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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

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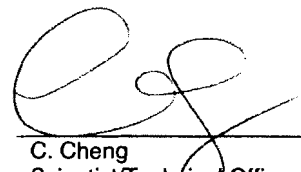
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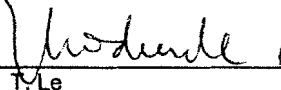
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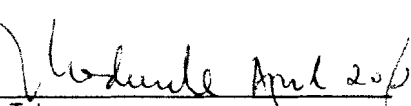
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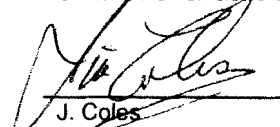

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Acknowledgement

Ontario Power Generation, Nuclear would like to thank the residents of the local communities in the vicinity of Pickering and Darlington stations, and throughout the Province of Ontario who have voluntarily participated in our environmental monitoring programs. We appreciate their contribution of access to their properties for our monitoring equipment and supplying samples of vegetables, fruits, honey, soil, silage, milk and water. Their participation and on-going assistance ensure that the annual public dose estimates are as accurate as possible.

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Executive Summary

Ontario Power Generation (OPG) conducts Radiological Environmental Monitoring Programs (REMPs) in the vicinity of Darlington Nuclear (DN) and Pickering Nuclear (PN) stations to determine the radiological impact on the public resulting from the operation of these stations. This annual report is a requirement of the station operating licenses. It contains the 2009 results of the above monitoring programs, which include concentrations of radionuclides in the air, water, milk, soil, sediments, vegetation and fish samples taken in the vicinity of DN and PN, and the associated radiation dose assessments. Samples at provincial locations were also taken to determine background radiation levels in areas away from the influence of nuclear stations.

A total of 2,783 laboratory analyses were performed on a variety of environmental media in 2009. With the exception of provincial tritium in air samples, the availability of samples analyzed for the dose calculation was well above the minimum annual performance requirements.

There were no changes to the PN and provincial REMP designs that affected dose. At DN, a change was made to the representative locations of the Industrial/Commercial and Rural Resident potential critical groups, which is discussed in Section 7.1.1.

In 2009, OPG implemented the 2008 updated Canadian Standards Association (CSA) N288.1-08 standard, Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities [R-14]. This revised standard introduced changes to dose modeling parameters and representative age groups for the public dose assessment. The most significant changes affecting dose are:

- Lower air inhalation and water ingestion rates, resulting in reduced dose received through these pathways.
- The amount of tritium oxide (HTO) inhalation dose assigned to represent the skin absorption pathway was revised to more accurately reflect dose uptake. This has led to a reduction in the representative dose for the skin absorption pathway.
- Two corrections made to the transfer parameter for radionuclides from terrestrial plants to terrestrial animals has led to an increase in dose from terrestrial animal consumption (from all radionuclides except tritium) and a decrease in dose from organically bound tritium (OBT).
- The six age classes for public dose estimates have been redistributed into the following three age classes:
 - (1) 1 year old infant which represents the age span 0 to 5 years,
 - (2) 10 year old child which represents the age span 6 to 15 years, and
 - (3) Adult which represents the age span 16 to 70 years.

IMPACT 5.4.0 software, which represents the method of dose calculation described in the CSA N288.1-08 standard, was used for the dose calculation.

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The 2009 radiation dose assessments for DN and PN demonstrate that the critical group doses resulting from the operation of the OPG Nuclear Generating Stations continue to be well below both the annual legal limit of 1,000 microsieverts (μSv) and the estimated annual average background radiation dose around DN and PN of 1,400 μSv . The official public doses for the DN and PN sites are summarized in Table 1 and described as follows:

- At the DN site, the highest dose calculated for the nine potential critical groups was 0.7 μSv (0.1% of the regulatory limit) for a 1 year old infant of the Dairy Farm critical group. This dose is lower than the 2008 dose of 1.3 μSv , reported for the same critical group, due to a decrease in measured carbon-14 (C-14) concentrations in milk as well as a reduction of dose from OBT and HTO inhalation based on the changes to model parameters specified by CSA N288.1-08.
- At the PN site, the highest dose calculated for the six potential critical groups was 1.8 μSv (0.2% of the regulatory limit) for an adult worker of the Industrial/Commercial critical group. There was a small reduction in HTO emissions to air, however the decrease from 4.1 μSv reported for the same critical group in 2008 is primarily due to a reduction in dose from HTO inhalation based on the changes to model parameters specified by CSA N288.1-08.

Table 1: OPG Public Dose Estimates – 2009

Facility	Critical Group (Receptor)	Effective Dose (μSv)	Percentage of Legal Limit (%)	Percentage of Background Radiation around DN and PN (%)
Darlington Nuclear	Dairy Farm (1 yr. old infant)	0.7	0.1	0.1
Pickering Nuclear	Industrial/Commercial (Adult)	1.8	0.2	0.1

Looking ahead, several changes will take place in 2010:

- The CSA N288.4 standard, Environmental Monitoring at Class I Nuclear Facilities and Uranium Mines and Mills, is scheduled for release in 2010. Following its release, an implementation plan will be prepared to incorporate the changes introduced by the standard.
- Based on results from a 2009 OPG study, molecular sieve samplers are the preferred HTO in air sampling method. As a result, passive HTO in air sampling will be discontinued in 2010.

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1.0 INTRODUCTION

Ontario Power Generation (OPG) owns and operates the Pickering Nuclear (PN) and Darlington Nuclear (DN) Generating Stations. To ensure nuclear activities at these stations are conducted in a manner that minimizes their adverse impact on the public and the natural environment, OPG has established an Environmental Management Program. This program is registered to the International Organization for Standardization (ISO) 14001 Environmental Management Systems standard.

As part of the implementation of this program, each station has a Radiological Environmental Monitoring Program (REMP), which monitors radiation in the environment surrounding the station to assess the radiological impact to the public. Samples are also collected from locations considered to be outside the influence of the PN and DN station operations to allow a baseline comparison with background values.

This annual REMP report is prepared and submitted to the Canadian Nuclear Safety Commission (CNSC) in accordance with the operating licenses issued to PN and DN. The report is also available to the public.

This report provides the radiological emissions and environmental data collected for the period from January 1st to December 31st, 2009 for each site, their interpretations, and the estimates of radiation doses to the public resulting from the operation of PN and DN stations. The REMP results for OPG's Western Waste Management Facility (WWMF) are reported by Bruce Power in their annual summary REMP report.

The radiological emissions and environmental data are summarized in Sections 3.3 and 5.0. The assessment of doses to the public is described in Section 7.0.

2.0 REMP OBJECTIVES

The OPG REMPs are designed to satisfy the following primary objectives:

- (a) To demonstrate, independent of effluent monitoring, that nuclear site emissions of radioactive materials are properly controlled.
- (b) To estimate annual doses to the public based on environmental data measured in the public domain.
- (c) To provide data for evaluation of assumptions and transport models used to calculate station derived release limits and public doses.

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3.0 OVERVIEW OF PICKERING AND DARLINGTON NUCLEAR STATIONS

3.1 Site Description

DN and PN Generating Stations have a combined generating capacity of about 6,600 megawatts (MW). A brief description of these two stations is as follows:

Darlington Nuclear

The DN Generating Station is OPG's newest CANDU (CANadian Deuterium Uranium) nuclear generating station. It is a four unit station with a total output of 3,500 MW and is located 70 km east of Toronto on the shores of Lake Ontario in the Municipality of Clarington in Durham Region. It provides about 20% of Ontario's electricity needs, enough to serve a city of two million people.



DN also has the Tritium Removal Facility (TRF), where tritium is extracted from tritiated heavy water, and the Darlington Waste Management Facility for used fuel dry storage.

The area around the Darlington station is mostly rural and farm lands with some industrial/commercial areas. The urban residential locations of Oshawa, Bowmanville and West/East Beach are more than 3 km from the site.

Based on the results of site specific surveys conducted every 5 years, the residents around DN are grouped into nine categories which best represent their locations and/or lifestyle characteristics. The nine categories are: urban residents in Oshawa and in the community of Courtice, Bowmanville urban residents, West/East Beach urban residents, Farmers, Dairy Farmers, Rural residents, Industrial/Commercial workers, Sport fishers, and Campers.

Pickering Nuclear

The PN site is located on the shores of Lake Ontario, about 30 km east of Toronto in the community of Pickering. The site contains the Pickering A (PN-A) and Pickering B (PN-B) Nuclear Generating Stations, and the Pickering Waste Management Facility (PWMF) which consists of the Used Fuel Dry Storage and the Re-Tube Components Storage Area.

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PN-A has two operating CANDU reactors and PN-B has four operating CANDU reactors. Together these stations have a total output of 3,100 MW, enough to serve a city of one and a half million people. PN-A Units 2 and 3 are in safe shutdown state.

Unlike DN, the area around PN is mainly urban residential and industrial/commercial. The closest farm lands are more than 6 km from the station.

Based on the results of site specific surveys conducted every 5 years, the residents around PN are grouped into six categories: Inhabitants of correctional institute, Urban residents, Farmers, Dairy Farmers, Industrial/Commercial workers and Sport fishers.

3.2 2009 Nuclear Generation Capacity

In 2009, OPG operated ten nuclear reactors that produced 46.7 terawatt hours (TWh) of electricity. This production is broken down as follows:

Darlington Nuclear DN's net electrical output in 2009 was 26.0 TWh.

Pickering Nuclear PN-A's net electrical output in 2009 was 5.7 TWh.

PN-B's net electrical output in 2009 was 15.0 TWh.

3.3 2009 Radioactive Emissions Data

The radioactive emissions from DN and PN in 2009 remain well below the station Derived Release Limits (DRLs). These limits represent radionuclide release rates that correspond to a critical group exposure at the legal public dose limit of 1000 microsievert per year ($\mu\text{Sv/a}$). See Section 4.1 for the description of a critical group.

Table 3-1 shows the 2009 total airborne and waterborne emissions for radionuclides measured at the DN and PN sites as both the annual activity released and as a percentage of the respective DRLs.

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Table 3-1: OPG Annual Nuclear Site Emissions – 2009

Site Emissions	DN		PN	
	Bq	% DRL	Bq	% DRL
AIR				
Tritium Oxide	1.7E+14	0.39	7.0E+14	1.3
Elemental Tritium ^(a)	5.4E+13	<0.01	NA	NA
Noble Gas ^(b)	1.5E+13	0.04	2.7E+14	0.94
¹³¹ I	1.2E+08	<0.01	2.9E+07	<0.01
Particulate	5.4E+07	<0.01	7.5E+07	<0.01
¹⁴ C	1.7E+12	0.10	2.5E+12	0.04
WATER				
Tritium Oxide	1.9E+14	<0.01	4.0E+14	0.08
Gross Beta/Gamma	2.6E+10	0.04	9.5E+10	2.0
¹⁴ C	3.9E+09	<0.01	4.4E+09	<0.01

NOTES: NA = Not Applicable, Bq = becquerels

(a) Emissions from Darlington Tritium Removal Facility

(b) Units for noble gas emissions are γ Bq-MeV

3.3.1 Emissions Trends

The long term tritium and carbon-14 (C-14) emissions to air and tritium emissions to water from DN and PN are provided in Figures 3-1 to 3-7. Since the reported noble gas stack emissions are at times below the instrument detection limits, the results of environmental noble gas monitors are used to track the station noble gas emissions, as described in Section 5.1.2. Waterborne emissions of C-14 and gross beta/gamma, and airborne emissions of iodine and particulate from PN and DN are not graphed because their contributions to public dose are minimal.

The station emissions continue to be significantly below the station DRLs (as indicated in Table 3-1) and the resulting public dose remains a small fraction of the regulatory limit.

Elemental Tritium Airborne Emissions

DN

As indicated in Figure 3-1, since 2006 the elemental tritium (HT) emissions at DN have returned to the emissions levels prior to 2004. In 2009, the HT emissions at DN were 5.4×10^{13} becquerels (Bq). The elevated HT emissions in 2004 and 2005 had minimal impact on public dose and were the result of a rupture disk failure and a human error event at the TRF, which have since been addressed.

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PN

PN has no HT emissions as it does not have a TRF which is a producer of HT.

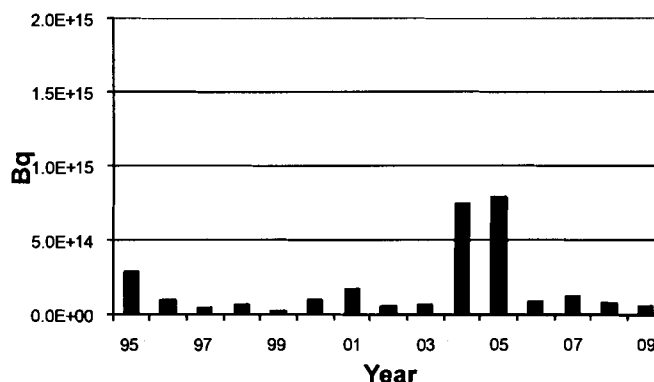


Figure 3-1: Darlington Nuclear Airborne Elemental Tritium Air Emissions

Tritium Oxide Airborne Emissions

DN

DN tritium oxide (HTO) airborne emissions have remained stable over the last 5 years. The 2009 HTO airborne emission was 1.7×10^{14} Bq.

PN

PN HTO airborne emissions decreased in 2009, though slightly higher than the average levels seen prior to 2008. Airborne HTO emissions in 2009 were 7.0×10^{14} Bq. The decrease is mostly attributed to a reduction of PN-A HTO emissions. Work is continuing in efforts to reduce HTO emissions for both PN-A and PN-B by improving leak management, improving reliability and operation of vapour recovery dryers, and reducing HTO source terms.

In May 2009, it was discovered that the tritium sampler post-media change leak check was potentially ineffective, biasing results low. Alternate sampling was invoked, which determined that emissions were approximately 20% higher than the tritium sampler results. Therefore, alternate sampling will continue to be used until the tritium sampler issue is resolved.

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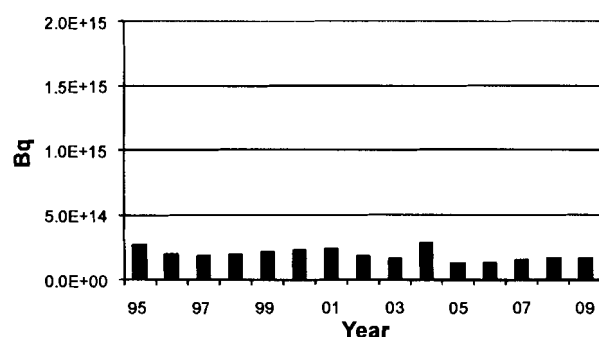


Figure 3-2: Darlington Nuclear Tritium Oxide Air Emissions

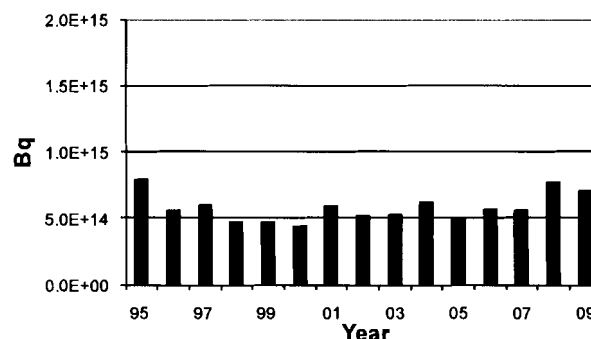


Figure 3-3: Pickering Nuclear Tritium Oxide Air Emissions

Carbon-14 Airborne Emissions

DN

DN C-14 airborne emissions have remained stable since 2004. The 2009 C-14 airborne emissions were 1.7×10^{12} Bq.

PN

PN C-14 airborne emissions trended upward from 2004 to 2007 due to a leak of carbon dioxide (CO_2) from the annulus gas into the Unit 7 moderator system. Moderator purification was increased in response to the leak to minimize airborne C-14 emissions. The emission level dropped significantly following the April 2008 replacement of the failed calandria tube that caused the CO_2 leak, and has since returned to pre-2005 levels. The 2009 C-14 airborne emissions were 2.5×10^{12} Bq.

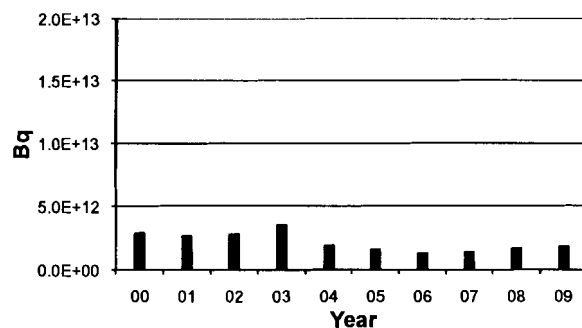


Figure 3-4: Darlington Nuclear C-14 Air Emissions

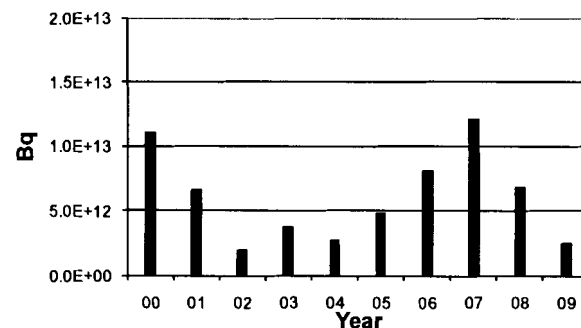


Figure 3-5: Pickering Nuclear C-14 Air Emissions

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Tritium Oxide Waterborne Emissions

DN

The reported DN HTO to water emissions have been trending slightly upward since 2004 due to a contamination issue with the autosampler in the field and therefore are not reflective of a true increase in emissions. However, the more pronounced increase in emissions observed in 2007 and 2008, which were still $<0.01\%$ of the DRL, was caused by more frequent drainage of the Emergency Coolant Injection (ECI) system and regular planned discharges of Vacuum Building Dousing Water in preparation for the 2009 Vacuum Building outage. Vacuum Building outages occur once every twelve years at DN. The 2009 DN tritium to water emission was 1.9×10^{14} Bq which is reflective of the level prior to 2007.

PN

The PN waterborne HTO emissions for 2008 and 2009 were elevated compared to the values observed in prior years. In 2008, this was due to a minor heavy water leak from a Unit 1 shutdown cooling heat exchanger. The leaked water is being captured and sent to the upgraders so the heavy water can be recovered and not released. The elevated level in 2009 is due to a small Unit 1 boiler tube leak. Due to the small volume of the leak, workers have not been able to isolate the specific boiler tube of origin, therefore the condition is being monitored closely by the Chemistry Technical group until repairs are feasible. Repairs to both the shutdown cooling heat exchanger leak and boiler tube leak are planned during the 2010 outage. PN tritium to water emissions were 4.0×10^{14} Bq in 2009.

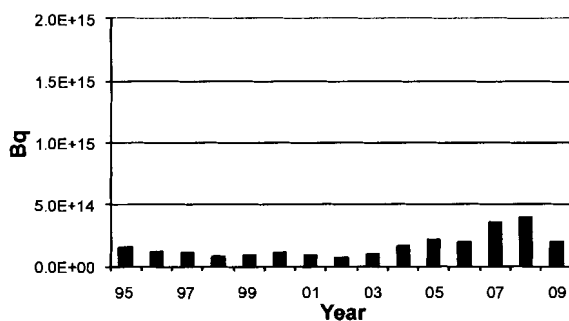


Figure 3-6: Darlington Nuclear Tritium Oxide Water Emissions

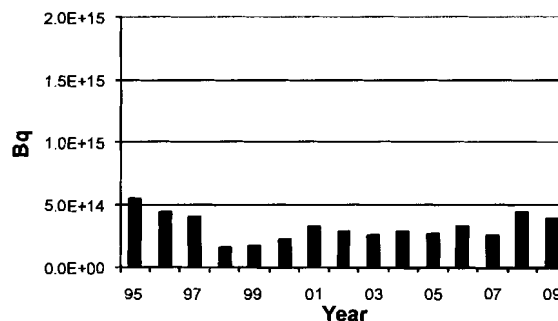


Figure 3-7: Pickering Nuclear Tritium Oxide Water Emissions

3.4 OPG Nuclear Carbon-14 Inventory Data

The C-14 inventories within the PN and DN stations are included in this report to fulfill a regulatory commitment to the CNSC. The 2009 estimates of C-14 inventory within the PN and DN stations are 7.6×10^{14} Bq and 6.5×10^{14} Bq, respectively [R-2].

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4.0 2009 SAMPLING AND ANALYSIS PLAN

The local members of the public living and working around a nuclear power station may be exposed to radiation dose due to radionuclide emissions from the plant via various pathways, such as food ingestion, inhalation, and water ingestion, as shown in Figure 4-1, Model of Exposure Pathways from Station Emissions. The dose impacts from all radionuclides and their dose pathways vary widely, with some being more significant than others.

The REMP's are designed to meet the three main objectives described in Section 2.0, but most important is the objective to ensure the significant human exposure pathways and radionuclides for the most affected receptors are routinely monitored so that the best estimate of site public dose can be performed. To do this, a site specific survey is conducted in the areas within approximately a 10 km radius from DN and PN sites. Data from the site specific surveys are used to establish the lifestyle characteristics (e.g., drinking water sources, consumption of local products, etc.) of the population around the sites and to identify the various potential critical groups for each site as defined in Section 4.1. Also, a site specific pathway analysis is performed to identify the important radionuclides and human exposure pathways. The results of these two studies, along with the REMP governing documents and individual site programs, form a basis for establishing the annual sampling plan for the site REMP's. Every 5 years, the site specific survey and pathway analysis are reviewed and the sampling plans are updated based on these results.

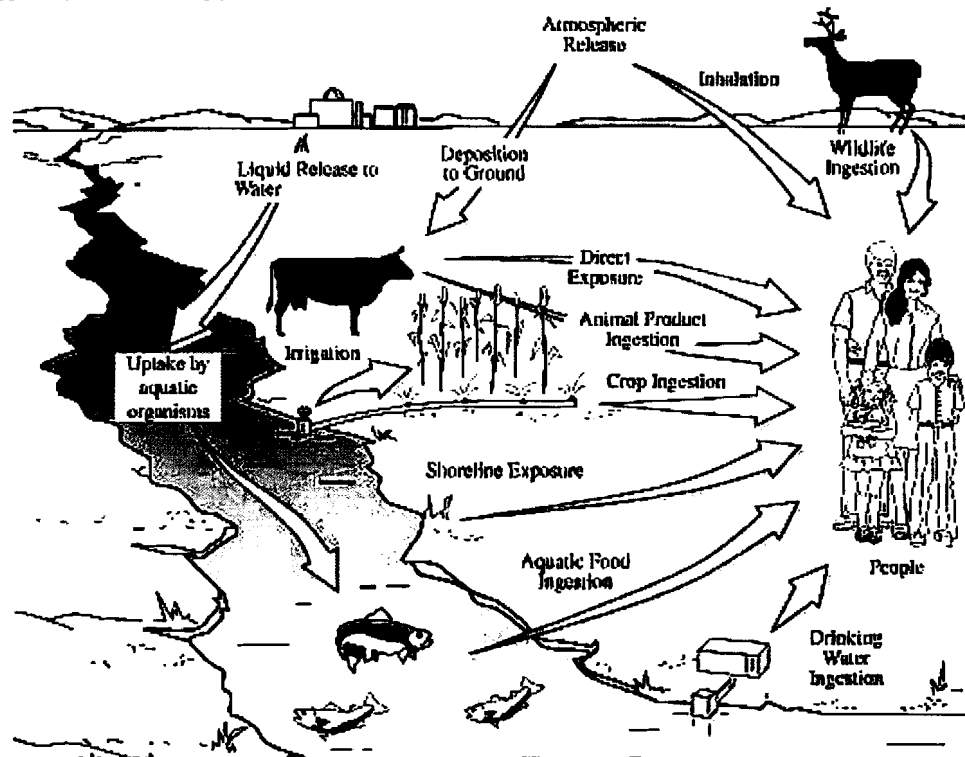


Figure 4-1: Model of Exposure Pathways from Station Emissions
Source: Based on United States Department of Energy/Hanford Site

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS**4.1 Critical Groups and Representative Person**

Members of the public living near the nuclear generating stations are represented using the "Critical Group" concept. Doses received by individual members of the public, as a result of station operations, vary depending on factors such as proximity to the station, diet, behavioural habits, age, and variations in environment. Individuals who form a homogeneous group with respect to these exposure factors can be grouped together into "potential critical groups". An individual with the average characteristics of the group is known as the "Representative Person" as described in CSA N288.1-08 [R-14].

The site specific surveys identified six potential critical groups at the PN site and nine potential critical groups at the DN site. The critical group, and corresponding Representative Person, that receives the highest annual dose may vary from year to year, therefore doses are calculated for all potential critical groups. The highest estimated potential critical group dose for each site establishes the official public dose for that site.

4.2 REMP Sampling Plan

The REMP sampling plan outlines the radionuclides monitored, the locations, types and number of samples collected, and the analyses performed on each sample. Table 4-1 provides a summary of the samples collected and the frequency of sample collection and analysis.

Samples are collected at station boundary locations as well as at critical group locations. Boundary locations are generally located close to the station perimeter. In Appendix D tables, the following represent boundary locations: D1, D2, D3, D4, D5, D6, P2, P3, P4, P6, P7, P8, P9, P10, and P11. Critical group sample locations are at the location of critical group members. For sample types that are not available at critical group locations, radionuclide concentrations at the critical group are estimated using atmospheric dispersion factors calculated from concentrations at the boundary locations.

The required sample media and locations are reviewed every 5 years after the site-specific surveys have been conducted. In the most recent reviews [R-37] [R-38], the existing REMP sampling programs were found to fulfill the sampling requirements for dose assessment purposes.

4.2.1 Radionuclides Monitored

Radionuclides that are emitted from PN and DN station operations are monitored in the REMP and are listed below. The specific sample analyses used in the public dose calculation are indicated in Table 4-1.

C-14 – is produced from the operation of nuclear stations. It is also a naturally occurring radionuclide and a by-product of past nuclear weapons testing with average background concentrations between 220 becquerels per kilogram carbon (Bq/kg-C) to

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240 Bq/kg-C. C-14 values detected above background are included in the dose calculation.

HTO – is a tritiated water molecule. T is used to represent an H-3 atom. HTO is a normal station emission of CANDU plants. Concentration measured in plants and animals refer to the HTO concentration in the free water portion of the sample.

HT – is a tritiated hydrogen gas molecule. HT is present in the atmosphere as a result of the emissions from the TRF at DN. Pickering does not have HT emissions. HT is modeled from emissions and not monitored in the environment.

Organically Bound Tritium (OBT) – is tritium that is bound to the organic molecules in organisms and is not readily exchanged with other hydrogen atoms. OBT is incorporated during the formation of the plant and animal products where HTO is present. As discussed in Section 5.5.2, OBT is monitored but sample results are not used in dose calculations as a standard method of measurement still needs to be established. OBT doses are currently modeled from HTO concentrations measured in terrestrial samples and fish.

Noble Gases – Radioactive noble gases released from the DN and PN plants are mostly Argon-41 (Ar-41), Xenon-133 (Xe-133) and Xenon-135 (Xe-135). The environmental detectors that measure noble gas doses may also detect Iridium-192 (Ir-192) skyshine from industrial radiography carried out in the stations.

Iodine-131 (I-131) – The dose from radioiodine emissions is calculated from I-131 emissions, with the assumption that I-131 emissions are accompanied by an equilibrium mixture of other short lived iodine fission products (i.e., I-132, I-133, I-134 and I-135) or mixed fission products [I(mfp)]. I-131 is monitored in milk, but is not normally detected, therefore concentrations modeled from emissions are used for dose calculations.

Particulates and gross beta-gamma – Atmospheric particulate emissions are represented by Cobalt-60 (Co-60) and liquid effluent beta-gamma emissions are represented by Cesium-137 (Cs-137) as this provides the most conservative assignment of dose. Cs-137 is also present in the environment as a result of historic weapons testing. Cobalt-60 (Co-60) and Cesium-134 (Cs-134) are representative of station emissions and are analyzed together with Cs-137, which helps distinguish between the Cs-137 resulting from station operations and that from weapons testing. Cs-137+ indicates that progeny are included.

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS**Table 4-1: Environmental Samples Used for the Darlington and Pickering REMP**

Environmental Medium of Interest	Radionuclides(s) Monitored	Sampling Frequency	Analyses Frequency
SAMPLES USED FOR PUBLIC DOSE CALCULATIONS			
Atmospheric Sampling			
Air	HTO (active monitor)	Continuously	Monthly
Air	HTO and C-14 (passive monitor)	Continuously	Quarterly
Air	Noble gases (Ar-41, Xe-133, Xe-135) and Ir-192, I-131*	Continuously	Reported monthly
Terrestrial Sampling			
Fruits, Vegetables, Silage	HTO and C-14	Annual (harvest)	Annual
Milk	HTO and C-14	Weekly	Monthly composite
Aquatic Sampling			
Municipal Drinking Water	HTO	2-3 times/day	Weekly composite
Well Water	HTO	Monthly	Monthly
Lake Water	HTO	Monthly	Monthly
Fish	HTO, C-14, Cs-137, Cs-134, Co-60	Bi-annual (June and November)	Annual
Beach Sand	Cs-137, Cs-134, Co-60	Annual	Annual
SAMPLES FOR OTHER REMP OBJECTIVES			
Air	Noble Gases (Thermoluminescent dosimeters)	Continuously	Quarterly
Precipitation	HTO	Monthly	Monthly
Dry/Wet Fallout	Gross beta	Monthly	Monthly
Fruits, Vegetables, Silage	OBT	Annual (harvest)	Annual
Garden and Inland Soils	Cs-137, Cs-134, Co-60	Annual (harvest)	Annual
Milk	I-131	Weekly	Weekly composite of locations
Milk	OBT	Weekly	Monthly
Municipal Drinking Water	Gross beta	2-3 times/day	Monthly composite
Well Water	Gross beta	Monthly	Quarterly composite
Fish	OBT	Bi-annual (June and November)	Annual
Sediment	C-14, Cs-137, Cs-134, Co-60	Annual	Annual

*air kerma is measured and converted to external air immersion dose

4.2.2 Atmospheric Sampling

Samples of air, precipitation, and fallout are collected to monitor the environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclide analyses performed and the sample collection frequency are detailed in Table 4-1 and discussed below.

Noble gas dose rate monitors and thermoluminescent dosimeters (TLDs) are set up around the sites and at background locations to continuously monitor external gamma dose.

The results of atmospheric sampling are summarized in Section 5.1 and detailed data is given in Appendix D, Environmental Monitoring Data, Tables D1 to D5.

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4.2.2.1 Air

Tritium Oxide

HTO in air around PN and DN is sampled continuously by two technologies; the molecular sieve (active) sampler and the passive sampler. The active sampler collects water vapour by passing air continuously at a steady rate through two molecular sieve canisters. The passive sampler works by diffusion of HTO molecules into a vial containing a sink consisting of a mixture of water and ethylene glycol. Passive sampling technology has been used to sample HTO in air on a trial basis to confirm its suitability to replace the molecular sieve technology. Details on results of the passive tritium sampling test program are presented in Section 5.5. OPG uses the higher HTO in air value at locations where both technologies are available to ensure the dose estimates remain conservative.

The active samplers are located at six site boundary REMP monitoring locations around DN and nine around PN, as identified in Figures C1 and C2 in Appendix C. These samples are collected and analyzed monthly.

The passive samplers are placed at most critical group locations and at several locations where the molecular sieve samplers already exist to allow a comparison of the two technologies. In total there are thirteen passive sampling locations around DN and nine around PN. The passive samplers are replaced and analyzed quarterly.

The background concentrations of HTO in air are measured at seven locations considered to be far from the influence of OPG nuclear stations. The HTO in air at these locations is measured using a combination of active and passive samplers.

Carbon-14

For 2009, C-14 in air was sampled using passive sampling technology. Years of side by side comparison between active and passive samplers provided confidence in the passive C-14 sampler. The performance of the passive C-14 sampler was assessed and documented as an acceptable method of measuring environmental concentration of C-14 in air [R-4].

The passive C-14 sampler works by absorption of CO₂ in air into soda lime pellets exposed for a period of an annual quarter. Samples are analyzed after each quarter.

C-14 in air concentrations were measured at ten critical group locations around DN and three site boundary locations, and at nine critical group locations around PN, three of which are also site boundary locations. Since C-14 in air is not a significant dose pathway via inhalation, it is not necessary to measure C-14 in air at all boundary locations. Only the high wind frequency sectors were chosen as site boundary monitoring locations for PN and DN.

Background concentrations of C-14 in air were measured at six locations considered to be far from the influence of OPG nuclear stations.

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Noble Gas Detectors

Doses from noble gases, Ir-192, and I-131 are measured using sodium iodide (NaI) spectrometers set up around the DN and PN sites. There are a total of seven detectors around the DN site boundary and nine detectors around the PN site boundary. These detectors continuously monitor doses and an annual total is used in the dose calculation.

Thermoluminescent Dosimeters

TLDs measure total gamma dose from background, as well as any gamma emitting radionuclides in the air, or radiography skyshine. Any normal station contribution is too small to be distinguished from the high and variable contribution from natural background because TLDs do not distinguish between different contributing radionuclides. However, a significant station emission would be captured by the TLD at levels where the noble gas detectors may become saturated.

A total of six TLDs are placed around the DN site boundary and four TLDs are located at critical group locations. PN has a total of nine TLDs around the site boundary and one TLD at a nearby critical group location.

Background measurements are taken at eleven locations around Ontario.

All TLDs around DN, PN and at background locations are collected and analyzed every quarter.

4.2.2.2 Precipitation and Wet/Dry Fallout

Precipitation and wet/dry fallout samples are collected monthly and analyzed for HTO and gross beta activity. Precipitation data is not used in the calculation of public dose but the long term data assists in understanding other indicators such as HTO in biota and HTO which will eventually reach the shallow drinking water well aquifers.

Samples were collected from twenty locations around DN and fourteen locations around PN. However, an assessment in 2009 determined that the number of sample locations was excessive, therefore starting in August 2009 this was reduced to six locations around DN and six locations around PN which provide representative overviews of each area. Precipitation and wet/dry fallout samples are not obtained from background locations.

4.2.3 Terrestrial Sampling

Terrestrial biota receive exposure from both airborne and waterborne emissions, as indicated in Figure 4-1. Cow's milk, for example, is affected by the air, plants, and various water sources that the cow consumes. It is therefore important to consider the combined effect of all these pathways when assessing the station impact on terrestrial samples.

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Samples of soil, fruits, vegetables, honey and milk are collected to monitor the environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclide analyses performed and the sample collection frequency are summarized in Table 4-1 and discussed below.

The results of terrestrial sampling are summarized in Section 5.2 and detailed data is given in Appendix D, Tables D10 to D12.

4.2.3.1 Garden and Inland Soils

As part of the operation of OPG nuclear stations, Cs-134, Cs-137 and Co-60 are released to the environment. These radionuclides can deposit on surrounding soil from the atmosphere and through irrigation. Soil samples around DN, PN, and background locations are collected and analyzed for gamma emitters to establish if OPG operations are having an effect on the surrounding soils.

Four samples of garden soils and two open field (undisturbed soil) samples are obtained at local farms and residences close to the DN site.

One garden soil and one open field sample are obtained from location P11 located NW of the PN site.

Replicate soil samples are collected from three background locations (Cobourg, Goderich, and Lakefield).

Soil data is not used in the calculation of public dose but the long term trend assists in understanding and verifying transfer model calculations.

4.2.3.2 Fruits, Vegetables, Silage and Honey

Samples of fruits, vegetables and silage representative of the 2009 growing season were taken from the vicinity of the DN and PN sites. Analyses were carried out for C-14 and HTO.

Sample locations, from which fruit, vegetable and silage samples were taken, in background locations and the areas surrounding DN and PN are shown in Appendix C, Maps of Environmental Monitoring and Critical Group Locations, Figures C1 to C3. Where multiple sample types were available (e.g., carrot and corn at a given location) the samples were combined into composites for analysis.

A number of commercial apiaries are located in the DN and PN area from which honey samples were obtained and analyzed for HTO, C-14, and gamma emitters. C-14 and gamma results have been consistent over the last 10 years, with HTO results corresponding roughly to air emissions trends. Since historical data has been consistent and honey samples are not used in the dose calculation (dose from honey is modeled from air emissions), starting in 2010 the frequency of sample collection will be reduced to once every five years.

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A total of thirty-three fruit and vegetable samples were obtained from various critical group locations around DN along with five silage samples. The population around PN is much more urban and, as a result, fewer residents in the surrounding areas grow their own fruits and vegetables. A total of twenty-four samples were collected from critical group locations around PN including one locally grown silage sample.

4.2.3.3 Milk

Milk sampling is used to estimate the portion of dose received from milk ingestion for the Dairy Farm critical group. Milk consumed by other members of the public consists of a composite of many dairy farms across Ontario. Values in this report are not representative of milk sold at a grocery store and are only applicable to residents of the surrounding dairy farms consuming raw milk.

Milk samples are collected weekly from dairy farms around DN and PN. For each of the site programs (DN and PN), a portion of the weekly samples from all dairy farms is combined to form a weekly composite sample and analyzed for I-131. At the end of the month, a portion of the weekly samples from each farm is combined to form a monthly composite for each farm and analyzed for HTO and C-14. Quarterly samples from background locations are collected and analyzed for HTO, C-14 and I-131.

Milk samples are collected from five dairy farms around DN, three dairy farms around PN and two dairy farms in background locations.

4.2.4 Aquatic Sampling

Samples of drinking water sources (municipal and well water), lake water, lake sediment, beach sand and fish are collected to monitor the aquatic environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclide analyses performed and the sample collection frequency are detailed in Table 4-1 and discussed below.

The results of aquatic sampling are summarized in Section 5.3 and detailed data is given in Appendix D, Tables D6 to D9.

4.2.4.1 Lake Water and Water Supply Plants

Samples of drinking water are taken during each 8-12 hour shift at water supply plants (WSPs) that supply water to Durham Region and the City of Toronto. Weekly composites of these samples are analyzed for HTO, and monthly composites are analyzed for gross beta activity.

The locations of the WSPs sampled relative to the nearest nuclear station discharge are indicated in Table 4-2.

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Table 4-2: Water Supply Plants Monitored and Distance from Stations

	Distance from Site
DN AREA WSPs	
Bowmanville WSP	7 km ENE of DN
Newcastle WSP	13 km E of DN
Oshawa WSP	8 km W of DN
PN AREA WSPs	
R.C. Harris WSP	22 km WSW of PN
Horgan WSP	11 km SW of PN
Ajax WSP	7 km ENE of PN
Whitby WSP	12 km ENE of PN

Lake water samples (non-drinking water) from three beach area locations around PN and two beach area locations around DN are collected and analyzed monthly for HTO and quarterly for gross beta activity.

Background grab samples are taken quarterly from drinking water supplies throughout the province and analyzed for HTO and gross beta activity.

4.2.4.2 Well Water

Monthly well water samples are collected from fifteen wells around the DN area (seven farms/dairy farms and eight residential locations).

Monthly well water samples are collected from seven wells around the PN area. Due to the urbanization of the area around PN, there are fewer residents that obtain their water from wells and most rely on the municipal water supply.

Samples are analyzed monthly for HTO and quarterly for gross beta activity.

4.2.4.3 Fish

At the DN site, fish sampling takes place over the cooling water discharge diffuser. At the PN site, the sampling location is in the PN-B outfall. Background locations in Lake Ontario were chosen to be a sufficient distance away from the influence of the stations.

- Target fish species to be collected at each site and at background locations are Lake Whitefish and White Sucker, with Round Whitefish and Brown Bullhead as their respective backup species.
- Eight replicate fish samples are collected and analyzed at each location.
- Four replicate samples of pan fish (i.e., crappie, sunfish, etc.) are obtained from McLaughlin Bay in Darlington Provincial Park, as campers are known to fish in this area.

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- HTO, C-14, Co-60, Cs-134, Cs-137, and Potassium-40 (K-40) measurements are performed on each replicate fish species sample.

4.2.4.4 Sediment

Lake bottom sediment can be an indicator of potential radionuclide build-up in the environment. Four replicate samples of sediment are obtained from each of three locations around the DN site, four locations around the PN site and two Lake Ontario background locations.

Samples are collected and analyzed annually for Cs-134 and Co-60, which are solely reactor produced, and for Cs-137 and C-14 which are a product of reactor operations and nuclear weapon tests.

Since sediment samples are not utilized in the dose calculation and historical data has shown no indication of accumulation, starting in 2010, the frequency of sample collection will be reduced to once every five years.

4.2.4.5 Beach Sand/Silt Samples

Sand/silt from beaches around DN and PN sites are collected annually as it represents a potential pathway for external dose. Gamma spectrometry is performed on these samples.

Beach sand samples were collected at Cobourg to determine the Cs-137 concentration in provincial background sand due to atmospheric weapons test fallout. Wave action continuously moves the beach sand around disturbing the original deposition patterns of cesium and, as a result, it is not possible to establish accumulation unless the concentrations of Cs-137 are significantly higher than background.

4.2.5 Sewage Sampling

The York-Durham Water Pollution Control Plant (WPCP) is located about 2 km E of the PN site. The WPCP treats sewage effluent streams from the PN site and from York-Durham Regions, and a portion of the resulting sludge is incinerated. Sewage sludge from the DN site sewage treatment plant may also be shipped to the York-Durham WPCP for treatment and disposal. This sludge is sampled and analyzed at DN before shipment to check for radioactivity. It is important to note that there is radioactivity in the sewage streams from sources other than PN and DN, primarily from the use of radionuclides in medical diagnosis and treatment.

4.2.5.1 WPCP Incinerator Ash

WPCP incinerator ash is collected as it is the form of sewage that has the highest concentration of gamma emitting radionuclides and has the potential to cause the highest dose to WPCP workers. Monthly samples of ash are analyzed by high resolution gamma spectrometry.

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4.2.5.2 PN Sewage Effluent

PN sewage effluent contains only a very small amount of incidental radioactivity from showers, toilets, janitorial sinks, etc. Since WPCP ash contains radionuclides from other sources such as medical treatment, PN sewage effluent is analyzed to determine the radioactivity of sewage leaving the property boundary that will end up at the WPCP. Weekly samples of PN sewage are analyzed for gamma emitters and quarterly composite samples, made up from the weekly samples, are analyzed for HTO and C-14.

5.0 2009 RESULTS OF ENVIRONMENTAL MONITORING DATA

This section contains the results of the environmental monitoring programs for the DN and PN sites, and those of the provincial background locations. All sampling locations are shown in Appendix C, Figures C1 to C3.

Radionuclide concentrations in the environment are low and at times below levels which can be detected by analytical techniques. In these situations the analytical result is reported as being below the detection limit (Ld) or critical level (Lc).

Lc: The critical level where the decision is made of whether the result indicates "detected" or "not detected" in reference to a blank sample.

Ld: The limit at which there is 95% certainty of detection, or at which there is only a 5% chance of failure to detect.

When reporting the environmental measurement values in the tables in Appendix D, the following protocols were used:

- If the sample analysis is lower than the Ld of the analytical method but higher than the Lc, the actual measurement is reported and is in bold type.
- If the measurement is less than the Lc, then "< Lc" is reported.
- When measurement averages are calculated, they are based on actual results obtained even if they are below the Lc.
- Gamma spectrometer results are reported as "< Ld" when their actual values are below the Ld.

5.1 Atmospheric Sampling

5.1.1 Air

Tritium Oxide

The 2009 annual average results of airborne HTO measured by the passive HTO samplers and the molecular sieve monitors at the DN, PN, and background sites are

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summarized in Appendix D, Table D3. See Section 5.5.2 for additional information on the active and passive HTO in air samplers.

The annual average HTO in air measured at the background locations was consistently below the active and passive samplers detection limits of 0.2 Bq/m³ and 0.3 Bq/m³, respectively. In 2009, the active sampler at Lambton experienced a problem with absolute humidity results that were much higher than the normal range. As this is indicative of a sampler problem, sample results for the months that exhibited this issue were not utilized in Lambton's annual average calculation. Therefore, the background average for active samplers was calculated based on 11 months of sample results from Nanticoke and 6 months of sample results from Lambton.

The boundary average values provide a valid year to year comparison of the HTO in air concentration around the sites since the measurements are consistently taken at the same locations. Apart from the station emissions, which are the main contributor to HTO concentrations in air, the levels of HTO observed in the environment are also affected by the wind direction, wind speed, ambient humidity, and seasonal variations. As such, fluctuations from year to year are expected even if station HTO emissions remain constant.

DN

The annual average HTO in air concentrations measured by the passive samplers ranged from 0.3 to 2.1 Bq/m³ around DN critical group sampling locations. These measurements were used in the public dose calculation.

The 2009 HTO in air annual average concentrations measured at boundary locations by molecular sieve samplers ranged from 0.3 to 0.9 Bq/m³. The average boundary concentration of 0.5 Bq/m³ is consistent with those observed in the environment over the last 5 years which fluctuate between 0.6 and 1.0 Bq/m³, as illustrated in Figure 5-1.

PN

The annual average HTO in air concentrations measured by the passive samplers ranged from 0.7 to 30 Bq/m³ around PN critical group sampling locations. These measurements were used in the public dose calculation.

The 2009 HTO in air annual average concentrations measured at boundary locations by molecular sieve samplers for PN ranged from 1.5 to 15.7 Bq/m³. The average boundary concentration of 6.4 Bq/m³ is consistent with those observed in the environment over the last 5 years which fluctuate between 6.2 and 7.7 Bq/m³, as illustrated in Figure 5-2.

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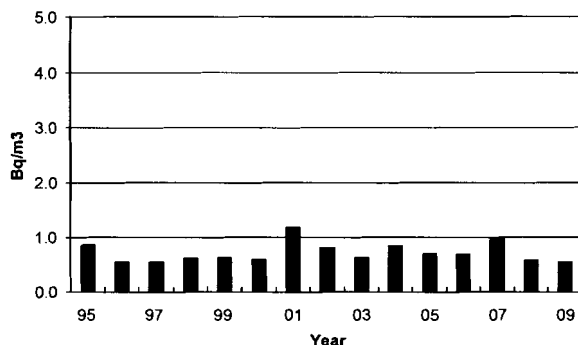


Figure 5-1: Darlington Nuclear Boundary Average HTO in Air

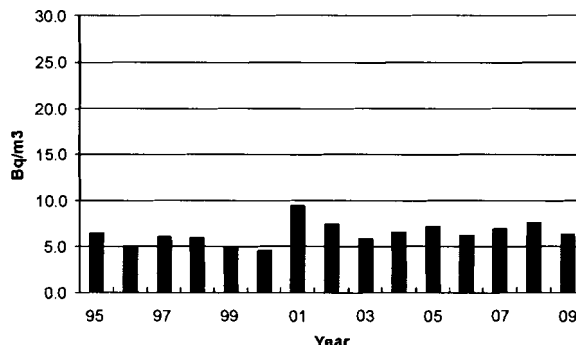


Figure 5-2: Pickering Nuclear Boundary Average HTO in Air

Carbon-14

The 2009 annual averages of airborne C-14 measured at the DN, PN and background sampling locations are summarized in Appendix D, Table D4.

C-14 is naturally occurring in the environment but is also a by-product of past nuclear weapons testing from the early 1960's. C-14 background concentrations around the world are currently decreasing as weapon test C-14 is being removed naturally from the environment. Pre-atmospheric weapons test levels were measured at 226 Bq/kg-C [R-11]. The annual average C-14 in air concentration observed at background locations was 245 Bq/kg-C in 2009.

DN

The annual average C-14 in air concentrations measured at the DN critical group sampling locations ranged from 228 to 272 Bq/kg-C. The 2009 C-14 in air average concentration measured at select high wind frequency boundary locations around DN was 259 Bq/kg-C. The values observed in the environment in previous years are illustrated in Figure 5-3, which shows that the 2009 average is consistent with levels observed in the environment over the last 5 years.

PN

The annual average C-14 in air concentrations measured at the PN critical group sampling locations ranged from 240 to 556 Bq/kg-C. The 2009 C-14 in air average concentration measured at select high wind frequency boundary locations around PN was 466 Bq/kg-C. The values observed in the environment in previous years are illustrated in Figure 5-4. In 2009, the average C-14 concentration in air decreased significantly based on data from three boundary locations. This trend reflects the lower station C-14 airborne emissions discussed in Section 3.3.

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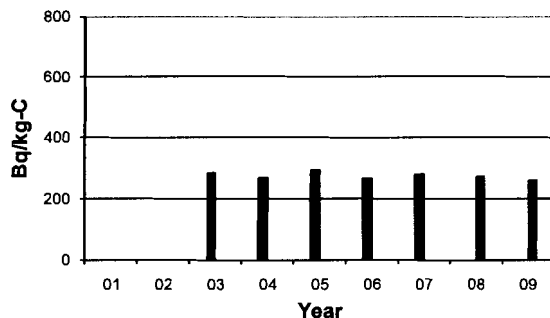


Figure 5-3: Darlington Nuclear Boundary
Average C-14 in Air

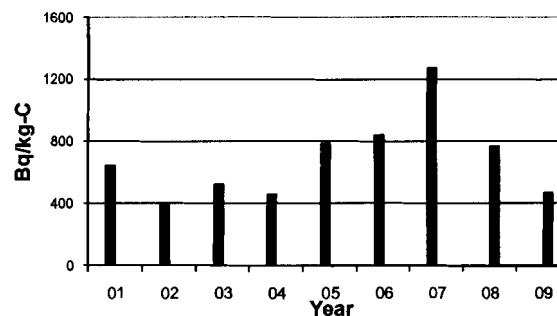


Figure 5-4: Pickering Nuclear Boundary
Average C-14 in Air

5.1.2 External Gamma

Noble Gas Detectors

The annual boundary average noble gas dose rate is estimated from the monthly data from each detector. For periods where data from one or more detector(s) was unavailable, the dose rate was estimated using the ratio of wind frequencies from the adjacent wind sector(s) to the missing wind sector. This ratio was then multiplied by the corresponding dose rate measured in the adjacent wind sector(s) during that period of time.

Results obtained in 2009 from the noble gas detectors are summarized in Appendix D, Table D2 and discussed below.

DN

Due to a different station design, DN does not experience the same level of emissions of noble gases as PN. The DN boundary average dose rates for Ar-41, Xe-133, Xe-135, Ir-192 and I-131 were all below the detection limits.

PN

Ar-41 is the predominant radionuclide measured in noble gas around PN followed by Xe-133 and Xe-135. The PN boundary average Ar-41 dose in air was 1.5 microgray (μ Gy)/yr in 2009.

Ar-41 emissions and measurements in the environment are largely related to the number of operating days of PN Units 1 and 4. The increasing trend of Ar-41 emissions starting in 2003 is the result of Unit 4 returning to service, and an additional contribution from Unit 1 returning to service in November 2005. In 2009, electricity power production from PN Units 1 and 4 was similar to 2008, therefore similar Ar-41 boundary average dose rates were observed. Figure 5-5 illustrates the trend of the boundary average Ar-41 dose rate for PN.

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Xe-133 and Xe-135 were also measured above the detection limit at PN. Measured boundary average values in 2009 were 0.04 $\mu\text{Gy/yr}$ for both Xe-133 and Xe-135, respectively. These values are consistent with air doses observed in previous years from Xe-133 and Xe-135.

Doses from Ir-192 and I-131 were below the detection limits.

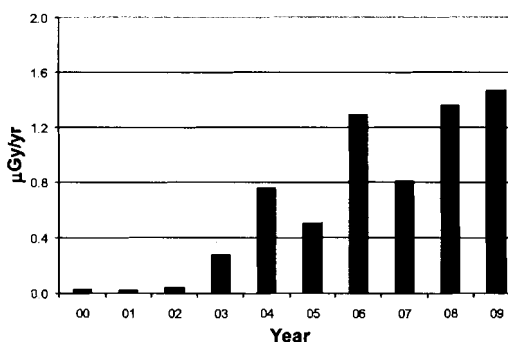


Figure 5-5: Pickering Nuclear Boundary Average Ar-41 Dose Rate in Air

Thermoluminescent Dosimeters

The 2009 annual average results from the TLDs at PN, DN and background sampling locations are summarized in Appendix D, Table D1. Figures 5-6 and 5-7 illustrate the trends in external gamma dose rates observed at DN and PN boundary locations over the last 15 years.

The 2009 boundary average external dose rates in air for the DN and PN sites remained consistent with the values established over the last 15 years. A small step change was observed in 2007 resulting from the replacement of the Panasonic TLD reader with the Harshaw TLD system. The difference was attributed to the difference in energy response between the two systems [R-3].

The 2009 background external total gamma dose rate in air averaged 492 $\mu\text{Gy/yr}$ from nine locations

DN

The boundary average external total gamma dose rate in air for 2009 was 503 $\mu\text{Gy/yr}$. This dose rate is mainly representative of background contributions.

PN

The boundary average external total gamma dose rate in air for 2009 was 460 $\mu\text{Gy/yr}$. This dose rate is mainly representative of background contributions.

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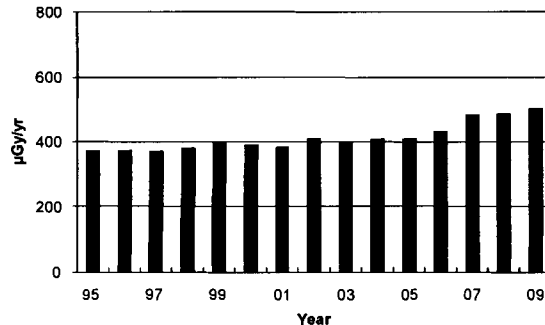


Figure 5-6: Darlington Nuclear Boundary Average TLD Gamma Dose Rate

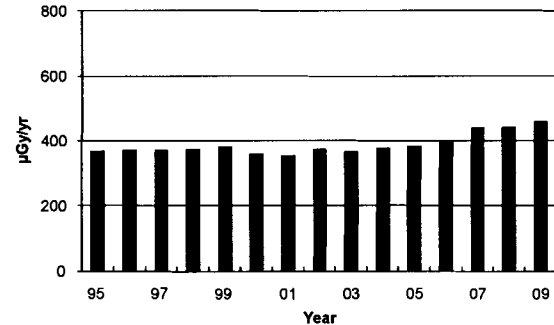


Figure 5-7: Pickering Nuclear Boundary Average TLD Gamma Dose Rate

5.1.3 Precipitation and Dry/Wet Fallout

Tritium Oxide

The 2009 annual average precipitation and wet/dry fallout sample results from DN and PN sampling locations are presented in Appendix D, Table D5, and annual trend plots of HTO in precipitation are shown in Figures 5-8 and 5-9.

HTO in precipitation values closely follow airborne HTO emissions trends.

DN

The DN boundary average tritium in precipitation value reflects the DN airborne tritium emissions trend which has been stable over the past 5 years.

PN

The decrease in PN tritium in air emissions in 2009 is reflected in the decreased level for PN boundary average HTO in precipitation.

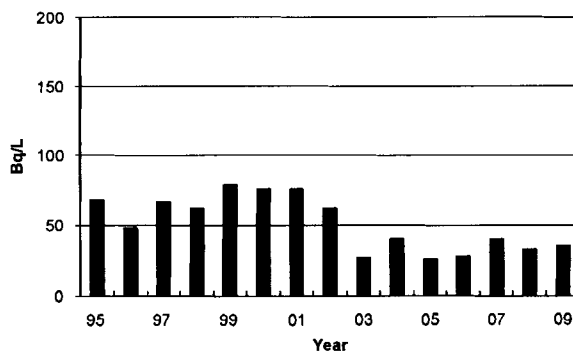


Figure 5-8: Darlington Nuclear Boundary Average HTO in Precipitation

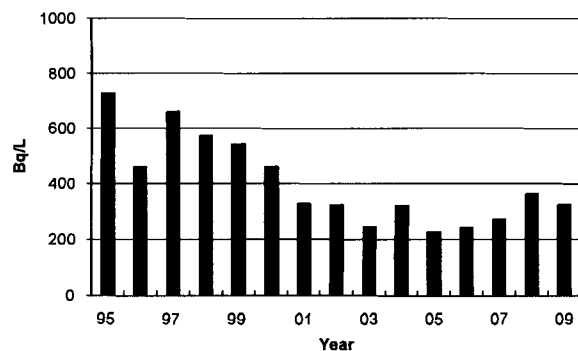


Figure 5-9: Pickering Nuclear Boundary Average HTO in Precipitation

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Gross Beta

Measurements of gross beta activity in wet/dry fallout are reported in units of Bq/(m²·month). These measurements represent the total fallout as a result of deposition of airborne radionuclides both as dry deposition and wet deposition (via precipitation). Gross beta in fallout in Canada normally averages from 5 to 40 Bq/(m²·month) on an annual basis due to radioactive fallout from natural sources (Beryllium-7 [Be-7], K-40, Uranium (U) and Thorium (Th) series radionuclides in dust from surface soil and other natural sources) and atmospheric nuclear weapons testing [R-5]. The 2009 averages for the DN and PN sites were within this range.

5.2 Terrestrial Sampling

The 2009 results of terrestrial sampling are given in Appendix D, Tables D10 to D12.

5.2.1 Garden and Inland Soils

Gamma Spectrometry

Background values of Cs-137 are present in the soil as a result of historic weapons testing fallout. However, Co-60 and Cs-134 would only be detected as a result of emissions from DN or PN.

Background soil samples analyzed in 2009 ranged in Cs-137 concentration from 0.5 Bq/kilogram (kg) to 6.3 Bq/kg. All the values around the sites except one are within the range of values seen at the background locations over the last 10 years (from 0.4 to 12.5 Bq/kg). Neither Cs-134 nor Co-60 were detected in any PN or DN soil samples in 2009. It is therefore suspected the Cs-137 measured in these soil samples is from historic weapons testing fallout and not from OPG operations.

DN

At the DN locations, Cs-137 in soil concentrations ranged from 3.9 to 15.9 Bq/kg. The non-irrigated soil at location F16, at 15.9 Bq/kg, was the only sample with a value higher than the historical range of background values. Results at this location will be examined in the subsequent year to determine if this was a one time occurrence which would not be indicative of accumulation. Cs-134 and Co-60 were not detected in any of the samples.

PN

At PN locations the Cs-137 in soil concentration was measured as 5.5 Bq/kg in the PN garden soil sample and 3.1 Bq/kg in the open area sample. Again, Cs-134 and Co-60 were not detected in any of the samples.

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5.2.2 Fruits, Vegetables, Silage

Tritium Oxide

The average HTO concentration measured in the vegetables in provincial background locations was 4.7 Bq/L for 2009. This average is based on 5 locations considered to be outside the area impacted by station operations.

HTO concentrations in vegetation around the nuclear sites tend to be variable from year to year as the values reflect the conditions (i.e., prevailing winds, HTO emissions, humidity etc.) a few hours prior to the time of sampling. Furthermore, the number of samples and their locations has changed throughout the years. These limitations should be noted when comparing long-term trends of HTO in vegetation surrounding the DN and PN sites as shown in Figures 5-10 and 5-11.

DN

Local fruit and vegetables collected around the DN site had HTO concentrations above the background average. The 2009 average concentration of HTO in vegetation was 22 Bq/L. The average concentration of HTO in vegetation measured in 2009 is consistent with values observed in the last 5 years.

PN

Local fruit and vegetables collected around the PN site had HTO concentrations above the background average. The 2009 average concentration of HTO in vegetation was 107 Bq/L. The average concentration of HTO in vegetation measured in 2009 is falls within the range of values observed in the last 5 years.

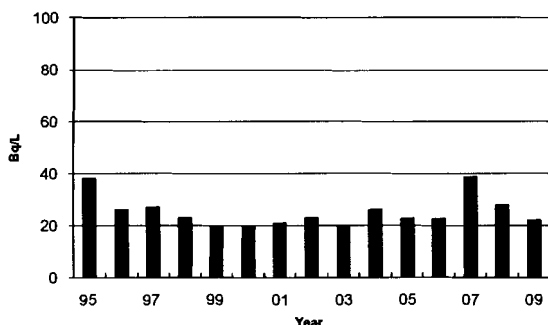


Figure 5-10: Darlington Nuclear HTO in Vegetation

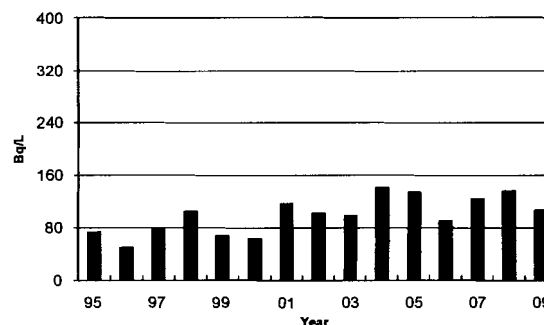


Figure 5-11: Pickering Nuclear HTO in Vegetation

Carbon-14

Background C-14 measurements have been trending downwards with time and are now similar to the conditions prior to weapons testing [R-36]. In 2009, the annual average C-14 in background vegetation was measured at 226 Bq/kg-C. This value was used as the background C-14 value for terrestrial vegetation.

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DN

The 2009 average concentration of C-14 in DN vegetation was 237 Bq/kg-C. Figure 5-12 indicates that over the long-term, C-14 levels in vegetation around DN are stable and near background levels.

PN

For PN, the average C-14 concentration in vegetation for 2009 was 288 Bq/kg-C. Figure 5-13 illustrates the trend of C-14 concentration in vegetation around PN. The increase in 2006 and 2007, and the drop observed in 2008 and 2009 emulate the trend observed in station C-14 airborne emissions discussed in Section 3.3.

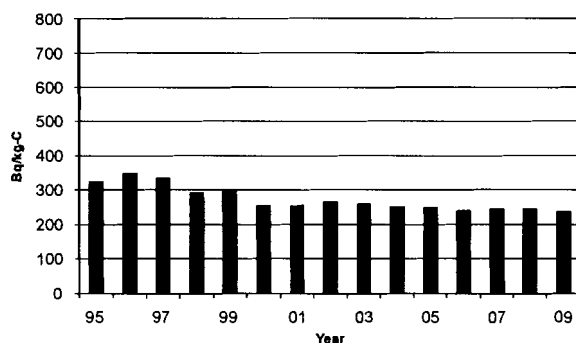


Figure 5-12: Darlington Nuclear C-14 in Vegetation

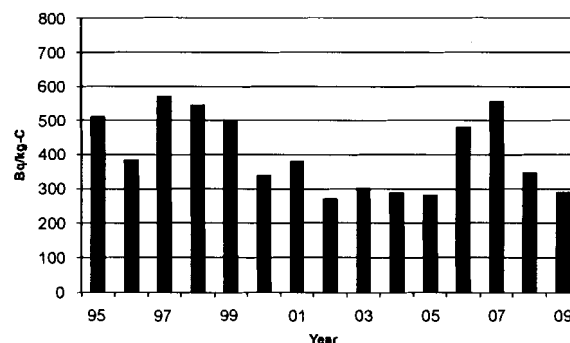


Figure 5-13: Pickering Nuclear C-14 in Vegetation

5.2.3 Milk

Annual average values of HTO and C-14 in milk are provided in Appendix D, Table D12.

The annual average HTO and C-14 in milk measurements around the nuclear sites vary from year to year due to changes in prevailing winds, emissions, humidity, cow's diet, and water sources. Furthermore, the number and location of dairy farms sampled at both PN and DN have changed over the years, which should be noted when reviewing long term trends.

Tritium Oxide

The background average HTO in milk concentration was below the Ld of 4.5 Bq/L, based on sampling at two farms outside the influence of the stations.

Due to the large distance between the dairy farms and the DN and PN sites, along with the many pathways which affect the concentration in milk shown in Figure 4-1, it is not expected that the trend of HTO in milk will follow closely with the trend of airborne HTO emissions. As expected, both the DN and PN values of HTO in milk were greater than the background average concentration.

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DN

At the DN site, the average level of HTO in milk was 6.8 Bq/L in 2009 from five dairy farms located within 15 km of the site. The trend of HTO in milk shown in Figure 5-14 indicates that the 2009 value is consistent with values observed in the past 5 years.

PN

At the PN site, the average concentration of HTO in milk was 21 Bq/L in 2009 based on three dairy farms located within 12 km of the site. The PN trend for HTO in milk shows a decline since 2004 but has remained stable since 2007 as illustrated in Figure 5-15.

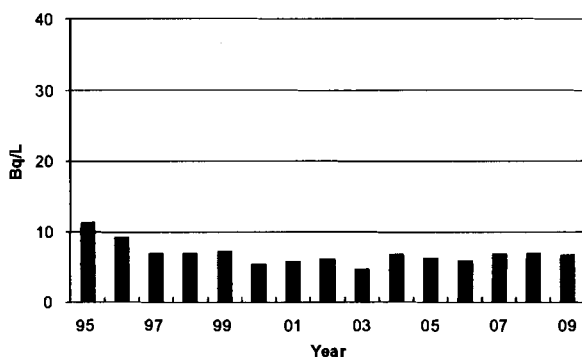


Figure 5-14: Darlington Nuclear HTO in Milk

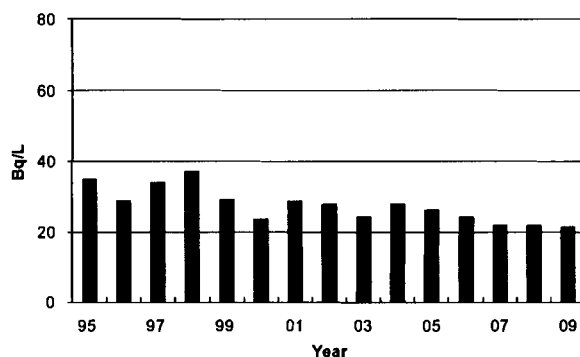


Figure 5-15: Pickering Nuclear HTO in Milk

Carbon-14

The background average C-14 in milk sampled from two farms on a quarterly basis was 226 Bq/kg-C. The 2009 C-14 levels in milk measured at the dairy farms around DN and PN are not significantly above background.

Since the cow's diet is the main contributing factor to the C-14 levels in milk, the C-14 levels in silage consumed by the cows serve as a verification of the concentrations found in milk. The silage contains C-14 from the previous year when it was grown, therefore emissions from the previous year could have an effect on the C-14 values measured in milk in the current year.

DN

The 2009 average concentration of C-14 in milk at surrounding DN locations was 238 Bq/kg-C. Figure 5-16 indicates that over the long-term, C-14 levels in milk around DN are fairly stable and near background levels. However, because concentrations are so close to background levels and C-14 in milk has a significant impact on dose to the Dairy Farm critical group, the slight decrease in 2009 has a noticeable effect on the dose to this group.

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The average C-14 concentration in silage was 243 Bq/kg-C over five samples at DN, which is within the range of values seen over the last 5 years.

PN

For PN, the average C-14 concentration in milk for 2009 was 247 Bq/kg-C. Figure 5-17 illustrates the trend of C-14 concentration in milk around PN. The concentration of C-14 in milk remains consistent with previous years and near background levels. However, because concentrations are so close to background levels and C-14 in milk has a significant impact on dose to the Dairy Farm critical group, the slight decrease in 2009 has a noticeable effect on the dose to this group.

The C-14 concentration in silage was 270 Bq/kg-C from a single sample at PN, which is within the range of values seen over the last 5 years.

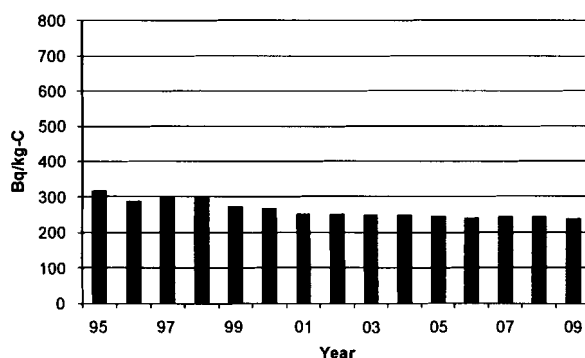


Figure 5-16: Darlington Nuclear C-14 in Milk

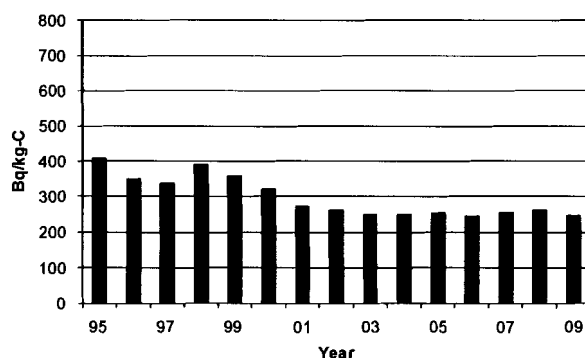


Figure 5-17: Pickering Nuclear C-14 in Milk

Iodine-131

In 2009, I-131 was not detected in any milk samples. The Ld for I-131 averaged approximately 0.1 Bq/L for all samples.

5.3 Aquatic Sampling

The results of the aquatic sampling program are given in Appendix D, Tables D6 to D9.

5.3.1 Lake Water and Water Supply Plants

The impact of HTO emissions from OPG stations on the nearby WSPs vary depending upon distance from the station, lake current direction, location and depth of the WSP intake pipe and general dispersion conditions. Annual average HTO levels at all WSPs were well below 7,000 Bq/L, which is the Ontario Drinking Water Quality Standard [R-39] limit for HTO in drinking water. OPG also met its voluntary commitment to maintain annual average HTO levels at all WSPs below 100 Bq/L.

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Tritium Oxide

HTO in Lake Ontario, along with all the Great Lakes, originates from several sources: natural cosmogenic tritium, residual tritium fallout from atmospheric weapons testing, current emissions from nuclear plants and residual HTO from past emissions of nuclear plants. For the purpose of calculating public dose resulting from OPG operations, a background HTO value that includes only natural cosmogenic tritium and residual weapons fallout tritium was used. The Lake Ontario background for 2009 was conservatively estimated to be 1.6 Bq/L, using the Great Lakes Time-Concentration Tritium Model [R-7].

The background concentration of tritium in Lake Ontario was measured at four locations farther than 40 km from either PN or DN. The average annual concentration measured was 4.4 Bq/L, which includes HTO from previous years of emissions. This supports OPG's practice of using the tritium value generated by the Great Lakes Time-Concentration Tritium model of 1.6 Bq/L as a conservative background subtract.

The monthly average HTO concentrations for 2009 at the Darlington and Pickering area WSP's are given in Figures 5-18 and 5-19.

The trend plots of all the WSPs annual average tritium in drinking water concentrations are shown in Figures 5-20 through 5-26. In the past 5 years, the annual average tritium concentrations at all WSPs have remained less than 10 Bq/L.

DN

For WSPs located in the DN area, the annual average HTO concentrations at the Newcastle, Bowmanville and Oshawa WSPs ranged from 5.0 to 6.7 Bq/L in 2009. HTO concentrations at these WSPs are consistent with results from previous years.

PN

The WSPs located in the PN area, Ajax, Whitby, Harris and Horgan, had annual average HTO concentrations between 4.6 and 6.2 Bq/L in 2009. HTO concentrations at these WSPs are consistent with results from previous years.

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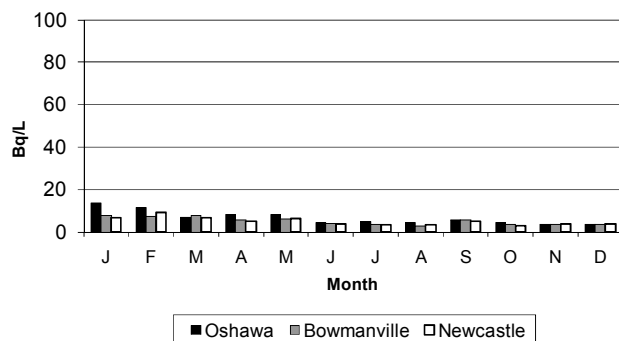


Figure 5-18: Darlington Nuclear WSPs HTO in Water Concentrations – 2009

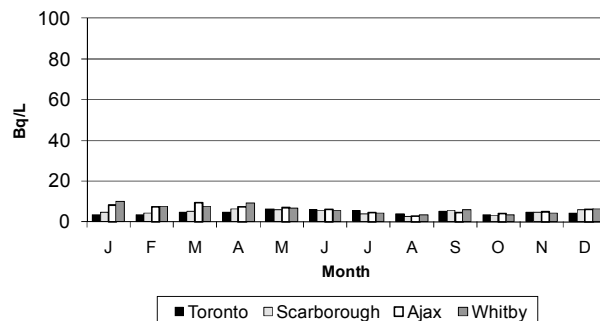


Figure 5-19: Pickering Nuclear WSPs HTO in Water Concentrations – 2009

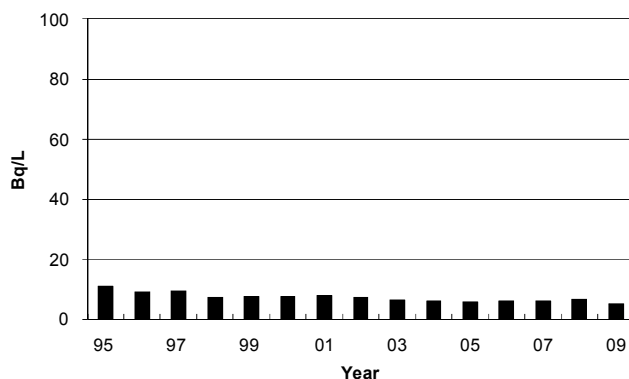


Figure 5-20: Bowmanville WSP – HTO in Water

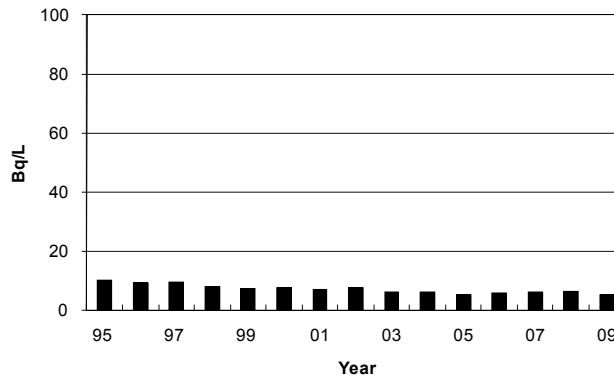


Figure 5-21: Newcastle WSP – HTO in Water

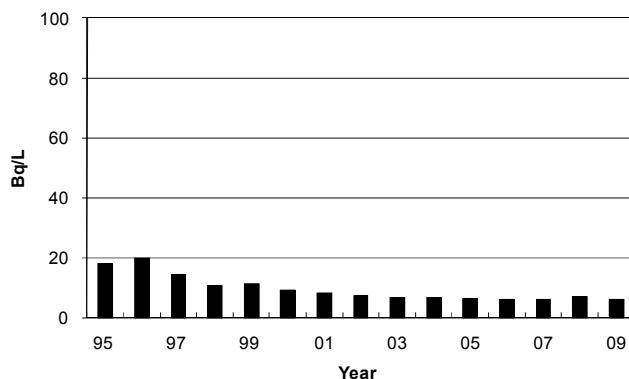


Figure 5-22: Ajax WSP – HTO in Water

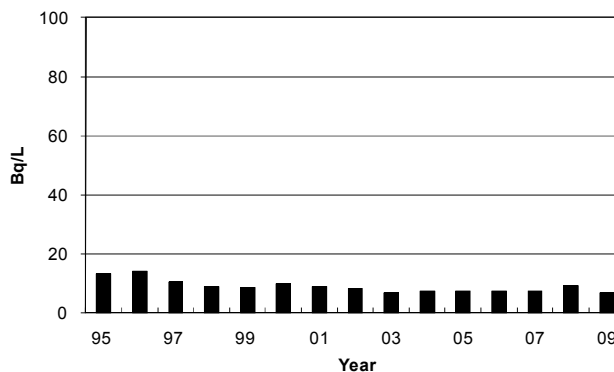


Figure 5-23: Oshawa WSP – HTO in Water

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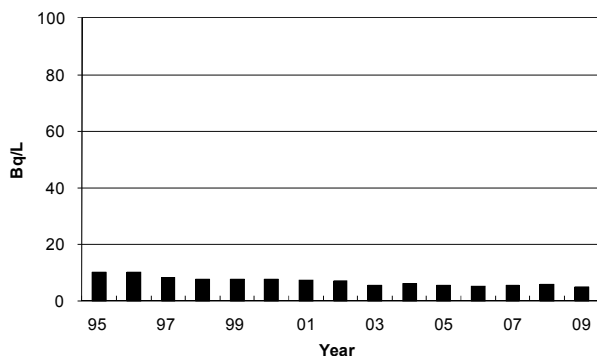


Figure 5-24: Scarborough Horgan WSP – HTO in Water

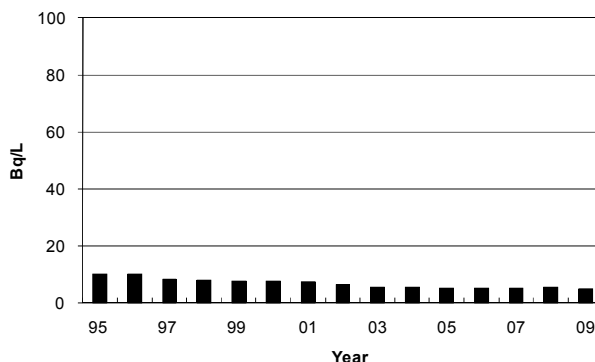


Figure 5-25: Toronto Harris WSP – HTO in Water

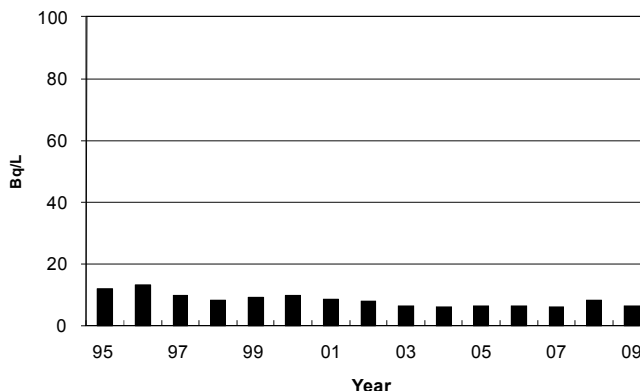


Figure 5-26: Whitby WSP – HTO in Water

Gross Beta

Annual average gross beta activity levels in samples from DN and PN area WSPs were both 0.11 Bq/L. These results are the same as the average of the four provincial background Lake Ontario measurements of 0.11 Bq/L.

5.3.2 Well Water

Monthly well water samples are collected from farms and residents near the DN and PN sites.

Tritium Oxide

HTO concentrations in well water depend on the depth of the well and thus the amount of time it takes for precipitation to reach the aquifer from where the well draws its water. Radioactive decay of the tritium during its transit time to the aquifer determines the residual activity level in the well water. Deeper wells tend to have lower HTO concentrations. Well water concentrations are also related to the level of past atmospheric HTO releases because of the time it takes for precipitation to reach the well.

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DN

The maximum annual average HTO concentration observed in well water samples collected from the DN area was 22.5 Bq/L, which is consistent with the values seen over the last 5 years.

PN

The maximum annual average HTO concentration observed in well water samples collected from the PN area was 74.9 Bq/L, which is consistent with the values seen over the last 5 years.

Gross Beta

DN

In samples from two residential wells around DN, gross beta activity was found to be higher than OPG's internal screening level of 1 Bq/L. The annual average gross beta activities at these two locations were measured as 1.2 and 1.7 Bq/L. Subsequent gamma analysis confirmed that the gross beta activity at these locations were due to naturally occurring K-40. Annual average gross beta activity from all other well water samples was below 0.4 Bq/L.

PN

Annual average gross beta activity in PN well water samples was below 0.2 Bq/L.

5.3.3 Fish

Tritium Oxide

The HTO levels in fish change quickly in response to changes in water HTO levels from station waterborne emissions. Thus, HTO concentrations measured in fish tissue reflect the HTO concentration in the water in the few hours before they were sampled. Long term graphs of fish HTO levels for PN and DN are provided in Figures 5-27 and 5-28.

In 2009, the HTO in Lake Ontario background fish samples averaged 4.1 Bq/L.

DN

The HTO levels in the DN outfall fish samples averaged 5.7 Bq/L. This value is consistent with the levels observed over the last 5 years.

PN

The HTO concentration in the PN outfall fish samples averaged 6.8 Bq/L. This value is consistent with the levels observed over the last 5 years.

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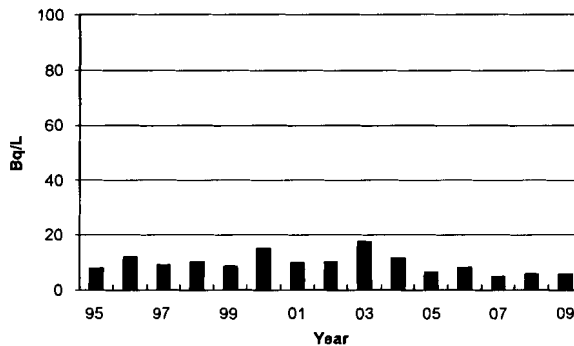


Figure 5-27: Darlington Nuclear HTO in Fish

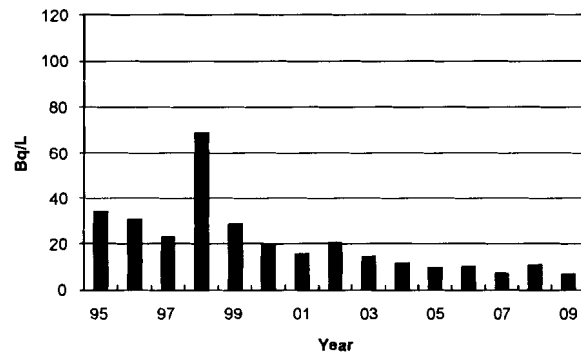


Figure 5-28: Pickering Nuclear HTO in Fish

Carbon-14

The average C-14 level in fish measured at a background Lake Ontario location was 235 Bq/kg-C in 2009.

The concentrations of C-14 in fish at both DN and PN for the past 5 years are consistent and comparable to background levels as shown in Figures 5-29 and 5-30.

DN

The 2009 annual average C-14 level in DN fish was 237 Bq/kg-C.

PN

The 2009 annual average C-14 level in PN fish was 241 Bq/kg-C.

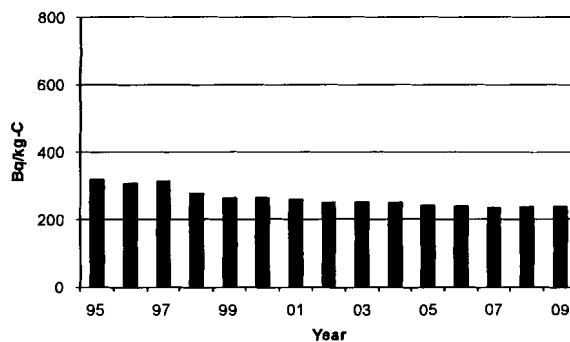


Figure 5-29: Darlington Nuclear C-14 in Fish

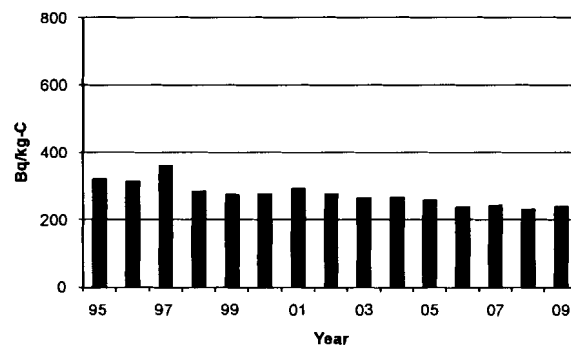


Figure 5-30: Pickering Nuclear C-14 in Fish

Gamma Spectrometry

The major portion of the gamma activity in fish is naturally occurring K-40. A small amount of Cs-137 is usually present due to nuclear weapons testing and, to a lesser extent, from reactor operation.

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The average Cs-137 value for background Lake Ontario fish was 0.3 Bq/kg.

Figures 5-31 and 5-32 illustrate that the Cs-137 levels in fish around DN and PN in the past 5 years are stable.

DN

The average Cs-137 value for DN fish was 0.3 Bq/kg, the same as background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at DN site in 2009.

PN

The average Cs-137 values for PN fish was 0.3 Bq/kg, the same as background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at PN site in 2009.

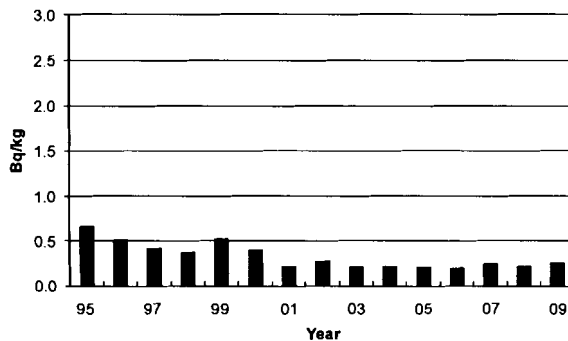


Figure 5-31: Darlington Nuclear Cs-137 in Fish

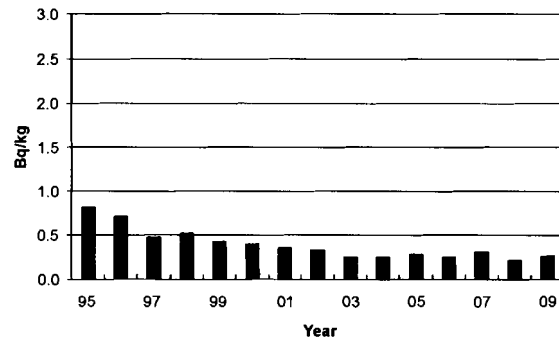


Figure 5-32: Pickering Nuclear Cs-137 in Fish

5.3.4 Sediment

Gamma Spectrometry

A major portion of the activity in sediment in the vicinity of the stations comes from naturally occurring radionuclides, such as K-40.

Background sediment samples collected at two background locations in Lake Ontario had Cs-137 concentrations ranging from 0.4 to 0.9 Bq/kg.

DN

Sediment samples collected around DN had an average Cs-137 concentration of 0.5 Bq/kg, which is within the range of background values. Cs-134 and Co-60 were not detected in any of the sediment samples at the DN site in 2009.

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PN

Sediment samples collected around PN had an average Cs-137 concentration of 1.2 Bq/kg. The Cs-137 concentration in PN surrounding sediments is slightly above the background values but is consistent with the values observed over the last 5 years, which ranged from 0.2 Bq/kg to 1.8 Bq/kg, which does not indicate accumulation.

Cs-134 and Co-60 were not detected in any of the sediment samples at PN site.

Carbon-14

The average concentrations of C-14 in sediments measured at PN, DN and background locations were below the terrestrial vegetation C-14 background level of 226 Bq/kg-C (see Section 5.2.2). This indicates the presence of low activity inorganic carbon, from lake bottom geologic material diluting the samples. The Lake Ontario background measurement of C-14 in sediments at Cobourg was 190 Bq/kg-C in 2009.

DN

Measurements of C-14 in lake bottom sediments averaged 160 Bq/kg-C around DN.

PN

Measurements of C-14 in lake bottom sediments averaged 196 Bq/kg-C around PN.

Given the low results and the uncertainty in C-14 measurements, it is not possible to observe accumulation from reactor operations.

5.3.5 Beach Sand/Silt Samples

Gamma Spectrometry

Background Cs-137 concentrations in beach sand samples measured at Cobourg averaged 0.5 Bq/kg. These values are consistent with values observed over the past 5 years.

DN

The Cs-137 concentration measured at the DN area beach was 0.2 Bq/kg. As reported in previous years, there was no Co-60 or Cs-134 detected in the sample.

PN

The Cs-137 concentrations measured at PN area beaches ranged from 0.2 Bq/kg to 0.7 Bq/kg. As reported in previous years, there was no Co-60 or Cs-134 detected in the samples.

Wave action continuously moves the beach sand around disturbing the original deposition patterns. This range of values is close to the background values measured

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and, without the presence of other radionuclides more closely related to reactor operation (such as Co-60 or Cs-134), the Cs-137 measured along the shoreline cannot be confirmed to be from OPG operations.

5.4 Sewage Sampling

The results for the PN sewage samples and the ash from the WPCP incinerator are provided in Appendix D, Tables D13 and D14.

PN

The concentrations of I-131 in ash were above the detection level and ranged from 2.5 Bq/kg to 19.3 Bq/kg. However, I-131 was not detected in any of the PN sewage samples. These results strongly suggest that PN operations are not a major contributor to the I-131 detected in the WPCP ash samples. The ash sample gamma scans also identified other radionuclides of medical or industrial origin, but these are not quantified in this report.

5.4.1 PN Sewage Effluent – HTO and C-14

The average HTO concentration in sewage was 3830 Bq/L, lower than in 2008, but still elevated compared to values reported prior to 2007 which ranged below 1600 Bq/L, with the exception of the first and second quarter of 2007. This is due, in part, to discharges of condensate from the administration building heating steam sump into a sewage sump to prevent overflow within the sump room. This discharge was stopped in February 2009 and routed to the appropriate building effluent stream. In addition, it is suspected that building heating steam is entering into the sewage sump, possibly via a leak from the Unit 1 inactive drainage system. An investigation is underway to determine the cause of the elevated tritium levels. Visual inspection of the Unit 1 steam condensate collection system and sewage system has not identified any deficiencies. Further investigation will take place during the 2010 Vacuum Building outage. The measured HTO concentration has a very small dose implication (<0.02 µSv) to the WPCP workers. C-14 was not detected in any of the quarterly composite samples.

5.5 Special Studies and Other Studies

5.5.1 Special Studies

Special Studies are conducted to investigate specific REMP issues or findings. Special Studies exclude development work such as improvement of measurement techniques or instruments.

There are currently no issues in the REMPs that require a special study.

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5.5.2 Other Studies

Cesium Bioaccumulation Factor (BAF) for Fish in Lake Ontario

Concentrations of total suspended solids (TSS) and potassium in lake water around PN, DN, and Cobourg are monitored annually to support the default cesium bioaccumulation factor (BAF) for fish of 3000 that was used in the station DRL calculations. The BAF value is based on an equation recommended by the International Atomic Energy Agency (IAEA) in the TRS-364 report [R-46] which considers the relationship of the BAF to lake water concentrations of potassium and TSS.

TRS-364 was revised in 2010 as IAEA report TRS-472 [R-48]. This revision provides an updated Cs BAF equation that is dependent only on potassium concentration in lake water. Using the past potassium concentration data, the BAF values calculated by the TRS-472 equation generally ranged from 3000-3500. Additionally, CSA N288.1-08 [R-14] recommends a Cs BAF of 3500. Therefore, this value will be used in the revision to the station DRLs.

Figure 5-33 is a graph of the Cs BAF as calculated by the TRS-472 equation.

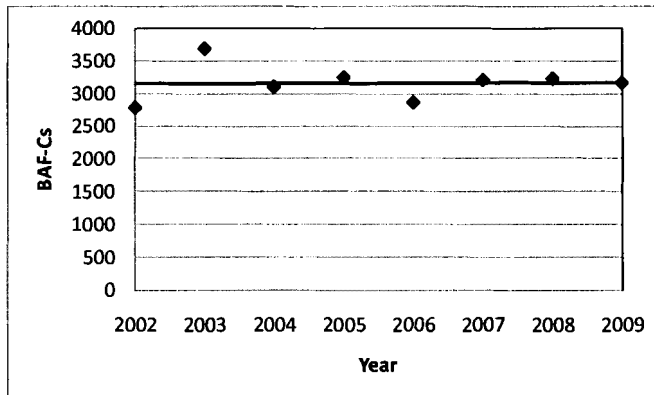


Figure 5-33: Annual Cs BAF (TRS-472)

Trend graphs for potassium and TSS concentrations in Lake Ontario for the last 5 years are provided in Figures 5-34 and 5-35. Measurement of TSS in lake water will be discontinued since it is no longer required to support the calculation of Cs BAF based on the TRS-472 equation. Since the potassium concentration in Lake Ontario is found to be relatively constant, the frequency of potassium concentration measurement will be reduced to once every three years.

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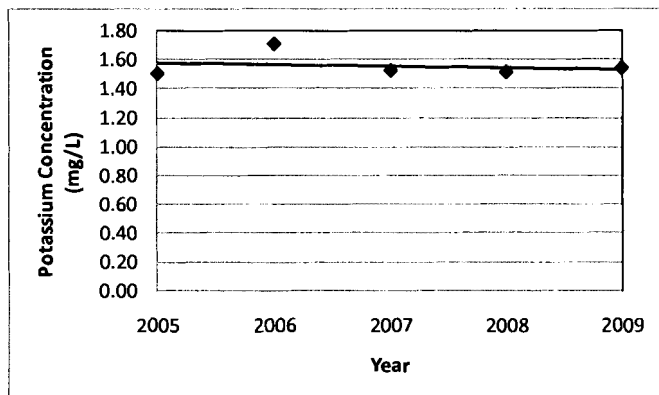


Figure 5-34: Potassium in Lake Water Trend

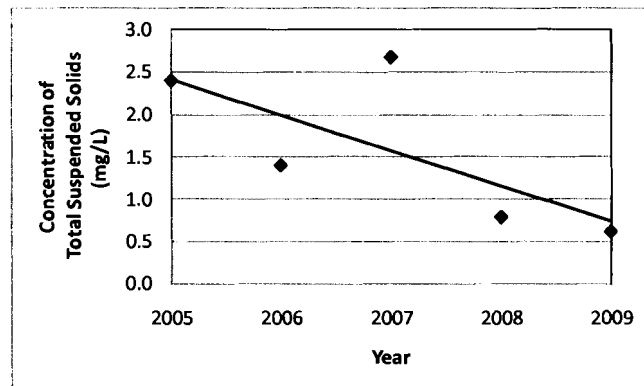


Figure 5-35: Total Suspended Solids in Lake Water Trend

Passive and Active HTO in Air Samplers

OPG has completed an assessment of the variability and accuracy of the existing active and passive tritium in air samplers used in the REMPs. The assessment was based on the results of a 2006 CANDU Owners Group (COG) study [R-6] and the results of a seven month OPG field test in 2009 with the passive sampler recommended by COG [R-41].

Results from this assessment support the conclusion that active samplers provide accurate measurements of HTO in air and are the preferred HTO in air sampling method. Therefore, OPG will continue to use the active samplers to sample tritium in air for the REMPs and will discontinue the use of passive tritium in air samplers in 2010.

Furthermore, as the existing active samplers are aging and spare parts for key components are no longer available, by the end of 2011, all existing active samplers will be replaced with the active sampler designed by COG with the exception of the D7 and Lambton locations. Location D7 will be decommissioned as this location is no longer representative of the most exposed member of the Oshawa/Courtice critical group due to the expansion of the residential area towards DN. The active sampler at Lambton will be removed since multiple background locations are only needed when a potential for effects has been identified in several areas with different environmental conditions. Since OPG historic data of tritium in air concentrations at both background locations show no significant differences, only the background location at Nanticoke will be retained. There will be new active samplers installed at locations where passive samplers will be removed to ensure adequate wind sector and critical group coverage.

Organically Bound Tritium

OPG public dose calculations incorporate dose from OBT via intake of terrestrial plants and animals, and from fish. Dose from OBT is calculated from measured HTO concentrations found in sample media at each critical group.

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OPG plans to use measured OBT values for model validation. However, the ratio of OBT to HTO specific activities in samples collected from background locations is higher than the expected value of about 1 to 2 reported in the literature review completed in the COG research and development (R&D) report, OBT/HTO Ratios in Plants COG-06-3053, [R-10]. This matter was investigated in the report, Vegetable OBT/HTO Ratios in Background Areas in Ontario COG-09-3015 [R-40], using background vegetable measurements which confirmed the higher than expected ratios. The report recommends the establishment of a standard method for the measurement of OBT in environmental samples, thus OPG plans to initiate a project to address this recommendation through the COG R&D organization.

6.0 ATMOSPHERIC MODELLING

6.1 Integrated Model for Probabilistic Assessment of Contaminant Transport (IMPACT)

The IMPACT version 5.4.0 program was used to calculate doses to the critical groups using 2009 environmental monitoring data. Where measured environmental data is not available, IMPACT calculates the doses from emissions. IMPACT 5.4.0 represents the method of dose calculation described in the CSA N288.1-08 standard [R-14].

The CSA N288.1 standard, issued in 2008, introduced a number of changes that have been incorporated into IMPACT 5.4.0. The following are the more significant changes affecting dose:

- Lower air inhalation rates for the Adult and 1 year old age classes.
- Lower water ingestion rates for all three age classes.
- To more accurately reflect HTO uptake by absorption through the skin, a dose equal to half the HTO inhalation dose is assigned to the skin absorption pathway. The skin absorption pathway was previously assigned a dose equal to the HTO inhalation dose. Therefore, the representative HTO dose for skin absorption has reduced for all three age classes.
- Correction to the transfer parameter for radionuclides from terrestrial plants to terrestrial animals. As a result, dose from terrestrial animal consumption has increased for all radionuclides except tritium.
- Correction in the application of the transfer parameter of OBT from terrestrial plants to terrestrial animals. As a result, OBT dose from terrestrial animal consumption was reduced.
- The six age classes for public dose estimates have been redistributed into the following three age classes:

(1) 1 year old infant which represents the age span 0 to 5 years,

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- (2) 10 year old child which represents the age span 6 to 15 years, and
- (3) Adult which represents the age span 16 to 70 years.

6.2 Calculated Atmospheric Dispersion Factors

Atmospheric dispersion factors (Ka) provide a measure of the dilution of station radiological stack emissions to the atmosphere. Ka values are used to estimate radionuclide concentrations in air at the critical group locations when there are no local measured values available. Details of how and when the Ka values are used are provided in Appendix F, Dose Calculation Procedure and Concentrations.

Factors influencing atmospheric dispersion at a specific location include wind speed and direction, as well as the level of turbulence in the atmosphere.

Ka values are calculated from the measured HTO in air concentrations and station HTO emissions using the relationship:

$$K_a = C/Q \text{ (s/m}^3\text{)}$$

Where C is the annual average HTO in air concentration (Bq/m³) above background measured outside the station boundary, and Q is the average annual HTO release rate (Bq/s) measured by stack monitors at the point of release. The release rate is determined by dividing the station total annual emission of HTO as given in Table 3-1 by 3.16×10^7 seconds per year.

For the purpose of maintaining a consistent historical comparison, Ka values have been calculated using HTO in air concentrations from the active samplers at the boundary location. These values are listed in Tables 6-1 and 6-2 for DN and PN, respectively. Figures 6-1 and 6-2 graphically show how these measured Ka values have varied historically at the DN and PN sites.

The boundary average Ka values at both DN and PN show a decrease since 2007. A decrease in Ka values means there is more dilution of emissions released to air. The Ka values obtained from the boundary HTO in air measurements represent a valid year over year comparison of air dispersion around DN and PN since the locations are always the same.

Separate Ka values are calculated for the dose calculations based on the measured concentration of HTO in air at each critical group location.

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS**Table 6-1: Darlington Nuclear Annual Boundary Dispersion Factors – 2009**

DESCRIPTION	Measured Average Airborne Tritium Concentration (Bq/m ³)	Measured Ka (s/m ³)
INDICATOR SITES:		
D1 – Southeast Fence	0.9	1.7E-07
D2 – East Fence	0.9	1.7E-07
D3 – Maple Grove	0.6	1.0E-07
D4 – Park Road	0.3	4.7E-08
D5 – Knight Road	0.3	4.4E-08
D6 – Provincial Park	0.3	4.9E-08
Average		9.6E-08

NOTE: The measured annual HTO to air emission is used together with the measured levels of HTO in the environment to calculate Ka.

Table 6-2: Pickering Nuclear Annual Boundary Dispersion Factors – 2009

DESCRIPTION	Measured Average Airborne Tritium Concentration (Bq/m ³)	Measured Ka (s/m ³)
INDICATOR SITES:		
P2 – Montgomery Park Rd.	15.7	7.0E-07
P3 – Sandy Beach Rd.	4.0	1.8E-07
P4 – Liverpool Rd.	1.5	6.4E-08
P6 – East Boundary	6.9	3.1E-07
P7 – Central Maintenance – West	8.2	3.7E-07
P8 – Frenchman's Bay	1.5	6.8E-08
P9 – Petticoat Creek	2.0	8.6E-08
P10 – Central Maintenance – East	14.5	6.5E-07
P11 – Alex Robertson Park	3.0	1.3E-07
Average		2.8E-07

NOTE: The measured annual HTO to air emission is used together with the measured levels of HTO in the environment to calculate Ka.

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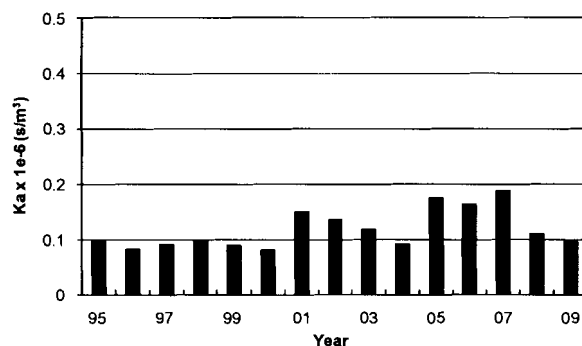


Figure 6-1: Darlington Nuclear Calculated Boundary Average Ka Values

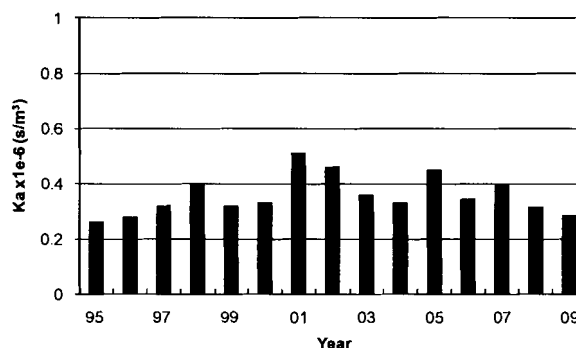


Figure 6-2: Pickering Nuclear Calculated Boundary Average Ka Values

6.3 Meteorological Data

Wind speed, direction and frequency are measured continuously at meteorological towers at each nuclear site. The average annual wind frequencies at a 10 m height in 2009 for the DN and PN sites are presented in Table 6-3 [R-24].

The meteorological data is used in the IMPACT program to model radionuclide concentrations at the critical group locations where measured data is not available. In 2009, the wind sectors from which the wind predominantly blew towards the land are the ESE and WSW for DN, and the SSW and E for PN. Table 6-3 indicates the wind frequencies blowing from each direction.

Table 6-3: Darlington and Pickering Nuclear – 2009 Annual Average Wind Frequency by Direction (at 10 m height)

Direction From	Darlington Nuclear Wind Frequency (%)	Pickering Nuclear Wind Frequency (%)
N	8.76	9.23
NNE	4.60	4.96
NE	2.45	3.07
ENE	4.64	6.13
E	6.66	8.22
ESE	10.58	3.91
SE	3.09	2.48
SSE	2.46	1.86
S	2.30	4.47
SSW	2.40	10.42
SW	4.63	6.90
WSW	9.90	6.24
W	7.10	6.79
WNW	9.30	8.14
NW	8.20	8.91
NNW	12.95	8.27
Total	100.02	100.00

Note: Shaded fields indicate landward wind sectors.

7.0 ASSESSMENT OF DOSES TO THE PUBLIC

This section contains an assessment of doses to the public resulting from the operation of OPG's Nuclear Generating Stations. These doses are based, as much as possible, on environmental concentrations of radionuclides measured at the potential critical group locations and surrounding environment. For the radionuclides and pathways where environmental measurements were not available, dose was modeled from emissions.

In this report, dose to members of the public is calculated only for members of potential critical groups that reside in the vicinity of DN and PN. The calculation follows the method described in OPG's Methodology for Data Analysis and Public Dose Determination for the Radiological Environmental Monitoring Program [R-12]. Assumptions, modeling parameters, and mean intake rates were used in accordance with CSA N288.1-08 [R-14]. Annual average meteorological data is used along with local intake fractions and representative locations for critical groups as identified in the reviews of the site specific surveys [R-1] [R-16]. Details on how the data was used are provided in Appendix F.

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7.1 Critical Group Dose

The calculation of public dose in this report is intended to be as realistic as possible using the potential critical group lifestyles and attributes collected in the DN and PN site specific surveys [R-1] [R-13] [R-15] [R-16].

In public dose assessments, "critical groups" are used to estimate the mean realistic impacts of emissions on the most affected individuals. An individual with the average characteristics of the group is known as the "Representative Person" as described in CSA N-288.1-08 [R-14]. A single critical group with the highest total dose estimate is identified for each nuclear site, DN and PN. Since it is not apparent beforehand which group this may be, a number of potential critical groups are identified and dose estimates are calculated for each one. Doses are calculated for all age classes within each potential critical group.

For groups that occupy a relatively small geographic location, radionuclide measurements taken at that location were used in the potential critical group calculations. For groups such as the Farm, Dairy Farm or Urban Resident that are spread over much wider geographic areas, the maximum measured value of each sample type from all group members was used in order to keep the calculated doses conservative.

7.1.1 Age Classes

Prior to 2009, doses were estimated for six age classes. However, in accordance with CSA N-288.1-08, and as recommended by the ICRP [R-9], three age classes will now be used for estimating annual dose to the representative person. The three age classes are 0-5 years (infant), 6-15 years (child), and 16-70 years (adult). The dose estimates to these three age groups are sufficient to characterize doses to the public. For practical implementation in dose calculations, the dose coefficients and characteristics for a 1 year old infant, a 10 year old child, and an adult are used to represent the three age classes [R-9].

In the past, the nursing infant in some critical groups had received the highest dose. To demonstrate that the nursing infant dose is adequately accounted for in the new age groups, the 2009 dose was calculated for the nursing infant in each potential critical group and it was confirmed that dose to the nursing infant group was not the highest dose at PN or DN.

7.1.2 Darlington Nuclear Potential Critical Groups

The nine potential critical groups at DN for which doses are calculated in this report are shown in Figure C1, Appendix C and are described in Appendix E, Potential Critical Group Descriptions. The critical groups and their representative locations are based on the DN site specific survey review [R-1] conducted in 2006. In 2008, the representative location used for modeling the Dairy Farm critical group was relocated to a location approximately 1 km closer to DN, which provides greater conservatism to the modeled air concentrations. Further, a 2009 review of the representative potential

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critical group locations determined that the Rural Resident and Industrial/Commercial critical group representative locations should be shifted to the west of DN based on updated meteorological data used for atmospheric dispersion and the construction of a new industrial/commercial site.

7.1.3 Pickering Nuclear Potential Critical Groups

The six potential critical groups at PN for which doses are calculated in this report are shown in Figure C2, Appendix C and are described in Appendix E. The potential critical groups and their representative locations are based on the site specific survey review conducted in 2005 [R-16].

7.2 Exposure Pathways

The dose calculations include all pathways of radionuclide uptake or external exposure by humans, as illustrated previously in Section 4.0, Figure 4-1. The dose contribution from each pathway was estimated using IMPACT 5.4.0 either using direct measurements in the environment or by modeling from emissions.

7.3 Critical Group Dose Calculations

Although doses are calculated for several potential critical groups, only the group and age class with the highest dose is reported as the official site public dose in the given year. The following sections provide the basis for the dose calculation, results, and interpretation of the official public dose for DN and PN. Details on the calculations, how the radionuclide concentrations are determined, background subtractions, and whether data is measured or modeled are provided in Appendix F. Tables of doses calculated for all the potential critical groups are provided in Appendix G; Tables of Public Doses by Radionuclide, Pathway and Age Group for Darlington Nuclear and Pickering Nuclear Critical Groups.

7.3.1 2009 Darlington Nuclear Public Dose

For 2009, the limiting critical group at DN was the Dairy Farm 1 year old infant with a dose of 0.7 $\mu\text{Sv/a}$, as indicated in Table 7-1.

The Dairy Farm critical group represents dairy farms located within approximately 10 km of the DN site. The closest dairy farm is in the North wind sector about 3 km from the site. Members of this group obtain their water supply from wells and use it for drinking, bathing, irrigation, and livestock watering. They also obtain a large fraction of their annual fruit, vegetable and animal product consumption, including fresh cow's milk, from local sources.

7.3.1.1 Basis of Dose Calculation

- Measurements of HTO and C-14 in air, fruits, vegetables, and milk were taken at five dairy farms around DN. HTO was also measured in wells at local dairy farms to calculate the dose from water ingestion. The highest annual concentration

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from each medium was used for the dose calculation with the background subtracted out.

- OBT dose from terrestrial animals and plants were modeled from measured HTO concentrations in terrestrial media at the dairy farm locations.
- Dose from noble gases was estimated from dose measurements at the fence line boundary by applying a calculated air dispersion ratio for the critical group location being evaluated.
- Doses from the remaining radionuclides, I(mfp), Co-60, Cs-137+ and HT, were modeled from emissions applying the Ka dispersion factor as per Section 6.2.

7.3.1.2 Dose Calculation Results

The results of the 2009 DN public dose calculation are presented in Table 7-1.

Table 7-1: 2009 Darlington Nuclear Critical Group Doses

Potential Critical Group	Dose per Age Class (microsieverts)		
	Adult	Child (10 year old)	Infant (1 year old)
Campers	0.1	0.1	0.1
Dairy Farm Residents	0.4	0.4	0.7
Farm Residents	0.4	0.4	0.3
Sport Fishers	0.1	0.1	0.0
Bowmanville Residents	0.2	0.2	0.1
Oshawa Residents	0.1	0.1	0.0
Rural Residents	0.3	0.3	0.2
West/East Beach Residents	0.2	0.2	0.1
Industrial/Commercial Workers	0.1		

Table 7-2 illustrates the dose by each radionuclide for the Dairy Farm 1 year old infant and the percent contribution to the total dose. C-14, HTO, and noble gases contribute more than 90% of the total dose.

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS**Table 7-2: 2009 Darlington Nuclear Public Dose – Dairy Farm 1 yr. Old Infant**

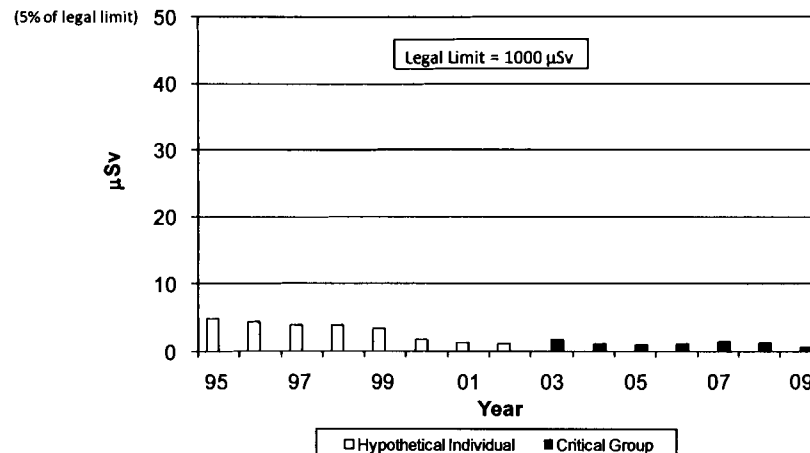
Radionuclide	Dose (μSv/a)	% Dose Contribution
C-14	4.66E-01	69%
Co-60	3.38E-03	1%
Cs-137+	1.40E-05	<1%
HT	7.72E-07	<1%
HTO	1.30E-01	19%
Noble Gas	2.68E-02	4%
OBT	1.51E-02	2%
I (mfp)	1.74E-02	3%
Total	0.7	100%

“+” indicates that contributions from progeny are included.

This distribution of dose by radionuclides reflects the characteristics of the Dairy Farm group. C-14 dose is mostly from ingestion of terrestrial plants and animals. The Dairy Farm 1 year old infant consumes animal products that are almost entirely from local sources, including milk from local cows, as well as a portion of its fruits and vegetables. Dose from HTO is attributed to air inhalation and ingestion of terrestrial plants and animals, and dose from noble gases is attributed to external exposure.

The public dose trend for DN is presented in Figure 7-1. Hypothetical Individual dose was reported as the site official dose up to 2002, and thereafter, the official dose has been based on the site Critical Group. A description of Hypothetical Individual dose calculation methodology can be found in previously published annual reports.

The DN dose remained essentially unchanged over the last 5 years and significantly below 1% of the legal limit.

**Figure 7-1: Darlington Nuclear Public Dose Trend**

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7.3.1.3 Discussion of Results

The 2009 DN site public dose of 0.7 μSv , as represented by the Dairy Farm 1 year old infant, is about 0.1% of the 1000 $\mu\text{Sv/a}$ legal limit for a member of the public. The DN dose for 2009 is lower than the dose of 1.3 μSv for the Dairy Farm 1 year old infant reported in 2008. This decrease in dose is mainly attributed to a decrease in measured C-14 concentrations in milk and the changes in methodology and transfer parameters specified by CSA N288.1-08 [R-14] as detailed in Section 6.1.

More specifically, the decrease in dose in 2009, when compared with 2008, is attributed to the following:

- There was a decrease in the measured C-14 concentration in milk. Although the difference in C-14 concentration between 2008 and 2009 is small, it represents a 35% decrease in concentration when background is subtracted. Since milk constitutes almost all the dose received through consumption of terrestrial animal products by the Dairy Farm 1 year old infant, the decrease had a significant effect in reducing the overall dose.
- There was a decrease in modeled OBT concentration in milk. The contribution of OBT to the overall 2009 dose is 2%, a sizable decrease from the 11% contribution it had in 2008. This reduction is largely due to the corrected application of the transfer parameter of OBT from terrestrial plants to terrestrial animals described in Section 6.1.
- Dose from HTO in air decreased by 53% from 2008 mainly as the result of a lower air inhalation rate and a reduction in the representative dose for the skin absorption pathway as described in Section 6.1. In addition, a reduction in wind frequency towards the Dairy Farm critical group representative location in 2009 led to a sizable decrease in the measured HTO in air concentration at the receptor.

The DN dose for 2009 is less than 0.1% of the total public background dose. The estimated average background public dose around DN from naturally occurring and anthropogenic (man-made) radiation is about 1,400 $\mu\text{Sv/a}$ (excluding medical doses, refer to Section 7.4). Figure 7-2 is a graphical representation of critical group dose compared to background radiation around DN. As an additional source of comparison, Table 7-5 provides examples of typical doses from exposure to natural and anthropogenic sources.

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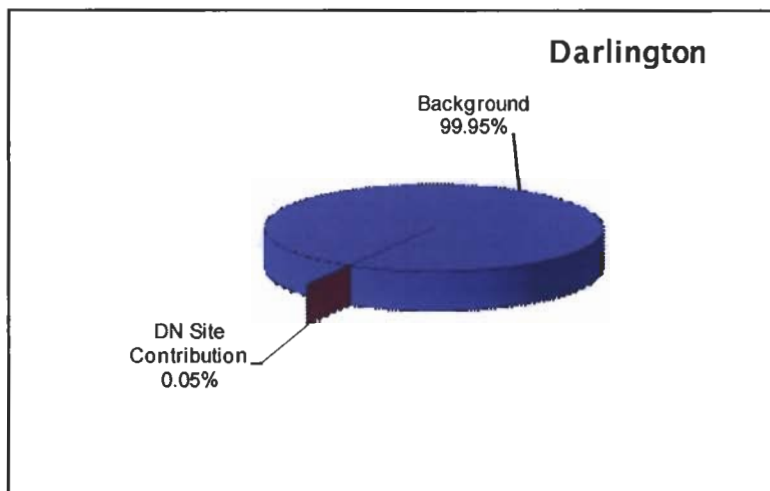


Figure 7-2: Comparison of Darlington Nuclear Public Dose to Background Dose

7.3.2 2009 Pickering Nuclear Public Dose

For 2009, the limiting critical group at PN was the Industrial/Commercial Adult with a dose of 1.8 $\mu\text{Sv/a}$, as indicated in Table 7-3.

The Industrial/Commercial critical group consists of adult workers whose work location is close to the PN site. Members of this group are typically at this location about 23% of their time and they consume water from the Ajax WSP during that time. The most affected location for this group is about 1 km NNE of the site.

7.3.2.1 Basis of Dose Calculation

- Measurements of HTO and C-14 in air were taken at the Industrial/Commercial locations around PN. HTO in water was measured at the Ajax WSP to calculate the dose from water ingestion. The highest annual concentrations of HTO and C-14 in air, and the average annual concentration of HTO in water from the Ajax water supply plant, were used for the dose calculation with the background subtracted out.
- Dose from noble gases was calculated from dose measurements at the Industrial/Commercial locations around PN.
- Doses from the remaining radionuclides Co-60, Cs-137+ and I(mfp) were modeled from emissions applying the Ka dispersion factor, as per Section 6.2.

7.3.2.2 Dose Calculation Results

The results of the 2009 PN public dose calculation are presented in Table 7-3.

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Table 7-3: 2009 Pickering Nuclear Critical Group Doses

Potential Critical Group	Dose per Age Class (microsieverts)		
	Adult	Child (10 year old)	Infant (1 year old)
Farm Residents	0.7	0.7	0.6
Dairy Farm Residents	0.6	0.6	0.6
Sport Fishers	0.4	0.5	0.4
Urban Residents	1.2	1.3	1.1
C2 Correctional Institution	1.5	1.6	
Industrial Workers	1.8		

Table 7-4 illustrates the dose by radionuclide for the Industrial/Commercial Adult and the percent contribution to the total dose. HTO and noble gases contribute more than 90% of the total dose.

Table 7-4: 2009 Pickering Nuclear Public Dose – Industrial/Commercial Adult

Radionuclide	Dose (μSv/a)	% Dose Contribution
C-14	1.03E-03	<1%
Co-60	4.62E-05	<1%
Cs-137+	2.80E-03	<1%
HTO	1.25E+00	68%
Noble Gas	5.80E-01	32%
OBT	0.00E+00	<1%
I (mfp)	5.59E-05	<1%
Total	1.8	100%

"+" indicates that contributions from progeny are included.

This distribution of dose by radionuclides reflects the characteristics of the Industrial/Commercial group since their exposure is from inhalation, external exposure and water ingestion. The majority of the HTO dose is attributed to air inhalation.

The public dose trend for PN is presented in Figure 7-3. Hypothetical Individual dose was reported as the site official dose up to 2002, and thereafter, the official dose has been based on the site Critical Group. A description of Hypothetical Individual dose calculation methodology can be found in previously published annual reports.

The PN dose remains below 1% of the legal limit.

One step change is observed in the PN trend over the last 5 years. The decrease in 2006 is due to the closure of the correctional institution (C1) and the expropriation of the Squires Beach community for the expansion of the municipal WPCP. These two former potential critical groups were located close to the station and often had the highest doses around the PN site.

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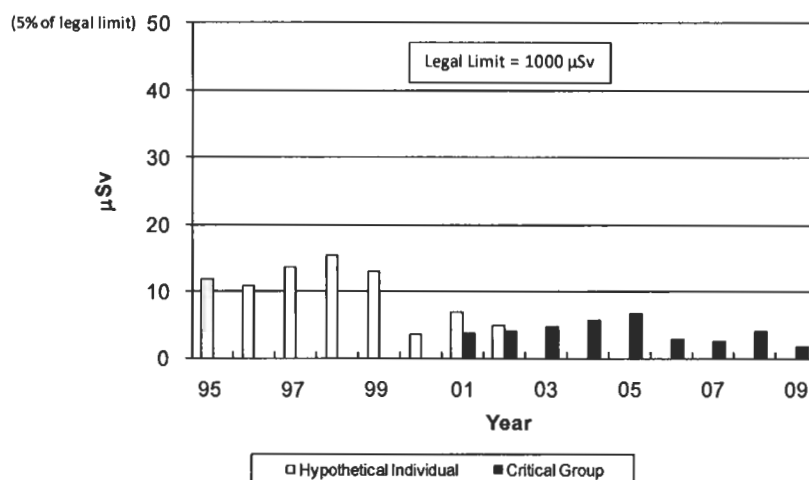


Figure 7-3: Pickering Nuclear Public Dose Trend

7.3.2.3 Discussion of Results

The 2009 PN site public dose of 1.8 μSv , as represented by the Industrial/Commercial Adult, is about 0.2% of the 1000 $\mu\text{Sv/a}$ legal limit for a member of the public. The PN dose is lower than the 2008 reported dose value of 4.1 μSv , also represented by the Industrial/Commercial Adult. The decrease in dose is mainly attributed to the changes in methodology and transfer parameters specified by CSA N288.1-08 [R-14] as detailed in Section 6.1.

More specifically, the decrease in dose in 2009, when compared with 2008, is attributed to the following:

- Dose from HTO in air decreased from 2008 as a result of a lower air inhalation rate and a reduction in the representative dose for the skin absorption pathway as described in Section 6.1. In addition, a decrease in HTO emissions in 2009 contributed to a reduction in HTO in air concentrations measured at the Industrial/Commercial critical group representative location.

The PN dose for 2009 was equivalent to about 0.1% of the total public background dose. The estimated background dose around PN is 1400 $\mu\text{Sv/a}$ from naturally occurring and anthropogenic (man-made) radiation (excluding medical doses, refer to Section 7.4). Figure 7-4 is a graphical representation of critical group dose compared to background radiation around PN.

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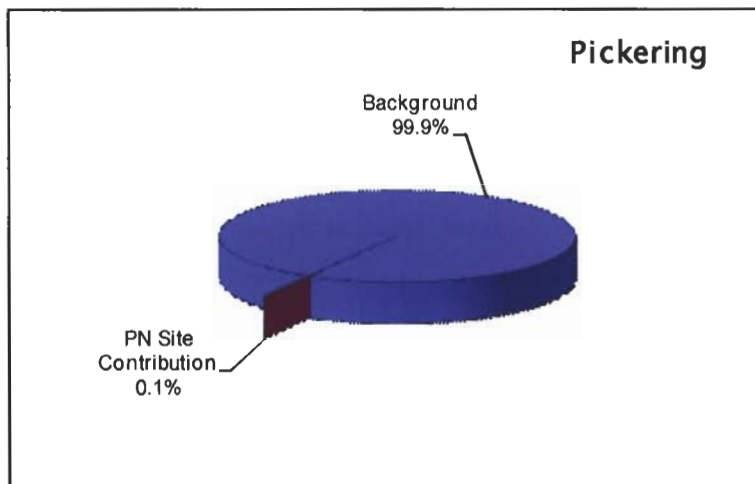


Figure 7-4: Comparison of Pickering Nuclear Public Dose to Background Dose

7.4 Natural and Anthropogenic Dose Data

Table 7-5 provides some typical doses received by members of the public from exposure to natural and anthropogenic sources.

Table 7-5: Typical Doses from Exposure to Natural and Anthropogenic Sources

Source of Exposure	Effective Dose (μSv)
Annual External Exposure during Precipitation Events (Gamma Radiation from Naturally Occurring Radon Gas Decay Products) [R-49]	4
Chest X-Ray (single film) [R-50]	10
Airplane Travel (2 hours flight) [R-51]	12

Information on Canadian public doses from naturally occurring sources was updated in 2002, including new data from ground gamma surveys in four major Canadian cities [R-28] [R-29]. Results are summarized in Table 7-6, where it can be seen that most of the variation is due to the inhalation dose from Radon-222 (Rn-222).

Table 7-6: Naturally Occurring Annual Public Effective Doses

Radiation Source	Worldwide Average (μSv)	Canada (μSv)	Toronto (μSv)	Montreal (μSv)	Winnipeg (μSv)	Pickering Nuclear Site (μSv)	Darlington Nuclear Site (μSv)
Cosmic	380	318	313	313	315	313	313
Internal	306	306	306	306	306	306	306
Inhalation ^(a)	1,256	926	757	667	3,225	565	565
External	480	219	178	278	176	154	154
Total^(b)	2,400	1,800	1,600	1,600	4,000	1,300	1,300

(a) Mostly from Rn-222.

(b) Total doses have been rounded to two significant figures to reflect the inherent uncertainty. Some components are based on direct measurements and others are estimated from related measurements.

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In addition to naturally occurring radiation, the public also receives about 70 $\mu\text{Sv/a}$ effective dose from anthropogenic sources such as nuclear weapon test fallout, and exposures from technological processes and consumer products and services, excluding medical sources. Thus, the total background dose around PN and DN from naturally occurring and anthropogenic sources is 1,400 $\mu\text{Sv/a}$. The average Canadian dose from medical sources averages 1,100 $\mu\text{Sv/a}$ per person. The legal limit of 1,000 μSv per year from licensed industrial practices is over and above the dose the public already receives from the natural environment and from medical procedures [R-30].

8.0 QUALITY ASSURANCE PROGRAM

The Quality Assurance (QA) program for the REMP encompasses all activities in field sample collection, laboratory analysis, laboratory quality control, and external laboratory comparison. The objective is to ensure the accuracy of REMP samples and their analytical results such that best estimates of radiation doses to the public resulting from the operations of OPG Nuclear Generating Stations are provided. This section provides an overview of quality assurance activities that are critical to ensuring the quality of the REMP data.

8.1 Laboratory Quality Assurance and Quality Control

The OPG Health Physics Laboratory (HPL) is accredited for radioanalysis of drinking water and soil by the Canadian Association for Laboratory Accreditation (CALA). The accreditation is based on demonstrated compliance with ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories. HPL is also licensed for radioanalysis of drinking water by the Province of Ontario's Ministry of Environment. HPL performs laboratory activities in accordance with OPG Dosimetry and Radiological Environmental Quality Assurance Program [R-31].

8.1.1 Laboratory Quality Control

Quality control (QC) samples are used to estimate the precision and accuracy of analytical results and to examine any sources of error introduced by laboratory practices which require corrective actions. Two types of QC samples are used to accompany the analyses of the environmental samples collected for the REMP:

- (a) Process control samples are 'dead water' (radiation free water/blank) samples that go through the same handling process as the real samples.
- (b) QC standards are samples with predetermined values (usually traceable standards) to be included for final analysis. The analysis of the environmental sample is considered valid when the results of the accompanying QC samples are within $\pm 10\text{-}20\%$ of the known/expected values, depending on the analysis type.

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For 2009, the results for the QC samples were all within the required range. These results provide added confidence in terms of the quality of data for the program and the consistency of laboratory measurements.

8.1.2 Laboratory Performance Testing

The main purpose of the laboratory performance testing programs is to provide assurance to OPG Nuclear and the CNSC of the laboratory's analytical proficiency (i.e., the accuracy of the measurements). The testing programs provide a quality check to laboratory operations including equipment calibration, analytical procedures, data review and internal QC. These testing programs are a crucial part of the laboratory QA program to demonstrate that the laboratory is performing within the acceptable limits as measured against external unbiased standards.

OPG Nuclear participated in two independent laboratory performance testing programs in 2009 [R-32]. The suppliers of the test samples and irradiations were:

- (a) Eckert and Ziegler Analytics Inc. and;
- (b) National Research Council of Canada (NRCC).

These programs involved the measurement of tritium, gross beta, and gamma in water/drinking water, gamma emitters in milk and soil, and environmental gamma measurements using TLDs.

- (a) Eckert and Ziegler Analytics Inc.

QA test samples are supplied on a quarterly basis by Eckert and Ziegler Analytics Inc. Results of analyses are reported back to Eckert and Ziegler Analytics, who then provide performance reports for each of the analytical types. The performance test limits used are as follows:

$$-25\% \leq \text{Mean Relative Difference} \leq +50\%$$

$$\text{Relative Precision} \leq 40\%$$

These test limits correspond to the *in vitro* accuracy specifications of the CNSC's Regulatory Standard S-106 Revision 1, Technical and Quality Assurance Requirements for Dosimetry Services, which are used in the absence of any prescribed or generally accepted limits for environmental QA tests.

All QA performance test results in 2009 met the specified limits. The maximum and minimum Mean Relative Difference and Relative Precision are summarized for each sample type and presented in Table 8-1.

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Table 8-1: Summary of Analytics Performance Test Results – 2009

Sample Types	Mean Relative Difference (%)		Relative Precision (%)	
	High	Low	High	Low
Tritium in Water	+1	-1	3	2
Gross Beta in Water	+26	-2	9	7
Gamma in Milk	+16	-15	12	1
Gamma in Water	+21	-11	23	2
Gamma in Soil	+28	-21	7	1

(b) NRCC Environmental Gamma QA Program

The laboratory QA test program for environmental gamma measurements consists of sending 16 Harshaw TLDs on a quarterly basis to the NRCC where they are irradiated to 2 different levels of exposure.

The Mean Relative Bias is required to be less than $\pm 35\%$ [R-32]. All testing met performance requirements. The Mean Relative Bias of the quarterly measurements was between 0% to +6%.

8.2 Audits and Self Assessments

In 2009, HPL performed one self assessment and Environment Programs Department (EPD) performed two self assessments on different elements of the REMP. Furthermore, an independent audit was performed by CALA and the results from a 2007 CNSC Type II Inspection were issued.

A summary of the audits and assessments are provided in the following sections.

8.2.1 Audits

CALA performs audits of accredited laboratories once every two years as a requirement for maintaining accreditation. A CALA audit was performed in November 2009. No significant findings with regard to the quality assurance program were reported.

8.2.2 Self Assessments

(a) Review of REMP Documentation (EPD)

The objective of self assessment NO09-000392 was for the EPD to perform a review of the REMP documents to identify any gaps in the program, inconsistencies, or areas for improvement. As a result of this review, a number of findings have been identified. The majority of these findings were minor in nature involving grammatical/formatting corrections or information that needs to be

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updated. All findings will be addressed and incorporated during the next document revisions.

(b) Collection of Terrestrial Samples (EPD)

Self assessment NO09-000393 was carried out by the EPD to observe procedural compliance of HPL personnel and to assess adequacy of the procedures for collection of terrestrial samples. The assessment involved observation of the collection of fruit, vegetables, animal feed, soil, and beach sand samples.

Conclusions of the assessment were that HPL personnel safely and effectively carried out terrestrial sampling tasks. Procedural compliance was adequate, however an opportunity for improvement was identified regarding procedure quality. Review and revision of HPL terrestrial sampling procedure documents is required to provide clarification on specific tasks and requirements, and for minor corrections. HPL has been undertaking long term revisions to restructure the sampling procedures. However, due to the prolonged period of time that these revisions have taken, there is concern that current sampling procedures may be outdated or incomplete. Prompt completion of revisions and issuance of new procedures is required. The above findings have been accepted by HPL and the necessary actions have been captured under an action request to be completed by June 2010.

(c) QA of Radiological Environmental Verification Program (HPL)

Self assessment NO09-000566 was a "horizontal slice" assessment performed by the HPL which looked at several elements of the QA program applying to multiple sample types. The scope included a review of selected activities that occur from when an environmental sample is brought into the lab through to provision of analytical results to EPD.

The assessment identified one adverse condition that involves the timing of procedure revisions. Procedures revised using hand-written mark-ups are required to undergo formal revision within 90 days. Hand-written mark-ups up to two years old were discovered during the assessment. Actions to address this finding will be performed together with actions for self assessment NO09-000393. The assessment also noted that not all analysis results identified the Health Physics Technologist performing the analysis. Actions addressing this finding were completed in March 2010.

8.2.3 CNSC Type II Inspection

A CNSC Type II Inspection was conducted in 2007 with a focus on the sampling and analysis of tritium in air and drinking water. The results of the inspection were issued to OPG in June 2009 [R-42] and raised three action notices in the areas of field check and laboratory check. The action notices were associated with:

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- (a) a written procedure step for leak checking the active sampler that was not followed,
- (b) documentation of the performance of the tritium in air passive and active samplers and addressing recommendations for the passive sampler made by COG, and
- (c) the representativeness of water recovered from the tritium in air molecular sieves.

OPG has completed appropriate actions to address the CNSC action notices. OPG responses to the CNSC are detailed in letters sent in August 2009 [R-43] and March 2010 [R-44].

8.3 Third Party Verification

An independent third party verification of the annual dose calculations and this report was carried out by EcoMetrix Incorporated. Verification was done on the methodology used, assumptions made, input parameter values and data used. This involved checking the dose calculations, IMPACT scenarios, and performing independent replicate IMPACT model runs and hand calculations to validate the results obtained by OPG.

9.0 PROGRAM PERFORMANCE

9.1 Sample Unavailability

A total of 2,783 laboratory analyses were performed for the 2009 REMP. The analyses covered HTO, gross beta, C-14, I-131, TLD gamma, OBT, gamma scan, and organic carbon. The DN site accounted for 45% of these sample analyses, while the PN and Provincial programs accounted for 39% and 14% respectively. More samples were analyzed for DN than PN because samples are required to represent a greater number of critical groups at DN. Of the total analyses performed, 1,178 analyses were used in the dose calculation. Table 9-1 shows the sample types, number of locations, and number of samples used for the dose calculation. It should be noted that Table 9-1 only lists the sample analyses used for dose assessment and does not include all REMP samples.

The unavailability indicator tracks the performance of sample collection and analysis for the REMP. The field sampling campaign of the REMP is designed to collect representative field samples from selected pathways near each nuclear site and from background locations, in order to meet the program objectives as defined in Section 2.0. The sample analyses unavailability percentage is determined by dividing the number of missed or invalid sample analyses by the number of planned sample analyses for each REMP site.

An important objective of the REMP is to estimate the doses to the public based on environmental data measured in the public domain. In accordance with the updated

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REMP governing document [R-45], the requirement to meet unavailability limits is specific to the analysis of samples used in the dose calculation. These limits are applied to the PN, DN and provincial REMPs separately.

The unavailability limits for samples used in the dose calculation are provided in Table 9-1 and range from 10-25%. The unavailability limits were derived based on the relative contributions to total dose, therefore higher dose contributors have a lower unavailability limit. The overall unavailability for PN, DN and Provincial REMPs were 0%, 0% and 3%, respectively. For 2009, all unavailability limits for individual analyses used in dose calculations were met, with the exception of the tritium in air sample analyses for the Provincial REMP.

The unavailability of tritium in air analyses for the Provincial REMP exceeded the 10% limit due to problems at the Lambton location as discussed in Section 5.1.1. This issue is being investigated and corrective actions have been implemented in efforts to address this problem. However, since the provincial background value calculated from available sample results is below detection, consistent with previous years, there was no impact on the dose assessment. It also should be noted that, as part of the implementation of new active samplers discussed in Section 5.5.2, tritium in air measurements at the Lambton location are planned to be discontinued by 2011.

These low levels of unavailability provide confidence in the estimation of dose received by the site critical groups.

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Table 9-1: Unavailability of REMP Sample Data Used for Dose Calculation Purposes

Sample Types	Collection Frequency	Pickering Nuclear				Darlington Nuclear				Provincial Controls				Unavailability Limit
		Number of Locations	Plan	Actual	Unavailability	Number of Locations	Plan	Actual	Unavailability	Number of Locations	Plan	Actual	Unavailability	
Tritium														
Tritium in Air (Molecular Sieve/Passive)	Monthly/Quarterly	12	71	70	1%	15	76	76	0%	8	48	40	17%	10%
Water Supply Plants	Weekly Composite	1	48	48	0%	2	96	96	0%					15%
Residential Wells	Monthly	5	60	60	0%	15	180	176	2%					15%
Milk	Monthly Composite	3	31	31	0%	5	60	60	0%					25%
Milk	Quarterly									2	8	8	0%	25%
Lake Water	Monthly ^(a)	2	18	18	0%	2	16	16	0%					25%
Fruits	Annual	8	8	8	0%	18	18	18	0%					20%
Vegetables	Annual	14	14	14	0%	15	15	15	0%	5	5	5	0%	20%
Animal Silage Feed	Annual	1	1	1	0%	5	5	5	0%					25%
Fish	Annual	1	16	16	0%	2	20	20	0%					25%
Carbon-14														
Carbon-14 in Air	Quarterly	9	35	34	3%	13	52	52	0%	6	24	23	4%	25%
Milk	Monthly Composite	3	31	31	0%	5	60	60	0%					10%
Fruits	Annual	8	8	8	0%	18	18	18	0%					20%
Vegetables	Annual	14	14	14	0%	15	15	15	0%	5	5	5	0%	20%
Animal Silage Feed	Annual	1	1	1	0%	5	5	5	0%					25%
Fish	Annual	1	16	16	0%	2	20	20	0%	1	16	16	0%	25%
Noble Gases														
External Gamma (Noble Gas Monitors) ^(b)	Continuous	4	NA	NA	2%	5	NA	NA	4%					25%
Gamma														
Fish	Annual	1	16	16	0%	2	20	20	0%	1	16	16	0%	25%
Beach Sand	Annual	3	3	3	0%	1	2	2	0%	1	2	2	0%	25%
Overall dose sample Unavailability ^(c)			391	389	0%		678	674	0%		124	115	3%	

Notes: NA = Not Applicable.

(a) For safety considerations, samples are not required during the winter months(Dec. – Mar.).

(b) Noble gas detector unavailability is based on an average of actual run time of all monitors for PN and DN.

(c) Unavailability defined as an average of the percent unavailability of all sample types.

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10.0 SUMMARY OF 2009 REMP

10.1 Overall Program Performance

The results of OPG's 2009 REMPs are summarized as follows:

- Overall, the REMPs met their objectives in collecting radiological environmental data for the PN and DN site public dose estimations, for supporting the DRL model and assumptions, and for confirming station emission control.
- Redistribution of age groups into three age classes and changes to dose modeling parameters, in accordance with CSA N288.1-08 [R14], were incorporated into the 2009 public dose calculations, as described in Section 6.1.
- There were few changes to the REMP designs this year. The representative locations for the DN Industrial/Commercial and Rural Resident potential critical groups were moved west of DN. Also, DN and PN precipitation and particulate sample collection locations, which are not used in the dose calculation, were reduced to six locations per site.
- There were no significant deficiencies in sample collection and sample analyses this year. Close to 2,800 environmental data analyses were completed for samples collected around DN and PN sites and at various Ontario background locations. The performance of sample analyses used in the dose calculations was excellent with an overall unavailabilities of 0%, 0%, and 3% for the PN, DN, and Provincial REMPs, respectively.
- Problems experienced in 2008 in maintaining the availability of the noble gas detectors have been addressed and, as a result, the 2009 unavailabilities for detectors used in the dose calculation were only 2% and 4% for PN and DN, respectively.
- Three self assessments relating to the REMPs were completed this year. Findings included the need to issue revised sample collection procedures as well as identifying a number of updates required to program documents.

10.2 Darlington

10.2.1 Summary of Sampling Results

- Most radionuclide emissions to air from DN did not change much over the previous year. There was a small decrease in noble gas emissions, which had a minor effect on the overall dose.
- There was a decrease in HTO emissions, a notable increase in gross beta-gamma emissions (due to background no longer being subtracted out at DN), and a decrease in C-14 emissions to water. Environmental concentrations of HTO, C-

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14 and gross beta-gamma activity in fish, and HTO and gross beta-gamma activity in drinking water were consistent with previous years. Radioactivity in drinking water from the nearby water supply plants was well below the standard of 7,000 Bq/L. There was no evidence of accumulation of activity in lake sediments.

- HTO and gross beta-gamma activity in well water remained about the same as the previous year.
- One soil sample had a Cs-137 result above the range of historic background over the last 10 years, but had no detectable Co-60 or Cs-134. The result at this location will be examined in the subsequent year to determine if it was a one time occurrence. There was no indication of a buildup of activity in soil at any other location.
- Concentrations of HTO and C-14 in air, vegetation, and milk were in line with results seen over the last 5 years.

10.2.2 Summary of Site Public Dose

The 2009 public dose for the DN site was 0.7 μ Sv and was represented by the 1 year old infant of the Dairy Farm critical group. This dose is lower than the 2008 dose of 1.3 μ Sv reported for the same receptor due mainly to the changes in methodology and transfer parameters specified by CSA N288.1-08 [R-14] as detailed in Section 6.1. The 2009 site public dose has not changed significantly over the last 5 years.

10.3 Pickering

10.3.1 Summary of Sampling Results

- C-14 emissions were notably lower than the previous year, resulting in a decrease in C-14 measured in air, vegetation and milk around the PN site.
- A decrease in HTO airborne emissions contributed to a decrease in measured HTO in air and vegetation concentrations.
- Noble gas emissions to air increased, however this only had a minor effect on the dose measured by environmental noble gas monitors at the boundary locations.
- There was a small decrease in HTO emissions, an increase in gross beta-gamma emissions, and a small increase in C-14 emissions to water. Environmental concentrations of HTO, C-14 and gross beta-gamma activity in fish, and HTO and gross beta-gamma activity in drinking water were consistent with previous years. Tritium in drinking water from the nearby water supply plants was well below the standard of 7,000 Bq/L. There was no evidence of accumulation of activity in lake sediments.
- HTO and gross beta-gamma activity in well water remained the same as the previous year.

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- Soil samples had Cs-137 at levels within the range of historic background over the last 10 years, and had no detectable Co-60 or Cs-134. There was no indication of a buildup of activity in soil.

10.3.2 Summary of Site Public Dose

The 2009 public dose for the PN site was 1.8 μ Sv and was represented by adult workers of the Industrial/Commercial critical group. This dose is lower than the PN 2008 dose of 4.1 μ Sv for the same receptor. The decrease is due to lower measured HTO in air concentrations at the critical group location as well as changes to dose modeling parameters in accordance with CSA N288.1-08 [R-14].

11.0 OUTLOOK FOR 2010

- CSA N288.4, Environmental Monitoring at Class I Nuclear Facilities and Uranium Mines and Mills is scheduled for release in 2010. This updated standard will require environmental monitoring for radionuclides and conventional contaminants, impact assessments to human and non-human biota, and will result in future changes to OPG's environmental monitoring programs.
- A reduction in the frequency of sample collection for a number of samples, which are not utilized in the dose calculation, will occur starting in 2010. As discussed in Section 4.2, the frequency of lake sediment and honey sample collection will be reduced to once every five years. As discussed in Section 5.5.2, the frequency of lake water collection for potassium analysis will be reduced to once every three years and lake water will no longer be analysed for TSS.
- As discussed in Section 5.5.2, all passive HTO in air samplers will be removed from the REMP in 2010. Further to this, a number of changes to the active HTO sampler locations will be made over the next two years. These include the following:
- DN location D7 will be decommissioned as this location is no longer representative of the most exposed member of the critical group due to the expansion of the Oshawa/Courtice critical group residential area towards DN.
- The active sampler at Lambton will be decommissioned since multiple background locations are only needed when a potential for effects has been identified in several areas with different environmental conditions. Since OPG historic data of tritium in air concentrations at both background locations show no significant differences, only the background location at Nanticoke will be retained.
- New active sampler sites will be installed to ensure adequate wind sector and critical group coverage.

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Appendix A: Radiological Units and Conversions

Absorbed Dose

1 gray (Gy)	=	1 joule/kg
1 gray (Gy)	=	100 rad
1 milligray (mGy)	=	100 millirad (mrad)

Effective Dose

1 sievert (Sv)	=	100 rem
1 millisievert (mSv)	=	100 millirem (mrem)
1 microsievert (μ Sv)	=	0.1 millirem (mrem)

Quantity of Radionuclide

1 becquerel (Bq)	=	1 disintegration per second
1 curie (Ci)	=	3.7×10^{10} Bq
1 mCi/(km ² ·month)	=	37 Bq/(m ² ·month)

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Appendix B: Glossary of Acronyms and Symbols

Radionuclides and Units of Measure

Ar-41	Argon-41
Be-7	Beryllium-7
Bi-214	Bismuth-214
C-14	Carbon-14
CO₂	Carbon Dioxide
Co-60	Cobalt-60
Cs-134	Cesium-134
Cs-137	Cesium-137
Cs-137+	Cesium-137 including progeny
H-3	Tritium (Hydrogen-3)
HT	Elemental Tritium
HTO	Tritium Oxide
I(mfp)	Mixed Fission Products Radioiodines
I-131	Iodine-131
Ir-192	Iridium-192
K-40	Potassium-40
Rn-222	Radon-222
Th	Thorium
U	Uranium
Xe-133	Xenon-133
Xe-135	Xenon-135

μGy	microgray
μSv	microsievert
Bq	becquerel
Bq/kg-C	becquerels per kilogram carbon
Ci	Curie
Gy	Gray
kg	kilogram
L	Litre
mGy	milligray
mSv	millisievert
Sv	Sievert

Acronyms and Abbreviations

BAF	Bioaccumulation Factor
CALA	Canadian Association for Laboratory Accreditation
CANDU	Canadian Deuterium Uranium
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	Canadian Standards Association
DN	Darlington Nuclear
DRL	Derived Release Limit
E	East wind sector

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ECI	Emergency Coolant Injection
ENE	East North East wind sector
EPD	Environment Programs Department
ESE	East South East wind sector
HPL	OPG Health Physics Laboratory
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IMPACT	Integrated Model for Probabilistic Assessment of Contaminated Transport
ISO	International Organization for Standardization
Ka	Atmospheric Dispersion Factor (s/m^3)
Lc	Critical Level
Ld	Limit of Detection
MW	Megawatts
N	North wind sector
NaI	Sodium Iodide
NE	North East wind sector
NNE	North North East wind sector
NNW	North North West wind sector
NRCC	National Research Council of Canada
NW	North West wind sector
OBT	Organically Bound Tritium
OPG	Ontario Power Generation
PN	Pickering Nuclear
PN1-4	Reactors 1 through 4 at the Pickering Nuclear Site
PN5-8	Reactors 5 through 8 at the Pickering Nuclear Site
PN-A	Pickering A
PN-B	Pickering B
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
REMP	Radiological Environmental Monitoring Program
S	South wind sector
SE	South East wind sector
SSE	South South East wind sector
SSW	South South West wind sector
SW	South West wind sector
TFWT	Tissue Free Water Tritium
TLD	Thermoluminescent Dosimeter
TRF	Tritium Removal Facility
TSS	Total Suspended Solids
TWh	Terawatt Hour
W	West wind sector
w.e.	Water Equivalent
WNW	West North West wind sector
WPCP	Water Pollution Control Plant
WSP	Water Supply Plant
WSW	West South West wind sector
WWMF	Western Waste Management Facility

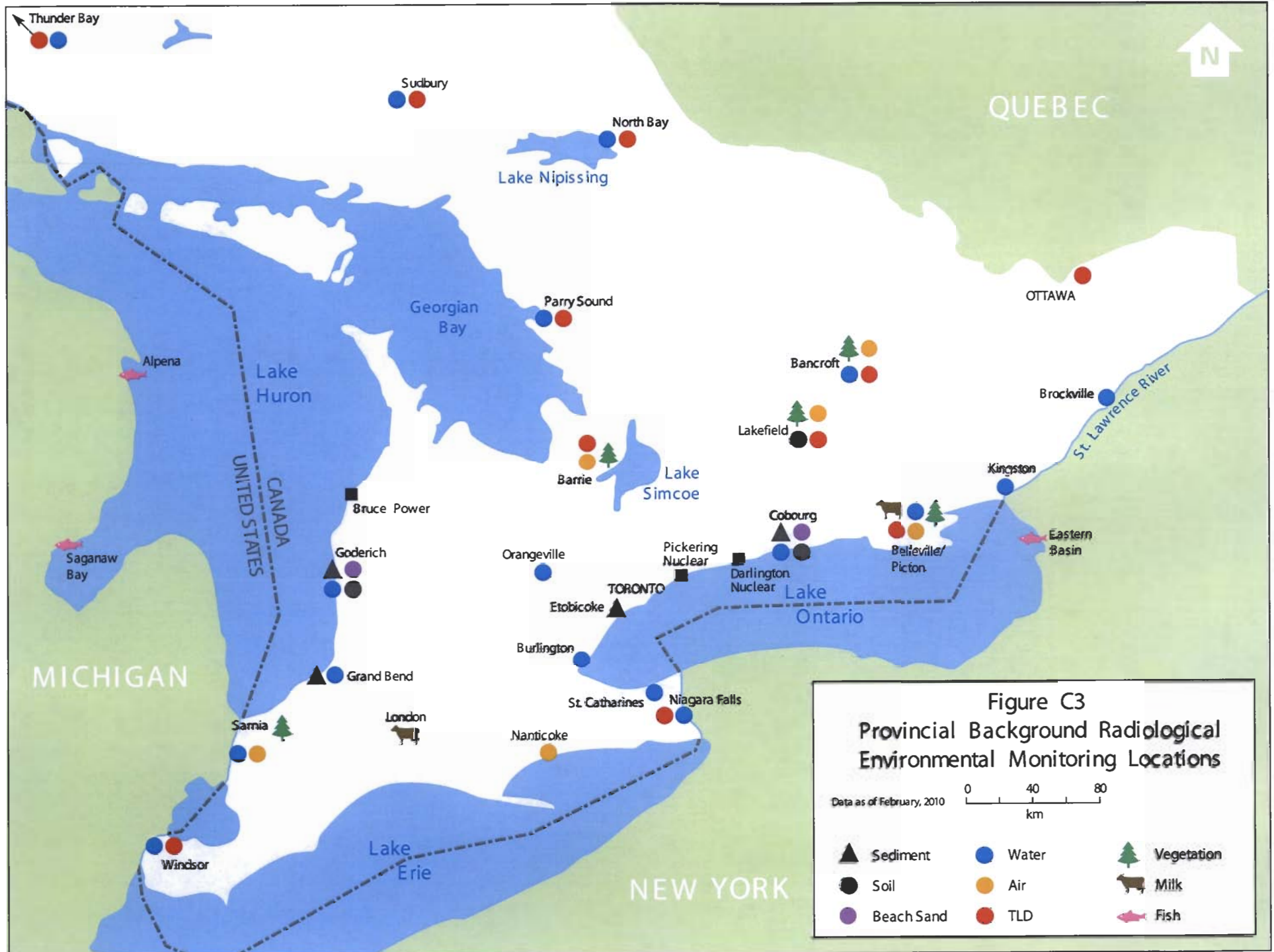
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Appendix C: Maps of Environmental Monitoring and Critical Group Locations



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Appendix D: Environmental Monitoring Data

Table D1: TLD External Gamma Measurements – 2009

DN REMP			PN REMP			Background Locations		
Site Description	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)	Site Description	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)	Site Description	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)
D1	54.5	477	P2	53.4	468	Bancroft	63.4	555
D2	58.7	514	P3	52.0	456	Belleville	65.6	575
D3	58.7	514	P4	53.4	468	Windsor	51.3	449
D4	54.7	479	P6	60.5	530	Niagara Falls	44.2	387
D5	55.8	489	P7	47.1	413	North Bay	58.8	515
D6	62.3	546	P8	47.6	417	Barrie ^(a)	57.3	502
			P9	55.0	482	Ottawa	52.2	458
			P10	43.3	379	Parry Sound ^(a)	54.6	478
			P11	60.0	526	Sudbury	56.4	494
						Thunder Bay	69.4	608
						Lakefield	65.5	574
Average	57.4	503	Average	52.5	460	Average ^(b)	56.2	492
CRITICAL GROUP LOCATIONS			CRITICAL GROUP LOCATIONS					
D7	59.2	519	C2	64.5	565			
D8	57.3	502						
R275	61.6	539						
DF5	60.3	528						

NOTES:

(a) Annual average based on three quarters due to TLDs not returned or problem at the location.

(b) Bancroft and Thunder Bay are excluded from the average due to historically higher than normal levels of natural radioactivity that are inappropriate to be used in comparison with nuclear facility results [R-34].

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Table D2: Noble Gas, Skyshine and I-131 Dose in Air – 2009

Site Description	Total Measured Dose in Air (nGy/yr) ^(a)				
	Xe-133	Xe-135	Ar-41	Ir-192 Skyshine	I-131 ^(b)
DN REMP					
D1	< 4	< 8	< 34	< 25	< 14
D2 ^(d)	< 3	< 9	< 34	< 23	< 13
D3	< 4	< 10	< 36	< 30	< 19
D4	< 4	< 9	< 35	< 26	< 17
D5	< 4	< 9	< 33	< 27	< 16
D6 ^(d)	< 4	< 9	< 38	< 26	< 15
D8	< 4	< 9	< 39	< 27	< 17
Average ^(c)	< 4	< 9	< 36	< 26	< 16
PN REMP					
P2	83	92	2580	< 27	< 18
P3	32	22	1239	< 27	< 18
P4	10	16	658	< 25	18
P6	37	53	1101	< 27	< 18
P7	50	42	2319	< 24	< 16
P8	13	9	533	< 23	< 13
P9	11	< 9	333	< 27	< 17
P10	97	63	3546	< 23	< 14
P11	18	19	932	< 31	< 20
Average ^(c)	39	36	1471	< 26	< 17

Notes:

- (a) Bolded values are greater than Lc but less than Ld. "<" indicates less than the Lc.
- (b) In this context, dose means the air immersion effective dose from gamma radiation.
- (c) Annual averages are calculated from monthly measurements and compared with the Lc or Ld to determine how they will be reported.
- (d) Locations had months with low availability. Values for these months were adjusted as described in Section 5.1.2.

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Table D3: Tritium in Air Concentrations – 2009

DN REMP			PN REMP			Background Locations		
Site Description	Molecular Sieve Tritium in Air (Bq/m ³) ^(a)	Passive Sampler Tritium in Air (Bq/m ³) ^(a)	Site Description	Molecular Sieve Tritium in Air (Bq/m ³) ^(a)	Passive Sampler Tritium in Air (Bq/m ³) ^(a)	Site Description	Molecular Sieve Tritium in Air (Bq/m ³) ^(a)	Passive Sampler Tritium in Air (Bq/m ³) ^(a)
D1	0.9	2.1	P2	15.7	22.3	Lambton ^f	0.1 ^(c)	< 0.2
D2 ^(b)	0.9	1.9	P3	4.0	NR	Nanticoke	< 0.1 ^(b)	NR
D3 ^(b)	0.6	NR	P4 ^(b)	1.5	NR	Lakefield	NR	< 0.2
D4	0.3	NR	P6 ^(b)	6.9	14.8	Bancroft	NR	< 0.2
D5	0.3	NR	P7	8.2	NR	Barrie ^(d)	NR	0.2
D6	0.3	0.5	P8	1.5	NR	Belleville	NR	< 0.2
			P9 ^(b)	2.0	NR	Picton	NR	< 0.2
			P10	14.5	30.4			
			P11	3.0	NR			
Average	0.5	-	Average	6.4	-	Average	< 0.1	< 0.2
CRITICAL GROUP LOCATIONS			CRITICAL GROUP LOCATIONS					
D7	0.2	NR	DF1	NR	0.7			
D8	0.4	NR	DF8	NR	1.0			
R2	NR	0.4	DF11 ^(d)	NR	1.4			
R27	NR	0.5	C2	NR	5.4			
R275	NR	0.6	F31	NR	1.4			
F1	NR	0.7	R145	NR	1.6			
R329	NR	0.3						
DF12	NR	0.3						
DF5	NR	0.3	OTHER LOCATIONS					
DF7	NR	0.3	Ajax Hospital	1.1	NR			
DF8	NR	0.3	HPL	0.7	NR			
DF9	NR	0.3						

NOTES:

NR = Not Required by Program

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(e) Molecular Sieve Tritium Ld = 0.2 Bq/m³ and Lc = 0.1 Bq/m³; Passive Tritium Ld = 0.3 Bq/m³ and Lc = 0.2 Bq/m³

(f) Annual average based on 11 monthly samples due to sampler component failures.

(g) Annual average based on 6 monthly samples due to higher than expected absolute humidity results at this location.

(h) Annual average based on 3 quarterly samples due to change in participant/sample location.

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Table D4: Carbon-14 in Air Concentrations – 2009

DN REMP		PN REMP		Background Locations	
Site Description	Passive Sampler C-14 in Air (Bq/kg-C) ^{(a) (b)}	Site Description	Passive Sampler C-14 in Air (Bq/kg-C) ^{(a) (b)}	Site Description	Passive Sampler C-14 in Air (Bq/kg-C) ^{(a) (b)}
D1 ^(c)	267	P2 ^(c)	556	Lambton	239
D2 ^(c)	272	P6 ^(c)	350	Nanticoke	NR
D6 ^(c)	238	P10 ^(c)	491	Lakefield	232
R2	250	DF1 ^(e)	252	Bancroft	246
R27	232	DF8	256	Barrie ^(d)	266
R275	245	DF11 ^(d)	252	Belleville	242
F1	246	C2	314	Picton	248
R329	234	F31	240	Average	245
DF12	235	R145	250		
DF5	246				
DF7	228				
DF8	233				
DF9	231				

NOTES:

NR = Not Required by Program

(a) Bq/kg-C (Bq per kg of carbon).

(b) The measurement of C-14 using molecular sieve samplers was discontinued in 2008.

(c) Site boundary location

(d) Annual average based on 3 quarterly samples due to change in participant/sample location.

(e) Annual average based on 3 quarterly samples due to incomplete transfer of sample for Q1 analysis resulting in reduced sample volume.

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Table D5: Tritium in Precipitation and Gross Beta in Wet/Dry Fallout – 2009

DN REMP			PN REMP		
Site Description	Average Tritium Concentration in Precipitation (Bq/L)	Average Gross Beta Deposition Rate (Bq/(m ² ·month))	Site Description	Average Tritium Concentration in Precipitation (Bq/L)	Average Gross Beta Deposition Rate (Bq/(m ² ·month))
D1	51	14.0	P2 ^(a)	556	17.6
D2 ^(a)	61	18.8	P3 ^(a)	243	15.5
D3	34	14.6	P4 ^(a)	96	16.5
D4	23	17.9	P6	431	16.8
D5 ^(a)	23	13.6	P7 ^(a)	315	17.1
D6 ^(a)	22	15.7	P8	215	220
			P9 ^(a)	296	16.7
			P10	524	14.8
			P11	221	14.6
Average	36	15.8	Average	322	16.8
CRITICAL GROUP LOCATIONS			CRITICAL GROUP LOCATIONS		
D7 ^(a)	12	14.6	R143 ^(a)	34	NR
D8 ^(a)	28	13.8	DF8 ^(a)	28	NR
R2 ^(a)	43	NR	F25 ^(a)	17	NR
R29 ^(a)	12	NR	F31	19	NR
R47 ^(a)	23	NR	F10	33	NR
R275 ^(a)	21	NR			
F1	36	NR			
R329 ^(a)	15	NR			
F15 ^(a)	17	NR			
DF12	11	NR			
DF5 ^(a)	14	NR			
DF7 ^(a)	10	NR			
DF8	11	NR			
DF9 ^(a)	7	NR			

NOTES: NR = Not Required by Program

(a) Annual average was based on 6 monthly samples as precipitation/fallout sample collection has been discontinued at this location.

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Table D6: Tritium and Gross Beta Activity Concentrations in Drinking Water and Lake Water – 2009

DN REMP			PN REMP		
Site Description	Annual Average Tritium Concentration (Bq/L) ^(a)	Annual Average Gross Beta Activity Concentration (Bq/L) ^(b)	Site Description	Annual Average Tritium Concentration (Bq/L) ^(a)	Annual Average Gross Beta Activity Concentration (Bq/L) ^(b)
Bowmanville WSP	5.0	0.11	Ajax WSP	6.0	0.10
Newcastle WSP	5.0	0.11	Scarborough Horgan WSP	4.9	0.11
Oshawa WSP	6.7	0.11	Toronto Harris WSP ^(c)	4.6	0.10
			Whitby WSP	6.2	0.11
CRITICAL GROUP LOCATIONS (Well Water)			CRITICAL GROUP LOCATIONS (Well Water)		
DF12	5.8	0.32	R11 (Deep) ^(d)	74.9	0.16
DF5	< 2.3	0.21	R11 (Shallow) ^(d)	89.4	0.15
DF7	< 2.3	0.08	F10	15.4	NR
DF8	4.8	0.11	DF8	13.1	NR
DF9	< 2.3	0.08	F25	< 2.3	NR
F1	< 2.3	0.04	R143	19.9	NR
R329	17.4	1.18	F31	20.6	NR
F15 ^(g)	4.3	0.19			
R2	22.5	1.67			
R29	< 2.3	0.07			
R47 ^(h)	10.9	0.09			
R279	< 2.3	0.21			
R294	13.8	0.08			
R316	9.9	0.05			
R320 ^(g)	12.7	0.06			
LAKE WATER LOCATIONS			LAKE WATER LOCATIONS		
Darlington Provincial Park ^(e)	6.5	0.15	Frenchman's Bay ^(e)	38.4	NR
McLaughlin Bay ^(e)	26.2	0.19	Beachpoint Promenade ^(e)	23.4	NR
St. Mary's Cement ^(f)	6.2	0.14	Squire's Beach ^(e)	28.7	NR

NOTES:

NR = Not Required by Program

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) Ld for gross beta = 0.03 Bq/L and Lc = 0.02 Bq/L.

(c) No samples analysed for 2 week period as plant was shut down for maintenance.

(d) Annual averages do not include February to May because the participant was not available to provide a sample. These samples were not a requirement of the program.

(e) Annual averages based on 9 (PN) or 10 (DN) monthly samples because sampling is not required during the winter months when the lake/shoreline is frozen.

(f) Annual averages based on 10 monthly samples as sampling at this location was discontinued in November.

(g) Annual averages based on 11 monthly samples since one sample was not available from the participant.

(h) Annual averages based on 10 monthly samples since two samples were not available from the participant.

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Table D6: Tritium and Gross Beta Activity Concentrations in Drinking Water and Lake Water – 2009 (Continued)

Background Locations			
Site Description	Water Source	Annual Average Tritium Concentration (Bq/L) ^(a)	Annual Average Gross Beta Activity Concentration (Bq/L) ^(b)
Bancroft ^(c)	Clarke Lake	< 2.3	0.04
Belleville ^(c)	Bay of Quinte	3.1	0.08
Brockville	Lake Ontario	4.0	0.11
Burlington	Lake Ontario	5.2	0.11
Cobourg ^(c)	Lake Ontario	4.0	0.11
Goderich	Lake Huron	4.2	0.09
Kingston	Lake Ontario	4.5	0.11
London	Lake Huron	3.4	0.08
Niagara Falls	Niagara River	3.0	0.10
North Bay	Trout Lake	< 1.8	0.07
Orangeville	Well Water	< 1.9	0.12
Parry Sound	Georgian Bay	2.6	0.06
Sarnia	Lake Huron	3.5	0.09
St. Catharines	Lake Moodie/Gibson	2.9	0.11
Sudbury	Ramsay Lake	< 2.3	0.03
Thunder Bay	Lake Superior	< 2.3	0.05
Windsor	Lake St. Clair	3.7	0.08

NOTES:

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) Ld for gross beta = 0.03 Bq/L and Lc = 0.02 Bq/L.

(c) Fourth quarter samples were not available because the lake was frozen. Annual average is based on three quarterly samples.

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Table D7: Lake Sediment – 2009

DN REMP					
Site Description	C-14 Composites (Bq/kg-C $\pm$ 2 σ)	Gamma Analysis Bq/kg $\pm$ 2 σ (dry weight) ^(b)			
		Cs-137	Cs-134	Co-60	K-40
Darlington Provincial Park -A	134 $\pm$ 27	0.5 $\pm$ 0.1	< 0.1	< 0.1	343.5 $\pm$ 4.3
-B		0.5 $\pm$ 0.1	< 0.2	< 0.2	319.5 $\pm$ 5.7
-C		0.4 $\pm$ 0.1	< 0.1	< 0.1	351.5 $\pm$ 5.0
-D		0.5 $\pm$ 0.1	< 0.2	< 0.2	354.2 $\pm$ 5.1
Port Darlington -A	153 $\pm$ 28	0.3 $\pm$ 0.1	< 0.1	< 0.2	376.5 $\pm$ 5.5
-B		0.3 $\pm$ 0.1	< 0.2	< 0.2	406.1 $\pm$ 6.6
-C		0.3 $\pm$ 0.1	< 0.2	< 0.2	399.3 $\pm$ 6.6
-D		0.3 $\pm$ 0.1	< 0.1	< 0.1	408.3 $\pm$ 5.6
DN Diffuser -A	193 $\pm$ 27 ^(a)	0.8 $\pm$ 0.1	< 0.1	< 0.2	392.0 $\pm$ 6.3
-B		0.5 $\pm$ 0.1	< 0.1	< 0.1	363.8 $\pm$ 5.1
-C		1.3 $\pm$ 0.1	< 0.1	< 0.2	472.9 $\pm$ 5.6
-D		0.8 $\pm$ 0.1	< 0.2	< 0.2	408.6 $\pm$ 6.4

NOTES:

(a) The total organic carbon content of the DN Diffuser composite sediment samples was 5,100 ppm.

(b) For gamma analysis "<" indicates less than Ld.

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Table D7: Lake Sediment – 2009 (Continued)

PN REMP					
Site Description	C-14 Composites (Bq/kg-C $\pm 2\sigma$)	Gamma Analysis (dry weight) (Bq/kg $\pm 2\sigma$) ^(c)			
		Cs-137	Cs-134	Co-60	K-40
PN "A" Discharge -A	281 $\pm$ 31 ^(a)	1.4 $\pm$ 0.1	< 0.1	< 0.1	396.7 $\pm$ 4.8
-B		1.7 $\pm$ 0.1	< 0.1	< 0.1	406.9 $\pm$ 5.6
-C		1.3 $\pm$ 0.2	< 0.2	< 0.2	340.1 $\pm$ 5.9
-D		1.4 $\pm$ 0.1	< 0.1	< 0.1	383.2 $\pm$ 4.7
PN "B" Discharge -A	204 $\pm$ 30 ^(b)	1.8 $\pm$ 0.1	< 0.2	< 0.1	410.5 $\pm$ 4.7
-B		1.3 $\pm$ 0.1	< 0.1	< 0.1	377.4 $\pm$ 5.3
-C		1.5 $\pm$ 0.1	< 0.1	< 0.1	414.0 $\pm$ 4.9
-D		1.3 $\pm$ 0.2	< 0.1	< 0.2	367.8 $\pm$ 6.1
Liverpool Road Beach -A	195 $\pm$ 28	1.6 $\pm$ 0.2	< 0.1	< 0.1	409.7 $\pm$ 5.5
-B		1.8 $\pm$ 0.2	< 0.2	< 0.2	411.1 $\pm$ 6.5
-C		1.6 $\pm$ 0.2	< 0.2	< 0.2	401.0 $\pm$ 6.5
-D		1.6 $\pm$ 0.2	< 0.2	< 0.2	421.4 $\pm$ 5.6
Duffin's Creek -A	104 $\pm$ 26	0.3 $\pm$ 0.2	< 0.2	< 0.2	382.0 $\pm$ 6.3
-B		< 0.2	< 0.1	< 0.2	401.6 $\pm$ 5.6
-C		0.3 $\pm$ 0.1	< 0.2	< 0.1	372.6 $\pm$ 6.1
-D		0.3 $\pm$ 0.1	< 0.1	< 0.2	385.4 $\pm$ 5.3

NOTES:

- (a) The total organic content of the PN "A" discharge composite sediment samples was 1,100 ppm.
 (b) The total organic content of the PN "B" discharge composite sediment samples was 1,000 ppm.
 (c) For gamma analysis "<" indicates less than Ld.

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Table D7: Lake Sediment – 2009 (Continued)

Background Locations						
Site Description		C-14 Composites (Bq/kg-C±2σ)	Gamma Analysis (dry weight) (Bq/kg ± 2σ) ^(b)			
			Cs-137	Cs-134	Co-60	K-40
Cobourg	-A	190 ± 27 ^(a)	0.9 ± 0.1	< 0.1	< 0.1	503.4 ± 5.7
	-B		0.7 ± 0.1	< 0.2	< 0.2	468.5 ± 6.1
	-C		1.0 ± 0.2	< 0.2	< 0.2	464.6 ± 7.5
	-D		1.0 ± 0.1	< 0.1	< 0.2	473.0 ± 6.4
Marie Curtis Park	-A	NR	0.7 ± 0.1	< 0.1	< 0.2	574.0 ± 6.1
	-B		0.5 ± 0.1	< 0.2	< 0.2	504.3 ± 7.4
	-C		0.6 ± 0.1	< 0.2	< 0.1	528.9 ± 6.7
	-D		0.4 ± 0.1	< 0.2	< 0.1	485.3 ± 5.3

NOTES:

NR = Not required by the program.

(a) The total organic content of the Cobourg composite sediment samples was 7,200 ppm.

(b) For gamma analysis "<" indicates less than Ld.

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Table D8: Beach Sand – 2009

Site Description	Gamma Analysis (dry weight) (Bq/kg $\pm 2\sigma$) ^(a)			
	Cs-137	Cs-134	Co-60	K-40
DN REMP				
Darlington Provincial Park	0.2 $\pm$ 0.1	< 0.1	< 0.1	314.3 $\pm$ 4.1
Darlington Provincial Park	0.2 $\pm$ 0.1	< 0.1	< 0.1	330.0 $\pm$ 5.1
PN REMP				
Beach Point Promenade	0.7 $\pm$ 0.1	< 0.1	< 0.1	331.1 $\pm$ 4.9
Squires Beach	0.4 $\pm$ 0.1	< 0.2	< 0.1	211.2 $\pm$ 4.6
Liverpool Road Beach	0.2 $\pm$ 0.1	< 0.1	< 0.1	370.7 $\pm$ 4.4
Background Locations				
Cobourg – A	0.5 $\pm$ 0.1	< 0.1	< 0.1	366.8 $\pm$ 5.4
Cobourg – B	0.5 $\pm$ 0.1	< 0.1	< 0.2	353.7 $\pm$ 4.5

NOTES:

(a) For gamma analysis "<" indicates less than Ld.

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Table D9: Lake Fish – 2009

DN REMP									
Site Description	Fish Type Composites		HTO (Bq/L $\pm 2\sigma$) ^(a)	C-14 (Bq/kg-C $\pm 2\sigma$)	Gamma Analysis (wet weight) (Bq/kg $\pm 2\sigma$) ^(b)				OBT Composites (Bq/L [water equivalent (w.e.)] $\pm 2\sigma$)
					Cs-137	Cs-134	Co-60	K-40	
Darlington Diffuser	White Sucker	-A	8.9 $\pm$ 2.5	240 $\pm$ 19	0.2 $\pm$ 0.1	< 0.1	< 0.1	~~133.8 $\pm$ 3.8~~	19 $\pm$ 3
		-B	7.3 $\pm$ 2.4	223 $\pm$ 19	0.2 $\pm$ 0.1	< 0.1	< 0.1	~~127.1 $\pm$ 2.7~~	
		-C	6.2 $\pm$ 2.3	235 $\pm$ 18	0.2 $\pm$ 0.1	< 0.1	< 0.1	~~126.0 $\pm$ 3.6~~	
		-D	5.8 $\pm$ 2.3	243 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	138.6 $\pm$ 4.0	
		-E	5.9 $\pm$ 2.3	224 $\pm$ 18	0.3 $\pm$ 0.1	< 0.1	< 0.1	~~141.5 $\pm$ 2.9~~	
		-F	5.0 $\pm$ 2.3	243 $\pm$ 19	0.2 $\pm$ 0.1	< 0.1	< 0.1	~~131.8 $\pm$ 3.7~~	
		-G	6.8 $\pm$ 2.4	226 $\pm$ 18	0.1 $\pm$ 0.1	< 0.1	< 0.1	~~134.6 $\pm$ 2.9~~	
		-H	6.1 $\pm$ 2.3	220 $\pm$ 18	0.2 $\pm$ 0.1	< 0.1	< 0.1	134.2 $\pm$ 3.6	
Darlington Diffuser	Round Whitefish	-A	4.8 $\pm$ 2.3	234 $\pm$ 18	0.4 $\pm$ 0.1	< 0.1	< 0.1	130.6 $\pm$ 4.1	14 $\pm$ 3
		-B	4.8 $\pm$ 2.3	228 $\pm$ 18	0.2 $\pm$ 0.1	< 0.1	< 0.1	~~138.6 $\pm$ 3.8~~	
		-C	6.2 $\pm$ 2.4	252 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	~~132.7 $\pm$ 2.8~~	
		-D	4.8 $\pm$ 2.3	237 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	~~140.4 $\pm$ 3.2~~	
		-E	4.9 $\pm$ 2.3	250 $\pm$ 20	0.4 $\pm$ 0.1	< 0.1	< 0.1	140.2 $\pm$ 3.1	
		-F	3.5 $\pm$ 2.2	242 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	~~139.6 $\pm$ 3.8~~	
		-G	3.7 $\pm$ 2.2	248 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	~~136.6 $\pm$ 3.0~~	
		-H	6.4 $\pm$ 2.4	252 $\pm$ 20	0.2 $\pm$ 0.1	< 0.1	< 0.1	132.3 $\pm$ 3.5	
Average			5.7	237	0.3	< 0.1	< 0.1	134.9	16
McLaughlin Bay	Assorted Pan Fish	-A	25.0 $\pm$ 3.2	224 $\pm$ 19	< 0.1	< 0.1	< 0.1	76.6 $\pm$ 2.3	37 $\pm$ 3
		-B	26.0 $\pm$ 3.3	237 $\pm$ 20	< 0.1	< 0.1	< 0.1	~~77.9 $\pm$ 2.0~~	
		-C	22.5 $\pm$ 3.1	251 $\pm$ 20	< 0.1	< 0.1	< 0.1	~~75.4 $\pm$ 2.0~~	
		-D	24.6 $\pm$ 3.2	238 $\pm$ 20	< 0.1	< 0.1	< 0.1	87.9 $\pm$ 1.9	
Average			24.5	238	< 0.1	< 0.1	< 0.1	100	

NOTES:

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) For gamma analysis "<" indicates less than Ld.

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Table D9: Lake Fish – 2009 (Continued)

PN REMP									
Site Description	Fish Type Composites		HTO (Bq/L ± 2σ) ^(a)	C-14 (Bq/kg-C ± 2σ)	Gamma Analysis (wet weight) (Bq/kg ± 2σ) ^(b)				OBT Composites (Bq/L (w.e.) ± 2σ)
					Cs-137	Cs-134	Co-60	K-40	
Pickering 5-8 Outfall	White Sucker	-A	7.2 ± 2.4	237 ± 20	0.2 ± 0.1	< 0.1	< 0.1	118.7 ± 2.6	28 ± 4
		-B	7.6 ± 2.4	230 ± 19	0.2 ± 0.1	< 0.1	< 0.1	120.2 ± 2.6	
		-C	7.4 ± 2.4	243 ± 20	0.2 ± 0.1	< 0.1	< 0.1	129.1 ± 2.9	
		-D	7.2 ± 2.4	255 ± 20	0.3 ± 0.1	< 0.1	< 0.1	132.9 ± 2.9	
		-E	5.5 ± 2.4	226 ± 19	0.2 ± 0.1	< 0.1	< 0.1	126.2 ± 3.5	
		-F	7.3 ± 2.5	234 ± 20	0.2 ± 0.1	< 0.1	< 0.1	119.1 ± 2.5	
		-G	6.4 ± 2.5	249 ± 20	0.3 ± 0.1	< 0.1	< 0.1	124.8 ± 2.9	
		-H	6.7 ± 2.5	234 ± 20	0.3 ± 0.1	< 0.1	< 0.1	126.3 ± 3.6	
Pickering 5-8 Outfall	Round Whitefish	-A	6.5 ± 2.4	227 ± 20	0.4 ± 0.1	< 0.1	< 0.1	146.5 ± 3.1	29 ± 3
		-B	5.2 ± 2.4	248 ± 20	0.3 ± 0.1	< 0.1	< 0.1	135.1 ± 3.9	
		-C	5.7 ± 2.4	246 ± 20	0.2 ± 0.1	< 0.1	< 0.1	142.6 ± 3.4	
		-D	6.1 ± 2.4	242 ± 20	0.3 ± 0.1	< 0.1	< 0.1	153.8 ± 3.2	
		-E	8.8 ± 2.6	248 ± 20	0.3 ± 0.1	< 0.1	< 0.1	124.6 ± 3.6	
		-F	6.8 ± 2.5	252 ± 20	0.3 ± 0.1	< 0.1	< 0.1	149.1 ± 3.5	
		-G	8.7 ± 2.5	236 ± 20	0.2 ± 0.1	< 0.1	< 0.1	151.4 ± 3.1	
		-H	5.5 ± 2.4	249 ± 20	0.3 ± 0.1	< 0.1	< 0.1	134.4 ± 3.8	
Average			6.8	241	0.3	<0.1	<0.1	133.4	28

NOTES:

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) For gamma analysis "<" indicates less than Ld.

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Table D9: Lake Fish – 2009 (Continued)

Background Locations									
Site Description	Fish Type Composites		HTO (Bq/L $\pm 2\sigma$) ^(a)	C-14 (Bq/kg-C $\pm 2\sigma$)	Gamma Analysis (wet weight) (Bq/kg $\pm 2\sigma$) ^(b)				OBT Composites (Bq/L (w.e) $\pm 2\sigma$)
					Cs-137	Cs-134	Co-60	K-40	
Lake Ontario- Far Field	White Sucker	-A	2.3 $\pm$ 2.3	249 $\pm$ 20	0.4 $\pm$ 0.1	< 0.1	< 0.1	112.7 $\pm$ 2.7	19 $\pm$ 4
		-B	3.4 $\pm$ 2.3	252 $\pm$ 21	0.3 $\pm$ 0.1	< 0.1	< 0.1	112.6 $\pm$ 3.5	
		-C	3.4 $\pm$ 2.3	240 $\pm$ 21	< 0.1	< 0.1	< 0.1	122.1 $\pm$ 2.8	
		-D	5.6 $\pm$ 2.3	241 $\pm$ 20	0.3 $\pm$ 0.1	< 0.1	< 0.1	120.8 $\pm$ 3.2	
		-E	3.2 $\pm$ 2.2	232 $\pm$ 20	0.5 $\pm$ 0.1	< 0.1	< 0.1	121.9 $\pm$ 2.8	
		-F	3.1 $\pm$ 2.2	235 $\pm$ 20	0.2 $\pm$ 0.1	< 0.1	< 0.1	119.9 $\pm$ 3.5	
		-G	3.5 $\pm$ 2.2	228 $\pm$ 20	0.2 $\pm$ 0.1	< 0.1	< 0.1	121.3 $\pm$ 2.8	
		-H	5.4 $\pm$ 2.3	227 $\pm$ 20	0.4 $\pm$ 0.1	< 0.1	< 0.1	122.3 $\pm$ 3.3	
	Lake Whitefish	-A	5.0 $\pm$ 2.3	238 $\pm$ 19	0.3 $\pm$ 0.1	< 0.1	< 0.1	137.9 $\pm$ 2.4	22 $\pm$ 4
		-B	3.3 $\pm$ 2.2	239 $\pm$ 18	0.5 $\pm$ 0.1	< 0.1	< 0.1	145.6 $\pm$ 3.0	
		-C	5.4 $\pm$ 2.4	228 $\pm$ 18	0.4 $\pm$ 0.1	< 0.1	< 0.2	138.4 $\pm$ 3.8	
		-D	4.8 $\pm$ 2.3	226 $\pm$ 18	0.3 $\pm$ 0.1	< 0.1	< 0.1	138.6 $\pm$ 3.0	
		-E	2.8 $\pm$ 2.2	226 $\pm$ 18	0.4 $\pm$ 0.1	< 0.1	< 0.1	143.8 $\pm$ 3.5	
		-F	4.9 $\pm$ 2.3	230 $\pm$ 19	0.5 $\pm$ 0.1	< 0.1	< 0.1	120.0 $\pm$ 3.6	
		-G	5.3 $\pm$ 2.4	242 $\pm$ 19	< 0.1	< 0.1	< 0.1	137.6 $\pm$ 3.4	
		-H	4.2 $\pm$ 2.3	225 $\pm$ 18	0.3 $\pm$ 0.1	< 0.1	< 0.1	135.9 $\pm$ 3.0	
Average			4.1	235	0.3	<0.1	<0.1	127.8	21

NOTES:

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) For gamma analysis "<" indicates less than Ld.

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Table D10: Terrestrial Biota – 2009

DN REMP							
Site Description	Sample Type Composite ^(a)	HTO (Bq/L $\pm 2\sigma$)	C-14 (Bq/kg-C $\pm 2\sigma$)	Site Description	Sample Type Composite ^(a)	HTO (Bq/L $\pm 2\sigma$)	C-14 (Bq/kg-C $\pm 2\sigma$)
R2	Fruit	40.5 $\pm$ 3.9	233 $\pm$ 18	R2	Vegetable	38.5 $\pm$ 3.7	233 $\pm$ 19
R85	Fruit	25.6 $\pm$ 3.3	228 $\pm$ 18	F2	Vegetable	18.0 $\pm$ 2.9	228 $\pm$ 21
R122	Fruit	18.3 $\pm$ 3.0	226 $\pm$ 18	R19	Vegetable	13.7 $\pm$ 2.7	241 $\pm$ 20
R19	Fruit	17.9 $\pm$ 3.0	237 $\pm$ 19	DF2	Vegetable	11.2 $\pm$ 2.6	229 $\pm$ 21
R24	Fruit	17.1 $\pm$ 3.0	239 $\pm$ 18	F13	Vegetable	14.3 $\pm$ 2.7	220 $\pm$ 20
DF12	Fruit	19.0 $\pm$ 3.1	220 $\pm$ 19	F16	Vegetable	17.0 $\pm$ 2.9	223 $\pm$ 20
R27	Fruit	30.7 $\pm$ 3.5	259 $\pm$ 20	DF6	Vegetable	7.3 $\pm$ 2.4	227 $\pm$ 19
R35/Loc 1	Fruit	17.3 $\pm$ 3.0	223 $\pm$ 19	R335	Vegetable	26.2 $\pm$ 3.3	243 $\pm$ 20
R39	Fruit	22.6 $\pm$ 3.2	238 $\pm$ 19	DF7	Vegetable	5.7 $\pm$ 2.3	236 $\pm$ 21
F18	Fruit	13.3 $\pm$ 2.8	217 $\pm$ 19	R228	Vegetable	21.1 $\pm$ 3.1	240 $\pm$ 21
R335	Fruit	35.1 $\pm$ 3.7	249 $\pm$ 19	F25	Vegetable	12.2 $\pm$ 2.6	232 $\pm$ 21
R63	Fruit	14.6 $\pm$ 2.8	237 $\pm$ 19	R275	Vegetable	43.8 $\pm$ 3.9	247 $\pm$ 20
DF7	Fruit	12.9 $\pm$ 2.8	352 $\pm$ 20	R357	Vegetable	9.4 $\pm$ 2.5	233 $\pm$ 20
R65	Fruit	73.9 $\pm$ 4.9	259 $\pm$ 20	R358	Vegetable	15.8 $\pm$ 2.8	225 $\pm$ 20
R228	Fruit	43.4 $\pm$ 4.0	256 $\pm$ 20	R356	Vegetable	19.3 $\pm$ 3.0	253 $\pm$ 20
F26	Fruit	12.6 $\pm$ 2.7	232 $\pm$ 19	DF12	Silage	16.3 $\pm$ 2.8	230 $\pm$ 20
R275	Fruit	48.6 $\pm$ 4.2	253 $\pm$ 19	DF5	Com	20.2 $\pm$ 3.0	255 $\pm$ 20
DF9	Fruit	17.9 $\pm$ 3.0	220 $\pm$ 19	DF7	Silage	11.5 $\pm$ 2.6	233 $\pm$ 20
				DF8	Silage	18.5 $\pm$ 2.6	245 $\pm$ 19
				DF9	Com	14.1 $\pm$ 2.7	250 $\pm$ 21
Average (Fruits, Vegetables, and Silage)						22.0	237

NOTES:

- (a) Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onion, potato, beet and carrot); Leafy (e.g., chard, cabbage, parsley, sorrel, rhubarb and beet leaves). Two of the 3 types (i.e., above ground, below ground or leafy) are required to form a valid composite. Typical fruits collected are apples, pears, berries, chestnuts and grapes.

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Table D10: Terrestrial Biota – 2009 (Continued)

PN REMP									
Site Description	Sample Type Composite ^(a)	HTO (Bq/L $\pm$ 2 σ)	C-14 (Bq/kg-C $\pm$ 2 σ)	OBT (Bq/L (w.e.) $\pm$ 2 σ)	Site Description	Sample Type Composite ^(a)	HTO (Bq/L $\pm$ 2 σ)	C-14 (Bq/kg-C $\pm$ 2 σ)	OBT (Bq/L (w.e.) $\pm$ 2 σ)
L35	Fruit	144.4 $\pm$ 6.7	262 $\pm$ 19	NR	P9	Vegetable	160.6 $\pm$ 7.0	240 $\pm$ 20	NR
R152	Fruit	75.0 $\pm$ 5.0	249 $\pm$ 19	NR	R144	Vegetable	115.7 $\pm$ 6.1	257 $\pm$ 20	NR
F10	Fruit	26.9 $\pm$ 3.4	225 $\pm$ 18	76 $\pm$ 5	Location 16	Vegetable	18.6 $\pm$ 3.1	224 $\pm$ 19	36 $\pm$ 4
Location 7	Fruit	108.1 $\pm$ 5.9	295 $\pm$ 20	NR	DF1	Vegetable	24.6 $\pm$ 3.4	234 $\pm$ 19	NR
Location 12	Fruit	81.8 $\pm$ 5.2	258 $\pm$ 19	NR	P11	Vegetable	102.5 $\pm$ 5.6	349 $\pm$ 22	NR
Location 10	Fruit	209.8 $\pm$ 7.9	423 $\pm$ 23	NR	F13	Vegetable	16.6 $\pm$ 3.0	242 $\pm$ 19	NR
Location 22	Fruit	203.3 $\pm$ 7.8	316 $\pm$ 21	221 $\pm$ 8	F40	Vegetable	21.1 $\pm$ 3.2	249 $\pm$ 19	NR
F31	Fruit	36.5 $\pm$ 3.8	252 $\pm$ 19	NR	F41	Vegetable	18.5 $\pm$ 3.1	225 $\pm$ 18	36 $\pm$ 4
DF8	Silage	27.2 $\pm$ 3.6	270 $\pm$ 22	NR	P2 ^(b)	Vegetable	956.6 $\pm$ 16.4	809 $\pm$ 29	NR
					F36	Vegetable	28.6 $\pm$ 3.6	249 $\pm$ 20	NR
					R153	Vegetable	51.6 $\pm$ 4.4	254 $\pm$ 20	NR
					DF3	Vegetable	14.6 $\pm$ 3.0	232 $\pm$ 19	NR
					R156	Vegetable	78.8 $\pm$ 5.2	272 $\pm$ 20	NR
					R157	Vegetable	25.9 $\pm$ 3.4	290 $\pm$ 21	NR
					R158	Vegetable	19.2 $\pm$ 3.2	242 $\pm$ 20	NR
Average (Fruits, Vegetables, and Silage)							70.0	266	92

NOTES:

- Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onions, potato, beet and carrots); Leafy (e.g., chard, cabbage, parsley, sorrel, rhubarb and beet leaves). Two of the 3 types (i.e., above ground, below ground or leafy) are required to form a valid composite. Typical fruits collected are apples, pears, berries, chestnuts and grapes.
- The value for location P2 is excluded from the calculation of the average as it is an OPG grown garden analysed for trending purposes and is not used for the public dose calculation. Location P2 will be removed from subsequent reports.

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Table D10: Terrestrial Biota – 2009 (Continued)

Background Locations				
Site Description	Sample Type Composite ^(a)	HTO (Bq/L $\pm 2\sigma$) ^(b)	C-14 (Bq/kg-C $\pm 2\sigma$)	OBT (Bq/L (w.e.) $\pm 2\sigma$)
Lakefield	Vegetable	5.3 $\pm$ 2.1	223 $\pm$ 20	17 $\pm$ 3
Bancroft	Vegetable	3.6 $\pm$ 2.0	232 $\pm$ 20	23 $\pm$ 3
Barrie	Vegetable	4.7 $\pm$ 2.1	229 $\pm$ 20	20 $\pm$ 5
Sarnia	Vegetable	6.7 $\pm$ 2.2	222 $\pm$ 20	23 $\pm$ 3
Picton	Vegetable	3.0 $\pm$ 2.0	223 $\pm$ 20	15 $\pm$ 3
Average (Vegetables and Fruits)		4.7	226	20

NOTES:

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

- (a) Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onions, potato, beet and carrots); Leafy (e.g., chard, cabbage, parsley, sorrel, rhubarb and beet leaves). Two of the 3 types (i.e., above ground, below ground or leafy) are required to form a valid composite. Typical fruits collected are apples, pears, berries, chestnuts and grapes.
- (b) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

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Table D10: Terrestrial Biota – 2009 (Continued)

Site Description	Sample Type	HTO (Bq/L ± 2σ)	C-14 (Bq/kg-C ± 2σ)	Gamma Analysis (Bq/kg ± 2σ) ^(b)				OBT (Bq/L (w.e.) ± 2σ)
				Cs-137	Cs-134	Co-60	K-40	
DN REMP								
F27	Honey	11.8 ± 2.6	241 ± 19	< 0.1	< 0.1	< 0.1	21.6 ± 1.5	NR
R326	Honey	49.7 ± 9.3	276 ± 22	< 0.1	< 0.1	< 0.1	26.8 ± 1.6	NR
R328	Honey	(a)	(a)	(a)	(a)	(a)	(a)	NR
R32	Honey	(a)	(a)	(a)	(a)	(a)	(a)	NR
R327	Honey	18.5 ± 2.9	249 ± 19	< 0.1	< 0.1	< 0.1	18.1 ± 1.5	NR
PN REMP								
R148	Honey	43.9 ± 3.9	228 ± 18	< 0.1	< 0.1	< 0.1	16.1 ± 1.3	NR
R150	Honey	44.0 ± 3.9	234 ± 19	< 0.1	< 0.1	< 0.1	18.3 ± 1.5	44 ± 4
R154	Honey	41.4 ± 3.8	232 ± 18	< 0.1	< 0.1	< 0.1	19.6 ± 2.0	NR

NOTES:

NR = Not Required by Program

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Sample not available.

(b) For gamma analysis "<" indicates less than Ld.

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Table D11: Inland Soils and Garden Soils – 2009

Site Description	Sample Type	Gamma Analysis (dry weight) (Bq/kg ± 2σ) ^(a)			
		Cs-137	Cs-134	Co-60	K-40
DN REMP					
F1	Soil (open area – not irrigated)	9.1 ± 0.4	< 0.3	< 0.2	591.9 ± 9.7
F2	Garden Soil (irrigated – shallow well water)	3.9 ± 0.2	< 0.2	< 0.2	735.3 ± 8.3
F16	Soil (open area – not irrigated)	15.9 ± 0.5	< 0.3	< 0.2	639.6 ± 10.0
F16	Garden soil (irrigated – shallow well water)	5.3 ± 0.3	< 0.2	< 0.2	620.8 ± 7.7
R2	Garden Soil (irrigated – deep well water)	4.7 ± 0.2	< 0.2	< 0.2	682.8 ± 7.1
R316	Garden Soil (irrigated – deep well water)	4.8 ± 0.3	< 0.2	< 0.3	564.8 ± 9.4
PN REMP					
P11	Soil (open area – not irrigated)	3.1 ± 0.3	< 0.2	< 0.2	603.5 ± 8.8
P11	Soil (irrigated)	5.5 ± 0.3	< 0.3	< 0.2	711.1 ± 9.5
Background Locations					
Cobourg – A	Inland Soil	0.5 ± 0.1	< 0.1	< 0.1	465.8 ± 5.8
Cobourg – B	Inland Soil	0.5 ± 0.1	< 0.2	< 0.2	441.0 ± 7.3
Goderich – A	Inland Soil	1.6 ± 0.2	< 0.2	< 0.1	366.6 ± 5.8
Goderich – B	Inland Soil	1.8 ± 0.1	< 0.1	< 0.2	377.3 ± 5.1
Lakefield – A	Inland Soil	5.9 ± 0.3	< 0.2	< 0.3	716.1 ± 8.9
Lakefield –B	Inland Soil	6.3 ± 0.2	< 0.2	< 0.2	750.4 ± 8.3

NOTES:

(a) For gamma analysis "<" indicates less than Ld.

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Table D12: Tritium, I-131, and C-14 Annual Average Concentrations in Milk = 2009

Site Description	Distance and Direction from Station (km)	HTO ^{(a) (b)} (Bq/L)	I-131 ^(c) (Bq/L)	C-14 ^(a) (Bq/kg-C)	OBT (Bq/L - w.e.)
DN REMP					
DF12	15 km NW	9.9	(c)	238	NR
DF5	3 km N	6.3	(c)	245	NR
DF7	9 km NNE	3.3	(c)	235	NR
DF8	10 km NE	9.2	(c)	243	NR
DF9	13 km ENE	5.2	(c)	232	NR
Average		6.8	< 0.1	238	-
PN REMP					
DF1	12 km WNW	17.9	(c)	241	NR
DF8	10 km NNE	22.4	(c)	252	30
DF11 ^(e)	10 km NE	24.0	(c)	249	NR
Average		21.4	< 0.1	247	-
Background Locations					
Belleville		2.5	< 0.1	231	NR
London		< 2.3	< 0.1	222	NR
Average		< 2.3 ^(d)	< 0.1	226	-

NOTES:

NR = Not Required by Program

Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

(a) Weekly samples are used to form monthly composite samples at each farm for HTO and C-14 analysis.

(b) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(c) For I-131 "<" indicates less than Ld. Weekly samples from all farms are combined to form a weekly composite for I-131 analysis. The annual average I-131 concentration is presented in the table.

(d) The background average tritium concentration is calculated from the actual measurements and then compared to the Lc and Ld.

(e) Annual averages based on January to July results as sampling at this location was discontinued in August since it was no longer operating as a dairy farm.

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Table D13: Pickering Nuclear Sewage Effluent H-3, C-14 and Gamma Scan Results – 2009

Date	I-131 (Bq/kg) (a) (b)	Cs-137 (Bq/kg) (a) (b)	Cs-134 (Bq/kg) (a) (b)	Co-60 (Bq/kg) (a) (b)	K-40 (Bq/kg) (a) (b)	Date ^(c)	H-3 (Bq/L)	C-14 (Bq/L) ^{(d) (e)}
January	< 0.3	< 0.3	< 0.3	< 0.3	5.2	Quarter 1	4370 ± 33	< 2.3
February	< 0.3	1.0	< 0.3	< 0.3	5.7			
March	< 0.3	< 0.3	< 0.3	< 0.3	7.1			
April	< 0.3	< 0.3	< 0.3	< 0.3	4.5	Quarter 2	2258 ± 26	< 2.3
May	< 0.3	< 0.3	< 0.3	< 0.2	11.8			
June	< 0.3	< 0.2	< 0.2	< 0.2	8.3			
July	< 0.2	0.9	< 0.2	< 0.1	10.9	Quarter 3	3015 ± 29	< 2.3
August	< 0.3	< 0.2	< 0.2	< 0.1	10.2			
September	< 0.3	< 0.1	< 0.2	< 0.2	8.4			
October	< 0.2	< 0.2	< 0.2	< 0.1	11.4	Quarter 4	5678 ± 40	< 2.3
November	< 0.2	< 0.3	< 0.2	< 0.3	8.9			
December	< 0.3	< 0.2	< 0.2	< 0.2	5.8			

NOTES:

- (a) For gamma analysis "<" indicates less than Ld.
- (b) Monthly average of PN Site Sewage Effluent weekly sample results. The sewage stream is treated at the York Durham WPCP.
- (c) Quarterly composite samples are prepared from weekly samples.
- (d) Ld for C-14 is 4.5 Bq/L and Lc for C-14 is 2.3 Bq/L.
- (e) Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

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Table D14: York Durham Water Pollution Control Plant Ash Gamma Scan Results – 2009^(a)

Month	I-131 (Bq/kg±2σ)	Cs-137 (Bq/kg±2σ) ^(b)	K-40 (Bq/kg±2σ)	Co-60 (Bq/kg±2σ)	Cs-134 (Bq/kg±2σ)
January	2.5 ± 0.3	< 0.3	167.4 ± 4.8	< 0.3	< 0.3
February	8.2 ± 0.3	< 0.4	167.7 ± 5.5	< 0.3	< 0.4
March	6.5 ± 0.5	< 0.4	242.6 ± 7.2	< 0.4	< 0.4
April	19.3 ± 0.8	0.4 ± 0.3	212.6 ± 6.7	< 0.4	< 0.4
May	7.4 ± 0.4	0.5 ± 0.2	233.1 ± 6.4	< 0.3	< 0.4
June	9.6 ± 0.5	0.8 ± 0.3	262.0 ± 7.5	< 0.4	< 0.4
July	2.8 ± 0.3	0.4 ± 0.2	160.5 ± 5.0	< 0.2	< 0.3
August	5.5 ± 0.3	0.5 ± 0.2	164.9 ± 5.1	< 0.2	< 0.2
September	7.9 ± 0.5	4.5 ± 0.2	195.8 ± 5.4	< 0.2	< 0.3
October	8.3 ± 7.6	0.9 ± 0.4	290.1 ± 10.2	< 0.3	< 0.5
November	4.3 ± 0.3	5.6 ± 0.3	166.9 ± 5.6	< 0.2	< 0.3
December	4.3 ± 0.3	0.3 ± 0.2	147.9 ± 5.2	< 0.2	< 0.3

NOTES:

For gamma analysis "<" indicates less than Ld.

- (a) The ash samples contain elevated concentrations of natural background and medical source radionuclides.
- (b) The low Cs-137 levels detected are believed to be from atmospheric testing of nuclear weapons from the 1960's.

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Appendix E: Potential Critical Group Descriptions

E.1.0 DARLINGTON NUCLEAR POTENTIAL CRITICAL GROUPS

Nine potential critical groups are identified for Darlington Nuclear and are shown in Figure C1 (see Appendix C, Maps of Environmental Monitoring and Critical Group Locations). All of the potential critical groups, with exception of the Industrial/Commercial critical group, consume some locally caught fish near the DN diffuser or in McLaughlin Bay. All critical groups with the exception of the Fisher and Industrial/Commercial critical groups are assumed to be exposed to local beach sand (Darlington Provincial Park). The 1 year old infant is assumed to drink cow's milk and water (not infant formula). For all potential critical groups except the dairy farm infant, who drinks fresh local cow's milk, the assumption is made that the milk is a composite from dairy farms all over Ontario which are not affected by station operations.

The DN potential critical groups are described as follows:

- (a) The **Oshawa/Courtice** potential critical group consists of urban residents in Oshawa and in the community of Courtice within the Municipality of Clarington located to the W and WNW of the site starting at about 6 km from the site. These residents obtain drinking water from the Oshawa WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens.
- (b) The **Bowmanville** potential critical group consists of urban residents located to the NE and NNE of the site at distances from 4 to 7 km from DN. These residents obtain drinking water from the Bowmanville WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens. They also purchase a small percentage of their annual meat, poultry and egg consumption from local farms.
- (c) The **West/East Beach** potential critical group consists of urban residents located to the ENE of the site at distances from 3.5 km to 7 km. These residents obtain their drinking water from both wells and the Bowmanville WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens. They also purchase a small percentage of their annual poultry and egg consumption from local farms.
- (d) The **Non-Dairy Farm** potential critical group consists of agricultural non-dairy farms located in all landward wind sectors around the DN site at distances from 1.5 km to over 10 km. The closest is in the WNW wind sector. Members of this group obtain their water supply mostly from wells and use it for drinking, bathing, irrigation and watering livestock. They also obtain a large fraction of their annual fruit, vegetable and animal product consumption from locally grown products.
- (e) The **Dairy Farm** potential critical group consists of dairy farms located in all landward wind sectors around the DN site at distances from 3 km to over 10 km. The closest is in the N wind sector. Members of this group obtain their water

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supply from wells and use it for drinking, bathing, irrigation, and livestock watering. They also obtain a large fraction of their annual fruit, vegetable and animal product consumption, including fresh cow's milk, from locally grown products.

- (f) The **Rural Residents** potential critical group consists of residents in rural areas in all landward wind sectors around the site at distances of about 2 km to 5 km. Members of this group obtain about half of their water supply from wells and half from the Bowmanville WSP, and use it for drinking, bathing, and irrigation. They obtain a moderate fraction of their annual fruits, vegetables, poultry and eggs from locally grown products.
- (g) The **Industrial/Commercial** potential critical group consists of adult workers whose work location is close to the nuclear site. The closest location for this group is the St. Mary's cement plant about 1.8 km NE of the site, however, the most affected location due to updated meteorological data is the water pollution control plant under construction about 2 km W of DN. Members of this group are typically at this location about 23% of the time. They consume water from the Bowmanville WSP.
- (h) The **Sport Fisher** potential critical group is comprised of non-commercial individuals fishing near the DN site discharge, about 0.5 km S of the DN site. Members of this group were conservatively assumed to obtain their entire amount of fish for consumption from the vicinity of the DN site and spend 1% of their time at the discharge location where atmospheric exposure occurs.
- (i) The **Camper** potential critical group consists of campers at the Darlington Provincial Park, located from 4 to 6 km W of the site at the lakeshore, and includes McLaughlin Bay, a shallow water body where some fishing takes place. The campers are assumed to be in the park no more than 6 months of the year. They consume drinking water from the Oshawa WSP, and purchase a small fraction of their annual fruits, vegetables, meat, poultry, and eggs from locally grown sources.

E.2.0 PICKERING NUCLEAR POTENTIAL CRITICAL GROUPS

Six potential critical groups are identified for Pickering Nuclear and are shown in Figure C2 (see Appendix C). The 1 year old infant is assumed to drink cow's milk and water (not infant formula). For all potential critical groups except the dairy farm infant, who drinks fresh local cow's milk, the assumption is made that the milk is a composite from dairy farms all over Ontario which are not affected by station operations.

The PN potential critical groups are described as follows.

- (a) The **C2** potential critical group consists of inhabitants at a correctional institute, located approximately 3 km NNE of the PN Site. The C2 group obtains drinking water from the Ajax WSP and does not consume locally produced fruits or

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vegetables. The C2 resident is conservatively assumed to be at this location 100 percent of the time over at least 1 year.

- (b) The **Industrial/Commercial** potential critical group consists of adult workers whose work location is close to the nuclear site. Members of this group are typically at this location about 23% of the time. They consume water from the Ajax WSP. The closest location for this group is about 1 km NNE of the site.
- (c) The **Urban Residents** potential critical group consists of Pickering and Ajax area residents which surround the PN Site (e.g., Fairport, Fairport Beach, Rosebank, Liverpool, Pickering Village, etc.). The members of this group mostly consume water from the Ajax WSP and also consume a diet composed in part of locally grown produce and some locally caught fish. Members of this potential critical group are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).
- (d) The **Non-Dairy Farm** potential critical group consists of residents of agricultural non-dairy farms within a 10 km radius of the PN Site. Members of this group obtain most of their water supply from wells but also a portion from the Ajax WSP. Members of this potential critical group consume locally grown produce and animal products, as well as locally caught fish. They are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).
- (e) The **Dairy Farm** potential critical group consists of residents of dairy farms within a 20 km radius of the PN Site. This group obtains most of their water supply from local wells. They also consume locally grown fruit and vegetables and locally produced animal products, including fresh cow's milk. Members of this potential critical group are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).
- (f) The **Sport Fisher** potential critical group is comprised of non-commercial individuals fishing near the PN site outfalls, 0.5 km S of the PN site. Members of this group were conservatively assumed to obtain their entire amount of fish for consumption from the vicinity of the PN site and spend 1% of their time at the outfall location where atmospheric exposure occurs.

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Appendix F: Dose Calculation Procedure and Concentrations

F.1.0 CRITICAL GROUP DOSE CALCULATION PROCEDURE

The dose calculations were performed according to N-INS-03481.21-10000, Methodology for Data Analysis and Public Dose Determination for the Radiological Environmental Monitoring Program [R-12]. Where there was a deviation from this methodology that deviation is listed below:

- OBT doses from terrestrial animals and terrestrial plants were modeled using HTO concentrations measured in terrestrial samples at the critical groups. OBT doses from fish were modeled from HTO concentrations in fish.
- HTO and C-14 concentrations in terrestrial animal products other than milk are modeled from measured concentrations of HTO and C-14 in animal feed, forage, air and water. The concentrations are used to calculate the dose from ingestion of animal products. The dose resulting from I(mfp) and particulate is modeled from emissions and empirical Ka values.
- Location specific measures of each radionuclide were used in the potential critical group calculations where the group occupied a relatively small geographic location. Some groups such as the Farm, Dairy Farm or Urban Resident are spread over much wider geographic areas, and for these the maximum value of all measurements for members of the group was used in order to keep the calculated doses conservative.
- Only dairy farm residents ingest local cow's milk.
- People are assumed to be at the critical group location 100% of the time, with the exception of the Industrial/Commercial workers and the Fisher groups. Details are provided in Appendix E.
- No local grain products are consumed by humans.
- The Fisher critical group is located offshore and it is impractical to measure radionuclide concentrations in the air at that location. Therefore, air concentrations are modeled from emissions for this critical group location, while fish concentrations are measured.
- Dose calculation parameters have been updated to align with CSA N288.1-08 [R-14]

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F.2.0 CRITICAL GROUP RADIONUCLIDE CONCENTRATIONS AND BACKGROUND SUBTRACTIONS

The following section details how the radionuclide concentrations are determined, whether they are measured or modeled, and any calculations made to obtain results.

A summary on the radionuclides and pathways measured and modeled in the critical group dose calculation is presented in Table F1. OPG DRL Guidance document [R-17] provides a description of each pathway.

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Table F1: Radionuclide and Pathway Data Used in the Critical Group Dose Calculation

Pathway	Radionuclide	Modeled ⁽¹⁾	Measured
Air Inhalation	HTO	✓ (Fisher)	✓
	HT	✓ ⁽²⁾	
	C-14	✓ ⁽²⁾	✓
	I(mfp)	✓ ⁽²⁾	
	Co-60	✓ ⁽²⁾	
Air External Exposure	Noble Gas		✓ ⁽³⁾
	C-14	✓ ⁽²⁾	✓
	I(mfp)	✓ ⁽²⁾	
	Co-60	✓ ⁽²⁾	
Soil External Exposure	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
Sand External Exposure	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137+		✓
Water External Exposure (Lakes, WSPs, Wells)	HTO	✓ (wells)	✓
	C-14	✓	
	I(mfp)	✓	
	Cs-137+	✓	
Terrestrial Animals Ingestion	HTO	✓	✓ (milk)
	C-14	✓	✓ (milk)
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
	OBT	✓ ⁽⁴⁾	
Terrestrial Plants Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
	OBT	✓ ⁽⁴⁾	
Aquatic Animals Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+		✓
	OBT	✓ ⁽⁴⁾	
Sand and Soil Incidental Ingestion	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137+, Co-60	✓	✓ (sand)
Water Ingestion (WSPs, Wells)	HTO		✓
	C-14	✓	
	I(mfp)	✓	
	Cs-137+	✓	

“+” indicates that contributions from progeny are included.

- (1) Modeling is based on emissions or from local air measurements where they are available.
- (2) Concentrations are modeled from emissions and adjusted using empirical Ka determined for each critical group location.
- (3) Doses are measured directly at the site boundary and adjusted to critical group locations using the ratio of modeled air dispersion factors for the boundary monitor and critical group.
- (4) OBT dose is modeled from HTO concentration in terrestrial plants, terrestrial animals, or fish respectively.

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F.2.1 Tritium

For the purpose of estimating the critical group dose, the concentrations used in the corresponding pathways were determined as follows:

- (a) **Air** – Tritium in air is measured at each critical group location with measured background tritium in air subtracted (except for the Fisher critical group where it is modeled from emissions). At some locations there are two different types of tritium samplers, the active molecular sieve sampler, and the passive sampler which was part of a trial program. In order to remain conservative in making dose estimates, the higher concentration was used. A study completed in 2009 assessed the performance of the passive samplers. As per the recommendations of this study [R-41], passive tritium in air samplers will be removed from the REMP starting in 2010.
- (b) **Water** – Drinking water is sampled and measured at the local WSPs and also at wells where local residents obtain their water. For the WSPs, the annual average concentration is used with background tritium concentration subtracted, as calculated from the Great Lakes Time-Concentration Tritium Model [R-7], is used. For wells, the maximum annual average concentration found at each critical group is used and background is assumed to be zero. Tritium concentration in wells used for purposes other than drinking water is modeled. Lake water HTO concentrations are measured monthly and used to calculate the dose from water immersion. Background HTO concentrations from the Great Lakes Time-Concentration Tritium model [R-7], are subtracted.
- (c) **Milk** – Milk from local dairy farms is sampled on a weekly basis and a monthly composite is analyzed. The highest annual average of all the dairy farms is used for the dose calculation, with background tritium in milk concentration subtracted. Only dairy farm residents drink local milk since it is illegal to sell unprocessed milk.
- (d) **Fruits and Vegetables** – Fruit and vegetable tritium concentrations are measured at each critical group location and the background tritium concentration is subtracted. The maximum concentration measured from all samples measured for each critical group is used in the dose calculation.
- (e) **Silage** – Silage is a dry animal feed (e.g. hay, corn) used at farms and dairy farms and is usually harvested from the previous year. In Pickering, one silage sample is obtained from a Dairy Farm around the site. Since the Farms and the Dairy Farms are located at a fair distance away from the nuclear station (>8 km) it is assumed that there is not a large difference in radionuclide concentrations in silage obtained at these locations. Therefore, a silage sample taken at one location is applied to both the Farm and Dairy Farm critical groups. Background values are subtracted. At Darlington, silage samples are obtained from Dairy Farms. The maximum value is used for the Dairy Farm critical group. However this value cannot be used for the Farm critical group because it is located much

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closer to DN, therefore radionuclide concentrations in silage for the DN Farm is modeled from concentrations in air.

- (f) **Forage** – Forage includes plants consumed by animals during pasture or in the wild. Where possible, measured HTO and C-14 in vegetable concentrations were used to represent forage in the dose model. For critical groups with forage as a dose pathway but for which vegetable samples are not collected (i.e. DN Camper), forage is modeled from radionuclide concentrations in air.
- (g) **Fish** – The radionuclide concentrations used for locally caught fish is the maximum measured in the fish samples with the background tritium in water value, as calculated from the Great Lakes Time-Concentration Tritium Model [R-7], subtracted.

F.2.2 Carbon-14

For the purpose of estimating the critical group dose, the concentrations used in the corresponding pathways were determined as follows:

- (a) **Air** – C-14 via air inhalation is not a significant contributor to public dose and therefore is only monitored at select high frequency wind sector locations. Where C-14 in air measurements are available, the concentration of C-14 in air is based on the annual average of measurements for each critical group location. If more than one sample location is used to represent one critical group, then the maximum of the annual averages is taken. Where C-14 in air measurements are not available (PN Urban Residents, DN Oshawa Residents and DN Bowmanville Residents), C-14 in air is modeled from emissions and adjusted using the empirical Ka as described in Section 6.2. For all measurements, the average background C-14 concentration in air is subtracted.
- (b) **Water** – Concentrations of C-14 in well water are modeled from measured local air concentrations at each critical group location, and concentrations in the WSPs and lake water are modeled from site waterborne emissions.
- (c) **Terrestrial media** – The concentrations of C-14 in terrestrial media (plants, milk, hay) are based on the maximum of the measurements for each sample type for each critical group, minus the average C-14 concentration measured in background vegetables.
- (d) **Fish** – For fish, the maximum C-14 concentration of all samples per site is used, minus the average concentration of C-14 in Lake Ontario fish measured in background locations.

F.2.3 Noble Gases and Skyshine

The noble gas detectors measure the air kerma rate, which is converted to effective dose using appropriate age-specific conversion factors (effective dose/air kerma rate)

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[R-25] and standard occupancy and shielding factors for air immersion dose as described in CSA N288.1-08 [R14].

Noble gas dose is measured directly in most landward wind sectors around the DN site and PN site boundaries, and adjusted to the critical group location using calculated air dispersion ratios.

The air kerma rate from the PWMF at the PN site was measured in September 2000 over water on Lake Ontario [R-26]. The results showed a rapid drop in the measured air kerma rate with distance, such that it is below the detection limit (0.13 nGy/h) at a distance of 500 m from these storage areas. At 1 km distance, the air kerma rate is estimated to be negligible assuming an inverse square relation with distance as well as a further reduction of a factor of 1,000 due to scattering in air (effective half distance of 56 m for skyshine radiation at 300 keV [R-27]). The skyshine dose from this source is therefore not significant for critical groups outside the 1 km boundary, which are all the critical groups except the Fisher which is assumed to be located 500 m south of PN in Lake Ontario. Skyshine doses from the PWMF and PN station are estimated and included in the total noble gas dose for all critical groups.

Similarly, skyshine doses at DN are estimated and included in the critical group noble gas doses. Skyshine doses are found to be negligible for all critical groups.

F.2.4 Radioiodines

Radioiodine emissions are assumed to have an equilibrium mixture of radioiodines based on I(mfp). This is to account for short lived radioiodines which may be emitted along with I-131. Emissions for each short lived radioiodine are incorporated into the dose model based on its equilibrium ratio to the measured I-131 emission. Doses are modeled for the individual radioiodines and summed for the total I(mfp) dose. Because of the very short half-lives of some of these radioiodines, this calculation may overestimate the doses.

Radioiodines are an airborne emission, therefore radioiodine doses are modeled using air concentrations calculated from airborne emissions and the empirical Ka at each critical group location, as described in Section 6.2. Where no empirical Ka values are available, air concentrations are directly modeled from emissions.

F.2.5 Particulates and Gross-Beta Gamma

Both airborne particulates and waterborne gross-beta emissions represent a mixture of beta and gamma emitting radionuclides. In order to obtain conservative doses for these mixtures, they are represented by the most limiting radionuclides typically found in the mixtures. According to the latest REMP reviews [R-37][R-38], the most limiting radionuclide for atmospheric particulate emissions is Co-60 and for liquid effluent beta-gamma emissions it is Cs-137. There was no analysis for alpha radioactivity because alpha radionuclide emissions from the stations are extremely low [R-35].

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For airborne particulates, concentrations in air are modeled using the empirical Ka at each critical group location, as described in Section 6.2, and concentrations in terrestrial media are subsequently modeled from the airborne concentrations. These concentrations are used to calculate doses to critical group individuals.

For waterborne gross-beta gamma, critical group doses are directly modeled from emissions in aquatic media where no local measurements are available. The only pathways used for dose calculation in which gross beta-gamma activity is measured in environmental samples are fish and beach sand. Background values of activity in Lake Ontario fish and beach sand are subtracted from these measurements.

F.2.6 Elemental Tritium

For HT, the inhalation pathway is the only direct pathway to humans resulting in dose. Concentrations in air are modeled from emissions data and the Ka values measured from HTO data, as described in Section 6.2. HT converts into HTO through interaction with microbes in the soil. The resultant HTO is routinely measured in air and local biota around nuclear sites.

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Appendix G: Tables of Public Doses by Radionuclide, Pathway and Age Group for Darlington Nuclear and Pickering Nuclear Critical Groups

Table G1: Darlington Nuclear – Farm Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	8.13E-12	9.35E-15	3.09E-13	3.15E-17	0.00E+00	0.00E+00	3.09E-16	1.98E-17	0.00E+00	7.05E-10	4.56E-08	1.60E-08	6.23E-08
	Co-60	Sv/a	1.07E-11	4.07E-13	2.34E-13	3.17E-14	1.04E-14	1.08E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-10	4.77E-12	1.09E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.80E-11	3.94E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.67E-10	0.00E+00	0.00E+00	5.99E-10
	HT	Sv/a	2.17E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-12
	HTO	Sv/a	1.00E-07	0.00E+00	1.26E-07	2.93E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.39E-11	2.65E-08	4.33E-09	2.60E-07
	NobleGases	Sv/a	0.00E+00	6.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.40E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E-11	4.01E-09	2.93E-09	6.97E-09
	I (mfp)	Sv/a	7.35E-11	5.91E-12	6.07E-13	3.19E-15	3.78E-16	1.67E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-09	7.56E-10	2.75E-09
	Total	Sv/a	1.01E-07	6.41E-08	1.26E-07	2.93E-09	1.08E-14	1.08E-08	3.09E-16	1.98E-17	0.00E+00	1.36E-09	7.80E-08	2.41E-08	4.08E-07
Child-10y	C-14	Sv/a	1.16E-11	9.35E-15	2.19E-13	3.15E-17	0.00E+00	0.00E+00	1.71E-15	1.98E-17	0.00E+00	4.16E-10	3.36E-08	1.24E-08	4.65E-08
	Co-60	Sv/a	1.53E-11	4.07E-13	3.89E-13	3.17E-14	1.35E-13	1.08E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E-10	8.79E-12	1.10E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.11E-11	3.94E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-10	0.00E+00	0.00E+00	2.02E-10
	HT	Sv/a	2.57E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-12
	HTO	Sv/a	1.19E-07	0.00E+00	8.09E-08	2.44E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.42E-11	1.77E-08	2.50E-09	2.23E-07
	NobleGases	Sv/a	0.00E+00	6.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.40E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-11	3.06E-09	1.76E-09	4.84E-09
	I (mfp)	Sv/a	1.67E-10	5.91E-12	7.37E-13	3.19E-15	3.57E-15	1.67E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.24E-09	1.25E-09	3.67E-09
	Total	Sv/a	1.20E-07	6.41E-08	8.09E-08	2.44E-09	1.39E-13	1.08E-08	1.71E-15	1.98E-17	0.00E+00	6.53E-10	5.69E-08	1.79E-08	3.53E-07
Infant_1y	C-14	Sv/a	7.92E-12	9.35E-15	0.00E+00	5.70E-19	0.00E+00	0.00E+00	3.41E-15	1.98E-17	0.00E+00	2.45E-10	2.94E-08	1.51E-08	4.48E-08
	Co-60	Sv/a	1.12E-11	5.29E-13	0.00E+00	4.12E-14	3.31E-13	1.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-10	1.38E-11	1.43E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.60E-11	0.00E+00	0.00E+00	6.60E-11
	HT	Sv/a	1.76E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-12
	HTO	Sv/a	8.18E-08	0.00E+00	0.00E+00	6.86E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-11	1.71E-08	2.68E-09	1.02E-07
	NobleGases	Sv/a	0.00E+00	7.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.86E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.78E-12	2.71E-09	1.64E-09	4.36E-09
	I (mfp)	Sv/a	1.95E-10	7.68E-12	0.00E+00	4.15E-15	1.25E-14	2.17E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-09	3.52E-09	6.84E-09
	Total	Sv/a	8.21E-08	7.86E-08	0.00E+00	6.86E-10	3.44E-13	1.41E-08	3.41E-15	1.98E-17	0.00E+00	3.42E-10	5.25E-08	2.29E-08	2.51E-07

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Table G2: Darlington Nuclear – Dairy Farm Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	9.92E-13	1.14E-15	2.29E-14	3.03E-17	0.00E+00	0.00E+00	3.09E-16	1.98E-17	0.00E+00	1.50E-10	2.38E-08	1.52E-07	1.76E-07
	Co-60	Sv/a	4.70E-12	1.78E-13	9.19545e-434	1.02158e-434	2.39E-15	2.47E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.03E-11	1.06E-11	2.54E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	3.94E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-10	0.00E+00	0.00E+00	1.25E-10
	HT	Sv/a	9.47E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.47E-13
	HTO	Sv/a	4.39E-08	0.00E+00	5.88E-08	2.32E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-11	1.21E-08	2.74E-08	1.44E-07
	NobleGases	Sv/a	0.00E+00	2.18E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.84E-12	1.85E-09	6.14E-09	8.00E-09
	I (mfp)	Sv/a	3.22E-11	2.40E-12	0.00E+00	0.00E+00	1.61E-16	7.12E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E-10	1.87E-09	2.77E-09
	Total	Sv/a	4.39E-08	2.18E-08	5.88E-08	2.33E-09	2.55E-15	2.48E-09	3.09E-16	1.98E-17	0.00E+00	2.90E-10	3.86E-08	1.87E-07	3.55E-07
Child-10y	C-14	Sv/a	1.42E-12	1.14E-15	1.62E-14	3.03E-17	0.00E+00	0.00E+00	1.71E-15	1.98E-17	0.00E+00	8.86E-11	1.75E-08	2.07E-07	2.25E-07
	Co-60	Sv/a	6.70E-12	1.78E-13	1.53E-433	1.02158e-434	3.09E-14	2.47E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.15E-11	3.28E-11	2.59E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	3.94E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.97E-11	0.00E+00	0.00E+00	4.37E-11
	HT	Sv/a	1.13E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-12
	HTO	Sv/a	5.22E-08	0.00E+00	3.78E-08	1.94E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.28E-12	8.09E-09	3.57E-08	1.36E-07
	NobleGases	Sv/a	0.00E+00	2.18E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.43E-12	1.41E-09	6.79E-09	8.20E-09
	I (mfp)	Sv/a	7.29E-11	2.40E-12	0.00E+00	0.00E+00	1.52E-15	7.12E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-09	4.43E-09	5.51E-09
	Total	Sv/a	5.23E-08	2.18E-08	3.78E-08	1.94E-09	3.24E-14	2.48E-09	1.71E-15	1.98E-17	0.00E+00	1.39E-10	2.81E-08	2.54E-07	3.99E-07
Infant_1y	C-14	Sv/a	9.66E-13	1.14E-15	0.00E+00	6.88E-20	0.00E+00	0.00E+00	3.41E-15	1.98E-17	0.00E+00	5.22E-11	1.52E-08	4.51E-07	4.66E-07
	Co-60	Sv/a	4.91E-12	2.31E-13	0.00E+00	5.46689e-435	7.58E-14	3.21E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.88E-11	8.40E-11	3.38E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-11	0.00E+00	0.00E+00	1.40E-11
	HT	Sv/a	7.72E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.72E-13
	HTO	Sv/a	3.58E-08	0.00E+00	0.00E+00	3.23E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.55E-12	7.63E-09	8.59E-08	1.30E-07
	NobleGases	Sv/a	0.00E+00	2.68E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-12	1.23E-09	1.38E-08	1.51E-08
	I (mfp)	Sv/a	8.53E-11	3.12E-12	0.00E+00	0.00E+00	5.33E-15	9.26E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-09	1.59E-08	1.74E-08
	Total	Sv/a	3.59E-08	2.68E-08	0.00E+00	3.23E-10	8.11E-14	3.22E-09	3.41E-15	1.98E-17	0.00E+00	7.28E-11	2.55E-08	5.67E-07	6.59E-07

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G3: Darlington Nuclear – Bowmanville Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	2.61E-10	3.00E-13	2.72E-12	7.03E-17	8.71E-19	1.62E-17	3.09E-16	1.98E-17	0.00E+00	7.47E-11	1.73E-08	1.47E-09	1.91E-08
	Co-60	Sv/a	6.76E-12	2.56E-13	0.00E+00	0.00E+00	3.45E-15	3.58E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-11	4.84E-13	3.62E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	4.13E-10	9.19E-12	5.09E-14	3.32E-09	0.00E+00	0.00E+00	0.00E+00	6.01E-11	9.50E-12	0.00E+00	3.82E-09
	HT	Sv/a	1.36E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-12
	HTO	Sv/a	6.32E-08	0.00E+00	2.79E-08	2.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.78E-12	1.07E-08	6.15E-10	1.05E-07
	NobleGases	Sv/a	0.00E+00	3.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.90E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-12	1.59E-09	3.96E-10	1.99E-09
	I (mfp)	Sv/a	4.63E-11	3.37E-12	0.00E+00	0.00E+00	2.32E-16	1.03E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.33E-10	6.27E-11	7.55E-10
	Total	Sv/a	6.36E-08	3.90E-08	2.83E-08	2.26E-09	5.46E-14	6.91E-09	3.09E-16	1.98E-17	0.00E+00	1.44E-10	3.02E-08	2.54E-09	1.73E-07
Child-10y	C-14	Sv/a	3.72E-10	3.00E-13	1.93E-12	7.03E-17	4.80E-18	1.62E-17	1.71E-15	1.98E-17	0.00E+00	4.41E-11	1.28E-08	1.18E-09	1.44E-08
	Co-60	Sv/a	9.65E-12	2.56E-13	0.00E+00	0.00E+00	4.47E-14	3.58E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.36E-11	8.59E-13	3.65E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.63E-10	9.19E-12	1.57E-13	3.32E-09	0.00E+00	0.00E+00	0.00E+00	1.98E-11	3.86E-12	0.00E+00	3.52E-09
	HT	Sv/a	1.62E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-12
	HTO	Sv/a	7.52E-08	0.00E+00	1.79E-08	1.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.63E-12	7.16E-09	3.41E-10	1.03E-07
	NobleGases	Sv/a	0.00E+00	3.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.90E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E-12	1.21E-09	2.31E-10	1.45E-09
	I (mfp)	Sv/a	1.05E-10	3.37E-12	0.00E+00	0.00E+00	2.19E-15	1.03E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.45E-10	1.08E-10	9.72E-10
	Total	Sv/a	7.57E-08	3.90E-08	1.81E-08	1.89E-09	2.03E-13	6.91E-09	1.71E-15	1.98E-17	0.00E+00	6.93E-11	2.19E-08	1.86E-09	1.65E-07
Infant-1y	C-14	Sv/a	2.54E-10	3.00E-13	0.00E+00	1.04E-17	9.61E-18	1.62E-17	3.41E-15	1.98E-17	0.00E+00	2.60E-11	1.16E-08	1.21E-09	1.31E-08
	Co-60	Sv/a	7.07E-12	3.33E-13	0.00E+00	0.00E+00	1.10E-13	4.65E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E-11	1.07E-12	4.72E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	1.77E-12	1.88E-13	4.33E-09	0.00E+00	0.00E+00	0.00E+00	6.99E-12	1.89E-12	0.00E+00	4.34E-09
	HT	Sv/a	1.11E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-12
	HTO	Sv/a	5.15E-08	0.00E+00	0.00E+00	1.95E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.26E-12	7.17E-09	3.87E-10	5.93E-08
	NobleGases	Sv/a	0.00E+00	4.78E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.78E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-12	1.11E-09	2.52E-10	1.37E-09
	I (mfp)	Sv/a	1.23E-10	4.39E-12	0.00E+00	0.00E+00	7.68E-15	1.34E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-09	2.19E-10	1.41E-09
	Total	Sv/a	5.19E-08	4.78E-08	0.00E+00	1.97E-10	3.05E-13	9.00E-09	3.41E-15	1.98E-17	0.00E+00	3.63E-11	2.10E-08	2.07E-09	1.32E-07

Table G4: Darlington Nuclear – Industrial/Commercial Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	8.81E-11	1.01E-13	7.96E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.90E-11
	Co-60	Sv/a	8.63E-12	3.27E-13	0.00E+00	0.00E+00	7.86E-15	8.15E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.16E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.21E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-10
	HT	Sv/a	1.74E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E-12
	HTO	Sv/a	8.07E-08	0.00E+00	8.17E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.89E-08
	NobleGases	Sv/a	0.00E+00	9.14E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.14E-09
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	Sv/a	5.91E-11	4.17E-12	0.00E+00	0.00E+00	3.03E-16	1.34E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.66E-11
	Total	Sv/a	8.08E-08	9.14E-09	8.29E-09	0.00E+00	8.16E-15	8.16E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-07

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G5: Darlington Nuclear – West/East Beach Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	0.00E+00	0.00E+00	4.93E-13	3.19E-17	2.41E-19	4.49E-18	3.09E-16	1.98E-17	0.00E+00	1.27E-09	1.63E-08	4.59E-09	2.21E-08
	Co-60	Sv/a	1.02E-11	3.86E-13	1.76E-13	1.77E-14	3.83E-15	3.97E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.88E-11	6.68E-13	4.02E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	7.49E-11	4.16E-12	1.41E-14	9.20E-10	0.00E+00	0.00E+00	0.00E+00	1.02E-09	8.50E-13	2.89E-13	2.02E-09
	HT	Sv/a	2.05E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-12
	HTO	Sv/a	9.53E-08	0.00E+00	9.10E-08	3.18E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-10	1.04E-08	4.89E-10	2.00E-07
	NobleGases	Sv/a	0.00E+00	1.21E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.94E-11	1.55E-09	3.05E-10	1.91E-09
	I (mfp)	Sv/a	6.98E-11	5.21E-12	1.14E-12	4.46E-15	3.47E-16	1.53E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-10	4.66E-11	7.56E-10
	Total	Sv/a	9.53E-08	1.21E-08	9.10E-08	3.18E-09	1.83E-14	4.91E-09	3.09E-16	1.98E-17	0.00E+00	2.45E-09	2.89E-08	5.43E-09	2.43E-07
Child-10y	C-14	Sv/a	0.00E+00	0.00E+00	3.50E-13	3.19E-17	1.33E-18	4.49E-18	1.71E-15	1.98E-17	0.00E+00	7.49E-10	1.20E-08	5.77E-09	1.85E-08
	Co-60	Sv/a	1.45E-11	3.86E-13	2.93E-13	1.77E-14	4.96E-14	3.97E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.30E-11	1.94E-12	4.05E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.96E-11	4.16E-12	4.33E-14	9.20E-10	0.00E+00	0.00E+00	0.00E+00	3.36E-10	3.32E-13	2.03E-13	1.29E-09
	HT	Sv/a	2.44E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-12
	HTO	Sv/a	1.13E-07	0.00E+00	5.85E-08	2.65E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.16E-11	6.94E-09	5.24E-10	1.82E-07
	NobleGases	Sv/a	0.00E+00	1.21E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-11	1.17E-09	3.57E-10	1.56E-09
	I (mfp)	Sv/a	1.58E-10	5.21E-12	1.39E-12	4.46E-15	3.28E-15	1.53E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.28E-10	1.00E-10	1.01E-09
	Total	Sv/a	1.13E-07	1.21E-08	5.85E-08	2.65E-09	9.62E-14	4.91E-09	1.71E-15	1.98E-17	0.00E+00	1.18E-09	2.09E-08	6.75E-09	2.20E-07
Infant_1y	C-14	Sv/a	0.00E+00	0.00E+00	0.00E+00	1.67E-18	2.66E-18	4.49E-18	3.41E-15	1.98E-17	0.00E+00	4.41E-10	1.10E-08	1.20E-08	2.34E-08
	Co-60	Sv/a	1.07E-11	5.02E-13	0.00E+00	2.30E-14	1.22E-13	5.16E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-11	4.88E-12	5.24E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	2.85E-13	5.20E-14	1.20E-09	0.00E+00	0.00E+00	0.00E+00	1.19E-10	1.68E-13	2.59E-13	1.32E-09
	HT	Sv/a	1.67E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-12
	HTO	Sv/a	7.76E-08	0.00E+00	0.00E+00	7.83E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.84E-11	6.93E-09	1.15E-09	8.65E-08
	NobleGases	Sv/a	0.00E+00	1.49E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-11	1.08E-09	7.66E-10	1.86E-09
	I (mfp)	Sv/a	1.85E-10	6.77E-12	0.00E+00	5.80E-15	1.15E-14	1.99E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-09	3.11E-10	1.55E-09
	Total	Sv/a	7.78E-08	1.49E-08	0.00E+00	7.83E-10	1.85E-13	6.38E-09	3.41E-15	1.98E-17	0.00E+00	6.16E-10	2.01E-08	1.43E-08	1.35E-07

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G6: Darlington Nuclear – Rural Resident Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	6.53E-11	7.50E-14	1.22E-12	4.20E-17	8.38E-20	1.56E-18	3.09E-16	1.98E-17	0.00E+00	4.19E-10	2.17E-08	7.74E-09	2.99E-08
	Co-60	Sv/a	1.07E-11	4.07E-13	2.85E-13	2.18E-14	9.69E-15	1.00E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.82E-11	3.20E-12	1.01E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	8.32E-11	4.15E-12	4.90E-15	3.20E-10	0.00E+00	0.00E+00	0.00E+00	3.37E-10	2.86E-12	2.70E-13	7.47E-10
	HT	Sv/a	2.17E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-12
	HTO	Sv/a	1.00E-07	0.00E+00	1.09E-07	2.79E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-11	2.07E-08	1.94E-09	2.35E-07
	NobleGases	Sv/a	0.00E+00	6.68E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-11	3.09E-09	1.23E-09	4.33E-09
	I (mfp)	Sv/a	7.35E-11	5.40E-12	7.93E-13	2.36E-15	3.76E-16	1.67E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.70E-10	1.56E-10	1.02E-09
	Total	Sv/a	1.01E-07	6.68E-08	1.09E-07	2.79E-09	1.50E-14	1.04E-08	3.09E-16	1.98E-17	0.00E+00	8.10E-10	4.63E-08	1.11E-08	3.48E-07
Child-10y	C-14	Sv/a	9.31E-11	7.50E-14	8.69E-13	4.20E-17	4.63E-19	1.56E-18	1.71E-15	1.98E-17	0.00E+00	2.47E-10	1.61E-08	9.44E-09	2.58E-08
	Co-60	Sv/a	1.53E-11	4.07E-13	4.74E-13	2.18E-14	1.25E-13	1.00E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.83E-11	9.05E-12	1.01E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	3.29E-11	4.15E-12	1.51E-14	3.20E-10	0.00E+00	0.00E+00	0.00E+00	1.11E-10	1.16E-12	1.83E-13	4.69E-10
	HT	Sv/a	2.57E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-12
	HTO	Sv/a	1.19E-07	0.00E+00	7.03E-08	2.32E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-11	1.39E-08	1.48E-09	2.07E-07
	NobleGases	Sv/a	0.00E+00	6.68E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.56E-12	2.35E-09	1.01E-09	3.38E-09
	I (mfp)	Sv/a	1.67E-10	5.40E-12	9.63E-13	2.36E-15	3.56E-15	1.67E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.09E-10	3.24E-10	1.42E-09
	Total	Sv/a	1.20E-07	6.68E-08	7.03E-08	2.33E-09	1.44E-13	1.04E-08	1.71E-15	1.98E-17	0.00E+00	3.88E-10	3.33E-08	1.23E-08	3.15E-07
Infant_1y	C-14	Sv/a	6.36E-11	7.50E-14	0.00E+00	5.45E-18	9.25E-19	1.56E-18	3.41E-15	1.98E-17	0.00E+00	1.46E-10	1.48E-08	1.98E-08	3.48E-08
	Co-60	Sv/a	1.12E-11	5.29E-13	0.00E+00	2.83E-14	3.08E-13	1.31E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-11	2.33E-11	1.32E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	2.71E-13	1.81E-14	4.17E-10	0.00E+00	0.00E+00	0.00E+00	3.92E-11	6.07E-13	2.31E-13	4.57E-10
	HT	Sv/a	1.76E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-12
	HTO	Sv/a	8.18E-08	0.00E+00	0.00E+00	5.80E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-11	1.38E-08	2.91E-09	9.92E-08
	NobleGases	Sv/a	0.00E+00	8.19E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.19E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.81E-12	2.15E-09	1.92E-09	4.08E-09
	I (mfp)	Sv/a	1.95E-10	7.02E-12	0.00E+00	3.07E-15	1.25E-14	2.16E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-09	1.18E-09	2.66E-09
	Total	Sv/a	8.21E-08	8.19E-08	0.00E+00	5.80E-10	3.38E-13	1.35E-08	3.41E-15	1.98E-17	0.00E+00	2.03E-10	3.21E-08	2.58E-08	2.36E-07

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G7: Darlington Nuclear – Provincial Park Camper Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	1.63E-11	1.88E-14	1.84E-12	5.15E-17	0.00E+00	0.00E+00	3.09E-16	1.98E-17	0.00E+00	2.71E-09	9.26E-09	1.60E-09	1.36E-08
	Co-60	Sv/a	3.19E-12	1.21E-13	0.00E+00	0.00E+00	2.92E-15	3.03E-09	0.00E+00	0.00E+00	0.00E+00	5.98E-13	2.48E-11	1.08E-12	3.06E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.80E-10	6.74E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-09	0.00E+00	0.00E+00	1.41E-09
	HT	Sv/a	6.43E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.43E-13
	HTO	Sv/a	2.98E-08	0.00E+00	2.60E-08	2.07E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-10	5.37E-09	6.57E-10	6.44E-08
	NobleGases	Sv/a	0.00E+00	2.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.83E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E-10	8.16E-10	4.16E-10	1.47E-09
	I (mfp)	Sv/a	2.18E-11	1.67E-12	0.00E+00	0.00E+00	1.12E-16	4.95E-12	0.00E+00	0.00E+00	0.00E+00	3.28E-13	3.87E-10	7.22E-11	4.88E-10
	Total	Sv/a	2.99E-08	2.83E-08	2.63E-08	2.08E-09	3.03E-15	3.03E-09	3.09E-16	1.98E-17	0.00E+00	4.61E-09	1.59E-08	2.74E-09	1.13E-07
Child-10y	C-14	Sv/a	2.33E-11	1.88E-14	1.31E-12	5.15E-17	0.00E+00	0.00E+00	1.71E-15	1.98E-17	0.00E+00	1.60E-09	6.81E-09	1.85E-09	1.03E-08
	Co-60	Sv/a	4.55E-12	1.21E-13	0.00E+00	0.00E+00	3.78E-14	3.03E-09	0.00E+00	0.00E+00	0.00E+00	8.29E-13	4.00E-11	3.00E-12	3.08E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.11E-10	6.74E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-10	0.00E+00	0.00E+00	4.87E-10
	HT	Sv/a	7.64E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.64E-13
	HTO	Sv/a	3.54E-08	0.00E+00	1.67E-08	1.73E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-10	3.59E-09	4.15E-10	5.82E-08
	NobleGases	Sv/a	0.00E+00	2.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.83E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-10	6.20E-10	2.78E-10	1.04E-09
	I (mfp)	Sv/a	4.95E-11	1.67E-12	0.00E+00	0.00E+00	1.06E-15	4.95E-12	0.00E+00	0.00E+00	0.00E+00	3.32E-13	4.54E-10	1.49E-10	6.60E-10
	Total	Sv/a	3.55E-08	2.83E-08	1.68E-08	1.74E-09	3.89E-14	3.03E-09	1.71E-15	1.98E-17	0.00E+00	2.40E-09	1.15E-08	2.70E-09	1.02E-07
Infant_1y	C-14	Sv/a	1.59E-11	1.88E-14	0.00E+00	5.54E-18	0.00E+00	0.00E+00	3.41E-15	1.98E-17	0.00E+00	9.41E-10	5.96E-09	3.27E-09	1.02E-08
	Co-60	Sv/a	3.33E-12	1.57E-13	0.00E+00	0.00E+00	9.28E-14	3.94E-09	0.00E+00	0.00E+00	0.00E+00	5.99E-13	3.89E-11	7.26E-12	3.99E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	9.43E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-10	0.00E+00	0.00E+00	1.31E-10
	HT	Sv/a	5.24E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.24E-13
	HTO	Sv/a	2.43E-08	0.00E+00	0.00E+00	1.43E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-10	3.45E-09	6.99E-10	2.88E-08
	NobleGases	Sv/a	0.00E+00	3.47E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.47E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.38E-11	5.50E-10	4.57E-10	1.09E-09
	I (mfp)	Sv/a	5.79E-11	2.17E-12	0.00E+00	0.00E+00	3.70E-15	6.43E-12	0.00E+00	0.00E+00	0.00E+00	3.42E-13	6.31E-10	4.18E-10	1.12E-09
	Total	Sv/a	2.44E-08	3.47E-08	0.00E+00	1.44E-10	9.65E-14	3.94E-09	3.41E-15	1.98E-17	0.00E+00	1.34E-09	1.06E-08	4.85E-09	8.00E-08

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G8: Darlington Nuclear – Oshawa Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	4.04E-11	4.64E-14	3.07E-12	7.29E-17	9.28E-19	1.73E-17	3.09E-16	1.98E-17	0.00E+00	1.32E-09	1.04E-08	6.75E-12	1.17E-08
	Co-60	Sv/a	1.05E-12	3.97E-14	0.00E+00	0.00E+00	9.94E-16	1.03E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E-11	7.03E-15	1.05E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	4.68E-10	9.53E-12	5.42E-14	3.54E-09	0.00E+00	0.00E+00	0.00E+00	1.06E-09	7.67E-12	0.00E+00	5.09E-09
	HT	Sv/a	2.11E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.11E-13
	HTO	Sv/a	9.79E-09	0.00E+00	4.33E-08	2.57E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-10	5.29E-09	4.55E-11	6.11E-08
	NobleGases	Sv/a	0.00E+00	7.22E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E-09
	OBt	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.16E-11	7.98E-10	3.01E-11	8.80E-10
	I (mfp)	Sv/a	7.15E-12	6.08E-13	0.00E+00	0.00E+00	3.68E-17	1.62E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-10	1.36E-13	2.76E-10
	Total	Sv/a	9.84E-09	7.22E-09	4.38E-08	2.58E-09	5.53E-14	4.57E-09	3.09E-16	1.98E-17	0.00E+00	2.56E-09	1.67E-08	8.25E-11	8.74E-08
Child-10y	C-14	Sv/a	5.76E-11	4.64E-14	2.18E-12	7.29E-17	5.12E-18	1.73E-17	1.71E-15	1.98E-17	0.00E+00	7.82E-10	7.64E-09	3.86E-12	8.49E-09
	Co-60	Sv/a	1.49E-12	3.97E-14	0.00E+00	0.00E+00	1.29E-14	1.03E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-11	9.43E-15	1.06E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.85E-10	9.53E-12	1.67E-13	3.54E-09	0.00E+00	0.00E+00	0.00E+00	3.51E-10	3.13E-12	0.00E+00	4.09E-09
	HT	Sv/a	2.51E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-13
	HTO	Sv/a	1.16E-08	0.00E+00	2.79E-08	2.14E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.43E-11	3.55E-09	2.36E-11	4.53E-08
	NobleGases	Sv/a	0.00E+00	7.22E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E-09
	OBt	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-11	6.09E-10	1.71E-11	6.56E-10
	I (mfp)	Sv/a	1.62E-11	6.08E-13	0.00E+00	0.00E+00	3.47E-16	1.62E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-10	1.33E-13	3.33E-10
	Total	Sv/a	1.17E-08	7.22E-09	2.80E-08	2.15E-09	1.80E-13	4.57E-09	1.71E-15	1.98E-17	0.00E+00	1.23E-09	1.21E-08	4.47E-11	6.71E-08
Infant_1y	C-14	Sv/a	3.93E-11	4.64E-14	0.00E+00	1.11E-17	1.02E-17	1.73E-17	3.41E-15	1.98E-17	0.00E+00	4.60E-10	6.56E-09	4.93E-12	7.06E-09
	Co-60	Sv/a	1.10E-12	5.16E-14	0.00E+00	0.00E+00	3.16E-14	1.34E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E-11	1.48E-14	1.37E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	1.89E-12	2.00E-13	4.62E-09	0.00E+00	0.00E+00	0.00E+00	1.24E-10	1.51E-12	0.00E+00	4.74E-09
	HT	Sv/a	1.72E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-13
	HTO	Sv/a	7.98E-09	0.00E+00	0.00E+00	2.85E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.01E-11	3.45E-09	3.19E-11	1.18E-08
	NobleGases	Sv/a	0.00E+00	8.87E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.87E-09
	OBt	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-11	5.45E-10	2.25E-11	5.86E-10
	I (mfp)	Sv/a	1.90E-11	7.91E-13	0.00E+00	0.00E+00	1.22E-15	2.10E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.44E-10	2.98E-13	4.66E-10
	Total	Sv/a	8.04E-09	8.87E-09	0.00E+00	2.87E-10	2.33E-13	5.96E-09	3.41E-15	1.98E-17	0.00E+00	6.43E-10	1.10E-08	5.97E-11	3.49E-08

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G9: Darlington Nuclear – Fisher Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	1.56E-10	1.79E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.57E-09	0.00E+00	0.00E+00	5.73E-09
	Co-60	Sv/a	4.05E-12	1.53E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-12
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-09	0.00E+00	0.00E+00	4.49E-09
	HT	Sv/a	8.16E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.16E-13
	HTO	Sv/a	3.85E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.06E-10	0.00E+00	0.00E+00	3.90E-08
	NobleGases	Sv/a	0.00E+00	1.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-09
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-10	0.00E+00	0.00E+00	2.17E-10
	I (mfp)	Sv/a	2.77E-11	1.83E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-11
	Total	Sv/a	3.87E-08	1.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-08	0.00E+00	0.00E+00	5.14E-08
Child-10y	C-14	Sv/a	2.23E-10	1.79E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.29E-09	0.00E+00	0.00E+00	3.52E-09
	Co-60	Sv/a	5.78E-12	1.53E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.93E-12
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-09	0.00E+00	0.00E+00	1.48E-09
	HT	Sv/a	9.71E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.71E-13
	HTO	Sv/a	4.58E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-10	0.00E+00	0.00E+00	4.61E-08
	NobleGases	Sv/a	0.00E+00	1.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-09
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-10	0.00E+00	0.00E+00	1.27E-10
	I (mfp)	Sv/a	6.27E-11	1.83E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.46E-11
	Total	Sv/a	4.61E-08	1.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E-09	0.00E+00	0.00E+00	5.31E-08
Infant_1y	C-14	Sv/a	1.52E-10	1.79E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.94E-09	0.00E+00	0.00E+00	2.09E-09
	Co-60	Sv/a	4.23E-12	2.00E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-12
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-10	0.00E+00	0.00E+00	5.22E-10
	HT	Sv/a	6.65E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.65E-13
	HTO	Sv/a	3.14E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-10	0.00E+00	0.00E+00	3.16E-08
	NobleGases	Sv/a	0.00E+00	2.30E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-09
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.74E-11	0.00E+00	0.00E+00	7.74E-11
	I (mfp)	Sv/a	7.34E-11	2.39E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.58E-11
	Total	Sv/a	3.16E-08	2.31E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-09	0.00E+00	0.00E+00	3.66E-08

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G10: Pickering Nuclear – Farm Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	6.88E-11	7.91E-14	5.69E-12	5.65E-16	6.00E-19	1.12E-17	5.54E-15	3.54E-16	0.00E+00	3.09E-10	4.95E-08	5.59E-08	1.06E-07
	Co-60	Sv/a	9.53E-12	3.61E-13	8.51E-14	1.02E-14	4.36E-15	4.52E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.95E-11	5.10E-12	4.59E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.35E-09	2.28E-10	1.10E-13	7.20E-09	1.17E-12	5.93E-10	0.00E+00	2.11E-10	2.19E-10	4.24E-11	1.08E-08
	HTO	Sv/a	2.66E-07	0.00E+00	1.42E-07	4.05E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E-11	3.30E-08	1.10E-08	4.57E-07
	NobleGases	Sv/a	0.00E+00	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-11	4.97E-09	6.92E-09	1.19E-08
	I (mfp)	Sv/a	1.12E-11	8.02E-13	7.81E-14	3.65E-16	5.59E-17	2.47E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-10	8.87E-11	2.90E-10
	Total	Sv/a	2.66E-07	1.10E-07	1.45E-07	4.28E-09	1.15E-13	1.17E-08	1.18E-12	5.93E-10	0.00E+00	5.53E-10	8.79E-08	7.39E-08	7.00E-07
Child-10y	C-14	Sv/a	9.82E-11	7.91E-14	4.03E-12	5.65E-16	3.31E-18	1.12E-17	3.05E-14	3.54E-16	0.00E+00	1.82E-10	3.66E-08	6.11E-08	9.80E-08
	Co-60	Sv/a	1.36E-11	3.61E-13	1.42E-13	1.02E-14	5.65E-14	4.52E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.01E-11	1.35E-11	4.63E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	9.31E-10	2.28E-10	3.39E-13	7.20E-09	3.60E-12	5.93E-10	0.00E+00	6.96E-11	8.92E-11	1.99E-11	9.13E-09
	HTO	Sv/a	3.17E-07	0.00E+00	9.16E-08	3.38E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-11	2.21E-08	8.98E-09	4.43E-07
	NobleGases	Sv/a	0.00E+00	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-12	3.79E-09	6.18E-09	9.98E-09
	I (mfp)	Sv/a	2.54E-11	8.02E-13	9.48E-14	3.65E-16	5.28E-16	2.47E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-10	1.69E-10	4.18E-10
	Total	Sv/a	3.17E-07	1.10E-07	9.25E-08	3.60E-09	3.96E-13	1.17E-08	3.63E-12	5.93E-10	0.00E+00	2.70E-10	6.29E-08	7.65E-08	6.75E-07
Infant_1y	C-14	Sv/a	6.70E-11	7.91E-14	0.00E+00	1.86E-17	6.62E-18	1.12E-17	6.11E-14	3.54E-16	0.00E+00	1.07E-10	3.30E-08	1.17E-07	1.50E-07
	Co-60	Sv/a	9.97E-12	4.70E-13	0.00E+00	1.33E-14	1.39E-13	5.88E-09	0.00E+00	0.00E+00	0.00E+00	7.73E-11	3.12E-11	6.00E-09	6.00E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	7.92E-12	4.07E-13	9.38E-09	4.32E-12	7.70E-10	0.00E+00	2.46E-11	4.83E-11	1.81E-11	1.02E-08
	HTO	Sv/a	2.17E-07	0.00E+00	0.00E+00	1.20E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.85E-12	2.16E-08	1.63E-08	2.56E-07
	NobleGases	Sv/a	0.00E+00	1.34E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-12	3.40E-09	1.09E-08	1.43E-08
	I (mfp)	Sv/a	2.97E-11	1.04E-12	0.00E+00	4.74E-16	1.85E-15	3.21E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.04E-10	4.63E-10	8.01E-10
	Total	Sv/a	2.17E-07	1.34E-07	0.00E+00	1.21E-09	5.47E-13	1.53E-08	4.38E-12	7.70E-10	0.00E+00	1.43E-10	5.84E-08	1.45E-07	5.72E-07

Table G11: Pickering Nuclear – Dairy Farm Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	1.51E-10	1.74E-13	2.78E-12	5.64E-16	0.00E+00	0.00E+00	5.54E-15	3.54E-16	0.00E+00	0.00E+00	1.42E-08	9.47E-08	1.09E-07
	Co-60	Sv/a	8.61E-12	3.27E-13	0.00E+00	3.07E-15	4.71E-15	4.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E-11	1.02E-11	4.95E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.93E-10	2.22E-10	0.00E+00	0.00E+00	1.17E-12	5.93E-10	0.00E+00	0.00E+00	0.00E+00	1.38E-12	1.11E-09
	HTO	Sv/a	2.41E-07	0.00E+00	8.80E-08	3.89E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-08	3.16E-08	3.86E-07
	NobleGases	Sv/a	0.00E+00	7.44E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.44E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.49E-09	1.14E-08	1.49E-08
	I (mfp)	Sv/a	1.01E-11	7.09E-13	0.00E+00	9.22E-17	5.08E-17	2.25E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-10	2.35E-10	4.20E-10
	Total	Sv/a	2.41E-07	7.44E-08	8.83E-08	4.11E-09	4.76E-15	4.88E-09	1.18E-12	5.93E-10	0.00E+00	0.00E+00	3.93E-08	1.38E-07	5.90E-07
Child-10y	C-14	Sv/a	2.15E-10	1.74E-13	1.97E-12	5.64E-16	0.00E+00	0.00E+00	3.05E-14	3.54E-16	0.00E+00	0.00E+00	1.04E-08	1.01E-07	1.12E-07
	Co-60	Sv/a	1.23E-11	3.27E-13	0.00E+00	3.07E-15	6.10E-14	4.88E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.81E-11	2.54E-11	5.00E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.16E-10	2.22E-10	0.00E+00	0.00E+00	3.60E-12	5.93E-10	0.00E+00	0.00E+00	0.00E+00	4.08E-13	9.34E-10
	HTO	Sv/a	2.86E-07	0.00E+00	5.66E-08	3.24E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-08	3.33E-08	3.94E-07
	NobleGases	Sv/a	0.00E+00	7.44E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.44E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-09	9.15E-09	1.18E-08
	I (mfp)	Sv/a	2.29E-11	7.09E-13	0.00E+00	9.22E-17	4.80E-16	2.25E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.01E-10	4.72E-10	7.00E-10
	Total	Sv/a	2.86E-07	7.44E-08	5.67E-08	3.46E-09	6.14E-14	4.88E-09	3.63E-12	5.93E-10	0.00E+00	0.00E+00	2.76E-08	1.44E-07	5.98E-07
Infant_1y	C-14	Sv/a	1.47E-10	1.74E-13	0.00E+00	1.02E-17	0.00E+00	0.00E+00	6.11E-14	3.54E-16	0.00E+00	0.00E+00	7.86E-09	1.89E-07	1.97E-07
	Co-60	Sv/a	9.01E-12	4.25E-13	0.00E+00	4.00E-15	1.50E-13	6.35E-09	0.00E+00	0.00E+00	0.00E+00	7.27E-11	5.82E-11	6.49E-09	6.49E-09
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-12	7.70E-10	0.00E+00	0.00E+00	0.00E+00	3.65E-13	7.75E-10
	HTO	Sv/a	1.96E-07	0.00E+00	0.00E+00	9.93E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-08	7.23E-08	2.81E-07
	NobleGases	Sv/a	0.00E+00	9.05E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.05E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.06E-09	1.44E-08	1.64E-08
	I (mfp)	Sv/a	2.68E-11	9.22E-13	0.00E+00	1.20E-16	1.68E-15	2.92E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-10	1.66E-09	1.96E-09
	Total	Sv/a	1.96E-07	9.05E-08	0.00E+00	9.93E-10	1.51E-13	6.35E-09	4.38E-12	7.70E-10	0.00E+00	0.00E+00	2.16E-08	2.78E-07	5.94E-07

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2009 RESULTS OF RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAMS

Table G12: Pickering Nuclear – Industrial/Commercial Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	1.02E-09	1.17E-12	5.86E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-09
	Co-60	Sv/a	4.45E-11	1.69E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-11
	Cs-137+	Sv/a	0.00E+00	0.00E+00	2.80E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E-09
	HTO	Sv/a	1.24E-06	0.00E+00	1.05E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-06
	NobleGases	Sv/a	0.00E+00	5.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.80E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	Sv/a	5.22E-11	3.62E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.59E-11
	Total	Sv/a	1.24E-06	5.80E-07	1.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-06

Table G13: Pickering Nuclear – Correctional Institute (C2) Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	9.76E-10	1.12E-12	2.55E-11	7.66E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-09
	Co-60	Sv/a	3.39E-11	1.28E-12	0.00E+00	0.00E+00	1.79E-14	1.85E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.22E-08	3.15E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-08
	HTO	Sv/a	9.46E-07	0.00E+00	4.55E-08	2.86E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.92E-07
	NobleGases	Sv/a	0.00E+00	4.62E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	Sv/a	3.98E-11	2.82E-12	0.00E+00	0.00E+00	1.99E-16	8.82E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.14E-11
	Total	Sv/a	9.47E-07	4.62E-07	5.77E-08	3.18E-10	1.81E-14	1.85E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-06
Child-10y	C-14	Sv/a	1.39E-09	1.12E-12	1.81E-11	7.66E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-09
	Co-60	Sv/a	4.83E-11	1.28E-12	0.00E+00	0.00E+00	2.31E-13	1.85E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	4.82E-09	3.15E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.85E-09
	HTO	Sv/a	1.13E-06	0.00E+00	2.92E-08	2.39E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-06
	NobleGases	Sv/a	0.00E+00	4.62E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	Sv/a	9.02E-11	2.82E-12	0.00E+00	0.00E+00	1.88E-15	8.82E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-10
	Total	Sv/a	1.13E-06	4.62E-07	3.41E-08	2.70E-10	2.33E-13	1.85E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-06

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Table G14: Pickering Nuclear – Fisher Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	4.66E-10	5.36E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E-09	0.00E+00	0.00E+00	7.02E-09
	Co-60	Sv/a	1.17E-11	4.45E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-11
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-09	0.00E+00	0.00E+00	4.49E-09
	HTO	Sv/a	3.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.99E-10	0.00E+00	0.00E+00	3.28E-07
	NobleGases	Sv/a	0.00E+00	7.57E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.57E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.14E-10	0.00E+00	0.00E+00	2.14E-10
	I (mfp)	Sv/a	1.37E-11	8.98E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-11
	Total	Sv/a	3.28E-07	7.57E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-08	0.00E+00	0.00E+00	4.16E-07
Child-10y	C-14	Sv/a	6.65E-10	5.36E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.87E-09	0.00E+00	0.00E+00	4.54E-09
	Co-60	Sv/a	1.67E-11	4.45E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-11
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-09	0.00E+00	0.00E+00	1.48E-09
	HTO	Sv/a	3.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-10	0.00E+00	0.00E+00	3.90E-07
	NobleGases	Sv/a	0.00E+00	7.57E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.57E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-10	0.00E+00	0.00E+00	1.26E-10
	I (mfp)	Sv/a	3.11E-11	8.98E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-11
	Total	Sv/a	3.90E-07	7.57E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-09	0.00E+00	0.00E+00	4.72E-07
Infant_1y	C-14	Sv/a	4.54E-10	5.36E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-09	0.00E+00	0.00E+00	2.73E-09
	Co-60	Sv/a	1.23E-11	5.78E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-11
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-10	0.00E+00	0.00E+00	5.22E-10
	HTO	Sv/a	2.67E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-10	0.00E+00	0.00E+00	2.67E-07
	NobleGases	Sv/a	0.00E+00	9.28E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.28E-08
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.63E-11	0.00E+00	0.00E+00	7.63E-11
	I (mfp)	Sv/a	3.64E-11	1.17E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.76E-11
	Total	Sv/a	2.68E-07	9.28E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.04E-09	0.00E+00	0.00E+00	3.63E-07

Table G15: Pickering Nuclear – Urban Resident Critical Group Doses – 2009

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	Sv/a	9.95E-10	1.14E-12	2.14E-11	8.35E-16	6.60E-18	1.23E-16	5.54E-15	3.54E-16	0.00E+00	4.59E-12	2.19E-08	6.35E-12	2.29E-08
	Co-60	Sv/a	2.60E-11	9.84E-13	4.81E-300	1.68E-15	2.53E-14	2.62E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-11	2.28E-15	2.62E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	1.01E-08	3.42E-10	1.21E-12	7.92E-08	1.17E-12	5.93E-10	0.00E+00	3.14E-12	1.81E-10	4.12E-15	9.04E-08
	HTO	Sv/a	7.09E-07	0.00E+00	3.94E-08	2.77E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.49E-13	1.67E-08	5.06E-12	7.68E-07
	NobleGases	Sv/a	0.00E+00	2.71E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-13	2.61E-09	3.11E-12	2.62E-09
	I (mfp)	Sv/a	3.03E-11	2.22E-12	0.00E+00	2.90E-17	1.55E-16	6.91E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.04E-11	1.46E-13	8.99E-11
	Total	Sv/a	7.10E-07	2.71E-07	4.95E-08	3.11E-09	1.24E-12	1.05E-07	1.18E-12	5.93E-10	0.00E+00	8.22E-12	4.14E-08	1.47E-11	1.18E-06
Child-10y	C-14	Sv/a	1.42E-09	1.14E-12	1.51E-11	8.35E-16	3.64E-17	1.23E-16	3.05E-14	3.54E-16	0.00E+00	2.71E-12	1.61E-08	7.00E-12	1.75E-08
	Co-60	Sv/a	3.70E-11	9.84E-13	8.01E-300	1.68E-15	3.27E-13	2.62E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-11	6.65E-15	2.62E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	4.00E-09	3.42E-10	3.73E-12	7.92E-08	3.60E-12	5.93E-10	0.00E+00	1.03E-12	7.33E-11	1.53E-15	8.42E-08
	HTO	Sv/a	8.43E-07	0.00E+00	2.53E-08	2.31E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-13	1.11E-08	3.22E-12	8.82E-07
	NobleGases	Sv/a	0.00E+00	2.71E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.79E-14	2.00E-09	2.03E-12	2.00E-09
	I (mfp)	Sv/a	6.87E-11	2.22E-12	0.00E+00	2.90E-17	1.47E-15	6.91E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-11	3.14E-13	1.37E-10
	Total	Sv/a	8.45E-07	2.71E-07	2.93E-08	2.65E-09	4.06E-12	1.05E-07	3.63E-12	5.93E-10	0.00E+00	4.02E-12	2.94E-08	1.26E-11	1.28E-06
Infant_1y	C-14	Sv/a	9.69E-10	1.14E-12	0.00E+00	7.66E-17	7.28E-17	1.23E-16	6.11E-14	3.54E-16	0.00E+00	1.59E-12	1.36E-08	1.38E-11	1.46E-08
	Co-60	Sv/a	2.71E-11	1.28E-12	0.00E+00	2.19E-15	8.02E-13	3.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-11	1.72E-14	3.41E-08
	Cs-137+	Sv/a	0.00E+00	0.00E+00	0.00E+00	4.01E-11	4.47E-12	1.03E-07	4.32E-12	7.70E-10	0.00E+00	3.65E-13	3.60E-11	1.09E-15	1.04E-07
	HTO	Sv/a	5.78E-07	0.00E+00	0.00E+00	3.88E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-13	9.80E-09	4.38E-12	5.88E-07
	NobleGases	Sv/a	0.00E+00	3.30E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-07
	OBT	Sv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.34E-14	1.65E-09	2.42E-12	1.65E-09
	I (mfp)	Sv/a	8.04E-11	2.88E-12	0.00E+00	3.76E-17	5.14E-15	8.98E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.05E-11	1.16E-12	1.74E-10
	Total	Sv/a	5.79E-07	3.30E-07	0.00E+00	4.28E-10	5.28E-12	1.37E-07	4.38E-12	7.70E-10	0.00E+00	2.13E-12	2.52E-08	2.18E-11	1.07E-06

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