that two buildings such as the UFDSBs will be constructed at the same time and in close proximity to each other. The WSB may also be constructed at the same time as the UFDSBs. However, it is possible that in a different area within the existing WWMF property or in a different expansion area, construction of two other buildings such as L&ILW storage buildings or the LOPB, will occur at the same time as the construction of the UFDSBs.
- Operation and maintenance phase: this phase includes the period during which waste is processed or stored in the new facilities.

The following sections describe the major works and activities that are expected to occur during the various Project phases. It should be noted that the exact design of the expansion buildings is not currently available. However, it is anticipated that the design of the facilities will be the same or similar to the design of the applicable existing facilities. The specific project designs will be refined to incorporate new codes and standards, lesson learned, operational improvements, and any site-specific constraints. The details of the buildings will evolve through detailed Project planning and design.

4.3.1.1 Site Preparation Phase Works and Activities

Site preparation involves the preparation of the site infrastructure for construction activities. All site preparation activities are assumed to occur at once in order for this assessment to be considered bounding. However, development of the site will likely be staggered over time, i.e., in stages. For the purpose of this PEA the following assumptions have been made for site preparation works and activities:

<u>Site Clearing and Maintenance of the Cleared Area</u>

As indicated in Figure 4-4, potential expansion areas 1, 2, and 3 are vegetated. In total, up to five hectares of vegetation could be cleared. In addition, some minor clearing activities may occur in area 4. Trees and stumps within the cleared areas will be removed from the site using conventional equipment such as chain saws and heavy machinery (e.g., bulldozers and excavators). Vegetation cleared from the WWMF expansion area could be transported off-site for disposal in accordance with regulatory requirements but will likely remain on the Bruce nuclear site. Some of the vegetation may be chipped and used as mulch on the Bruce nuclear site; the remainder will be disposed of in accordance with regulatory requirements.

Areas that have been cleared will be maintained by ensuring new vegetation does not grow in the area and that the area remains clear of debris. This will be performed with conventional equipment (e.g., chainsaws, bulldozers, shovels) as required by the activity.

<u>Excavation</u>

During site preparation, all undeveloped areas used by the Project will be excavated and levelled as needed to establish appropriate grading for future development. Excavation will be performed with conventional heavy machinery such as bulldozers and excavators. The excavation required for each building will be performed immediately prior to construction of the building. Techniques required will depend on the specific requirements of each building. Where possible, uncontaminated materials excavated during site preparation will be used as fill at other locations within the Bruce nuclear site or sent to an appropriate off-site facility for disposal. Boulders and soil may be stockpiled on the Bruce nuclear site for future use.

Grading and Compaction

Grading and compaction will be required on the overall site and in areas where backfilling of building/structure foundations has occurred. Conventional construction equipment such as graders and vibratory rollers will be used.

Expansion of Stormwater Management System, Including Drainage System

The WWMF stormwater management system collects, transports, samples, and discharges precipitation that falls onto the WWMF site. The expansion of the site and associated construction of new structures, removal of vegetation and overall reduction in infiltration capacity of the site will necessitate expansions and possibly modifications to the existing stormwater system. The expansions will require excavations and installation of infrastructure for sub-surface collection, conveyance, and storage (e.g., catch basins, storm sewer lines and stormceptors).

The primary activity related to the expansion of the stormwater management network is excavation. The perimeter of any new structures will be graded and paved to direct water to specific catch basins for collection, sampling, and free release via drainage ditches flowing to the South Railway Ditch or to the West Ditch and off site (see Figure 5-8).

During construction of the drainage system, measures consistent with similar construction projects will be put in place to minimize the impact of site runoff. These temporary measures may include: ditching, sediment basins, berms and hay bales to reduce sediment loadings in run off.

Expansion of Fenced Property

Development of the WWMF expansion areas will require extending or installing of perimeter fencing. Modifications to the fence will involve minor excavations and use of small-scale construction equipment.

The Used Fuel Dry Storage area will be a "protected area" as required by the Canadian Nuclear Safety Commission and must comply with the Nuclear Safety Regulations. Security provisions will be in accordance with the regulations.

Installation of Services

The services that may be connected to the new structures include electricity, communication services, domestic and fire water supply, sewage, and inactive drainage.

Internal Road Construction and Upgrading

Procedures for road construction and upgrading at the WWMF will be consistent with conventional practices and will include excavation and compaction activities previously described. Road surfaces will be constructed using bituminous asphalt and/or concrete.

Transportation of Materials, Equipment and Personnel

During the site preparation phase, materials, equipment and personnel will be transferred to and from the WWMF. This will result in an increase in the number of passenger vehicles and heavy construction vehicles which will require access to the WWMF on a daily basis.

Vehicle and Equipment Refuelling and Maintenance

Refuelling and maintenance of construction equipment and vehicles will occur on an as-needed basis within the WWMF in areas designated for such activities.

Stormwater Management

Stormwater Management will be performed for the WWMF as per the Stormwater Management Plan (to be developed as part of the Project).

4.3.1.2 Construction Phase Works and Activities

The construction phase involves the construction of the new buildings at the WWMF. Multiple buildings may be constructed in parallel. However, development of the entire site will likely be staggered over time, i.e., in stages. For the purpose of this PEA the following assumptions have been made for construction works and activities:

Transportation of Materials, Equipment and Personnel

During the site preparation phase and the construction phase, materials, equipment and personnel will be transferred to and from the WWMF. This will result in an increase in the number of passenger vehicles and heavy construction vehicles which will require access to the WWMF on a daily basis.

Vehicle and Equipment Refuelling and Maintenance

Refuelling and maintenance of site preparation equipment and vehicles will occur on an as-needed basis within the WWMF in areas designated for such activities.

Building Construction

Construction activities and materials will be similar to those used for conventional industrial buildings. On-site construction activities will be limited through the use of pre-fabricated wall and roof panels. Following placement of the pre-fabricated roof panels, a bituminous surface will be applied to the roof.

Once each building is constructed, the area(s) surrounding the building that do not require further excavation (such as for the construction of another building) will be paved over. At the end of the construction period, it is assumed that the entirety of expansion areas 1 through 4 will have been cleared and paved.

Construction Waste Management

Construction activities are expected to generate negligible quantities of conventional construction waste, none of which is likely to be radioactive. Potential waste streams include wood (from foundation form work), domestic refuse as well as small quantities of metal and concrete. On-site waste management and off-site disposal will be the responsibility of the construction contractor selected by OPG. Construction waste will be monitored for radioactivity and will not leave the site until it is below clearance levels.

Stormwater Management

Stormwater Management will be performed for the WWMF as per the Stormwater Management Plan (to be developed as part of the Project).

4.3.1.3 Operation and Maintenance Phase Works and Activities

The operation and maintenance phase is assumed to commence for each facility when construction is complete. The operation of the WWMF is governed by the Waste Facility Operating Licence and OPG policies and procedures covering all aspects of the used fuel and L&ILW management systems and structures. The new structures to be built and associated activities will be incorporated into the WWMF operating policies and procedures.

The waste generator will be responsible for filling, sealing and preparing the waste packages for transfer, as per the appropriate waste acceptance criteria. Similarly, the transfer of steam generators and new waste packages for retube components to the WWMF will be the responsibility of the waste generator. OPG will take responsibility for the waste and waste packages once they are received at the WWMF.

On-Site Transfer of Waste within the WWMF

Waste transportation procedures for the new buildings will be the same as the applicable waste transfer procedures for the existing buildings. Transportation vehicles for large items such as steam generators will deliver their wastes directly to applicable storage buildings. Vehicles transporting smaller waste packages such as retube waste containers will enter through a WWMF perimeter gate and be unloaded in front of the storage structure loading door.

Loaded DSCs will continue to be processed at the existing DSC processing building prior to storage in one of the new UFDSBs. The DSC is transferred from the processing building to storage using a DSC Transporter.

Unloading and placement of waste in storage buildings will be done in accordance with approved practices.

Storage of Waste in Buildings

Storage of waste will be performed in accordance with approved practices.

Steam generators will be sited on floor-mounted saddles. Aisles will be provided between the rows of SGs to allow for visual inspection on an as-required basis during storage.

The storage of retube waste containers is anticipated to be arranged in rows within the structures. The containers will be stacked, with aisles provided between the container rows for inspection on an as-required basis. Spacing will be provided between individual stacks to facilitate handling tolerances.

All wastes in an LLSB are packaged to minimize the spread of contamination and are stored in containers that are generally stackable. All units are placed to maximize storage space utilization.

DSCs will be stored in the new UFDSBs in accordance with approved DSC storage practices. Waste will not be stored long-term in the WSB or LOPB.

Waste Sorting at the WSB

The existing WWMF licence allows for the retrieval and reprocessing of L&ILW, including sorting, processing and/or diversion to conventional disposal or free release, subject to meeting the established clearance level. OPG is planning on constructing and operating a building specifically for this purpose in order to lower the volume of L&ILW stored on site. The low-level radioactive wastes received at the WWMF will be sorted in the WSB based on the characteristics of the waste. They will then be stored in the LLSBs after appropriate processing. More details of the waste sorting at the WSB can be found in Section 4.3.4.

Waste Processing at the LOPB

The large waste objects such as steam generators or heat exchangers will be safely processed in the LOPB into segments that can be placed in the DGR hoist cage and lowered to the DGR for disposal. More details of the waste processing at the LOPB can be found in Section 4.3.5.

Monitoring (Effluent and Environment)

Environmental monitoring will be performed as per the Environmental Management System (EMS).

Effluent monitoring is currently performed at the WWMF, and the program will be expanded to include the new facilities to meet regulatory requirements and CSA N288.5 *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* [7].

Facility Inspection and Maintenance

The new buildings will require regular inspection and maintenance; maintenance is anticipated to consist largely of lamp replacement for overhead lights, roof inspections and routine scheduled maintenance of mechanical components (e.g., fans, service doors) and maintenance of the equipment used for waste sorting and large object processing. Access will be required for periodic inspection of containers.

Operational Waste Management

Radioactive contamination is not expected in the new storage structures outside of waste containers; waste packages must be surveyed and be free of loose external contamination before leaving the Protected Area boundary of the generating station according to the Waste Acceptance Criteria.

Based on historical performance of existing buildings, it is expected that negligible quantities of LLW, such as contaminated wipes, floor sweepings, rags and cleaning materials, will be produced in LLSBs, SGSBs, and RCSBs during the operation and maintenance phase. All LLW will be placed in appropriate containers and will be transferred to the WSB or WVRB for processing prior to storage. The waste generated at the LOPB is further discussed in Section 4.3.5.

Operation and maintenance of the Project structures will require minimal use of hazardous substances. Small quantities of non-radioactive domestic waste typical of a commercial/industrial facility may be produced during operation and maintenance of the facilities.

Stormwater Management

Infiltration capacity of the WWMF expansion area will be decreased by Project activities (due to vegetation clearing, grading and compaction, and paving of surfaces). This may result in an increase in peak flows.

To the extent possible, site grading should direct surface runoff to the existing drainage infrastructure. All site grading and other stormwater management activities will be undertaken during the site preparation phase.

Surface water and subsurface drainage will be expanded as required to permit collection and discharge to the South Railway Ditch or the West Ditch.

Repurposing a LLSB for DGR Use

Although designed for the storage of LLW, either an existing LLSB or one of the new LLSBs will be repurposed for staging and overpacking of waste that is to be transferred to the DGR for disposal.

4.3.2 Used Fuel Dry Storage Buildings

UFDSBs are currently used as interim storage for the used fuel, stored in DSCs, from Bruce A and Bruce B. DSCs are loaded with used fuel, dewatered and vacuum dried at the stations, and transferred on Bruce nuclear site roads to the WWMF's DSC processing building using a DSC Transporter. In the DSC processing building, final processing, sealing, and leak testing of the DSC is performed. Once sealed, the DSCs are transferred to storage in the UFDSBs using the DSC Transporter. The Used Fuel Dry Storage Process is illustrated in Figure 4-5.

The design of UFDSBs 5 to 8 is not currently available. However, it is anticipated that the design will be the same or similar to the design of the existing UFDSBs at the WWMF. The design of the existing UFDSBs is described below for reference.

4.3.2.1 Structural Description

The current UFDSBs have each been designed to have an approximate area of 5,300 m^2 and a nominal storage capacity of approximately 500 DSCs.

Walls in the storage buildings consist of precast concrete panels. Vertical louvres and metal cladding are installed at upper wall elevations. The precast concrete wall system provides radiation shielding additional to the shielding provided by the DSCs.

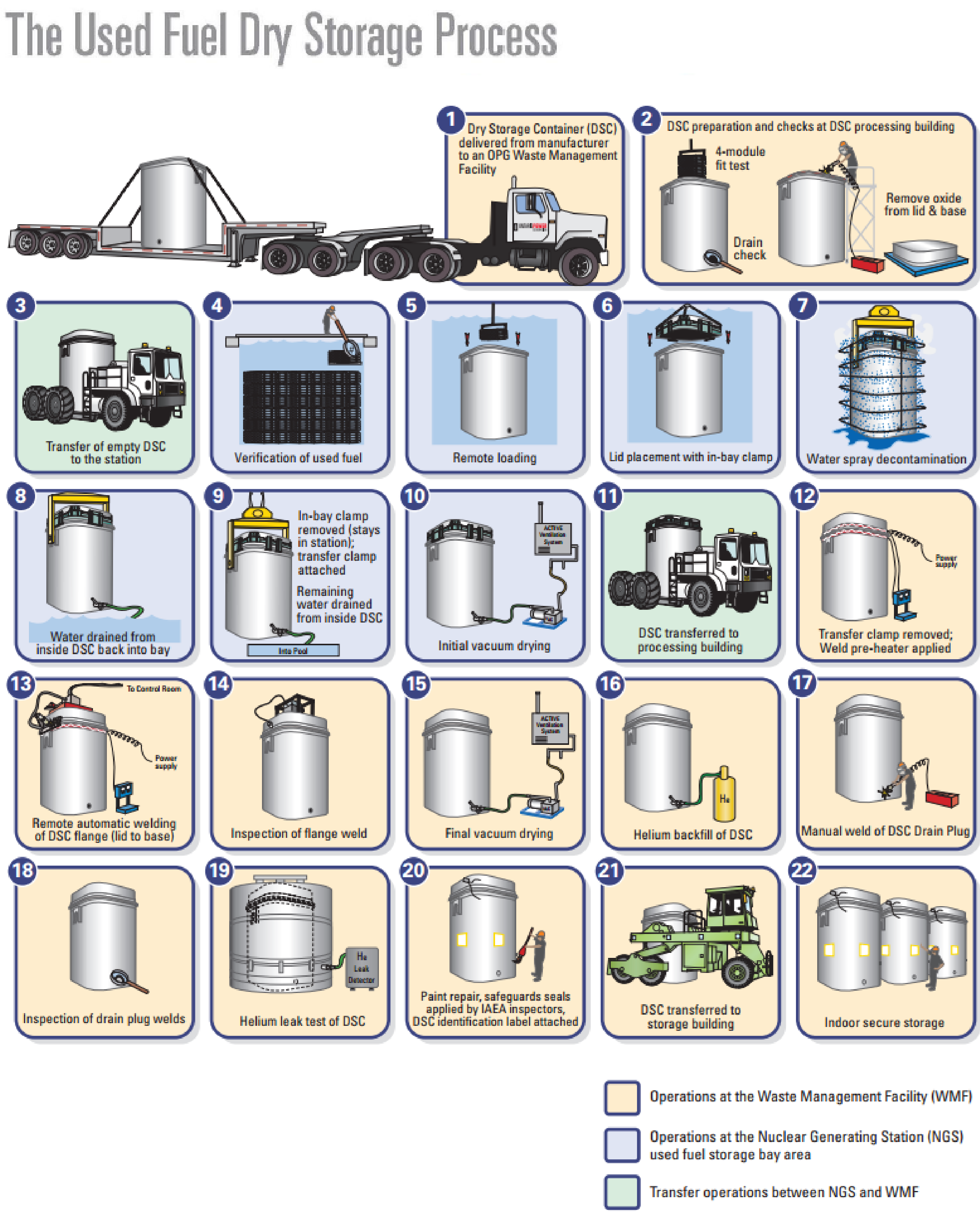

Figure 4-5: Used Fuel Dry Storage Process

Reinforced concrete floor slabs are designed to accommodate heavy wheel load traffic and the weight of the loaded DSCs. The floors are constructed for long service with minimal maintenance, to retain surface alignment and provide a hard, smooth and durable surface. Floors are sloped to provide drainage to floor drains. The building roof has provisions for drainage of rainwater and melted snow. Access to the roof is provided by use of an outside, all-weather, permanent stairway. The building is grounded to protect against lightning.

The DSC storage buildings are designed to facilitate all-weather operation. DSCs are stored in a pattern that allows retrieval, if needed, of any DSC. Layout of the storage areas permits placement of DSCs using the Transporter to achieve the desired storage capacity.

4.3.2.2 Building Services

The reference design of the UFDSBs includes the following services:

- Fire protection and fire detection: The site has hydrants located around the building perimeter. Fire extinguishers are provided inside the storage buildings. Fire detection in the storage buildings is accomplished through the use of non-restorable linear heat detectors. Manually operated hand pull stations are provided at exits from a floor or building. Fire detectors are connected to the main fire alarm panel and that panel feeds into a building management system which annunciates in the WVRB control room at the WWMF. Activation of the heat detectors or hand pull stations initiates an audible alarm to alert personnel.
- Ventilation: The UFDSBs use passive ventilation through wall louvers as well as turbine ventilators on the roof to adequately dissipate decay heat from used fuel in storage to the atmosphere. The louvers prevent the ingress of rain and snow. Screens reduce the likelihood of small animals or birds entering the building through the ventilation system. Note that the existing DSC processing building will be used to process any DSCs prior to being transferred to UFDSBs 5 to 8 for storage.
- Internal drainage: No contaminated liquid effluents are expected to be generated during DSC storage and floor drains in the UFDSBs are connected to the inactive drainage system. Inactive drainage is normally directed to the Bruce nuclear site sewage system. If contamination is suspected to have entered the drainage system, then system sump pumps would be turned off and testing of the effluent would be performed. If contamination is detected, the effluent would be transferred to an appropriate licensed facility such as the Bruce Power active liquid waste management system.
- Electrical services: The electrical distribution system/lighting system for the UFDSB consists of the following classes of power:
    - Class IV power – for general building loads, and electrical equipment within the UFDSB;
    - Class III power – considered stand-by power to selected WWMF equipment and is provided from a stand-by diesel generator within the WWMF. In the event of a loss of Class IV power, the diesel generator

will automatically start and feed power through an automatic transfer switch to the Uninterruptable Power Supply to supply the Class II power system. The diesel generator will also support other emergency loads such as security lighting; and,

- Class II power – for emergency lighting, exit lighting, security system check, International Atomic Energy Agency (IAEA) safeguards cameras and camera lighting, fire protection panel and alarms, radiation monitoring and required instrumentation, and telephone and public address systems.

4.3.3 Low and Intermediate Level Waste Storage Buildings

The four L&ILW storage buildings to be constructed as the part of the Project could be a combination of LLSBs, RCSBs, and SGSBs. The descriptions of these three types of buildings are provided below for reference.

4.3.3.1 Low Level Storage Buildings

The LLSBs provide storage capacity for low level Type 1 and 2 solid waste packages with gamma dose rates up to 10 mSv/h at 30 cm, and liquid wastes awaiting incineration (i.e., contaminated oil). LLW primarily consists of common industrial items that have become contaminated with low levels of radioactivity during routine clean-up and maintenance activities. These can include lightly contaminated small metal objects and parts, incinerator ash, insulation, solidified liquids, and desiccant.

Structural Description

The LLSBs are warehouse-like buildings. The LLSB structural design utilizes prefabricated, pre-stressed concrete (Figure 4-6). The structure consists of concrete roof support columns with thick prefabricated concrete walls and a concrete roof. The LLSB floor is constructed of poured concrete. A geomembrane is provided below the building.

The above-ground nature of the LLSB requires additional concrete, in excess of structural requirements, for radiation shielding. The wall thicknesses are chosen to meet radiation shielding requirements and the concrete wall panels are joined in an overlapping configuration to prevent radiation streaming between the panels.

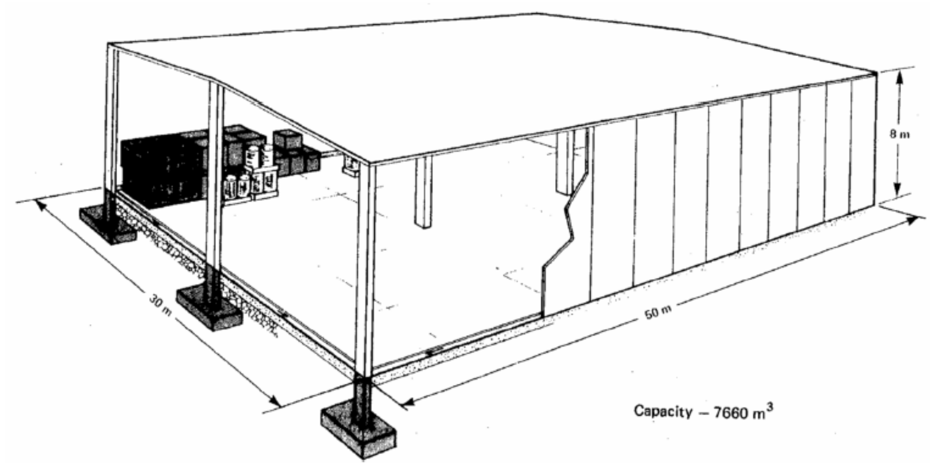

Figure 4-6: Perspective View of a Typical LLSB

<u>Building Services</u>

The reference design of the LLSB includes the following services:

- Fire Protection: The LLSB is provided with heat detection equipment and a CO_2 gas fire extinguishing system. A liquid CO_2 storage tank is located outside the building and is connected to the building through a discharge header. The gaseous CO_2 injection system is designed to be manually actuated on a fire alarm.
- Ventilation: An air ventilation system is provided for the LLSB. The primary function of the ventilation system is to provide general ventilation and cooling during the summer months while the building is in the active loading phase, and to lower any tritium levels before personnel entry to minimize occupational exposure.
- Internal Drainage: Internal drainage in the LLSB consists of a water collection system which collects both floor and sub-floor drainage. These drainage lines are directed to a partitioned sub-surface internally-sealed sump. The sump water is transported by tanker truck to Bruce Power where it is treated in the Active Liquid Waste Treatment Facility.
- Lighting: Internal and external fixed lighting is provided.

4.3.3.2 Design of Retube Component Storage Building

The RCSB provides storage capacity for retube component waste containers from the retubing of reactor units. The retube component waste could include Pressure Tubes, Calandria Tubes, Annulus Spacers, and End Fittings. Additional suitably packaged L&ILW from reactor refurbishment or operation may also be stored in the building.

<u>Structural Description</u>

The RCSB structural design utilizes prefabricated, pre-stressed concrete similar to a LLSB. The walls and roof are designed to provide adequate shielding based on the retube components to be placed within the building. The RCSB floor is constructed of poured concrete. A geomembrane is provided below the building.

The above-ground nature of the RCSB requires additional concrete, in excess of structural requirements, for radiation shielding. The wall thicknesses are chosen to meet radiation shielding requirements. In addition, the concrete wall panels are joined in an overlapping configuration to prevent radiation streaming between the panels.

Building Services

The reference design of the RCSB includes the following services:

- Fire protection: Fire hydrants are provided outside of the building; the RCSB is expected to contain a minimal amount of combustible material.
- Ventilation: An air ventilation system is provided for the RCSB. The primary function of the ventilation system is to provide general ventilation and some heat removal during the summer months while the building is in the active loading phase, and to remove any vehicle/forklift exhausts inside the building.
- Internal drainage: Internal drainage in the RCSB is similar to the LLSB. Water collection systems are provided by floor drains and a sub-floor membrane. These drainage lines are directed to a partitioned sub-surface sump. The sump water is transported by tanker truck to Bruce Power where it is treated in the Active Liquid Waste Treatment Facility.
- Lighting: Internal and external fixed lighting is provided.

4.3.3.3 Design of Steam Generator Storage Building

The SGSB provides a usable storage space for steam generators.

Structural Description

The SGSB structural design utilizes prefabricated, pre-stressed concrete. The walls and roof are designed to provide adequate shielding based on the components to be placed within the building. The SGSB floor is poured concrete. The geomembrane is provided below the building.

The above-ground nature of the SGSB requires additional concrete, in excess of structural requirements, for radiation shielding. The wall thicknesses are determined to meet radiation shielding requirements. In addition, the concrete wall panels are joined in an overlapping configuration to prevent radiation streaming between the panels.

Building Services

The reference design of the SGSB includes the following services:

- Fire Protection: Fire hydrants are provided outside of the building; the SGSB is expected to contain a minimal amount of combustible material.
- Ventilation: An air ventilation system is provided for the SGSB. The primary function of the ventilation system is to provide general ventilation and some heat removal during the summer months while the building is in the active loading phase, and to remove any vehicle/forklift exhausts inside the building.

- Internal Drainage: Internal Drainage in the SGSB is similar to the LLSB. Water collection systems are provided by floor drains and a sub-floor membrane. These drainage lines are directed to a partitioned sub-surface sump. The sump water is transported by tanker truck to Bruce Power where it is treated in the Active Liquid Waste Treatment Facility.
- Lighting: Internal and external fixed lighting is provided.

4.3.4 Design of Waste Sorting Building

The WSB provides for the management of low-level radioactive wastes such as waste receiving, handling, sorting and segregation.

Details of the WSB will evolve through detailed Project planning and design; however, for planning purposes, the WSB is assumed to be designed similar to the sorting facility within the WVRB which is described below for reference.

4.3.4.1 Structural Description

The framework of the structure is fabricated from structural steel beams, columns and a poured concrete floor. The lower portion of the external walls is constructed of pre-cast panels and the upper portion is frame covered by coloured insulated metal sheeting. Main division walls are constructed of hollow concrete block. Secondary division walls are light partitions either of steel or hollow concrete block.

The WSB may consist of the following main areas:

- Truck Bays: The enclosed truck bays provide weather protection of transportation vehicles during material receipt and unloading operations. The bays are sized to accommodate two semi-trailers and road tractors with the entrance doors closed. A loading dock is provided.
- Material Handling, Storage and Sorting Area: This area allows for material movement and sorting, and provides temporary storage of incoming and processed wastes. This area will include several sorting tables, some of which will have local HEPA ventilation units. There will be many hand-held and stationary radiation instruments used in the surveying of materials. Areas will be set aside for staging the outputs of the sorting process such as clean scrap metal, incinerable waste, and compactable waste.
- Electrical Room: A room is provided for electrical equipment.
- Storage Room: Rooms are provided for supplies and non-waste storage; and,
- Ventilation Equipment Areas: These areas contain air intake filters, intake fans, heating coils, air exhaust filters and exhaust fans. Radioactive airborne effluent monitors for building ventilation are also located in this area.

4.3.4.2 Building Services

The design of the WSB may include the following services:

- Water Systems: Water is supplied to the WSB through the Bruce nuclear site domestic water system and the Bruce nuclear site fire protection water system. The domestic water and service water system supplies the janitor's sinks and hose outlets. Domestic water goes to the Bruce Power-operated sewage treatment plant located between the SSTF and WWMF. The fire protection system supplies fire hose cabinets located throughout the WSB, and the sprinkler systems in the WSB.

- Ventilation: The detailed design of the ventilation system is not available as yet. However, the ventilation exhaust system will pass through prefilters and High Efficiency Particulate Air (HEPA) filters before being discharged to the atmosphere through a dispersal stack extending well above the building roof.
- Fire Detection System: A smoke and heat detection system is provided to give early warning of fires in the building; and,
- Electrical System: Power for all auxiliary systems is at nominal voltage levels of 600/347 and 208/120 volts, 60 hertz. Emergency lighting is available to provide adequate illumination for personnel exit during loss of normal power.

4.3.5 Design of the Large Object Processing Building

Following a period of storage, the large metallic components (e.g., steam generators, heat exchangers) will be retrieved from their storage structures and transferred to the LOPB for processing. In the LOPB, large metallic components will be segmented to ensure their mass and geometry is within the design limits of the hoist cage for the DGR. As the disposal ready segments are produced, they would be stored temporarily or transferred to the DGR for long term disposal.

Details of the LOPB will evolve through detailed Project planning and design. A conceptual design of the LOPB is presented here.

4.3.5.1 Structural Description

The LOPB will be a single-story structure consisting of prefabricated pre-stressed concrete for the structure, walls and roof; the concrete roof will be supported by concrete support columns, and the walls will be made of prefabricated concrete. The concrete panels will be joined in an overlapping configuration similar to the existing SGSB design. The floor will be robust and will be capable of supporting a rail-mounted gantry crane loaded with a grouted steam generator.

The LOPB will have sufficient capacity and the necessary design features to safely receive, survey, process, and package large metallic components.

The conceptual floor plan for the LOPB is given in Figure 4-7 for illustrative purposes. For planning purposes, the LOPB is expected to house the following functional spaces and processes.

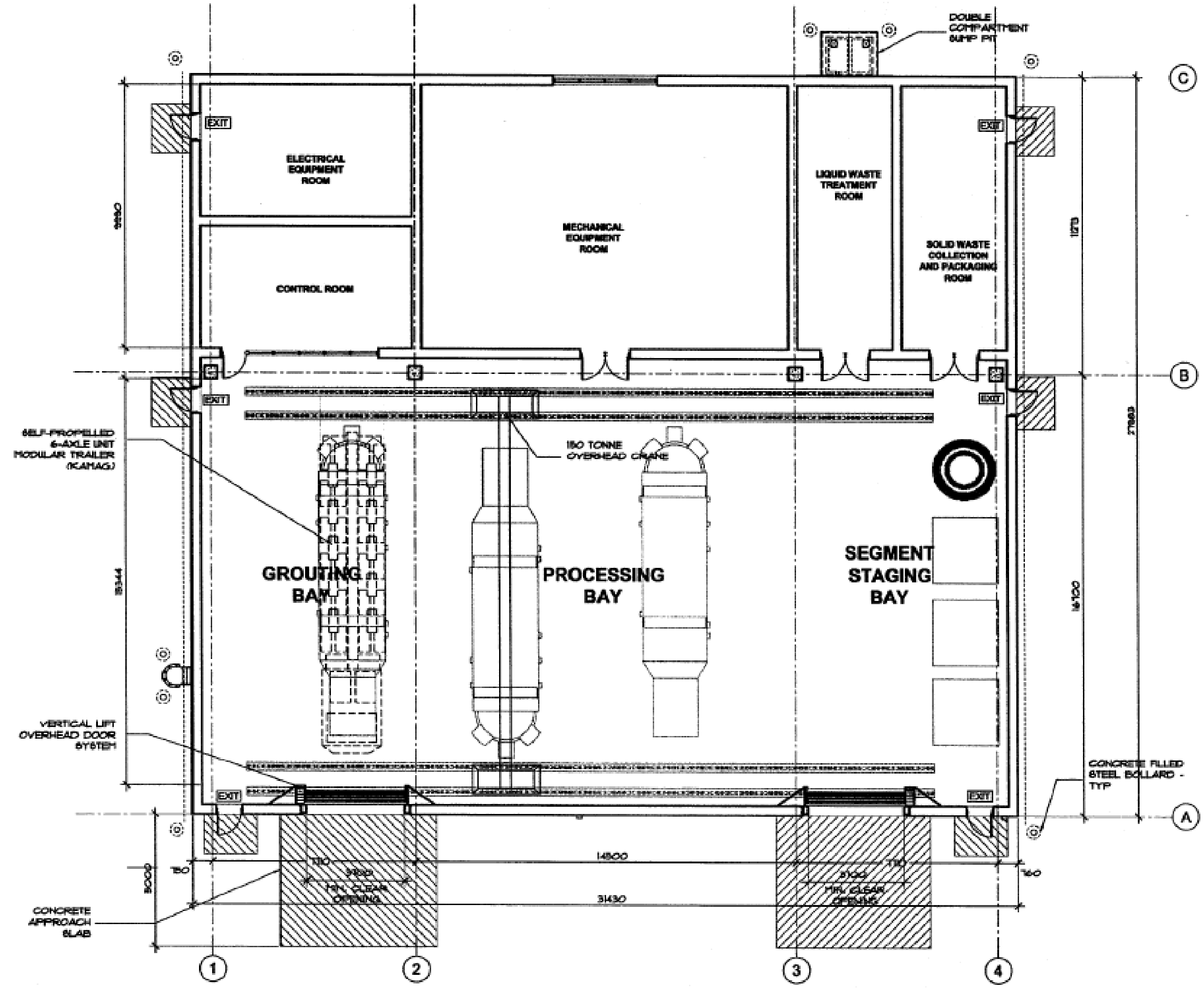

Figure 4-7: LOPB Conceptual Floor Plan

- Grouting Bay: This bay will provide an area for receipt of intact steam generators with crane coverage for removal from the transfer vehicle. The grouting station (e.g., cement or foam filler) is to fill the large metallic components with grout prior to cutting, as required. The grouting bay will be equipped with a ventilation line that will route the displaced gases from the interior of the large metallic components to the HEPA-filtered ventilation system in the mechanical equipment room.
- Processing Bay: Steam generators will be segmented and have metal shield plates installed over exposed surfaces in the process bay. The processing bay will employ a mechanical cutting system such as a diamond wire cutting system and/or plasma arc welding system. Among other services, the processing bay will feature piping connections to the liquid waste collection and treatment system. A ventilation duct will ensure all gases are discharged to the HEPA ventilation system. The processing bay will be constructed with an integral water containment barrier, and liquid and solid waste generated by cutting will be captured by a plastic catch containment installed under the contamination control enclosure. Collected coolant will be pumped to the liquid waste treatment system.
- Segment Staging Bay: This bay will provide an area for staging of segments. Staging includes attaching brackets to facilitate handling by forklift. Segments will be monitored for radiation levels and external contamination. Any external contamination will either be removed or fixed with a suitable paint or coating.
- Liquid Waste Treatment Room: This room provides process support space for treatment of secondary liquid LLW generated by grouting, processing, liquid waste treatment and decontamination operations. Liquid waste generated will be collected in the primary settling tank in the liquid waste treatment room. Any solids collected in the primary settling tank will periodically be allowed to flow into a drum as a sludge. The remaining liquid will be transferred to a secondary settling tank where some of the liquid will be drawn from the tank and serve as the cutting system liquid coolant after appropriate filtering. Any excess water will be collected in a drum and will be heated to evaporate to the processing building HEPA ventilation system or sent to an appropriate licence facility such as Bruce Power active liquid waste system.
- Solid Waste Collection and Packaging Room: This room provides process support space for collection and packaging of solid LLW generated in the grouting bay, processing bay, and segment staging bay. The waste can include spent cutting wires, plastic contamination control enclosure liners, decontamination wipes, personal protective equipment (PPE) and welding debris.
- Control Room: This room provides area for operations control and work control.
- Mechanical Equipment Room(s): This room provides area for the building plumbing and air handling systems.
- Electrical Equipment Room(s): This room provides area for the building electrical service and distribution systems.

4.3.5.2 Building Services

Building services may include a fire detection and suppression system, lightning protection, electrical grounding, and heating and cooling. Other services may include service water, active drainage, and instrument air.

5.0 SELECTION OF CHEMICAL, RADIOLOGICAL AND PHYSICAL STRESSORS

The selection of chemical, radiological and physical stressors is based on the identification of potential Project-Environment interactions and the existing environment as described in the Environmental Risk Assessment for the Western Waste Management Facility [8], [9]. Based on this assessment the potential levels for the chemical, radiological and physical stressors were estimated for the WWMF expansion project. This process is described in more detail in the following sections.

5.1 Identification of Potential Project-Environment Interactions

The Project has the potential to affect various components of the environment, including groundwater, the atmospheric environment (air quality and noise), the aquatic environment (surface water quantity and quality, sediment quality, and aquatic biota), and the terrestrial environment (soil quality and terrestrial biota). Based on the qualitative analysis of the Project works and activities involved as discussed in Section 4.3.1, the potential Project-environment interactions are identified in Table 5-1.

Table 5-1: Identification of Project-Environment Interactions

Project works and activities	Atmospheric environment (air quality and noise)	Surface water (water flow and quality, sediment quality)	Groundwater (groundwater flow and quality)	Geology (soil quality)	Terrestrial environment (species and habitat)	Aquatic environment (species and habitat)	Human health (members of the public)
Site preparation and construction							
Site clearing and maintenance of the cleared area	√	√	√	√	√	√	√
Excavation	√	√	√	√	√	√	√
Grading and compaction	√	√	√	√	√	√	√
Expansion of stormwater management system including drainage system	√	√	√	√	√	√	√
Expansion of fenced property	√						√
Installation of service (electrical, water, security, communication)	√			√	√		√
Internal road construction and upgrading	√	√		√	√		√
Transportation of construction materials, equipment and personnel	√	√		√	√		√
Vehicle /equipment refuelling and maintenance	√	√		√			√
Construction of UFDSBs 5 to 8, four L&ILW storage buildings, LOPB and WSB	√	√		√	√		√
Construction waste management	√	√	√	√			√
Stormwater management		√	√			√	

Project works and activities	Atmospheric environment (air quality and noise)	Surface water (water flow and quality, sediment quality)	Groundwater (groundwater flow and quality)	Geology (soil quality)	Terrestrial environment (species and habitat)	Aquatic environment (species and habitat)	Human health (members of the public)
Operation and maintenance							
On-site transfer of the waste within the WWMF	√			√	√		√
Storage of used fuel in UFDSBs, and L&ILW in L&ILW Storage Buildings					√	√	√
Waste processing at LOPB	√						√
Waste sorting at WSB	√						√
Monitoring (effluent and environment)							√
Facility inspection and maintenance, including testing of standby generation and fire systems	√						√
Operational waste management	√	√		√		√	√
Stormwater management		√	√			√	
Repurposing an LLSB or using one of the new LLSBs to be a "staging and over packing" building for DGR.							√

Note: √ represents the potential interaction between Project work and activity and the environmental component.

Based on Table 5-1, further assessment of the potential effects of the Project on the following environmental components is carried out:

- Air;
- Noise;
- Soil;
- Surface water;
- Sediment; and,
- Groundwater.

The results of the assessment are presented in the sections below. This will be the basis for the prediction of the potential effects to human health and ecological receptors resulting from the Project. The scenarios considered are for individual components of the environment. These scenarios may differ among environmental components in order to ensure the most conservative, bounding scenario has been considered.

5.2 Atmospheric Environment

5.2.1 Estimation of Radiological Emissions and Concentrations

No radiological materials will be involved during site preparation and construction. Therefore, it is unlikely that there will be airborne radiological emissions from the Project during site preparation and construction. However, it is possible that there will be airborne radiological emissions during operation and maintenance from the following buildings:

- Four UFDSBs 5 to 8;
- Four L&ILW storage buildings which could be any combination of LLSBs, SGSBs and RCSBs;
- One WSB, and;
- One LOPB.

Also the Project consists of repurposing an existing LLSB or using one of the new LLSBs for staging and overpacking of L&ILW.

The potential radiological airborne emissions from these buildings are discussed below.

- UFDSBs: At the WWMF, it is standard practice that the used fuel dry storage containers are sealed and the outer surfaces are cleaned of any loose contamination prior to being transferred to the UFDSBs for storage. It is assumed that the UFDSBs 5 to 8 will be operated similarly to what is currently practiced on site. As such, it is expected that airborne emissions from the UFDSBs 5 to 8 to the environment are negligible during normal operation and maintenance.
- SGSBs and RCSBs: The steam generators and retube component storage containers will be sealed and the outer surfaces of the containers will be free of loose contamination prior to being transferred to the SGSBs and the RCSBs

for storage. Therefore it is expected that airborne emissions from the SGSBs and RCSBs to the environment are negligible during normal operation and maintenance.

- LLSB: The containers stored in LLSBs are not sealed. Therefore, there is a potential for airborne emissions of tritium and gaseous Carbon-14 (C-14) from LLSBs during normal operation and maintenance. The LLSB which is repurposed for staging and overpacking will have negligible emissions.
- WSB: The material handled in the WSB will be disturbed during sorting process and the containers will not be sealed, similar to the WVRB. Therefore, there is potential for airborne emissions from the WSB during normal operation and maintenance.
- LOPB: Large objects such as steam generators (SGs) and heat exchangers will be processed in the LOPB by segmentation, re-welding and/or packaging for storage at the WWMF and/or disposal at the DGR. During these processes, airborne emissions are generated. Therefore, there is potential for airborne emissions from the LOPB during normal operation and maintenance.

The estimated airborne emissions from these buildings, based on the analysis of historical data, are summarized in Table 5-2. Detailed analysis is provided in Appendix B.

Table 5-2: Estimated Airborne Emissions Resulting from the Project

Facilities	Tritium Oxide (HTO)	Iodine-131 (I-131)	Particulate	C-14
Total emission (Bq/y)	2.4E+12	7.4E+04	2.4E+05	1.6E+10

Accordingly, the radionuclide concentrations in air in the vicinity of the WWMF were estimated using the code IMPACT. The meteorological data used for air dispersion modelling are the same as those used in the ERA for the baseline conditions [8].

The air concentrations were estimated at four locations using IMPACT based on the estimated airborne emission data presented in Table 5-2. They are located west, north, east and south of the WWMF, each approximately 100 m from the center of the WWMF. The maximum concentrations from these four locations, presented in Table 5-3, will be used for the calculation of doses to non-human biota.

Table 5-3: Estimated Maximum Concentration of Radionuclides in Air in the Vicinity of the WWMF Resulting from the Project

	HTO	C-14	I-131	Cobalt-60 (Co-60)
Concentration (Bq/m^3)	6.4E+00	4.4E-02	2.0E-07	6.6E-07

It should be noted that particulates consist of a group of radionuclides. For the purposes of the PEA, the total emissions of particulates were conservatively assigned to Co-60, the limiting radionuclide for particulates in airborne emissions [10].

Doses to human receptors including exposure to radionuclides in air at off-site locations are directly calculated using the IMPACT code based on the airborne and waterborne emissions estimated (see Section 6.2.4). Therefore, the radionuclide concentrations in air at off-site locations are not provided here.

5.2.2 Estimation of Non-Radiological Emissions and Concentrations

Non-radiological emissions resulting from the Project were estimated. Accordingly, the environmental concentrations due to the emissions from the Project were predicted.

5.2.2.1 Assessment Indicators

Ambient air quality may be affected by one or more of the Project works and activities. In order to assess the effects of the Project on air quality, the following air quality indicators were selected:

- Total suspended particulate (TSP);
- Fine (PM_{10}) and Respirable ($PM_{2.5}$) particulate matter;
- Sulphur oxides (SO_x), mainly as sulphur dioxide (SO_2);
- Carbon monoxide (CO); and,
- Nitrogen dioxide (NO_2).

These indicators of air quality were selected based on the following criteria:

- The indicators are expected to be emitted in measurable quantities;
- The indicators have been used in previous assessments to assess potential impacts to air quality as a result of development within the Bruce nuclear site [5]; and,
- The indicators have established regulatory criteria, i.e., Ambient Air Quality Criteria (AAQC) [11].

It should be noted that only contaminants emitted as a result of the Project were considered, i.e., ongoing emissions from the existing site not emitted from the Project were not assessed as there would be no measurable change.

Also, ozone was not selected as an indicator although it is measured across Ontario at various monitoring stations. Ozone is generated in the atmosphere through a series of complex interactions with sunlight, hydrocarbons and nitrogen oxides. Since it is not directly emitted from Project activities or components and is more an indicator of regional air quality, ozone has been excluded from this effects assessment.

5.2.2.2 Selection of Air Dispersion Model

AERMOD, a sixth generation Gaussian dispersion model, was considered to be the most appropriate model for assessment as it is capable of handling multiple sources of varying types such as point and area sources. The input data required for AERMOD includes five years of local, hourly meteorological data, terrain elevations for the site and vicinity, and the characteristics of the buildings (dimensions, shape, number of tiers, coordinates) and emission sources (dimensions, type, coordinates). The model uses these input parameters to predict the resultant air concentrations at receptor locations, and is capable of predicting these effects for each of the relevant averaging times.

Meteorological data used for the AERMOD modelling consisted of five years (2009 to 2013) of surface and upper air meteorological data developed by Lakes Environmental specifically for the Bruce nuclear site and is considered to be representative meteorological data ([12], [13]). The use of a 5-year meteorological data set is to ensure that all climatic influences are included.

Although the immediate area surrounding the proposed facility does not have significant topographical features such as mountains, valleys, or canyons, the topography was included in the AERMOD modelling. Digital terrain data (30 m resolution) for the facility and surrounding area was obtained from the MOECC web site [14].

Version 14134 of AERMOD was used in conjunction with AERMET version 14134, AERMOD's meteorological data processor. These versions are now required by the MOECC for use in Ontario and are the MOECC approved dispersion modelling software.

5.2.2.3 Sources of Air Emissions

The Project works and activities can be grouped into three phases: site preparation, construction, and operation and maintenance. The sources of air emissions from each phase are discussed below.

Site Preparation

Site preparation activities are those required to prepare the ground prior to construction and include land clearing, grubbing, removing overburden, grading, compacting, expansion of the fenced property, and expansion of the stormwater management system. These activities have the potential to temporarily increase emissions of dust and products of fuel combustion by ground disturbance, material handling, increased road traffic and tailpipe emissions from the equipment fleet.

Construction

The construction phase of the Project involves activities that will install permanent structures and utilities: installation of underground services, internal road upgrades, transportation of materials, vehicle maintenance, construction of new buildings and waste management. These activities have the potential to temporarily increase emissions of dust and products of fuel combustion by ground disturbance, material handling, increased road traffic and tailpipe emissions from the equipment fleet.

Operation and Maintenance

Operation and maintenance activities at the new buildings include transfer of waste, storage of used fuel and L&ILW, waste processing, waste sorting and maintenance of equipment and facilities. These activities have the potential to increase emissions of dust and products of fuel combustion from vehicle traffic.

5.2.2.4 Scenarios

Considerations for the purposes of modelling bounding scenarios for site preparation, construction, and operation and maintenance are discussed below.

Site preparation may occur any time from October to March concurrently at areas 1, 2 and 3. This phase was not necessary for area 4 as the current state of the ground does not require these activities. Minor activities such as vegetation removal may occur at area 4 during the site preparation phase but activities of this nature and scale were considered negligible.

Construction of all buildings simultaneously was considered unrealistic, and therefore was not considered as the bounding scenario. The scenarios listed below are realistic based on the schedule in Table 4-1 and bounding as they define the maximum number of areas being developed simultaneously. Construction activities may occur concurrently at potential expansion areas from February to December as follows, where “1/2” indicates expansion areas 1 and 2 are to be considered a consolidated construction area:

- Scenario A: areas ½ and 3;
- Scenario B: areas ½ and 4; and
- Scenario C: areas 3 and 4.

The modelling considerations identified in Appendix C are the same for Scenarios A, B and C. The only difference between Scenarios A, B and C is the combination of areas being developed at the same time. For the purposes of this assessment, the construction phase may be divided into stages as indicated in Table 5-4. The stage that would generate the highest levels of emissions for each time period was chosen and modelled for that time period. This was evaluated for each indicator.

Table 5-4: Construction Phase Stages

Stage	Timeframe*
Underground services	February – March
Final preparation	April – September
Foundation	
Walls	
Roof	October – December
Floor	
Torched on roof	

* Timeframes are provided for modelling purposes only and reflect possible time of year occurrence for each stage.

Operation and maintenance activities at the future WWMF include transfer of waste; used fuel and L&ILW storage; waste sorting and processing; monitoring; regular inspections such as testing of standby generation and fire systems; operational waste management; stormwater management; and staging of an LLSB for DGR. Operation and maintenance of future buildings at the WWMF are not expected to result in a measureable change in emissions from existing operations for the following reasons:

- LOPB and WSB will be equipped with filtration in the ventilation system with a removal efficiency that is equivalent to HEPA filtration. This level of filtration minimizes releases to the atmosphere and therefore, emissions from operational buildings were considered negligible. UFDSBs and L&ILW SBs do not have non-radiological atmospheric emissions associated with their operations.
- Testing of the future emergency generator will only be performed periodically (once per month) for a short duration (approximately 20 minutes or less). The magnitude of emissions is expected to be low due to the small output capacity of the generator. Since the magnitude of emissions is low and the duration is short and periodic, these emissions were considered negligible.
- Vehicular traffic to the future WWMF is not expected to increase significantly.

Therefore, no further assessment was carried out for the Operation and Maintenance phase of the Project.

5.2.2.5 Modelling Inputs

Atmospheric dispersion modelling is used to predict ground level concentrations of assessment indicators. These results were used to compare predicted concentrations of such indicators against MOECC AAQC [11] for the effects assessment. A main component of preparing the modelling input is emission estimation, i.e., quantification of emissions from Project activities. Emission rates were developed for the following processes and equipment used to carry out Project activities:

- Construction power generation;
- Material handling;
- Compacting and grading;
- Wood chipping;
- Equipment movement on unpaved road;
- Truck traffic on internal paved and unpaved roadways;
- Tailpipe emissions from fuel combusting equipment; and
- Concrete batching.

Emissions were calculated using activity data and emission factors published by the United States Environmental Protection Agency (US EPA). Emission rates from the existing Bruce nuclear site and WWMF sources were obtained from the DGR TSD [15][6] and WWMF's ESDM report [16], respectively. Emissions for each phase were quantified separately as well as for each stage of construction.

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[6] This reference was an enclosure to the DGR EA submission document [6].

Emission Sources

Source characterization is another main input into the dispersion model. Each emission source is represented in the model depending on the nature of its emissions. The source types used were point, area, volume and line volume.

Point sources were used to represent stacks or vents and they include emergency generators at the Bruce nuclear site, steam boilers at the Bruce nuclear site, the WWMF incinerator, the existing WWMF emergency generator[7] and construction generator. Source parameters for the existing Bruce nuclear site and WWMF sources were obtained from DGR TSD [15] and WWMF's ESDM report [16], respectively. The point source parameters are summarized in Table 5-5.

Table 5-5: Point Source Parameters

Model ID	Description	Base Elevation* (m)	Release Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (°K)
EX_A1_1	Emerg Gen A Side 15 MW	179.83	4.7	4.08	24.5	938
EX_B1_1	Emerg Gen B Side 15 MW	180	4.7	4.08	24.5	938
EX_E7_1	Emerg Gen B Side 2 MW	186	6.4	0.4	65	755
EX_E10_1	Bruce Steam Plant Boilers (3)	186	51.8	2.1	12.6	408
EX_M1	WWMF – Radioactive Waste Incinerator	190	21	0.343	11.7	421.25
EX_S8	Emergency Diesel Generator WWMF	189	16.7	0.075	3.4	755
CGEN	Construction Generator	190	3	0.5	73.8	752.15

* Base elevation measured in meters above sea level.

Locations of point sources are depicted in Figure 5-1.

Area sources are used to represent low level sources that emit fugitive emissions close to the ground. Fugitive emissions from potential expansion areas 1 to 4, also known as "areas 1 to 4", were modelled as area sources using the potential area of construction as the boundary extents for each area defined in Figure 4-4. As such, there are four area sources to represent material handling and ground disturbance activities in areas

[7] Emissions from the existing emergency generator at the WWMF are considered negligible based on magnitude and duration, but have been modelled for inclusiveness.

1 to 4, and four area sources to represent tailpipe emissions from equipment in areas 1 to 4. In addition, one area source for concrete batching (model ID CBP, Table 5-6) was also modelled. Individual area sources are not generated for each emission source, i.e., only the aggregate emissions from equipment and processes for each area are considered. The area source parameters are summarized in Table 5-6.

Table 5-6: Area Source Parameters

Model ID	Description	Base Elevation (m)	Release Height (m)	Area (m^2)
CBP	Concrete Batch Plant	189.47	4	400
AREA1	Material Handling and Road Dust – area 1	188	1	11929
AREA2	Material Handling and Road Dust – area 2	188	1	22689
AREA3	Material Handling and Road Dust – area 3	190	1	56306
AREA4	Material Handling and Road Dust – area 4	190	1	78434
AREA2T	Equipment Tailpipe - area 2	188	2.5	11929
AREA3T	Equipment Tailpipe - area 3	190	2.5	22689
AREA1T	Equipment Tailpipe - area 1	188	2.5	56306
AREA4T	Equipment Tailpipe - area 4	190	2.5	78434

Locations of area sources are depicted in Figure 5-2.

Volume sources are used to model emissions that could not be classified as point or area sources. For the Project, they include road traffic and the wood chipper. Road traffic is modelled as a line volume source (a string of very small volume sources). Parameters for the roads are consistent with the US EPA's recommendations [17]. The volume source parameters are summarized in Table 5-7.

Table 5-7: Volume Source Parameters

Model ID	Description	Length (m)	Release Height (m)
EX_RD_NORTH	North Access Road	2015	1.5
RD_MAIN	Main Access Road	355	3.0
EX_RD_SOUTH	South Access Road	1688	1.5
RD_1&2	Road to areas 1 & 2	1088	3.0
RD_3	Road to area 3	842	3.0
RD_4	Road to area 4	222	3.0
RD_MAINT	Main Access Road - Tailpipe	355	3.8
RD_3T	Road to area 3 Tailpipe	842	3.8
RD_4T	Road to area 4 Tailpipe	222	3.8
RD_1&2T	Road to areas 1 & 2 - Tailpipe	1088	3.8
WC1	Wood Chipper – area 1	n/a	1
WC2	Wood Chipper – area 2	n/a	1
WC3	Wood Chipper – area 3	n/a	1

n/a – not applicable

Locations of volume sources are depicted in Figure 5-3.

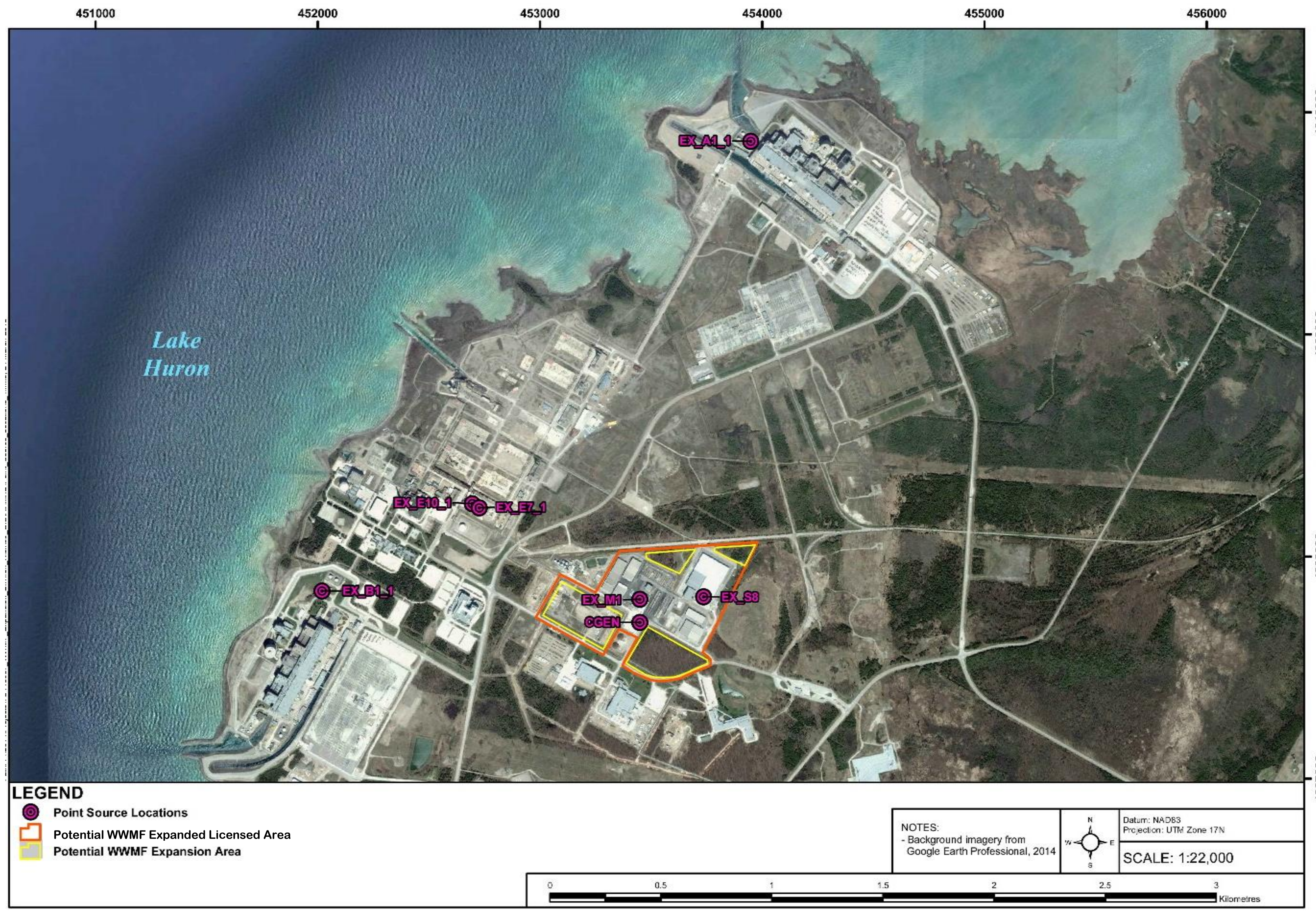

Figure 5-1: Point Source Locations (see Table 5-5 for definition of point sources)

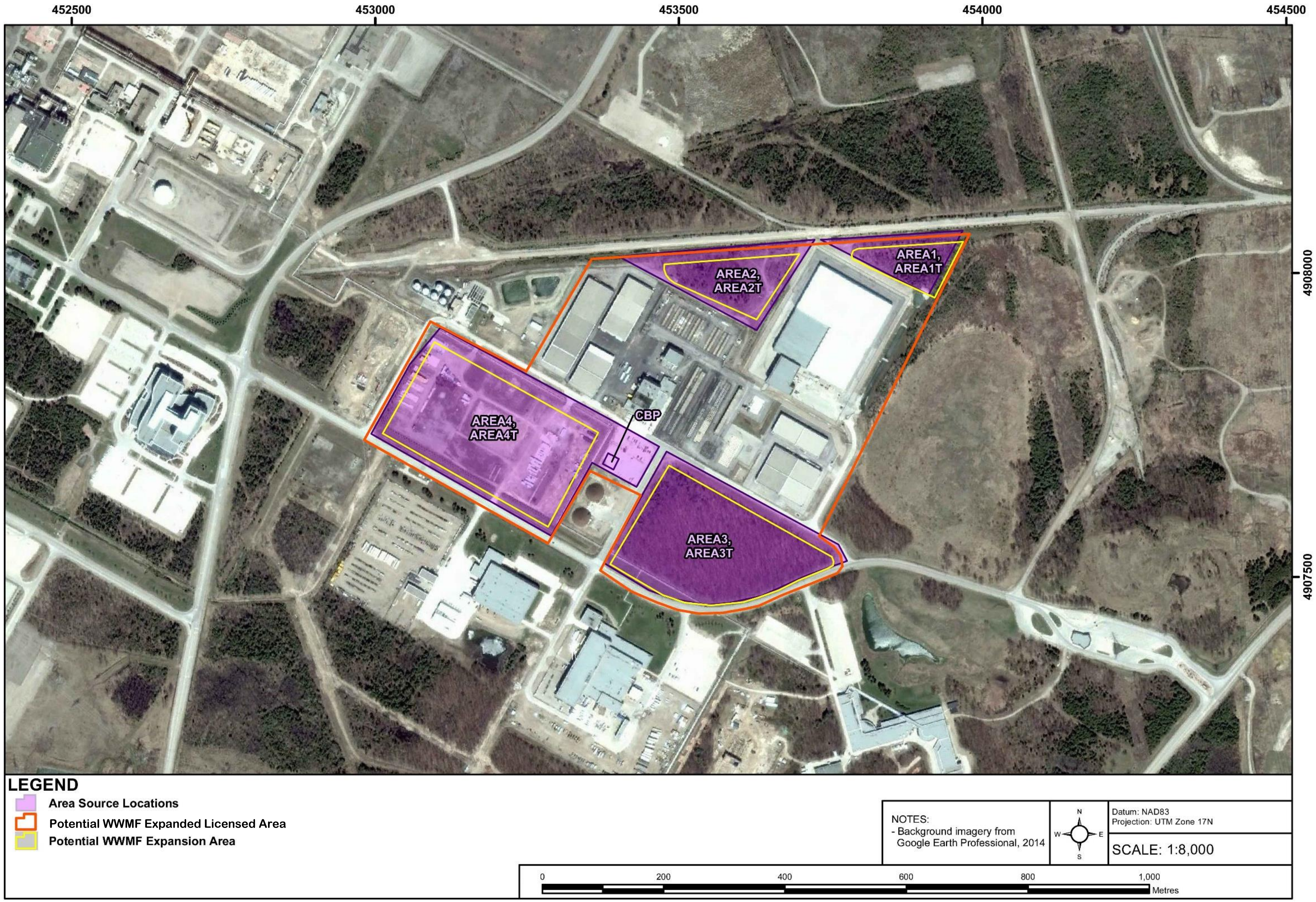

Figure 5-2: Area Source Locations

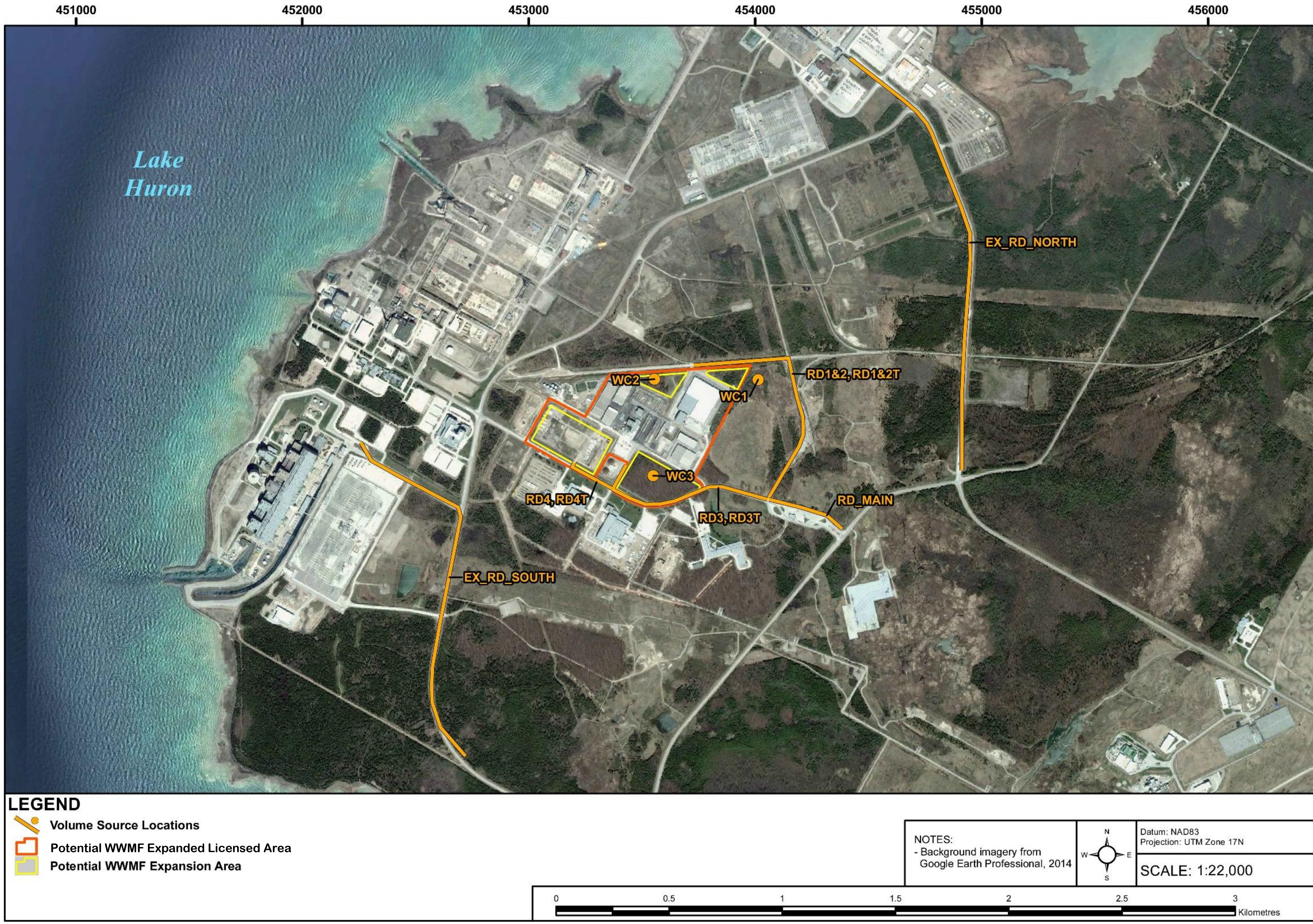

Figure 5-3: Volume Source Locations (see Table 5-7 for definition of volume sources)

Combustion emissions are emitted mainly as nitric oxide (NO), with a smaller fraction as NO_2 from the source. To account for the reaction of NO and ozone to form NO_2 in the atmosphere, the ozone limiting method was chosen because of its suitability to low-level fugitive releases. Sources of emissions that were in close proximity to each other were grouped as a single ozone limiting method source as it would be reasonable to expect those sources to compete for ambient ozone for conversion.

Receptors

The dispersion modelling software was used to predict the air concentrations at different locations. As general air quality is typically evaluated at the fence line and in the vicinity beyond a facility's operational control, i.e., areas that are accessible to the public, receptors were placed at points along the Bruce nuclear site boundary and in the area around the boundary in a nested grid as shown in Figure 5-4. In addition, air concentrations for the following specific set of receptors were also evaluated.

- Discrete ecological receptors for the EcoRA; and
- Discrete human receptors for the HHRA.

Locations of discrete receptors discussed above are shown in Figure 5-5.

The nested grid of receptors for air dispersion modelling is the recommended approach in Ontario for air quality assessments. This grid is needed to improve the quality of the modelling assessment, as including only human and ecological receptors is not adequate for the assessment.

The selection of human and ecological receptors is further discussed in Sections 6.1 and 7.1. For each set of receptors, the emissions scenarios discussed in Section 5.2.2.4 were modelled. The sources and modelling considerations for each set of receptors and emissions scenarios modelled are provided in Table C-1 to Table C-3 in Appendix C. Ground level air concentrations of indicator contaminants are used in the PEA for these receptors.

Figure 5-4: Bruce Nuclear Site Boundary

Figure 5-5: Discrete Receptor Locations

Equipment Considered

The assumed maximum engine ratings for the equipment fleet as shown in Table 5-8 were based on specifications for typical construction machinery. Also provided is the distribution of equipment across the site preparation and construction phases. Table 5-8 lists the equipment required for each area of construction, except where construction occurs at areas 1 and 2 where one fleet is shared between the two sites in any given scenario. All equipment identified under a specific activity is assumed to operate simultaneously at their maximum capacity and typical utilization rate. The equipment fleet is assumed to be the same regardless of building type and size (LLSB, UFDSB, RCSB, SGSB, LOPB, etc.). Estimates of travel on unpaved surfaces, truck traffic and loading rates were assumed based on engineering judgement.

Table 5-8: Site Preparation and Construction Equipment Fleet

Equipment	Engine Power Rating (kW)	Emissions*	Clearing	Removing Overburden	Underground Services	Final Preparation	Foundation	Walls	Roof	Floor	Torched on Roof
Feller/Buncher	226	Tier 3	1								
Dump Truck	280	Tier 4	2	4	4	4					
Stationary Chipper	63	Tier 3	1								
Back-Hoe	149	Tier 4		1	2		1				
Bulldozer	325	Tier 4		1	1	1					
Front-end Loader	414	Tier 3		1	1	1	1	1	1	1	1
Grader	196	Tier 4				1					
Compactor	97	Tier 2				1					
Crane	552	Tier 2						1	1		1
Concrete truck	400	Tier 3				1	2			1	
Flatbed truck	300	Tier 3					1	1	1	1	
Concrete conveyor		Electric				1	1	1	1	1	
Concrete Troweller/ Leveler	26	Tier 4								1	
Mini-Elevator		Electric									1
Generator	3600	Tier 3			1	1	1	1	1	1	1

*US EPA emission standards for non-road diesel engines [18]

Equipment numbers are given for site preparation and construction activities in any one of areas 1 & 2, area 3, or area 4.

5.2.2.6 Discipline-Specific Assumptions

The main assumptions used for the air quality assessment for the Project are described in this section.

Particulate Emissions

During winter months, it was assumed there will be no particulate emissions from ground disturbance activities since the soil is frozen and has a high moisture content.

In quantifying emissions from fugitive dust sources, mitigation measures were incorporated in the estimates. These in-design measures are considered integral to the design and implementation of the Project as follows:

- The LOPB and WSB will be constructed with adequate ventilation and controls to minimize emissions to air. The ventilation system will be equipped with filtration with a removal efficiency equivalent to HEPA filtration;
- Site roadways are maintained in good condition;
- Dust suppressant to control dust from material handling activities during Site Preparation and Construction; and,
- Dust suppressant on unpaved roadways travelled by trucks during site preparation and construction.

These mitigation measures to control fugitive particulate generating activities such as material movement and ground disturbance will be identified in a dust management plan. The dust management plan will also detail inspection and record keeping to demonstrate the effectiveness of mitigation carried out.

Site Preparation, Construction, and Operation and Maintenance Phases

For modelling purposes, site preparation may occur any time from October to March concurrently at areas 1, 2 and 3. This phase was not necessary for area 4 as the current state of the ground does not require these activities. Minor activities such as vegetation removal may occur at area 4 during the site preparation phase but activities of this nature and scale were considered negligible.

For modelling purposes, the construction phase may be divided into stages as indicated in Table 5-4. The stage that would generate the highest levels of emissions for each time period was chosen and modelled for that time period. This was evaluated for each indicator. Construction activity is limited to the allowable timeframes as specified in the Kincardine Noise Bylaw [19].

It was assumed any process non-radiological emissions released to air from the LOPB and WSB will be negligible, since ventilation systems will be equipped with filtration that has a removal efficiency equivalent to that of HEPA filtration. Further assessment of operations was therefore not undertaken as part of the HHRA or EcoRA.

5.2.2.7 Results

Human Health

Air dispersion modelling outputs are maximum ground level concentrations at the modelling boundary. All results include general background concentrations which represent non-specific source air quality for the geographical area in the vicinity of the Bruce nuclear site. Data for background concentrations were obtained from Environment and Climate Change Canada monitoring stations [20].

Results of the dispersion modelling evaluated at the Bruce nuclear site boundary for each scenario are provided in Table 5-9. For the construction phase, only the maximum value from Scenario A, B, or C has been reported.

Table 5-9: Maximum Concentration Results at the Bruce Nuclear Site Boundary

Contaminant	Averaging Period	Concentration (µg/m^3)		
		Baseline	Site Preparation	Construction (Max from all Scenarios)
TSP	24 h	51	96	219
	annual	45	-*	52
PM_{10}	24 h	27	45	87
$PM_{2.5}$	24 h	14	24	29
NO_2	1 h	263	320	345
	24 h	27	27	47
CO	1 h	485	2352	2096
	8 h	464	726	668
SO_2	24 h	85	85	85
	1 h	230	230	232
	annual	18	-*	18

*The annual averaging period for site preparation was not assessed since the duration of this phase is only expected to occur within a 6 month time frame.

Results of the dispersion modelling, inclusive of background concentrations, evaluated at human receptors for each scenario are provided in Table 5-10. For each indicator, only the highest concentration resulting from all human receptors is presented.

Table 5-10: Maximum Concentration Results at Human Receptors

Contaminant	Averaging Period	Concentration (µg/m^3)		
		Baseline	Site Preparation	Construction
TSP	24 h	47	53	52
	annual	45	-*	45
PM_{10}	24 h	24	27	30
$PM_{2.5}$	24 h	12	16	18
NO_2	1 h	187	355	339
	24 h	17	21	36

Contaminant	Averaging Period	Concentration (μg/m^3)		
		Baseline	Site Preparation	Construction
CO	1 h	471	2423	2346
	8 h	461	703	789
SO_2	24 h	44	44	45
	1 h	304	304	315
	annual	24	-*	25

*The annual averaging period for site preparation was not assessed since the duration of this phase is only expected to occur within a 6 month time frame.

Non-Human Biota

Changes in air quality have the potential to interact with plant and wetland Valued Ecosystem Components (VECs) and associated receptors, as well as all wildlife VECs and associated receptors. An evaluation of the worst-case scenario for the terrestrial environment was undertaken for the purpose of presenting Project-related air quality effects on terrestrial VECs and associated receptors. Ten ecological receptor locations were selected to assess changes in air quality parameters that would potentially pose adverse effects to plant and wildlife species (Figure 5-6). These 10 ecological receptor locations include the locations previously identified from environmental assessments, designated as "ER" ([15], [21]), and additional locations for this Project.

Based on this terrestrial based evaluation of air quality emissions, the worst-case scenario included:

- Site preparation: area 1 & 2 (shared fleet) and area 3 (full fleet);
- Construction: area 1 & 2 (shared fleet) and area 3 (full fleet) (Scenario A).

The baseline and worst-case modelled concentration in air quality parameters (TSP[8], NO_2, CO, and SO_2) relative to the terrestrial environment VECs are provided in Table 5-11 through Table 5-14. All modelled air quality parameters and results of the dispersion modelling at ecological receptors are provided in Appendix H.

Operation and maintenance of the future buildings at the WWMF are not expected to result in a measureable change in air emissions from existing operations, as identified under Section 5.2.2.4. As such, measureable changes to soils, surface water quality or the terrestrial environment via air emissions are not expected and are not further assessed.

[8] TSP is inclusive of all particulate fractions from 0 – 44 μm in diameter, including PM_{10} and $PM_{2.5}$. An inclusive size range has been used for the ecological risk assessment as there is no screening value for non-human biota.

Figure 5-6: Terrestrial Biota Air Quality and Noise Locations

Table 5-11: Predicted Worst-Case Changes in TSP Concentration at Ecological Receptors

Receptor Location	24-Hour TSP		Annual TSP	
	Baseline Concentration (μg/m^3)	Predicted Concentration (μg/m^3)	Baseline Concentration (μg/m^3)	Predicted Concentration (μg/m^3)
Site Preparation (1/2+3)				
1	47.8	124.8	-	-
2 (ER7)	48.2	176.5	-	-
3 (ER4)	48.2	228.4	-	-
4	48.3	345	-	-
5	48.4	63.6	-	-
6 (ER3)	47.9	62.6	-	-
7	48.4	57	-	-
8 (ER5)	48.1	68.6	-	-
9 (ER6)	48.6	74.4	-	-
10	47.9	75.5	-	-
Construction (1/2+3)				
1	47.8	145.6	45.2	51.5
2 (ER7)	48.2	104.1	45.2	50.3
3 (ER4)	48.2	304.2	45.3	67.3
4	48.3	280.9	45.3	71.1
5	48.4	71.7	45.2	46.4
6 (ER3)	47.9	65.3	45.2	46.2
7	48.4	63.4	45.2	46.2
8 (ER5)	48.1	80.4	45.2	48.3
9 (ER6)	48.6	81.7	45.2	47.1
10	47.9	74.8	45.2	46.6

Table 5-12: Predicted Worst-Case Changes in NO_2 Concentrations at Ecological Receptors

Receptor Location	1-Hour NO_2		24-Hour NO_2	
	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)
Site Preparation (1/2+3)				
1	140.8	660.9	22	30
2 (ER7)	139.7	343.2	19.7	25.1
3 (ER4)	101.8	412	37.8	38.1
4	107.6	668.3	22.8	42.1
5	129	496	21.9	33.4
6 (ER3)	75.7	355.3	19.1	28.3
7	130.2	304	20.3	18.7
8 (ER5)	122.9	322.2	19.4	23.9
9 (ER6)	119.7	527.4	20.9	27.1
10	75.7	472	18.6	30.6
Construction (1/2+3)				
1	140.8	558.1	22	74
2 (ER7)	139.7	545.6	19.7	73.2
3 (ER4)	101.8	784.1	37.8	100.7
4	107.6	1,146.30	22.8	127.9
5	129	757.4	21.9	44.5
6 (ER3)	75.7	423.7	19.1	46.2
7	130.2	306.8	20.3	52.4
8 (ER5)	122.9	720.7	19.4	68.5
9 (ER6)	119.7	505.5	20.9	53.2
10	75.7	783.6	18.6	70.1

Table 5-13: Predicted Worst-Case Changes in SO_2 Concentration at Ecological Receptors

Receptor Location	1-Hour SO_2		24-Hour SO_2	
	Baseline Concentration (μg/m³)	Predicted Concentration (μg/m³)	Baseline Concentration (μg/m³)	Predicted Concentration (μg/m³)
Site Preparation (1/2+3)				
1	253.4	253.4	50.2	50.2
2 (ER7)	317	317.1	55.6	55.6
3 (ER4)	193.7	193.7	55.5	55.5
4	280.5	280.5	56.6	56.6
5	178.6	178.6	58.5	58.5
6 (ER3)	191.4	191.4	52.9	52.9
7	172.5	172.5	58.2	58.2
8 (ER5)	219.2	219.2	54.5	54.5
9 (ER6)	206.2	206.2	60.8	60.8
10	199.1	199.1	52.8	52.8
Construction (1/2+3)				
1	253.4	260.3	50.2	52
2 (ER7)	317	317.3	55.6	55.6
3 (ER4)	193.7	193.7	55.5	55.9
4	280.5	280.6	56.6	56.9
5	178.6	178.7	58.5	58.5
6 (ER3)	191.4	191.6	52.9	52.9
7	172.5	172.5	58.2	58.2
8 (ER5)	219.2	219.3	54.5	54.6
9 (ER6)	206.2	206.5	60.8	60.8
10	199.1	199.4	52.8	52.9

Table 5-14: Predicted Worst-Case Changes in CO Concentration at Ecological Receptors

Receptor Location	1-Hour CO		8-Hour CO	
	Baseline Concentration (μg/m³)	Predicted Concentration (μg/m³)	Baseline Concentration (μg/m³)	Predicted Concentration (μg/m³)
Site Preparation (1/2+3)				
1	484.4	6,703.30	470.1	1,362.30
2 (ER7)	495.4	3,226.50	470.7	830.7
3 (ER4)	496.3	3,960.30	479.5	966.2
4	493	6,556.90	476	1,360.30
5	487.5	4,684.90	468.3	1,079.60
6 (ER3)	482.9	2,344.60	469.9	698
7	480.3	2,459.70	465.6	708.4
8 (ER5)	482.4	2,009.80	467.8	688.9
9 (ER6)	477.2	4,032.00	467	917.4
10	477.8	3,650.00	467.8	858.3
Construction (1/2+3)				
1	484.4	3,385.30	470.1	982.5
2 (ER7)	495.4	2,137.10	470.7	670.8
3 (ER4)	496.3	4,329.60	479.5	975
4	493	4,612.90	476	1,198.20
5	487.5	4,167.90	468.3	921.7
6 (ER3)	482.9	2,087.40	469.9	661.7
7	480.3	2,019.20	465.6	653.2
8 (ER5)	482.4	3,470.10	467.8	840.3
9 (ER6)	477.2	1,890.80	467	644.5
10	477.8	3,812.00	467.8	1,090.80

5.2.3 Estimation of Noise Levels

The modelled noise levels presented in this section are for the purposes of the HHRA and the EcoRA. The human health risk assessment for noise is further discussed in Section 6.4. The detailed noise levels estimated for ecological receptors are presented in Appendix D. Discussions regarding the ecological risk assessment for noise are included in Section 7.5.

5.2.3.1 Assessment Indicators

The three human receptors have been identified within the noise technical study for the Bruce Power New Build environmental assessment [21]. These receptors are representative of all human noise sensitive receptors in the local area.

The human receptor locations are identified as R1 (Albert Street), R2 (Baie du Doré) and R3 (Inverhuron Park) and are shown in Figure 5-7. The 10 ecological receptor locations for noise are shown in Figure 5-6. They were selected to assess changes in noise that would potentially pose adverse effects to wildlife species.

Ambient noise levels at the human receptor locations may be affected by one or more of the Project components. The effect assessment indicator selected is the modelled noise levels at each receptor location, and is detailed in Table 5-15.

Table 5-15: Effects Assessment Indicators Selected for Noise

Effect Assessment Indicator	Rationale for Selection
Noise Level (dBA)	Noise level in dBA is most relevant to human hearing and perception of loudness
Noise Level (dB)	Noise level in dB is most relevant to non-human biota hearing

Figure 5-7: Noise Receptors, Human

5.2.3.2 Model

Noise levels for the Project were modelled at the identified surrounding human (as well as ecological) receptors using the Cadna/A software package, published by Datakustik GmbH. The Cadna/A software was configured to implement the International Standards Organisation (ISO) 9613-2 [22] environmental noise propagation algorithm. The Cadna/A software, when used with the ISO 9613-2 algorithm, is widely accepted as meeting the industry standard for noise modelling, both within consulting practices and the MOECC. The model takes into account many physical propagation factors, including, but not necessarily limited to:

- Source sound power levels;
- Source directivity;
- Distance attenuation;
- Source, receptor and propagation path geometry;
- Barrier effects of buildings and topography;
- Ground attenuation; and,
- Atmospheric attenuation.

5.2.3.3 Identification of Sources

The following noise sources were assumed for the purposes of modelling bounding scenarios for the PEA. For the purposes of this modelling, it is assumed that noise levels of equipment listed in this section meet applicable noise standards and legislation.

Site Preparation

Noise emission sources, and their specific distribution between activities, for the Site Preparation phase of the Project are provided in Table 5-16. These include the list of equipment, the reference model used, and the associated sound power level. For each activity (clearing, grubbing), the number of each piece of equipment that would be used in one fleet, at one expansion area/location, is provided.

Table 5-16: WWMF Noise Sources and Distribution, Site Preparation

Source Name	Model	Sound Power Levels (dBA)	Number of Sources per Activity	
			Clearing	Grubbing and Removing Overburden
Back Hoe	CAT 335F L CR	104	-	1
Bulldozer	CAT D9T	114	-	1
Dump Truck	CAT 730	110	2	4
Feller Buncher	CAT 522	114	1	-
Front Loader	CAT 988H	114	-	1
Stationary Chipper	CR100	121	1	-

Construction

Noise emission sources for the construction phase of the Project are provided in Table 5-17. Noise source distribution by activity is also provided in this table. As with the site preparation phase discussed above, a list of construction equipment is identified, with the reference model that was used (if available), and the associated sound power level. For each activity, the number of each particular piece of equipment that is used for one construction fleet, at one expansion area, is provided.

Table 5-17: WWMF Noise Sources, Construction

Equipment	Model	Sound Power Levels (dBA)	Number of Sources per Activity						
			Underground Services	Final Preparation	Foundation	Walls	Roof	Floor	Torched on Roof
Dump Truck	CAT 730	110	4	4	-	-	-	-	-
Back-Hoe	CAT 335F L CR	104	2	-	1	-	-	-	-
Bulldozer	CAT D9T	114	1	1	-	-	-	-	-
Front-end Loader	CAT 988H	114	1	1	1	1	1	1	1
Grader	CAT 140M	107	-	1	-	-	-	-	-
Compactor	CAT CS533	111	-	1	-	-	-	-	-
Crane	-	118	-	-	-	1	1	-	1
Concrete truck	-	104	-	1	2	-	-	1	-
Flatbed truck	-	98	-	-	1	1	1	1	-
Concrete conveyor	-	NA - insignificant	-	1	1	1	1	1	-
Concrete Troweller/Leveler	-	NA - insignificant	-	-	-	-	-	1	-
Mini-Elevator	-	NA - insignificant	-	-	-	-	-	-	1
Generator	-	118	1	1	1	1	1	1	1
Concrete Batch Plant	-	114	-	1	1	-	-	1	-

Operation and Maintenance

A virtual noise source approach (described in Appendix I), which is used to represent the various building types that are expected to be constructed for the future operating scenarios, has been adopted for assessment of the Project. A list of virtual sources used to represent the various building types expected for the WWMF expansion project is provided in Table 5-18.

Table 5-18: Virtual WWMF Expansion Noise Sources by Building Type

Building	Source Description	Sound Power Levels (dBA)
LLSB	LLSB Exhaust 1	93
	Representative Virtual Source	**93**
LOPB	Grouting Bay Exhaust	93
	Processing Bay Exhaust	93
	Liquid Waste Treatment Exhaust	93
	Segment Staging Bay Exhaust	93
	Representative Virtual Source	**99**
RCSB	RC Storage Exhaust 1	93
	RC Storage Exhaust 2	93
	Representative Virtual Source	**96**
SGSB	SG Storage Exhaust 1	93
	SG Storage Exhaust 2	93
	Representative Virtual Source	**96**
UFDSB*	Emergency Generator	101
WSB	Exhaust 1	93
	Representative Virtual Source	**93**

*This identifies a group of four UFDSBs, with one generator source for all of these buildings.
The UFDSBs have no significant noise sources associated with them. The generator is an actual source in this case, but included in the virtual source list above.

The full list of modeling scenarios (OA through OT) considered for the Project is provided in Appendix I. From the results of the noise assessment, scenarios OD and ON were considered to be the worst-case impact scenarios, and are presented in Table 5-19.

Table 5-19: Virtual WWMF Expansion Noise Sources by Future Operational Worst Case Scenario

Future Operational Scenario	Expansion Location	Building Type	Sound Power Levels (dBA)
OD	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
ON	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96

Note:

1) WSB or LLSB could replace the RCSB/SGSB building sources in the table. If so, then as the WSB or LLSB is 3 dB quieter than the RCSB/SGSB building sources (as noted in Table 5-18) the resulting modelled noise impact would be lower than modelled with the RCSB/SGSB.

2) Table 5-19 to be read in tandem with Table 5-22.

Existing Operations

Noise emission sources used for modelling the noise emissions from the existing operational WWMF are provided in Table 5-20. Sources were determined from the building locations given in Figure 4-2.

Table 5-20: Existing WWMF Noise Sources

Building	Source Description	Sound Power Levels (dBA)
LLSB #1-14	LLSB Exhaust 1	93
	LLSB Exhaust 2	93
	LLSB Exhaust 3	93
	LLSB Exhaust 4	93
	LLSB Exhaust 5	93
	LLSB Exhaust 6	93
	LLSB Exhaust 7	93
	LLSB Exhaust 8	93
	LLSB Exhaust 9	93
	LLSB Exhaust 10	93
	LLSB Exhaust 11	93
	LLSB Exhaust 12	93
	LLSB Exhaust 13	93
	LLSB Exhaust 14	93
RCSB #1 & SGSB #1	RCSB Exhaust 1	93
	RCSB Exhaust 2	93
	SGSB Exhaust 1	93
	SGSB Exhaust 2	93
Used Fuel Processing	DSC processing Building Exhaust Stack	97
	Paint Bay Exhaust	109
	Drain Weld Exhaust Fan	87
UFDSB	Emergency Generator	101
WVRB and Amenities	Lime Silo Dust Collector	78
	Incinerator Exhaust Stack	101
	Truck Bay Area Exhaust Stack	100
	WVRB Ventilation Stack	112
Transportation Package Maintenance Building	TPMB Exhaust Stack	107
Outdoor	Idling Truck 1	98
	Idling Truck 2	98
	Idling Truck 3	98

Noise sources used for the noise emissions from other Bruce nuclear site facilities are provided in Table 5-21. These are based on 2008 noise modelling results from spot measurements around the site, referenced from the Bruce Power New Build EA Air Quality and Noise Technical Support Document [21], and adjusted based on revised spot measurements conducted in 2015 [8]. These revised measurements indicated that the other Bruce nuclear site noise levels had increased by approximately 2 dB since the original assessment; the other Bruce nuclear site noise sources were adjusted accordingly to reflect this 2 dB increase.

Table 5-21: Noise Sources from Other Bruce Nuclear Site Operations

Source Name	Sound Power Levels (dBA)
Other Bruce nuclear site General Operating Noise Source 1 (nighttime)	121
Other Bruce nuclear site Emergency Generator 1 (daytime)	122
Other Bruce nuclear site General Operating Noise Source 2 (nighttime)	121
Other Bruce nuclear site Emergency Generator 2 (daytime)	122

5.2.3.4 Scenarios

<u>Site Preparation</u>

Two site preparation activities have been identified: clearing the site, and grubbing and removing overburden. Clearing and grubbing activities are to occur in expansion areas 1, 2 and 3. For modelling purposes, site preparation activities have been considered to occur independently in each expansion area (1, 2, or 3), and simultaneous activities occurring in expansion areas 1+3 and 2+3.

Although some marginal clearing or grubbing activities can be expected in expansion area 4, activities of this nature and scale were considered negligible. As such, area 4 site preparation activities will not result in adverse effects and hence are not considered further.

<u>Construction</u>

Seven construction activities have been identified for the Project:

1. Install underground site services;
2. Final preparation of site (to get the level compacted gravel to be smooth and ready for construction of buildings and asphalt);
3. Pour foundation/footings;
4. Install walls (walls, columns, roof beams and roofs);
5. Install roof;
6. Pour the floor; and
7. Install torched on roof onto concrete.

Construction activities may occur concurrently at potential expansion areas, as follows:

- Scenario A: areas 1/2 and 3;
- Scenario B: areas 1/2 and 4; and,
- Scenario C: areas 3 and 4

"1/2" indicates expansion areas 1 and 2 are to be considered a consolidated construction area.

Operation and Maintenance

For the purpose of defining the future expansion WWMF operating scenarios, the following have been considered for noise modelling purposes:

- There will be ten buildings constructed for future operation and maintenance;
- Building types include four UFDSBs; four L&ILW Storage Buildings; LOPB; and WSB;
- The L&ILW Storage Buildings could be a combination of LLSBs, SGSB and RCSB; and,
- The final location of each building has not yet been determined.

To address the bullets immediately above, the number of potential buildings that could be located on any one expansion area must be defined. As a conceptual design exercise, and notwithstanding space or operational limitations on which buildings could be placed on a given expansion area (to be specified during detailed design), the following future operating scenarios based on the number of buildings on a given expansion location have been defined for modelling purposes (Table 5-22). The full list of modeling scenarios (OA through OT) considered for the Project is provided in Appendix I. From the results of the noise assessment, scenarios OD and ON were considered to be the worst-case impact scenarios, and are presented in Table 5-22.

Table 5-22: WWMF Expansion Building Distributions (Worst Case Scenarios)

Future Operating Scenarios	Number of Buildings per Expansion Location			
	1	2	3	4
OD	3	1	4UFDSB+1	1
ON	3	1	1	4UFDSB+1

Note:
1) There will be 4 UFDSBs constructed in a cluster, located at either expansion area 3 or 4. A maximum of 10 buildings could be constructed on expansion areas 3 and 4, including the 4 UFDSB cluster.
2) Table 5-22 should be read in tandem with Table 5-19.

Effects from Existing Facilities

The noise impact from the existing WWMF has been based on the building types identified for the Project. This includes LLSBs, SGSB, RCSB, UFDSBs, WVRB and a TPMB. Noise sources for the existing WWMF were identified from the MOECC ECA and the supporting ESDM Report [16].

Noise impacts from other Bruce nuclear site operations were based upon predicted noise levels provided in the Bruce Power New Build Environmental Assessment Air Quality and Noise Technical Support Document [21]. These predictions were based on

2008 noise modelling results from spot measurements[9] around the site. Noise measurements have been revised [8] to provide a 2015 estimate which indicated the other Bruce nuclear site noise levels had increased by approximately 2 dB since the original assessment. The noise effects from other Bruce nuclear site noise sources were adjusted accordingly to reflect this 2 dB increase.

5.2.3.5 Modelling Inputs

The topographical data between sources and receptors, which is used by the Cadna/A model for predicting noise propagation, was determined for the Project based on Google Earth imagery.

Noise sources are characterized by entering the sound power and/or sound pressure level associated with each source. For the Project, noise source emissions were determined from manufacturers' data and when available, based on manufacturer model types (refer to Table 5-16, Table 5-17, and Table 5-18). For all modelling scenarios, all noise sources are assumed to be operating simultaneously within the same one-hour period.

5.2.3.6 Discipline-Specific Assumptions

One emergency generator (150 kW) is required for the four UFDSBs during the operation and maintenance phase. Typically, the generator runs for approximately 20 min for monthly maintenance testing. For the future expansion, four UFDSBs would likely be constructed on expansion area 3 or 4, due to space considerations.

Site preparation activities (clearing, grubbing) will be considered for expansion locations 1, 2, and 3. While it has been acknowledged that there may be some marginal clearing and/or grubbing in expansion location 4, it is likely to have an insignificant noise impact. Therefore, site preparation for expansion location 4 was not modelled. Site preparation modeling scenarios (1, 2, 3, 1+3, 2+3) represent the one-hour noise impact periods when site preparation activities occur concurrently.

Construction equipment required is the same regardless of specific building type (LLSB, UFDSB, RCSB, SGSB, LOPB, etc.). Generators (300 kW) on each expansion location will be running to provide power to support construction activity. Construction activity is limited to the allowable timeframes as specified in the Kincardine Noise Bylaw [19]. Construction activity outside these times and days will require a construction noise impact assessment to be completed by the contractor as part of any noise bylaw exemption to address expected impacts to noise sensitive receptors. Construction equipment is expected to meet applicable noise standards and legislation.

Noise sources have been provided by supporting documentation and reference material where available. Reasonable engineering assumptions regarding the number of sources, sound levels, and associated locations when and where detailed information has not been available have been provided.

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[9] These are defined as short-duration (usually around 5 minutes) to give a representative sample of the acoustic environment being measured.

The type of noise sources and their respective sound power levels for construction were taken from reference [15].

The LOPB is a new building type and new operation at the WWMF site. A description of the LOPB operations indicates diamond wire cutting or plasma arc welding system will occur inside the building. Due to the expected construction of the building, it was considered to be designed such that cutting noise (whether from diamond or plasma operations) will be internal to the building, and no significant cutting noise will be heard outside the building itself.

5.2.3.7 Results

Terrestrial noise impact results are presented in Appendix D for reference.

Human Health

Noise impact results for human receptors (R1, R2, and R3) are provided below. Human receptor locations are given in Figure 5-7.

Site Preparation

The full list of modelling scenarios (1, 2, 3, 1+3, 2+3) for the Project is provided in Appendix I, and represents the expected one-hour noise impacts where all expansion areas for site preparation occur concurrently. From the results of the site preparation noise assessment, the worst-case impact scenarios occur during clearing the site, when construction occurs concurrently in areas 1+3 or 2+3, with the modelled noise level presented in Table 5-23.

Table 5-23: Modelled Noise Levels - Site Preparation (Worst-Case Impact Scenarios)

Name	Modelled Noise Level L_{eq} (1 h), dBA	
	Clearing the Site	
	1+3	2+3
R1 - Albert Street	35	35
R2 - Baie du Doré	38	37
R3 - Inverhuron Park	34	34

Construction

The full list of modeling construction scenarios for the Project is provided in Appendix I. From the results of the construction noise assessment, the worst-case impact scenarios are presented in Table 5-24.

Table 5-24: Modelled Noise Levels – Construction (Worst-Case Impact Scenarios)

Name	Maximum Modelled Noise Level from Construction L_{eq} (1 h), dBA
R1 - Albert Street	34
R2 - Baie du Doré	37
R3 - Inverhuron Park	34

Operation and Maintenance

The modelled noise impacts for the future operating scenarios are provided in Table 5-25. The full list of modeling scenarios (OA through OT) considered for the Project is provided in Appendix I. From the results of the noise assessment, scenarios OD and ON were considered to be the worst-case impact scenarios, and are presented in Table 5-25.

Table 5-25: Modelled Noise Levels - Operation and Maintenance (Worst-Case Impact Scenarios)

Future Operating Scenario	Modelled Noise Level L_{eq} (1 h), dBA					
	R1		R2		R3	
	Day	Night	Day	Night	Day	Night
OD	17	16	19	19	16	14
ON	17	16	19	19	16	14

Combined Operation

The modelled operational noise impacts for the existing and future WWMF with other Bruce nuclear site operations, and comparison to the noise criteria outlined in Section 6.4.1 is provided in Table 5-26.

Table 5-26: Operational Noise Levels - WWMF and Other Bruce Nuclear Site Operations and Maintenance

Receptor Description	Modelled WWMF Current Operational Noise Levels L_{eq} (1 h) dBA		Modelled WWMF Future Operational Noise Levels L_{eq} (1 h) dBA		Modelled WWMF Combined Operational Noise Levels L_{eq} (1 h) dBA		Modelled Other Bruce Nuclear Site Operational Noise Levels L_{eq} (1 h) dBA		Modelled Total Operational Noise Levels L_{eq} (1 h) dBA	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R1 - Albert Street	26	26	17	16	27	26	30	29	32	31
R2 - Baie du Doré	26	26	19	19	27	27	42	41*	42	41*
R3 - Inverhuron Park	25	25	16	14	26	25	34	33	35	34

* For the combined WWMF and other Bruce nuclear site night levels (41 dBA total) which exceed the MOECC night criteria, the main contribution is from other Bruce nuclear site operations (41 dBA). The noise levels emitted from the WWMF (27 dBA) are significantly lower than the other Bruce nuclear site operations and as such do not significantly contribute to the total noise levels at R2.

Non-human Biota

Changes in noise levels have the potential to interact with mammalian receptors, bird receptors, and amphibian receptors. An evaluation of the worst-case bounding scenario for the terrestrial environment was undertaken for the purpose of presenting Project-related noise effects on VECs and associated ecological receptors. The same ecological receptor locations selected for air quality modelling were used to assess changes in noise level that would potentially pose an adverse effect to wildlife species (Figure 5-6).

Worst case scenarios for site preparation, construction and operations phases were selected with respect to terrestrial VECs as per the following criteria:

- Greatest number of ecological receptor locations having an exceedance of the noise effect criteria on wildlife (see Section 7.5.1.3 for noise effect thresholds to wildlife); and,
- Exceedance of noise level criteria at ecological receptor location(s) which were located within proximity to known occurrence of indicator species.

Based on this terrestrial based evaluation of noise scenarios, the worst-case scenario included:

- Site preparation: areas 2 & 3 (shared fleet);
- Construction: areas 1 & 2 (shared fleet) and area 3 (full fleet); and
- Operation and maintenance: Scenarios OI and OJ (both equally).

The baseline and worst-case modelled linear noise levels (dB) relative to the terrestrial environment are provided in Table 5-27. All modelled scenarios are provided in Appendix D.

Table 5-27: Modelled Maximum Changes to Noise Levels (in L_{eq} (1 h)) at Ecological Receptors

Receptor Location	WWMF Baseline ERA Noise Levels (dB)	Modelled Noise Levels due to Project Activities (dB)	Combined Modelled Noise Levels (dB)
Site Preparation			
1	64	72	73
2 (ER7)	69	71	73
3 (ER4)*	67	90	90
4	67	78	78
5	76	67	77
6 (ER3)	65	68	70
7	76	68	77
8 (ER5)	69	73	74
9 (ER6)	66	68	70
10	64	71	72
Construction			
1	64	70	71
2 (ER7)	69	71	73
3 (ER4)*	67	85	85
4	67	75	76
5	76	63	76
6 (ER3)	65	64	68
7	76	63	76
8 (ER5)	69	70	73
9 (ER6)	66	68	70
10	64	69	70
Operation and Maintenance			
1	64	53	64
2 (ER7)	69	51	69
3 (ER4)*	67	66	70

Receptor Location	WWMF Baseline ERA Noise Levels (dB)	Modelled Noise Levels due to Project Activities (dB)	Combined Modelled Noise Levels (dB)
4	67	47	67
5	76	47	76
6 (ER3)	65	47	65
7	76	42	76
8 (ER5)	69	44	69
9 (ER6)	66	42	66
10	64	52	64

*3 (ER4) is within the footprint of area 3.

5.3 Soil

5.3.1 Estimation of Radiological Concentrations

As discussed in Section 5.2.1, airborne radiological emissions from site preparation and construction are negligible. Therefore, soil contamination due to deposition of airborne radionuclides is unlikely. During operation and maintenance, it is likely that airborne radionuclides will deposit to the ground through dry and wet deposition. The radionuclide concentrations in soil in the vicinity of the WWMF were estimated using the IMPACT code based on the predicted airborne emissions discussed in Section 5.2.1. The results are provided in Table 5-28, which are used for the calculation of doses to non-human biota. Note that doses to human receptors including exposure to radionuclides in soil at off-site locations are directly calculated using the IMPACT code based on the airborne (Section 5.2.1) and waterborne emissions (Section 5.4.2) estimated. Therefore, the radionuclide concentrations in soil at off-site locations are not provided here.

Table 5-28: Estimated Concentration of Radionuclides in Soil Resulting from the Project

Radionuclide	HTO	C-14	I-131	Co-60
Concentration in soil (Bq/kg ww)*	2.0E+01	1.8E-05	4.6E-06	1.7E-03
Concentration in soil (Bq/m^2)**	6.0E+03	5.4E-03	1.4E-03	5.2E-01

ww – wet weight
* Based on the default values for transfer of HTO and C-14 from air to soil pore water in [23]. It is assumed that 1 kg of wet soil contains 0.93 kg of dry soil.
** It is assumed that the density of dry soil is 1500 kg/m^3 and the soil depth is 20 cm.

5.3.2 Estimation of Non-Radiological Concentrations

The sources of non-radiological emissions during the Site Preparation and Construction phases are as follows:

- Disturbance and transfer of soil during site clearing and maintenance of the cleared area;
- Disturbance and transfer of soil during excavation; and,
- Disturbance of soil during grading, compaction, paving and landscaping.

The disturbance and transfer of soil from the WWMF expansion area could result in the generation of dust and subsequent deposition onto uncovered soil areas surrounding the WWMF expansion area.

Neither health nor ecological risks were identified due to exposure to soil from the WWMF expansion area in the ERA [8]. As such, measureable changes to soil, via air emissions and resulting deposition onto soil from the Site Preparation and Construction phases, are not expected and therefore are not assessed further.

Other sources of non-radiological emissions during the Site Preparation and Construction phases would include:

- Road dust emissions (re-entrained dust);
- Tailpipe exhaust from vehicles (including construction machinery); and
- Exhaust from back-up power generation.

The nature of these emissions from the Site Preparation and Construction activities (i.e., tail-pipe exhausts and exhaust from back-up power generation) are temporary and have a sufficiently low magnitude such that the existing soils are not anticipated to be affected and therefore are not assessed further.

Operation and Maintenance of the future buildings at the WWMF are not expected to impact soils. Furthermore, a measureable change in air emissions from existing operations as identified under Section 5.2.2.4, which could impact deposition onto soil, is not expected. As such, measureable changes to soil, via air emissions and resulting deposition onto soil from Operation and Maintenance activities, are not expected and therefore are not assessed further.

5.4 Surface Water and Sediment

5.4.1 Surface Water Flow

5.4.1.1 Assessment Indicators

The proposed site layout includes four potential expansion areas, presented in Figure 5-8. The surface water quantity results were developed assuming concurrent development of all four areas to provide conservative estimates of potential adverse effects, and to allow for flexibility in the design. The potential expansion areas are located primarily within two watersheds (the South Railway Ditch and the West Ditch watersheds), with a small portion of potential expansion area 3 located in a third watershed (draining to the Central Pond).

The water quantity assessment requires comparing the results of the water quantity analysis to evaluation criteria to determine whether there are potential adverse effects on the environment. For a change to be considered to have a potential adverse effect, it must be measurable (i.e., detectable by using standard streamflow measurement techniques). The typical flowmeter accuracy is assumed to be ±15% as per the DGR Surface Water TSD [24][10]. Therefore changes in flow greater than ±15% are measureable and could cause potential impacts.

[10] This reference was an enclosure to the DGR EA submission document [6].

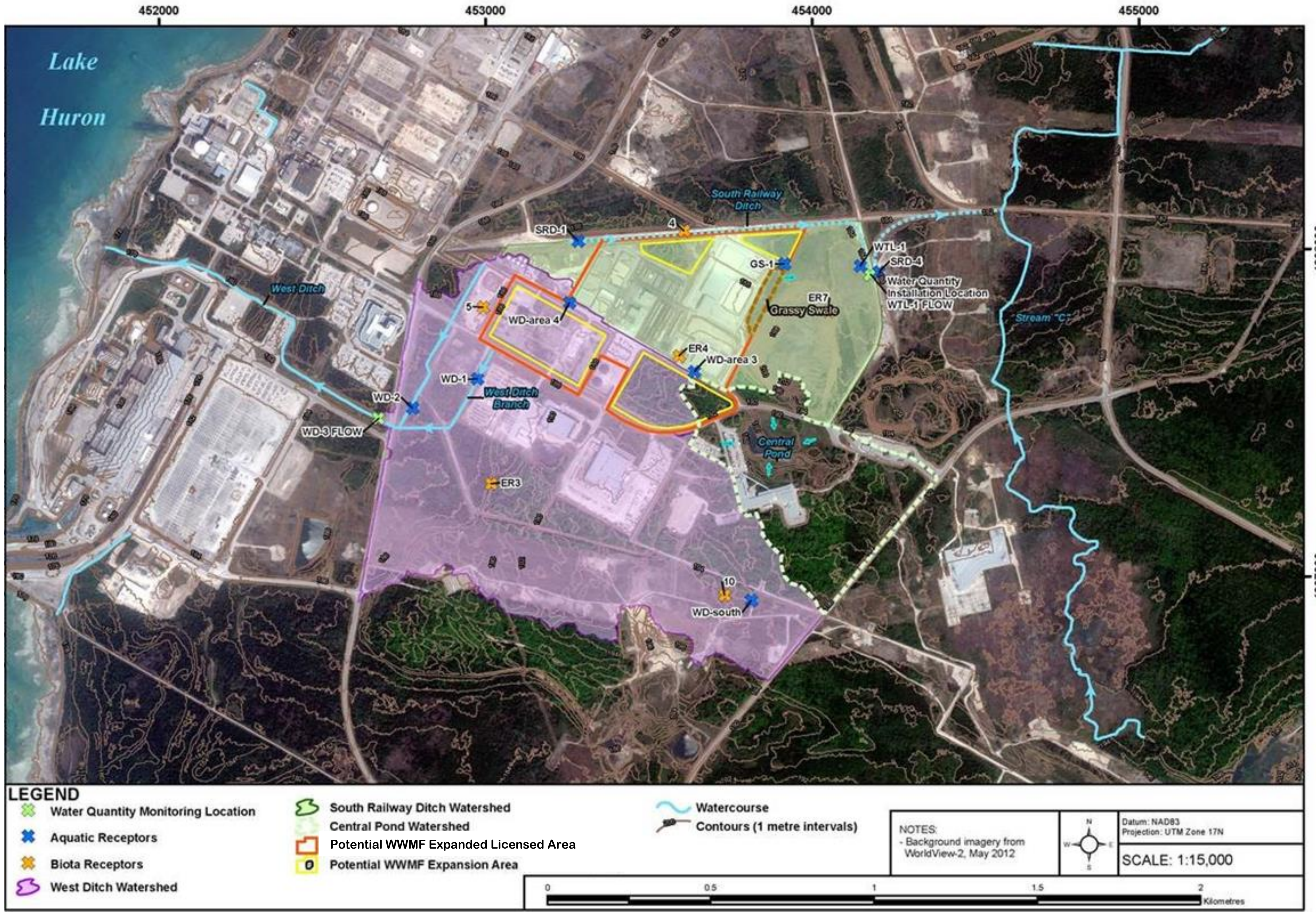

Figure 5-8: Potential Expansion and Watershed Areas

5.4.1.2 Model

Expected changes to annual flow in the South Railway Ditch and West Ditch as a result of the development of the WWMF expansion were quantified. The flow to the South Railway Ditch was assessed at the point where the South Railway Ditch enters the Bruce Power leased lands (flow monitoring point WTL-1 FLOW as shown in Figure 5-8), which is at the culvert crossing located immediately downstream of the wetland. The flow to the West Ditch was assessed at the culvert crossing of the Interconnecting Road (flow monitoring point WD-3 FLOW as shown in Figure 5-8). These assessment points were selected due to their upstream location in the affected watersheds, which provides a more conservative indication of the impact of the WWMF expansion.

The annual flows in each ditch were calculated using the following equation:

$$Q_{total} = Q_{undeveloped} + Q_{developed}$$

$$Q_{undeveloped} = P * C_{undeveloped} * (A_{exist} - A_{dev\_in\ WS})$$

$$Q_{developed} = P * C_{developed} * A_{totaldev}$$

Where:

Q_{total} = the total annual runoff from the watershed;

$Q_{undeveloped}$ = the total annual runoff from the undeveloped portion of the watershed;

$Q_{developed}$ = the total annual runoff from the developed portion of the watershed;

P is the annual rainfall amount (average, 1 in 20 wet year or 1 in 20 dry year);

$C_{undeveloped}$ = the undeveloped runoff coefficient corresponding to the rainfall condition;

A_{exist} = the existing watershed area of the watershed being considered;

$A_{dev\_in\ WS}$ = the area of potential expansion within the existing watershed being considered;

$C_{developed}$ = the developed runoff coefficient corresponding to the rainfall condition; and,

$A_{totaldev}$ = the total developed area of all four potential expansion areas.

In addition, the Personal Computer Storm Water Management Model (PCSWMM) software was used (Section 5.4.1.5). This is a continuous simulation stormwater/drainage modelling software package commonly used for hydrologic and hydraulic simulations. The model is based on U.S. Environmental Protection Agency's Storm Water Management Model [25].

5.4.1.3 Sources of Effect

Direct effects during construction are anticipated to be less than those during operation and maintenance, as there is a smaller extent of hardened surface areas. The operation and maintenance period represents the worst case scenario in terms of increases to annual flow, and any effect generated during the site preparation and construction period would be lower than the effect generated during the operation and maintenance period. Therefore the water quantity analysis has been carried out on the operation and maintenance phase only.

5.4.1.4 Scenarios

The entirety of potential expansion areas 1, 2, 3 and 4 were assumed to be developed, resulting in an upper bound scenario in terms of impacts on surface water flow. Two cases were considered:

- Case 1 – All the runoff from potential expansion areas 1, 2, 3 and 4 is assumed to be directed to the South Railway Ditch; and
- Case 2 – All the runoff from potential expansion areas 1, 2, 3 and 4 is assumed to be directed to the West Ditch.

These two evaluation cases, by directing all the expansion area runoff entirely to one of the two drainage ditches (as opposed to distributing this runoff between two ditches), represent the most conservative assumptions for impacts on runoff quantity. These cases are considered unlikely, as topography and grading constraints will likely result in runoff being split between the two watersheds. Average, wet and dry precipitation years have been considered for Case 1 and Case 2.

5.4.1.5 Model Inputs

<u>Drainage Areas</u>

The locations and boundaries of the existing watersheds draining to the South Railway Ditch and West Ditch are provided in Figure 5-8. The size of the existing watersheds draining to the South Railway Ditch and West Ditch are listed in Table 5-29.

Table 5-29: Existing Watershed Areas

Watershed	Area (ha) A_{exist}
South Railway Ditch	40.88
West Ditch	103.54

A previous study of the area [26] indicated a much larger drainage area to the South Railway Ditch (and ultimately Stream C), which included the area draining to the Central Pond (shown in Figure 5-8). The Central Pond has sufficient capacity to retain surface runoff up to the volume of the 100-year event before discharging to the South Railway Ditch. Therefore the drainage area of the Central Pond has a negligible contribution to the South Railway Ditch under the conditions assessed and therefore has not been included in the water quantity assessment.

The size of the potential expansion areas 1, 2, 3 and 4 are listed in Table 5-30.

Table 5-30: Potential Expansion Areas 1, 2, 3 and 4

Potential Expansion Area	Total Area (ha) $A_{totaldev}$	Area in South Railway Ditch Watershed (ha) $A_{dev\_in\ SRD}$	Area in West Ditch Watershed (ha) $A_{dev\_in\ WD}$	Area in Central Pond Watershed (ha)
1	0.93	0.93	-	-
2	1.30	1.30	-	-
3	4.70	-	3.69	1.01
4	5.42	-	5.42	-
Total	12.36	2.23	9.11	1.01

The entirety of potential expansion areas 1, 2, 3 and 4 were assumed to be developed, resulting in an upper bound scenario in terms of impacts on surface water flow.

Climate Data

Precipitation data for the nearby Wiarton A climate station were obtained from Environment Canada [27] for the period from 1981-2010, which are the most recent data available. The data are presented in Table 5-31. Data from the Wiarton A climate station is considered appropriate as precipitation data from the community of Tiverton was not available from Environment Canada.

Table 5-31: Mean Monthly and Annual Precipitation at Wiarton A

Month	Precipitation (mm)
January	99.5
February	74.0
March	67.4
April	73.1
May	83.5
June	76.4
July	65.8
August	77.7
September	103.1
October	101.0
November	115.7
December	110.6
Annual	**1047.9**

Table 5-32 summarizes the mean and return period annual rainfall data for the WWMF site used in the water quantity assessment.

Table 5-32: Annual Precipitation Data

Condition	Value (mm)	Source
Average Year	1047.9	1981-2010 annual data for Wiarton A
1 in 20 Wet Year	1261.3	Gumbel double exponential distribution for annual extremes (method of moments)
1 in 20 Dry Year	786.5	3 parameter log normal distribution

Baseline Stream Flow Data and Runoff Coefficients

Stream flow data were utilized to develop annual runoff coefficients for the undeveloped conditions. Baseline stream flow data for nearby stream gauges were obtained from the Water Survey of Canada's hydrometric database HYDAT [28]. The gauges considered are Pine River at Lurgan (02FD001), Teeswater River near Paisley (02FC015), North Saugeen River near Paisley (02FC013), and Saugeen River near Port Elgin (02FC001). These are the same Water Survey of Canada gauges considered in the DGR Technical Support Document [24]. The duration of historical flow data, drainage areas, and mean monthly stream flows are provided in Table 5-33.

The average annual flows per unit area in Table 5-33 are similar for all streams analyzed, ranging from 0.014 to 0.017 $m^3/s/km^2$. The close range of these values and the proximity of the gauged watersheds to the study area indicate that this average watershed response can be considered representative of the undeveloped area reporting to the South Railway Ditch and the West Ditch.

Table 5-33: 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)	156		670		262		3954	
Data Duration	1974-2013		1972-2013		1972-1986		1914-2013	
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	$m^3/s/km^2$
January	2.54	0.016	14.15	0.021	3.8	0.014	61.0	0.015
February	3.20	0.021	13.28	0.020	4.5	0.017	60.7	0.015
March	6.77	0.043	27.97	0.042	8.8	0.034	129.5	0.033
April	3.23	0.021	24.97	0.037	9.7	0.037	144.6	0.037
May	1.02	0.007	9.42	0.014	5.5	0.021	61.0	0.015
June	0.75	0.005	5.28	0.008	3.5	0.013	34.1	0.009
July	0.24	0.002	3.03	0.005	2.5	0.009	24.2	0.006
August	0.21	0.001	2.53	0.004	2.2	0.009	17.7	0.004
September	0.94	0.006	3.44	0.005	2.6	0.010	20.5	0.005

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)	156		670		262		3954	
Data Duration	1974-2013		1972-2013		1972-1986		1914-2013	
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	$m^3/s/km^2$
October	1.27	0.008	5.64	0.008	2.9	0.011	32.0	0.008
November	2.57	0.016	10.74	0.016	3.9	0.015	51.6	0.013
December	3.26	0.021	13.24	0.020	4.5	0.017	60.4	0.015
Annual	2.17	0.014	11.14	0.017	4.53	0.017	58.11	0.015

Note: Data obtained from [28].

The average flow per unit area from these four stations is 0.016 $m^3/s/km^2$. This value generally agrees with the continuous flow data collected in the South Railway Ditch as part of the 2014 baseline monitoring studies. An average flow of approximately 0.0061 m^3/s was observed over the course of one year (April 2014-May 2015). The continuous monitoring location had a drainage area of approximately 0.4088 km^2, resulting in an average flow per unit area of 0.015 $m^3/s/km^2$. This indicates that, although there are significant areas already developed within the South Railway Ditch and West Ditch watersheds (in contrast to the Water Survey of Canada gauges which are in largely undeveloped watersheds), the average flow per unit area from the Water Survey of Canada data can be considered representative.

Utilizing this average annual streamflow of 0.016 $m^3/s/km^2$, and average year precipitation of 1047.9 mm, an annual runoff coefficient of 0.47 is obtained for the undeveloped (existing) condition. For wet and dry years, annual flows for representative years were selected from the available streamflow and precipitation data, allowing calculation of runoff coefficients for existing conditions in wet and dry years. The resulting runoff coefficients for the undeveloped condition are provided in Table 5-34.

The runoff coefficient for average year developed conditions (due to the Project) was based on a continuous rainfall runoff simulation from PCSWMM for Stormceptor [25] for the nearest available rainfall station (Owen Sound) assuming 70% impervious area. The resulting runoff coefficient for the average rainfall scenario for the developed condition (0.64), is approximately 35% larger than the undeveloped runoff coefficient. The developed runoff coefficients for wet and dry years were increased by the same proportion (35%), with the resulting runoff coefficients listed in Table 5-34.

Table 5-34: Annual Runoff Coefficients

Condition	Undeveloped $C_{undeveloped}$	Developed $C_{developed}$
Average	0.47	0.64
1 in 20 Year Wet	0.55	0.74
1 in 20 Year Dry	0.45	0.61

5.4.1.6 Discipline-Specific Assumptions

The potential impacts of the Project on surface water flow and quantity are assessed based on the following assumptions:

- As mentioned above in Section 5.4.1.3, the operation and maintenance phase is expected to cause a larger increase to annual flow than the site preparation and construction period, therefore the operation and maintenance period has been used as the basis for the evaluation of potential adverse effects;
- It is assumed that the WWMF stormwater management system (in-design mitigation) will be built to an enhanced level of water quality protection as per MOECC design guidelines and meet the criteria for peak flow control: peak flows must not exceed pre-development values for storms with return periods ranging from 2 to 100 years [29]. As such, no change to existing channel forming flows, flood risk, or erosion potential will be expected. The stormwater management system itself will not represent an adverse effect to water quantity;
- Typically, stormwater management systems aim to reduce flooding and erosion risk by retaining runoff from developed areas and releasing it at a controlled rate (similar to pre-development conditions) to the environment. However, the annual runoff volume discharged through a stormwater management system is a function of the upstream catchment area and land use, and is generally not affected by stormwater management. Therefore the proposed stormwater management systems are not expected to have a potential adverse impact on annual runoff rates to the South Railway Ditch and West Ditch; and,
- Based on Section 5.5.1, it is understood that the thin sand / gravel / fill unit at the surface currently discharges rapidly to local drainage features and from there to the South Railway Ditch or West Ditch. The deepest excavation for the new buildings is assumed to not affect the hydraulic functioning of the silt till aquitard beneath the sand / gravel / fill unit. Thus any water that is expected to be intercepted and pumped to surface water features during construction is water that would be expected to discharge rapidly to surface water under current conditions. Therefore, there are likely no adverse effects from groundwater flow.

5.4.1.7 Results

Table 5-35 provides a summary of results of the water quantity assessment, and Appendix E provides the complete water quantity analysis. The results show that the expected change in flow during a wet year exceeds the expected change during average conditions, while the expected change in flow during a dry year is less than the expected change for average conditions. The percentage change in flow is the same for average, wet and dry years, as the developed runoff coefficients were all calculated based on the same proportion.

For Case 1, where all runoff from the potential expansion areas is directed to the South Railway Ditch, the change in runoff to the South Railway Ditch is estimated to be 35.4% compared to baseline conditions, while the change to the West Ditch is estimated to be -8.8% compared to baseline conditions. For Case 2, where all runoff from the potential expansion areas is directed to the West Ditch, the change in runoff to the West Ditch is estimated to be 7.3% compared to baseline conditions, while the change to the South Railway Ditch is estimated to be -5.5% compared to baseline conditions.

Table 5-35: Expected Effects on Surface Water Quantity and Flow

	Precipitation Condition		
	Average Annual	**1 in 20 Wet Year**	**1 in 20 Dry Year**
Existing Conditions (Baseline)			
Annual Flow (L/s)			
South Railway Ditch	6.4	8.9	4.6
West Ditch	16.2	22.6	11.6
Case 1			
Annual Flow (L/s)			
South Railway Ditch	8.7	12.1	6.2
West Ditch	14.8	20.6	10.6
Change in Annual Flow from Baseline (L/s)			
South Railway Ditch	2.3	3.2	1.6
West Ditch	-1.4	-2.0	-1.0
Change in Annual Flow from Baseline (%)			
South Railway Ditch	35.4%	35.4%	35.4%
West Ditch	-8.8%	-8.8%	-8.8%
Case 2			
Annual Flow (L/s)			
South Railway Ditch	6.0	8.4	4.3
West Ditch	17.4	24.3	12.5
Change in Annual Flow from Baseline (L/s)			
South Railway Ditch	-0.3	-0.5	-0.3
West Ditch	1.2	1.7	0.9
Change in Annual Flow from Baseline (%)			
South Railway Ditch	-5.5%	-5.5%	-5.5%
West Ditch	7.3%	7.3%	7.3%

Notes:
Case 1 – Runoff from potential expansion areas 1, 2, 3 and 4 is directed to South Railway Ditch
Case 2 – Runoff from potential expansion areas 1, 2, 3 and 4 is directed to West Ditch

5.4.2 Estimation of Radiological Emissions and Concentrations in Surface Water and Sediment

5.4.2.1 Site Preparation and Construction

No radiological materials will be involved during site preparation and construction. Therefore, it is likely that there will be no radiological emissions to surface water. It is possible that stormwater runoff during these stages could become contaminated due to existing soil contamination resulting from the historical operation of the WWMF. However, it is likely that waterborne emissions during these stages will be bounded by those during the operation and maintenance phase.

5.4.2.2 Operation and Maintenance

As discussed in Section 5.2.1, tritium and other radionuclides could be released to air during the operation and maintenance phase. Therefore, stormwater could be contaminated by deposition of these radionuclides. As such, there is the potential that waterborne emissions could occur via stormwater runoff during operation and maintenance. In this assessment, the waterborne emissions resulting from the Project were estimated based on the predicted bounding airborne emission and the results, representing the bounding waterborne emissions, are presented in Table 5-36. Detailed analysis is provided in Appendix B.

Table 5-36: Predicted Waterborne Emissions Resulting from the Project

Waterborne emission	HTO	Gross Beta/Gamma	C-14
Predicted waterborne emissions resulting from the Project (Bq/y)	1.4E+11	1.7E+07	9.7E+08

*The total airborne emissions of I-131 and particulates are used to estimate waterborne emissions of gross beta/gamma.

Accordingly, the radionuclide concentrations in water in the vicinity of the WWMF were estimated for the following two cases:

- Case One: All additional drainage will be discharged to South Railway Ditch; and,
- Case Two: All additional drainage will be discharged to West Ditch.

The waterborne emissions and flow rates for the two cases are presented in Section B.2 and Section 5.4.1, respectively. The concentrations were calculated using the following equation:

$$\text{Concentrations (Bq/L)} = \text{Emission rate (Bq/s)} / \text{Flow rate (L/s)}$$

The results, representing the bounding incremental water concentrations due to the Project, are presented in Table 5-37. The maximum values will be used for dose calculations for non-human biota.

Note that doses to human receptors including exposure to radionuclides in water at off-site locations are directly calculated using the IMPACT code based on the airborne and waterborne emissions estimated. Therefore, the radionuclide concentrations in water at off-site locations are not provided here.

Table 5-37: Estimated Concentration of Radionuclides in Water Resulting from the Project and Baseline

Radionuclide		HTO (Bq/L)	C-14 (Bq/L)	Cesium-137* (Cs-137) (Bq/L)
Case One	**South Railway Ditch**	2.9E+02	3.4	5.2E-02
	West Ditch**	0	0	0
Case Two	**South Railway Ditch†**	1.3E+02	2.8	3.9E-02
	West Ditch	2.2E+02	8.3E-01	1.8E-02
Maximum‡		2.9E+02	3.4	5.2E-02

* The total activity of gross beta/gamma was assigned to Cs-137, which is the limiting radionuclide for the beta/gamma emitters for waterborne emissions [10].
** No data available for baseline.
† Levels from the South Railway Ditch are not 0 for Case Two due to existing baseline flows, which will continue to be directed to the South Railway Ditch.
‡ The results represent the bounding incremental water concentrations due to the Project.

The concentrations of radionuclides in sediment were then estimated using IMPACT based on the highest water concentrations presented in Table 5-37. The results are shown in Table 5-38. Doses to human receptors including exposure to radionuclides in sediment at off-site locations are directly calculated using the IMPACT code. Therefore, the radionuclide concentrations in sediment at off-site locations are not provided here.

Table 5-38: Estimated Concentration of Radionuclides in Sediment Resulting from the Project

Radionuclide	HTO	C-14	Cs-137
Concentration in sediment (Bq/kg ww)*	2.3E+02	3.4E+01	3.1E+01

ww – wet weight
* It is assumed 80% of that sediment consists of water.

5.4.3 Estimation of Non-Radiological Emissions and Concentrations in Water and Sediment

5.4.3.1 Assessment Indicators

Water Quality Indicators

Water quality is critical for various life stages of organisms that inhabit the aquatic environment for all or part of their life cycle. Changes to water quality parameters such as suspended sediment concentration (i.e., water clarity), nutrients, trace metal concentrations, salinity and temperature can potentially affect the survival, reproduction and growth of sensitive species. Therefore, maintaining water quality within the range of natural variability will increase the probability that a sensitive species will be maintained in the environment.

The assessment indicators for the surface water quality are:

- Total suspended solids (TSS);
- Metals concentrations;
- Salinity (dissolved chlorides);
- Nutrients (phosphorus); and
- Water temperature.

Water quality indicators for the PEA were selected using the following criteria:

- The indicator groups listed above have previously been used to assess potential impacts to water quality as a result of Project development within the Bruce nuclear facility [24];
- Indicators were identified as being historically elevated ([24], [4]) within the surface waters within the vicinity of the Project or were identified as parameters with elevated concentrations when compared to existing criteria (i.e., Tier 1 ERA [8]);
- Indicators were reasonably expected to be present in surface runoff as a result of site clearing, construction and/or operation and maintenance for the WWMF expansion project. This was further considered within the context that soil contamination was not identified as a potential pathway of effect to water quality under the existing site conditions [8];
- There was an availability of literature values with respect to potential sources of the metals used as an indicator from industrial/commercial land use runoff sources. This was considered within the context that there was no industrial process identified as part of the Project that would constitute a point source input and increased risk to the environment (except for the LOPB which is assumed to have no impact on surface water as airborne emissions from this building are assumed to be negligible).

Further details with respect to identification of indicators are provided below.

In the absence of site specific data on wet weather flow water quality for the indicators, reasonable Event Mean Concentrations (EMCs) can be used from literature for industrial sites. The availability of EMCs from literature was important to allow for conservative modelling of potential changes in loadings of indicator parameters to surface waters.

Sodium adsorption ratio present in soil at the WWMF, as measured during the 2014 baseline monitoring studies, marginally exceeded Ontario background standards at localized areas. A risk to terrestrial plants and invertebrates by these parameters was not identified through the ERA process [8]. It is assumed that soils from these locations will be available for transport prior to clearing and construction of the site, and will be properly contained or remediated as per appropriate practices and following applicable regulations (*O. Reg. 153/04* [30]).

The concentration of TSS is a measure of the amount of particulates within the water column. Aquatic biota have varying sensitivities to TSS, yet elevated levels of TSS may affect behaviour, feeding success, respiration, and habitat structure and availability over the longer term. As TSS concentrations increase, the amount of light that penetrates into the water can also decrease. A decrease in light can affect plant growth and the health of benthic organisms.

Surface water metal concentrations identified through the WWMF ERA and 2014 baseline monitoring study [8] which were present at levels that may have the potential to affect biota (plants, invertebrates, fish and herpetofauna) included: cobalt, copper, iron and zinc. Concentrations of these metals in soils assessed through the WWMF baseline study and ERA were not identified to be above background criteria [8]. Following the criteria and rationale identified above for the selection of water quality indicators, copper and zinc were identified as having elevated concentrations in the past and may be expected to be released as a result of construction and operation and maintenance of the Project. Copper and zinc also had available EMC values for industrial land use. As such, these two parameters were chosen as reasonable indicators of potential increase in metals in the receiving surface water environment as a result of surface water runoff from the Project site. Each is a heavy metal which is capable of having acute and chronic toxicological effects to biota at elevated levels [31]. It was assumed that these parameters provided a reasonable indication of potential effects by the Project. Potential sources of zinc and copper in runoff are discussed in Section 5.4.3.5.

Stormwater management facilities (in particular wet ponds) have the potential to result in increased in-stream water temperatures by increasing the surface area of water exposed to sunlight, which results in a higher input of heat energy into the water column during summer and fall periods. Water temperature is an important component of the habitat for aquatic biota and influences species presence, community structure, growth, nutrient availability and dissolved oxygen concentration. Some species are sensitive to changes in water temperature during specific life stages. Changes to water temperature may affect overall water quality in supporting aquatic biota.

Nutrients (nitrogen, phosphorous and ammonia) in a water body control 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. Phosphorus is not considered toxic to aquatic organisms at levels and forms present in the environment. However the addition of phosphorous to an aquatic system can result in increased plant and algal growth which can results in negative effects to the ecosystem. Given the low flow drainage and depositional nature of the surface water at the WWMF site, the surface water bodies are considered to have meso-eutrophic to eutrophic characteristics.

Salinity (as indicated and measured as the concentration of dissolved chloride) in surface water although not directly toxic to aquatic biota, may influence presence, survival, growth and behaviour of aquatic biota. Concentrations of chloride in surface water exceeded the short-term and long-term benthic invertebrate toxicity benchmarks [31] at specific locations in the South Railway Ditch (identified during the 2014 baseline monitoring surveys). The potential for increases to salt content in surface water is assessed within the context of expected sources and changes that may occur as a result of the Project. Dissolved chloride was carried into the Tier 2 ERA [8] as it is expected to have the potential for increase due to an increase in impervious structures and, therefore, a marginal increase in the area that may require de-icing agents (i.e., sodium chloride); it was therefore used as an indicator of an effect to water quality (although one that is expected to be seasonal [spring high runoff events]).

Sediment Quality Indicators

Sediment quality is critical for organisms that inhabit the aquatic environment for all or part of their life cycle. Changes to sediment quality may affect benthic invertebrate communities. Therefore, maintaining sediment quality within the range of current site conditions will increase the probability that a species inhabiting the environment will be maintained. Elevated sediment concentrations of metals within the WWMF study area that were identified through the 2014 baseline assessment and the ERA [8] included: arsenic, copper, manganese, molybdenum, silver, sodium, strontium, tungsten and zinc. The levels of these parameters present in sediments are assumed to be due to historical inputs and represent the baseline condition prior to assessing potential effects of the Project. Potential effects to sediment quality by the Project are considered to be limited to potential changes to water quality and any potential loading of sediments from the site. Potential changes to water quality are too small to affect sediment quality, and therefore, sediment is not quantitatively assessed further.

5.4.3.2 Model

Expected changes to concentrations of surface water quality parameters in the receptor ditches as a result of the development of the WWMF expansion were quantified. The flows were assessed at the same points as were used in the water quantity assessment (Figure 5-8). Specifically, water quality for the purposes of this assessment was estimated at the following locations:

- The flow to the South Railway Ditch was assessed at the point where the South Railway Ditch enters the Bruce Power leased lands (flow monitoring point WTL-1 FLOW), which is at the culvert crossing located immediately downstream of the Wetland; and
- The flow to the West Ditch was assessed at the culvert crossing of the Interconnecting Road (flow monitoring point WD-3 FLOW).

These assessment points were selected due to their upstream location in the affected watersheds, which provides a more conservative indication of the impact of the WWMF expansion.

Flow rates applied in each ditch were derived as described in Section 5.4.1.5, using the average annual precipitation condition.

Runoff concentrations of TSS were estimated using a Soil Loss Tool based on the Universal Soil Loss Equation [32].

Surface water concentrations for all parameters (except temperature) were calculated using the following mass balance equation:

$$C_{overall} = \left(\frac{V_{undeveloped} C_{undeveloped} + V_{developed} C_{developed}}{V_{undeveloped} + V_{developed}} \right)$$

Where:

$V_{undeveloped}$ = the annual runoff volume from the undeveloped portion of the watershed;

$V_{developed}$ = the annual runoff volume from the developed portion of the watershed;

$C_{undeveloped}$ = the undeveloped area runoff concentration for the indicator of interest;

$C_{developed}$ = the developed area runoff concentration for the indicator of interest; and,

$C_{overall}$ = the resultant concentration for the indicator of interest, after combining runoff from undeveloped and developed areas.

Surface water temperature was calculated using the following energy balance equation:

$$T_{overall} = \left(\frac{M_{undeveloped} T_{undeveloped} + M_{developed} T_{developed}}{M_{undeveloped} + M_{developed}} \right)$$

Where:

$M_{undeveloped}$ = the mass of annual runoff from the undeveloped portion of the watershed;

$M_{developed}$ = the mass of annual runoff from the developed portion of the watershed;

$T_{undeveloped}$ = the undeveloped area runoff temperature;

$T_{developed}$ = the developed area runoff temperature; and,

$T_{overall}$ = the mixed temperature, after combining runoff from undeveloped and developed areas.

5.4.3.3 Identification of Sources

Direct effects during site preparation and construction are anticipated to be less than those during operation and maintenance, as there are no continuous loading sources to surface water during site preparation and construction. The only potential sources would be runoff from excavated soils that may be contaminated; however it is assumed that any contaminated soils would be properly contained or remediated as per appropriate practices and following applicable regulations [30], thus would not contribute loadings to surface water.

The only indicator which is expected to have a greater effect during site preparation than during operation and maintenance is TSS, as site preparation and construction activities typically provide an increased potential for erosion and sediment loading.

Therefore the water quality analysis for copper, zinc, total phosphorus, temperature and chloride has been carried out on the operation and maintenance phase only, whereas the water quality analysis for TSS was carried out for both phases.

5.4.3.4 Scenarios

The scenarios modelled are the same as those modelled in the water quantity assessment (Section 5.4.1.4), in which the entirety of potential expansion areas 1, 2, 3 and 4 were assumed to be developed, with two cases for directing the runoff:

- Case 1 – All the runoff from potential expansion areas 1, 2, 3 and 4 is assumed to be directed to the South Railway Ditch; and
- Case 2 – All the runoff from potential expansion areas 1, 2, 3 and 4 is assumed to be directed to the West Ditch.

These were selected to provide consistency with the water quantity assessment (Section 5.4.1.4), as the flow values developed are used as inputs to the water quality assessment. Flow values for average annual precipitation were used.

The potential expansion areas are located primarily within the South Railway Ditch and the West Ditch watersheds, with a small portion of potential expansion area 3 draining to the Central Pond. The results presented in this assessment were developed assuming total clearing of all potential development areas prior to construction to provide conservative estimates of potential adverse effects, and to allow for flexibility in the design. Under this approach, all four development areas will be considered hardened surfaces. All stormwater runoff from the proposed development areas (1 to 4) is assumed to be directed through the drainage system to only one of the two potential discharge areas, that is, the South Railway Ditch or West Ditch. This ensures the most bounding scenarios due to waterborne emissions are considered. Flow rates for the assessment were taken from the Water Quantity assessment (Section 5.4.1.5).

5.4.3.5 Model Inputs

Drainage Inputs

The drainage areas modelled are those discussed in Section 5.4.1.5., i.e., the South Railway Ditch area is 40.88 ha and the West Ditch is 103.54 ha (Table 5-29); similarly the drainage areas of potential expansion areas 1, 2, 3 and 4 total 12.36 ha as modelled in Section 5.4.1.5 (Table 5-30).

Water Quality in Runoff from Existing Site

Baseline water quality conditions were used to represent existing levels for indicators in runoff from the existing site, as current baseline conditions reflect the effect of existing infrastructure within currently developed portions of the drainage areas. The values and sources are presented as follows:

- Metals: Maximum measured background concentrations were estimated from baseline data collected in 2013 and 2014. Surface water trace metal indicator (copper and zinc) concentrations were measured and included for the South Railway Ditch (channel proper) and West Ditch as part of the 2013 EMP sampling, as described in the baseline ERA [8] and as identified during the 2014 baseline monitoring surveys. Maximum measured background concentrations were used unless otherwise stated.
    - Copper concentrations in water quality data collected in South Railway Ditch in 2013 and 2014 ranged from 0.000416 mg/L to 0.002 mg/L. Copper concentrations in water quality data collected in the West Ditch collected in 2014 ranged from 0.00078 to 0.00098 mg/L. The maximum measured background concentration for copper for the South Railway Ditch used in the analysis was 0.002 mg/L while the maximum for the West Ditch was 0.00098 mg/L.
    - Zinc concentrations in the South Railway Ditch and West Ditch during baseflow conditions between April 2014 and October 2014 ranged from 0.00268 mg/L to 0.0241 mg/L. The maximum measured zinc concentration for the South Railway Ditch used in the analysis was 0.1033 mg/L while the maximum measured concentration for the West Ditch was 0.00981 mg/L.
- Nutrients (Phosphorus): Measureable changes in nutrients as indicated by phosphorus were estimated using the background concentration of total phosphorus as identified during the 2014 baseline monitoring surveys. Total phosphorus concentrations in the South Railway Ditch and the West Ditch during baseflow conditions between April 2014 and October 2014 ranged from <2 to <4 µg/L (<0.002 to <0.004 mg/L). Concentrations below detection limits were assumed to have a total phosphorus concentration of 0.002 mg/L (except for one instance where detection was listed at 0.004 mg/L and included in average estimates as such). The maximum phosphorus concentration for the South Railway Ditch used in the analysis was 0.0263 mg/L while the maximum for the West Ditch was 0.0039 mg/L.
- Temperature: The baseline average annual temperature of both ditches was measured hourly from April to October 2014 as identified during the 2014 baseline monitoring surveys. The average temperatures over this period were similar for both ditches (15.9°C in the South Railway Ditch and 15.6°C in the West Ditch). The temperature history of the South Railway Ditch was considered to be representative of both ditches and was used for further analysis. Results from a level velocity probe installed in the South Railway Ditch with temperature measurements at 10-minute intervals from April 2014 to May 2015 were compared with the South Railway Ditch temperature data as identified during the 2014 baseline monitoring surveys and found to be in good

agreement. The level velocity probe data were added to the South Railway Ditch data to obtain an entire year of temperature measurements, which is considered to be representative of baseline average annual conditions for both ditches. The average baseline temperature assumed for both the South Railway Ditch and the West Ditch is 8.5°C.

- Chlorides: Baseline chloride concentrations in the South Railway Ditch (SRD-1) and West Ditch are consistently elevated upstream of the WWMF due to historic activities. Other areas sampled within the WWMF study area showed seasonal fluctuations in chloride concentration (i.e., Wetland, Grassed Swale). Concentrations within these features are more likely influenced by road salting practices on site. Baseline maximum concentrations of 460 mg/L (South Railway Ditch) and 420 mg/L (West Ditch) were used for estimating the potential for measurable change.
- TSS: Water quality was measured in the South Railway Ditch and West Ditch as part of the 2014 baseline field study. TSS concentrations in the South Railway Ditch and West Ditch during baseflow conditions between April 2014 and October 2014 ranged from <1 mg/L to 5 mg/L (3 sampling events). Concentrations measured after storm events ranged from <1 mg/L to 12 mg/L (2 sampling events). Due to the relatively small number of samples (5 sampling events), and anticipation that the observed post-storm event baseline condition may not necessarily reflect typical event-based upset conditions with drainage originating from a commercial/industrial based land use, the baseline TSS data were supplemented with site specific sampling data collected as part of the Surface Water Technical Support Document for the DGR [24]. An average TSS concentration of all samples collected in the South Railway Ditch and West Ditch was calculated to be 11.1 mg/L. TSS concentrations below detection limits were assumed to have a TSS concentration of 1 mg/L. A Soil Loss Tool was used to compute the baseline TSS for the site, and this gave a value of 13.5 mg/L. This value is similar to the average TSS concentration of 11.1 mg/L from baseline data collection, and as such is considered representative of the site and was utilized as a conservative average annual TSS concentration for baseline conditions for the South Railway Ditch and West Ditch. Further detail on use of the Soil Loss Tool estimates for TSS is provided in Appendix F.

The above values and the data sources are summarized in Table 5-39.

Table 5-39: Modelling Inputs - Water Quality in Runoff from the Existing Site

Indicator	Units	Maximum Measured Background Concentration		South Railway Ditch Data Source	West Ditch Data Source	Discussion
		Conc. South Railway Ditch	Conc. West Ditch			
Copper	mg/L	0.002	0.00098	Baseline Data - 2014-May-01 SURF-E (SRD-3)	Baseline Data - WWMF WD-4 07/14/14 WS2387	Max values 2013-2014
Zinc	mg/L	0.1033	0.00981	Baseline Data - 2014-May-01 SURF-E (SRD-3)	Baseline Data - Duplicate Average WD-4 (VP4127) and (VP4129)	Max values 2013-2014. Note that the value of 0.1033 mg/L is used for screening purposes and is not necessarily indicative of background conditions
Total Phosphorus	mg/L	0.0263*	0.0039*	Baseline Data - 2013-Jun-24 SURF-E (SRD-3)	Baseline Data - WWMF WD-4 07/14/14 WS2387	Max values 2013-2014
Temperature	°C	8.5*	8.5*	2014 Water Temperature Monitoring SRD1_Adj average from 2014-04-16 to 2015-04-15		Average value 2014-2015
Chloride	mg/L	460	420	Baseline Data - WWMF SRD-1 07/14/14 WS2383	Baseline Data - Duplicate Average WD-4 (VP4127) and (VP4129)	Max values 2013-2014
TSS (clearing and construction)	mg/L	13.55*	13.55*	Soil Loss Risk Tool (Pre-Development) with 15% of site (7.65 ha) silt loam; 85% of site (43.35 ha) sand; 99% Good Industry Management Practices efficiency representing undisturbed natural vegetation		Value used close to baseline average (11.1 mg/L, data from 2007-05-03 to 2014-11-09 from [24] and 2014 baseline monitoring)
TSS (operation and maintenance)	mg/L	13.55*	13.55*			

*Value represents average annual background concentration or temperature rather than maximum measured concentration value.

Water Quality in Runoff from Proposed Developed Lands

The values and sources for concentrations for indicators in runoff from the proposed developed lands are discussed below.

- Metals: The potential sources of zinc in urban runoff include: unprotected outdoor surfaces such as galvanized roofing, gutters, fencing, piping, guard rails, light poles and mechanical equipment, zinc metal sheet roofing and siding and zinc-containing paints. Rubber debris from tires is also a potential contributing source. Zinc oxide or zinc salts may be added to de-icing salts to reduce corrosivity. When used, de-icing salts may also come in contact with galvanized surfaces thereby enhancing corrosion and increasing zinc runoff from galvanized sources [33], [34].

  - Potential sources of copper in urban runoff include: building siding corrosion, roofs/gutters and tire wear. Wearing of disc brake pads is a major source of copper in urban runoff [34].
  - The values for these indicators (copper and zinc) are Wet Weather Average EMC data values [35]. Values used are average values for industrial land use.

- Nutrients (Total Phosphorus): Development may result in the loss of phosphorus from the impacted area to the ditches. The value for this indicator is Wet Weather Average EMC values [35]. Values used are the average value for industrial land use.
- Temperature: The runoff from the potential expansion areas was assumed to be on average 5.1°C warmer than the average baseline ditch temperature based on the assumed use of a wet pond for stormwater management [29]. This value (quoted from [36]) represents the average temperature increase for a wet pond (extended detention). This is the stormwater management measure that produces the highest increase in temperature, and it was selected to provide the most conservative results. For the baseline average annual temperature of 8.5°C, the runoff from the potential expansion areas will have an average annual temperature of 13.6°C.
- Chloride: Chloride concentrations in runoff from the developed site areas were estimated as the maximum measured background value plus 171 mg/L. The latter value represents the estimated additional loading from road salt application, computed from information on typical road salt application based on information received from OPG; further details on the derivation of this value are provided in Table F-8.
- TSS:
  - Site Preparation and Construction: TSS provides an indication of the degree of erosion and sedimentation (natural or otherwise) in the drainage area. Suspended sediments from land based sources that contribute to TSS vary but characteristically relate to more easily mobilized silt and clay particles. An increase in TSS may be expected as a result of clearing and construction activities. Relative to the construction phase and associated work activities, the expected mean runoff concentration was derived through the application of a Soil Loss Risk Tool [32] to reflect site specific conditions. In this case an assumed site area of 51 ha was applied, which consisted of 38.6 ha of natural ground and 12.4 ha under development and construction related disturbance. See Figure 5-8 for a visual representation of the watersheds. These values were derived as follows. The existing South Railway Ditch watershed area is 40.88 ha (as per Table 5-29). The sum of the potential expansion areas 1, 2, 3 and 4 is 12.36 ha, of which 2.33 ha are in the South Railway Ditch watershed (as per Table 5-30). The area of natural ground (defined as ground outside the potential expansion areas) within South Railway Ditch watershed is 38.6 ha,

which is the difference between the existing South Railway Ditch watershed area (40.88 ha) and the potential expansion areas within the South Railway Ditch watershed (2.33 ha). For the expansion scenario in which all runoff from all four potential expansion areas is directed to the South Railway Ditch, the post-expansion South Railway Ditch watershed area is 51 ha, which is the sum of the expansion areas (12.36 ha) plus the area of natural ground (38.6 ha). Soil profiles were reviewed and a conservative assessment of the disturbed ground was applied assuming soils as 85% sand and 15% silty loam. This is corroborated by the 2014 baseline monitoring study, which states "Grain size distribution for samples show that the soil in the sampling areas are generally coarser grained ranging from sandy silts to silty sandy gravel with an observed high percentage of organic matter" [8]. The statement is specifically supported as a general summary of borehole record results as reported for up to the 2.5 m horizon. The expected mean runoff concentration for TSS originating from the construction-area was thereby determined to be 1,311 mg/L. More information on the derivation of this value is provided in Appendix F.

- Operation and Maintenance: The Wet Weather Average EMC values [35] for TSS for an industrial land use (during site operation) was determined to be 67.0 mg/L, and was assumed to be representative for the potential expansion areas.

The above values and the data sources are summarized in Table 5-40.

Table 5-40: Modelling Inputs - Runoff Water Quality from Developed Lands

Indicator	Units	South Railway Ditch	West Ditch	Data Source	Discussion
Copper	mg/L	0.027	0.027	Wet Weather Average Event Mean Concentration Data [35]	Mean value for Industrial Land Use
Zinc	mg/L	0.22	0.22	Wet Weather Average Event Mean Concentration Data [35]	Mean value for Industrial Land Use
Total Phosphorus	mg/L	0.30	0.30	Wet Weather Average Event Mean Concentration Data [35]	Mean value for Industrial Land Use
Temperature	°C	13.6	13.6	Background value + 5.1 °C [29]	5.1 °C increase for a stormwater pond
Chloride	mg/L	631	591	Background value + 171 mg/L additional loading from road salt application	30 loads road salt/year of 1 ton hopper @ 61% Cl over 14.55 ha with 1048 mm precip. x 0.64 runoff coeff. = 171 mg/L added by road salt application

Indicator	Units	South Railway Ditch	West Ditch	Data Source	Discussion
TSS (clearing and construction)	mg/L	1311	1311	Soil Loss Risk Tool (developed area no controls) with 15% of developed area (1.85 ha) silt loam; 85% of developed area (10.5 ha) sand; 0% Good Industry Management Practices efficiency representing under-development exposed soil	Results considered more representative that US EPA data for construction sites [37]
TSS (operation and maintenance)	mg/L	67	67	Wet Weather Average Event Mean Concentration Data [35]	Mean value for Industrial Land Use

Removal Efficiency for Water Quality Parameters

Removal rates are based on literature values for treatment efficiency of urban storm water management, which is assumed to be in place during operation and maintenance. The expected removal efficiencies for water quality parameters are summarized in Table 5-41. These were applied to each indicator as in-design mitigation is expected to include a form of enhanced stormwater management which will deliver the listed level of removal efficiency.

Table 5-41: Removal Efficiency for Water Quality Parameters

Indicator	Removal Efficiency %	Source
Copper	65	Adapted from [29], [35]
Zinc	72	Adapted from [29], [35]
Total Phosphorus	65	Adapted from [29], [35]
Temperature	0	conservative assumption
Chloride	0	conservative assumption
TSS (clearing and construction)	80	Adapted from [29], [35]
TSS (operation and maintenance)	80	Adapted from [29], [35]

Note: Removal efficiencies are applied as representative proportions only for the context of the effects assessment and are not intended to be applied as targets for site specific practical applications.

5.4.3.6 Discipline-Specific Assumptions

The potential impacts of the Project on surface water quality are assessed based on the following assumptions:

- Under this approach, all four development areas (Figure 4-4) will be considered hardened surfaces.
- The potential expansion areas are located primarily within the South Railway Ditch and the West Ditch watersheds, with a small portion of potential expansion area 3 draining to the Central Pond. The results presented in this assessment were developed assuming concurrent development of all four potential development areas to provide conservative estimates of potential adverse effects, and to allow for flexibility in the design. All stormwater runoff from the proposed development areas (1 to 4) will be directed through the drainage system to only one of the two potential discharge areas, that is, South Railway Ditch or West Ditch. This ensures the most bounding scenarios due to waterborne emissions are considered. Flow rates for the assessment were taken from Section 5.4.1.5.
- It is assumed that the WWMF stormwater management system will be expanded with application of Good Industry Management Practices, design and mitigation measures to ensure containment, and treatment measures available prior to and during construction and throughout operation and maintenance, as per typical site management practices within the province of Ontario [29], [38]. It is assumed that the WWMF stormwater management system will be built to an enhanced level of water quality protection as per MOECC design guidelines. However, this assumption is used for effects assessment purposes only and is not meant to reflect a target for site management purposes.
- The operation and maintenance period is expected to generate higher levels (in comparison to site preparation and construction) for all water quality indicators except for TSS; as the latter activities are likely to provide an increase in potential for erosion and sediment loading. Therefore all indicators except TSS were assessed for the operation and maintenance period, whereas TSS was assessed for preparation and construction activities and the operation and maintenance period.
- Operation and maintenance of the future buildings at the WWMF are not expected to result in a measureable change in air emissions from existing operations as identified under Section 5.2.2.4. As such, measureable changes to surface water quality or the aquatic environment via air emissions are not expected and are not further assessed.
- The approach taken in this assessment is that the only source of increased chloride loadings will be from road salt application to the new road and paved surfaces within the proposed expansion areas. Typically industrial sites do not release chloride to surface runoff, and no wet weather average EMC value is given [35].

5.4.3.7 Results

Effect of Surface Water-Induced Loadings

A summary of the results of the water quality assessment is provided in Table 5-42. Example calculations for each of the indicator types are provided in Appendix F.

Table 5-42: Summary of Calculated Concentrations for Water Quality Indicators

Indicator	Units	Case 1		Case 2	
		South Railway Ditch	West Ditch (Note 1)	South Railway Ditch (Note 2)	West Ditch
Copper	mg/L	0.004	0.00098	0.002	0.0023
Zinc	mg/L	0.091	0.00981	0.1033	0.018
Total Phosphorus	mg/L	0.050	0.0039	0.0263	0.019
Temperature	°C	10.04	8.5	8.5	9.27
Chloride	mg/L	395	420	460	392
TSS (site preparation and construction)	mg/L	88.6	13.55	13.55	50.9
TSS (operation and maintenance)	mg/L	13.50	13.55	13.55	13.53

Note 1: For Case 1 all runoff from developed lands reports to South Railway Ditch, therefore the calculated concentrations in West Ditch for Case 1 are the same as the background values shown in Table 5-39.

Note 2: For Case 2 all runoff from developed lands reports to West Ditch, therefore the calculated concentrations in South Railway Ditch for Case 2 are the same as the background values shown in Table 5-39.

Note 3: Calculated concentrations represent annual averages.

The following is a general discussion of the results.

- For Case 1, for all indicators (except chloride and TSS during operation and maintenance), the South Railway Ditch gives higher results (calculated concentrations) than the West Ditch, as all the developed runoff is directed to the South Railway Ditch for this case. For chloride, the South Railway Ditch shows a slight improvement over the West Ditch since a portion of the developed site runoff would be industrial site runoff that does not release chloride (see Section 5.4.3.6). For TSS during operation and maintenance, the South Railway Ditch shows a slight improvement over the West Ditch (which is at background level), due to the assumed 80% removal efficiency from the developed site runoff.
- For Case 2 for Copper, Temperature, and TSS during site preparation and construction the West Ditch gives higher calculated concentrations than the South Railway Ditch, as all the developed runoff is directed to the West Ditch for this case. As for the other indicators:
    - Zinc, Total Phosphorus and Chloride - calculated concentrations in West Ditch are lower than in the South Railway Ditch for Case 2, even though

all the developed runoff is directed to the West Ditch, due to the lower background levels in the West Ditch than the South Railway Ditch.

- TSS - during operation and maintenance the calculated concentration in the West Ditch is lower than in the South Railway Ditch for Case 2, even though all the developed runoff is directed to the West Ditch, due to the assumed 80% removal efficiency from the developed site runoff.

The calculated concentrations for parameters in the drainage ditches are listed in Table 5-42. The calculated concentrations in the ditches (South Railway Ditch and West Ditch) at the assessment points were computed using the mass balance/energy balance equations presented in Section 5.4.3.2.

5.5 Groundwater

5.5.1 Assessment Indicators

The indicators selected for groundwater assessment are as follows:

- Changes to groundwater flow; and
- Changes to groundwater quality.

These changes to groundwater may arise from changes to the existing surface and shallow soils and overburden of areas 1 to 4 resulting from the Project. The changes that will affect groundwater flow and quality fall under the following categories:

- Changes to the quantity of water infiltrating to ground and flowing vertically to the groundwater system (i.e., recharge). The groundwater recharge may comprise infiltration water from direct precipitation (i.e., precipitation recharge) and / or infiltration water from collection and redirection of precipitation through temporary or permanent storm water management facilities;
- Changes to the water quality of the groundwater recharge;
- Removal of groundwater during construction, i.e., construction dewatering; and
- Changes to the groundwater flow regime and how these affect groundwater discharge to surface.

The effects that the Project may have on the groundwater assessment indicators are considered through a source – pathway – receptor assessment methodology. To identify the potential linkages between the source and receptor it is necessary to have an understanding of the pathway, which in the present context is the groundwater system comprising groundwater bearing and transmitting units (i.e., aquifers) and groundwater retarding units (i.e., aquitards) as discussed below.

The groundwater system at the WWMF and within the expansion areas is relatively well known from investigations and analysis undertaken for previous environmental assessments for the WWMF [39] and the DGR [5], [40][11]. The conceptual model in

[11] This reference was an enclosure to the DGR EA submission document [6].

these reports describes the two main water-bearing units beneath the WWMF and the expansion areas. These are:

- The Middle Sand Aquifer: This unit is approximately 2 to 4 m thick situated between silt till units of low hydraulic conductivity that are considered aquitards. Precipitation recharge to the Middle Sand Aquifer occurs in areas where the upper silt till unit is absent and the Middle Sand Aquifer is close to the surface. This is known to occur in area 2 and area 4. For the present analysis these areas are referred to as "recharge window". Groundwater flow in the Middle Sand Aquifer is towards the east / northeast with respect to geographic north and is related to where precipitation recharge occurs, such as in area 4 to the south west of the present boundary of the WWMF. Downward vertical flow from the Middle Sand Aquifer to the Bedrock aquifer occurs, particularly towards the east of the WWMF where the silt tills beneath the Middle Sand Aquifer are thinner. Under natural conditions it would not discharge to surface; however, there is a potential for intermittent discharge to the South Railway Ditch through a stormceptor breaching the Middle Sand Aquifer; and
- The Bedrock (Lucas and Amherstburg Formation): This is a carbonate aquifer and the most transmissive unit beneath the WWMF. Groundwater flow in the bedrock is towards the northwest with respect to geographic north across the WWMF towards Lake Huron. The Bedrock is not expected to receive any recharge water directly from surface at the WWMF however some recharge water may reach the Bedrock where the silt till units are absent in the Middle Sand Aquifer as noted above.

Above the till units there is a discontinuous thin sand / gravel / fill unit at the surface that is mostly thinner than 2 m. This unit is locally saturated and water levels may be within 1 m below ground surface. Groundwater levels within the till units, Middle Sand Aquifer and the Bedrock are at the interface or below the surficial sand / gravel / fill unit consistent with the downward vertical gradients known to occur across the site [39], [40]. Within the WWMF and expansion areas this sand / gravel / fill unit is expected to discharge proximally and relatively quickly to local stormwater surface and drainage features and from there to the South Railway Ditch or West Ditch. Consequently, for the present assessment the discontinuous thin sand / gravel / fill unit is considered part of the surface water system as the sand / gravel / fill unit has very limited potential to generate sustained baseflow to either the South Railway Ditch or West Ditch.

5.5.2 Description of Conditions Assessed

The groundwater assessment is qualitative based on the present understanding of the hydrogeology as described in [39] and [40] and summarized above in Section 5.5.1. The assessment considers the hardening of all surfaces within the expansion areas, which are assumed impervious for the "worst case condition" relevant to the Project as described in Section 4.0. This takes into account all stages of the Project including site preparation, construction, operation and maintenance. In the present context the precipitation recharge is the "source" in relation to the groundwater system "pathway", as described by the conceptual model.

The hardening of all surfaces imposes the greatest likely change to the precipitation recharge, which will have the greatest negative effect on groundwater quantity. Groundwater quality will unlikely be affected by changes in precipitation recharge rates assuming the recharge water is uncontaminated. Nevertheless, changes to precipitation recharge are considered in relation to the movement of existing groundwater contamination within the WWMF.

5.5.3 Discipline-Specific Assumptions

The potential impacts of the Project on groundwater flow and quality are assessed based on the following assumptions:

- The existing conceptual model for groundwater flow still applies as documented in the assessment for the expansion of the WWMF in 2005 [39] and the DGR in 2011 [40];
- Groundwater in the discontinuous thin sand / gravel / fill unit at the WWMF and the expansion areas is assumed to discharge to the drainage features which is considered in the surface water assessment (as discussed in Section 5.5.1 and noted in Section 5.4.1.1);
- The entire area of areas 1 to 4 are assumed impervious;
- Construction excavation depths are not known in detail, but are assumed to be relatively shallow and will not significantly affect the hydraulic functioning of the silt tills as an aquitard within the present WWMF area and expansion areas (area 1 to 4); and
- Buildings are constructed and operated to meet the necessary design criteria for the protection of groundwater as noted in Section 8.2.

5.5.4 Analysis and Discussion of Results

The qualitative analysis is presented below according to the two main assessment indicators. Following standard practice in hydrogeology, groundwater flow is considered prior to groundwater quality as the former provides the framework to assess the latter.

<u>Groundwater Flow</u>

The conceptual model for the WWMF is briefly outlined under Section 5.5.1. According to this conceptual model groundwater recharge from precipitation presently mainly occurs to the Middle Sand Aquifer through recharge windows where the upper silt till unit is absent. The locations of the recharge windows are reasonably well known based on the geological data collected from the WWMF and are estimated to have an area of the order of 50,000 m^2. The recharge windows in the expansion areas are located in area 2 and area 4. The silt till unit is known to thin towards the southern edge of area 3, but no recharge windows through the silt till have been identified in area 1 or area 3.

The condition considered under Section 5.5.2 and the assumptions under Section 5.5.3 imply that the recharge windows are covered and that very limited precipitation recharge enters the Middle Sand Aquifer. Current literature on precipitation recharge strongly suggests that large-scale urbanization does not necessarily lead to a reduction in recharge due to a combination of factors such as leaking water mains and sewers, and localized recharge through swales and drainage ditches. The particular condition for the present analysis assumes precipitation recharge will be reduced at the WWMF as the engineering of diversion of runoff water and the sewer system in the locality of the recharge windows is taken to be 100% efficient. This is a worst case condition that is not expected to occur during construction and / or after completion of construction and subsequent operation and maintenance of the new facilities within the expansion areas of the WWMF. However, changes in precipitation recharge rates could change the flow of groundwater across the site, where hard surface runoff (roof tops, roads, etc.) is directed to areas that previously only received direct precipitation. In addition, where the Middle Sand Aquifer is close to the surface, foundation drainage systems may intersect groundwater.

Based on the current conceptual model, changes to groundwater flow rates in the bedrock are only likely to occur due to changes at surface that affect precipitation recharge to the Middle Sand Aquifer (area 2 and 4) or possibly areas where the silt till is thin (southern edge of area 3).

Given the condition that the entirety of the expansion areas 1 through 4 will have impervious surfaces, recharge that is through the Middle Sand Aquifer to the Bedrock would be eliminated. This would lead to some reduction in recharge to the Bedrock of the order of 20 m^3/day[12], which would have an insignificant effect on bedrock groundwater flows across the site and regionally. Groundwater discharge from the bedrock aquifer to the surface water occurs at Lake Huron, which is remote from the WWMF. The recharge quantities generated at very limited local site scale will not have an impact on water levels in this significantly large receiving surface water body.

Based on the current conceptual model, groundwater (specifically relating to the Middle Sand Aquifer and Bedrock) does not discharge to the surface water at the WWMF under natural conditions. Some very localised intermittent discharge may occur at the west end of the existing WWMF site, near the LLSBs, to the South Railway Ditch through a stormceptor that breaches the top of the Middle Sand Aquifer. Data from the 2014 baseline monitoring surveys shows the South Railway Ditch to have intermittent flow and also indicates the West Ditch as intermittent. The intermittent flow is consistent with relatively short duration discharge from the thin surficial sand / gravel / fill unit, and no or very limited discharge from the Middle Sand Aquifer and no discharge from the Bedrock. Discharge from the Bedrock would be expected to provide a reliable baseflow throughout the year. Consequently, a reduction in recharge to the Middle Sand Aquifer and Bedrock is not expected to affect the South Railway Ditch or West Ditch.

It is expected that excavations for construction would be largely limited to the surficial sand / gravel / till unit and / or the weathered silt till. Construction dewatering may be required depending on the location within the expansion areas and depths of any excavations. Based on present hydrogeological understanding, dewatering and drawdown would be expected to be limited for many locations within areas 1 to 4.

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[12] Present groundwater recharge to the Bedrock from the Middle Sand Aquifer is conservatively estimated of the order of 7500 m^3/y (~20 m^3/day), based on a recharge area of 50,000 m^2 and a recharge to the Middle Sand Aquifer of 150 mm/y from precipitation.

Nevertheless, quantities greater than 50 m^3/day cannot be ruled out, requiring a Permit to Take Water from the MOECC. The size of excavation may mean the 50 m^3/day threshold is exceeded due to pumping of incident precipitation alone, depending on runoff management and return period for the storm event used to assess dewatering requirements. Excavation specific mitigation measures and requirements for discharge of water may then be set based on the Permit to Take Water requirements as approved by the MOECC[13].

It is possible that, in certain areas, permanent dewatering may occur if the foundation drainage system intercepts the Middle Sand Aquifer where it is relatively close to the surface. However, the rates of such inflows are expected to be very low with limited effects.

Groundwater Quality

With the exception of tritium, results of the 2014 baseline monitoring surveys showed no contaminants of concern in groundwater. It is not expected that activities associated with the Project will interact appreciably with groundwater locally such that new contaminants will be introduced into the groundwater system through precipitation recharge. The last environmental assessment for Refurbishment Waste Storage [39] showed that atmospheric deposition of tritium and C-14 through precipitation is expected to be low.

The only potential change to groundwater quality may occur in the tritium plume that is known to exist at monitoring well WSH-231 and vicinity within the present footprint of the WWMF. WSH-231 monitors groundwater from the Middle Sand Aquifer within the WWMF. Existence of this relatively localised plume near LLSB #1 is considered in the assessment for the expansion of the WWMF in 2005 [39].

The source term of the tritium plume has been investigated by OPG and the mitigation measures are currently being implemented at the source at LLSB #1 to minimize further interaction with the Middle Sand Aquifer and site surface drainage and stormwater systems that discharge to the South Railway Ditch. It is therefore expected that the concentrations presently measured at WSH-231 (on average, approximately 3.8E+04 Bq/L in 2013) will not increase significantly. Current mitigation measures to reduce/eliminate the interaction between LLSB #1 and the stormwater system will likely cause greater absolute changes to tritium concentrations in the groundwater than any other effects associated with the construction and operation and maintenance of the new facilities in the expansion areas.

The tritium plume migration direction may be affected by changing precipitation recharge rates within area 2 and 4 or by interception of the plume in the Middle Sand Aquifer in area 2 by deep foundation drains. In the case of the latter, any intercepted tritiated water would be collected by the drainage system, which would likely have some remedial effect on the tritium plume assuming the water is removed (i.e.,

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[13] On April 01, 2016, the MOECC implemented the Environmental Activity and Sector Registry, which replaces the need to obtain a Permit to Take Water and ECA for certain dewatering activities. Construction dewatering of less than 400 m^3/day will qualify for an Environmental Activity and Sector Registry permit if the Project meets the MOECC eligibility requirements.

pumped out) and disposed of an appropriate waste disposal system at the Bruce nuclear site.

Changes in precipitation recharge may be due to one or a combination of the following factors:

- Increased area of impermeable surfaces;
- Excavations and grading required for construction; and,
- Stormwater management facilities and discharge to ground.

Increased movement of the tritium plume would be expected if precipitation recharge to the Middle Sand Aquifer was increased. This is only considered possible if the areas within and immediately around the recharge areas to the Middle Sand Aquifer were to receive diverted runoff from other areas. This may increase advective velocities of the groundwater in the Middle Sand Aquifer and consequently movement of the tritium plume. However for the present assessment the precipitation recharge is reduced in the recharge windows which would cause the opposite and reduce the movement of the tritium plume. Therefore, it is concluded that no increase in movement of the tritium plume will occur, given appropriate stormwater management around the recharge areas to the Middle Sand Aquifer.

It can therefore be concluded that there will be no adverse effects from changes in groundwater conditions from the Project.

6.0 HUMAN HEALTH RISK ASSESSMENT

6.1 Problem Formulation

In this PEA, the receptors considered for the HHRA consist of off-site members of the public. Health and safety of on-site workers will be protected by OPG's Radiation Protection Program and Conventional Safety Program, as described briefly in Section 6.1.1, below.

6.1.1 Health and Safety of On-site Workers

On-site workers[14], such as OPG employees, contractors, and visitors, will be potentially exposed to radiological and non-radiological emissions resulting from the Project. OPG has developed robust programs to protect their health and safety.

On-site workers receive radiation doses from works and activities relating to the WWMF operation and maintenance. These exposures are monitored and controlled through OPG's Radiation Protection Program. The Radiation Protection Program is designed to ensure that doses for employees, contractors and visiting members of the public are below regulatory limits, and as low as reasonably achievable, social and economic factors being taken into account.

On-site workers could also potentially be exposed to non-radiological substances. These exposures are considered and controlled through OPG's Conventional Safety Program. The Conventional Safety Program involves a systematic approach to manage risks associated with the activities, products and services of OPG's nuclear operations. The approach includes planning all work through pre-job briefings, and by using approved procedures and operating instructions. All work planned or conducted is subject to safe work planning requirements where safety hazards are identified and mitigating measures, such as the use of PPE, are identified and implemented.

As it is expected that the health and safety of on-site workers is sufficiently protected with the implementation of OPG's Radiation Protection Program and Conventional Safety Program, no further assessment will be performed for on-site workers.

6.1.2 Receptor Selection and Characterization

6.1.2.1 Receptor Selection

For off-site members of the public, the receptors are selected based on the results of Bruce Power's latest site-specific survey carried out in 2011. Bruce Power's Environmental Monitoring Program requires that a site specific survey be conducted at least every five years. The latest survey was conducted in 2011 and gathered information regarding land usage, population distribution, meteorology, hydrology, water sources, water uses and food sources [41]. The survey processed the

[14] On-site workers refer to those working on the OPG-retained lands, to whom OPG's Radiation Protection Program and Conventional Safety Program are applicable.

information gathered to determine the relevant receptors[15] to be used for HHRA, and the relevant receptor characteristics.

Based on the 2011 site-specific survey, the following five types of receptors were identified:

- Non-farm residents;
- Farm residents;
- Mennonite farm residents;
- Dairy farm residents; and,
- Industry workers.

Industry workers are all adults. The resident receptor groups will include different age classes. The age class affects the resident's habits, intake rates and dose coefficients, which are used for dose calculations. In this assessment, residents were categorized into three age classes as defined in CSA N288.1-14 [23], i.e., adult, child, and infant.

The locations of the receptors are shown in Figure 6-1. The general characteristics of the receptors are provided in Table 6-1.

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[15] From the perspective of radiological risk assessment, a human receptor is defined as a representative person or "potential critical group", which is defined by the International Commission on Radiological Protection as "the group or groups of people that are thought most likely to receive the largest exposure for a particular site and scenario" [1]. For a non-radiological HHRA, human receptors are "likely to be exposed to contaminants and physical stressors related to the site" [1].

Figure 6-1: Potential Critical Groups

Table 6-1: Identification of Human Receptors for the HHRA

Receptor Group		General Characteristics of Receptors
Non-farm residents	BR1	Non-farm resident, Lakeshore Scott Point, Located north of the Bruce nuclear site, about 4 km from the WWMF
	BR17	Non-farm resident, Inland Located to the east of the Bruce nuclear site, about 4 km from the WWMF
	BR25	Non-farm resident, Inland Located to the southeast of the Bruce nuclear site, about 3 km from the WWMF
	BR27	Non-farm resident, Inland, Trailer Park Located to the south of the Bruce nuclear site, about 3 km from the WWMF
	BR32	Non-farm resident, Lakeshore Located to the south of Bruce nuclear site in Inverhuron, about 4 km from the WWMF
	BR48	Non-farm resident, Inland Located to the east of the Bruce nuclear site near Baie du Doré, about 3 km from the WWMF
Farm residents	BF8	Agricultural, farm resident Located to the southeast of the Bruce nuclear site, about 7 km from the WWMF
	BF14	Agricultural, farm resident Located to the southeast of the Bruce nuclear site, about 3 km from the WWMF
	BF16	Agricultural, farm resident Located to the east of the Bruce nuclear site, about 7 km from the WWMF
Mennonite farm residents	BMF2	Agricultural, farm resident Located to the southeast of the Bruce nuclear site, about 8 km from the WWMF
	BMF3	Agricultural, farm resident Located to the southeast of the Bruce nuclear site, about 7 km from the WWMF
Dairy farm residents	BDF9	Agricultural, dairy farm resident Located to the southeast of the Bruce nuclear site, about 11 km from the WWMF
Industry workers	BEC	Worker in BEC (Now known as Bruce Eco-Industrial Park) Located to the east of the Bruce nuclear site, about 3 km from the WWMF

There are also some Aboriginal communities in the Bruce Peninsula. In this assessment, the Aboriginal community members are considered under the category of off-site members of the public. However, they were not identified as a specific receptor group for the purposes of the HHRA. A further discussion is presented in Section 6.2.5.

6.1.2.2 Receptor Characterization

Food and Water Consumption

Bruce Power's 2011 site specific survey identified the characteristics of different receptors, specifically consumption of home grown produce and the use of local water supplies [41].

The receptors' average use of home grown or locally grown produce in each food category was determined based on the values reported by respondents. The sum of home grown and locally grown produce consumed is used to represent the food sources which were assumed to be affected by the emissions from the Bruce nuclear site.

Various sources of water used for drinking, bathing, livestock watering and irrigation are identified in the survey; these sources include private wells, community wells and lake water, as well as bottled water, ponds, cisterns, and municipal water. The receptors' average use of each water source was determined based on the values reported by respondents. It is assumed that all sources of water except bottled water were potentially affected by the emissions from Bruce nuclear site.

Exposure Duration and Frequency

For the purposes of the HHRA, it is assumed that all the receptors, except for the Bruce Eco-Industrial Park workers, spend 100% of their time in a single location as shown in Figure 6-1. For the Bruce Eco-Industrial Park workers, they are assumed to have an occupancy factor of 0.23 at their work place (8 hours per day, 5 days per week and 50 weeks per year).

6.1.3 Human Health Exposure Pathways and Conceptual Model

Radiological and non-radiological materials are released to the environment as a result of operations at the WWMF. Consequently, this could result in the emissions to various media, potentially including air, surface water, soil, sediment, groundwater, and other media such as vegetation. Receptors could be exposed to contamination through the following pathways:

- Air inhalation / skin absorption;
- Air immersion (external exposure);
- Water ingestion;
- Water immersion (via swimming or bathing);
- Soil external exposure;
- Soil ingestion (incidental);
- Terrestrial plant ingestion;

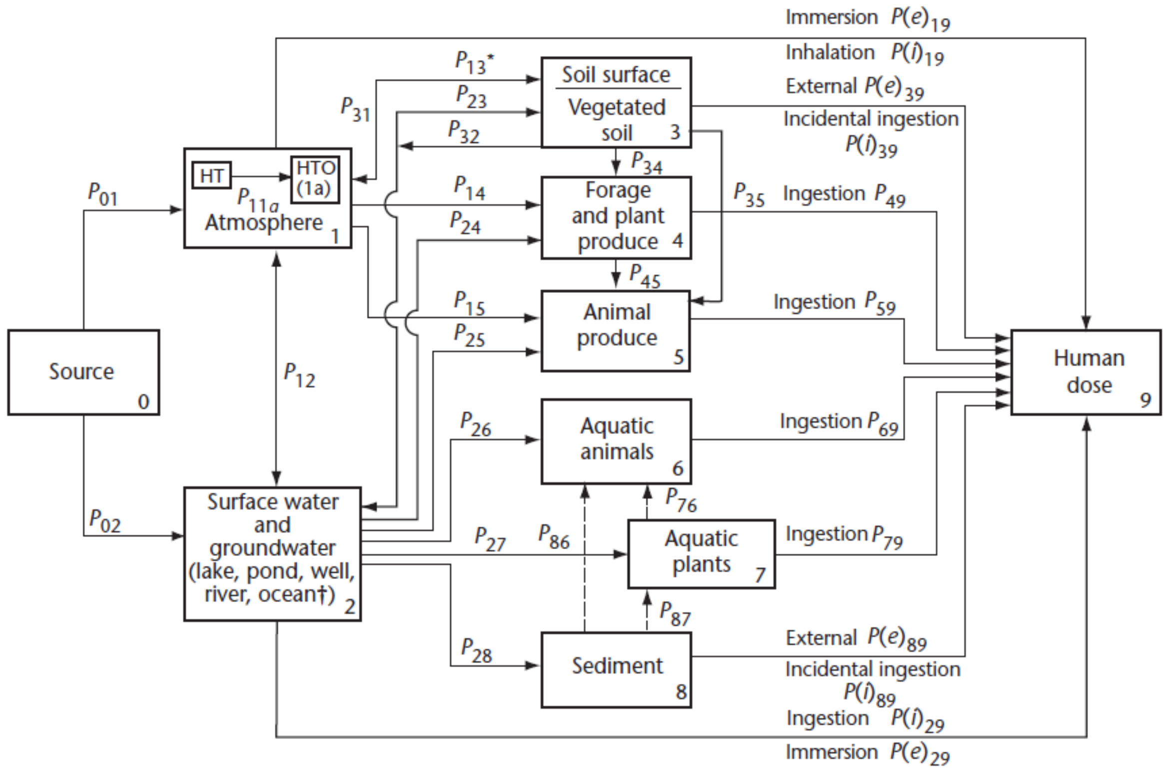
- Terrestrial animal ingestion;
- Aquatic plant ingestion;
- Aquatic animal ingestion;
- Sediment external exposure; and,
- Sediment ingestion (incidental).

A generalized model of environmental radioactivity transport and human exposure pathways is shown in Figure 6-2.

Using the concept of compartments, each environmental source/receptor is presented as a numbered compartment. The quantity in compartment i is denoted by X_i. Transfer from compartment i to compartment j is characterized by a transfer parameter P_{ij}. The amount present in compartment j under steady-state conditions due to transfer from compartment i to compartment j is therefore $P_{ij}X_i$. The magnitude of the quantity (concentration or dose) represented by any compartment j is therefore

$$X_j = \sum_i P_{ij} X_i$$

Where the summation is over all compartments i transferred into compartment j. Detailed information about the compartments and transfer parameters is provided in CSA N288.1-14 [23].



*Includes transfer factors P_{13area}, P_{13mass}, and P_{13spw}.
†For ocean water, pathways P_{23}, P_{24}, P_{25}, and $P(i)_{29}$ are not used.

Figure 6-2: Environmental Transfer Model [23]

6.2 Assessment of Radiological Impact

6.2.1 Radiological Emissions

As discussed in Sections 5.2.1 and 5.4.2, there will be incremental radiological emissions to air and water as a result of the Project. The estimated emissions discussed in Section 5.0, taking into account the baseline conditions, are used for the calculation of doses to off-site members of the public.

6.2.2 Radiological Criteria for HHRA

The Canadian Nuclear Safety Commission has set regulatory limits for exposure to workers and members of the public to ensure that the probability of occurrence of effects is acceptably low [42].

In this assessment, the regulatory limit established to protect members of the public, 1 mSv (1000 µSv) per year from licensed activities, will be used as the criterion for the assessment of the impact of radiological contaminants on human health.

6.2.3 Dose to Off-Site Receptors due to Direct External Exposure

Off-site receptors could receive radiation doses from direct external exposure to gamma radiation from the waste in the storage facilities at the WWMF and from other CNSC licensed facilities at the Bruce nuclear site. In the past five years (from 2009-2013), the quarterly average external dose rates at the boundary of the WWMF ranged from 0.061 µGy/h to 0.075 µGy/h and the maximum dose rate was 0.155 µGy/h [8]. It is expected that the external dose rate during the operation and maintenance of the Project will be similar in range and will not exceed 0.5 µGy/h[16].

As the dose resulting from the direct exposure to radioactivity falls off with distance and the WWMF is located approximately 1 km from the Bruce nuclear site perimeter, the direct external dose from the WWMF is not a significant contributor to the radiological dose received by a member of the public. Therefore, the following assessment will be focused on the other exposure pathways.

6.2.4 Doses to Potential Critical Groups from Other Pathways

Incremental doses to members of the public resulting from the Project were estimated using IMPACT 5.4.0, based on the estimated emissions discussed in Section 5.0 and the receptors' characteristics discussed in Section 6.1.2. The meteorological data used as inputs to the IMPACT code are the same as those used in the ERA for baseline conditions [8]. The following two cases were considered[17]:

- Case One: All additional drainage will be discharged to South Railway Ditch; and,
- Case Two: All additional drainage will be discharged to West Ditch.

The estimated doses to public for the two cases are presented in Table 6-2 and Table 6-3.

Table 6-2: Estimated Doses to Human Receptors for Case One

Human Receptors	Adult (µSv/y)	Child – 10 y (µSv/y)	Infant – 1 y (µSv/y)
BDF9	0.01	0.01	0.01
BEC	0.00	0.00	0.00
BF14	0.25	0.12	0.03
BF16	0.23	0.11	0.02
BF8	0.24	0.11	0.02
BMF2	0.06	0.02	0.13
BMF3	0.06	0.02	0.13
BR1	0.12	0.07	0.02
BR27	0.12	0.07	0.02

[16] A maximum of 0.5 µGy/h at the WWMF site boundary is a facility dose rate target.
[17] Airborne emissions were the same in both cases.

Human Receptors	Adult (µSv/y)	Child – 10 y (µSv/y)	Infant – 1 y (µSv/y)
BR32	0.12	0.07	0.02
BR17	0.11	0.07	0.02
BR25	0.12	0.07	0.02
BR48	0.12	0.07	0.02

Table 6-3: Estimated Doses to Human Receptors for Case Two

Human Receptors	Adult (µSv/y)	Child – 10 y (µSv/y)	Infant – 1 y (µSv/y)
BDF9	0.00	0.00	0.00
BEC	0.00	0.00	0.00
BF14	0.13	0.07	0.02
BF16	0.12	0.06	0.01
BF8	0.12	0.06	0.01
BMF2	0.04	0.01	0.07
BMF3	0.04	0.01	0.07
BR1	0.06	0.04	0.01
BR27	0.06	0.04	0.01
BR32	0.06	0.04	0.01
BR17	0.06	0.04	0.01
BR25	0.06	0.04	0.01
BR48	0.06	0.04	0.01

Total doses to members of the public were estimated by adding the estimated doses from the Project to the range of doses resulting from the existing facilities at Bruce nuclear site for the period of 2009-2013 ([43], [44], [45], [46], [47]). The results are shown in Table 6-4.

Table 6-4: Estimated Total Doses to Human Receptors resulting from the Operation of Existing Nuclear Facilities and the Expansion Project

Human Receptors	Adult (µSv/y)	Child – 10 y (µSv/y)	Infant – 1 y (µSv/y)
BDF9	1.2 - 4.4	1.2 - 4.4	1.2 - 4.4
BEC	1.2 - 4.4	1.2 - 4.4	1.2 - 4.4
BF14	1.4 - 4.6	1.3 - 4.5	1.2 - 4.4
BF16	1.4 - 4.6	1.3 - 4.5	1.2 - 4.4
BF8	1.4 - 4.6	1.3 - 4.5	1.2 - 4.4
BMF2	1.2 - 4.4	1.2 - 4.4	1.3 - 4.5
BMF3	1.2 - 4.4	1.2 - 4.4	1.3 - 4.5
BR1	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4
BR27	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4

Human Receptors	Adult (µSv/y)	Child – 10 y (µSv/y)	Infant – 1 y (µSv/y)
BR32	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4
BR17	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4
BR25	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4
BR48	1.3 - 4.5	1.2 - 4.4	1.2 - 4.4

Note: A dose of 1.2 to 4.4 µSv/y (the range of doses resulting from the existing facilities at Bruce nuclear site for the period of 2009-2013) was added to the estimated dose from the Project regardless of the age/locations of the receptors. Doses resulting from the Project used in the above calculation of total dose are based on Case 1 which is expected to result in higher dose as shown in Table 6-2.

The highest potential doses to human receptors from the Project for Case 1 and Case 2 are 0.25 µSv/y and 0.13 µSv/y, respectively. Taking into account the operation of the existing nuclear facilities at the Bruce nuclear site, the highest estimated dose to a member of the public is less than 5 µSv/y, less than 0.5% of the dose criterion of 1 mSv/y or 1000 µSv/y for a member of the public. Therefore, it can be concluded that there will be no adverse radiological effects to the public as a result of the Project.

6.2.5 Doses to Aboriginal Peoples

There are Aboriginal communities in the vicinity of Bruce nuclear site. For example, Historic Saugeen Métis Community is located at the mouth of the Saugeen River in Southampton (25 km north on Lake Huron). The two closest First Nations groups in the vicinity of the Bruce nuclear site are the Chippewas of Saugeen First Nation (25 km north on Lake Huron) and the Chippewas of Nawash Unceded First Nation (70 km north of the Bruce nuclear site). However, Aboriginal community members were not identified as a specific receptor group, and a detailed specific dose calculation was not carried out. The rationale is provided below.

The potential dose received by any individual is dependent on both the environmental concentration of radionuclides and the habits of potential critical groups. A comparison has been conducted between a representative individual within an Aboriginal group and the critical group, who represents the most exposed member of the public [8]. The comparison indicated that the concentrations of radionuclides in air, water and foodstuff at the nearest Aboriginal communities were expected to be lower than those at critical group due to dispersion and dilution. Therefore, the total dose to a member of an Aboriginal community was expected to be less than that received by the critical group. Similarly, it is expected that the doses to members of Aboriginal peoples resulting from the Project are bounded by the highest dose estimated above. Therefore, it can be concluded that there will be no adverse radiological effects to the Aboriginal Peoples as a result of the Project.

6.3 Assessment of Non-Radiological Impact

Non-radiological materials could be released to the environment as a result of the Project. In this section, the impacts of non-radiological contaminants on human health are assessed at the screening level (Tier 1) first. The Preliminary Quantitative Risk Assessment (PQRA), or Tier 2, is carried out if necessary based on the results of Tier 1.

6.3.1 Screening Criteria

The non-radiological substances in different environmental media, including air, surface water, soil, sediment and groundwater, will be screened to identify Contaminants of Potential Concerns (COPCs). The screening criteria for Tier 1 are applicable federal or provincial human health based guidelines. The guidelines used will be specified in the screening processes described in Section 6.3.2.

6.3.2 Screening

6.3.2.1 Air

Screening Criteria

The indicators that affect air quality have short, medium or long term effects. Therefore, regulators have established criteria based on specific contaminants and averaging periods. The MOECC AAQCs [11] for the selected indicators are shown in Table 6-5. AAQCs are set with different averaging times appropriate for the protection of human health or non-human biota and are appropriate for use in assessing general air quality from multiple sources.

Table 6-5: List of Indicator Contaminants and Associated Criteria

Contaminant	Averaging Period	Ontario AAQC (μg/m^3)	Limiting Effect
TSP	24 h	120	visibility
	annual	60	
PM_{10}	24 h	50	health
$PM_{2.5}$	24 h	25	health
NO_2	1 h	400	health
	24 h	200	
CO	1 h	36200	health
	8 h	15700	
SO_2	24 h	275	health and vegetation
	1 h	690	
	annual	55	

In Ontario, the MOECC sets forth a separate list of contaminants and criteria for evaluation of local air quality for compliance with *Ontario Regulation 419/05* which is more comprehensive than the AAQC list. However, the regulation is specific to facility emissions from stationary sources only and does not consider background concentrations. Site Preparation and Construction activities are exempt and therefore are not covered under the regulation. Since the HHRA and EcoRA includes mobile sources, background concentrations, site preparation activities and construction activities, the criteria listed in *Ontario Regulation 419/05* are not applicable. Therefore, ambient air quality standards from the AAQC list are used as the criteria for assessment.

Screening

Table 6-6 shows maximum predicted air concentrations of indicators during site preparation evaluated at the Bruce nuclear site boundary compared with AAQC. Contaminant concentrations are given in Table 5-9. As shown in the table, all indicators are less than the AAQC values.

Table 6-6: Screening of Air Quality for Site Preparation - Maximum Concentrations at the Bruce Nuclear Site Boundary

Contaminant	Averaging Period	Ontario AAQC (μg/m³)	Concentration (μg/m³)	% of Criteria
TSP*	24 h	120	96	80%
PM_{10}	24 h	50	45	90%
$PM_{2.5}$	24 h	25	24	96%
NO_2	1 h	400	320	80%
	24 h	200	27	14%
CO	1 h	36200	2352	6%
	8 h	15700	726	5%
SO_2*	24 h	275	85	31%
	1 h	690	230	33%

*The annual averaging period for site preparation was not assessed since the duration of this phase is only expected to occur within a 6 month time frame.

Table 6-7 shows predicted air concentrations of indicators during construction evaluated at the Bruce nuclear site boundary compared with AAQC. The concentrations presented in the table are maximum values of all possible construction scenarios considered (A, B and C), as shown in Table 5-9. Construction Scenario C had the highest number of contaminants with maximum values and is considered the worst case scenario. As shown in the table, exceedances were observed for some indicators including TSP, PM_{10} and $PM_{2.5}$.

Table 6-7: Screening of Air Quality for Construction - Maximum Concentrations at Bruce Nuclear Site Boundary

Contaminant	Averaging Period	Ontario AAQC (μg/m³)	Concentration (μg/m³)	% of Criteria
TSP	24 h	120	219	**183%**
	annual	60	52	87%
PM_{10}	24 h	50	87	**174%**
$PM_{2.5}$	24 h	25	29	**116%**
NO_2	1 h	400	345	86%

Contaminant	Averaging Period	Ontario AAQC (µg/m³)	Concentration (µg/m³)	% of Criteria
	24 h	200	47	23%
CO	1 h	36200	2096	6%
	8 h	15700	668	4%
SO_2	24 h	275	85	31%
	1 h	690	232	34%
	annual	55	18	33%

Table 6-8 shows predicted maximum air concentrations at the modelled specific human receptor locations (refer to Figure 5-5) as proportions of the AAQC levels. Concentration results at individual receptor locations are provided in Appendix H. Contaminant concentrations are given in Table 5-10 and repeated in the table below.

Table 6-8: Screening of Air Quality Results – Maximum Concentrations at Human Receptor Locations

Contaminant	Averaging Period	Ontario AAQC (µg/m³)	Baseline		Site Preparation		Construction	
			Result (µg/m³)	Proportion of AAQC	Result (µg/m³)	Proportion of AAQC	Result (µg/m³)	Proportion of AAQC
TSP	24 h	120	47	39%	53	45%	52	43%
	annual	60	45	75%	-**	-	45	75%
PM_{10}	24 h	50	24	48%	27	53%	30	60%
$PM_{2.5}$	24 h	25	12	49%	16	66%	18	70%
NO_2	1 h	400	187	47%	355	89%	339	85%*
	24 h	200	17	8%	21	10%	36	18%
CO	1 h	36200	471	1%	2423	7%	2346	6%
	8 h	15700	461	3%	703	4%	789	5%
SO_2	24 h	275	44	16%	44	16%	45	16%
	1 h	690	304	44%	304	44%	315	46%
	annual	55	24	44%	-**	-	25	45%

*after elimination of meteorological anomalies

**The annual averaging period for site preparation was not assessed since the duration of this phase is only expected to occur within a 6 month time frame.

Particulates (all fractions) show potential for adverse effects at the Bruce nuclear site boundary during construction for all construction scenarios with the highest concentrations expected for Scenario C. All other indicators and phases were not considered for further assessment as the resulting concentrations are below the AAQC and therefore there will be likely no adverse effects.

6.3.2.2 Soil

Members of the public have no direct access to on-site soil at the WWMF. Therefore, it is unlikely that off-site human receptors will come into contact with non-radiological substances in soil. Therefore there will be no adverse effects to off-site human receptors.

As discussed in Section 5.3.2, measureable changes to soil, via air emissions and resulting deposition onto soil from the Site Preparation and Construction phases and Operation and Maintenance activities, are not expected.

As such, it can be concluded that there is no adverse effects to the off-site human receptors associated with exposure to non-radiological contaminants in soil.

6.3.2.3 Groundwater

Members of the public have no access to on-site groundwater or surface water and there are no downstream water wells. Therefore the public has no means of interaction with on-site groundwater and this exposure pathway is incomplete. Therefore there will be no adverse effects to off-site human receptors.

The current groundwater assessment at the WWMF suggests that groundwater from the WWMF will discharge to surface water (Lake Huron) through the Bedrock aquifer. Very small amounts of groundwater flow from the Middle Sand Aquifer could discharge to the South Railway Ditch. However, as discussed in Section 5.5.4, groundwater contamination resulting from the Project is unlikely. Therefore, it is expected that changes to the surface water quality due to the discharge of groundwater will be negligible.

Off-site groundwater could also be potentially affected by airborne contaminants as the contaminants could deposit to the ground and possibly infiltrate to the groundwater system. However, as discussed in Section 6.2.2, the impact of non-radiological substances on off-site soil is negligible. Therefore, it is expected that the potential impact of airborne emissions on off-site groundwater quality is negligible.

In summary, the adverse effect of the Project on human health due to exposure to non-radiological contaminants in groundwater is expected to be unlikely.

6.3.2.4 Surface Water

Surface Water Flow and Quantity

The increase in annual flow does not represent an adverse effect to human health. An appropriately designed stormwater management system (as described in Section 5.4.1.6) will mitigate any flood risk, and therefore changes to water quantity do not represent an adverse effect to human health.

Surface Water Quality

Members of the public have no direct access to on-site surface water. They may be exposed to the surface water from Baie Du Doré or Water Supply Plants where dilution is expected. However, for the purposes of the screening assessment, the predicted on-site concentrations have been used. Screening of non-radiological contaminants in surface water was conducted based on the comparison of predicted environmental concentrations against appropriate screening criteria.

The screening criteria are taken from the following sources:

- Health Canada Guidelines for Canadian Drinking Water Quality [48]; and
- Ontario Drinking Water Quality Standards, Objectives and Guidelines [49].

Note that for the purposes of screening, the guideline values which represent the most restrictive values from the federal and provincial sources listed above were chosen. The screening results are presented in Table 6-9.

As shown in Table 6-9, the non-radiological contaminants in surface water are either below the screening criteria or the contaminants represent no adverse effects to human health. Therefore, no non-radiological waterborne substances are identified as COPCs for further assessment.

Table 6-9: Surface Water Screening – HHRA

Water Quality Indicator	Calculated Concentration (mg/L)	Screening Criteria (mg/L)	Discussion	Exceedance of Threshold of Effect	Reference
Copper	0.004	AO: ≤ 1.0	Essential element; adverse health effects occur at levels much higher than the aesthetic objective. Aesthetic objective (AO) based on taste.	None	[50]
Zinc	0.103	AO: ≤ 5.0	AO based on taste.	None	[50]
Total Phosphorus	0.050	NV	Phosphorous is an essential nutrient which is present at a 98th percentile concentration of 8 mg/L in municipal water sources.	None	[51]
Chloride	460	AO: ≤ 250	Although the AO (based on taste and potential for corrosion) is exceeded, there is no human toxicity benchmark for the parameter. It is unlikely to present an adverse effect to human health at the predicted concentration.	None	[50]
TSS*	88.6	NV	There are no criteria for TSS	None	

AO – Aesthetic Objective
NV – No Value
* Site Preparation and Construction Phase

It should be noted that although the aesthetic objective for chloride (based on taste and potential for corrosion) is exceeded, there is no human toxicity benchmark for the parameter. However, due to the lack of expected human interaction with the drainage ditches an adverse effect to human health is not carried forward for further assessment.

6.3.2.5 Summary

Based on the screening assessment performed above, the only non-radiological contaminant identified as a COPC was airborne particulates (all fractions) at the Bruce nuclear site boundary during construction. Therefore this COPC will be carried forward for further assessment.

6.4 Assessment of Impact of Noise on Human Health

Noise is the only physical stressor to be considered for the HHRA, which is consistent with CSA N288.6-12 [1]. The results of the assessment are presented below.

6.4.1 Assessment Criteria

Site Preparation and Construction Criteria

Noise levels from site preparation and construction activities are excluded from the Environmental Noise Guideline MOECC NPC-300 [52]. Therefore, for the purpose of this assessment, they are assessed as an increase in noise levels relative to the existing (i.e., baseline) noise conditions. An increase of 5 dB or more from the baseline noise level is used as the screening criterion for the Site Preparation and Construction phase. This is in line with the standard engineering practice associated with construction noise and noise monitoring criteria [53]. The baseline noise levels are presented in Table 6-10 below. Baseline noise levels for R1 and R2 are as identified in the detailed summary of WWMF baseline measurements taken in 2014, and that for R3 are from the 2008 baseline noise study in the Bruce Power New Build Environmental Assessment Air Quality and Noise Technical Support Document [21], as data for R3 from the 2014 baseline monitoring study was contaminated by construction activities occurring at the time of the monitoring. These were the lowest (minimum) one-hour L_{eq} noise levels that were measured during the monitoring periods identified in the WWMF baseline ERA [8] and [21].

Table 6-10: Baseline Noise Levels

Receptor Description	Minimum L_{eq} (1 h) Noise Levels dBA
R1 - Albert Street	37
R2 - Baie du Doré	40
R3 - Inverhuron Park	41

Operational Criteria

The applicable noise guideline for the WWMF operations is the MOECC Environmental Noise Guideline NPC-300 [52]. The guideline stipulates that the assessment consider the potential noise impact during a predictable worst-case hour of operation and maintenance, which is defined as noise impact associated with a planned and predictable mode of operation for a noise source(s), during the hour when the noise emissions from the stationary source(s) have the greatest impact at a point of reception, relative to the applicable limit.

The MOECC NPC-300 guideline describes a Class 3 Area as an area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as: a small community; agricultural area; a rural recreational area such as a cottage or a resort area; or a wilderness area. The site for the WWMF expansion is located in a rural area and is best classified as a Class 3 Area.

NPC-300 states that the steady state one hour equivalent noise levels (L_{eq} (1 h)) from stationary noise sources in Class 3 Areas (rural) shall not exceed:

- Either the 45 dBA MOECC exclusionary daytime limit, or the existing background noise level at both outdoor and plane of window receptor locations during daytime hours (07:00 – 19:00), whichever is higher; and
- Either the 40 dBA MOECC exclusionary nighttime limit, or the background noise at both outdoor receptor and plane of window receptor locations during the early evenings (19:00 – 23:00), and at the plane of window during nighttime (23:00 – 07:00), whichever is higher.

The MOECC's exclusionary limits were used for this PEA for the WWMF operation and maintenance phase. The operational noise limits at the human receptors are presented in Table 6-11.

Table 6-11: Operational Noise Criteria

Receptor Description	MOECC Noise Level Limits L_{eq} (1 h) dBA	
	Daytime (07:00 to 19:00)	Nighttime* (19:00 to 07:00)
R1 - Albert Street	45	40
R2 - Baie du Doré	45	40
R3 - Inverhuron Park	45	40

*The nighttime is inclusive of both the early evening (19:00-21:00) and night (21:00 – 07:00) as the noise criteria is the same for both for a Class 3 area in NPC-300.

6.4.2 Screening

Site Preparation

The Site Preparation noise levels at the receptors for the Project were modelled and results are presented in Table 6-12.

Table 6-12: Site Preparation Noise Screening

Receptor Description	Baseline Minimum Noise Levels L_{eq} (1 h) dBA	Modelled WWMF Site Preparation Maximum Noise Levels L_{eq} (1 h) dBA*	Combined Maximum Noise Levels (Baseline, Site Preparation) dBA	Maximum Increase In Noise Levels from Baseline Expected dB
R1 - Albert Street	37	35	39	2
R2 - Baie du Doré	40	38	42	2
R3 - Inverhuron Park	41	34	42	1

*Site preparation noise impacts include both Clearing and Grubbing activities.

The noise levels at the human receptor locations during site preparation are not expected to increase more than 1-2 dB above the existing minimum L_{eq} (1 h) baseline levels. The increase in noise levels are not considered to have an adverse effect as the increase is less than 5 dB above the baseline noise level. Note that these impacts are assessed for daytime site preparation periods.

Construction

The construction noise levels at the receptors for the Project were modelled and results are presented in Table 6-13.

Table 6-13: Construction Noise Screening

Receptor Description	Baseline Minimum Noise Levels L_{eq} (1 h) dBA	Modelled WWMF Construction Maximum Noise Levels L_{eq} (1 h) dBA	Combined Maximum Noise Levels (Baseline, Construction) dBA	Maximum Increase in Noise Levels from Baseline Expected dB
R1 - Albert Street	37	34	39	2
R2 - Baie du Doré	40	37	42	2
R3 - Inverhuron Park	41	34	42	1

The noise levels at the human receptor locations during construction are not expected to increase more than 1-2 dB above the existing minimum L_{eq} (1 h) baseline levels. The increase in noise levels are not considered to have an adverse effect as the increase is less than 5 dB above the baseline noise level. Note that these impacts are assessed for daytime construction periods.

Operation and Maintenance

The operational noise levels at the receptor locations during the operation and maintenance were modelled and assessed in Table 6-14.

Table 6-14: Future Operational Noise Screening

Receptor Description	Modelled WWMF Existing and Future Operational Noise Levels, Maximum L_{eq} (1 h) dBA		MOECC Day/Night Noise Level Limits L_{eq} (1 h) dBA
	Day	Night	
R1 - Albert Street	27	26	45/40
R2 - Baie du Doré	27	27	45/40
R3 - Inverhuron Park	26	25	45/40

The modelled noise level during operation and maintenance alone are well below the applicable MOECC NPC-300 noise limits [52] at all receptor locations, and are not considered to have an impact at the nearest receptors.

Summary

During the site preparation and construction phases, the modelled noise levels at all three locations are lower than the assessment criteria. During the operation and maintenance phase, the modelled noise levels at all three receptor locations are well below the applicable NPC-300 criteria. Therefore, noise from the Project will not have an adverse effect on human health.

6.5 Risk Characterization

6.5.1 Radiological Risk

Doses to the public resulting from the Project taking into account the existing conditions were estimated to be less than 5 µSv/y, less than 0.5% of the dose limit of 1 mSv/y (1000 µSv/y) for members of the public. As such, there are no adverse radiological effects to the public resulting from the Project.

6.5.2 Risk Associated with Air Quality

Based on the screening level risk assessment, which takes into account the potential contamination of different media including air, surface water, soil, sediment, and groundwater, it is expected that non-radiological contaminants resulting from the Project pose no adverse effects to human health from all pathways except air. The effects associated with air quality are characterized below.

During the construction phase, it is likely that TSP (24-h), $PM_{2.5}$, and PM_{10} will exceed the AAQC at the Bruce nuclear site boundary. The construction scenario assumes two areas being developed simultaneously and is bounding since, according to Table 4-1, buildings will likely be constructed in a staggered manner over time. Therefore, the concentrations were estimated based on conservative assumptions. The adverse effect is reversible with cessation of emission generating activities. In addition, the frequency of occurrence is low. For example, the exceedances of AAQC at the Bruce nuclear site boundary occur less than 1% of the time while construction activities are taking place (refer to Appendix G for frequency of exceedance analysis). Furthermore, the concentrations of these indicators at all specific human receptor locations, which are further afield than the Bruce nuclear site boundary, are below the AAQC values. Therefore, it can be concluded that there are likely no adverse effects to human health due to the elevated air concentrations.

6.6 Uncertainty Associated with HHRA

Uncertainty can be introduced into the HHRA during the process of screening, exposure assessment and risk characterization. The uncertainty can be minimized through the analysis of sources and historic trends, along with the use of conservative assumptions throughout the effects assessment, to ensure that the effect on human health is not underestimated. A qualitative analysis of the uncertainty associated with the HHRA is presented below.

6.6.1 Uncertainty Related to Radiological Risk

For the radiological effects assessment, the computer code used for the dose calculation, including the value of the parameters for the embedded models, is in line with CSA standard N288.1-08 [54]. In addition, doses to the public resulting from the Project were calculated based on a conservative estimate of radiological emissions. Furthermore, the total doses to members of the public taking into account the existing conditions and the emissions from the Project represent less than 0.5% of the dose limit to public. Therefore, it is expected that the uncertainty associated with the dose calculation has no impact on the conclusions.

6.6.2 Uncertainty Related to Non-Radiological Risk

The assessment of non-radiological emissions is carried out based on the comparison of modelling air and water concentrations against the assessment criteria. The modelled potential contamination concentrations represent the bounding scenarios. Furthermore, the most restrictive guidelines from reputable sources are adopted as the assessment criteria. This will ensure that the conclusion of the assessment is valid, with a high level of confidence. Specific uncertainty associated with air quality assessment and water quality assessment which is applicable for HHRA is discussed below.

6.6.2.1 Uncertainty Related to Air Quality Assessment

Uncertainties in the approach and assumptions used to arrive at the predicted air concentrations are as follows:

- The stage selected for each construction time period, as shown in Table 5-4, represented the highest emitting stage and therefore contributed to a conservative estimate (in actuality, the highest emitting stage will not take place for the entire duration of the time period). For example, from October to December, only the highest emitting stage of Roof, Floor and Torched on Roof was modelled for that time period;
- The assumption that all equipment operate simultaneously is not likely to occur; and

- The dispersion model software automatically outputs the maximum possible concentration for a given averaging period.

Collectively, all the above assumptions bias towards conservative predictions. It is not anticipated that the uncertainty will affect the conclusion of the HHRA.

6.6.2.2 Uncertainty Related to Surface Water Quality Assessment

There is uncertainty associated with the assumed developed site runoff concentrations for the various indicators, as they are not site-specific, but are the average of values collected from many industrial sites in different areas, and for various industries.

There is uncertainty associated with the pollutant removal rates used, as the values are used are averages of many studies carried out in different areas; the achieved efficiencies will vary depending on the type of stormwater management used.

It should be noted that the assessment of surface water quality does not indicate the variability that may be measured during short-term conditions, such as site responses during high precipitation events. For example, it is generally found in urban settings that runoff from sites with significant impervious area can be of poorer water quality during high-intensity precipitation events following an extended dry period ("first-flush") as compared to annual average values. Therefore, the results presented here should not be considered as necessarily inclusive of those types of conditions. Rather, the assessment of surface water quality performed on an average annual basis represents the outcome of long-term conditions.

The uncertainties associated with the surface water quality assessment will have no impact on the conclusions of the assessment.

6.6.3 Uncertainty Related to Physical Stressor Assessment (Noise)

Uncertainty in the modelled noise levels originates within the sound propagation standard ISO 9613-2 [22] calculation and the source sound power levels. The ISO 9613-2 prediction method addresses this uncertainty as it assumes that all receptors are downwind from the noise source or that a moderate ground-based temperature inversion exists. In addition, it was assumed that all noise sources, for each modelling scenario, operate simultaneously in a given one-hour period. The ground cover and physical barriers, either natural (terrain-based) or constructed are included where and as they relate specifically to this Project.

Also, reference or manufacturer noise sound levels based on the source capacity were used in modelling, which results in the greatest uncertainty in the predictions of noise resulting from the Bruce nuclear site or the existing WWMF. To address uncertainty with the 2008 Bruce nuclear site noise levels [15], additional noise measurements were conducted in 2015 [8] to establish current operational levels and the modelled noise source emissions from other Bruce nuclear site facilities were adjusted accordingly.

Based on these modelled emissions and the relatively low impact that future operations have at human receptors, the uncertainty associated with the source noise levels are not expected to impact the conclusions of the assessment.

6.6.4 Summary of Uncertainty Assessment

In summary, the assessment method and the conservative assumptions used for the HHRA ensure that the actual effects are not underestimated. Therefore, it is anticipated that the uncertainty associated with the assessment has no impact on the conclusions of the PEA for human health.

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 Receptor Selection and Characterization

The ERA for the existing environment [8] determined a comprehensive list of VECs as well as a group of indicator species to represent the on-site non-human biota which was used to assess the effects of radiological and non-radiological emissions on the environment. The indicator species listed in Table 7-1 of the WWMF baseline ERA [8] will continue to be used for the current PEA. For reference, the list of VECs, including species of ecological significance, has been reproduced in Table 7-2 and the Terrestrial Monitoring Area is shown in Figure 7-1.

Given that the same indicator species are being used to represent the same VECs, the receptor characterization and assessment endpoints given in [8] continue to apply.

Table 7-1: Representative Indicator Species

Class	Indicator Species
Aquatic Vegetation	Cattail
Aquatic Invertebrates	Digger Crayfish
	Benthic Invertebrates
Fish	Northern Redbelly Dace
	Spottail Shiner
	Smallmouth Bass
	Lake Whitefish
	Deepwater Sculpin
Terrestrial Vegetation	Grass
	Eastern White Cedar
Terrestrial Invertebrates	Earthworm
	Bee
Herpetofauna	Northern Leopard Frog
	Spring Peeper
	Midland Painted Turtle
	Northern Water Snake
Birds	Wild Turkey
	Red-eyed Vireo
	American Robin
	Mallard
	Bald Eagle
Aquatic Mammals	Muskrat
Terrestrial Mammals	Northern Short-tailed Shrew
	Little Brown Myotis (Little Brown Bat)
	White-tailed Deer
	Red Fox

Table 7-2: Full List of VECs for the EcoRA [8]

Class	VEC	Indicator Species	Rationale
Water bodies	Baie du Doré Wetland	Cattails Benthic Invertebrate Community Northern Redbelly Dace Midland Painted Turtle	The Baie du Doré Wetland is a Provincially Significant Wetland. Although the Baie du Doré wetland lies outside the future WWMF, it does partially overlap with the Bruce nuclear site. Protection of aquatic receptor group populations (plants, fish, and invertebrates) is the goal for this VEC. A specific species of interest is the Midland Painted Turtle [55][18].
	Lake Huron and Embayments	Smallmouth Bass Lake Whitefish	Protection of aquatic receptor group populations (plants, fish, and invertebrates) is the goal for this VEC. Specific species of interest: Lake Whitefish, salmonids (i.e., whitefish, salmon, Brook Trout). Salmonids including whitefish are of importance to fisheries (Aboriginal, commercial and/or recreational). Salmonids are a sensitive receptor and their health provides an indicator of water quality.
	South Railway Ditch and Wetland Complex adjacent to WWMF expansion area (cedar swamp and marsh complex)	Cattails Digger Crayfish Benthic Invertebrate Community Northern Redbelly Dace Northern Leopard Frog	Wetlands are a critical component of the ecosystems, providing multiple functions including flood attenuation, water quality improvement, and potential groundwater recharge and wildlife habitat. Protection of various receptor groups present in wetlands and aquatic environments is the goal for this VEC. Specific species of interest: cattails, Northern Redbelly Dace, Creek Chub and Green Frog. Northern Redbelly Dace are an indicator of small-bodied fish

[18] This reference was an enclosure to the DGR EA submission document [6].

Class	VEC	Indicator Species	Rationale
			community (productivity). Inhabits South Railway Ditch, is common in wetland conditions, cool/warm water tolerant, and has an affinity for organic substrates and aquatic vegetation. Creek Chub - Inhabits the South Railway Ditch, cool water species, tolerant of organic pollution and low dissolved oxygen, and moderately intolerant to turbidity. Green Frogs are an obligate wetland species, spending its entire life within or immediately adjacent to permanent wetlands, it is vulnerable to direct contact with discharges to water. Cattail - major vegetation type in South Railway Ditch and Wetland, provides bio-remediation properties. As described below, indicator species have been chosen for the specific species of interest in this PEA. For the fish species (Northern Redbelly Dace and Creek Chub), the Northern Redbelly Dace has been chosen as the representative indicator for this assessment. For the Green Frog, the Northern Leopard Frog has been chosen as the representative indicator.
	West Ditch	Cattail Digger Crayfish Benthic Invertebrate Community Northern Redbelly Dace	Protection of aquatic receptor group populations (plants, fish, and invertebrates) is the goal for this VEC. Northern Redbelly Dace are an indicator of the small-bodied fish community (productivity). They inhabit the West Ditch, are common in wetland conditions, cool/warm water tolerant, and have an affinity for organic substrates and aquatic vegetation. Creek Chub are an abundant species within the West Ditch. A cool water species, tolerant of organic pollution and low dissolved oxygen, and moderately intolerant to turbidity. As described below, the Northern Redbelly Dace, has been chosen as the indicator species for both the Northern Redbelly

Class	VEC	Indicator Species	Rationale
			Dace and Creek Chub. Cattail - major vegetation type in the West Ditch, provides bio-remediation properties.
	Stream C	Cattails Digger Crayfish Benthic Invertebrate Community Northern Redbelly Dace Smallmouth Bass	The South Railway Ditch discharges to Stream C which, in turn, discharges into Baie du Doré, a provincially significant wetland. Stream C provides cold water fish habitat (i.e., Brook Trout). Protection of aquatic receptor group populations (plants, fish, and invertebrates) is the goal for this VEC. Specific species of interest: Salmonids (i.e., Brook Trout).
Habitat	Terrestrial Crayfish Habitat	Digger Crayfish	Digger Crayfish is a species of interest to the community based on its limited geographic distribution. Terrestrial crayfish habitats were evaluated as 'significant' based on the criteria outlined in the Significant Wildlife Habitat Technical Guide [56] and the associated criteria schedules. Digger Crayfish burrows have been seen on the WWMF during the most recent baseline monitoring surveys. The Digger Crayfish have been included as an indicator species due to their status as a species of interest to the community; however, it should be noted that the Digger Crayfish is not a Species At Risk (SAR).
	Turtle Wintering Habitat	Midland Painted Turtle	Both Snapping Turtle and Midland Painted Turtle are present and have wintering habitat in the OPG-retained lands, and have been observed in ponds on the WWMF during the most recent baseline monitoring survey. Midland Painted Turtle has been chosen as the indicator species for turtles as this species forms the majority of the turtle population on site, based on the most recent survey. Turtle Wintering Habitats were evaluated as 'significant' based

Class	VEC	Indicator Species	Rationale
			on the criteria outlined in the Significant Wildlife Habitat Technical Guide [56] and the associated criteria schedules.
	Amphibian Woodland Breeding Habitat	Spring Peeper	Spring Peeper is common on the WWMF, throughout lowland (moist soils) and treed wetland habitats, and represents a large component of the biomass within the lower trophic levels. As a terrestrial amphibian, Spring Peeper is more vulnerable than birds and mammals to direct contact with airborne contaminants and changes in soil quality. Since this species lives in terrestrial environments, it is susceptible to road-related mortality. Amphibian Woodland Breeding Habitats were also evaluated as 'significant' based on the criteria outlined in the Significant Wildlife Habitat Technical Guide [56] and the associated criteria schedules.
	Amphibian Wetland Breeding Habitat	Northern Leopard Frog	Northern Leopard Frogs were common throughout lowland (moist soils) and treed wetland habitats and represent a large component of the biomass within the lower trophic levels. As an amphibian, Northern Leopard Frog is more vulnerable than birds and mammals to direct contact with airborne contaminants, water discharges and changes in soil quality. Since this species spends the majority of its adult life stage in terrestrial environments, it is susceptible to road-related mortality. The Northern Leopard Frog has been identified as the indicator VEC for evaluating the Amphibian Wetland Breeding Habitat. Amphibian Wetland Breeding Habitats were also evaluated as 'significant' based on the criteria outlined in the Significant Wildlife Habitat Technical Guide [56] and the associated criteria

Class	VEC	Indicator Species	Rationale
			schedules.
Terrestrial Vegetation	Trees	Eastern White Cedar	An abundant tree species in the OPG-retained lands. The Eastern White Cedar is slow growing, and plays an important role in providing conditions that support wildlife habitat and presence of plant species. The Eastern White Cedar is preferred by White-tailed Deer for both shelter and as an important food source in the winter, and is also used by such animals as Snowshoe Hare, porcupine and Red Squirrel. As a coniferous plant, the Eastern White Cedar may be more susceptible to foliar damage from changes in air quality.
	Graminoids (grasses, sedge, and rushes)	Grass	Graminoids are abundant within the Terrestrial Monitoring Study Area (the area that was surveyed in 2014 to characterize the Terrestrial baseline) and are representative of a ground cover species and are chosen to assess the effects associated with vegetation loss and radiological and non-radiological emissions on understory vegetation. Ground cover provides food and shelter for a variety of species and is relevant in the maintenance of a healthy ecosystem.
Aquatic Vegetation	Aquatic Vegetation Community	Cattail	Aquatic vegetation provides a source of shelter and food for aquatic species. It assists in water quality and provides an indication of habitat quality. Cattail is an emergent wetland species which grows intermittently in drainage ditches and remnant pools on the OPG-retained lands. Cattail is known for its ability to filter wastewater, which may lead to pollutant (including heavy metals) accumulation in the plant tissues.

Class	VEC	Indicator Species	Rationale
			It is used by Red-winged Blackbird for nesting and by Muskrat as a primary food source and as a shelter material. It can be used to assess the effects of both radiological and non-radiological emissions, in particular those to the surface water environment, on vegetation. Tissue samples have been collected.
Terrestrial Invertebrates	Terrestrial Invertebrates	Earthworm	Soil invertebrates such as earthworms, grubs, arthropods, etc. are present on the OPG-retained lands. Invertebrates provide a food source to mammals and birds and the community can reflect the health of the environment. Earthworms are only assessed for the purpose of the radiological assessments.
	Insects	Bee	Insects are important to all ecological environments. As pollinators, bees are an ecologically important insect species. They live wherever there are flowers to feed on and are therefore likely present on site. Bees are used as an indicator for flying insects. Bees are only assessed for the purpose of the radiological assessments.
Aquatic Invertebrates	Aquatic Invertebrates	Digger Crayfish	Aquatic invertebrates, including species living in the water column, are an important food item for many species of fish and waterfowl. Aquatic invertebrates living in the water column are used in the evaluation of surface water quality. Active crayfish burrows and chimneys have been observed within the WWMF. The Digger Crayfish (*Fallicambrius fodiens*), also known as Chimney Building Crayfish, has been seen on site and is used as an indicator for other crayfish species that may

Class	VEC	Indicator Species	Rationale
			be present on site.
	Benthic Invertebrates	Benthic Invertebrate Community	Aquatic invertebrates living on or in sediment. Aquatic invertebrates are an important food item for many species of fish and waterfowl. Benthic invertebrates are used to provide an indication of habitat quality in the drainage features at the OPG-retained lands.
Fish	Inshore and Forage Fish	Spottail Shiner Smallmouth Bass	The Spottail Shiner is common in Lake Huron near shore areas within the study area and is an important source of food for predatory fish and is used as a baitfish by anglers. They are a small minnow species; the indicator species is the Northern Redbelly Dace. The Smallmouth Bass is a warm-water, near-shore species in Lake Huron. The species is important to the recreational fishery and feeds on several trophic levels as an omnivore (benthic invertebrates, crayfish, and fish). The species is sensitive to changes in near shore habitat (physical, chemical and thermal).
	Offshore Fish	Lake Whitefish Deepwater Sculpin	Lake Whitefish is an important species to commercial, recreational and Aboriginal fisheries. The Lake Whitefish has been chosen as the indicator species, given its relevance to the commercial fisheries. Deepwater Sculpin is a threatened species and of special concern in the Great Lakes. These indicator species have been included in order to assess the potential impact of surface water contaminants from the WWMF on species in Lake Huron, as surface water can migrate offsite.
Herpetofauna	Snake	Northern Water Snake	The Northern Water Snake was most recently documented within the South Railway Ditch in September 2013. Northern Water Snake can be found in and around almost any permanent

Class	VEC	Indicator Species	Rationale
			body of fresh water, rarely occurring far from shore. The Northern Water Snake is an important component of the aquatic and adjacent terrestrial ecosystems as it preys on fish and amphibians.
	Frogs	Northern Leopard Frog	See Amphibian Wetland Breeding Habitat
		Spring Peeper	See Amphibian Woodland Breeding Habitat
	Turtles	Midland Painted Turtle	See Turtle Wintering Habitat
Birds	Red-eyed Vireo	Red-eyed Vireo	Red-eyed Vireo is one of the most common species in the Terrestrial Monitoring Study Area and is representative of a forest dwelling bird species. Habitat typically consists of large expanses of deciduous forest; however, this species is not area sensitive and frequently inhabits small forest fragments with mature deciduous trees. It is insectivorous and gleans insects (mainly caterpillars) off leaves and bark in the sub-canopy and canopy of trees.
	Wild Turkey	Wild Turkey	Wild Turkey is a territorial omnivorous ground dwelling bird using deciduous forest habitat near open communities. Wild Turkey is an important subsistence, cultural and recreational feature of the study areas that was nearly extirpated from Canada because of unrestrained hunting and habitat loss, but has been successfully re-established in southern Ontario through Ministry of Natural Resources and Forestry reintroduction and conservation efforts. This species over-winters within the area of the site (deciduous forest and coniferous swamp). This species can be used to assess the effects of habitat loss on ground dwelling game birds with larger territorial areas as well as noise disturbance associated with traffic, construction

Class	VEC	Indicator Species	Rationale
			equipment, and increased human activity.
	American Robin	American Robin	The American Robin is particularly sensitive to COPCs in soil due to their high ingestion of earthworms. The American Robin has been identified at OPG-retained lands. The American Robin lives in a variety of habitats, including woodlands, wetlands, suburbs, and parks. They forage on the ground in open areas, such as meadows or parkland.
	Mallard	Mallard	The Mallard is an omnivorous waterfowl species that has been observed at the Bruce nuclear site, utilizing stable shallow areas for foraging and nesting. This omnivorous species primarily feeds on aquatic vegetation, seeds, acorns and grains, and occasionally on fish and other aquatic organisms. The Mallard can be used to assess the effects of airborne and waterborne emissions that may, in turn, influence forage opportunities as well as noise disturbance associated with traffic, construction equipment, and increased human activity.
	Bald Eagle	Bald Eagle	The Bald Eagle is a carnivorous bird that preferentially eats fish. It has been identified as having a winter population on the Bruce nuclear site. It is considered a socially important species.
Aquatic Mammals	Muskrat	Muskrat	The presence of the Muskrat has decreased on the OPG-retained lands and is now absent from the Terrestrial Study Area, as previously documented in the DGR EA [5]; however, it is known to be present elsewhere at the Bruce nuclear site. This herbivorous aquatic mammal has a limited home range and can occur in high densities in areas with appropriate food and shelter (i.e., cattail marsh). Muskrats can be used to assess the effects of emissions on local

Class	VEC	Indicator Species	Rationale
			vegetation and surface water resources.
Terrestrial Mammals	Small Mammals	Northern Short-tailed Shrew	The Northern Short-tailed Shrew may or may not be present at the OPG-retained lands. It has been selected as a representative species for small mammals. The Northern Short-tailed Shrew is omnivorous and eats almost its own weight daily. Their diet includes ground-dwelling species (e.g., earthworms) and plant matter. They are common in areas with abundant vegetative cover and can be found in a variety of habitats. They are an important food source for birds of prey, foxes and coyotes. In the context of physical impacts, affects are not commonly assessed. This species can be used to assess the effects of airborne and waterborne emissions that may, in turn, influence forage opportunities.
	Bats	Little Brown Myotis (Little Brown Bat)	Bats are present on-site and are part of the Ontario SAR list.
	Herbivores	White-tailed Deer	Sustainable population of White-tailed Deer, that overwinters in the coniferous forest cover and grazes in the fields and woodlands from spring to fall, are present on the Bruce nuclear site. The deer population has influenced the development of forested communities at the Bruce nuclear site through selective browsing. The White-tailed Deer can be used to assess the effects of emissions that may, in turn, influence forage opportunities, the potential effects of road-related wildlife mortality within the Bruce nuclear site and noise disturbance associated with traffic,

Class	VEC	Indicator Species	Rationale
			construction equipment, and increased human activity.
	Carnivores	Red Fox	A potential Red Fox den was observed adjacent to the South Railway Ditch, but was not observed to be active. Additionally, no Red Foxes or evidence of Red Foxes (e.g., scat, footprints) were observed during baseline surveys for the Project. As such, this species has been chosen as a representative species for carnivorous mammals only for the purpose of the radiological and non-radiological assessments.
Species of Ecological Significance (e.g., SAR)	Barn Swallow Eastern Meadowlark Eastern Wood Pewee Golden-winged Warbler Olive-sided Flycatcher Wood Thrush Rusty Blackbird	Red-eyed Vireo American Robin	Species of ecological significance which either breed or permanently reside at the OPG-retained lands. These species are either listed under the provincial Endangered Species Act, and/or the federal Species at Risk Act, or are considered provincially rare. Indicator species for the SAR have been chosen from the indicators listed above to represent the SAR in the assessment. For non-radiological contaminants, the assessment is not species-specific for terrestrial plants and invertebrates (including insects). For the Snapping Turtle, individual contaminants are examined for herpetofauna, so there is no difference between species of turtle. For radiological contaminants, the benchmarks are not specified for SAR/non-SAR, and exposures are conservative, so the SAR and the indicator species are conservatively assumed to receive similar doses. Red-eyed Vireos and American Robin were selected as receptor species for SAR VECs due to their similar foraging characteristics with the other bird SAR (e.g., Eastern Wood-Pewee and Red-eyed Vireo are both forest canopy foragers). Little Brown Myotis was selected as the indicator species for bats as all three Myotis species have similar foraging
	Little Brown Myotis Northern Myotis Eastern Small-footed Myotis	Little Brown Myotis (Little Brown Bat)	
	Monarch Butterfly	Bees	
	Butternut	Eastern White Cedar	

Class	VEC	Indicator Species	Rationale
	Sharp Fruited Rush	Grass	habits. Therefore the indicator species are considered appropriate for this assessment.
	Snapping Turtle	Midland Painted Turtle	
	Deepwater Sculpin	Deepwater Sculpin	

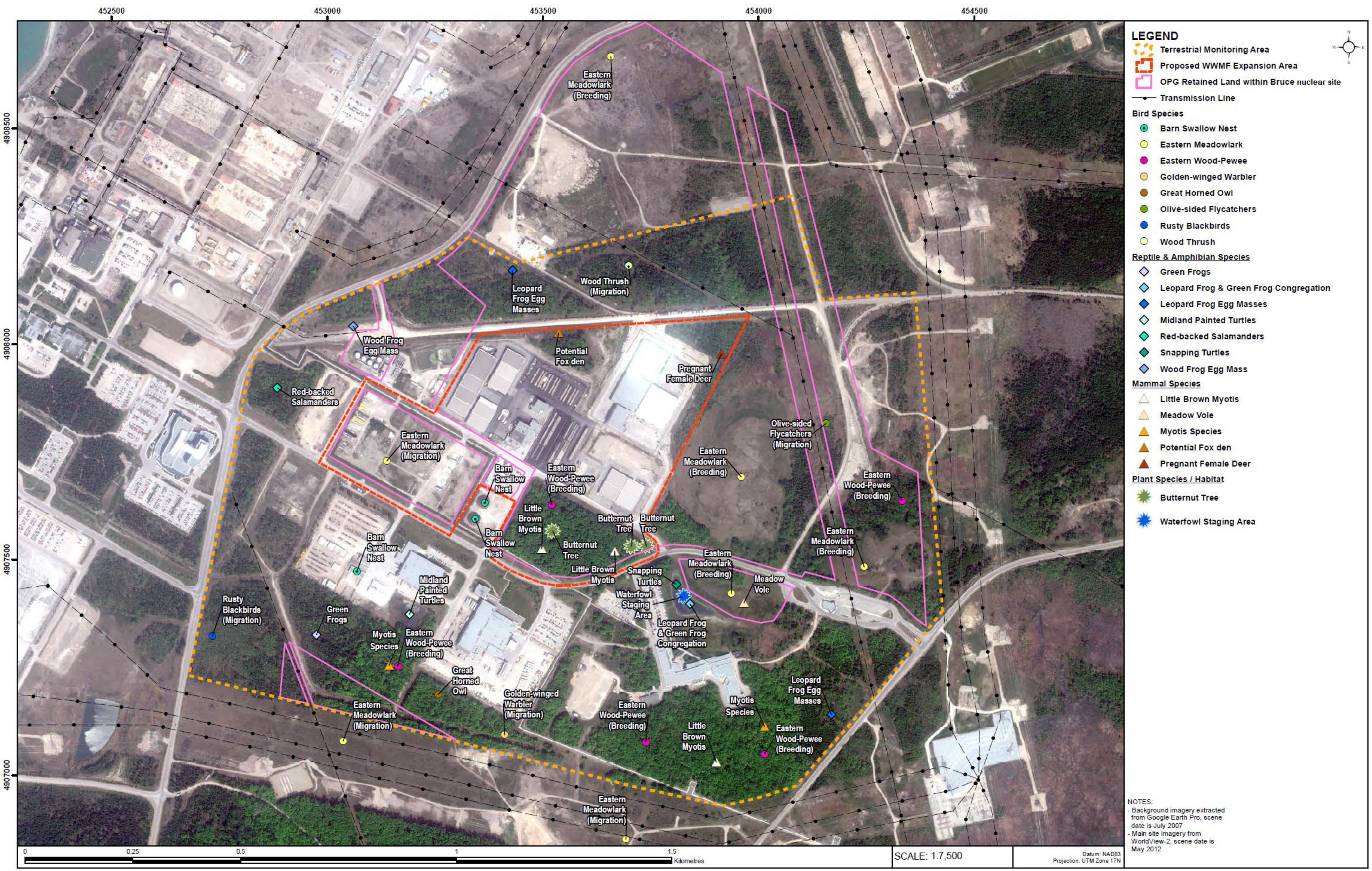


Figure 7-1: WWMF Terrestrial Monitoring Area

7.2 Ecological Conceptual Model and Exposure Pathways

7.2.1 Conceptual Model

The conceptual model illustrates how receptors are exposed to COPCs. It identifies the source of contaminants, receptor locations, and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which COPCs enter the body of the receptor, or (for radionuclides) how they may exert effects from outside the body.

The potential exposure pathways considered in this assessment included exposure to air, water, soil, and sediment, and various dietary components for different species and receptor categories. Detailed potential exposure pathways for aquatic and terrestrial receptors for both radiological and non-radiological contaminants are given in Figure 7-2 and Figure 7-3. Exposure pathways considered in the assessment differ between the radiological and non-radiological COPCs, as discussed in the sections below.

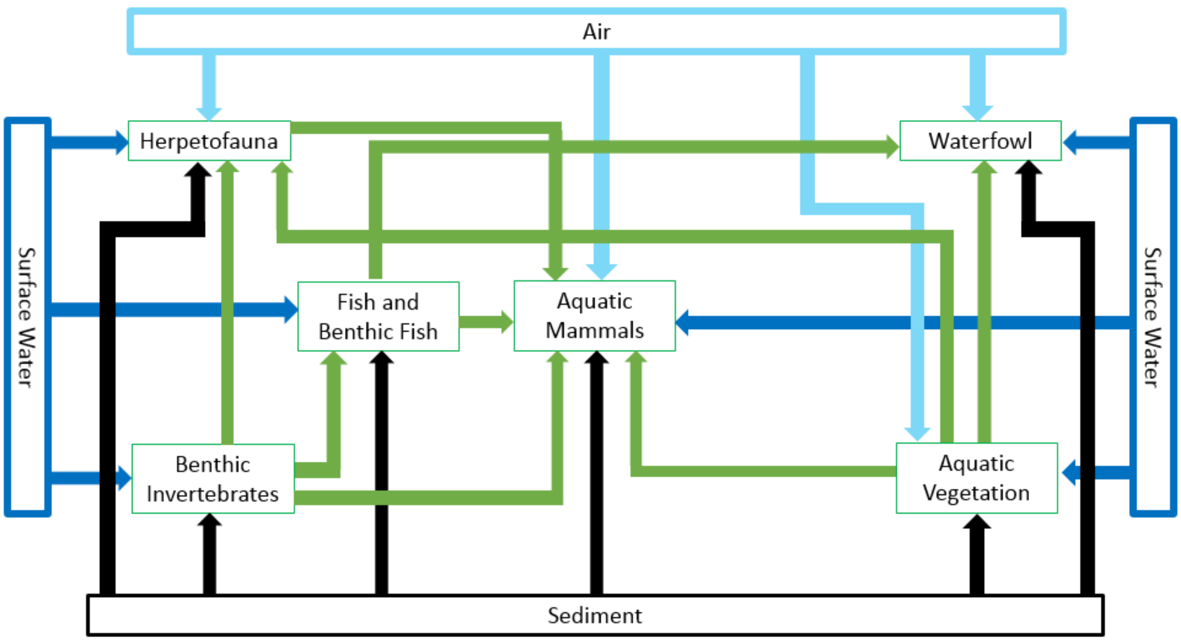


Figure 7-2: Potential Exposure Pathways for Aquatic Receptors

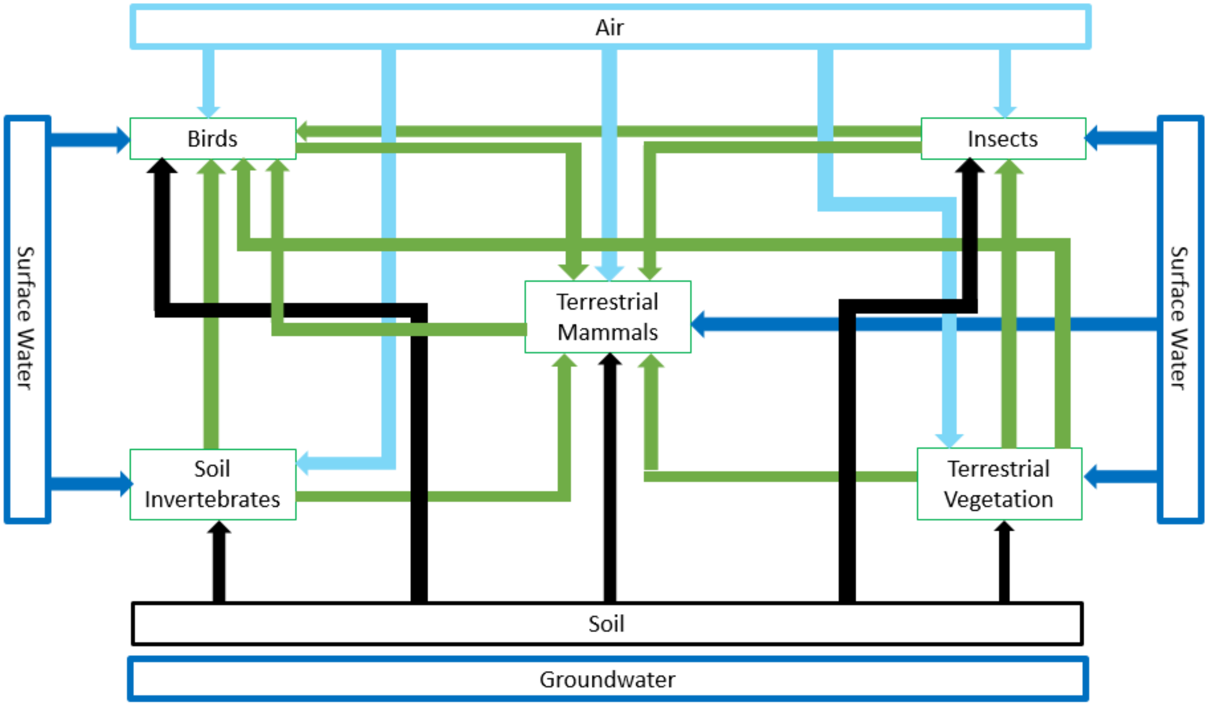


Figure 7-3: Potential Exposure Pathways for Terrestrial Receptors

7.2.1.1 Radiological Contaminants

For radiological contaminants, exposures from air, surface water, soil, sediment, and vegetation are relevant. Exposures from each medium are considered for each receptor; no pathway is considered to result in minimal exposure and therefore no pathway is excluded from the assessment.

For radiological contaminants, the conceptual model for ecological receptors should also take into account direct external radiation exposure in addition to exposure to environmental contamination through different pathways.

7.2.1.2 Non-Radiological Contaminants

The potential exposure pathways given in Figure 7-2 and Figure 7-3 were assessed for non-radiological COPCs as part of the screening assessment in Section 7.4.2. The result was that exposure to COPCs from groundwater and sediment was determined to not be a concern. Media with COPCs, as determined by the screening assessment in Section 7.4.2, are air and surface water. The changes to soil COPCs were determined to be negligible. These media were considered with their various routes of exposure in Figure 7-4 to form the site-specific conceptual model for non-radiological COPCs and to determine the relevant exposure pathways for ecological receptors to non-radiological COPCs.

Exposure pathways were screened in Figure 7-4 as complete, minimal, incomplete, and not applicable. Complete pathways were included in the assessment. Pathways by which a receptor may receive minimal exposure to a COPC have not been included in the assessment as they are not considered to be significant in comparison to the exposure from the complete pathways. Pathways that are "not applicable" are pathways by which it is not considered possible or probable for a receptor to be exposed by a COPC, either due to lack of exposure to the medium or the nature of the receptor. Alternatively, "not applicable" may indicate that the media is not applicable, as exposure is assessed through other media.

Pathways with minimal exposure are identified as such in Figure 7-4. For example:

- Dermal exposure to ecological receptors is generally prevented by fur or feathers, and has therefore not been included for terrestrial receptors;
- Exposure through the ingestion of surface water by terrestrial receptors results in minimal exposure in comparison to exposure to aquatic receptors, and has therefore not been included;
- Soil exposure pathways have been included for illustration; changes to soil COPCs were determined to be negligible; and,
- Inhalation exposures are typically much less than from the ingestion pathway [1]; however, COPCs which do not partition to soil were identified and are therefore included.

Source	Release and Transport	Exposure Route	WWMF and Bruce nuclear site: Terrestrial Plants	Terrestrial Insects	Terrestrial Soil Invertebrates	Terrestrial Mammals and Birds	Aquatic Mammals and Birds	Amphibians	Reptiles	Aquatic Plants	Aquatic Invertebrates	Fish	Lake Huron: Fish
COPCs in Air		Inhalation	N/A	Min	Min	Yes	Yes	Yes	Yes	N/A	N/A	N/A	N/A
COPCs in Air		Immersion / Dermal Contact	Yes	Yes	Min	Min	Min	Min	Min	N/A	N/A	N/A	N/A
	Deposition												
COPCs in Soil		Soil Ingestion	N/A	Yes	Yes	Yes	Min	Yes	Yes	N/A	N/A	N/A	N/A
COPCs in Soil		Soil Inhalation	N/A	Min	Min	Min	Min	Min	Min	N/A	N/A	N/A	N/A
COPCs in Soil		Root Uptake/ Dermal Contact	Yes	Min	Yes	Min	Min	Min	Yes	N/A	N/A	N/A	N/A
COPCs in Soil	Particulate Matter	Inhalation	Min	Min	Min	Min	Min	Min	Min	N/A	N/A	N/A	N/A
COPCs in Soil	Uptake by plants/ intake by prey	Ingestion of Plants and Prey	N/A	Yes	Min	Yes	Min	Yes	Yes	N/A	Min	N/A	N/A
	Leaching												
COPCs in Surface Water		Water Ingestion	N/A	N/A	N/A	Min	Yes	Yes	Yes	N/A	Yes	Yes	Yes
COPCs in Surface Water		Immersion / Dermal Contact	N/A	N/A	N/A	Min	Yes	Yes	Yes	Yes	Yes	Yes	Yes
COPCs in Surface Water	Uptake by plants/ intake by prey	Ingestion of Plants and Prey	N/A	N/A	N/A	Min	Yes	Yes	Yes	N/A	N/A	Yes	Yes

Yes Exposure pathway complete
Min Exposure considered minimal and will not be assessed quantitatively.
N/A Not applicable

Figure 7-4: Conceptual Model for COPCs at the WWMF and Vicinity

7.2.2 Exposure Pathways for Non-Radiological COPCs

The exposure pathways are the routes by which COPCs gain access to a receptor.

The exposure pathways examined in the conceptual site model for non-radiological COPCs are presented in Table 7-3. These pathways were considered for the non-radiological assessment.

Pathways shown in Figure 7-4 as minimal exposure ("Min") were excluded from the table due to being relatively insignificant.

Most of the habitats considered in this assessment are within the bounds of the Bruce nuclear site, in areas on or immediately adjacent to the WWMF to ensure that the most exposed species are evaluated ("On-site" locations). A single exception is fish, which was considered in Lake Huron as well as in the ditches in the vicinity of WWMF. This was included to ensure that deepwater fish species are considered.

Table 7-3: Exposure Pathways for Non-radiological COPCs

Class/Community	Location	Exposure Pathways	Environmental Medium	Receptor
Aquatic Vegetation	On-Site	Immersion	Surface Water	Cattail population
Benthic Invertebrates	On-Site	Immersion	Surface Water	Benthic invertebrate community
			Sediment	Benthic invertebrate community
Fish	On-Site / Lake Huron	Immersion	Surface Water	Northern Redbelly Dace, Spottail Shiner, Smallmouth Bass, Lake Whitefish, Deepwater Sculpin[A, B] populations
Terrestrial Vegetation	On-Site	Root Uptake/ Immersion	Soil	Grass and Eastern White Cedar populations
Terrestrial Invertebrates	On-Site	Immersion/ Direct Contact	Soil	Earthworm and Bee populations
Amphibians / Reptiles	On-Site	Immersion	Surface Water	Northern Leopard Frog, Spring Peeper, and Midland Painted Turtle populations
	On-Site	Direct Contact	Soil	
Aquatic Birds	On-Site	Ingestion	Surface Water	Mallard and Bald Eagle populations
			Sediment	
			Food Item (cattail measurements, uptake into fish and invertebrates)	
Terrestrial Birds	On-Site	Ingestion	Soil	Wild Turkey, American Robin, Red-eyed Vireo, and Bald Eagle populations
			Food Items (uptake into vegetation, earthworms and/or prey items)	
Aquatic Mammals	On-Site	Ingestion	Surface Water	Muskrat population
			Sediment	
			Food Items (cattail measurements)	
Terrestrial Mammals	On-Site	Ingestion	Soil	Northern Short-tailed Shrew, Little Brown Myotis (bat), White-tailed Deer and Red Fox populations
			Food Items (uptake into vegetation, earthworms and/or prey items)	

A. Most sensitive species assessed, based on available toxicological information.
B. Deepwater Sculpin are a benthic species, and are exposed to sediment in their habitat. However, Deepwater Sculpin are not present on-site and evaluation of off-site sediment is not included in the scope of this assessment. Therefore, exposure to sediment is not included in this assessment for the Deepwater Sculpin.

7.3 Assessment of Radiological Impact

In this assessment, all radiological contaminants will be directly passed forward to a Tier 2 assessment (or PQRA). In the Tier 2 assessment, the total doses to non-human biota resulting from the exposure to multiple radionuclides are calculated. On this basis, a Hazard Quotient (HQ) is determined and the effects are quantitatively assessed.

7.3.1 Exposure Point Concentrations and Doses

The predicted exposure point concentrations due to the Project are presented in Section 5.0. On this basis, doses to receptor species were calculated using the computer code AICER (Version 1.0.0.0) [57]. AICER is consistent with CSA N288.6-12 [1] regarding EcoRA for radiological contamination for non-human biota. The results are presented both as a total dose and dose by radionuclide in Table 7-4.

The total projected doses to non-human biota, taking into account the operation of existing nuclear facilities at the Bruce nuclear site, are presented in Table 7-5.

It should be noted that indicator species are exposed to radiation through direct external exposure to gamma radiation from the waste in the storage facilities at the WWMF and from other CNSC licensed facilities at the Bruce nuclear site. The direct external gamma dose rate for non-human biota for baseline conditions was conservatively assumed to be 0.155 µGy/h; which is the maximum dose rate measured at the boundary of the WWMF for the period of 2009-2013. The dose rate target at the WWMF site boundary is 0.5 µGy/h, hence the Project will be designed such that this dose rate is not exceeded. The direct external gamma dose rate for non-human biota from the Project was therefore conservatively assumed to be 0.345 µGy/h, i.e., 0.5 µGy/h – 0.155 µGy/h.

The theoretical basis and the default AICER parameter values used for dose calculation can be found in the ERA for the existing environment [8].

Table 7-4: Estimated Radiological Doses to Ecological Receptors Resulting from the Project

Species	Environmental Pathways Dose by Radionuclide (µGy/h)					Direct External Gamma Dose (µGy/h)	Total Dose (µGy/h)
	HTO	C-14	Co-60	I-131	Cs-137		
Cattail	1.43E-03	5.68E-01	0.00E+00	0.00E+00	5.41E-03	0.345	0.92
Grass	2.09E-03	5.93E-04	7.34E-06	3.08E-07	0.00E+00	0.345	0.35
Eastern White Cedar	3.39E-04	2.58E-03	1.85E-05	6.01E-07	0.00E+00	0.345	0.35
Digger Crayfish	1.43E-03	5.01E-01	0.00E+00	0.00E+00	5.41E-03	0.345	0.85
Benthic Invertebrates	1.43E-03	5.01E-01	0.00E+00	0.00E+00	5.41E-03	0.345	0.85
Northern Redbelly Dace	1.43E-03	5.49E-01	0.00E+00	0.00E+00	3.78E-02	0.345	0.93
Spottail Shiner	1.43E-03	5.49E-01	0.00E+00	0.00E+00	3.78E-02	0.345	0.93
Lake Whitefish	1.43E-03	5.49E-01	0.00E+00	0.00E+00	3.38E-02	0.345	0.93
Smallmouth Bass	1.43E-03	5.49E-01	0.00E+00	0.00E+00	3.34E-02	0.345	0.93
Deepwater Sculpin	1.43E-03	5.49E-01	0.00E+00	0.00E+00	3.56E-02	0.345	0.93
Earthworm	6.32E-03	5.36E-04	2.61E-06	1.13E-09	0.00E+00	0.345	0.35
Bee	1.04E-02	2.97E-03	5.95E-07	2.44E-06	0.00E+00	0.345	0.36
Northern Leopard Frog	1.91E-03	7.03E-01	0.00E+00	0.00E+00	1.53E-02	0.345	1.07
Spring Peeper	1.91E-03	7.03E-01	4.90E-06	2.15E-09	1.28E-02	0.345	1.06
Midland Painted Turtle	1.91E-03	7.03E-01	0.00E+00	0.00E+00	1.53E-02	0.345	1.07
Northern Water Snake	1.91E-03	7.03E-01	0.00E+00	0.00E+00	1.53E-02	0.345	1.07
Red-eyed Vireo	3.88E-03	1.08E-03	5.87E-09	4.88E-12	1.05E-07	0.345	0.35
American Robin	3.88E-03	1.08E-03	4.69E-06	2.05E-09	2.90E-07	0.345	0.35
Mallard	1.20E-03	1.04E+00	1.12E-10	6.68E-14	9.57E-04	0.345	1.38
Wild Turkey	1.47E-03	3.55E-03	7.23E-06	3.69E-09	5.53E-06	0.345	0.35
Bald Eagle	1.19E-03	1.09E+00	1.22E-08	2.56E-11	4.35E-02	0.345	1.48
Muskrat	1.20E-03	1.13E+00	2.03E-11	4.50E-12	8.38E-02	0.345	1.56
Little Brown Bat	5.07E-03	5.93E-03	1.26E-09	6.30E-09	1.37E-06	0.345	0.36
Northern Short-tailed Shrew	3.31E-03	1.07E-03	3.67E-06	1.57E-09	4.10E-06	0.345	0.35
White-tailed Deer	1.07E-03	3.17E-03	4.69E-06	2.33E-07	1.81E-05	0.345	0.35
Red Fox	1.70E-03	2.10E-03	2.51E-06	2.44E-09	6.22E-06	0.345	0.35

Table 7-5: Estimated Radiological Doses to Ecological Receptors Resulting from the Operation of Existing Nuclear Facilities at the Bruce Nuclear Site and the Project

Species	Dose from Baseline Conditions (µGy/h)	Dose from the Project (µGy/h)	Total Dose (µGy/h)
Cattail	0.43	0.92	1.36
Grass	0.20	0.35	0.55
Cedar	1.08	0.35	1.43
Digger Crayfish	0.38	0.85	1.24
Benthic Invertebrates	0.38	0.85	1.24
Northern Redbelly Dace	1.05	0.93	1.98
Spottail Shiner	1.05	0.93	1.98
Lake Whitefish	1.02	0.93	1.95
Smallmouth Bass	1.02	0.93	1.95
Deepwater Sculpin	1.04	0.93	1.97
Earthworm	0.25	0.35	0.61
Bee	0.42	0.36	0.78
Northern Leopard Frog	0.65	1.07	1.72
Spring Peeper	0.64	1.06	1.70
Midland Painted Turtle	0.65	1.07	1.72
Northern Water Snake	0.65	1.07	1.72
Red-eyed Vireo	0.20	0.35	0.55
American Robin	0.21	0.35	0.56
Mallard	0.51	1.38	1.89
Wild Turkey	0.18	0.35	0.53
Bald Eagle	1.41	1.48	2.89
Muskrat	2.00	1.56	3.57
Little Brown Bat	0.19	0.36	0.54
Northern Short-tailed Shrew	0.21	0.35	0.56
White-tailed Deer	0.35	0.35	0.69
Red Fox	0.18	0.35	0.53

7.3.2 Radiation Benchmarks

The following dose benchmark values, as recommended in CSA N288.6-12 [1], will be used in this assessment:

- 100 µGy/h for terrestrial biota, and;
- 400 µGy/h for aquatic biota[19].

7.3.3 Risk Characterization

Effects will be quantified for each category based on the calculation of a HQ.

If the HQ for each radiological COPC is less than one, then adverse effects are not expected as concentrations are below levels that are known to cause adverse effects. If the HQ exceeds one, it is inferred that adverse effects to the species are possible. Inferences about potential effects can be made given a certain magnitude and type of effect associated with the assessment benchmark or endpoint. An HQ > 1 indicates that there is the potential for adverse effects and further assessment is required.

In general terms, an increase in exposure is associated with an increase in risk. As the magnitude of HQ increases so does the potential for environmental effects, the likelihood of the effects depending on the magnitude of exposure and the endpoint used to assess effects.

The radiological effects to non-human biota will be quantified based on the calculation of a HQ for each indicator species using the following equation:

$$HQ = \frac{Calculated\ radiation\ dose}{Radiological\ criteria}$$

For radiological effects, the HQ is calculated based on the total dose received by each receptor from all radionuclides through all pathways. The calculated radiation dose received by each receptor is given in Table 7-4 and the radiological criteria are listed in Section 7.3.2 as dose benchmark values.

The HQ for each category of non-human biota is given in Table 7-6. Results are presented for each indicator species in each non-human biota category.

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[19] To be conservative, the criterion of 100 µGy/h is applied to Muskrat although it was identified as an aquatic species.

Table 7-6: Radiological Risk Characterization

Class/Community	Indicator Species	Total Dose (µGy/h)	Criterion (µGy/h)	HQ
Aquatic Vegetation	Cattail	1.36	400	0.003
Terrestrial Vegetation	Grass	0.55	100	0.005
	Eastern White Cedar	1.43	100	0.014
Aquatic Invertebrates	Digger Crayfish	1.24	400	0.003
	Benthic Invertebrates	1.24	400	0.003
Fish	Northern Redbelly Dace	1.98	400	0.005
	Spottail Shiner	1.98	400	0.005
	Lake Whitefish	1.95	400	0.005
	Smallmouth Bass	1.95	400	0.005
	Deepwater Sculpin	1.97	400	0.005
Terrestrial Soil Invertebrate	Earthworm	0.61	100	0.006
Insects	Bee	0.78	100	0.008
Herpetofauna	Northern Leopard Frog	1.72	100	0.017
	Spring Peeper	1.70	100	0.017
	Midland Painted Turtle	1.72	100	0.017
	Northern Water Snake	1.72	100	0.017
Birds	Red-eyed Vireo	0.55	100	0.006
	American Robin	0.56	100	0.006
	Mallard	1.89	100	0.019
	Wild Turkey	0.53	100	0.005
	Bald Eagle	2.89	100	0.029
Aquatic Mammals	Muskrat	3.57	100	0.036
Terrestrial Mammals	Little Brown Bat	0.54	100	0.005
	Northern Short-tailed Shrew	0.56	100	0.006
	White-tailed Deer	0.69	100	0.007
	Red Fox	0.53	100	0.005

The radiological HQ for each indicator species is less than 1; therefore the total dose received by each indicator species is below the benchmark values given in CSA N288.6-12 [1]. Therefore, there are no adverse effects from the radiological COPCs and no further analysis is required.

7.4 Assessment of Non-Radiological Impact

7.4.1 Screening Criteria

CSA N288.6-12, Clause 7.2.5.3.1, indicates that "For non-radiological COPCs, the most restrictive applicable federal or provincial guidelines for environmental quality should be used as screening criteria, if such guidelines are available, because their values are intended to be protective of all or most organisms in the media to which they apply" [1].

The ERA conducted for the WWMF baseline conditions [8] is built on the CSA guidance. Provincial and federal environmental guidelines and objectives have been used to determine the screening criteria for non-radiological contaminants, using the same sources as the WWMF baseline ERA [8]. Specific Toxicity Reference Values (TRVs) were developed for the WWMF, taking into account non-human biota presented in the vicinity of the WWMF. Therefore, these site specific TRV values are used in this analysis as the screening criteria where appropriate and when other criteria were unavailable. Details on specific criteria are provided in the relevant sub-sections of Section 7.4.2.

7.4.2 Screening

Screening of non-radiological contaminants to determine COPCs was performed in accordance with CSA N288.6-12 [1]. The primary environmental data for air, soil, surface water, and groundwater used as inputs to the screening assessment were discussed in Sections 5.2 through 5.5. Environmental concentrations that do not exceed the screening criteria are not considered to be of concern and do not require further assessment.

7.4.2.1 Air

Modelling as described under Section 5.2.2.5 specific to ground-level air quality was used to further assess potential impacts to the environment. The results of the worst-case modelling are provided in Section 5.2.2.7. The results of all modelled scenarios are provided in Appendix H. Interpretation and assessment of these data is provided in the appropriate section with respect to surface water (Sections 5.4.3.7 and 7.4.2.5).

Changes in air quality have the potential to interact with plant and wetland VECs and associated receptors, as well as all wildlife VECs and associated receptors. Ten receptor locations were selected to assess changes in air quality parameters that would potentially pose adverse effects to plant and wildlife species (Figure 5-6). The receptor locations were within and outside the boundaries of the proposed WWMF expansion area and within areas considered representative locations of select VEC/receptor locations, with receptor location 3 (ER4) located directly within an expansion area (area 3). Air modelling methodology is provided in Section 5.2.2.

Regulated standards for effects of TSP and NO_2, SO_2, and CO emissions on wildlife and their habitats do not currently exist in Ontario; however, animal toxicology studies suggest evidence of effects of NO_2 on wildlife species for one to two hour periods (based on peak concentrations) occurs at 940 µg/m^3 [5]. Similarly, regulated standards for effects of TSP and NO_2, SO_2, and CO emissions on plants do not currently exist in Ontario, although plants are generally much less sensitive than wildlife to short-term exposures of NO_2, SO_2, and CO emissions. Given the absence of regulated standards for effects of TSP and NO_2, SO_2, and CO emissions on wildlife and plants, the Ontario AAQC [11] was applied to identify potential effects of the Project, except where exceedances of 940 µg/m^3 of NO_2 were observed relative to wildlife VECs and associated receptors.

Total Suspended Particulate (TSP)

Based on the assessment of potential air quality contaminants relative to plant and wildlife VECs and associated receptors, predicted 24-hour TSP levels during site preparation exceed AAQC criteria at four of ten receptor locations (Table 7-7). During construction, predicted 24-hour TSP levels and annual TSP levels exceed AAQC criteria at three of ten receptor locations and two of ten receptor locations, respectively (Table 7-7). Importantly, the exceedance of the TSP criterion at receptor location 3 (ER4) is irrelevant based on the premise that under the assumed worst-case site preparation and construction scenario (area 1/2 + 3), area 3 will be cleared of all vegetation and associated wildlife attributes.

Suspended particulate matter is primarily a concern with respect to potential effects on vegetation, whereas wildlife species are generally considered to be able to temporarily modify their behaviour to avoid impacts of elevated TSP. There may be some minor adverse response to dust resuspension on vegetation and general avoidance of these affected areas by wildlife, but this is considered to be of short-term duration with light particulate depositions being removed from vegetation through wind and precipitation events. The dust management plan is expected to be developed and implemented during the Project and will identify all potential sources of fugitive dusts, outline mitigation measures to be employed to control dust generation, and detail the inspection and recordkeeping to demonstrate that fugitive dusts are being effectively managed. Accordingly, adverse effects on plant and wildlife VECs and associated receptors due to changes in air quality during the site preparation and construction phases of the Project are not expected due to the anticipated short term duration of dust resuspension and the availability of mitigation measures associated with dust management to manage the magnitude and extent of such dust resuspension.

Nitrogen Dioxide (NO_2)

Predicted 1-hour NO_2 levels exceed AAQC levels at six of ten receptor locations during site preparation, whereas NO_2 levels exceed AAQC levels at nine of ten receptor locations during construction (Table 7-8). Predicted 24-hour NO_2 levels do not exceed AAQC levels at any of the receptor locations during any phase of the Project. Exceedance of 940 $\mu g/m^3$ was predicted at receptor location 4 during the construction phase of the Project. No exceedance of 940 $\mu g/m^3$ was predicted during site preparation.

Animal toxicology studies suggest that peak concentrations contribute more to the toxicity of NO_2 than does duration. The predicted peak 1-hour NO_2 concentration at receptor location 4 during construction is predicted to be 1,146 $\mu g/m^3$. Wildlife and wildlife habitat VECs receptors within the vicinity of receptor location 4 include White-tailed Deer, American Robin, Red-eyed Vireo, Northern Water Snake, and amphibian woodland breeding habitat. The adverse effects associated with this exceedance during construction at receptor location 4 will be further assessed (see Section 7.4.3.1).

Although AAQC exceedances of 1-hour NO_2 were predicted relative to plant VEC and associated receptors, the levels are short-term in duration and are unlikely to affect plant growth. Research suggests more long-term exposure to elevated NO_2 (188 to 564 $\mu g/m^3$), as is closely emulated by the 24-hour exposure modelling, is more likely to affect the growth and seed production of plants; however, plant growth and seed productions respond positively upon removal of the elevated NO_2 exposure [58],

[59]. Given the predicted 24-hour NO_2 concentrations at all receptor locations was below AAQC levels, there are likely no adverse effects on plant VECs and associated receptors due to changes in NO_2 during the site preparation and construction phase of the Project.

Sulphur Dioxide (SO_2) and Carbon Monoxide (CO)

Predicted 1-hour and 24-hour SO_2 levels are below AAQC levels at all receptor locations during site preparation and construction (Table 7-9). Predicted 1-hour and 8-hour CO levels are well below AAQC levels at all receptor locations (Table 7-10).

Accordingly, there are likely no adverse effects on plant and wildlife VECs and associated receptors due to changes in SO_2 and CO during all phases of the Project.

Table 7-7: Predicted Worst-Case Changes in TSP Concentration at Ecological Receptors

Receptor Location	24-Hour TSP			Annual TSP		
	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)	Predicted Change in Concentration (µg/m^3)	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)	Predicted Change in Concentration (µg/m^3)
Site Preparation (1/2+3)						
1	47.8	124.8*	+77.0	-	-	-
2 (ER7)	48.2	176.5*	+128.3	-	-	-
3 (ER4)	48.2	228.4*	+180.2	-	-	-
4	48.3	345.0*	+296.7	-	-	-
5	48.4	63.6	+15.1	-	-	-
6 (ER3)	47.9	62.6	+14.7	-	-	-
7	48.4	57.0	+8.7	-	-	-
8 (ER5)	48.1	68.6	+20.5	-	-	-
9 (ER6)	48.6	74.4	+25.9	-	-	-
10	47.9	75.5	+27.5	-	-	-
Construction (1/2+3)						
1	47.8	145.6*	+97.9	45.2	51.5	+6.3
2 (ER7)	48.2	104.1	+55.9	45.2	50.3	+5.1
3 (ER4)	48.2	304.2*	+256.0	45.3	67.3*	+22.0
4	48.3	280.9*	+232.6	45.3	71.1*	+25.8
5	48.4	71.7	+23.3	45.2	46.4	+1.1
6 (ER3)	47.9	65.3	+17.3	45.2	46.2	+1.0
7	48.4	63.4	+15.0	45.2	46.2	+1.0
8 (ER5)	48.1	80.4	+32.3	45.2	48.3	+3.1
9 (ER6)	48.6	81.7	+33.1	45.2	47.1	+1.9
10	47.9	74.8	+26.9	45.2	46.6	+1.4

* Denotes exceedance of AAQC. 24-hour TSP AAQC = 120 µg/m^3; annual TSP AAQC = 60 µg/m^3

Table 7-8: Predicted Worst-Case Changes in NO_2 Concentrations at Ecological Receptors

Receptor Location	1-Hour NO_2			24-Hour NO_2		
	Baseline Concentration (µg/m³)	Predicted Concentration (µg/m³)	Predicted Change in Concentration (µg/m³)	Baseline Concentration (µg/m³)	Predicted Concentration (µg/m³)	Predicted Change in Concentration (µg/m³)
Site Preparation (1/2+3)						
1	140.8	660.9*	+520.1	22.0	30.0	+8.0
2 (ER7)	139.7	343.2	+203.5	19.7	25.1	+5.4
3 (ER4)	101.8	412.0*	+310.2	37.8	38.1	+0.3
4	107.6	668.3*	+560.7	22.8	42.1	+19.2
5	129.0	496.0*	+367.1	21.9	33.4	+11.5
6 (ER3)	75.7	355.3	+279.7	19.1	28.3	+9.1
7	130.2	304.0	+173.8	20.3	18.7	-1.6
8 (ER5)	122.9	322.2	+199.3	19.4	23.9	+4.5
9 (ER6)	119.7	527.4*	+407.7	20.9	27.1	+6.2
10	75.7	472.0*	+396.3	18.6	30.6	+11.9
Construction (1/2+3)						
1	140.8	558.1*	+417.3	22.0	74.0	+52.1
2 (ER7)	139.7	545.6*	+405.9	19.7	73.2	+53.5
3 (ER4)	101.8	784.1*	+682.3	37.8	100.7	+62.8
4	107.6	1,146.3*	+1,038.7	22.8	127.9	+105.1
5	129.0	757.4*	+628.4	21.9	44.5	+22.6
6 (ER3)	75.7	423.7*	+348.0	19.1	46.2	+27.1
7	130.2	306.8	+176.6	20.3	52.4	+32.1
8 (ER5)	122.9	720.7*	+597.8	19.4	68.5	+49.1
9 (ER6)	119.7	505.5*	+385.8	20.9	53.2	+32.2
10	75.7	783.6*	+707.9	18.6	70.1	+51.5

* Denotes exceedance of AAQC. 1-hour NO_2 AAQC = 400 µg/m³; 24-hour NO_2 AAQC = 200 µg/m³

Table 7-9: Predicted Worst-Case Changes in SO_2 Concentration at Ecological Receptors

Receptor Location	1-Hour SO_2			24-Hour SO_2		
	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)	Predicted Change in Concentration (µg/m^3)	Baseline Concentration (µg/m^3)	Predicted Concentration (µg/m^3)	Predicted Change in Concentration (µg/m^3)
Site Preparation (1/2+3)						
1	253.4	253.4	0	50.2	50.2	0
2 (ER7)	317.0	317.1	+0.1	55.6	55.6	0
3 (ER4)	193.7	193.7	0	55.5	55.5	0
4	280.5	280.5	0	56.6	56.6	0
5	178.6	178.6	0	58.5	58.5	0
6 (ER3)	191.4	191.4	0	52.9	52.9	0
7	172.5	172.5	0	58.2	58.2	0
8 (ER5)	219.2	219.2	0	54.5	54.5	0
9 (ER6)	206.2	206.2	0	60.8	60.8	0
10	199.1	199.1	0	52.8	52.8	0
Construction (1/2+3)						
1	253.4	260.3	+6.9	50.2	52.0	+1.8
2 (ER7)	317.0	317.3	+0.3	55.6	55.6	0
3 (ER4)	193.7	193.7	0	55.5	55.9	+0.4
4	280.5	280.6	+0.1	56.6	56.9	+0.3
5	178.6	178.7	0	58.5	58.5	+0.1
6 (ER3)	191.4	191.6	+0.2	52.9	52.9	0
7	172.5	172.5	0	58.2	58.2	0
8 (ER5)	219.2	219.3	+0.1	54.5	54.6	+0.1
9 (ER6)	206.2	206.5	+0.3	60.8	60.8	0
10	199.1	199.4	+0.3	52.8	52.9	+0.1

* Denotes exceedance of AAQC. 1-hour SO_2 AAQC = 690 µg/m^3; 24-hour SO_2 AAQC = 275 µg/m^3

Table 7-10: Predicted Worst-Case Changes in CO Concentration at Ecological Receptors

Receptor Location	1-Hour CO			8-Hour CO		
	Baseline Concentration (µg/m³)	Predicted Concentration (µg/m³)	Predicted Change in Concentration (µg/m³)	Baseline Concentration (µg/m³)	Predicted Concentration (µg/m³)	Predicted Change in Concentration (µg/m³)
Site Preparation (1/2+3)						
1	484.4	6,703.3	+6,218.8	470.1	1,362.3	+892.1
2 (ER7)	495.4	3,226.5	+2,731.1	470.7	830.7	+360.0
3 (ER4)	496.3	3,960.3	+3,464.0	479.5	966.2	+486.7
4	493.0	6,556.9	+6,064.0	476.0	1,360.3	+884.3
5	487.5	4,684.9	+4,197.4	468.3	1,079.6	+611.3
6 (ER3)	482.9	2,344.6	+1,861.6	469.9	698.0	+228.0
7	480.3	2,459.7	+1,979.4	465.6	708.4	+242.8
8 (ER5)	482.4	2,009.8	+1,527.3	467.8	688.9	+221.1
9 (ER6)	477.2	4,032.0	+3,554.8	467.0	917.4	+450.4
10	477.8	3,650.0	+3,172.1	467.8	858.3	+390.5
Construction (1/2+3)						
1	484.4	3,385.3	+2,900.9	470.1	982.5	+512.3
2 (ER7)	495.4	2,137.1	+1,641.7	470.7	670.8	+200.1
3 (ER4)	496.3	4,329.6	+3,833.3	479.5	975.0	+495.6
4	493.0	4,612.9	+4,120.0	476.0	1,198.2	+722.2
5	487.5	4,167.9	+3,680.4	468.3	921.7	+453.4
6 (ER3)	482.9	2,087.4	+1,604.5	469.9	661.7	+191.8
7	480.3	2,019.2	+1,538.9	465.6	653.2	+187.6
8 (ER5)	482.4	3,470.1	+2,987.7	467.8	840.3	+372.5
9 (ER6)	477.2	1,890.8	+1,413.6	467.0	644.5	+177.5
10	477.8	3,812.0	+3,334.2	467.8	1,090.8	+623.0

* Denotes exceedance of AAQC. 1-hour CO AAQC = 36,200 µg/m³; 8-hour CO AAQC = 15,700 µg/m³

7.4.2.2 Soil

As discussed in Section 5.3.2, measureable changes to soil, via air emissions and resulting deposition onto soil from the Site Preparation and Construction Phases and Operation and Maintenance activities, are not expected. Therefore, it is expected that there are no adverse effects on ecological receptors resulting from the Project. No further assessment is warranted.

7.4.2.3 Groundwater

The current qualitative assessment for groundwater at the WWMF suggests that the groundwater from the WWMF will discharge to surface water (Lake Huron) through bedrock aquifer. A relatively small amount of intermittent discharge to the South Railway Ditch occurs from the Middle Sand Aquifer through interception by on-site stormwater management facilities. However, as discussed in Section 5.5.4, groundwater contamination resulting from the Project is unlikely. Therefore, there are no adverse effects on ecological receptors resulting from the Project. No further assessment is required.

7.4.2.4 Surface Water Quantity and Flow

The expected effects on surface water quantity and flow as a result of the Project are given in Table 5-35. The screening results are presented in Table 7-11.

As shown in Table 7-11, all but one scenario can be screened out based on the measurable change criteria (greater than ±15%). The scenario where drainage from potential expansion areas 1-4 are directed towards the South Railway Ditch (Case 1) produces a change in annual flow of 35.4% in the South Railway Ditch, which is larger than the measurable change criteria and will therefore be assessed further in Section 7.4.3.2. All other scenarios would not produce a measureable change to surface water quantity and therefore do not require further assessment.

Table 7-11: Summary of Surface Water Quantity and Flow Screening

Scenario	Average Change in Annual Flow* (%)	Measureable Change Criteria (%)	Exceeds Criteria?
Case 1 (All flow directed to South Railway Ditch)			
South Railway Ditch	35.4	±15	**Yes**
West Ditch	-8.8	±15	No
Case 2 (All flow directed to West Ditch)			
South Railway Ditch	-5.5	±15	No
West Ditch	7.3	±15	No

* These results are valid for all climate conditions, including average, 1:20 year wet and 1:20 year dry conditions.

7.4.2.5 Surface Water Quality

The potential contamination of surface water resulting from the Project is discussed in Section 5.4.3.7. The calculated concentrations are compared against the screening criteria and the results are discussed below.

Evaluation Criteria

The water quality assessment requires comparing the results of the water quality analysis to evaluation criteria to determine whether there are potential adverse effects on the environment. For a change to be considered to have a potential adverse effect, it must exceed the threshold for effect. This is identified from environmental guidelines (where applicable) or is based on TRVs as developed in the baseline ERA [8]. These evaluation criteria are presented below:

- Metals (Zinc): The Interim Provincial Water Quality Objective (PWQO) for zinc is 0.02 mg/L [60] and the Canadian Environmental Quality Guideline (CEQG) aquatic life long term zinc concentration is 0.03 mg/L [31]. The baseline ERA [8] TRV for zinc is 0.08175 mg/L (as per [61]). The US EPA Hardness Adjusted Guideline is 0.174 mg/L [62].
- Metals (Copper): The toxicity of copper is hardness dependent. The Interim PWQO for copper where water hardness exceeds 20 mg/L (which is the case for each of the South Railway Ditch and the West Ditch throughout all open water seasons) is 0.005 mg/L [60]. The CEQG long term copper concentration for aquatic life is 0.004 mg/L where hardness exceeds 180 mg/L [31]. TRVs have been developed and are presented in [8] as based on [63]. TRVs for aquatic invertebrates (*Daphnia pulex*) at hardness values of 57.5 mg/L and 230 mg/L are 0.00283 mg/L and 0.00916 mg/L, respectively. A TRV is not readily available for a hardness of 164 mg/L as encountered on-site when copper concentrations reached 0.002 mg/L. However, it is assumed that a TRV above 0.005 mg/L is applicable and conservative for assessment purposes.
- Nutrients (Phosphorus): The PWQO states that a total phosphorus concentration below 0.03 mg/L will eliminate excessive plant growth in rivers and streams [60]. The Canadian Council of Ministers of the Environment provides the Canadian Guidance Framework for phosphorus for developing phosphorus guidelines. It provides the following trigger ranges for Total Phosphorus (mg/L): ultra-oligotrophic <0.004; oligotrophic 0.004-0.01; mesotrophic 0.01-0.02; meso-eutrophic 0.02-0.035; eutrophic 0.035-0.1; hyper-eutrophic >0.1 [31]. As per the baseline ERA, the trophic condition of the receiving drainages is considered meso-eutrophic to eutrophic.
- Temperature: The general PWQO for temperature states that "the natural thermal regime of any body of water shall not be altered so as to impair the quality of the natural environment. In particular, the diversity, distribution and abundance of plant and animal life shall not be significantly changed" [60]. British Columbia Ministry of Environment identifies the use of the maximum weekly mean temperature (MWMT), as the average of the warmest daily maximum temperatures for seven consecutive days [64]. Provincially in Ontario a threshold for this measure under a chronic exposure scenario has not been identified, however, for the purposes of this assessment the MWMT within the

South Railway Ditch was calculated as 20.2°C in mid-summer in 2014. Increases in temperature as assessed within the context of expected annual average increases to water temperature that may similarly increase the MWMT. This increase is evaluated in a qualitative fashion with respect to impacting aquatic communities.

- Chloride: There is no PWQO guideline for salinity (represented by Chloride in this assessment). There is also no Canadian Council of Ministers of the Environment guideline for freshwater salinity. As such, the evaluation criterion selected is therefore the maximum baseline data value of 460 mg/L. This is considered appropriate because, as noted in reference [8], baseline chloride concentrations up to 460 mg/L have not been identified as resulting in an unacceptable risk to aquatic receptors at the WWMF. The revised TRV based on water hardness of 160 mg/L is 465 mg/L (in reference to *Daphnia pulex*, IC_{10}[2] = 368).
- TSS: There is no PWQO guideline for TSS. The Canadian Council of Ministers of the Environment guideline [31] for TSS is defined for clear flow and high flows. For this evaluation it is considered that the long-term clear flow requirement applies (maximum increase of 5 mg/L from background levels):
    - Clear flow: Maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-hour period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 hours and 30 days).
    - High flow: Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. This should not increase by more than 10% of background levels when background is ≥ 250 mg/L.

Screening

Table 7-12 provides screening of the results by comparison to the calculated concentrations for indicators that represent the threshold for causing an effect.

Table 7-12: Screening of Water Quality Results

Indicator	Calculated Concentration	Unit	Threshold for Effect	Exceedances of Threshold for Effect
Copper	0.004 (South Railway Ditch) 0.0023 (West Ditch)	mg/L	• 0.005 mg/L where hardness > 20 mg/L (the case for South Railway Ditch and West Ditch throughout all open water seasons) (Interim PWQO, [60]) • 0.004 mg/L where hardness is > 180 mg/L (CEQG aquatic life long term, [31]) • 0.005 mg/L is ERA TRV assumed for aquatic invertebrates [8]	None
Zinc	0.103 (South Railway Ditch) 0.018 (West Ditch)	mg/L	• 0.02 mg/L (Interim PWQO, [60]) • 0.03 mg/L (CEQG aquatic life long term, [31]) • 0.08175 mg/L is ERA TRV (Hardness Adjusted Guideline [61]) • 0.174 mg/L is Hardness Adjusted Guideline [62]	• South Railway Ditch exceeds PWQO, CEQC and ERA TRV ([61]) at maximum background condition; however this background condition is not considered representative. • South Railway Ditch does not exceed the ERA TRV ([61]) at 0.052 mg/L (second highest background condition), therefore no adverse effect to biota is expected.
Total Phosphorus	0.05 (South Railway Ditch) 0.019 (West Ditch)	mg/L	• 0.03 mg/L [60] • ultra-oligotrophic <0.004; oligotrophic 0.004-0.01; mesotrophic 0.01-0.02; meso-eutrophic 0.02-0.035; eutrophic 0.035-0.1; hyper-eutrophic >0.1. Trophic condition of the receiving drainages are considered meso-eutrophic to eutrophic [31]	None, values are within range for meso-eutrophic to eutrophic systems
Temperature	10.04 (South Railway Ditch) 9.27 (West Ditch)	°C	Thermal additions to the receiving water should be such that the MWMT is not appreciably elevated to levels expected to impact the diversity, distribution and abundance of aquatic species.	An estimated increase of 1.5°C in South Railway Ditch (Case 1) and an increase of 0.8°C in the West Ditch (Case 2), above the baseline annual average temperature and therefore a potential similar increase to the MWMT.

Indicator	Calculated Concentration	Unit	Threshold for Effect	Exceedances of Threshold for Effect
Chloride	460 (South Railway Ditch) 420 (West Ditch)	mg/L	465 mg/L (Revised TRV based on Water Hardness =160 mg/L, *Daphnia pulex*) [8]	None
TSS (site preparation and construction)	88.6 (South Railway Ditch) 50.9 (West Ditch)	mg/L	The criterion for clear flow, is a maximum average increase of 25 mg/L from background levels for short-term exposure and 5 mg/L from background levels for longer term exposures [31]	South Railway Ditch and West Ditch exceed criteria of increase of 25 mg/L (short-term) and 5 mg/L (long-term) from background levels
TSS (operation and maintenance)	13.55 (South Railway Ditch) 13.55 (West Ditch)	mg/L		None

The results of this assessment are as follows:

- Copper: The highest calculated copper concentration is 0.004 mg/L for the South Railway Ditch in Case 1; this concentration equals the lower threshold value of 0.004 mg/L (aquatic life long term guideline, [31]), and the estimated copper concentration under Case 1 in the South Railway Ditch does not exceed the toxicity benchmark relevant to water hardness (assumed TRV 0.005 mg/L). Therefore, impacts to aquatic vegetation, invertebrate communities or fish populations are not expected based on copper concentrations in water, and the operation and maintenance of the expansion project is not considered to have adverse effects on the environment in regard to copper concentration in the drainage ditches.
- Zinc: The calculated zinc concentration in the South Railway Ditch for Case 1 and 2 (0.09 mg/L and 0.1 mg/L, which is the maximum measured value as noted in Table 5-42) exceeds the PWQO and CEQG guidelines (0.02 mg/L and 0.03 mg/L). Also, the predicted zinc concentrations are in exceedance of the British Columbia Ministry of Environment hardness based chronic value [61] for Case 1 in the South Railway Ditch (0.08175 mg/L). However, they are not above the US EPA hardness based chronic value (0.174 mg/L). The value of 0.103 mg/L as sampled in the South Railway Ditch at SRD-3 (location E) in May 2014 was significantly greater than concentrations found in the South Railway Ditch both upstream and downstream of this location (i.e., SRD-1 and SRD-4) in April and July 2014 (maximum value of 0.0241 mg/L). The next greatest concentration of surface water zinc in the South Railway Ditch was found at SRD-2 (location C) in May 2014 at 0.052 mg/L (at an estimated water hardness of 164 mg/L). Samples for zinc in May, 2014, are suspect and may not reflect baseline conditions. Considering 0.052 mg/L as a baseline condition, the estimated zinc concentration in the South

Railway Ditch for Case 1 would be 0.055 mg/L, which is below the adjusted TRV of 0.0855 mg/L at a water hardness of 164 mg/L [61]. This TRV is well above the concentrations typically measured within the South Railway Ditch in 2013 and 2014 and above the predicted concentration due to development of the WWMF expansion. Therefore, no adverse effect to aquatic vegetation, invertebrates communities or fish populations are expected based on zinc in surface waters. As such, a residual effect to water quality is not identified through this indicator.

- Total Phosphorus: The calculated total phosphorus concentration in the South Railway Ditch for Case 1 of 0.05 mg/L exceeds both PWQO (0.03 mg/L) and CEQG guidelines for meso-eutrophic systems (0.02-0.035 mg/L). However, it is within the CEQG guideline for eutrophic systems (0.035-0.1 mg/L). Since the trophic condition of the drainage ditches are considered meso-eutrophic to eutrophic, the operation and maintenance of the expansion project is therefore not considered to have adverse effects on the environment in regard to increased levels of total phosphorus in the drainage ditch. However, nutrient enrichment is likely contributing to enhanced plant (algae and macrophytes) growth within the ditch, which may contribute to low aqueous oxygen concentrations during periods of stagnation due to decay of plant material and perhaps even on a diel cycle as plants cycle between photosynthesis during the day and respiration during the night.
- Temperature: The maximum estimated increase in mean annual water temperature in the South Railway Ditch (under Case 1) is 1.5°C. The maximum estimated increase in mean annual water temperature in the West Ditch (under Case 2) is 0.8°C. These results are specific to operation and maintenance. Although weekly temperature variations were not predicted, it is reasonable to consider that the MWMT may increase as much as the annual average temperature. In the case of the South Railway Ditch, this suggests that the Project development has the potential to increase the MWMT to 1.5°C above the measured average maximum weekly temperature (20.2°C in 2014). Therefore, operation and maintenance of the expansion project could potentially increase the average maximum weekly water temperature in the South Railway Ditch slightly. However, the risk associated with this increase is regarded as being low. For fish indicator species associated with the South Railway Ditch (i.e., Northern Redbelly Dace and Creek Chub), the preferred temperatures are 25.3°C ([65], [66]) and 20.8°C [65], respectively, with maximum tolerances of higher temperatures (approaching 30°C) [67]. Such temperatures are limited to summer drought conditions in the drainage ditches. It is expected that water temperatures within the ditches will be more influenced by seasonal and annual variations in precipitation, air temperature, and direct solar exposure (which is variable based on cloud cover, riparian and in-water cover) than inputs from a stormwater facility. Therefore, changes to the thermal habitat of biota in drainage ditches are not expected to pose an adverse effect. Therefore temperature is not carried forward for further assessment.
- Chloride: The calculated chloride concentrations in the South Railway Ditch for Case 1 (395 mg/L) and in the West Ditch for Case 2 (392 mg/L) do not

exceed the TRV of 465 mg/L. The remaining values (West Ditch for Case 1 and South Railway Ditch for Case 2) are the background chloride values. The reduction from the background values derives from the approach taken in this assessment that typical industrial sites do not release chloride to surface runoff (no EMC value is provided in [35]), and thus the only potential source of increased chloride loadings will be from road salt application to the new road and paved surfaces within the proposed expansion areas. These areas were estimated to be 39% of the developed area, based on an aerial evaluation of the current WWMF layout. The area to be occupied by buildings (estimated to be 61% of the developed area) will not contribute to chloride loading. Therefore operation and maintenance of the expansion project is not considered to have adverse effects on the environment in regard to chloride concentration in the ditches.

- TSS:
  - Clearing and construction: The calculated TSS concentration in the South Railway Ditch for Case 1 (88.6 mg/L) and in the West Ditch for Case 2 (50.9 mg/L) exceed the clear flow criterion, which is a maximum average increase of 5 mg/L from background levels for longer term exposures [31]. Therefore clearing and construction of the expansion project is considered to have potential adverse effects on the environment in regard to TSS concentration in the drainage ditches; and
  - Operation and maintenance: The calculated of TSS concentrations during operation and maintenance (13.5 mg/L) are essentially at background (due to the 80% removal rate considered in the assessment). Therefore operation and maintenance of the expansion project is not considered to have adverse effects on the environment in regard to TSS concentration in the ditches.

Therefore, TSS (during clearing and construction) was found to exceed guidelines for the protection of aquatic ecosystems and therefore may impact VECs, and as such is moved forward for further assessment.

7.4.2.6 Screening Summary

An exceedance of acceptable NO_2 levels was identified for wildlife at receptor location 4 during the site preparation and construction phases. TSS was found to exceed guidelines for the protection of aquatic ecosystems during site preparation and construction.

7.4.3 Risk Characterization

7.4.3.1 Air Quality

Four wildlife receptor species (White-tailed Deer, Red-eyed Vireo, American Robin, and Northern Water Snake) were identified as having a potential adverse effect due to exposure to NO_2 during construction. The potential adverse effect for all four species is associated with a predicted 1-hour NO_2 exposure greater than the lowest observed effect on wildlife (940 µg/m^3) at receptor location 4. The 1,146 µg/m^3 predicted at receptor location 4 represents an increased 1-hour exposure of 21.9%.

The effects of acute NO_2 exposure on mammals, snakes, and birds are not well understood. Similar to humans, the main health effect of NO_2 on mammals and birds is on the respiratory system. Inhalation of NO_2 increases the risk of respiratory infection and may lead to poorer lung function with chronic exposure; however, annual toxicity experiments rarely indicate effects of acute exposure to NO_2 at concentrations less than 1,880 µg/m^3 [5]. Any exposure to an exceedance of 1-hour NO_2 concentrations is acute and unlikely to result in any chronic exposure, as is evident by the levels being below the AAQC during a 24-hour period (Table 7-8). Exposure to wildlife species exceeds the predicted 1-hour NO_2 criteria but does not exceed the acute effect level during the construction period; there are likely no adverse effects to wildlife VECs and associated receptors due to a brief exposure to the predicted maximum NO_2 levels, which are restricted to the area immediately surrounding the potential Project footprint.

7.4.3.2 Surface Water Quantity and Flow

An increase in surface water flow of 35.4% was predicted for Case 1 (i.e., if all drainage from potential expansion areas 1-4 is directed towards the South Railway Ditch). This exceeded the assessment criteria. Higher surface water quantities and flows may impact the aquatic environment. The associated effects are discussed below.

In its current condition, the South Railway Ditch exhibits a stable morphology due to its low gradient and connectivity to the Wetland Complex through its middle section. The ability to attenuate water within this system is increased by the presence of the wetland. Assuming management of peak flows and water quality through a stormwater facility, the maximum mean annual increase (35.4% under Case 1 in South Railway Ditch) is likely to have a positive effect by increasing inundation of cattail-dominated areas of the main channel and areas of the Wetland associated with the South Railway Ditch. This will increase habitat suitability for indicator species (Northern Redbelly Dace, or cattail) and should be considered a positive effect.

7.4.3.3 Surface Water Quality

As discussed in Section 7.4.2.5, changes to surface water quality are expected in regards to TSS during site preparation and construction. If all drainage from potential expansion areas 1-4 is directed towards the South Railway Ditch, a value of 88.6 mg/L is predicted, and if all drainage from potential expansion areas 1-4 is directed towards the West Ditch a value of 50.9 mg/L is predicted. However, no adverse effects are likely for the following reasons:

- Site clearing and construction is a short-term condition (not expected to exceed one year in duration, assuming concurrent development of all four potential development areas). Thus any potential adverse will be of short duration.
- High TSS values are typically experienced only during part of the year (open-water conditions) and only during high intensity runoff events. These are thus non-continuous, intermittent events, which limits the effect on environmental receptors.
- No sports fishes or sensitive species are found in the drainage ditch.

Potential changes to water temperature in the South Railway Ditch under Case 1 may impact VECs. However, it is expected that there is no likely adverse effect. For fish indicator species associated with the South Railway Ditch (i.e., Northern Redbelly Dace and Creek Chub), the preferred temperature is 25.3°C [66], [65] and 20.8°C [65], respectively, with maximum tolerances of higher temperatures (approaching 30°C) [67]. It is expected that water temperatures within the South Railway Ditch will be more influenced by seasonal and annual variations in precipitation, air temperature, and direct solar exposure (which is variable based on cloud cover, riparian and in-water cover) than inputs from the stormwater facility. Therefore, changes to the thermal habitat of VEC indicator biota in the South Railway Ditch is not expected to pose an adverse effect.

7.5 Assessment of Physical Stressors

For ecological receptors, the physical stressors considered include:

- Sensory disturbance (light, noise);
- Mortality (road kill and/or bird strikes); and,
- Loss, alteration, and fragmentation of habitat.

Physical stressors such as entrainment/impingement of aquatic biota, and thermal releases to the aquatic environment are not applicable to this assessment.

7.5.1 Screening Criteria

7.5.1.1 Impact of Light

For the impact of artificial night light, modelling at the ecological receptor locations was not conducted due to the absence of proposed artificial light placements during the site preparation, construction, and operation and maintenance phases of the Project. As such, only a qualitative assessment of artificial light is conducted.

7.5.1.2 Mortality and Loss, Alteration and Fragmentation of Habitat

Screening criteria for mortality (road kill and bird strikes) and habitat loss, alteration and fragmentation are defined based on work for the DGR EA [5], and based on professional judgement for screening criteria for VECs/Terrestrial receptors that are not in the DGR EA. These screening criteria are presented in Table 7-13.

Table 7-13: Screening Criteria for Mortality, Loss, Alteration and Fragmentation of Terrestrial Habitat

VEC	Terrestrial Receptor	Screening Criteria
Plants	Eastern White Cedar	Loss of some trees at a few locations; reduction in conifer forest type by >5% or deciduous / mixedwoods forest type by >10 % in the Project Area compared with baseline
	Cattail	Loss of >50% of the plants in the Terrestrial Monitoring Area
	Graminoids	Loss of >50% of the plants in the Terrestrial Monitoring Area
Wetland Complex (adjacent to WWMF expansion area)	Cattails	Any loss of Wetland Complex, loss of habitat for receptor species and associated VECs, significant impacts to the water hydrology (habitat alteration, fragmentation of wetland)
Baie du Doré Wetland	Midland Painted Turtle	Any loss of wetland complex, loss of habitat for receptor species, significant impacts to the water hydrology
Mammals	Northern Short-tailed Shrew	Relocation or loss of animals (>25)
	Muskrat	Mortality increase of several individuals (>3 per year), relocation or avoidance of suitable habitat by individuals in the local population
	White-tailed Deer	Mortality increase of several individuals (>3 per year), relocation or avoidance of suitable habitat by individuals in the local population
Birds	Red-eyed Vireo	Avoidance/relocation or mortality of a number of individuals resulting in a noticeable change in the local population
	Wild Turkey	Mortality increase of several individuals (>5 per year), relocation or avoidance of suitable habitat by several individuals in the local population
	American Robin	Avoidance/relocation or mortality of a number of individuals resulting in a noticeable change in the local population
	Mallard	Loss of foraging habitat (>5%) associated with wetland edges or open water

VEC	Terrestrial Receptor	Screening Criteria
	Bald Eagle	Loss of nesting habitat or winter foraging opportunities
Reptiles	Northern Water Snake	Mortality increase of several individuals (>2 per year), relocation or avoidance of suitable habitat by several individuals in the local population
Terrestrial Crayfish Habitat	Digger Crayfish	Loss of habitat for Digger Crayfish
Turtle Wintering Habitat	Painted Turtle	Mortality increase of a few individuals (>2 per year), relocation or avoidance of suitable habitat by individuals in the local population
	Painted Turtle	Mortality increase of a few individuals (>2 per year), relocation or avoidance of suitable habitat by individuals in the local population
Amphibian Woodland Breeding Habitat	Spring Peeper	Mortality increase of several individuals (>5 per year), relocation or avoidance of suitable habitat by several individuals in the local population
Amphibian Wetland Breeding Habitat	Northern Leopard Frog	Mortality increase of several individuals (>5 per year), relocation or avoidance of suitable habitat by several individuals in the local population
Species of Ecological Significance	Barn Swallow	Loss of habitat; avoidance/relocation or mortality of one individual
	Eastern Meadowlark	Loss of habitat; avoidance/relocation or mortality of one individual
	Eastern Wood-Pewee	Loss of habitat; avoidance/relocation or mortality of one individual
	Golden-winged Warbler	Loss of habitat; avoidance/relocation or mortality of one individual
	Olive-sided Flycatcher	Loss of habitat; avoidance/relocation or mortality of one individual
	Wood Thrush	Loss of habitat; avoidance/relocation or mortality of one individual
	Rusty Blackbird	Loss of habitat; avoidance/relocation or mortality of one individual
	Little Brown Myotis	Loss of habitat; avoidance/relocation or mortality of one individual

VEC	Terrestrial Receptor	Screening Criteria
	Monarch Butterfly	Loss of habitat; avoidance/relocation or mortality of one individual
	Butternut	Loss/removal of any tree
	Sharp-fruited Rush	Loss of >25% of the plants in the Project Area
	Snapping Turtle	Loss of habitat; mortality increase of one individual; relocation or avoidance of suitable habitat by individuals in the local population

7.5.1.3 Impacts of Noise

For the impact of noise, it is assumed that a change of 3 dB or more in linear noise levels is likely to have an adverse effect on the conditions experienced by mammals and amphibians. This was based on changes in noise levels perceptible to humans, as was applied in the DGR EA [5]. Guidance from Environment Canada identifies that an increase of 10 dB or more, could have impacts on birds [68]. As such, the noise screening criteria applied for mammals and amphibians is an increase of more than 3 dB and the noise screening criteria for birds is an increase of 10 dB or more. Modelled changes in noise parameters relative to the terrestrial environment are summarized in Appendix D and summarized below in Section 7.5.2.4.

7.5.2 Screening

Screening is conducted based on qualitative analysis and/or quantitative information if available. The screening results are presented below.

7.5.2.1 Impact of Light

Artificial night lighting has the potential to interact with birds, mammals and amphibians through habitat avoidance, changes in rates of predation and mortality, and/or changes in food resource availability [69].

For birds, interior and exterior lighting on tall buildings and decorative lighting on all structures tends to confuse birds. Night migrants use the stars as navigational tools and may mistake building light sources as celestial lights. The situation is exacerbated during foggy or rainy weather when cloud cover is low and birds fly at lower altitudes. Birds can also become “entrapped” by light sources. Once inside a beam of light, they are reluctant to fly out into the darkness, and they will continue to fly around within the light beam. Fatigue sets in, collisions with other birds or the structure occurs, or the birds simply collapse from exhaustion. They frequently die from injuries or fall prey to predators.

For small, nocturnal, herbivorous mammals, artificial night lighting may increase risk of being killed by a predator and decrease food consumption. Circadian rhythms and melatonin production (which control such behaviours as nocturnal calling and migratory patterns) may also be disrupted by artificial night lighting, whereas for larger mammals, night lighting may increase collisions with vehicles and can disrupt dispersal movements and corridor use. Amphibians (frogs) are affected through changes in calling rates, changes in frog prey or predation interactions, and tadpole survivorship.

Artificial night lighting at the existing WWMF likely does not represent an adverse effect to wildlife species VECs and receptors. The presence of birds, mammals and frogs within the immediate vicinity of the WWMF would suggest that wildlife species currently using these areas are habituated or not detrimentally affected by artificial night lighting associated with the WWMF.

To alleviate potential effects of artificial night lighting, in-design mitigation measures are required, within the regulatory requirements for safety and security of the facility. Such mitigation measures include designing of artificial night lighting fixtures in a strategic downward orientation, minimizing the intensity of night lighting, and/or using dark sky lighting fixtures (such as high pressure sodium lights) where feasible, to reduce excess artificial light production and associated light penetration into adjacent wildlife habitat areas beyond the Project boundary.

Based on the in-design mitigation measures, the Project will have likely no adverse effects to ecological receptors due to artificial night lighting.

7.5.2.2 Mortality – Bird strike

Birds are prone to collisions with buildings due to confusion with the lighting and/or glass reflection; however, the proposed structures on site which may be reflective or produce light are expected to be very limited. Therefore, bird injury/mortality due to collision with the buildings and light structures are not expected to cause a change to the local population of VECs and associated receptors at a level exceeding the screening criteria. No further assessment is required.

7.5.2.3 Mortality – Road Kill

Mortality of VECs and associated receptors due to collisions with vehicles has been assessed and the results are presented in Table 7-14. Based on the analysis presented in Table 7-14, mortality due to collision with traffic is not expected to cause a change to the local population of VECs and associated receptors at levels exceeding the screening criteria. No further assessment is required.

Table 7-14: Screening of Road Kill

Receptors	Screening of Road Kill
Northern Short-tailed Shrew	The increase in Project-related vehicle strikes may result in a small increase (less than 25 individuals) in Northern Short-tailed Shrew mortality; however, Northern Short-tailed Shrews have a naturally high mortality rate, but also a high reproduction rate. This increase is considered to be negligible since the loss of a few individuals will not affect the local populations. As such, the screening criterion is not exceeded.
White-tailed Deer	Data on deer collisions and mortalities have been collected at the Bruce nuclear site between 1998 and 2012 [46] and range from 4 to 13 collisions per year and 0 to 6 mortalities per year, with the highest deer collision and mortality occurring in the first year of monitoring (1998). Overall, collision and mortalities have shown a decreasing trend during the monitoring period [46] despite increased traffic during the large construction projects on site (i.e., refurbishment of U1 and U2 at Bruce A) and increased security vehicle activity during this monitoring period. Deer mortalities have likely been limited by traffic control and posted speed limits (which are strictly adhered to by all site personnel). In addition, collisions and mortalities are likely limited by the 10 ft. fencing (with barbed wire) currently surrounding the entire Bruce nuclear site which inherently has reduced the movement of deer onto the site from the Huron Fringe Deer Yard. The traffic increase associated with the Project is expected to be negligible compared to the existing traffic on-site. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >3 per year due to the Project. As such, the screening criterion is not exceeded.
Muskrat	Though Muskrats may travel overland when dispersing to new territories, many of the preferred Muskrat habitat areas within the Terrestrial Monitoring Area are linked via wetted ditches and culverts to habitats within the area and beyond, such that animals could disperse through waterways without traversing roadways. As such, there is a slight chance that vehicle strikes with Muskrats will increase; however, this increase is considered to be negligible since collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >3 per year due to the Project. As such, the screening criterion is not exceeded.

Receptors	Screening of Road Kill
Wild Turkey	Wild Turkeys frequently travel along roads making them susceptible to vehicle strikes; however, they can easily avoid on-coming traffic through flight. As well, existing measures, including traffic control and enforced speed limits at the Bruce nuclear site, mitigate Turkey-vehicle interactions. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >5 per year due to the Project. As such, the screening criterion is not exceeded.
Mallard	Road-related mortality is not a particularly important consideration for the Mallard since they can easily avoid on-coming traffic through flight. While a few ducks may not be able to avoid a collision in the event they choose to cross the road on the ground, it will have a negligible effect upon the local population.
Bald Eagle	As habitat within the Terrestrial Monitoring Area does not provide habitat utilized by Bald Eagles, it would be extremely unlikely for any individual to be struck by Project-related vehicles.
Barn Swallow, Eastern Meadowlark, Eastern Wood Pewee, Golden-winged Warbler, Olive-sided Flycatcher, Wood Thrush, Rusty Blackbird, Red-eyed Vireo and American Robin	These passerine species may be susceptible to vehicle strikes when moving between habitats for foraging activities; however, vehicle strikes with these species are uncommon and unpredictable and presumably these species can avoid on-coming traffic. As such, the screening criterion is not exceeded.
Green Frog, Northern Leopard Frog	Road-related mortality is an important consideration for amphibian species because of their movements overland between one body of water and another. However, the majority of large wetlands exist east of the WWMF Expansion Area and frogs are not likely to cross this area with any frequency. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >5 per year due to the Project. As such, the screening criterion is not exceeded.
Spring Peepers	Road-related mortality is an important consideration for amphibian species because of their movements overland between one body of water and another. However, the majority of large wetlands exist east of the WWMF Expansion Area and frogs are not likely to cross this area with any frequency. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >5 per year due to the Project. As such, the screening criterion is not exceeded.

Receptors	Screening of Road Kill
Northern Water Snake	Increased vehicular traffic due to Project activities is estimated to contribute very little to the overall Bruce nuclear site traffic. Additionally, the majority of large wetlands exist east of the WWMF Expansion Area and Northern Water Snake is not likely to cross this area with any frequency. Therefore, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >5 per year due to the Project. As such, the screening criterion is not exceeded.
Midland Painted Turtle	Road-related mortality is an important consideration for Midland Painted Turtle because of their movements overland between one body of water and another. However, the majority of large wetlands exist east of the WWMF Expansion Area and turtles are not likely to cross this area with any frequency. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >2 per year due to the Project. As such, the screening criterion is not exceeded.
Snapping Turtle	Road-related mortality is an important consideration for Snapping Turtle because of their movements overland between one body of water and another. However, the majority of large wetlands exist east of the WWMF Expansion Area and turtles are not likely to cross this area with any frequency. Consequently, collisions and mortalities are not expected to cause mortality at a rate that would produce a change to the local population or increase by >2 per year due to the Project. As such, the screening criterion is not exceeded.
Bats (Little Brown Myotis)	Little Brown Myotis may be susceptible to vehicle strikes when moving between habitats for foraging activities; however, vehicle strikes with these species are uncommon and unpredictable and presumably they can avoid on-coming traffic through flight. As such, the screening criterion is not exceeded.
Monarch Butterfly	Monarch Butterfly may be susceptible to vehicle strikes when moving between habitats and during migration; however, vehicle strikes with this species are uncommon and unpredictable. Monarch Butterflies are seldom observed in the vicinity of the WWMF and are, therefore, not predicted to interact with vehicular traffic. As such, the screening criterion is not exceeded.
Digger Crayfish	Digger Crayfish are not anticipated to interact with vehicular traffic.

Note: Red Fox is not included in this assessment due to the lack of confirmed presence at the Bruce nuclear site. "WWMF expansion area" in this table refers to the potential WWMF Expanded Licensed Area in its entirety.

7.5.2.4 Noise

Changes in noise levels have the potential to interact with mammalian receptors, bird receptors, and amphibian receptors. The same receptor locations selected for air quality modelling were used to assess changes in noise level that would potentially pose an adverse effect to wildlife species (Figure 5-6). Noise modelling worst-case scenario results are provided in Section 5.2.3.7. The results of all modelled noise scenarios are provided in Appendix D.

The maximum noise levels modelled for receptor locations during the site preparation and construction phases of the Project are summarized in Table 7-15. The modelled changes in linear noise levels (dB) are compared with the screening criteria.

During the site preparation and construction stages, the increases to noise levels depend on the activity being performed. For the site preparation stage, the activity with the largest modelled increases to noise levels is grubbing and overburden removal, with an increase of 0 to 23 dB. For the construction stage, the activity with the largest modelled increases to noise levels is roof installation, with an increase of 0 to 14 dB.

It should be noted that exceedance of noise at receptor location 3 (ER4) for birds is irrelevant based on the premise that under the assumed bounding site preparation and construction scenario (area 1/2 + 3), area 3 will be cleared of all vegetation and associated wildlife attributes.

A 3 dB increase in noise levels was modelled at receptor location 3 (ER4) during the operation and maintenance scenario (Table 7-15); however, as discussed above, this area will be cleared of all vegetation and associated wildlife attributes. Accordingly, changes in noise levels require no further assessment for operation and maintenance of the WWMF site.

As these modelled noise levels at multiple receptor locations and at various stages of the Project are above the 3 dB increase threshold for mammals and amphibians and above the 10 dB increase threshold for birds, the potential effects to these VECs and associated receptors are further assessed in Section 7.5.3.1.

Table 7-15: Modelled Maximum Changes to Noise Levels (in L_{eq} (1 h)) at Ecological Receptors

Receptor Location	WWMF Baseline ERA Noise Levels (dB)	Modelled Noise Levels due to Project Activities (dB)	Combined Modelled Noise Levels (dB)	Modelled Change to Noise Levels (dB)	Exceeding the screening criteria for mammalian and amphibian receptors?	Exceeding the screening criteria for avian receptors?
Site Preparation						
1	64	72	73	+9	Yes	No
2 (ER7)	69	71	73	+4	Yes	No
3 (ER4)*	67	90	90	+23	Yes	Yes
4	67	78	78	+11	Yes	Yes
5	76	67	77	+1	No	No
6 (ER3)	65	68	70	+5	Yes	No
7	76	68	77	+1	No	No
8 (ER5)	69	73	74	+5	Yes	No
9 (ER6)	66	68	70	+4	Yes	No
10	64	71	72	+8	Yes	No
Construction						
1	64	70	71	+7	Yes	No
2 (ER7)	69	71	73	+4	Yes	No
3 (ER4)*	67	85	85	+18	Yes	Yes
4	67	75	76	+9	Yes	No
5	76	63	76	0	No	No
6 (ER3)	65	64	68	+3	Yes	No
7	76	63	76	0	No	No
8 (ER5)	69	70	73	+4	Yes	No
9 (ER6)	66	68	70	+4	Yes	No
10	64	69	70	+6	Yes	No
Operation and Maintenance						
1	64	53	64	0	No	No
2 (ER7)	69	51	69	0	No	No
3 (ER4)*	67	66	70	+3	Yes	No
4	67	47	67	0	No	No
5	76	47	76	0	No	No
6 (ER3)	65	47	65	0	No	No
7	76	42	76	0	No	No
8 (ER5)	69	44	69	0	No	No
9 (ER6)	66	42	66	0	No	No
10	64	52	64	0	No	No

*3 (ER4) is within the footprint of area 3.

7.5.2.5 Loss, Alteration and Fragmentation of Habitat

Aquatic Receptors

Assuming a stormwater management facility is in place, peak flows will be mitigated, reducing the potential for ditch-bed scour and physical alteration or erosion of channel banks and in-ditch aquatic habitat. Project development in areas 1-4 (as shown in Figure 5-8) will not include the removal of riparian vegetation or the physical alteration of in-ditch habitat along the South Railway Ditch, or the West Ditch as current access to these locations is possible through existing access points (i.e., culvert crossing near SRD-3 of South Railway Ditch) (Figure 5-8). Potential alterations due to the inclusion of an outlet structure from a stormwater feature (if applicable) are expected to be minor and identified through the detailed design process. No channel realignment, new crossing installation, or grade control installation is expected as part of this Project. Therefore, physical stressors are not expected to adversely affect the aquatic environment.

Terrestrial Receptors

In its current existing condition the South Railway Ditch exhibits a stable morphology due to its low gradient and connectivity to the Wetland Complex through its middle section. The ability to attenuate water within this system is therefore increased by the presence of the wetland. Assuming management of peak flows and water quality through a stormwater facility, the maximum mean annual increase (35% under Case 1 in South Railway Ditch) is likely to provide a positive condition with increased potential for inundation of cattail dominated areas of the main channel and a higher potential for inundation of the wetland complex associated with the South Railway Ditch. This will not reduce habitat suitability for indicator species (cattails, wetland complex, frogs, turtles or snakes). In fact it is expected that some increase in suitability for these may be experienced at the wetland margins.

Furthermore, it is assumed that the WWMF stormwater management system will be built to an enhanced level of protection as per Ontario MOECC design guidelines [29] and will meet the criteria for maximum peak flow rates. Peak flows are not assumed to exceed pre-development values for storms with return periods ranging from 2 to 100 years. Accordingly, no change to existing channel forming flows will be expected relative to site development. As such increased flooding will not be a factor in habitat alteration or loss for herpetiles or aquatic vegetation.

However, site preparation involves land clearance and preparation of construction laydown areas. It will physically remove, alter, and/or fragment habitats for some VECs and associated receptors. The areas of habitat to be removed as a result of the Project are summarized in Table 7-16. Ecological Land Classification communities within the Terrestrial Monitoring Area, as per [70], are illustrated in Figure 7-5.

The screening assessment is conducted to identify the potential impact on indicator species resulting from the loss of habitat. The results, summarized in Table 7-17, show that most of the indicator species are not affected at a level exceeding the screening criteria. The exceptions are:

- The Wetland Complex (habitat for cattails and Green Frog);
- Eastern White Cedar;

- Butternut;
- Eastern Wood Pewee; and,
- Bats (Little Brown Myotis).

The potential effects on these five indicators due to loss of habitat during site preparation and construction will be further assessed.

LEGEND

- Substrate Sampling Locations
- Terrestrial Monitoring Area
- Proposed WWMF Expansion Area
- OPG Retained Land within Bruce nuclear site
- Transmission Line
- Wetlands
- Ecological Land Classifications

Ecosite Code	Ecosite Type
CUM1-1	Dry – Moist Old Field Meadow Type
CUS1-2	White Cedar – Green Ash Cultural Savannah Type
CUS1 (Type 1)	Mineral Cultural Savannah Ecosite
CUT1	Mineral Cultural Thicket Ecosite
CVI_2	Constructed Disposal Area
FOC2-2	Dry – Fresh White Cedar Coniferous Forest Type
FOD4-2	Dry – Fresh White Ash Deciduous Forest Type
FOD5-8 / FOD5-2 Complex	Dry – Fresh Sugar Maple – White Ash / Sugar Maple – Beech Deciduous Forest Type
FOD8-1	Fresh – Moist Poplar Deciduous Forest Type
FOM7-2	Fresh – Moist White Cedar – Hardwood Mixed Forest Type
MAM2	Mineral Meadow Marsh Ecosite
MAM2-5 / MAS2-1 Complex	Narrow-leaved Sedge Mineral Meadow Marsh Type / Cattail Mineral Shallow Marsh Type
MAS2-1	Cattail Mineral Shallow Marsh Type
SAS1	Submerged Shallow Aquatic Ecosite
SWC1-1 / MAM2-10 Complex	White Cedar Mineral Coniferous Swamp Type / Forb Mineral Meadow Marsh
SWC1-1 / SWC3-1 Complex	White Cedar Mineral Coniferous Swamp Type / White Cedar Organic Coniferous Swamp Type
SWD2-1 (Type 1)	Black Ash Mineral Deciduous Swamp
SWD2-1 (Type 2)	Black Ash Mineral Deciduous Swamp
SWD2-2	Green Ash Mineral Deciduous Swamp Type
SWD4-3 / MAM2-10 / MAS2-1 Complex	White Birch – Poplar Mineral Deciduous Swamp Type / Forb Mineral Meadow Marsh Type / Cattail Mineral Shallow Marsh Type)
SWM1-1	White Cedar – Hardwood Mineral Mixed Swamp Type
SWM4-1 / MAS3-1 Complex	White Cedar – Hardwood Organic Mixed Swamp Type / Cattail Organic Shallow Marsh Type

Figure 7-5: Ecological Land Classification of the Terrestrial Monitoring Area

0 0.25 0.5 1 1.5 Kilometres

SCALE: 1:5,750

Datum: NAD83
Projection: UTM Zone 17N

NOTES:
- Imagery from WorldView-2, scene date is May 2012

Table 7-16: Areas of Removal and Percent Change in Vegetation and Wetland Communities in the Terrestrial Monitoring Area

Community Type	Area of Community (ha)	ELC Community[1,2]	Area of ELC Community in the Terrestrial Monitoring Area (ha)	Area Impacted (ha)	Percentage of ELC Community Impacted	Percentage of Community Type Impacted
Deciduous/Upland Forest and Swamp	39.7	FOD5-8 / FOD5-2 Complex	26.7	5.2	19%	14%
		FOD8-1	6.1	0.4	6%	
		FOD4-2	4.1	--	--	
		Various SWD	2.8	--	--	
Mixedwood Forest and Swamp	22.5	FOM7-2	19.0	0.5	3%	2%
		SWM1-1	2.9	--	--	
		SWM4-1 / MAS3-1 Complex	0.6	--	--	
Coniferous Upland Forest and Swamp	5.7	FOC2-2	3.2	--	--	10%
		SWC1-1 / SWC3-1 Complex*	2.1	0.6	29%	
		SWC1-1 / MAM2-10 Complex	0.4	--	--	
Shallow and Meadow Marsh	3.2	Various	3.2	--	--	--
Cultural Meadow	19.6	CUM1-1	19.6	0.7	4%	4%
Cultural Savannah and Thicket	10.4	Various	10.4	--	--	--
Wetland Complex Adjacent to WWMF Expansion Area	5.4	SWC1-1 / SWC3-1 Complex*	2.1	0.6	29%	11.5%
		Various	4.8	--	--	
Baie du Doré Wetland	--	Various	--	--	--	--

[1] ELC: Ecological Land Classification for Southern Ontario [70]

[2] FOD8-1: Fresh – Moist Poplar Deciduous Forest Type; FOC2-2: Dry – Fresh White Cedar Coniferous Forest Type; FOD5-8 / FOD5-2: Complex: Dry – Fresh Sugar Maple – White Ash / Sugar Maple – Beech Deciduous Forest Type; FOD4-2: Dry – Fresh White Ash Deciduous Forest Type; FOM7-2: Fresh – Moist White Cedar – Hardwood Mixed Forest Type; CUM1-1: Dry – Moist Old Field Meadow Type; SWC1-1 / MAM2-10 Complex: White Cedar Mineral Coniferous Swamp Type / Forb Mineral Meadow Marsh Type; SWC1-1 / SWC3-1 Complex: White Cedar Mineral Coniferous Swamp Type / White Cedar Organic Coniferous Swamp Type; SWM4-1 / MAS3-1 Complex: White Cedar – Hardwood Organic Mixed Swamp Type / Cattail Organic Shallow Marsh Type; SWM1-1: White Cedar – Hardwood Mineral Mixed Swamp Type; SWD: Deciduous Swamp.

Note: *The same SWC1-1/SWC3-1 Complex appears twice in the table under two community type categories; however, represents the same polygon within the Project Area.

Table 7-17: Screening of Impact Resulting from Loss, Alteration, and/or Fragmentation of Habitat

Receptors	Screening Results
Cattail	Cattail is present in almost all of the locations within the Terrestrial Monitoring Area where there is standing water for at least a portion of the year. The majority of land clearing (28.5 ha, or 80% of all lands within the WWMF Expansion Area) will occur in industrial / un-vegetated areas (i.e., lands already cleared by past anthropogenic activities). It is expected that the amount of deciduous, mixedwood and coniferous forests and swamps, and cultural meadow communities which will be removed will not result in the exceedance of the screening criterion for cattails (loss of >50% of the species).
Eastern White Cedar	The removal of 10% (0.6 ha) of coniferous forests and swamps in the Terrestrial Monitoring Area will result in a loss of >5% of coniferous communities. The screening criterion is exceeded for Eastern White Cedar.
Northern Short-tailed Shrew	The removal of vegetation communities supporting Northern Short-tailed Shrew sheltering, foraging, or nesting activities (all upland communities) is not expected to cause the loss of more than 25 individuals in the local population. Therefore, the screening criterion is not exceeded.
White-tailed Deer	Vegetation clearing during site preparation will result in an overall loss of 10% (6.7 ha) of forested and swamp habitats (14% of deciduous forest, 2% of mixedwood forest, and 10% of coniferous swamp), which is sheltering and foraging habitat for White-tailed Deer. However, it is unlikely that screening criterion will be exceeded for this species. The Huron Fringe Deer Yard, although overlapping with the Terrestrial Monitoring Area, will not be subject to vegetation removal. Therefore, the screening criterion is not exceeded.
Muskrat	Muskrat habitat in South Railway Ditch and Wetland Complex is not suitable for long-term survival of this species. No vegetation communities (wetlands and marshes with open water) key to supporting Muskrat sheltering, foraging, or breeding activities will be removed during site preparation and construction. Therefore, the screening criterion is not exceeded. It should be noted that the previously documented Muskrat den site within proximity to the WWMF expansion area (the Wetland, area 6 on Figure 4-4) was no longer active due to reduced water levels within the wetland and the transitional state of the wetland (succeeding to meadow marsh).
Red-eyed Vireo and American Robin	Vegetation clearing during site preparation will result in the loss of 14% (5.6 ha) of deciduous forests and 2% (0.5 ha) of mixedwood forests (11% decrease of the two forest types cumulatively). However, this loss of habitat is not expected to cause a change on the local populations of either Red-eyed Vireo or American Robin at levels exceeding the screening criterion.

Receptors	Screening Results
Wild Turkey	Vegetation clearing during site preparation will result in the loss of 11% (6.1 ha) of upland forest (deciduous and mixedwood combined) and 4% (0.7 ha) of cultural meadow. However, Wild Turkeys have very large home ranges and can easily travel several kilometres in one day. As such, this loss of habitat is not expected to cause a change in the local Wild Turkey population at the level exceeding the screening criterion.
Mallard	No vegetation communities (wetlands and marshes with open water) key to supporting Mallard sheltering, foraging, or breeding activities will be removed. The screening criterion will not be exceeded.
Bald Eagle	Since Bald Eagles do not rely on habitat within the Terrestrial Monitoring Area, no change to their habitat utilization patterns is expected. The screening criterion will not be exceeded.
Terrestrial Crayfish Habitat	Significant terrestrial crayfish habitat was identified within the Terrestrial Monitoring Area. However, there will be no direct loss of habitat as a result of land clearing activities during site preparation. The screening criterion will not be exceeded.
Northern Water Snake	No vegetation communities associated with Northern Water Snake habitat will be removed during site preparation. The screening criterion will not be exceeded.
Midland Painted Turtle	No vegetation communities associated with Midland Painted Turtle habitat will be removed during site preparation. Significant turtle wintering habitat was identified within the Terrestrial Monitoring Area; however, no land clearing or changes to hydrology will occur within this habitat. The screening criterion will not be exceeded.
Northern Leopard Frog, Spring Peeper, Amphibian Wetland/ Woodland Breeding Habitats	Amphibian wetland breeding habitat will not be subject to vegetation clearing. Though 24% of coniferous swamp communities will be removed, this represents a removal of only 7% (0.6 ha) of all swamp types (deciduous, mixedwood and coniferous) in the Project area. Approximately 3% (0.5 ha) of the amphibian woodland breeding habitat will be removed within the Terrestrial Monitoring Area. Amphibian populations are generally low within this habitat, as identified during the terrestrial baseline surveys, with the greater numbers of amphibians (Spring Peepers) located in suitable habitats north of WWMF expansion area. No measureable changes in habitat utilization opportunities are likely to exceed the screening criteria within the WWMF expansion area, and in turn, no changes in the populations of Spring Peeper within the Terrestrial Monitoring Area are anticipated to exceed the screening criterion.

Receptors	Screening Results
Wetland Complex	Approximately 11.5% (0.6 ha) of the Wetland Complex will be removed and may result in habitat alteration (wetland hydrology) and fragmentation. As such, the screening criterion is exceeded for the Wetland Complex.
Barn Swallow	No Barn Swallow nests were identified within the WWMF Expansion Area; however, Barn Swallow nests were located immediately adjacent to WWMF Expansion area 4 (on Bruce Power-leased lands). The nests outside the WWMF Expansion Area will not be subject to land clearing activities. Vegetation clearing will result in the loss of 4% (0.7 ha) of cultural meadows available for Barn Swallow foraging, but will not result in critical habitat alteration or fragmentation. As such, it is unlikely that changes in habitat utilization opportunities exceed the screening criteria, and in turn, changes in local population of Barn Swallow are not likely to exceed the screening criterion.
Eastern Meadowlark	Vegetation clearing will result in the loss of 4% (0.7 ha) of cultural meadows available for potential Eastern Meadowlark habitat; however, this loss represents the removal of only roadside meadow habitat which is too small and narrow to support Eastern Meadowlark breeding habitat. As such, exceedance of screening criteria in habitat utilization opportunities is unlikely (no alteration or fragmentation of critical habitat), and in turn, changes in local population of Eastern Meadowlark are not likely to exceed the screening criterion.
Eastern Wood-Pewee	Vegetation clearing during site preparation will result in the loss of 14% (5.6 ha) of deciduous forests and 2% (0.5 ha) of mixedwood forests (11% decrease of the two forest types cumulatively), including a forest patch where one of the five Eastern Wood-Pewee observations were made during surveys undertaken in 2014. This loss of habitat would be considered an exceedance of the screening criterion. As the woodland to be removed is isolated (surrounded by roads and non-forested habitats), habitat fragmentation is a non-factor.
Golden-winged Warbler, Olive-sided Flycatcher, Wood Thrush, Rusty Blackbird	No critical habitat or vegetation communities associated with these species recorded during migration will be removed during site preparation (no habitat alteration or fragmentation). As such, the screening criterion will not be exceeded.

Receptors	Screening Results
Bats (Little Brown Myotis)	Vegetation clearing during site preparation will result in an overall loss of 10% (6.7 ha) of forested and swamp habitats (14% of deciduous stands, 2% of mixedwood stands, and 10% of coniferous stands), including a deciduous forest stand where Little Brown Myotis observations were made during surveys undertaken in 2014. The deciduous forest is assumed to be utilized for either brood rearing and/or foraging. Though significant maternal roost habitat was not identified, several roost trees were identified within forested habitats requiring removal. This loss of habitat is considered an exceedance of the screening criterion. However, as the woodland to be removed is isolated (surrounded by roads and non-forested habitats), it is expected that habitat fragmentation will not result in an adverse effect on Little Brown Myotis.
Monarch Butterfly	Vegetation clearing will result in the loss of 4% (0.7 ha) of cultural meadows available for monarch butterflies; however, this habitat is not deemed to be significant (no alteration or fragmentation of critical habitat). As such, it is unlikely that the changes to habitat utilization opportunities will exceed the screening criteria, and therefore, changes in local population of Monarch Butterfly will not exceed the screening criterion as a result of site preparation.
Butternut	Vegetation clearing will result in the loss of three Butternut trees identified in the Project Area (area 3). As such, the screening criterion is exceeded for Butternut trees.
Sharp-fruited Rush	No vegetation communities associated with sharp-fruited rush habitat will be removed during site preparation (no habitat alteration or fragmentation). As such, the screening criterion will not be exceeded.
Snapping Turtle	No vegetation communities associated with Snapping Turtle habitat will be removed during site preparation (no habitat alteration or fragmentation). Accordingly, it is unlikely that the changes to habitat utilization opportunities will exceed the screening criteria, and therefore, change to Snapping Turtle populations will not exceed the screening criterion as a result of site preparation.
Digger Crayfish	No vegetation communities with Digger Crayfish habitat will be removed during site preparation (no habitat alteration or fragmentation). Therefore, the change in terrestrial crayfish habitat screening criterion will not be exceeded.

Notes: 1. Earthworm and Bee are excluded from this assessment. These are only assessed for the purpose of the radiological assessments.

2. Red Fox are not included in this assessment due to the lack of confirmed presence at the Bruce nuclear site.

3. “WWMF expansion area” in this table refers to the potential WWMF Expanded Licensed Area in its entirety.

7.5.2.6 Screening Summary

In summary, potential adverse effects of the Project were identified to terrestrial VECs and associated receptors. Predicted effects on VECs and associated receptors include:

- Exceedance of acceptable noise levels to birds, amphibians and mammals at select locations during site preparation and construction;
- Removal of Eastern White Cedar during site preparation;
- Removal of a part of the Wetland Complex during site preparation;
- Removal of habitat for Eastern Wood-Pewee and Little Brown Myotis during site preparation; and,
- Removal of Butternut trees during site preparation.

Potential adverse effects of the Project on these VECs and associated receptors will be further assessed.

7.5.3 Risk Characterization

7.5.3.1 Noise

Bird Disturbance

Excluding the greater than 10 dB noise increase modelled at receptor location 3 (ER4) during the site preparation and construction phases of the Project (as this receptor location is within the clearing area), birds are only predicted to experience noise level increases of 10 dB at receptor location 4 during site clearing and grubbing and overburden removal. Receptor location 4 is located along the South Railway Ditch between the WWMF Project footprint and the DGR project footprint. Based on Environment Canada guidance [68], a 10 dB increase from baseline is considered the point at which birds may be adversely affected.

Birds can habituate to disturbances and birds that choose to inhabit developed areas are less susceptible to given degrees of disturbance; however, noise disturbance to birds is most recognized during the breeding season [68]. The exceedance of 10 dB at receptor location 4 was modelled during work activities undertaken during the period when breeding bird activity generally does not occur (October to March), except for some raptor species, woodpeckers, and a few other species not present in the region (e.g., crossbills). Birds potentially affected by the increase in noise are the small number of permanent residents that remain in the region throughout the non-breeding season. The only two bird VECs potentially within the vicinity of receptor location 4 between October and March are the American Robin and Wild Turkey. American Robins are not particularly sensitive to noise, given their affinity for nesting along roadways and other urban settings, and are not sedentary during the non-breeding season. As such, American Robins are not expected be adversely affected by increased noise levels during the winter months due to their ability to easily move to less disturbed areas. Wild Turkeys are commonly found throughout the remaining habitat at the Bruce nuclear site and are well adapted to noise disturbance. As such, the short-term nature of the site preparation noise is expected to have no adverse effect on Wild Turkeys, given their habituation to disturbance and their ability to move to nearby areas suitable for overwintering.

Mammal and Amphibian Disturbance

Many scientific studies of man-made noise effects on mammals have been conducted; however, many of these are limited to behavioural effects from periodic and/or very loud sources (e.g., aircraft over flights) and are rarely linked to constant industrial sound exposure levels (e.g., relatively constant numeric values above 50 dB). Primary effects of noise include direct physical auditory changes, such as hearing loss or hearing threshold shifts, and the masking of auditory environmental signals, such as mating calls, predator approach, or prey sounds. Secondary effects can include non-auditory effects such as stress and changes in mating, feeding, or resting patterns and abilities [71]. The most common concern regarding the effects of noise on wildlife is the masking of acoustic signals on which an animal relies for survival. For example, high levels of noise can make it more difficult for an animal to defend its territory, attract mates, or participate in alarm or distress calls [72].

Individual reproductive success has also been directly related to calling effort in frogs [73]. As a result, noise emissions may be a concern because they can interfere with calling rates, which could in turn impact fitness [73], [74]. A review of the effects on a leptodactylid frog exposed to band-pass noise of different intensities and found that they increased their call rate in response to exposures of 66 to 78 dB [74]. As well, noise may not allow breeding frogs to properly hear and move toward breeding aggregations [75]. Preliminary results from [76] indicated that Spring Peepers increased both the frequency and intensity of their calls in the presence of traffic noise.

In response to noise, some species have resorted to modifying their call rather than increasing its amplification. Some species have developed a low, clicking sound, which they use when the background noise threatens to mask their regular call [73], [74]. Though calling adaptations by some frog species have been necessary, it was concluded that some frogs can quickly adapt to considerable levels of noise interference [74].

Bats have also been shown to modify their echolocation search calls in noise disturbance, producing longer calls with a narrower bandwidth [77]. The number of individual bats using the built environment and adjacent areas that will be subjected to Project-related increases in noise levels is limited. It should be noted that bats currently range throughout the Bruce nuclear site and are exposed to industrial activities.

Habituation of wildlife to disturbance is believed to primarily occur when the disturbance is frequent, regular, and the result of identical stimulus types [78]. As such, it is reasonable to assume that even if species initially display an escape response to the increased noise disturbance that is modelled to occur in the vicinity of the Project during the Site Preparation and Construction phase, they may habituate and resume current behaviours at the affected locations upon operation and maintenance of the WWMF expansion facilities.

The number of individuals using the built environment and adjacent areas that will be subjected to Project-related increases in noise levels is limited when compared with the populations found elsewhere at the Bruce nuclear site. It should be noted that most of the wildlife including bats that currently range throughout the Bruce nuclear site are exposed to industrial activities. Therefore, it can be concluded that there are likely no adverse effects on ecological receptors from changes in noise levels that may arise from the Project.

7.5.3.2 Loss, Alteration and Fragmentation of Habitat

Risk characterization is required for Eastern White Cedar and wetland habitat associated with area 1, loss of Butternut within area 3, and loss of habitat for Eastern Wood-Pewee and Little Brown Myotis in area 3. The purpose of the risk characterization is to identify if effects to populations, individual species and/or habitats are likely. For the purpose of this assessment, local population refers to the Terrestrial Monitoring Area and regional population refers to the Bruce nuclear site and immediate surrounding areas. In this assessment, the criteria used for judging and describing the effect are based on criteria outlined in CSA N288.6-12 [1] and on professional judgement. Criteria are either quantitative or qualitative, and include magnitude and geographic (spatial) extent. Criteria applicable to VECs and receptors are shown in Table 7-18.

Table 7-18: Effects Levels for Assigning Likely or Unlikely Effects to Terrestrial VECs

VEC Receptor	Criteria	Unlikely	Likely
Eastern White Cedar	Magnitude	Loss of some trees at several locations leading to reduction in conifer forests by 5 to 10% or mixedwood forests by 10 to 25% within the Project area. No effect on regional populations.	Local population decrease of >25% in conifer woodlands or >40% of mixed woodlands attributed to loss of forest communities throughout the Terrestrial Monitoring Area. Decrease in regional populations.
	Geographic Extent	Effect limited to the footprint of the Project.	Effect extending beyond the footprint of the Project.
Wetland Complex	Magnitude	Minor loss of some wetland vegetation. Minimal alteration to some wetland functions (biological, hydrological, special features). No fragmentation of wetland.	Major loss of some wetland vegetation. Alteration to all wetland functions (biological, hydrological, special features). Fragmentation of wetland.
	Geographic Extent	Effect limited to the Wetland Complex.	Effect extending to nearby and/or hydrologically connected wetlands.
Eastern Wood-Pewee	Magnitude	Loss of habitat that would not have detrimental effects on the population abundance and distribution.	Loss of habitat that would have detrimental effects on the population abundance and distribution.
	Geographic Extent	Effect limited to the footprint of the Project.	Effect extending beyond the footprint of the Project.
Little Brown Myotis	Magnitude	Loss of habitat that would not have detrimental effects on the population abundance and distribution.	Loss of habitat that would have detrimental effects on the population abundance and distribution.

VEC Receptor	Criteria	Unlikely	Likely
	Geographic Extent	Effect limited to the footprint of the Project.	Effect extending beyond the footprint of the Project.
Butternut	Magnitude	Loss of no trees.	Loss of any trees.
	Geographic Extent	Effect limited to the footprint of the Project.	Effect extending beyond the footprint of the Project.

Eastern White Cedar

The Project is expected to remove 0.5 hectares (ha) of mixed forest (FOM7-2) and 0.6 ha of coniferous forest swamp (SWC1-1 / SWC3-1 Complex) during site preparation.

Eastern White Cedar is valuable for wildlife habitat, particularly for White-tailed Deer for both shelter and browse, as well as such mammals as the snowshoe hare, porcupine, and red squirrel. Eastern White Cedar is very common throughout the area and is one of the most common tree species in Ontario (Secure [S5] – common, widespread, and abundant in the province) [79] where suitable habitats are present (cool, moist nutrient-rich sites, organic soils near streams or other drainage-ways, or on calcareous mineral soils). Dense, homogenous stands of Eastern White Cedar and mixed forest with dense patches of Eastern White Cedar are present in areas adjacent to the expansion area and throughout the Bruce nuclear site, and as such, the removal of Eastern White Cedar is not predicted to affect the local or regional population of Eastern White Cedar.

Therefore, the overall risk characterization determined that the removal of the Eastern White Cedar is acceptable as the magnitude of removal represents 2% of the mixedwood forest and 10% of the coniferous forest within the Terrestrial Monitoring Area and the spatial extent is limited to the footprint of the Project. Therefore, it is concluded that the potential adverse effect is acceptable and no mitigation/ compensation is required.

Wetland Complex

The Project is expected to remove 0.6 ha of coniferous forest swamp (SWC1-1 / SWC3-1 Complex) during site preparation.

The Wetland Complex has a history of anthropogenic disturbance and likely no longer functions in the manner it once did prior to construction of the Bruce nuclear site. The Wetland is surrounded by abandoned railways to the north and east (now a roadway named Siding Road), a capped landfill to the south, and the existing WWMF to the west. Although there is a history of wetland loss and anthropogenic disturbance within and in the vicinity of the Bruce nuclear site, the removal of the small transitional fragment of wetland on the edge of the larger Wetland Complex is not predicted to adversely alter the Wetland, or other wetlands within the Bruce nuclear site and surrounding areas. An assessment determined the functions of the wetland to be marginal due to its small size, isolated nature, limited vegetation community composition and open water habitat, limited flood attenuation and water quality improvement factor, and limited special features (e.g., no SAR or rare species presence and only supports amphibian woodland breeding habitat). In addition, the wetland provides little to no social value. The overall risk characterization determined that the removal of a small portion of the Wetland Complex is acceptable as the magnitude of removal represents minor loss of wetland vegetation (0.6 ha) and a minor loss of amphibian woodland breeding habitat. Additionally, removal of the wetland habitat is not predicted to have impacts on the biological function, hydrological functions, or special features of the Wetland. Removal of the wetland will not result in fragmentation of the Wetland given the Wetland interior will remain intact. Therefore, it is concluded that the potential adverse effect is acceptable and no mitigation/compensation is required. OPG will obtain any necessary permits or authorizations prior to the partial removal of the wetland.

<u>Species of Ecological Significance</u>

Three species of ecological significance were identified as having a potential adverse effect due to loss of habitat, including Eastern Wood-Pewee, Little Brown Myotis and Butternut. These three species are listed under the provincial *Endangered Species Act, 2007* (ESA) [80] as Special Concern, Endangered, and Endangered, respectively. Butternut and Little Brown Myotis are also listed under the federal *Species at Risk Act, 2002* (SARA) [81] as Endangered. The potential adverse effect for all three species is associated with the removal of area 3 (a 4.3-ha mature sugar maple – white ash – American beech woodland (FOD5-8 / FOD5-2 Complex)).

Eastern Wood-Pewee

As identified in the 2014 baseline monitoring surveys, one presumably breeding Eastern Wood-Pewee pair was recorded within the area 3 during the breeding season. The Eastern Wood-Pewee is showing widespread population declines across its range; however, the Ontario Breeding Bird Atlas shows a more stable population that is shifting northward, and migration monitoring also indicates a stable population [82]. Although food availability has likely resulted in population declines (this species is primarily an aerial insectivore), high northeastern populations of White-tailed Deer, who's browsing may cause changes to the intermediate canopy where Eastern Wood-Pewees forage, has been linked to these population declines [83]. Eastern Wood-Pewees are generally tolerant of forest fragmentation, since they live in both edge habitat and forest interiors. As suitable habitat is present throughout the Bruce nuclear site and surrounding area, as is evident by the greater number of Eastern Wood-Pewees elsewhere within the Bruce nuclear site, the displacement of habitat for one pair of breeding Eastern Wood-Pewees is not predicted to affect the local or regional population abundance and distribution of this species given this species is relatively common in Bruce county where suitable habitat is present. In addition, it is assumed that clearing activities are scheduled to occur between October and March when this species is not present on its breeding grounds.

Therefore, the overall risk characterization determined that the removal of habitat for Eastern Wood-Pewees is acceptable as the magnitude of removal represents a loss of habitat that would not have a detrimental effect of the population abundance and distribution of Eastern Wood-Pewee and the geographic extent is limited to the footprint of the Project. Therefore, it is concluded that the potential adverse effect is acceptable and no mitigation/compensation is required.

Little Brown Myotis

As identified in the WWMF Baseline ERA [8], Little Brown Myotis (and possible Northern Myotis and Eastern Small-footed Myotis) were recorded within area 3 during the maternal roosting season. The absolute number of Little Brown Myotis present within the woodland is unknown; however, Little Brown Myotis passes were recorded with relative frequency over 12 days of monitoring in June 2014. Based on the number of sampling days and total bat passes for species in the *Myotis* genus (includes potentially Little Brown Myotis, Northern Myotis, and/or Eastern Small-footed Myotis), an average of 4.1 and 13.9 *Myotis* bat passes per night were recorded at the two detectors within the woodland area. As bats regularly fly back and forth over an area while foraging, the low number of bat passes per day suggests the number of bats present is limited to a small number.

The primary cause of decline for Little Brown Myotis is the proliferation of White Nose Syndrome across its range. White Nose Syndrome is caused by infection from the fungus *Pseudogymnoascus destructans* which grows optimally in the same conditions under which bats hibernate. The infection causes bats to wake prematurely from hibernation resulting in energy reserves being depleted before the end of the hibernation period. Consequently, the bats die in the hibernaculum. Maternal roosting habitat loss has not been identified as contributing to the decline of this species.

As habitat loss, alteration and fragmentation is not a critical contributor to the decline of Little Brown Myotis, the overall risk characterization determined that the removal of habitat for Little Brown Myotis is acceptable. In addition, the woodland (area 3) was determined to not support significant wildlife habitat for bat maternal roosting during the 2014 field studies as the Terrestrial Monitoring Area did not meet the 10 candidate roost tree/ha threshold for significant wildlife habitat for bat maternal roosting [84]. The magnitude of habitat removal represents a loss of habitat that would not have a detrimental effect of the population abundance and distribution of Little Brown Myotis and the geographic extent is limited to the footprint of the Project. In addition, suitable habitat for Little Brown Myotis is present elsewhere on the Bruce nuclear site, as is evident by the presence of Little Brown Myotis in the southern areas of the Terrestrial Study Area. The clearing activity is also assumed to occur between October and March when this species is in its hibernation cycle (hibernaculum is not on the Bruce nuclear site; the location is unknown). Therefore, it is concluded that the potential adverse effect is acceptable.

Importantly, the determination of acceptable adverse effect to Little Brown Myotis does not preclude the potential requirement for permitting or authorizations under the ESA and/or its regulations. This is further discussed in Section 8.2.1.2.

Butternut

The woodland proposed for removal was identified as supporting three Category 2 Butternut trees, which represents a removal of 21.4% of Butternut trees (3 of 14) known at the Bruce nuclear site. As Category 2 trees, they are either not affected by Butternut canker or the Butternut tree is affected by Butternut canker, but the degree to which it is affected is not too advanced and retaining the tree could support the protection or recovery of Butternut trees in the area in which the tree is located. As the number of Butternut trees proposed for removal exceeds the acceptable threshold, mitigation measures are required to compensate for the removal of the three

Butternuts. Regulatory authorizations for removal of Butternut trees are required under the ESA and/or its regulations and following these standard process-related requirements are assumed to sufficiently mitigate for the removal of these three Butternut trees.

7.6 Uncertainties in the Ecological Risk Assessment

Uncertainty could be introduced into the EcoRA during the process of screening, exposure assessment and risk characterization. A qualitative analysis of the uncertainty associated with the EcoRA is presented below.

7.6.1 Uncertainty Related to Radiological Risk

For the radiological effects assessment, doses to non-human biota were calculated based on the conservative estimate of radiological emissions and the maximum allowable external gamma dose rate at the WWMF site boundary. Furthermore, the total estimated doses to non-human biota, which have taken into account the existing conditions, are a small percentage of the assessment criteria. Therefore, it is expected that the uncertainty associated with the dose calculation has no impact on the conclusion.

7.6.2 Uncertainty Related to Non-Radiological Risk

The assessment of non-radiological contamination is carried out based on the comparison of modelled concentrations and the assessment criteria. The modelled potential contaminations represent the bounding scenarios. Furthermore, the most restrictive guidelines from reputable sources are adopted as the assessment criteria. This will ensure that the conclusion of the assessment is valid, with a high level of confidence. Specific uncertainty associated with air quality and water quality which is applicable to EcoRA has been discussed in Section 6.6.2 as part of the HHRA. The specific uncertainties associated with soil quality, surface water quantity and flow which are applicable to the EcoRA are discussed below.

7.6.2.1 Uncertainty Related to Surface Water Quantity and Flow

There is uncertainty associated with the runoff coefficients for the undeveloped and developed conditions. Runoff coefficients will change from year to year depending on a number of factors, including total rainfall, rainfall intensity, rainfall distribution, seasonal vegetation, etc. The runoff coefficient estimates for undeveloped and developed conditions are utilized to quantify relative changes in water quantity associated with development.

Annual precipitation estimates were based on historical data, so there is some uncertainty associated with using this data for the future conditions; however it is not anticipated to be significant since all climate conditions (average, 1:20 year wet, and 1:20 year dry) produced the same percentage change in annual flow.

The overall uncertainty associated with the results is considered low, and is not anticipated to affect the conclusion of the EcoRA.

7.6.2.2 Uncertainty Related to Surface Water Quality and Sediment

There is uncertainty associated with the calculation concentrations of water quality indicators. The following are uncertainties that are in addition to those described in Section 7.6.2.1 which must also be considered within the context of calculated water quality concentrations for indicator parameters. Uncertainty in the assumed developed site runoff concentrations for the various indicators, as they are not site-specific, but are the average of values collected from many industrial sites in different areas, and for various industries. Additional uncertainty is associated with the pollutant removal rates used, as the values are used are averages of many studies carried out in different areas; the achieved efficiencies will vary depending on the type of storm water management used. As there is uncertainty associated with calculated concentrations, a supplemental stormwater monitoring study will be initiated during the operations and maintenance phase of the Project to confirm the predictions of the PEA.

7.6.3 Uncertainty Related to Physical Stressor Assessment

There may be uncertainty associated with the assessment of vehicle-wildlife collisions and/or bird strikes due to the Project, such as a flock of birds or a family of deer being struck by vehicles. These stochastic events are inherently unpredictable and may be attributable to a number of factors outside the control of Project activities (e.g., weather events, predator-prey interactions).

Overall, this assessment is an accurate estimate of the effects of the Project on terrestrial VECs and associated receptors. The uncertainly associated the Project is unlikely to change the conclusion of the physical stressor assessment.

7.6.4 Summary of Uncertainty Assessment

In summary, the assessment method and the conservative assumptions used for the EcoRA ensure that the actual effects are not underestimated. Therefore, it is anticipated that the uncertainty associated with the assessment has no impact on the conclusions of the PEA for ecological receptors.

8.0 ENVIRONMENTAL MANAGEMENT

8.1 Environmental Management Plan

Adverse environmental effects as a result of the Project will be precluded by the incorporation of practical mitigation and Good Industry Management Practice in the design and implementation plans for the Project.

OPG's contract management process requires that contract planning occurs prior to undertaking a contract. This planning stage includes the development of the statement of work, identification and evaluation of safety hazards and environmental risks, and identification of quality assurance requirements. To facilitate the environmental aspect evaluation, a worksheet provides a means of identifying issues which may be encountered during contracted work. This includes environmental considerations such as the site EMS requirements, regulatory approvals, Good Industry Management Practices, hazardous waste management, training and reporting requirements, and emergency response requirements.

An important element of the EMS Standard ISO 14001 requires that contractors working on behalf of OPG and whose work could cause environmental impairment be aware of their environmental policy, the environmental implications of their work, their roles and responsibilities and consequences of departure from specific procedures. During the procurement process, this expectation is communicated in the request for proposals or quotation.

Prior to commencing the Project works and activities, the contractor will be required to prepare and submit a procedure(s) for complying with OPG's EMS for the WWMF site. The objective of this procedure is to ensure consistency of contractor work plans and procedures with OPG operating policies and procedures and to satisfy OPG objectives for environmental protection.

Compliance with OPG's EMS and application of Good Industry Management Practices for controlling effects will involve environmental protection procedures and measures which are technically and economically feasible. These are related to environmental issues such as: dust and other airborne particulate, noise and odour, stormwater / water quality, groundwater quality, handling of fuels and lubricants during construction activities, and contingency measures in the event of spills or other upset conditions. It is anticipated that a Spill Management Procedure will be in place. In the event of a spill, an Emergency Response Team (either Bruce Power's or the contractor's depending on the location of the spill) would be mobilized to contain the spill, stop the source where possible, and direct the subsequent clean-up. In accordance with the contractual agreements between OPG and Bruce Power, Bruce Power provides Emergency Response Services to OPG for all fire, medical, rescue and spill emergencies that arise at the WWMF. The contractual agreements between OPG and Bruce Power for Bruce Power to provide Emergency Response Services will be reviewed and amended as required during the expansion of the WWMF. The emergency response for the new buildings should be similar to that for existing buildings. In general, OPG will monitor aspects of the performance of the contractor where there is an identified Project-related risk to the environment.

The specific mitigation measures required as part of the environmental management plan are discussed below.

8.2 Mitigation Measures

In-design mitigation measures required as part of this Predictive Effects Assessment are included in Table 8-1. Although it is unlikely that the Project will result in adverse effects to human health and non-human biota, as part of Project risk management, additional mitigation measures are recommended to minimize the potential environmental impacts of the Project on human and non-human biota. These additional mitigation measures are also included in Table 8-1.

Table 8-1: Summary of Mitigation Measures

Environmental components	Mitigation measures
Air	• Implement a dust management plan to identify all potential sources of fugitive dusts, outline the measures that will be employed to control dust generation, and detail the inspection and recordkeeping required to demonstrate that fugitive dusts are being effectively managed. The dust management plan should be consistent with Good Industry Management Practices and Ontario MOECC requirements [85], to ensure that these management practices and active mitigation are effective in mitigating the activities which may generate fugitive dusts. The dust management plan should track the implementation and effectiveness of the following measures: o Site roadways are maintained in good condition and dust suppressants (as needed) are used to control dust from material handling activities and unpaved roadways during site preparation and construction. • The LOPB and WSB should be constructed with adequate ventilation and controls to minimize emissions to air. The ventilation system will be equipped with filtration with a removal efficiency equivalent to HEPA filtration.
Noise	• Implementation of Good Industry Management Practices with respect to noise during the Site Preparation and Construction phases of the Project will be considered. Examples of Good Industry Management Practices of relevance to noise include requirements to maintain construction and operating equipment in proper mechanical condition, and the need to comply with applicable noise standards and regulations.

Surface water	• Develop the Project with the application of standard Stormwater Management Facility design as per provincial criteria [29]:
	  o To ensure peak flows do not exceed pre-development values for storms with return periods ranging from 2 to 100 years; and
	  o To design the stormwater management facility to meet

Environmental components	Mitigation measures
	an enhanced level of water quality protection. • Develop the Project with the application of appropriate erosion and sediment control measures applying Good Industry Management Practices during site clearing and construction, including a comprehensive Sediment and Erosion Control Plan to achieve the contaminant removal efficiency for TSS listed in Table 5-41 during clearing and construction.
Soil	• Develop and implement a soil management plan consistent with the MOECC guide [86] to manage on-site and off-site usage/disposal of excess soils. Controls will be implemented to ensure soils are not impacted by on-going activities. Should soils be encountered that are inconsistent with baseline monitoring, they will be screened and characterized accordingly. Characterized soil will be managed in accordance with the Soil Management Plan.
Groundwater	In-design mitigation measures for groundwater should be considered in relation to minimizing risk to groundwater during construction and operation and maintenance including: • The location and design of all buildings shall take into consideration groundwater recharge areas, i.e., areas 2, 3, and 4, to the Middle Sand Aquifer and Bedrock with respect to risks posed by buildings to groundwater. The design of the buildings will include engineering measures for the containment of radioactive and non-radioactive spills to groundwater. Design of the building subfloor containment system shall be informed by site specific investigations that will determine subsoil geological and hydrogeological conditions within the footprint of the new buildings; • Consideration of design measures for maintaining the present hydraulic function of the silt till aquitard according to best engineering practices for subsurface installations where excavations may be deep enough to compromise the integrity of the silt till aquitard (is dependent on the site specific hydrogeological conditions). Breaches of the silt till aquitard should be avoided; • Limiting stormwater infiltration in areas where recharge windows to the Middle Sand Aquifer are known to occur (area 2 and area 4) or where the silt till is known to be thin above the bedrock (area 3); and • Installation of low permeability barriers at regular intervals in the bedding material of subsurface sewers to minimize preferential pathways for groundwater migration to recharge windows or where the silt till is known to be thin.

Environmental components	Mitigation measures
Terrestrial environment	• Develop a compact WWMF expansion site to limit the extent of new disturbance of naturalized areas, reduce overall habitat loss, reduce the potential adverse effects related to interference with wildlife movement, and reduce noise effects, to the extent possible; • Erect exclusionary fencing to minimize disturbance to vegetation, wildlife, and their habitat beyond the expansion area during Site Preparation and Construction; • Follow Good Industry Management Practices to minimize the transfer of soils from the WWMF Expansion site to natural features to limit/prevent the transfer of invasive plants; • Where feasible and applicable, conduct active re-vegetation post-construction through seeding and/or planting of native species in expansion area areas as part of progressive reclamation; • Conduct vegetation clearing outside April 1 to August 31 in accordance with the guidelines provided by the Canadian Wildlife Service in accordance with the Migratory Birds Convention Act, 2007 [87]; • Within the regulatory requirements for safety and security of the facility, design artificial night lighting fixtures in a strategic downward orientation, minimize the intensity of night lighting, and/or use dark sky lighting fixtures (such as high pressure sodium lights) where feasible, to reduce excess artificial light production and associated light penetration into adjacent wildlife habitat areas beyond the Project boundary; • Conduct site preparation and construction works during daylight hours, unless otherwise necessary, to avoid potential effects of artificial night lighting; and, • Conduct Good Industry Management Practices such as dust suppression techniques in accordance with a dust management plan to minimize the zone of influence in wildlife habitats.

8.2.1 Species of Ecological Significance

8.2.1.1 Butternut

Mitigation measures as part of Project risk management include limiting the extent of new disturbance to naturalized areas and reducing overall habitat loss. However, in the event that removal of the category 2 Butternuts in area 3 is necessary, following standard ESA process-related requirements is assumed to sufficiently mitigate the removal of these trees. These standard process-related requirements are outlined in *O. Reg. 242/08*, section 23.7(10) [88], and include but are not limited to planting of Butternut seedlings, tending and monitoring their growth and health.

8.2.1.2 Bat Habitat

As described in Section 7.5.3.2, the primary cause of decline for Little Brown Myotis is the proliferation of White Nose Syndrome across its range. Habitat loss is not a critical contributor to the decline of Little Brown Myotis. The loss of potential maternity roost habitat for Little Brown Myotis is minor and acceptable, and therefore, no mitigation is required through the PEA. Currently there are no standard ESA permitting requirements available to use to determine possible mitigation (if required) of the removal of bat habitat. A potential mitigation could include:

- The strategic placement of bat boxes within the vicinity of the WWMF for the purpose of emulating maternal roost habitat for bats. The number of bat boxes and their subsequent location, would be determined with input from Ministry of Natural Resources and Forestry biologists or other bat specialists to optimize habitat use by bats; and,
- A monitoring program to obtain data. Such monitoring may require relocation of bat boxes to optimize habitat use.

9.0 ENVIRONMENTAL MONITORING PROGRAMS

Environmental monitoring at the WWMF has been conducted for many years. The environmental performance of the WWMF is reported to the CNSC on a regular basis as part of the quarterly operations report.

A baseline ERA [8] was developed in accordance with N288.6-12 to assess the potential risk posed by existing WWMF operation on human and non-human biota. The PEA, essentially a predictive ERA as defined in N288.6-12, estimated the effects of contaminants and stressors on the existing environment, resulting from the proposed new facilities to be constructed at the WWMF, prior to their release into the environment. The outcome of the ERA, both baseline or predictive, is to provide risk-based recommendations which in turn are intended to provide feedback to the EMPs.

EMPs are proposed to confirm the accuracy of the PEA and the effectiveness of the mitigation measures to be implemented, which are identified in Section 8.2. Based on the results of the PEA, the recommended EMP was identified and summarized in Table 9-1.

The existing effluent monitoring program at the WWMF will be expanded to include the new facilities to meet regulatory requirements such as MOECC ECAs, and CSA N288.5 Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills [7]. DRLs and Action Levels will be updated accordingly to be consistent with CSA N288.1 Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities [23].

The WWMF's existing groundwater program will be altered, if required, as detailed designs of the buildings are available and the site is developed over time. Implementation plans, compliant with N288.7-15 [89], will be developed for WWMF and the new facilities in any future programmatic changes.

Table 9-1: Recommended Environmental Monitoring Programs

	Program Description	Discipline Specific Objective	Location	Duration/Frequency
Air Quality	Monitoring of air quality during the construction phase to assess potential dust impacts. Specifically measure the levels of PM_{10}.	To verify that the PM_{10} assessment was reasonable and conservative. To verify that mitigation measures for dust management plan are effective.	Three locations: Two monitors along the downwind property boundary or other suitable impact location. One monitor in a location upwind of the construction activity to provide context against which the downwind data can be adjudged.	Monitoring to include: Periodic measurement of PM_{10} during construction activities (year 1 construction period) to confirm the effectiveness of the dust management plan and verify PEA predictions. Re-evaluation of future monitoring beyond the year 1 construction period will be considered based on the outcome of the monitoring program.
Soil	Project work activities should incorporate a sampling program, set out in the Soil Management Plan and prepared prior to the site preparation activities.	Compliance with OPG's EMS and the MOECC Management of Excess Soil Guideline [86]. This program will allow for the effective management of excess soil either for use on-site or disposal off-site.	The area as recommended in the guidance.	For the construction period, at a frequency as required by the guidance.

	Program Description	**Discipline Specific Objective**	**Location**	**Duration/Frequency**
Surface Water Quantity	Any monitoring specified by the MOECC for the ECA for the stormwater management facility (likely to include water level monitoring of stormwater management facility, but to be specified in the ECA).	Meet requirements of ECA conditions related to the stormwater management facility, and to ensure that the stormwater management facility is meeting MOECC guidance criteria [29].	Stormwater management facility outlet.	As specified by MOECC, for the operation of the stormwater management facility.
Surface Water Quality and Sediment	Monitoring of surface water for TSS should be performed following the requirements of MOECC ECA conditions for the monitoring of stormwater management facilities and sediment and erosion control measures during Site Preparation (clearing) and Construction. MOECC ECA issued as part of detailed design and permitting phase.	Meet requirements of MOECC ECA conditions related to the stormwater management facility and sediment and erosion control measures during site preparation and construction phases.	Stormwater management facility, erosion and sediment control features.	As specified by MOECC ECA conditions following detailed design approval.
	Conduct a stormwater monitoring study during the Operations and Maintenance phase. Parameters to be assessed to include water quality indicators used in PEA (i.e., TSS, total phosphorus, zinc, copper, and dissolved chloride).	The objective of stormwater monitoring study is to confirm the original predictions of the PEA, and to ensure that stormwater quality does not pose a risk to non-human biota.	Established through development of a stormwater monitoring study.	One year study including four representative storm events.
Radiation and Radioactivity	Additional TLDs will be installed around the expanded fence line to monitor ambient dose rate.	This is to ensure the average gamma dose rate remains below the dose rate target of 0.5 µGy/h.	The locations where the TLDs will be mounted on the expanded fence line	The measurement can be done on a quarterly basis, same as the current practice at the WWMF.

	Program Description	Discipline Specific Objective	Location	Duration/Frequency
			can be determined after the detailed design of the Project is available.	Note this can be integrated into the existing routine monitoring program at the WWMF operated by OPG.

10.0 QUALITY ASSURANCE

The PEA is conducted in accordance with the Amec Foster Wheeler Quality Assurance program [90]. The Amec Foster Wheeler Quality Assurance program is ISO 9001 registered and the scope of the ISO 9001:2000 registration covers "consulting, scientific and engineering services to nuclear and other industries to support siting, safety, licensing, design and operations by providing specialized: asset management, project management, procurement, software, environmental, integrated analytical and engineering solutions and services". The Amec Foster Wheeler Quality Assurance program has been audited by CANPAC and confirmed to meet the requirements of CSA Z299.1-85 [91] and the applicable sections of CSA N286-05 [92].

The main Amec Foster Wheeler Quality Procedures (NQP) applicable to this project include:

- NQP 6 - Work Planning and Execution;
- NQP 7 - Control of Documents;
- NQP 13 - Control of Records;
- NQP 32 - Software Development and Documentation; and,
- NQP 33 - Software Verification, Validation and Qualification.

Following Amec Foster Wheeler Quality Assurance requirements, reviews and verifications were carried out throughout the Project in relation to all project deliverables, models and results.

11.0 CONCLUSIONS

11.1 HHRA

11.1.1 Radiological Impact

It is estimated that the highest potential dose to members of the public, taking into account the existing conditions, is less than 5 µSv/y, less than 0.5% of the dose criterion of 1 mSv/y or 1000 µSv/y for members of the public. Therefore, it is concluded that there are no adverse radiological effects to the public.

11.1.2 Non-Radiological Impact

Of all the environmental media considered (including the atmospheric environment [air quality and noise], surface water (quantity and quality), sediment, soil, and groundwater), the only non-radiological contaminant which was estimated to exceed the assessment criteria was particulates at Bruce nuclear site boundary during construction. However, the concentrations were estimated based on conservative assumptions and the adverse effect is immediately reversible with cessation of the emission-generating activities. In addition, the frequency of occurrence is low. For example, the exceedances of AAQC at the Bruce nuclear site boundary occur less than 1% of the time while construction activities are occurring. Furthermore, the concentrations of these indicators at all specific human receptor locations, which are further afield than the Bruce nuclear site boundary, are below the AAQC values. Therefore, it is concluded that there are likely no adverse effects to human health due to the elevated air concentrations.

11.1.3 Physical Stressors

Noise is the only physical stressor considered for the purposes of the HHRA, which is consistent with CSA N288.6-12 [1]. The noise levels were modelled for the nearest human noise receptors for all phases of the Project. During the Site Preparation and Construction phases, the increased noise levels are not considered to have an adverse effect on human health as the increase from each Project phase is less than the 5 dB above baseline noise level criterion. During the Operation and Maintenance phase, the modelled noise levels are well below the NPC-300 criteria. Therefore, it is concluded that there are likely no adverse effects to human health due to increased noise.

11.2 EcoRA

11.2.1 Radiological Impact

The effects from radiological emissions from the WWMF were determined for indicator species across all trophic levels. The total radiological doses received by the indicator species, taking into account the existing conditions and the emissions from the Project, were estimated in the range of 0.53 µGy/h to 3.57 µGy/h, which are well below the benchmark values given in CSA N288.6-12 [1]. Therefore, it is concluded that there are no adverse radiological effects to the ecological receptors.

11.2.2 Non-Radiological Impact

It was determined there are no adverse effects on ecological receptors from air quality, soil and groundwater. It was anticipated that there would be likely no adverse effects from predicted air emissions since the levels are below screening levels and/or are short in duration. No adverse effects are expected from exposure to soil contaminants as the Project is not expected to release contaminants to soil. For groundwater there is no direct pathway to receptors and therefore there are no adverse effects due to the Project; there is potentially a reduction in recharge to the aquifers but this effect is negligible on a regional scale.

Changes to surface water quantity are expected in the South Railway Ditch in the event that drainage from all expansion areas is directed to the South Railway Ditch. However, no adverse effect to the biological integrity of the aquatic systems within the South Railway Ditch is expected.

The ecological risk characterization to VECs and associated receptors concluded there was potential for impacts due to changes in surface water quality due to TSS loading during site preparation and construction, even with the consideration of suspended solids removal rates under an enhanced level of water quality protection (i.e., stormwater facility). However, further general site erosion and sediment control measures, as identified in Table 8-1, could be implemented to further enhance the efficiency of TSS control and reduce the potential environmental impact. Therefore, it is expected that the changed TSS loading has no likely adverse effect. There are likely no adverse effects to aquatic receptors from any other surface water contaminants.

11.2.3 Physical Stressors

Quantitative analysis shows that the Project is unlikely to represent a noise disturbance beyond tolerance on species currently occurring within the vicinity of the WWMF. It is concluded that there are likely no adverse effects on ecological receptors from changes in noise levels that may arise from the Project.

A qualitative assessment was performed to determine the adverse effects associated with lighting, road kill, and bird strikes resulting from the Project. No likely adverse effects were identified for these physical stressors.

The ecological risk characterization on VECs and associated receptors concluded that there is no adverse effect on aquatic receptors from loss of habitat and the potential adverse effects due to the loss of habitat on Eastern White Cedar, the Wetland Complex, Eastern Wood-Pewee, and Little Brown Myotis are acceptable. The adverse effects identified for Butternut trees are acceptable if the identified mitigation measures are implemented.

11.3 Mitigation and Environmental Monitoring

Mitigation measures to minimize the potential environmental impacts of the Project on human and ecological receptors were identified for the following disciplines:

- Air Quality: Implementation of dust management plan;
- Noise: Implementation of Good Industry Management Practices;

- Surface Water: Application of a standard Stormwater Management Facility design, application of appropriate erosion and sediment control measures;
- Soil: Implementation of a soil management plan and the utilization of silt fences;
- Groundwater: Various measures in relation to minimizing risk to groundwater across the expansion areas, including appropriate location and design of buildings, maintaining the present hydraulic function of the silt till aquitard, limiting the stormwater infiltration in areas with recharge windows or thin silt till above the bedrock, and installation of low permeability barriers; and,
- Terrestrial environment: Various measures to minimize the impacts on terrestrial species and habitat, such as development of a compact WWMF expansion site, erection of exclusionary fencing, revegetation, avoiding vegetation clearing during the breeding bird season, and compensation offsets as per *O.Reg. 242/08* for removal of category 2 Butternuts.

The following EMP requirements have been identified:

- Air quality: Monitoring of PM_{10} during construction;
- Soil: Soil monitoring as set out in the Soil Management Plan;
- Surface water and sediment: monitoring of TSS during Site Preparation and Construction as per MOECC requirements for the Stormwater Environmental Compliance Approval. Stormwater monitoring during Operations and Maintenance; and,
- Radiation and radioactivity: Monitoring of ambient dose rate along the expanded fence line during the operation and maintenance.

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Appendix A: Acronyms

AAQC	Ambient Air Quality Criteria
BMP	Best Management Practice
CEQG	Canadian Environmental Quality Guideline
CO	Carbon Monoxide
COPC	Contaminants of Potential Concern
CSA	Canadian Standards Association
dB	Decibel
dBA	A-Weighted Sound Level
DGR	Deep Geologic Repository
DSC	Dry Storage Container
EA	Environmental Assessment
ECA	Environmental Compliance Approval
EcoRA	Ecological Risk Assessment
EIS	Environmental Impact Statement
EMC	Event Mean Concentration
EMP	Environmental Monitoring Program
EMS	Environmental Management System
ERA	Environmental Risk Assessment
ESA	Endangered Species Act
ESDM	Emission Summary and Dispersion Modelling
HEPA	High Efficiency Particulate Air
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
HTO	Tritium Oxide (tritiated water)
IC	In-ground Container (includes IC-18 and IC-HX)
ISO	International Standards Organisation
L&ILW	Low and Intermediate Level Waste
L_{eq}	Equivalent Sound Level
LLSB	Low Level Storage Building

LLW	Low Level Waste
LOPB	Large Object Processing Building
MOECC	Ministry of Environment and Climate Change
MWMT	Maximum Weekly Mean Temperature
NGS	Nuclear Generating Station
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NV	No Value
OPG	Ontario Power Generation
PCSWMM	Personal Computer Storm Water Management Model
PEA	Predictive Effects Assessment
PHC	Petroleum Hydrocarbons
PM	Particulate Matter
PM_{10}	Particulate matter < 10 μm
$PM_{2.5}$	Particulate matter < 2.5 μm
PPE	Personal Protective Equipment
PQRA	Preliminary Quantitative Risk Assessment
PWQO	Provincial Water Quality Objectives
RCSB	Retube Component Storage Building
RWS	Refurbishment Waste Storage
SAR	Species at Risk
SARA	Species at Risk Act
SG	Steam Generator
SGSB	Steam Generator Storage Building
SO_2	Sulphur Dioxide
SO_x	Sulphur Oxides
SRD	South Railway Ditch
SSTF	Spent Solvent Treatment Facility
TEF	Toxic Equivalent Factor
TEQ	Toxic Equivalency
TLD	Thermoluminescent Dosimeter

TPMB	Transportation Package Maintenance Building
TRV	Toxicity Reference Value
TSD	Technical Support Document
TSP	Total Suspended Particulate
TSS	Total Suspended Solids
UFDSB	Used Fuel Dry Storage Building
US EPA	United States Environmental Protection Agency
VECs	Valued Ecosystem Components
WD	West Ditch
WSB	Waste Sorting Building
WVRB	Waste Volume Reduction Building
ww	Wet Weight
WWMF	Western Waste Management Facility

Appendix B: Estimated Radiological Emissions from the WWMF Expansion Project

The WWMF expansion project includes site preparation, construction, operation and maintenance of the following buildings:

- Four UFDSBs 5 to 8;
- Four L&ILW storage buildings which could be any combination of LLSB, RCSB and SGSB;
- One WSB; and,
- One LOPB.

Also the Project includes repurposing an existing LLSB or using one of the new LLSBs for staging and overpacking of L&ILW.

The operation and maintenance of these buildings could result in radiological emissions to the environment. The airborne and waterborne emissions from these buildings are estimated and summarized below.

B.1 AIRBORNE EMISSIONS

B.1.1 Airborne Emissions from UFDSBs

As discussed in Section 5.2.1, it is expected that airborne emissions from the UFDSBs 5 to 8 to the environment are negligible during normal operation and maintenance.

B.1.2 Airborne Emissions from L&ILW Storage Buildings

L&ILW storage buildings to be built could be LLSBs, RCSBs and SGSBs. The airborne emissions from these types of buildings are discussed below.

B.1.2.1 Airborne Emissions from RCSBs and SGSBs

As discussed in Section 5.2.1, it is expected that airborne emissions from the SGSBs and RCSBs to the environment are negligible during normal operation and maintenance.

B.1.2.2 Airborne Emissions from LLSBs

As discussed in Section 5.2.1, there is potential for airborne emissions of tritium and gaseous C-14 from LLSBs to the environment as the containers stored in this type of buildings are not sealed. The airborne emissions from LLSBs were estimated based on the estimated total inventory of tritium and C-14 at the WWMF in 2025 and the emission rates of tritium and C-14.

It was estimated that the total inventory of tritium and C-14 at the WWMF in 2025 will be 1.4E+15 Bq and 7.8E+11 Bq, respectively [B-1]. In addition, the estimated emission rates of tritium and C-14 are 4.2E-3 Bq/y per Bq waste and 5.4E-2 Bq/y per Bq waste respectively [B-2]. Assuming the containers are stored in 12 LLSBs[20], the tritium and C-14 emissions from one LLSB will be 4.9E+11 Bq/y and 3.51E+9 Bq/y, respectively. Therefore, the airborne emissions of tritium and C-14 from four LLSBs will be 2.0E+12 Bq/y and 1.4E+10 Bq/y, respectively.

Based on the discussion above, airborne emissions from four LLSBs represent the bounding case for the airborne emissions from four L&ILW storage buildings. Therefore, the estimated emissions from four LLSBs, that is, 2.0E+12 Bq/y of tritium and 1.4E+10 Bq/y of C-14, are used to represent the airborne emissions from four L&ILW storage buildings.

B.1.3 Airborne Emissions from WSB

The WVRB at the WWMF is the facility for radioactive material handling, sorting and storage. The emissions from the WVRB ventilation system are monitored. The maximum annual airborne emissions from the WVRB ventilation system for the period of 2009-2013 are given in Table B-1.

Table B-1: Maximum Annual Airborne Emissions from the WVRB Ventilation System

Facility	Tritium Oxide (Bq)	I-131 (Bq)	Particulate (Bq)	C-14 (Bq)
WVRB Ventilation system	3.75E+11	7.37E+04	2.44E+05	0.00E+00

The detailed design of the WSB is not available. However, there is potential for airborne emissions from the WSB to the environment as discussed in Section 5.2.1. Assuming the emission control of the WSB will be as efficient as the WVRB and the waste processing/sorting rate will be the same as the WVRB, it is expected that the airborne emissions from the WSB will be bounded by those from the WVRB as processes in the WVRB include more vigorous operations such as compaction. Therefore, for the purpose of the PEA, it is conservatively assumed that the emission data in Table B-1 represent the airborne emissions from the WSB.

B.1.4 Airborne Emissions from LOPB

Large objects such as steam generators (SGs) and heat exchangers may be processed in the LOPB by segmentation, re-welding and/or packaging for storage at the WWMF and/or disposal at the DGR. Multiple cutting technologies have been investigated for large object segmentation. The equipment/technology considered include arc saw cutter, oxygen burning, plasma arc torch, band saw, abrasive wheel cutter, abrasive

[20] The calculated inventory in each LLSB used to estimate airborne emissions from the LLSB is conservative if it is assumed that the inventory of the LLW at year 2025 is being stored in 12 LLSBs which are full.

water jet and diamond wire cutter. Diamond wire cutting is the only method with the demonstrated capability to cut both the shell and the tubes of the SGs and heat exchangers. Although plasma arc torching could also be employed, this technology was identified as one of least viable options among all technologies considered and it might only be used for some processing tasks. Therefore, in this report, the emissions from LOPB are estimated based on the diamond wire cutting technology.

Diamond wire cutting is a wet cutting technique which uses water to provide cooling[21] and flush debris. As such the airborne particulate generated as a result of cutting will be negligible. Furthermore, the LOPB will be equipped with a HEPA filtered ventilation exhaust system which will collect and filter airborne emissions generated. A Continuous Emissions Monitor is also expected to be installed to monitor airborne emissions. Therefore release of particulates to the environment will not be considered further for the LOPB.

For the purpose of the PEA, it was assumed that tritium and C-14 will be the only radionuclides to be released to the environment in vapour/gaseous form during diamond wire cutting. Without detailed design of the LOPB and the specification of the equipment/system, it was assumed that the tritium release ratio of 0.11% per cut based on reference [B-3] applies to the release of these two radionuclides during large object processing. This is conservative as much of any gaseous C-14 in the SGs or heat exchangers will likely have previously degassed. It should be noted that the release ratio of 0.11% per cut was calculated based on the total emissions from the reactor segmentation project and therefore it represents the overall emission rate taking into account all processes carried out within the LOPB as described in Section 4.0.

The estimated radioactivities of SGs and heat exchangers in 2025 are given in Table B-2 [B-1]. As shown in Table B-2, the radioactivities of heat exchangers are much less than those of SGs. Therefore, SGs are used to represent the large objects to be processed in the LOPB for the purpose of emission estimate, which results in more conservative values.

[21] Liquid nitrogen could also be used to provide cooling.

Table B-2: Estimated Radioactivity of SG and Heat Exchanger*

Radionuclide	Heat Exchanger (Bq)	SG (Bq)
Ag-108m	2.0E+04	3.1E+06
Am-241	6.8E+08	9.5E+11
Am-242m	3.7E+03	6.1E+08
Am-243	9.5E+03	1.5E+09
Ba-133	8.7E+07	0.0E+00
C-14	2.1E+08	3.9E+11
Cf-252	5.4E+05	0.0E+00
Cl-36	3.3E+04	2.6E+07
Cm-244	9.4E+05	2.9E+11
Co-60	5.6E+08	9.7E+12
Cs-134	8.3E+05	7.7E+08
Cs-135	2.1E+03	0.0E+00
Cs-137+Ba-137m	6.5E+11	4.8E+11
Eu-152	2.5E+06	3.8E+09
Eu-154	1.3E+07	1.3E+10
Eu-155	0.0E+00	3.2E+10
Fe-55	8.8E+08	2.0E+13
H-3	1.7E+12	4.8E+12
I-129	7.1E+02	1.0E+05
Nb-94	4.4E+07	2.8E+09
Ni-59	2.1E+06	1.4E+10
Ni-63	1.3E+09	1.9E+12
Np-237	4.6E+02	7.0E+07
Pb-210	2.4E+09	0.0E+00
Pu-238	1.3E+06	3.6E+11
Pu-239	3.0E+06	4.7E+11
Pu-240	4.3E+06	6.4E+11
Pu-241	5.2E+07	1.1E+13
Pu-242	4.3E+03	7.0E+08
Ra-226	1.4E+08	0.0E+00
Ru-106	4.3E+06	9.4E+10
Sb-125	1.1E+07	6.8E+09
Se-79	7.3E+01	0.0E+00
Sm-151	5.8E+03	0.0E+00
Sn-126	1.1E+04	0.0E+00
Sr-90+Y-90	1.3E+10	3.9E+12
Tc-99	4.5E+03	5.2E+06
U-233	1.6E-02	2.6E+03
U-234	4.9E+03	7.7E+08

Radionuclide	Heat Exchanger (Bq)	SG (Bq)
U-235	7.9E+01	1.2E+07
U-236	9.0E+02	1.4E+08
U-238	1.3E+08	9.6E+08
Zr-93	2.5E+02	1.2E+06
Total as listed	2.4E+12	5.5E+13
Net Volume (m^3)	1720	5987

*The activities presented in the table are the estimated inventories in 2025. The activities of heat exchangers provided here are actually the total estimated inventories of large objects including heat exchangers, magnetite liners, tile hole liners and encapsulated tile holes.

It was conservatively assumed that all 32 SGs from Bruce A or Bruce B will be segmented in one year[22]. The airborne emissions during this process are estimated and summarized in Table B-3. The maximum emissions are conservatively used to calculate the total emissions from the Project.

Table B-3: Estimated Airborne Emissions for LOPB

Parameters	SGs from Bruce A	SGs from Bruce B
Number of SGs being processed per year	32	32
Volume of single SG (m^3 per SG) [B-2]	56.3	130.8
Activity of HTO per SG (Bq)	4.5E+10	1.0E+11
Activity of C-14 per SG (Bq)	3.7E+09	8.5E+09
Ratio of release per cut	0.11%	0.11%
HTO release rate (Bq/y)[23]	6.6E+09	2.7E+10
C-14 release rate (Bq/y)[23]	5.4E+08	2.2E+09
Maximum HTO release rate (Bq/y)	2.7E+10	
Maximum C-14 release rate (Bq/y)	2.2E+09	

B.1.5 Total Annual Airborne Emissions

The total airborne emissions resulting from the Project are summarized in Table B-4. The total airborne emissions, taking into account the current operation at the WWMF, are also presented in Table B-4.

[22] This is based on a very conservative assumption that SGs from all four units at Bruce A or Bruce B will be available for segmentation within a year.
[23] It is assumed that each SG from Bruce A will be cut into five pieces and each SG from Bruce B will be cut into eight pieces to meet the DGR's waste acceptance criteria [B-2].

Table B-4: Estimated Annual Airborne Emissions

Facilities	Tritium (Bq)	I-131 (Bq)	Particulate (Bq)	C-14 (Bq)
Four UFDSBs	0	0	0	0
Four L&ILW storage buildings	2.0E+12	0	0	1.4E+10
LOPB	2.7E+10	0	0	2.2E+09
WSB	3.8E+11	7.4E+04	2.4E+05	0
Predicted airborne emissions due to the WWMF expansion project	2.4E+12	7.4E+04	2.4E+05	1.6E+10
Predicted total airborne emissions	2.7E+13	1.5E+05	4.9E+05	2.0E+10

B.2 WATERBORNE EMISSIONS

The annual airborne and waterborne emissions from the WWMF for the period of 2009 to 2013 are presented in Table B-5 and Table B-6, respectively.

Table B-5: Annual Average Airborne Emissions from the WWMF (2009-2013)

Radionuclides	HTO	C-14 (Bq)	I-131 (Bq)	Particulate (Bq)
Airborne emission (Bq/y)	2.5E+13	3.7E+09	7.5E+04	2.5E+05

Table B-6: Maximum Annual Waterborne Emissions from the WWMF (2009-2013)

Radionuclides	HTO	Gross Beta/Gamma	C-14*
Maximum annual emission (Bq/y)	1.6E+11	7.0E+06	1.2E+08

*The waterborne emission of C-14 was estimated based on the measured C-14 concentration in surface water (1.02 Bq/L) in the South Railway Ditch and the annual flow rate of 3.7 L/s from the WWMF.

The predicted waterborne emissions were calculated using the following equation:

$$E_p = E_{c,water} \times (E_{t,air}/E_{c,air}) \times A_{total}/A_{cur}$$

Where,

E_p = Predicted total waterborne emissions from WWMF

$E_{t,air}$ =Total estimated airborne emissions (see Table B-4)

$E_{c,air}$ = Current airborne emissions (see Table B-5)

$E_{c,water}$ = Current waterborne emissions (see Table B-6)

A_{total} = Total paved area (29.7 ha, measured from Figure 5-8)

A_{cur} = Current paved area (17.4 ha, measured from Figure 5-8)

The predicted annual total waterborne emissions from the WWMF, along with the waterborne emissions due to the Project, are presented in Table B-7.

Table B-7: Predicted Annual Waterborne Emissions from the WWMF

Waterborne emission	HTO	Gross Beta/Gamma*	C-14
Predicted waterborne emissions resulting from the Project (Bq/y)	1.4E+11	1.7E+07	9.7E+08
Predicted total waterborne emissions from the WWMF(Bq/y)	2.9E+11	2.4E+07	1.1E+09

*The waterborne emissions of gross beta/gamma were conservatively estimated based on total airborne emissions of I-131 and particulate.

B.3 REFERENCES

[B-1] OPG. Reference Low- and Intermediate-Level Waste Inventory for the Deep Geologic Repository, 00216-REP-03902-00003 R04, April 2014.

[B-2] NWMO. OPG's Deep Geologic Repository for Low and Intermediate Level Waste: Preliminary Safety Report, 00216-SR-01320-00001 R00, March 2011.

[B-3] Keith Rule, Erik Perry, et al., Demonstrating Diamond Wire Cutting of the TFTR, WM'00 Conference, February 27 – March 2, 2000, Tucson, AZ.

Appendix C: Summary of Air Quality Modelling Parameters

Table C-1: Modelling Parameters for Receptors at Bruce Nuclear Site Boundary

<table>
<tr><th rowspan="2">Modelling Considerations</th><th rowspan="2">Existing</th><th rowspan="2">Site Preparation</th><th colspan="7">Construction</th></tr>
<tr><th>Underground Services</th><th>Final Preparation</th><th>Foundation</th><th>Walls</th><th>Roof</th><th>Floor</th><th>Torched on Roof</th></tr>
<tr><td colspan="10">Existing Sources</td></tr>
<tr><td>North Access Road</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Main Access Road</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>South Access Road</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Emerg Gen A Side 15 MW</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Emerg Gen B Side 15 MW</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Emerg Gen B Side 2 MW</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Bruce Steam Plant Boilers (3)</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>WWMF - Radioactive Waste Incinerator</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Emerg Gen WWMF</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td colspan="10">Site Preparation and Construction Equipment Fleet</td></tr>
<tr><td>Feller/Buncher</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Dump Truck</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stationary Chipper</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Back-Hoe</td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Front-end Loader</td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
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<tr><td>Compactor</td><td></td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Crane</td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Concrete truck</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Flatbed truck</td><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Concrete conveyor</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Concrete Troweller/Leveler</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Mini-Elevator</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Generator</td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="10">Other</td></tr>
<tr><td>Background Concentrations</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="10">Contaminants Modelled</td></tr>
<tr><td>Particulate matter (TSP, PM_{10}, $PM_{2.5}$)</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Nitrogen Dioxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Carbon Monoxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Sulfur Dioxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
</table>

Table C-2: Modelling Parameters for Ecological Receptors

<table>
<tr><th rowspan="2">Modelling Considerations</th><th rowspan="2">Existing</th><th rowspan="2">Site Preparation</th><th colspan="7">Construction</th></tr>
<tr><th>Underground Services</th><th>Final Preparation</th><th>Foundation</th><th>Walls</th><th>Roof</th><th>Floor</th><th>Torched on Roof</th></tr>
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<tr><td>Emerg Gen B Side 15 MW</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
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<tr><td>WWMF - Radioactive Waste Incinerator</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
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<tr><td>Feller/Buncher</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="10">Compounds Contaminants Modelled</td></tr>
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</table>

Table C-3: Modelling Parameters for Human Receptors

<table>
<tr><th rowspan="2">Modelling Considerations</th><th rowspan="2">Existing</th><th rowspan="2">Site Preparation</th><th colspan="7">Construction</th></tr>
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<tr><td>Stationary Chipper</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Back-Hoe</td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bulldozer</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Front-end Loader</td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Grader</td><td></td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Compactor</td><td></td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Crane</td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Concrete truck</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Flatbed truck</td><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Concrete conveyor</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Concrete Troweller/Leveler</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Mini-Elevator</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Generator</td><td></td><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="10">Other</td></tr>
<tr><td>Background Concentrations</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="10">Contaminants Modelled</td></tr>
<tr><td>Particulate matter (TSP, PM_{10}, $PM_{2.5}$)</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Nitrogen Dioxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Carbon Monoxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
<tr><td>Sulfur Dioxide</td><td>✓</td><td>✓</td><td colspan="7">✓</td></tr>
</table>

Appendix D: Terrestrial Noise Impact

D.1 MODELLED NOISE LEVELS

Ten locations for ecological receptors that may be impacted by noise have been defined. These include the locations previously identified from environmental assessments[24], identified as "ER" locations, and additional locations for this Project. The receptor locations are shown in Figure D-1.

The following terrestrial noise impact tables are provided for reference with the assessment presented in Section 7.5.2.4.

[24] Golder Associates Limited, Bruce Nuclear Power Plant Project Environmental Assessment EIS Studies Air Quality and Noise Technical Support Document, May 2008.

Figure D-1: Locations for Terrestrial Noise Receptors

Table D-1: Modelled Noise Level during Site Preparation-Clearing the Site

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Clearing the Site									
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB					Combined Noise Level L_{eq} (1 h), dB				
				1	2	3	1+3	2+3	1	2	3	1+3	2+3
1	64	67	74	67	61	72	73	72	69	66	73	74	73
2 (ER7)	69	72	79	75	65	70	76	71	76	70	73	77	73
3 (ER4)	67	70	77	60	71	82	82	82	68	72	82	82	82
4	67	70	77	67	78	64	69	78	70	78	69	71	78
5	76	79	86	59	63	65	66	67	76	76	76	76	77
6 (ER3)	65	68	75	56	63	66	66	68	66	67	69	69	70
7	76	79	86	64	67	59	65	68	76	77	76	76	77
8 (ER5)	69	72	79	71	72	61	72	73	73	74	70	74	74
9 (ER6)	66	69	76	71	67	60	72	68	72	70	67	73	70
10	64	67	74	63	62	70	71	71	67	66	71	72	72

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-2: Modelled Noise Level during Site Preparation-Grubbing and Removing Overburden

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Grubbing and removing overburden									
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB					Combined Noise Level L_{eq} (1 h), dB				
				1	2	3	1+3	2+3	1	2	3	1+3	2+3
1	64	67	74	64	58	68	69	68	67	65	69	70	69
2 (ER7)	69	72	79	71	61	66	73	67	73	70	71	74	71
3 (ER4)	67	70	77	57	67	90	90	90	67	70	90	90	90
4	67	70	77	64	75	60	66	76	69	76	68	70	77
5	76	79	86	55	59	62	63	64	76	76	76	76	76
6 (ER3)	65	68	75	52	59	61	62	63	65	66	66	67	67
7	76	79	86	61	64	56	62	64	76	76	76	76	76
8 (ER5)	69	72	79	68	69	58	68	69	72	72	69	72	72
9 (ER6)	66	69	76	68	63	57	68	64	70	68	67	70	68
10	64	67	74	60	59	67	68	68	65	65	69	69	69

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-3: Modelled Noise Level during Construction-Install Underground Site Services

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Install Underground Site Services					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	69	65	69	70	68	70
2 (ER7)	69	72	79	71	70	67	73	73	71
3 (ER4)	67	70	77	79	72	80	79	73	80
4	67	70	77	71	72	68	72	73	71
5	76	79	86	63	70	70	76	77	77
6 (ER3)	65	68	75	62	65	66	67	68	69
7	76	79	86	63	66	64	76	76	76
8 (ER5)	69	72	79	69	69	61	72	72	70
9 (ER6)	66	69	76	68	68	59	70	70	67
10	64	67	74	68	62	68	69	66	69

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-4: Modelled Noise Level during Construction-Final Preparation of Site

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Final preparation of site					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	70	66	70	71	68	71
2 (ER7)	69	72	79	71	69	68	73	72	72
3 (ER4)	67	70	77	85	74	85	85	75	85
4	67	70	77	75	76	68	76	77	71
5	76	79	86	66	72	72	76	77	77
6 (ER3)	65	68	75	64	67	68	68	69	70
7	76	79	86	65	67	65	76	77	76
8 (ER5)	69	72	79	70	70	63	73	73	70
9 (ER6)	66	69	76	68	67	61	70	70	67
10	64	67	74	69	65	69	70	68	70

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-5: Modelled Noise Level during Construction-Pour Foundation/Footings

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Pour foundation/footings					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	66	62	66	68	66	68
2 (ER7)	69	72	79	66	62	65	71	70	70
3 (ER4)	67	70	77	77	72	77	77	73	77
4	67	70	77	70	70	62	72	72	68
5	76	79	86	62	67	67	76	77	77
6 (ER3)	65	68	75	60	63	64	66	67	68
7	76	79	86	61	63	61	76	76	76
8 (ER5)	69	72	79	66	66	59	71	71	69
9 (ER6)	66	69	76	62	62	57	67	67	67
10	64	67	74	65	62	65	68	66	68

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-6: Modelled Noise Level during Construction-Install Walls

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Install walls					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	67	63	67	69	67	69
2 (ER7)	69	72	79	70	69	65	73	72	70
3 (ER4)	67	70	77	75	66	75	76	70	76
4	67	70	77	65	67	66	69	70	70
5	76	79	86	60	67	68	76	77	77
6 (ER3)	65	68	75	57	63	63	66	67	67
7	76	79	86	60	63	62	76	76	76
8 (ER5)	69	72	79	66	66	59	71	71	69
9 (ER6)	66	69	76	65	65	56	69	69	66
10	64	67	74	65	60	65	68	65	68

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-7: Modelled Noise Level during Construction-Install Roof

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Install roof					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	65	60	65	68	65	68
2 (ER7)	69	72	79	64	62	62	70	70	70
3 (ER4)	67	70	77	81	68	81	81	71	81
4	67	70	77	72	72	63	73	73	68
5	76	79	86	61	68	68	76	77	77
6 (ER3)	65	68	75	61	64	64	66	68	68
7	76	79	86	61	63	61	76	76	76
8 (ER5)	69	72	79	66	66	58	71	71	69
9 (ER6)	66	69	76	62	62	56	67	67	66
10	64	67	74	65	59	65	68	65	68

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-8: Modelled Noise Level during Construction-Pour the Floor

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Pour the floor					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	66	61	66	68	66	68
2 (ER7)	69	72	79	66	62	64	71	70	70
3 (ER4)	67	70	77	76	72	76	77	73	77
4	67	70	77	70	70	63	72	72	68
5	76	79	86	62	67	68	76	77	77
6 (ER3)	65	68	75	60	63	64	66	67	68
7	76	79	86	61	63	61	76	76	76
8 (ER5)	69	72	79	65	65	58	70	70	69
9 (ER6)	66	69	76	61	61	56	67	67	66
10	64	67	74	65	61	65	68	66	68

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-9: Modelled Noise Level during Construction-Install Torched on Roof

Receptor	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Install torched on roof					
		3 dB*	10 dB#	Modelled Noise Level L_{eq} (1 h), dB			Combined Noise Level L_{eq} (1 h), dB		
				1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
1	64	67	74	65	61	66	68	66	68
2 (ER7)	69	72	79	65	62	63	70	70	70
3 (ER4)	67	70	77	77	69	77	77	71	77
4	67	70	77	71	71	63	72	72	68
5	76	79	86	61	68	68	76	77	77
6 (ER3)	65	68	75	60	64	65	66	68	68
7	76	79	86	61	63	60	76	76	76
8 (ER5)	69	72	79	65	66	58	70	71	69
9 (ER6)	66	69	76	62	62	56	67	67	66
10	64	67	74	65	59	65	68	65	68

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-10: Modelled Noise Level during Operation and Maintenance - Scenarios OA, OB, OC[25,26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OA	OB	OC	OA	OB	OC
1	64	67	74	52	52	53	64	64	64
2 (ER7)	69	72	79	53	54	53	69	69	69
3 (ER4)[27]	67	70	77	62	62	62	68	68	68
4	67	70	77	55	53	54	67	67	67
5	76	79	86	50	49	51	76	76	76
6 (ER3)	65	68	75	48	47	48	65	65	65
7	76	79	86	46	46	46	76	76	76
8 (ER5)	69	72	79	51	51	50	69	69	69
9 (ER6)	66	69	76	48	50	48	66	66	66
10	64	67	74	51	51	52	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

[25] Modelled Noise levels are for the future WWMF operations only, and are independent of the noise impact from the existing WWMF. Applies to Tables D-10 – D-16.
[26] Refer to Table 5-22 for a description of the future operating scenarios OA through OT. Applies to Tables D-10 – D-16.
[27] 3 (ER4) is provided here for reference. However, this location is within the footprint of the future WWMF building (expansion location 4). Applies to Tables D-10 – D-16.

Table D-11: Modelled Noise Level during Operation and Maintenance - Scenarios OD, OE, OF[25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OD	OE	OF	OD	OE	OF
1	64	67	74	53	53	53	64	64	64
2 (ER7)	69	72	79	54	54	53	69	69	69
3 (ER4)[27]	67	70	77	62	62	63	68	68	68
4	67	70	77	53	53	53	67	67	67
5	76	79	86	50	50	50	76	76	76
6 (ER3)	65	68	75	48	48	48	65	65	65
7	76	79	86	46	46	46	76	76	76
8 (ER5)	69	72	79	50	50	50	69	69	69
9 (ER6)	66	69	76	49	49	48	66	66	66
10	64	67	74	52	52	52	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-12: Modelled Noise Level during Operation and Maintenance - Scenarios OG, OH, OI[25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OG	OH	OI	OG	OH	OI
1	64	67	74	53	53	53	64	64	64
2 (ER7)	69	72	79	52	52	52	69	69	69
3 (ER4)[27]	67	70	77	64	65	66	69	69	70
4	67	70	77	53	49	47	67	67	67
5	76	79	86	50	50	47	76	76	76
6 (ER3)	65	68	75	48	48	47	65	65	65
7	76	79	86	46	44	43	76	76	76
8 (ER5)	69	72	79	49	47	47	69	69	69
9 (ER6)	66	69	76	47	47	47	66	66	66
10	64	67	74	52	52	52	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-13: Modelled Noise Level during Operation and Maintenance - Scenarios OJ, OK, OL [25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OJ	OK	OL	OJ	OK	OL
1	64	67	74	53	50	50	64	64	64
2 (ER7)	69	72	79	51	52	53	69	69	69
3 (ER4)[27]	67	70	77	66	59	57	70	68	67
4	67	70	77	47	55	54	67	67	67
5	76	79	86	47	53	53	76	76	76
6 (ER3)	65	68	75	47	49	49	65	65	65
7	76	79	86	42	49	49	76	76	76
8 (ER5)	69	72	79	44	51	51	69	69	69
9 (ER6)	66	69	76	42	48	49	66	66	66
10	64	67	74	52	48	47	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-14: Modelled Noise Level during Operation and Maintenance - Scenarios OM, ON, OO[25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OM	ON	OO	OM	ON	OO
1	64	67	74	50	50	50	64	64	64
2 (ER7)	69	72	79	52	52	51	69	69	69
3 (ER4)[27]	67	70	77	59	57	58	68	67	68
4	67	70	77	54	54	55	67	67	67
5	76	79	86	54	54	55	76	76	76
6 (ER3)	65	68	75	50	50	50	65	65	65
7	76	79	86	49	49	49	76	76	76
8 (ER5)	69	72	79	50	50	49	69	69	69
9 (ER6)	66	69	76	48	49	47	66	66	66
10	64	67	74	48	47	48	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-15: Modelled Noise Level during Operation and Maintenance - Scenarios OP, OQ, OR[25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)			Combined Noise Levels L_{eq} (1 h) (dB)		
		3 dB*	10 dB#	OP	OQ	OR	OP	OQ	OR
1	64	67	74	50	50	50	64	64	64
2 (ER7)	69	72	79	52	51	50	69	69	69
3 (ER4)[27]	67	70	77	57	57	57	67	67	67
4	67	70	77	55	55	52	67	67	67
5	76	79	86	54	55	55	76	76	76
6 (ER3)	65	68	75	50	50	51	65	65	65
7	76	79	86	49	49	49	76	76	76
8 (ER5)	69	72	79	50	49	47	69	69	69
9 (ER6)	66	69	76	48	47	46	66	66	66
10	64	67	74	47	47	47	64	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

Table D-16: Modelled Noise Level during Operation and Maintenance - Scenarios OS, OT [25, 26]

Receptor ID	2015 Terrestrial Baseline Noise L_{eq} (1 h), dB	Criteria – dB Increase above Baseline		Modelled Noise Levels L_{eq} (1 h) (dB)		Combined Noise Levels L_{eq} (1 h) (dB)	
		3 dB*	10 dB#	OS	OT	OS	OT
1	64	67	74	48	48	64	64
2 (ER7)	69	72	79	49	44	69	69
3 (ER4)[27]	67	70	77	54	54	67	67
4	67	70	77	52	52	67	67
5	76	79	86	55	55	76	76
6 (ER3)	65	68	75	50	51	65	65
7	76	79	86	49	49	76	76
8 (ER5)	69	72	79	47	44	69	69
9 (ER6)	66	69	76	46	41	66	66
10	64	67	74	45	45	64	64

*Criteria for mammals and amphibians.
#Criteria for birds.

D.2 TERRESTRIAL NOISE IMPACT SCREENING RESULTS

Table D-17: Modelled Changes to Noise Levels (in L_{eq} (1 h)) at Ecological Receptor Locations during Site Preparation and Construction

Receptor Location	2015 Baseline Noise Levels (dB)	Modelled WWMF Noise Levels (dB)	Combined Modelled Noise Levels (dB)	Modelled Change to Noise Levels (dB)	Exceeding the screening criteria for mammalian and amphibian receptors?	Exceeding the screening criteria for avian receptors?
Site Preparation (Clearing the Site)						
1	64	72	73	+9	Yes	No
2 (ER7)	69	71	73	+4	Yes	No
3 (ER4)	67	82	82	+15	Yes	Yes
4	67	78	78	+11	Yes	Yes
5	76	67	77	1	No	No
6 (ER3)	65	68	70	+5	Yes	No
7	76	68	77	1	No	No
8 (ER5)	69	73	74	+5	Yes	No
9 (ER6)	66	68	70	+4	Yes	No
10	64	71	72	+8	Yes	No
Site Preparation (Grubbing and Removing Overburden)						
1	64	68	69	+5	Yes	No
2 (ER7)	69	67	71	+2	No	No
3 (ER4)	67	90	90	+23	Yes	Yes
4	67	76	77	+10	Yes	Yes
5	76	64	76	0	No	No
6 (ER3)	65	63	67	+2	Yes	No
7	76	64	76	0	No	No
8 (ER5)	69	69	72	+3	Yes	No
9 (ER6)	66	64	68	+2	No	No
10	64	68	69	+5	Yes	No
Construction (Install Underground Site Services)						
1	64	69	70	+4	Yes	No
2 (ER7)	69	71	73	+4	Yes	No
3 (ER4)	67	79	79	+12	Yes	Yes
4	67	71	72	+5	Yes	No
5	76	63	76	+0	No	No
6 (ER3)	65	62	67	+2	No	No
7	76	63	76	+0	No	No
8 (ER5)	69	69	72	+3	Yes	No

Receptor Location	2015 Baseline Noise Levels (dB)	Modelled WWMF Noise Levels (dB)	Combined Modelled Noise Levels (dB)	Modelled Change to Noise Levels (dB)	Exceeding the screening criteria for mammalian and amphibian receptors?	Exceeding the screening criteria for avian receptors?
9 (ER6)	66	68	70	+4	Yes	No
10	64	68	69	+5	Yes	No
Construction (Final Preparation of Site)						
1	64	70	71	+7	Yes	No
2 (ER7)	69	71	73	+4	Yes	No
3 (ER4)	67	85	85	+18	Yes	Yes
4	67	75	76	+9	Yes	No
5	76	66	76	0	No	No
6 (ER3)	65	64	68	+3	Yes	No
7	76	65	76	0	No	No
8 (ER5)	69	70	73	+4	Yes	No
9 (ER6)	66	68	70	+4	Yes	No
10	64	69	70	+6	Yes	No
Construction (Pour Foundation/Footings)						
1	64	66	68	+4	Yes	No
2 (ER7)	69	66	71	+2	No	No
3 (ER4)	67	77	77	+10	Yes	Yes
4	67	70	72	+5	Yes	No
5	76	62	76	0	No	No
6 (ER3)	65	60	66	+1	No	No
7	76	61	76	0	No	No
8 (ER5)	69	66	71	+2	No	No
9 (ER6)	66	62	67	+1	No	No
10	64	65	68	+4	Yes	No
Construction (Install Walls)						
1	64	67	69	+5	Yes	No
2 (ER7)	69	70	73	+4	Yes	No
3 (ER4)	67	75	76	+9	Yes	No
4	67	65	69	+2	No	No
5	76	60	76	0	No	No
6 (ER3)	65	57	66	+1	No	No
7	76	60	76	0	No	No
8 (ER5)	69	66	71	+2	No	No
9 (ER6)	66	65	69	+3	Yes	No
10	64	65	68	+4	Yes	No

Receptor Location	2015 Baseline Noise Levels (dB)	Modelled WWMF Noise Levels (dB)	Combined Modelled Noise Levels (dB)	Modelled Change to Noise Levels (dB)	Exceeding the screening criteria for mammalian and amphibian receptors?	Exceeding the screening criteria for avian receptors?
Construction (Install Roof)						
1	64	65	68	+4	Yes	No
2 (ER7)	69	64	70	+1	No	No
3 (ER4)	67	81	81	+14	Yes	Yes
4	67	72	73	+6	Yes	No
5	76	61	76	0	No	No
6 (ER3)	65	61	66	+1	No	No
7	76	61	76	0	No	No
8 (ER5)	69	66	71	+2	No	No
9 (ER6)	66	62	67	+1	No	No
10	64	65	68	+4	Yes	No
Construction (Pour Floor)						
1	64	66	68	+4	Yes	No
2 (ER7)	69	66	71	+2	No	No
3 (ER4)	67	76	77	+10	Yes	Yes
4	67	70	72	+5	Yes	No
5	76	62	76	0	No	No
6 (ER3)	65	60	66	+1	No	No
7	76	61	76	0	No	No
8 (ER5)	69	65	70	+1	No	No
9 (ER6)	66	61	67	+1	No	No
10	64	65	68	+4	Yes	No
Construction (Install Torched on Roof)						
1	64	65	68	+4	Yes	No
2 (ER7)	69	65	70	+1	No	No
3 (ER4)	67	77	77	+10	Yes	Yes
4	67	71	72	+5	Yes	No
5	76	61	76	0	No	No
6 (ER3)	65	60	66	+1	No	No
7	76	61	76	0	No	No
8 (ER5)	69	65	70	+1	No	No
9 (ER6)	66	62	67	+1	No	No
10	64	65	68	+4	Yes	No

Appendix E: Water Quantity Calculations

See the following pages for the water quantity calculations.

Water Balance Worksheet - Average Annual Precipitation

$Q_{total} = Q_{undeveloped} + Q_{developed}$ — Q_{total} = Annual runoff from watershed

$Q_{undeveloped} = P \times C_{undeveloped} \times (A_{exist} - A_{dev\_in\ WS})$ — $Q_{undeveloped}$ = Annual runoff from undeveloped portion of watershed

$Q_{developed} = P \times C_{developed} \times A_{totaldev}$ — $Q_{developed}$ = Annual runoff from developed portion of watershed

P = Annual precipitation

$C_{undeveloped}$ = Runoff coefficient for undeveloped ground

A_{exist} = Existing watershed area

$A_{dev\_in\ WS}$ = Areas of potential expansion within existing watershed area

C_{dev} = Runoff coefficient for developed area

$A_{totaldev}$ = Total area of proposed development in watershed

Precipitation and Runoff Coefficient Input

P =	1047.9	mm/year	Average Year
$C_{undeveloped}$ =	0.47		
C_{dev} =	0.64		

Existing Conditions

$A_{exist\ SRD}$ =	40.88	ha
$A_{exist\ WD}$ =	103.54	ha
$A_{dev\_in\ SRD}$ =	0.00	ha
$A_{dev\_in\ WD}$ =	0.00	ha
$A_{totaldev\ SRD}$ =	0.00	ha
$A_{totaldev\ WD}$ =	0.00	ha

Areas of Potential Expansion

Potential Expansion Area	Total Area (ha)	Area in SRD Watershed (ha)	Area in WD Watershed (ha)	Area in Central Pond Watershed (ha)
1	0.93	0.93	-	-
2	1.30	1.30	-	-
3	4.70	-	3.69	1.01
4	5.42	-	5.42	-
TOTAL	12.36	2.23	9.11	1.01

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0064 m^3/s	6.4 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0064 m^3/s	6.4 L/s

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0162 m^3/s	16.2 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0162 m^3/s	16.2 L/s

Case 1: Flow from Potential Expansion Areas 1-4 directed to SRD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	12.36	ha	All runoff to SRD
$A_{totaldev\ WD}$ =	0.00	ha	

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0060 m^3/s	6.0 L/s
$Q_{developed\ SRD}$ =	0.0026 m^3/s	2.6 L/s
$Q_{total\ SRD}$ =	0.0087 m^3/s	8.7 L/s
$\Delta Q_{total\ SRD}$ from existing =	35.4%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0148 m^3/s	14.8 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0148 m^3/s	14.8 L/s
$\Delta Q_{total\ WD}$ from existing =	-8.8%	

Case 2: Flow from Potential Expansion Areas 1-4 directed to WD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	0.00	ha	
$A_{totaldev\ WD}$ =	12.36	ha	All runoff to WD

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0060 m^3/s	6.0 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0060 m^3/s	6.0 L/s
$\Delta Q_{total\ SRD}$ from existing =	-5.5%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0148 m^3/s	14.8 L/s
$Q_{developed\ WD}$ =	0.0026 m^3/s	2.6 L/s
$Q_{total\ WD}$ =	0.0174 m^3/s	17.4 L/s
$\Delta Q_{total\ WD}$ from existing =	7.3%	

Water Balance Worksheet - 1:20 Year Wet Annual Precipitation

$Q_{total} = Q_{undeveloped} + Q_{developed}$

$Q_{undeveloped} = P \times C_{undeveloped} \times (A_{exist} - A_{dev\_in\ WS})$

$Q_{developed} = P \times C_{developed} \times A_{totaldev}$

Q_{total} = Annual runoff from watershed

$Q_{undeveloped}$ = Annual runoff from undeveloped portion of watershed

$Q_{developed}$ = Annual runoff from developed portion of watershed

P = Annual precipitation

$C_{undeveloped}$ = Runoff coefficient for undeveloped ground

A_{exist} = Existing watershed area

$A_{dev\_in\ WS}$ = Areas of potential expansion within existing watershed area

C_{dev} = Runoff coefficient for developed area

$A_{totaldev}$ = Total area of proposed development in watershed

Precipitation and Runoff Coefficient Input

P =	1261.3	mm/year	1:20 Year Wet Precipitation
$C_{undeveloped}$ =	0.55		
C_{dev} =	0.74		

Existing Conditions

$A_{exist\ SRD}$ =	40.88	ha
$A_{exist\ WD}$ =	103.54	ha
$A_{dev\_in\ SRD}$ =	0.00	ha
$A_{dev\_in\ WD}$ =	0.00	ha
$A_{totaldev\ SRD}$ =	0.00	ha
$A_{totaldev\ WD}$ =	0.00	ha

Areas of Potential Expansion

Potential Expansion Area	Total Area (ha)	Area in SRD Watershed (ha)	Area in WD Watershed (ha)	Area in Central Pond Watershed (ha)
1	0.93	0.93	-	-
2	1.30	1.30	-	-
3	4.70	-	3.69	1.01
4	5.42	-	5.42	-
TOTAL	12.36	2.23	9.11	1.01

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0089 m^3/s	8.9 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0089 m^3/s	8.9 L/s

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0226 m^3/s	22.6 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0226 m^3/s	22.6 L/s

Case 1: Flow from Potential Expansion Areas 1-4 directed to SRD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	12.36	ha	All runoff to SRD
$A_{totaldev\ WD}$ =	0.00	ha	

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0084 m^3/s	8.4 L/s
$Q_{developed\ SRD}$ =	0.0036 m^3/s	3.6 L/s
$Q_{total\ SRD}$ =	0.0121 m^3/s	12.1 L/s
$\Delta Q_{total\ SRD}$ from existing =	35.4%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0206 m^3/s	20.6 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0206 m^3/s	20.6 L/s
$\Delta Q_{total\ WD}$ from existing =	-8.8%	

Case 2: Flow from Potential Expansion Areas 1-4 directed to WD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	0.00	ha	
$A_{totaldev\ WD}$ =	12.36	ha	All runoff to WD

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0084 m^3/s	8.4 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0084 m^3/s	8.4 L/s
$\Delta Q_{total\ SRD}$ from existing =	-5.5%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0206 m^3/s	20.6 L/s
$Q_{developed\ WD}$ =	0.0036 m^3/s	3.6 L/s
$Q_{total\ WD}$ =	0.0243 m^3/s	24.3 L/s
$\Delta Q_{total\ WD}$ from existing =	7.3%	

Water Balance Worksheet - 1:20 Year Dry Annual Precipitation

$Q_{total} = Q_{undeveloped} + Q_{developed}$

$Q_{undeveloped} = P \times C_{undeveloped} \times (A_{exist} - A_{dev\_in\ WS})$

$Q_{developed} = P \times C_{developed} \times A_{totaldev}$

Q_{total} = Annual runoff from watershed

$Q_{undeveloped}$ = Annual runoff from undeveloped portion of watershed

$Q_{developed}$ = Annual runoff from developed portion of watershed

P = Annual precipitation

$C_{undeveloped}$ = Runoff coefficient for undeveloped ground

A_{exist} = Existing watershed area

$A_{dev\_in\ WS}$ = Areas of potential expansion within existing watershed area

C_{dev} = Runoff coefficient for developed area

$A_{totaldev}$ = Total area of proposed development in watershed

Precipitation and Runoff Coefficient Input

P =	786.5	mm/year	1:20 Year Dry Precipitation
$C_{undeveloped}$ =	0.45		
C_{dev} =	0.61		

Existing Conditions

$A_{exist\ SRD}$ =	40.88	ha
$A_{exist\ WD}$ =	103.54	ha
$A_{dev\_in\ SRD}$ =	0.00	ha
$A_{dev\_in\ WD}$ =	0.00	ha
$A_{totaldev\ SRD}$ =	0.00	ha
$A_{totaldev\ WD}$ =	0.00	ha

Areas of Potential Expansion

Potential Expansion Area	Total Area (ha)	Area in SRD Watershed (ha)	Area in WD Watershed (ha)	Area in Central Pond Watershed (ha)
1	0.93	0.93	-	-
2	1.30	1.30	-	-
3	4.70	-	3.69	1.01
4	5.42	-	5.42	-
TOTAL	12.36	2.23	9.11	1.01

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0046 m^3/s	4.6 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0046 m^3/s	4.6 L/s

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0116 m^3/s	11.6 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0116 m^3/s	11.6 L/s

Case 1: Flow from Potential Expansion Areas 1-4 directed to SRD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	12.36	ha	All runoff to SRD
$A_{totaldev\ WD}$ =	0.00	ha	

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0043 m^3/s	4.3 L/s
$Q_{developed\ SRD}$ =	0.0019 m^3/s	1.9 L/s
$Q_{total\ SRD}$ =	0.0062 m^3/s	6.2 L/s
$\Delta Q_{total\ SRD}$ from existing =	35.4%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0106 m^3/s	10.6 L/s
$Q_{developed\ WD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ WD}$ =	0.0106 m^3/s	10.6 L/s
$\Delta Q_{total\ WD}$ from existing =	-8.8%	

Case 2: Flow from Potential Expansion Areas 1-4 directed to WD

$A_{exist\ SRD}$ =	40.88	ha	
$A_{exist\ WD}$ =	103.54	ha	
$A_{dev\_in\ SRD}$ =	2.23	ha	Areas 1 & 2
$A_{dev\_in\ WD}$ =	9.11	ha	Areas 4 & Part of 3
$A_{totaldev\ SRD}$ =	0.00	ha	
$A_{totaldev\ WD}$ =	12.36	ha	All runoff to WD

South Railway Ditch Runoff

$Q_{undeveloped\ SRD}$ =	0.0043 m^3/s	4.3 L/s
$Q_{developed\ SRD}$ =	0.0000 m^3/s	0.0 L/s
$Q_{total\ SRD}$ =	0.0043 m^3/s	4.3 L/s
$\Delta Q_{total\ SRD}$ from existing =	-5.5%	

West Ditch Runoff

$Q_{undeveloped\ WD}$ =	0.0106 m^3/s	10.6 L/s
$Q_{developed\ WD}$ =	0.0019 m^3/s	1.9 L/s
$Q_{total\ WD}$ =	0.0125 m^3/s	12.5 L/s
$\Delta Q_{total\ WD}$ from existing =	7.3%	

Annual Precipitation Used in Water Balance

Average Annual Precipitation	1047.9	mm	(Climate Normals for Wiarton Airport, 1981-2010)
Wet and Dry Year Precipitation Calculations			
Mean Annual Precipitation	1002.3	mm	(Wiarton Airport data 1943-2013)
SD of Annual Precipitation	138.8	mm	(Wiarton Airport data 1943-2013)
Mean Ln Annual Precipitation	6.90		(Wiarton Airport data 1943-2013)
SD of Mean Ln Annual Precipitation	0.14		(Wiarton Airport data 1943-2013)
Return Period	20	Year	
1:20 Wet Year Precipitation	1261.3	mm	
1:20 Dry Year Precipitation	786.5	mm	

Notes:
Ln - natural logarithm

SD - standard deviation

Wet year precipitation calculated using Gumbel double exponential distribution for annual extremes (method of moments)

Dry year precipitation calculated using 3 parameter log normal distribution

Annual Runoff Coefficients Used In Water Balance

Precipitation Year	Natural	Developed
Average	0.47	0.64
20 Year Wet	0.55	0.74
20 Year Dry	0.45	0.61

Notes:

Natural Runoff Coefficients derived from streamflow data

Developed Runoff Coefficient for Average Precipitation Year from PC_SWMM for Stormceptor 70% of area impervious, using Owen Sound MOE rainfall data (1964-2003)

Developed Runoff coefficient is 35% larger than natural runoff coefficient for wet and dry years

Natural Ground Runoff Coefficient Worksheet

Average Monthly Flows Used to Determine Natural Ground Runoff Coefficient

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)	156		670		262		3954	
Data Duration	1974-2013		1972-2013		1972-1986		1914-2013	
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	$m^3/s/km^2$
January	2.54	0.016	14.15	0.021	3.8	0.014	61.0	0.015
February	3.20	0.021	13.28	0.020	4.5	0.017	60.7	0.015
March	6.77	0.043	27.97	0.042	8.8	0.034	129.5	0.033
April	3.23	0.021	24.97	0.037	9.7	0.037	144.6	0.037
May	1.02	0.007	9.42	0.014	5.5	0.021	61.0	0.015
June	0.75	0.005	5.28	0.008	3.5	0.013	34.1	0.009
July	0.24	0.002	3.03	0.005	2.5	0.009	24.2	0.006
August	0.21	0.001	2.53	0.004	2.2	0.009	17.7	0.004
September	0.94	0.006	3.44	0.005	2.6	0.010	20.5	0.005
October	1.27	0.008	5.64	0.008	2.9	0.011	32.0	0.008
November	2.57	0.016	10.74	0.016	3.9	0.015	51.6	0.013
December	3.26	0.021	13.24	0.020	4.5	0.017	60.4	0.015
Annual	2.17	0.014	11.14	0.017	4.53	0.017	58.11	0.015

Note:
Data obtained from Water Survey of Canada.

Average Annual Runoff Coefficient Calculation

Average streamflow = 0.01563 $m^3/s/km^2$
Average annual precipitation = 1047.9 mm
Runoff coefficient = 0.47

Wet Year Annual Runoff Coefficient Calculation

Wet Year 2008

Gauge No.	02FD001		02FC015		02FC013		02FC001	
	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	$m^3/s/km^2$
Annual Flow	3.67	0.024	16.34	0.024	-	-	102.68	0.026

Average streamflow = 0.02463 $m^3/s/km^2$
2008 annual precipitation = 1270.2 mm
Runoff coefficient = 0.61

Wet Year 2011

Gauge No.	02FD001		02FC015		02FC013		02FC001	
	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	$m^3/s/km^2$
Annual	-	-	13.45	0.020	-	-	74.78	0.019

Average streamflow = 0.01950 $m^3/s/km^2$
2011 annual precipitation = 1281.9 mm
Runoff coefficient = 0.48

Avg Wet Yr Runoff coefficient = 0.55

Dry Year Annual Runoff Coefficient Calculation

Dry Year 1948

Gauge No.	02FD001		02FC015		02FC013		02FC001	
	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	$m^3/s/km^2$
Annual	-	-	-	-	-	-	46.88	0.012

Average streamflow = 0.01186 $m^3/s/km^2$
Average annual precipitation = 806.4 mm
Runoff coefficient = 0.46

Dry Year 1964

Gauge No.	02FD001		02FC015		02FC013		02FC001	
	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	$m^3/s/km^2$
Annual	-	-	-	-	-	-	36.65	0.009

Average streamflow = 0.00927 $m^3/s/km^2$
1964 annual precipitation = 670.3 mm
Runoff coefficient = 0.44

Avg Dry Yr Runoff coefficient = 0.45

Appendix F: Water Quality Calculations

Table F-1: Sample Calculation for Copper

Copper Concentration in South Railway Ditch - Case 1					
1. Input Data					
Un-developed area concentration (mg/L)	c1= 0.002	Developed area concentration (mg/L)	c2= 0.027	Stormwater Removal rate	65%
2. Basic Calculation					
	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass	
	L/s	m^3/year	mg/L	kg/year	
Un-developed Site Area	6.04	v1= 190,536	c1= 0.002	m1= 0.38	
Developed Site Area	2.61	v2= 82,357	c2= 0.027	m2= 0.78	
Total Site Area	8.65	v total= 272,893	c total= 0.004	m total= 1.16	

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2

v total = v1 + v2

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff = v2 x c2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff

re = removal efficiency

3.3 Solution

Find m1 and m2		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 0.002 * (1/1,000) =	0.38	kg/year
m2 = v2 x c2 x (1-re)	=	82,357 * 0.027 * (1/1,000) * (1-.65) =	0.78	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2	=	0.38 + 0.78 =	1.16	kg/year
find v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(1.16)/(272,893) *1,000 =	0.004	mg/L

Table F-2: Sample Calculation for Zinc

Zinc Concentration in South Railway Ditch - Case 1					
1. Input Data					
Un-developed area concentration (mg/L)	c1= 0.10333	Developed area concentration (mg/L)	c2= 0.22	Stormwater Removal rate	72%
2. Basic Calculation					
	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass	
	L/s	m^3/year	mg/L	kg/year	
Un-developed Site Area	6.04	v1= 190,536	c1= 0.10333	m1= 19.69	
Developed Site Area	2.61	v2= 82,357	c2= 0.22	m2= 5.07	
Total Site Area	8.65	v total= 272,893	c total= 0.091	m total= 24.76	

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2

v total = v1 + v2

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff = v2 x c2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff

re = removal efficiency

3.3 Solution

Find m1 and m2		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 0.103 * (1/1,000) =	19.69	kg/year
m2 = v2 x c2 x (1-re)	=	82,357 * 0.220 * (1/1,000) * (1-.72) =	5.07	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2	=	19.69 + 5.07 =	24.76	kg/year
find v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(24.76)/(272,893) *1,000 =	0.091	mg/L

Table F-3: Sample Calculation for Total Phosphorus

Total Phosphorus Concentration in South Railway Ditch - Case 1					
1. Input Data					
Un-developed area concentration (mg/L)	c1= 0.0263	Developed area concentration (mg/L)	c2= 0.3	Stormwater Removal rate	65%
2. Basic Calculation					
	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass	
	L/s	m^3/year	mg/L	kg/year	
Un-developed Site Area	6.04	v1= 190,536	c1= 0.0263	m1= 5.01	
Developed Site Area	2.61	v2= 82,357	c2= 0.3	m2= 8.65	
Total Site Area	8.65	v total= 272,893	c total= 0.050	m total= 13.66	

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2

v total = v1 + v2

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff = v2 x c2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff

re = removal efficiency

3.3 Solution

Find m1 and m2		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 0.026 * (1/1,000) =	5.01	kg/year
m2 = v2 x c2 x (1-re)	=	82,357 * 0.300 * (1/1,000) * (1-.65) =	8.65	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2	=	5.01 + 8.65 =	13.66	kg/year
find v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(13.66)/(272,893) *1,000 =	0.05	mg/L

Table F-4: Sample Calculation for Temperature

Mixed Temperature of South Railway Ditch - Case 1

1. Input Data

Un-developed area runoff temperature (°C)	t1= 8.5	Developed area runoff temperature (°C)	t2= 13.6	Stormwater removal rate (heat loss)	0%

2. Basic Calculation

	Avg. Annual Flow	Avg. Annual Flow	Temperature	Energy (relative to 0°C)
	L/s	m^3/year	°C	cal/year
Un-developed Site Area	6.04	v1= 190,536	t1= 8.5	e1=1.62E+12
Developed Site Area	2.61	v2= 82,357	t2= 13.6	e2=1.12E+12
Total Site Area	8.65	v total= 272,893	t total= 10.04	e total=2.74E+12

3. Expanded Calculation

3.1 Mass-Balance Equation

t total = mixed temperature = e total (sum of energy) / v total (sum of runoff volume)

3.2 Definition of Variables

e total = e1 + e2

v total = v1 + v2

e1 = energy of water quality parameter in un-developed site runoff = v1 x t1

e2 = energy of water quality parameter in developed site runoff = v2 x t2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

t1 = temperature of un-developed site runoff

t2 = temperature of developed site runoff

re = removal efficiency

3.3 Solution

Find e1 and e2		*Units: 1 m^3/year x 10^6g/m^3 * 1 °C = 10^6 cal*		
		Since 1 m^3/year x 1 °C mg/L= 10^6 cal, multiply product by 10^6 to get cal		
e1 = v1 x t1	=	190,536 * 8.500 * (1,000,000) =	1.62E+12	cal/year
e2 = v2 x t2 x (1-re)	=	82,357 * 13.600 * (1,000.000) * (1-.00) =	1.12E+12	cal/year
find t total		*Units: cal/year*		
t total = t1 + t2	=	1.62E+12 + 1.12E+12 =	2.74E+12	cal/year
find v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find mixed temperature		*Units: 1 (cal/year)/(m^3/year) x (1 m^3/10^6g) = 1 cal/g = 10^{-6} °C*		
		Since 1 cal/year/(m^3/year) = 10^{-6} °C, divide product by 10^6 to get °C		
Mixed temperature	=	(02.74E+12)/(272,893) / 1,000,000 = 10.04 °C		

Table F-5: Sample Calculation for Chloride

Chloride Concentration in South Railway Ditch - Case 1

1. Input Data

Un-developed area concentration (mg/L)	c1= 460	Developed area concentration (mg/L)	c2= 631	Stormwater Removal rate	0%

2. Basic Calculation

	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass
	L/s	m^3/year	mg/L	kg/year
Un-developed Site Area	6.04	v1= 190,536	c1= 460	m1= 87,647
Developed - Buildings	1.59	v2= 50,238	c2= 0.0	m2= 0
Developed - Roads & Paved	1.02	v3= 32,119	c3= 631	m3= 20,273
total Site Area	8.65	v total= 272,893	c total= 395	m total= 107,919

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2 + m3

v total = v1 + v2 + v3

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff (Buildings) = v2 x c2

m3 = mass of water quality parameter in developed site runoff (Roads and Paved) = v3 x c3 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff (Buildings)

v3 = volume of developed site runoff (Roads and Paved)

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff (Buildings)

c3 = concentration of water quality parameter in developed site runoff (Roads and Paved)

re = removal efficiency

3.3 Solution

Find m1, m2 and m3		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 460.000 * (1/1,000) =	87,647	kg/year
m2 = v2 x c2	=	50,238 * 0.0 =	0	kg/year
m3 = v3 x c3 x (1-re)	=	32,119 * 631.172 * (1/1,000) * (1-.00) =	20,273	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2 + m3	=	87,647 + 0.0 + 20,273 =	107,919	kg/year
find v total		*Units: m^3/year*		
v total = v1 + v2 + v3	=	190,536 + 50,238 + 32,119 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(107,919)/(272,893) * 1,000 =	395	mg/L

Table F-6: Sample Calculation for TSS (Site Clearing and Construction)

TSS Concentration (Site Clearing and Construction) in South Railway Ditch - Case 1

1. Input Data

Un-developed area concentration (mg/L)	c1= 13.5	Developed area concentration (mg/L)	c2= 1311	Stormwater Removal rate	80%

2. Basic Calculation

	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass
	L/s	m^3/year	mg/L	kg/year
Un-developed Site Area	6.04	v1= 190,536	c1= 13.5	m1= 2,581
Developed Site Area	2.61	v2= 82,357	c2= 1311	m2= 21,596
Total Site Area	8.65	v total= 272,893	c total= 88.6	m total= 24,178

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2

v total = v1 + v2

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff = v2 x c2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff

re = removal efficiency

3.3 Solution

Find m1 and m2		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 13.548 * (1/1,000) =	2,581	kg/year
m2 = v2 x c2 x (1-re)	=	82,357 * 1311 * (1/1,000) * (1-.80) =	21,596	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2	=	2,581 + 21,596 =	24,178	kg/year
find v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(24,178)/(272,893) * 1,000 =	88.6	mg/L

Table F-7: Sample Calculation for TSS (Operation and Maintenance)

TSS Concentration (Operation and Maintenance) in South Railway Ditch - Case 1

1. Input Data

Un-developed area concentration (mg/L)	c1= 13.55	Developed area concentration (mg/L)	c2= 67	Stormwater Removal rate	80%

2. Basic Calculation

	Avg. Annual Flow	Avg. Annual Flow	Conc.	Mass
	L/s	m^3/year	mg/L	kg/year
Un-developed Site Area	6.04	v1= 190,536	c1= 13.55	m1= 2,581
Developed Site Area	2.61	v2= 82,357	c2= 67	m2= 1,104
total Site Area	8.65	v total= 272,893	c total= 13.50	m total= 3,685

3. Expanded Calculation

3.1 Mass-Balance Equation

c total = resultant concentration = m total (sum of mass of water quality parameter) / v total (sum of runoff volume)

3.2 Definition of Variables

m total = m1 + m2

v total = v1 + v2

m1 = mass of water quality parameter in un-developed site runoff = v1 x c1

m2 = mass of water quality parameter in developed site runoff = v2 x c2 x (1-re)

v1 = volume of un-developed site runoff

v2 = volume of developed site runoff

c1 = concentration of water quality parameter in un-developed site runoff

c2 = concentration of water quality parameter in developed site runoff

re = removal efficiency

3.3 Solution

Find m1 and m2		*Units: 1 m^3/year x 1000 L/m^3 x 1 mg/L x 1x 10^{-6}kg/mg= 0.001 kg/year= 1 g/year*		
		Since 1 m^3/year x 1 mg/L= 1 g/year, divide product by 1000 to get kg/year		
m1 = v1 x c1	=	190,536 * 13.548 * (1/1,000) =	2,581	kg/year
m2 = v2 x c2 x (1-re)	=	82,357 * 67 * (1/1,000) * (1-.80) =	1,104	kg/year
find m total		*Units: kg/year*		
m total = m1 + m2	=	2,581 + 1,104 =	3,685	kg/year
ind v total		*Units: m^3/year*		
v total = v1 + v2	=	190,536 + 82,357 =	272,893	m3/year
Find Resultant concentration		*Units: 1 kg/year/(m^3/year) x 1x10^6mg/kg x 1 m^3/1000 L = 1,000 mg/L= 1g/L*		
		Since 1 kg/year/(m^3/year) = 1 g/L, multiply product by 1,000 to get mg/L		
Resultant concentration	=	(3,685)/(272,893) *1,000 =	13.5	mg/L

Table F-8: Calculation of Additional Chloride Concentration from Road Salting

1. Input Data

Paved areas and shared access roads boarding the OPG-retained lands (ha)	Developed Site Area - South Railway Ditch - Case 1	Truck Hopper Capacity (lb)	Truck loads per year	Chloride fraction in salt	Avg. Annual Precip. (mm/y)	Developed runoff coefficient
14.55	4.82	2,000	30	0.61	1047.9	0.64

2. Calculation of Runoff and Chloride Concentration from Road Salting

	Avg. Annual Runoff	Source	Conc.	Conc. Formula	Mass	Mass Formula / Source
	m^3/y		mg/L		kg/y	
Site Area Subject to Road Salt Application	96,971	1,047.9 mm/y x 1E-3 m/mm x .64 x 14.55 ha x (1E4m2/ha) = m^3/y	171	(16,599 kg/y) / (96,971 m3/y) x 1 (m3/1,000 L) x 1E+06 mg/kg = mg/L	16,599	2,000 lb/load x 1 kg/2.205 lb x 30 loads/y x .61 Cl fraction in salt
South Railway Ditch - Case 1	32,119	1,047.9 mm/y x 1E-3 m/mm x .64 x 4.82 ha x (1E4m2/ha) = m^3/y	171	(5,498 kg/y) / (32,119 m3/y) x 1 (m3/1,000 L) x 1E+06 mg/kg = mg/L	5,498	16,599 kg x 4.82 ha / 14.55 ha

Table F-9: Example Soil Loss Tool Calculation

City or Weather Station:	**Owen Sound**
R Factor:	**90**
Mean Annual Sediment Yield (t/ha)	**0.1**
Mean Annual Runoff (mm)	**375**
Mean Annual Receiving Water TSS Concentration (mg/L)	**26.7**

51 ha ENTIRE SITE AREA PRE-DEVELOPMENT

ID	Land Disturbing Activities	Area (ha)	Percent of Total Area (%)	Average Slope (%)	Slope Length (m)	NN	LS Factor	Soil Texture Class:	OM Content	K factor (t/ha):	Bare Soil Loss (t/ha)	Bare Soil Erosion Risk	Erosion Control BMP Efficiency	Sediment Control BMP Efficiency	Soil Loss with BMP (t/ha)	BMP Reduction Efficiency (%)	Mean Annual TSS Concentration (mg/L)			Area Weighted Mean Annual TSS Concentration (mg/L)	Overall Mean Annual TSS Concentration (mg/L)
1	**Pre-Development Naturally Vegetated**	5.797065	11	2	200	0.3	0.35	**Silt Loam**	Average OMC	0.85	**27.0**	**High**	0.99	0	**0.3**	**99%**	**72**	**0.03**	**11%**	**8**	**13.5**
2	**Pre-Development Naturally Vegetated**	32.850035	64	2	200	0.3	0.35	**Sand**	Average OMC	0.04	**1.3**	**Very Low**	0.99	0	**0.0**	**99%**	**3**	**0.01**	**64%**	**2**	
3	**Under Development Exposed Soil**	1.853595	4	4	20	0.4	0.34	**Silt Loam**	Average OMC	0.85	**25.9**	**High**	0.99	0	**0.3**	**99%**	**69**	**0.01**	**4%**	**3**	
4	**Under Development Exposed Soil**	10.503705	21	4	20	0.4	0.34	**Sand**	Average OMC	0.04	**1.2**	**Very Low**	0.99	0	**0.0**	**99%**	**3**	**0.00**	**20%**	**1**	
NOTES	Site Areas being Assessed	Total site area = developed area 12.357 ha + 38.647 undeveloped = 51.00 ha	assumed from soils data	assumption	assumption	function of average slope	Function of Average Slope (%), Slope Length (m), NN	Based on soils data - 15% silt till , 85% sand & gravel	Optimum Moisture Content	function of OM Content	function of R, LS and K	function of Bare Soil Loss	Natural ground is vegetated giving 99% reduction in soil loss	No Sediment Control specified	Bare Soil Loss reduced by Erosion Control and Sediment Control (no reduction in this example)	99% reduction for undisturbed ground	g/ha soil / m3/ha runoff= g/m3 = mg/L	Soil Loss with BMP (t/ha)* % of total area	BMP Reduction Efficiency (%) * % of total area	Mean Annual TSS Concentration (mg/L) * % of total area	Sum of Weighted Mean Annual TSS Concentration (mg/L)

12.36 ha DEVELOPED AREA ONLY WITH NO EROSION OR SEDIMENT CONTROLS

ID	Land Disturbing Activities	Area (ha)	Percent of Total Area (%)	Average Slope (%)	Slope Length (m)	NN	LS Factor	Soil Texture Class:	OM Content	K factor (t/ha):	Bare Soil Loss (t/ha)	Bare Soil Erosion Risk	Erosion Control BMP Efficiency	Sediment Control BMP Efficiency	Soil Loss with BMP (t/ha)	BMP Reduction Efficiency (%)	Mean Annual TSS Concentration (mg/L)			Area Weighted Mean Annual TSS Concentration (mg/L)	Overall Mean Annual TSS Concentration (mg/L)
3	**Under Development Exposed Soil**	1.85	15	4	20	0.4	0.34	**Silt Loam**	Average OMC	0.85	**25.9**	**High**	0.00	0.00	**25.9**	**0%**	**6901**	**3.88**	**0%**	**1035**	**1311**
4	**Under Development Exposed Soil**	10.50	85	4	20	0.4	0.34	**Sand**	Average OMC	0.04	**1.2**	**Very Low**	0.00	0.00	**1.2**	**0%**	**325**	**1.04**	**0%**	**276**	
NOTES	Site Areas being Assessed	Total developed area 12.357 ha	assumed from soils data	assumption	assumption	function of average slope	Function of Average Slope (%), Slope Length (m), NN	Based on soils data - 15% silt till , 85% sand & gravel	Optimum Moisture Content	function of OM Content	function of R, LS and K	function of Bare Soil Loss	No Erosion Control specified	No Sediment Control specified	Bare Soil Loss reduced by Erosion Control and Sediment Control (no reduction in this example)	no reduction Bare Soil Loss in this example	g/ha soil / m3/ha runoff= g/m3 = mg/L	Soil Loss with BMP (t/ha)* % of total area	BMP Reduction Efficiency (%) * % of total area	Mean Annual TSS Concentration (mg/L) * % of total area	Sum of Weighted Mean Annual TSS Concentration (mg/L)

Appendix G: Frequency of Exceedance Analysis for Air Quality

The following procedure describes how the frequency of exceedance was determined:

1. The highest day per year was identified from full receptor grid run of five years.
2. These 5 days were removed from consideration in the surface meteorological file.
3. AERMOD was run with the modified file and the threshold violation file option was selected. Thresholds entered in the model corresponded with AAQC.
4. AERMOD outputs the total number of days that exceed AAQC in the modelling period. For construction, this is 334 days since January is excluded, i.e., no construction activities occur in January.
5. Frequency of exceedance is calculated as the total days of exceedance divided by the total number of days modelled over the five year period. Only the maximum of Scenarios A, B and C was considered.

Table G-1: Exceedances for Particulates

Contaminant	Exceedance
	# Days
TSP	18
PM_{10}	14
$PM_{2.5}$	6

Sample Calculation:

Frequency of Exceedance for TSP = Total Exceedances ÷ Total Days Modelled
= 18 ÷ [(365-31) x 5]
= 1.1%

Appendix H: Dispersion Modelling Results for Other Ecosystem Components

All modelled air quality parameters and the results of all modelled scenarios, including concentration results at individual receptor locations, are provided in the tables below.

Table H-1: Existing Results at Receptors

Category	ID	X	Y	TSP		PM_{10}		$PM_{2.5}$		NO_2		CO		SO_2		
				Concentration		Concentration		Concentration		Concentration		Concentration		Concentration		
				24 h	annual	24 h	annual	24 h	annual	1 h	24 h	1 h	8 h	1 h	24 h	annual
		(m)	(m)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)	(μg/m³)
Biota	ER3	453016	4907283	47.9	45.2	-	-	-	-	75.7	19.1	482.9	469.9	191.4	52.9	-
	ER4	453592	4907674	48.2	45.3	-	-	-	-	101.8	37.8	496.3	479.5	193.7	55.5	-
	ER5	453778	4908277	48.1	45.2	-	-	-	-	122.9	19.4	482.4	467.8	219.2	54.5	-
	ER6	454310	4908211	48.6	45.2	-	-	-	-	119.7	20.9	477.2	467.0	206.2	60.8	-
	ER7	454049	4907809	48.2	45.2	-	-	-	-	139.7	19.7	495.4	470.7	317.0	55.6	-
	1	453909	4907457	47.8	45.2	-	-	-	-	140.8	22.0	484.4	470.1	253.4	50.2	-
	4	453606	4908056	48.3	45.3	-	-	-	-	107.6	22.8	493.0	476.0	280.5	56.6	-
	5	452992	4907822	48.4	45.2	-	-	-	-	129.0	21.9	487.5	468.3	178.6	58.5	-
	7	453165	4908305	48.4	45.2	-	-	-	-	130.2	20.3	480.3	465.6	172.5	58.2	-
	10	453731	4906943	47.9	45.2	-	-	-	-	75.7	18.6	477.8	467.8	199.1	52.8	-
Human	BR1	455936	4911030	46.4	45.1	23.2	22.1	11.8	11.0	150.4	13.7	462.5	459.1	156.9	32.9	12.3
	BR48	455911	4908866	46.6	45.1	23.4	22.1	11.9	11.0	107.3	14.6	467.6	460.8	153.1	35.7	12.0
	BR17	457026	4906433	46.7	45.1	23.5	22.1	12.0	11.0	186.2	15.4	464.4	460.1	136.9	37.3	10.8
	BR25	454831	4904960	47.2	45.1	23.9	22.1	12.2	11.0	93.0	16.4	466.3	459.7	206.0	43.4	16.2
	BR27	453761	4904615	47.3	45.1	23.9	22.1	12.3	11.0	108.4	16.6	465.6	459.9	254.1	44.3	20.0
	BR32	452832	4904307	46.4	45.1	23.2	22.1	11.8	11.0	95.4	13.9	463.9	459.4	205.0	33.5	16.1
	BF8	456256	4901805	45.9	45.1	22.8	22.0	11.5	11.0	129.7	12.4	464.2	458.7	176.8	26.8	13.9
	BF14	454081	4905041	46.7	45.1	23.4	22.1	11.9	11.1	127.7	14.7	465.4	459.6	252.9	36.7	19.9
	BF16	460039	4906469	46.3	45.0	23.1	22.0	11.7	11.0	124.6	13.9	462.5	458.9	141.2	32.1	11.1
	BMF2	457776	4900933	45.8	45.0	22.7	22.0	11.4	11.0	128.3	12.2	461.5	458.5	115.4	25.2	9.1
	BMF3	458889	4902830	46.1	45.0	22.9	22.0	11.6	11.0	139.3	13.3	462.8	459.3	128.9	29.8	10.1
	BDF9	461071	4899042	46.2	45.0	23.0	22.0	11.7	11.0	125.4	13.2	464.6	458.9	234.9	30.4	18.5
	BEC	455781	4906226	47.3	45.1	24.0	22.1	12.3	11.0	187.5	16.9	470.6	460.7	304.2	44.2	23.9

Model Setup
- Existing Bruce sources
- Current buildings
- Existing WWMF sources

Table H-2: Site Preparation Results at Receptors

Category	ID	X	Y	TSP	PM10	PM2.5	NO2		CO		SO2	
				Concentration 24 h	Concentration 24 h	Concentration 24 h	Concentration 1 h	Concentration 24 h	Concentration 1 h	Concentration 8 h	Concentration 1 h	Concentration 24 h
		(m)	(m)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)
Biota	ER3	453016	4907283	62.6	-	-	355.3	28.3	2344.6	698.0	191.4	52.9
	ER4	453592	4907674	228.4	-	-	412.0	38.1	3960.3	966.2	193.7	55.5
	ER5	453778	4908277	68.6	-	-	322.2	23.9	2009.8	688.9	219.2	54.5
	ER6	454310	4908211	74.4	-	-	527.4	27.1	4032.0	917.4	206.2	60.8
	ER7	454049	4907809	176.5	-	-	343.2	25.1	3226.5	830.7	317.1	55.6
	1	453909	4907457	124.8	-	-	660.9	30.0	6703.3	1362.3	253.4	50.2
	4	453606	4908056	345.0	-	-	668.3	42.1	6556.9	1360.3	280.5	56.6
	5	452992	4907822	63.6	-	-	496.0	33.4	4684.9	1079.6	178.6	58.5
	7	453165	4908305	57.0	-	-	303.9	18.7	2459.7	708.4	172.5	58.2
	10	453731	4906943	75.5	-	-	472.0	30.6	3650.0	858.3	199.1	52.8
Human	BR1	455936	4911030	46.5	23.2	12.8	150.3	13.7	587.5	479.4	156.9	32.9
	BR48	455911	4908866	49.9	25.7	15.6	274.9	15.9	1773.1	622.4	153.1	35.8
	BR17	457026	4906433	46.5	23.2	12.8	186.1	14.3	565.1	483.9	137.0	37.3
	BR25	454831	4904960	49.5	24.9	13.7	109.9	16.6	719.2	502.2	206.0	43.4
	BR27	453761	4904615	49.0	24.6	13.7	251.7	16.8	1843.0	631.1	254.1	44.3
	BR32	452832	4904307	48.7	24.4	13.5	151.2	14.0	863.2	513.6	205.0	33.5
	BF8	456256	4901805	46.2	22.9	12.5	129.6	12.4	527.4	467.3	176.8	26.8
	BF14	454081	4905041	53.5	26.7	16.4	355.2	20.9	2423.0	703.3	252.9	36.7
	BF16	460039	4906469	46.1	22.9	12.6	124.6	12.4	531.5	467.3	141.3	32.1
	BMF2	457776	4900933	46.0	22.7	12.4	121.3	12.0	505.3	466.1	115.4	25.2
	BMF3	458889	4902830	46.2	22.8	12.5	139.2	12.0	569.8	471.6	128.9	29.8
	BDF9	461071	4899042	46.0	22.9	12.6	117.3	12.8	489.0	461.5	234.9	30.4
	BEC	455781	4906226	48.0	24.2	13.4	186.9	17.1	850.4	506.7	304.2	44.2

Model Setup
- Existing Bruce sources
- Existing WWMF sources
- Site preparation may occur from Oct - Mar
- During site preparation, clearing and removing overburden takes place at Area 1 & 2 (shared full fleet) and Area 3 (full fleet)

Table H-3: Construction (Scenario A) Results at Receptors

Category	ID	X	Y	TSP		PM$_{10}$		PM$_{2.5}$		NO$_2$		CO		SO$_2$		
				Concentration		Concentration		Concentration		Concentration		Concentration		Concentration		
				24 h	annual	24 h	annual	24 h	annual	1 h	24 h	1 h	8 h	1 h	24 h	annual
		(m)	(m)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)
Biota	ER3	453016	4907283	65.3	46.2	-	-	-	-	423.7	46.2	2087.4	661.7	191.6	52.9	-
	ER4	453592	4907674	304.2	67.3	-	-	-	-	784.1	100.7	4329.6	975.0	193.7	55.9	-
	ER5	453778	4908277	80.4	48.3	-	-	-	-	720.7	68.5	3470.1	840.3	219.3	54.6	-
	ER6	454310	4908211	81.7	47.1	-	-	-	-	505.5	53.2	1890.8	644.5	206.5	60.8	-
	ER7	454049	4907809	104.1	50.3	-	-	-	-	545.6	73.2	2137.1	670.8	317.3	55.6	-
	1	453909	4907457	145.6	51.5	-	-	-	-	558.1	74.0	3385.3	982.5	260.3	52.0	-
	4	453606	4908056	280.9	71.1	-	-	-	-	1146.3	127.9	4612.9	1198.2	280.6	56.9	-
	5	452992	4907822	71.7	46.4	-	-	-	-	757.4	44.5	4167.9	921.7	178.7	58.5	-
	7	453165	4908305	63.4	46.2	-	-	-	-	306.8	52.4	2019.2	653.2	172.5	58.2	-
	10	453731	4906943	74.8	46.6	-	-	-	-	783.6	70.1	3812.0	1090.8	199.4	52.9	-
Human	BR1	455936	4911030	47.1	45.1	24.0	22.1	12.8	12.1	150.4	14.9	638.3	480.7	156.9	32.9	12.3
	BR48	455911	4908866	50.4	45.2	27.5	22.2	15.0	12.1	319.6*	26.2	1023.7	528.5	153.4	35.7	12.1
	BR17	457026	4906433	48.4	45.1	24.4	22.1	15.0	12.1	186.2	17.5	671.7	490.6	139.6	37.6	11.0
	BR25	454831	4904960	48.3	45.2	24.7	22.1	13.3	12.1	138.1	17.4	636.5	493.8	214.6	43.8	16.9
	BR27	453761	4904615	49.8	45.2	27.3	22.2	16.4	12.1	272.9*	26.0	1935.5	726.4	256.1	44.3	20.2
	BR32	452832	4904307	48.1	45.1	25.3	22.1	15.2	12.1	242.0	22.3	934.3	517.4	205.1	33.5	16.1
	BF8	456256	4901805	46.2	45.1	22.9	22.1	12.5	12.0	131.1	12.9	521.6	471.4	181.4	26.9	14.3
	BF14	454081	4905041	51.0	45.2	27.8	22.2	16.5	12.1	293.4*	36.2	2338.2	773.6	254.2	36.7	20.0
	BF16	460039	4906469	46.9	45.1	23.5	22.1	12.8	12.0	124.6	14.8	549.3	475.0	144.1	32.3	11.3
	BMF2	457776	4900933	46.0	45.1	22.8	22.1	12.5	12.0	128.3	12.9	558.4	471.6	115.4	25.4	9.1
	BMF3	458889	4902830	46.8	45.1	23.3	22.1	12.8	12.0	139.3	14.3	517.0	476.1	133.1	30.0	10.5
	BDF9	461071	4899042	46.2	45.1	23.0	22.0	12.7	12.0	125.4	13.3	496.2	466.3	234.9	30.4	18.5
	BEC	455781	4906226	49.5	45.2	25.1	22.1	13.4	12.1	192.4	19.0	665.4	502.6	314.8	44.7	24.8

* after elimination of meteorological anomalies

Model Setup

- Existing Bruce sources
- Existing WWMF sources
- Scenario A considers construction at Area 1 & 2 (shared full fleet) and Area 3 (full fleet)
- Underground services may occur from Feb - Mar
- Final preparation, foundation and walls may occur from Apr - Sept
- Roof, floor and torched on roof may occur from Oct - Dec

Table H-4: Construction (Scenario B) Results at Receptors

Category	ID	X	Y	TSP		PM_{10}		$PM_{2.5}$		NO_2		CO		SO_2		
				Concentration		Concentration		Concentration		Concentration		Concentration		Concentration		
				24 h	annual	24 h	annual	24 h	annual	1 h	24 h	1 h	8 h	1 h	24 h	annual
		(m)	(m)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)	(μg/m^3)
Biota	ER3	453016	4907283	76.0	46.8	-	-	-	-	694.7	77.0	3431.7	829.7	191.6	52.9	-
	ER4	453592	4907674	146.2	51.6	-	-	-	-	611.2	72.1	3402.8	940.0	193.7	55.8	-
	ER5	453778	4908277	76.7	48.3	-	-	-	-	360.9	65.3	1920.6	643.9	219.3	54.6	-
	ER6	454310	4908211	90.4	47.0	-	-	-	-	676.5	77.0	2215.8	677.9	206.5	60.8	-
	ER7	454049	4907809	87.6	49.8	-	-	-	-	433.7	62.8	2239.5	691.1	317.3	55.6	-
	1	453909	4907457	97.8	49.7	-	-	-	-	556.0	56.1	3056.9	969.0	260.2	52.0	-
	4	453606	4908056	288.2	71.2	-	-	-	-	1146.3	109.6	4113.2	983.5	280.6	56.9	-
	5	452992	4907822	159.7	50.8	-	-	-	-	905.1	90.4	4498.1	967.3	178.7	58.6	-
	7	453165	4908305	65.9	46.6	-	-	-	-	376.0	55.1	1991.3	649.8	172.5	58.2	-
	10	453731	4906943	63.0	46.3	-	-	-	-	301.7	41.3	1796.7	688.9	199.4	52.9	-
Human	BR1	455936	4911030	46.8	45.1	23.7	22.1	12.9	12.1	150.4	16.0	587.0	474.3	156.9	32.9	12.3
	BR48	455911	4908866	52.0	45.2	29.1	22.2	15.5	12.1	338.7	28.8	1014.4	537.6	153.4	35.7	12.1
	BR17	457026	4906433	48.3	45.1	24.3	22.1	14.3	12.1	186.2	17.3	670.9	491.9	139.6	37.6	11.0
	BR25	454831	4904960	49.2	45.2	25.6	22.1	13.6	12.1	132.1	19.7	697.5	500.2	214.6	43.8	16.9
	BR27	453761	4904615	49.4	45.2	26.7	22.2	15.4	12.1	202.0*	24.5	1788.6	683.9	256.1	44.3	20.2
	BR32	452832	4904307	47.2	45.1	24.3	22.1	14.2	12.1	159.5	19.7	759.9	495.6	205.1	33.5	16.1
	BF8	456256	4901805	46.2	45.1	23.0	22.1	12.5	12.0	139.1	12.8	518.6	471.9	181.4	26.9	14.3
	BF14	454081	4905041	50.5	45.2	27.7	22.2	16.0	12.1	303.8	28.1	1596.7	655.5	254.2	36.7	20.0
	BF16	460039	4906469	46.9	45.1	23.4	22.0	12.8	12.0	124.6	14.8	553.2	474.9	144.1	32.3	11.3
	BMF2	457776	4900933	46.1	45.1	22.9	22.1	12.5	12.0	128.3	13.0	538.6	469.8	115.4	25.4	9.1
	BMF3	458889	4902830	46.8	45.1	23.3	22.1	12.7	12.0	139.3	14.2	522.1	477.9	133.1	30.0	10.5
	BDF9	461071	4899042	46.2	45.1	23.0	22.0	12.7	12.0	125.4	13.3	497.5	466.1	234.9	30.4	18.5
	BEC	455781	4906226	49.4	45.2	25.1	22.1	13.4	12.1	187.5	18.7	652.9	498.7	314.8	44.7	24.8

* after elimination of meteorological anomalies

Model Setup

- Existing Bruce sources
- Existing WWMF sources
- Scenario B considers construction at Area 1 & 2 (shared full fleet) and Area 4 (full fleet)
- Underground services may occur from Feb - Mar
- Final preparation, foundation and walls may occur from Apr - Sept
- Roof, floor and torched on roof may occur from Oct - Dec

Table H-5: Construction (Scenario C) Results at Receptors

Category	ID	X	Y	TSP		PM_{10}		$PM_{2.5}$		NO_2		CO		SO_2		
				Concentration		Concentration		Concentration		Concentration		Concentration		Concentration		
		(m)	(m)	24 h (µg/m³)	annual (µg/m³)	24 h (µg/m³)	annual (µg/m³)	24 h (µg/m³)	annual (µg/m³)	1 h (µg/m³)	24 h (µg/m³)	1 h (µg/m³)	8 h (µg/m³)	1 h (µg/m³)	24 h (µg/m³)	annual (µg/m³)
Biota	ER3	453016	4907283	76.6	47.0	-	-	-	-	376.1	58.4	2056.1	658.3	191.6	52.9	-
	ER4	453592	4907674	341.6	68.6	-	-	-	-	783.8	113.6	4358.4	975.5	193.7	55.9	-
	ER5	453778	4908277	61.3	46.3	-	-	-	-	402.0	44.0	2147.6	671.9	219.3	54.6	-
	ER6	454310	4908211	59.3	45.9	-	-	-	-	386.9	38.8	1580.5	601.5	206.5	60.8	-
	ER7	454049	4907809	83.0	47.4	-	-	-	-	548.5	52.1	2380.9	713.8	317.2	55.6	-
	1	453909	4907457	162.5	52.9	-	-	-	-	708.6	92.6	5409.9	1169.1	260.4	52.0	-
	4	453606	4908056	72.4	47.6	-	-	-	-	528.7	60.3	2906.9	769.4	280.6	56.7	-
	5	452992	4907822	163.3	51.0	-	-	-	-	821.8	93.7	2977.0	820.2	178.7	58.6	-
	7	453165	4908305	69.0	46.4	-	-	-	-	382.7	61.5	1467.5	588.9	172.5	58.2	-
	10	453731	4906943	83.3	46.9	-	-	-	-	521.1	58.6	2836.2	891.1	199.4	52.9	-
Human	BR1	455936	4911030	46.6	45.1	23.8	22.1	12.8	12.1	150.4	14.5	584.6	474.0	156.9	32.9	12.3
	BR48	455911	4908866	49.4	45.2	27.5	22.2	14.3	12.1	259.7	23.2	1033.8	529.8	153.4	35.7	12.1
	BR17	457026	4906433	49.9	45.1	24.7	22.1	16.8	12.1	186.2	17.8	644.8	507.8	139.6	37.6	11.0
	BR25	454831	4904960	48.6	45.2	25.6	22.2	13.3	12.1	176.4	17.6	799.7	503.2	214.6	43.8	16.9
	BR27	453761	4904615	50.6	45.2	29.4	22.2	17.5	12.1	225.5*	30.3	2346.3	789.2	256.1	44.3	20.2
	BR32	452832	4904307	47.9	45.2	25.6	22.1	14.8	12.1	161.9	19.6	766.7	496.7	205.1	33.5	16.1
	BF8	456256	4901805	46.1	45.1	23.0	22.1	12.5	12.0	151.0	12.9	542.1	475.2	181.5	26.9	14.3
	BF14	454081	4905041	51.9	45.2	30.2	22.2	17.0	12.1	277.2	32.3	1509.4	619.7	254.2	36.7	20.0
	BF16	460039	4906469	46.6	45.1	23.4	22.1	12.8	12.0	124.7	14.5	554.3	478.4	144.1	32.3	11.3
	BMF2	457776	4900933	46.2	45.1	23.0	22.1	12.5	12.0	128.3	12.7	536.4	470.6	115.4	25.4	9.1
	BMF3	458889	4902830	46.7	45.1	23.4	22.1	12.7	12.0	139.3	14.3	553.5	483.0	133.1	30.0	10.5
	BDF9	461071	4899042	46.2	45.1	23.1	22.0	12.7	12.0	125.4	13.4	511.8	468.1	234.9	30.4	18.5
	BEC	455781	4906226	49.4	45.2	25.5	22.2	13.4	12.1	217.0	18.5	818.9	520.2	314.9	44.7	24.8

* after elimination of meteorological anomalies

Model Setup

- Existing Bruce sources
- Existing WWMF sources
- Scenario C considers construction at Area 3 (full fleet) and Area 4 (full fleet)
- Underground services may occur from Feb - Mar
- Final preparation, foundation and walls may occur from Apr - Sept
- Roof, floor and torched on roof may occur from Oct - Dec

Appendix I: Noise Modelling Results

Noise impact results for human receptors (R1, R2 and R3) for all modelling scenarios during Site Preparation, Construction, and Operations and Maintenance are provided in Table I-2, Table I-3 and Table I-4, respectively. Modelling scenarios for Operations and Maintenance were based on the distribution of future buildings per expansion location presented in Table I-5 and virtual noise sources presented in Table I-6. The results in the following tables represent the expected one-hour noise impacts when all noise sources operate simultaneously for a given modelling scenario.

<u>Virtual Noise Source Approach</u>

The WWMF expansion operational noise model defines a virtual building source approach to determine building distribution on a given expansion area, and to investigate potential noise impacts within the context of operational noise criteria.

The assessment of the virtual building sources includes the following process/rationale:

1) Define all potential noise sources by building type;
2) Consolidate all individual noise sources for a particular building into a single virtual source unit, with an equivalent total sound power level. The result is that each building type has a specific virtual sound power level associated with it;
3) Virtual placement of buildings on expansion areas was then undertaken in the following order:
    a. Placement of the UFDSBs in expansion areas (as these represent the largest footprint and therefore must be accounted for (i.e., for areas 3 and 4 only);
    b. Placement of all other buildings using a hierarchical approach with the building placement occurring in order from the loudest to the quietest;
    c. Action "b" is also undertaken taking Project and building footprint constraints into consideration;
4) Virtual noise sources (as provided in Table 5-18) were included in the noise modelling in the four expansion areas (1-4, see Figure 4-4) for the possible future operational scenarios.

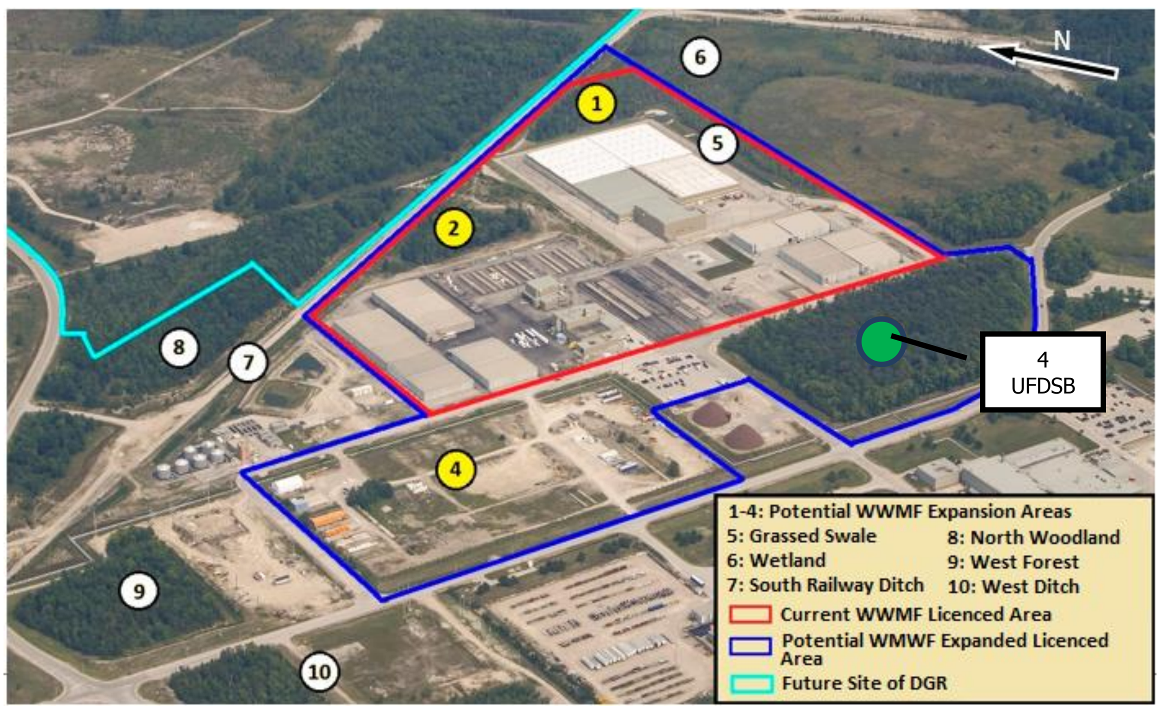
Table I-1 summarizes the results of such a virtual assessment for Future Operating Scenario OD. It consolidates Section 5.2.3.3 Table 5-19 and Table 5-22 and identifies the final distribution of virtual building noise sources that were used for operating scenario OD. For further clarity on how the virtual noise source approach for the operating scenarios is defined, the following process overview is provided for Future Operational Scenario OD.

Table I-1: WWMF Expansion Building Distributions (Scenario OD)

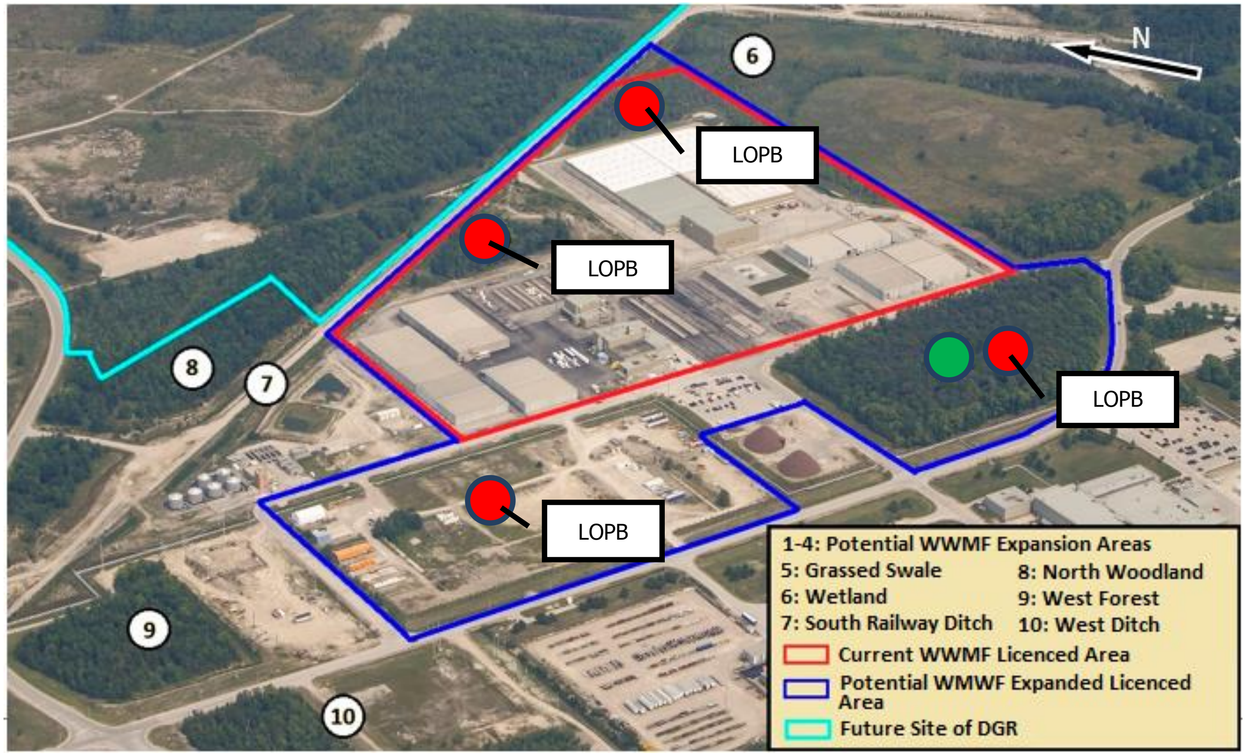
Future Operational Scenario	Expansion Area	# of Buildings	Building Type
OD	1	3	LOPB
			RCSB/SGSB
			RCSB/SGSB
	2	1	LOPB
	3	4UFDSB+1	UFDSB
			LOPB
	4	1	LOPB

The definition of the noise sources for the Project was done as follows:

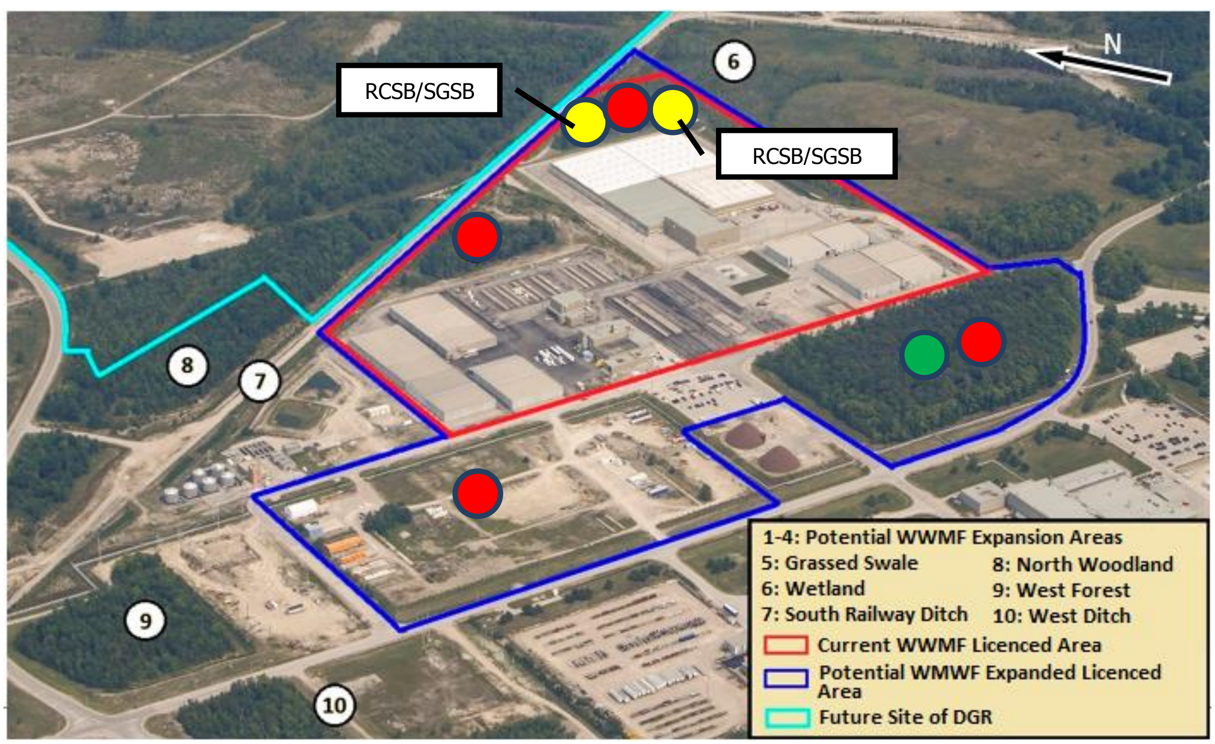
1) Based on the four expansion areas for the Project, up to ten buildings are defined to be constructed among the expansion areas.
Note that the four UFDSBs can be in either expansion area 3 or 4.
For Scenario OD, it was assumed the four UFDSBs are in expansion area 3 (represented by one virtual noise source in green).



2) Note that only one LOPB can be built for the Project, but it could be constructed in any expansion area. For Scenario OD, it was assumed that a virtual LOPB source (Red) was on each of the four expansion areas, to cover this construction option.



3) The remaining 2 buildings are then distributed on the site. Since the UFDSB and LOPB have been accounted for, the next loudest building(s) (as per Table 5-18) are the RCSB/SGSBs. For Scenario OD, the 2 virtual RCSB/SGSB sources (Yellow) are distributed on expansion area 1.



This example shows the 4 UFDSBs on expansion area 3; a LOPB at any of the expansion areas; and two RCSBs or SGSBs at expansion area 1. Alternatively, the buildings on area 1 could be a combination of LLSBs or WSBs, since they are quieter. This brings the total number of buildings to be constructed for the Project on the expansion areas to 10 for the future operation and maintenance phases for Scenario OD.

Table I-2: Modelled Noise Levels - Site Preparation

Name	Modelled Noise Level L_{eq} (1 h), dBA									
	Clearing the Site					Grubbing and Removing Overburden				
	1	2	3	1+3	2+3	1	2	3	1+3	2+3
R1 - Albert Street	31	31	33	35	35	28	28	30	32	32
R2 - Baie du Doré	36	35	31	38	37	34	33	29	35	34
R3 - Inverhuron Park	29	30	32	34	34	26	27	29	31	31

Note:
Maximum noise impact levels highlighted in yellow for each receptor (R1, R2, R3)
L_{eq} (1 h) – Equivalent Sound Level (1 h)

Table I-3: Modelled Noise Levels - Construction

	Modelled Noise Level L_{eq} (1 h), dBA																				
	Install underground site services			Final preparation of site			Pour foundation/footings			Install walls			Install roof			Pour the floor			Install torched on roof		
	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4	1/2+3	1/2+4	3+4
R1 - Albert Street	33	32	33	34	33	34	30	30	31	33	33	34	34	33	34	30	30	31	34	33	34
R2 - Baie du Doré	36	36	32	37	36	33	34	33	30	37	37	32	36	36	32	33	33	30	37	36	34
R3 - Inverhuron Park	32	32	33	33	33	34	30	30	31	32	32	33	33	33	34	30	30	31	33	33	34

Note: Maximum noise impact levels highlighted in yellow for each receptor (R1, R2, R3)

Table I-4: Modelled Noise Levels - Operation and Maintenance

Future Operating Scenario	Modelled Noise Level L_{eq} (1 h), dBA					
	R1		R2		R3	
	Day	Night	Day	Night	Day	Night
OA	16	15	19	18	15	14
OB	16	15	19	19	15	13
OC	17	16	19	18	16	14
OD	17	16	19	19	16	14
OE	17	16	18	18	16	15
OF	17	16	19	18	16	14
OG	17	16	18	18	16	15
OH	17	16	17	16	16	14
OI	17	15	17	16	15	14
OJ	17	15	15	13	15	14
OK	16	15	19	18	15	14
OL	16	15	19	19	15	13
OM	17	16	19	18	16	14
ON	17	16	19	19	16	14
OO	17	16	18	18	16	15
OP	17	16	19	18	16	14
OQ	17	16	18	17	16	15
OR	16	15	17	16	16	14
OS	16	14	17	16	16	14
OT	15	14	14	13	15	14

Note: Maximum noise impact levels highlighted in yellow for each receptor (R1, R2, R3) for both day and night operations.

Table I-5: WWMF Expansion Building Distributions

Future Operating Scenarios	Number of Buildings per Expansion Location			
	1	**2**	**3**	**4**
OA	2	2	*4UFDSB+0*	2
OB	4	1	*4UFDSB+0*	1
OC	2	1	*4UFDSB+1*	2
OD	3	1	*4UFDSB+1*	1
OE	1	1	*4UFDSB+2*	2
OF	2	1	*4UFDSB+2*	1
OG	1	1	*4UFDSB+3*	1
OH	1	0	*4UFDSB+4*	1
OI	1	0	*4UFDSB+5*	0
OJ	0	0	*4UFDSB+6*	0
OK	2	2	2	*4UFDSB+0*
OL	4	1	1	*4UFDSB+0*
OM	2	1	2	*4UFDSB+1*
ON	3	1	1	*4UFDSB+1*
OO	1	1	2	*4UFDSB+2*
OP	2	1	1	*4UFDSB+2*
OQ	1	1	1	*4UFDSB+3*
OR	1	0	1	*4UFDSB+4*
OS	1	0	0	*4UFDSB+5*
OT	0	0	0	*4UFDSB+6*

Note:

1) There will be 4 UFDSBs constructed in a cluster, located at either expansion area 3 or 4. A maximum of 10 buildings could be constructed on expansion areas 3 and 4, including the 4 UFDSB cluster.
2) Table I-5 should be read in tandem with Table I-6.
3) The table of scenarios (OA – OT) are representative of the worst-case impact building locations for the Project. Although additional scenarios can be considered beyond those noted here, it is expected that the scenarios presented in this table provide the bounding condition for the worst-case operational noise impact for the Project.
4) The scenarios above include scenarios for all ten buildings being constructed on either expansion area 3 or 4. This was completed as a conceptual exercise, and it is noted that in reality ten buildings cannot fit on either of these areas.

Table I-6: Virtual WWMF Expansion Noise Sources by Future Operational Scenario

Future Operational Scenario	Expansion Location	Building Type	Sound Power Levels (dBA)
OA	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	4	LOPB3	99
	1	RCSB/SGSB	96
	2	RCSB/SGSB	96
	4	RCSB/SGSB	96
OB	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	4	LOPB3	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
OC	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	4	RCSB/SGSB	96
OD	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
OE	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	3	RCSB/SGSB	96
	4	RCSB/SGSB	96
OF	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99

Future Operational Scenario	Expansion Location	Building Type	Sound Power Levels (dBA)
	4	LOPB4	99
	1	RCSB/SGSB	96
	3	RCSB/SGSB	96
OG	3	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
OH	3	UFDSB	101
	1	LOPB1	99
	3	LOPB2	99
	4	LOPB3	99
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
OI	3	UFDSB	101
	1	LOPB1	99
	3	LOPB2	99
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
OJ	3	UFDSB	101
	3	LOPB1	99
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
	3	RCSB/SGSB	96
OK	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	1	RCSB/SGSB	96
	2	RCSB/SGSB	96
	3	RCSB/SGSB	96
OL	4	UFDSB	101
	1	LOPB1	99

Future Operational Scenario	Expansion Location	Building Type	Sound Power Levels (dBA)
	2	LOPB2	99
	3	LOPB3	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
OM	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	3	RCSB/SGSB	96
ON	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	1	RCSB/SGSB	96
OO	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	3	RCSB/SGSB	96
	4	RCSB/SGSB	96
OP	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	1	RCSB/SGSB	96
	4	RCSB/SGSB	96
OQ	4	UFDSB	101
	1	LOPB1	99
	2	LOPB2	99
	3	LOPB3	99
	4	LOPB4	99
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96

Future Operational Scenario	Expansion Location	Building Type	Sound Power Levels (dBA)
OR	4	UFDSB	101
	1	LOPB1	99
	3	LOPB2	99
	4	LOPB3	99
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
OS	4	UFDSB	101
	1	LOPB1	99
	4	LOPB2	99
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
OT	4	UFDSB	101
	4	LOPB1	99
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96
	4	RCSB/SGSB	96

Note:

1) WSB or LLSB could replace the RCSB/SGSB building sources in the table. If so, then as the WSB or LLSB is 3 dB quieter than the RCSB/SGSB building sources (as noted in Table 5-18) the resulting modelled noise impact would be lower than modelled with the RCSB/SGSB.
2) Table I-5 should be read in tandem with Table I-6.