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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

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**Annual Summary And Assessment Of
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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**Preface**

This document has been prepared by the Environment Division (ED) of Nuclear Strategy and Support, Ontario Power Generation (OPG). The information presented is based on measurements and analyses performed by the OPG Health Physics Laboratory (HPL) of the Radiation Protection Division (RPD), with the exception of Lake Huron Provincial background sediment, sand, soil, and fish samples that were analyzed by Bruce Power (BP).

This report has been reviewed by OPG Radiation Protection Division, Nuclear Environment Division, Dr. E.L. Cooper of Atomic Energy of Canada Ltd. and Dr. R.L. Grasty of Gamma - Bob Inc.

This report was successfully completed with the special contributions of the following ED and RPD staff of OPG:

- Irvin Benovich, Senior Technical Expert, Environmental Health Physics and Andrea Polack, Co-op Student of the University of Waterloo, for completing the DN and PN critical group dose calculations and Section 4 of this report.
- Stephen Schweinsberg, Senior Technical Engineer, Anders Li, Senior Technical Engineer and Bill Wolodarsky, Safety Scientist at RPD for their Quality Assurance work and Section 5.0 of this report.

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Executive Summary

In 2003, Ontario Power Generation, Nuclear (OPGN) conducted Radiological Environmental Monitoring Programs (REMP) in the vicinity of the Darlington Nuclear (DN) and Pickering Nuclear (PN) sites to determine the radiological impact to the public resulting from the operations of these sites. OPG also conducted a similar monitoring program at various locations throughout Ontario to determine background radiation levels away from the influence of the nuclear station emissions.

The radiological impact of the OPG Western Waste Management Facility (WWMF) will be produced by Bruce Power in a separate report documenting the REMP results of the Bruce site.

For this reporting period a number of improvements within the OPG environmental monitoring and public dose programs have been made, especially the following key accomplishments:

- CNSC's approval of OPG's Derived Release Limit (DRL) Guidance Document in February 2003,
- Completion of the upgrade of the DN radiological environmental monitoring program in January 2003.

With these accomplishments and the completion of the upgrade of the PN radiological environmental monitoring program in January 2001, a new methodology of public dose calculation which follows OPG's DRL Guidance Document will be used to estimate the public dose starting from 2003. The new methodology introduces additional age groups and includes a 3-month nursing infant to represent the age span of birth to 12 months.

The REMP upgrade at DN and PN sites **[R-1]** **[R-2]** brought the program into better compliance with the CSA standard N288.4. **[R-3]** The upgraded program provides sufficient environmental data to allow calculation of doses to nine and eight potential critical groups around the DN and PN sites respectively. This dose calculation is as realistic as possible using the information from DN and PN site specific survey on the potential critical group locations and characteristics and brings OPG public dose reporting in line with Canadian Nuclear Safety Commission (CNSC) requirements. **[R-4]** As a result, the calculation of the hypothetical individual dose for DN and PN sites is no longer required and the critical group dose will be reported as the official public dose.

The 2003 assessments of the DN and PN REMP results demonstrate that the critical group doses resulting from the operation of the OPG nuclear generating stations are at a very small percentage of the annual legal limit of 1,000 μSv and the annual average Canadian background radiation dose of 1,840 μSv :

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- At the DN site, the highest dose calculated for the nine potential critical groups was 1.7 μSv for a three-month old farm nursing infant located about 1km from the site boundary. This limiting value is taken as the DN site critical group dose for 2003. The increase in dose from 1.2 μSv for the hypothetical adult in 2002 to 1.7 μSv for the 3-month old farm infant critical group dose in 2003 is attributable to the upgrade in the dose calculation methodology which included the introduction of the 3-month old nursing infant age group to the model.
- At the PN site, the highest dose calculated for the eight potential critical groups was 4.7 μSv for an adult at the Correctional Institute located about 1.3 km from the center of the PN reactors. This limiting value is taken as the PN site critical group dose for 2003. The increase compared to the 2002 critical group dose of 4.0 μSv is due to the change in dose calculation methodology and increased noble gas and radiography skyshine dose.

The official public doses for the DN and PN sites are summarized in Table E1¹ and their comparison to the Canadian background and medical public doses is presented in Figure E1.

Table E1 OPG Public Critical Group Doses - 2003

Facility	Critical Group ¹ Receptor	Effective Dose (μSv)	Percentage of Legal Limit ² (%)	Percentage of Canadian Background Radiation ³ (%)
Darlington Nuclear Site	Farm 3-month old nursing Infant	1.7	0.17	0.09
Pickering Nuclear Site	C1 Correctional Facility Adult	4.7	0.47	0.26

¹ This is the highest calculated dose (i.e., the "critical group" dose) for the eight potential critical groups living outside the PN perimeter and the nine potential critical groups living outside the DN perimeter. See Sections 4.3.1 and 4.3.2 for the identification of these public groups and Tables 4.6.1 and Table 4.6.2 for their calculated doses.

² The public legal limit in Canada for committed effective dose from the operation of nuclear facilities is 1,000 $\mu\text{Sv}/\text{year}$, effective May 31, 2000. The Canadian Nuclear Safety Commission of Canada lowered the limit from 5,000 $\mu\text{Sv}/\text{year}$ to bring Canada in line with the international value of 1,000 $\mu\text{Sv}/\text{year}$ as recommended by the International Commission on Radiological Protection (ICRP Publication 60). [R-5]

³ The total Canadian background (natural and human-made) radiation value is 1,840 $\mu\text{Sv}/\text{year}$. See Section 4.8.

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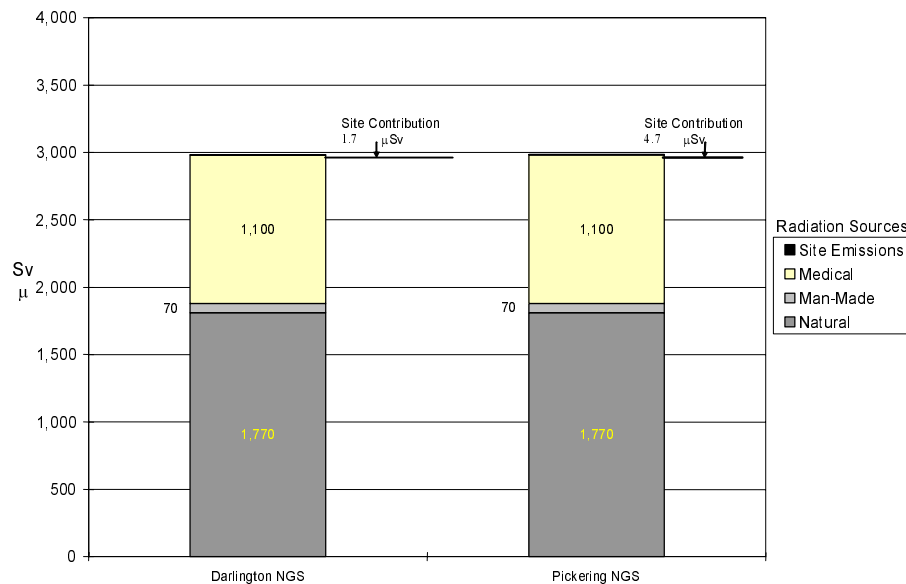


Figure E1¹ Graphical Presentation of 2003 OPG Critical Group Doses in Relation to Canadian Background and Medical Public Doses

¹ Data taken from Table 4.6.1, 4.6.2 and Table 4.8.1.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**1.0 INTRODUCTION**

Power reactor operating licences for Ontario Power Generation (OPG) Darlington and Pickering stations require an annual report to the Canadian Nuclear Safety Commission (CNSC) [R-6] on the results of the Radiological Environmental Monitoring Program (REMP) conducted at these stations. This annual summary and assessment document provides these results, their interpretations, and estimates radiation doses to the public resulting from operation of these stations.

The REMP results for OPG's Western Waste Management Facility (WWMF) will be prepared by Bruce Power and documented in a Bruce Power report.

The REMP is conducted in the vicinity of the OPG nuclear electric generating stations and at background locations by the Environment Division of Nuclear Strategy and Support. Environmental sampling and laboratory analyses are performed by the Health Physics Laboratories (HPL) of Radiation Protection Division (RPD).

The REMP program is designed to satisfy four primary objectives:

- (a) To confirm that nuclear site emissions of radioactive materials are under proper control.
- (b) To provide information that can be used to verify the validity of the assumptions made in deriving station release limits.
- (c) To permit an independent estimate of doses to the public based on environmental data measured in the public domain.
- (d) To provide data for the development and evaluation of transport models which adequately describe the movement of radionuclides through the environment.

The environmental data are summarized in this document on a calendar year basis along with the emission data from each site. Independent assessments of the public dose resulting from the site radiological emissions are made using these data.

Over past years, analysis of environmental radiological surveillance data has shown that tritium and ^{14}C concentrations are statistically greater than ambient background at all the operating nuclear electric generating sites in samples of:

- (a) Air
- (b) Precipitation
- (c) Lake or well water (tritium only)
- (d) Local produce including milk and honey
- (e) Fish

Background tritium and ^{14}C concentrations due to atmospheric nuclear weapons testing, natural occurrence, or other non-OPG sources have been subtracted where

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appropriate to determine the net environmental concentrations due to reactor operation.

In isolated cases, reactor operation is indicated by the presence of trace quantities of ^{60}Co and ^{134}Cs in the aquatic environment, particularly in sediments. Cesium-137 is more prevalent in such samples due to historic atmospheric nuclear weapons testing and reactor operation.

The contribution of ^{131}I , radioactive particulate and elemental tritium emissions to public dose cannot be reliably distinguished from natural background by the REMP program at the usual emission rates measured at the Darlington Nuclear (DN) and Pickering Nuclear (PN) sites. Estimates are therefore made of these contributors to dose, based on radiological emissions reported by each station.

A direct measurement method for distinguishing between human-made and natural background gamma radiation in the public domain was developed and installed at the PN site in 2000, and the DN site in 2003. These measurements are used to assess noble gas dose at those sites.

There is no technique available to directly measure the radiological dose to a person. Radiological dose to people living near the nuclear generating stations is estimated using a dose model, measured concentrations of radioactivity in environmental media, and by concentrations calculated from reported emissions (Section 4.0).

The REMP at the PN site was upgraded in late 2000. **[R-1]** OPG has now calculated a critical group dose for this site since the 2001 assessment. The DN program upgrade **[R-2]** was completed at the end of 2002 to allow critical group dose calculations at that site starting with the 2003 dose assessment. There are eight potential critical groups identified at the PN site and nine potential critical groups at the DN site for which doses are calculated in the 2003 assessment. A critical group is determined according to the CSA Standard N288.1 **[R-7]** as "a fairly homogenous group of people whose location, habits, diet, etc. cause them to receive doses higher than the average received by typical people in all other groups in the exposed population."

Historically, the OPG official public dose had been calculated for a hypothetical infant or adult living just outside the site boundary. The new approach to calculate critical group dose brings OPG into better compliance with Canadian Standards Association Guidelines **[R-3]** and CNSC reporting requirements. **[R-4]**

The Provincial Background REMP was also upgraded in late 2000. **[R-8]** New samples of environmental biota were collected for background comparison purposes starting in 2001 and are reported in this document.

The ^{14}C inventory at the Pickering and Darlington Nuclear sites has been included in Section 2.0 of this document. This is to fulfill a regulatory commitment to the CNSC to report such inventories on an annual basis.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**2.0 OPG SITE RADIOACTIVE EFFLUENT AND UNIT CAPACITY/PRODUCTION DATA**

During 2003, Ontario Power Generation (OPG) operated nuclear facilities at three sites: Darlington Nuclear (DN), Pickering Nuclear (PN), and Bruce Power (BP). The locations of these sites within the Province of Ontario are shown in Figure C1 in Appendix C.

Facilities at DN consist of one nuclear generating station and a Tritium Removal Facility (TRF). DN1-4 comprises four nuclear reactors with a total electrical power rating of 3,524 Megawatts electrical (MWe). At the TRF, tritium is extracted from tritiated heavy water and stored on site.

Facilities at the PN site comprise two nuclear generating stations, PN1-4 and PN5-8, and a Pickering Waste Management Facility. Each station consists of four nuclear reactors (units) which have electrical power ratings of 2,060 and 2,064 MWe, respectively. PN Units 1 through 3 were in lay-up for all of 2003. PN Unit 4 was returned to commercial operation September 25, 2003.

The Pickering Waste Management Facility consists of the Used Fuel Dry Storage Area and the Re-Tube Components Storage Area.

The WWMF is located on the Bruce Power site and consists of the Western Low and Intermediate Level Waste Storage Area (which includes the Waste Volume Reduction Building) and the Western Used Fuel Dry Storage Area.

Reporting of the OPG Western Waste Management Facility (WWMF) radiological emissions for 2003 will be made in a separate report by Bruce Power covering the entire Bruce Power site.

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The total airborne and waterborne emissions from the DN and PN sites are given in the following table:

Table 2.1 OPG Annual Nuclear Site Emissions - 2003

Site Emissions	Bq	
	DN	PN
AIR		
Tritium Oxide	1.7×10^{14}	5.2×10^{14}
Elemental Tritium ¹	6.6×10^{13}	N/A
Noble Gas ²	1.3×10^{13}	4.8×10^{14}
¹³¹ I	1.4×10^8	1.6×10^8
Particulates	6.9×10^7	3.6×10^8
¹⁴ C	3.5×10^{12}	3.7×10^{12}
WATER		
Tritium Oxide	1.0×10^{14}	2.6×10^{14}
Gross Beta/Gamma	7.3×10^9	1.0×10^{10}
¹⁴ C	1.2×10^9	1.1×10^{10}

The gross capacity factors and gross electrical output for each generating unit are provided in the following table: [R-9]

Table 2.2 OPG Nuclear Unit Capacity and Production – 2003

Unit		Gross Capacity Factor	Gross Electrical Output (MWhe)
DN1-4 Unit	1	85.7	7,017,088
	2	79.4	6,500,992
	3	89.1	7,295,488
	4	70.7	5,790,848
PN1-4 Unit ³	1	0	0
	2	0	0
	3	0	0
	4	20.9	896,440
PN5-8 Unit	5	69.2	3,272,070
	6	73.0	3,453,599
	7	40.1	1,894,390
	8	87.6	4,144,700

¹ Emissions from Darlington Tritium Removal Facility

² γ Bq-MeV

³ PN Units 1 through 3 were in lay-up state throughout 2003. Unit 4 was returned to commercial operation September 25, 2003.

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The following numbers are provided as the best estimate of the inventory of ^{14}C held on ion exchange resins in the station spent resin storage tanks at OPG nuclear sites.
[R-10]

Table 2.3 OPG ^{14}C Inventory Levels – 2003

Location	^{14}C Inventory (Bq)
Pickering Nuclear 1-8	6.3×10^{14}
Darlington Nuclear 1-4	3.9×10^{14}
Total	1.0×10^{15}

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3.0 ENVIRONMENTAL MONITORING DATA

This section contains the results of the environmental monitoring programs for the DN and PN sites, as well as those of the provincial background locations.

The environmental monitoring locations are classified as “indicator”, “area”, and “control” monitoring locations and defined as follows:

- (a) Indicator locations are used to assess the potential dose to the public. These locations are outside the facility perimeter, at points where the most significant public exposure (direct or indirect) occurs or is ‘predicted to occur’.
- (b) Area locations are used to provide information at population centers, which are farther away from the site boundary, and are used in conjunction with indicator locations to determine the atmospheric dilution as a function of distance from the site.
- (c) Control or background locations are used to provide information on the presence of naturally occurring radiation and radiation present in the environment as a result of nuclear atmospheric weapons testing, at locations well away from nuclear sources.

The results of the environmental monitoring programs consist of:

- (a) External gamma dose rates in air.
- (b) Airborne tritium oxide and ^{14}C .
- (c) Tritium oxide and gross beta in dry/wet fallout.
- (d) Tritium oxide, Organically Bound Tritium (OBT), ^{14}C and ^{131}I in milk.
- (e) Tritium oxide, gross beta in drinking water.
- (f) Tritium oxide, OBT, ^{14}C and gamma scan results in aquatic samples (e.g., fish, lake sediment, lake water and beach sand).
- (g) Tritium oxide, OBT, and ^{14}C in terrestrial samples (e.g., fruit, vegetables and honey).

The reported results in this document are final. In a few cases, these may differ from values already reported elsewhere during the year for example, in quarterly reports to local municipalities. Such differences may arise where additional information concerning the sampling and analyses becomes available subsequent to issuing the earlier reports.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**3.1 External Gamma Dose Rate Measurements**

Environmental external gamma dose rates were measured using Panasonic Type UD-814 AR1 Thermoluminescent Dosimeters (TLDs). The readouts of the three $\text{CaSO}_4:\text{Tm}$ elements are reported. The dosimeters are located at indicator locations near the facility boundary, and at area locations in local communities, and other locations within 10-20 km of the facility. Background dosimeters are also maintained at various locations around the Province of Ontario. Exact locations are given in Appendix C, Figures C2, C3 and C4. The dosimeters are changed quarterly.

These measurements are expressed as air absorbed dose rate (air kerma rate), measured in units of nanogray (to air) per hour (nGy/h) in accordance with international practice. The approximate conversion to old units is 1 nGy (air kerma) = 0.1141 μR exposure. **[R-11]**

The dosimeters are exposed for three-month periods and the annual doses quoted are the sum of the four quarterly results. The results are corrected for exposure during transit from the monitoring sites to the HPL. The accuracy of the dosimeters, under these conditions, is estimated to be $\pm 15\%$ as verified by a quality control program, which is reported in Section 5.0 of this document.

The dosimeters located throughout Ontario measure the range of naturally occurring background radiation levels well away from the influence of OPG nuclear sites. The type of dosimeters, exposure period, and transit exposure correction methodology are the same for all of these background measurements and for the site and control measurements.

Since 2000, a direct measurement of noble gases and ^{192}Ir radiography skyshine air kerma rates has been performed at the PN site as part of the routine radiological environmental monitoring program. The monitoring of ^{131}I was added in 2002. Exploranium G.S. Ltd. GR-150 Sodium Iodide (NaI) spectrometers have been set up at all air monitoring stations in close proximity to the DN and PN sites in order to perform these measurements. This array of monitors is known as the OPG Gamma Ray Monitoring Network. See locations shown in Figure C2 and C3 of Appendix C.

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Table 3.1.1 Darlington Nuclear Site External Gamma Measurements - 2003

Sites	Total Exposure Time (days)	Total Measured Dose in Air (μ Gy)	Annual Average Dose Rate in Air (nGy/h)
INDICATOR SITES:			
1. SE Fence	366	378	43.0
2. East Fence	366	390	44.4
3. Maple Grove	366	421	47.9
4. Park Road	366	396	45.1
5. Knight Road	366	408	46.4
6. Provincial Park	366	419	47.7
Average			45.8
AREA SITES:			
7. Oshawa Wilson TS	366	425	48.4
8. Bowmanville TS	366	409	46.6

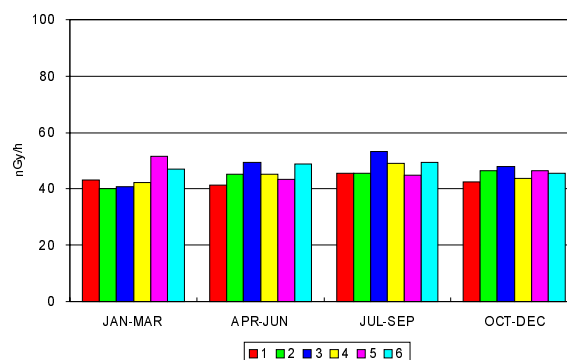


Figure 3.1.1a Darlington Nuclear Site Gamma Dose Rates - Indicator Sites (2003)

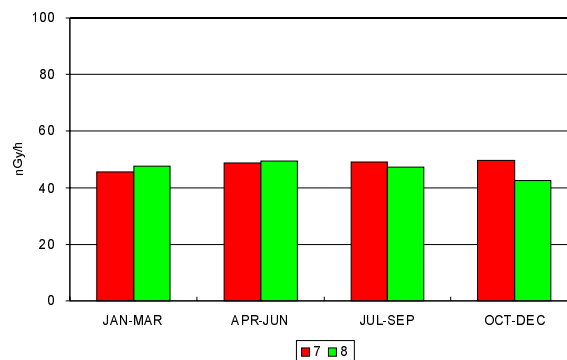


Figure 3.1.1b Darlington Nuclear Site Gamma Dose Rates - Area Sites (2003)

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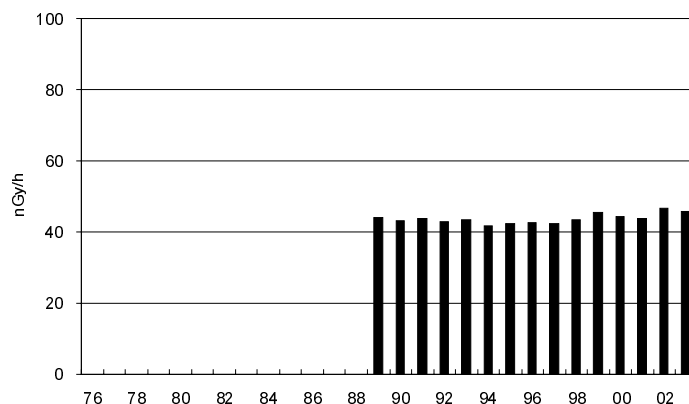


Figure 3.1.1c Darlington Nuclear Site - Indicator Average Gamma Dose Rate Trends

Table 3.1.2 Pickering Nuclear Site External Gamma Measurements - 2003

Sites	Total Exposure Time (days)	Total Measured Dose in Air (μ Gy)	Annual Average Dose Rate in Air (nGy/h)
INDICATOR SITES:			
2. Montgomery Park Road	376	385	42.7
3. Sandy Beach Road	376	399	44.2
4. Liverpool Road	376	378	41.9
6. East Boundary	376	384	42.6
7. Central Maintenance - West	376	341	37.8
8. Frenchman's Bay	376	357	39.6
9. Petticoat Creek	376	399	44.2
10. Central Maintenance - East ¹	376	321	35.6
11. Alex Robertson Park ¹	376	416	46.1
Average			41.6
AREA SITES:			
5. Highway 7	376	387	42.9
R120	370	452	50.9
C2	370	461	51.9

¹ New locations added in 2001 as part of the upgrade to the PN site radiological environmental monitoring program.

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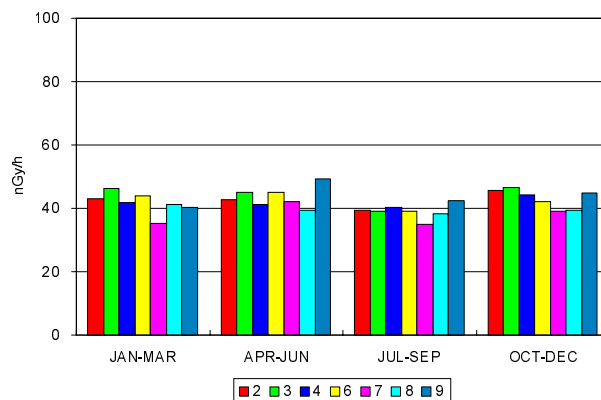


Figure 3.1.2a Pickering Nuclear Site Gamma Dose Rates - Indicator Sites (2003)

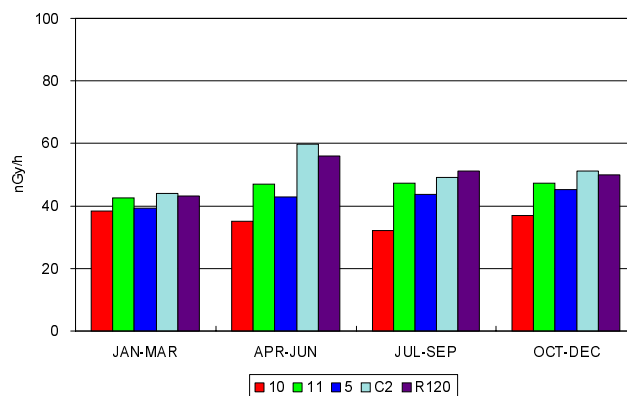


Figure 3.1.2b Pickering Nuclear Site Gamma Dose Rates - Indicator and Area Sites (2003)

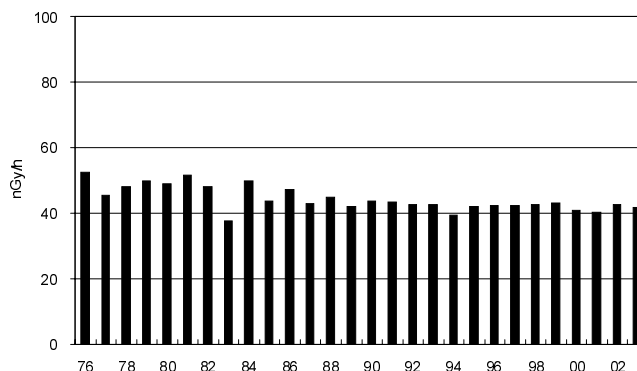


Figure 3.1.2c Pickering Nuclear Site - Indicator Average Gamma Dose Rate Trends

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Table 3.1.3 Provincial Background Sites Gamma Measurements - 2003

Background Sites	Total Exposure Time (days)	Total Measured Dose in Air (μGy)	Annual Average Dose Rate in Air (nGy/h)
1. Bancroft ¹	359	487	56.5
2. Belleville	366	447	50.9
3. Kapuskasing ¹	345	433	52.3
4. Windsor	392	384	40.8
5. Niagara Falls	382	348	38.0
6. North Bay	386	431	46.5
7. Orangeville	363	438	50.3
8. Ottawa	364	382	43.7
9. Parry Sound	384	351	38.1
10. Sudbury	264	354	55.9
11. Thunder Bay ¹	283	377	55.5
12. Lakefield	361	491	56.7
Average	362	403	46.8

**Gamma Dose Rates
Provincial Background Sites - 2003**

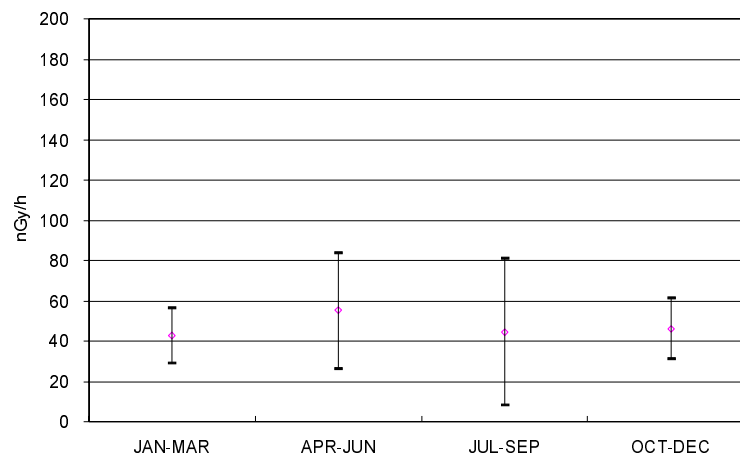


Figure 3.1.3a Provincial Gamma Dose Rates (2003)

¹ Bancroft, Thunder Bay, and Kapuskasing are excluded from the average due to historically higher than normal levels of natural radioactivity that are inappropriate to be used in comparison with OPG nuclear facility results. [R-8]

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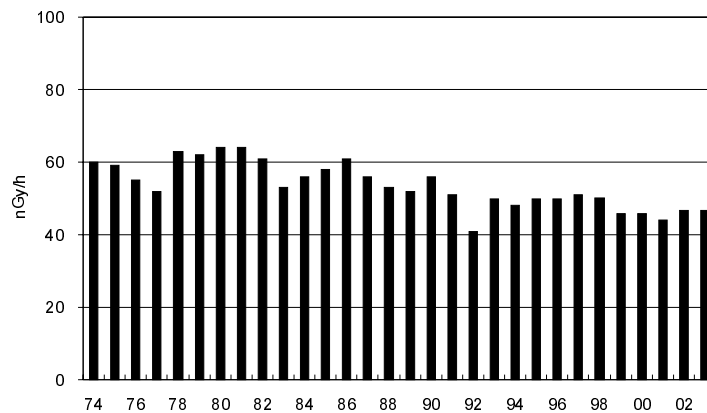


Figure 3.1.3b Provincial Average Gamma Dose Rate Trends

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**Table 3.1.4 Darlington Nuclear Site -
Noble Gas, Skyshine and ^{131}I Dose in Air - 2003**

Indicator Sites ¹	Total Measured Dose in Air (nGy)				
	^{133}Xe	^{135}Xe	^{41}Ar	Skyshine	^{131}I
1	1.7 ± 0.1	3.8 ± 0.3	70.9 ± 5.9	0	0
2	2.0 ± 0.2	4.4 ± 0.3	83.7 ± 6.4	0	0
3	0.8 ± 0.1	1.7 ± 0.3	32.9 ± 6.2	0	0
4	0.4 ± 0.2	0.8 ± 0.3	15.4 ± 6.3	0	0
5	0.5 ± 0.1	1.0 ± 0.3	19.2 ± 5.9	0	0
6	0.4 ± 0.2	1.0 ± 0.4	18.4 ± 6.7	0	0

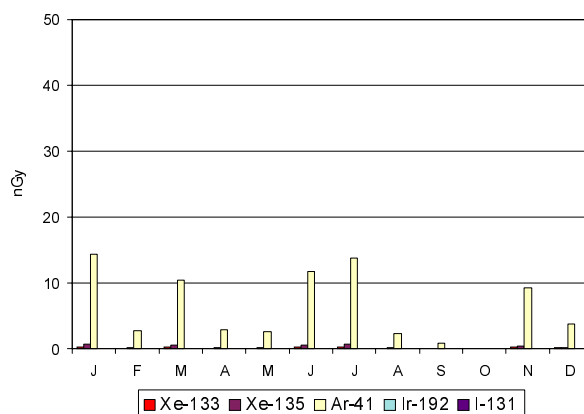


Figure 3.1.4a Darlington Nuclear Site Noble Gas and Skyshine Dose in Air - 1. Southeast Fence

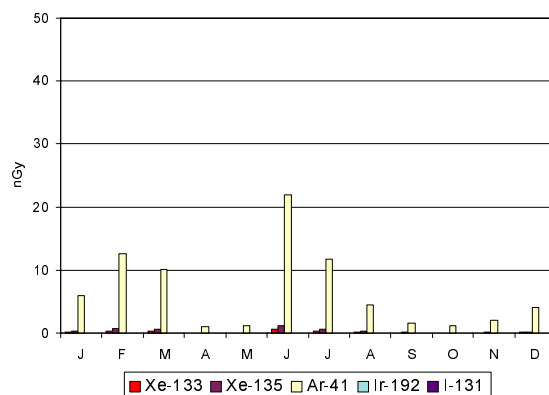


Figure 3.1.4b Darlington Nuclear Site Noble Gas and Skyshine Dose in Air - 2. East Fence

¹ See Figure C2 in Appendix C for location of indicator air monitoring stations 1 through 6.

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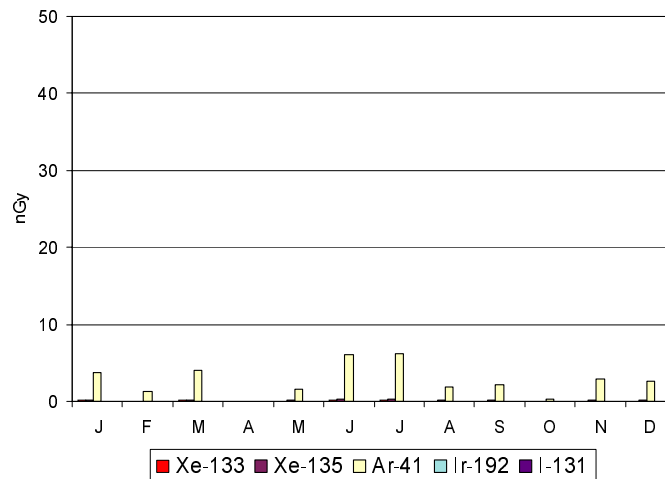


Figure 3.1.4c Darlington Nuclear Site Noble Gas and Skyshine Dose in Air - 3. Maple Grove

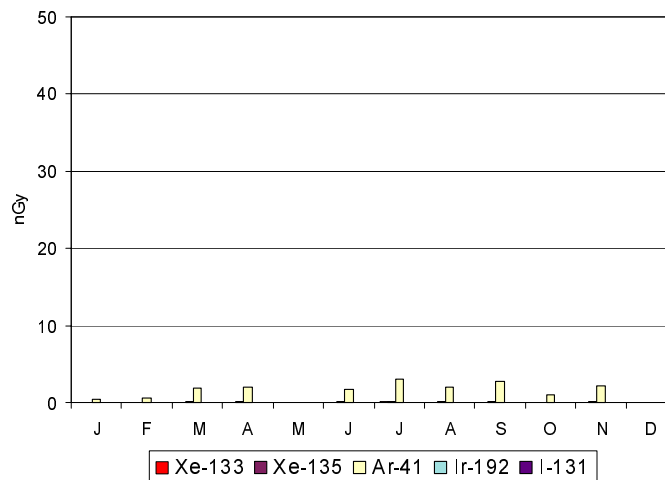


Figure 3.1.4d Darlington Nuclear Site Noble Gas and Skyshine Dose in Air – 4. Park Road

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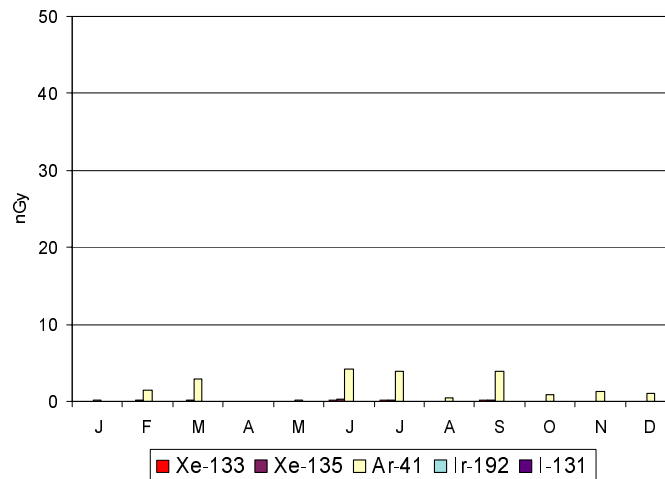


Figure 3.1.4e Darlington Nuclear Site Noble Gas and Skyshine Dose in Air – 5. Knight Road

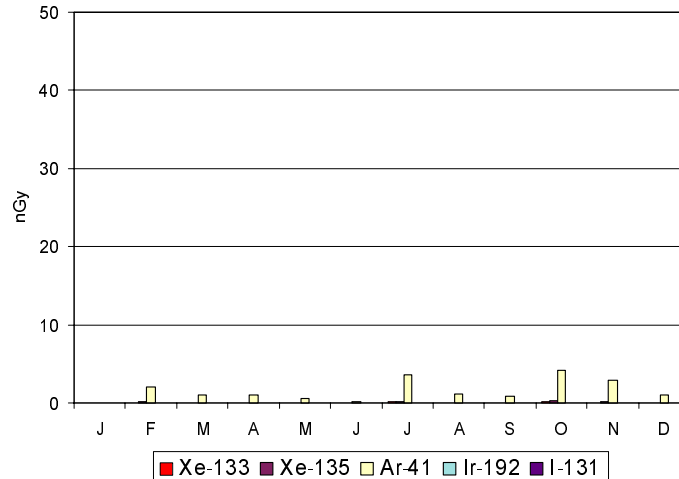


Figure 3.1.4f Darlington Nuclear Site Noble Gas and Skyshine Dose in Air – 6. Provincial Park

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Table 3.1.5 Pickering Nuclear Site -
Noble Gas, Skyshine and ^{131}I Dose in Air - 2003

Indicator Sites ¹	Total Measured Dose in Air (nGy)				
	^{133}Xe	^{135}Xe	^{41}Ar	Skyshine	^{131}I
2	3.2 ± 0.1	6.4 ± 0.1	455.4 ± 5.9	20.1 ± 4.9	0
3	1.4 ± 0.1	2.8 ± 0.1	198.6 ± 6.5	1.5 ± 5.4	0
4	1.2 ± 0.1	2.4 ± 0.1	170.0 ± 6.2	1.8 ± 4.9	0
6	2.4 ± 0.1	4.9 ± 0.1	347.8 ± 6.2	466.4 ± 4.4	0
7	2.5 ± 0.1	5.0 ± 0.1	359.4 ± 5.3	1.8 ± 4.4	0
8	1.0 ± 0.1	1.9 ± 0.1	139.0 ± 5.5	1.3 ± 4.5	0
9	0.7 ± 0.1	1.4 ± 0.1	102.5 ± 6.3	1.1 ± 5.2	0
10	3.4 ± 0.1	6.9 ± 0.1	492.2 ± 5.5	3.6 ± 3.8	0
11	1.3 ± 0.1	2.6 ± 0.1	184.3 ± 6.5	0.7 ± 5.4	0

¹ See Figure C3 in Appendix C for location of indicator air monitoring stations 2 through 11.

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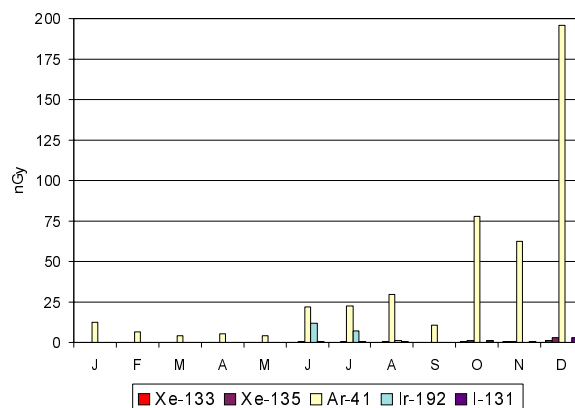


Figure 3.1.5a Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 2. Montgomery Park Road

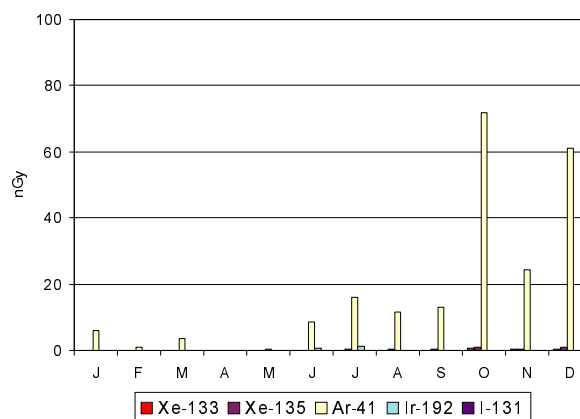


Figure 3.1.5b Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 3. Sandy Beach Road

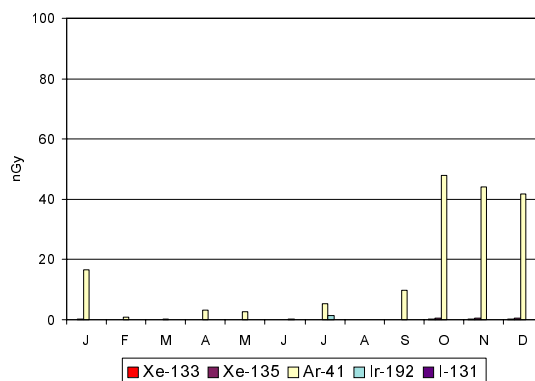


Figure 3.1.5c Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 4. Liverpool Road

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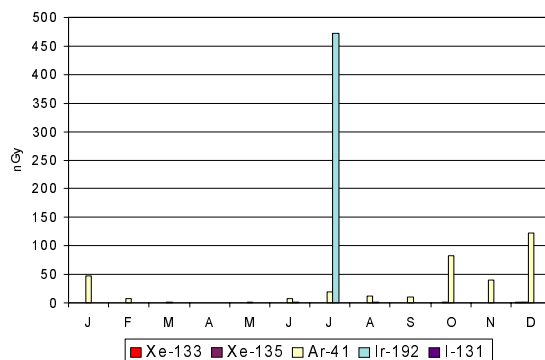


Figure 3.1.5d Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 6. East Boundary Road

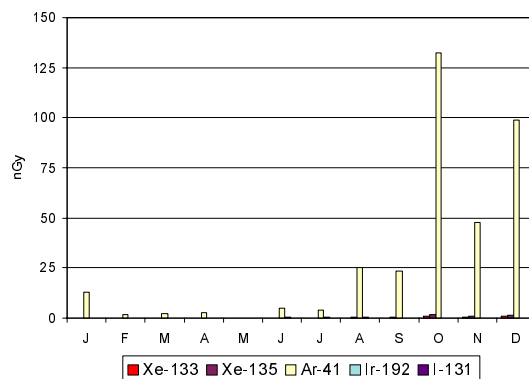


Figure 3.1.5e Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 7. Central Maintenance - West

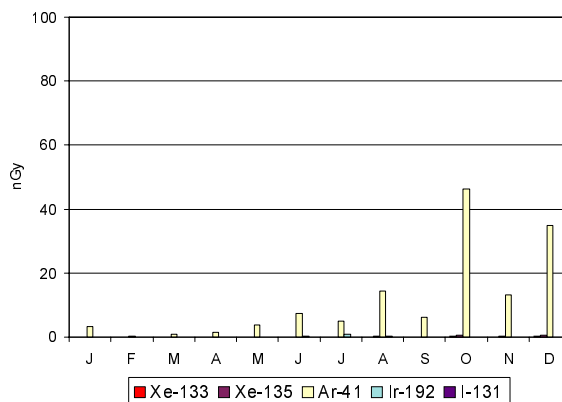


Figure 3.1.5f Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 8. Frenchman's Bay

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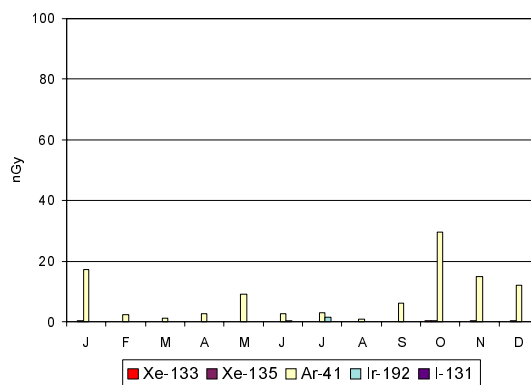


Figure 3.1.5g Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 9. Petticoat Creek Conservation Area

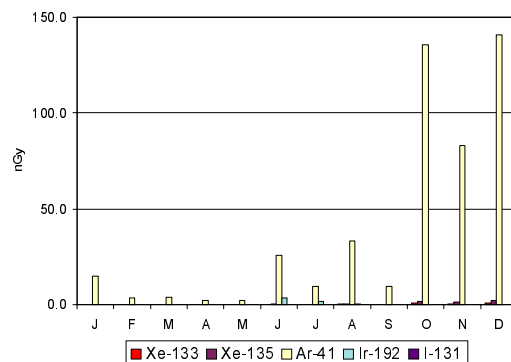


Figure 3.1.5h Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 10. Central Maintenance - East

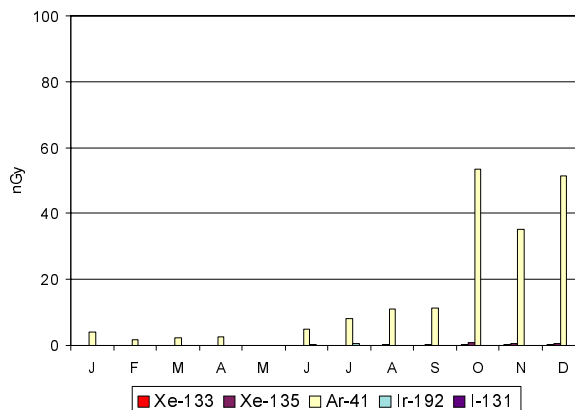


Figure 3.1.5i Pickering Nuclear Site Noble Gas and Skyshine Dose in Air - 11. Alex Robertson Park

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Discussion of Environmental Gamma Measurements

From the data in Tables 3.1.1 and 3.1.2 the annualized average 2003 indicator location external doses in air for the DN and PN sites are 401 μGy and 365 μGy respectively, while the annualized average of all the provincial background sites in Table 3.1.3 is 410 μGy .

External gamma dose rate trend plots (Figures 3.1.1c, 3.1.2c, and 3.1.3b) show that external dose rates have fluctuated within a comparatively narrow range at the DN site since 1989, and have a slight observable downward trend since the mid 1970s at both the PN site and at the Provincial background locations.

TLD measurements alone are not sufficiently sensitive to detect the very low gamma doses associated with station emissions. One method of separately detecting natural and human-made gamma radiation is through the use of a gamma ray spectrometer.

The CNSC has reviewed and approved the use of Exploranium G.S. GR-150 sodium iodide gamma spectrometers to measure and report noble gas dose and ^{192}Ir skyshine radiation. Two scientific papers describing the calibration of the GR-150 detectors [R-12] and the operation of the monitoring system/interpretation of the data [R-13] were published in 2001 in the International Journal 'Radiation Protection Dosimetry'.

OPG has GR-150 monitors at air monitoring stations 2, 3, 4, 6, 7, 8, 9, 10, and 11 in a ring around the PN site. See Figure C3 in Appendix C for locations. This new monitoring network was in full operation as of January 1, 2000¹, and has been used in calculating public doses starting in the year 2000.

Two Exploranium monitors were also installed at air monitoring stations 1 and 2 at the DN site, and were in full operation as of January 1, 2001. See Figure C2 in Appendix C for locations. Four additional monitors were installed in late 2002 as part of the implementation of the upgraded DN radiological environmental monitoring program. Health Canada also funded the installation of its own additional GR150 detector at Darlington air monitoring station 8 in 2003. The results of the six OPG monitors are reported in the 2003 assessment, and were used for determining the noble gas dose.

Results obtained in 2003 from the monitors installed at air monitoring locations near the DN and PN site boundaries are summarized in Tables 3.1.4 and 3.1.5 and shown graphically in Figures 3.1.4a through 3.1.4f, and Figures 3.1.5a through 3.1.5i, respectively. Xenon-133 and ^{135}Xe combined were detected on average at levels about 7.7 percent of ^{41}Ar levels at the DN site and about 2.1 percent of ^{41}Ar levels at the PN site. Argon-41 is therefore the predominant noble gas radionuclide measured by the detectors in the public domain accounting for about 95 percent of the public dose from noble gases. Iridium-192 dose rates were observed in some months at the PN site only, as a result of industrial radiography use. There was one notable

¹ With exception of air monitoring stations 10 and 11, which were added in December 2000.

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occurrence seen in July 2003 on the detector at air monitoring #6 on the east station boundary, which is discussed in more detail below.

Visual examination of the detector spectra is necessary in order to obtain accurate annual totals for ^{133}Xe and ^{135}Xe . The software used for automatically calculating the air kerma rates from these radionuclides could not completely eliminate the influence of radon decay products during periods of precipitation, as well as spectrum shape changes that occurred under different wind conditions. The automatic software had no trouble accurately determining the ^{41}Ar dose rates and in removing the effects of radon decay products from the measurement of this radionuclide. Steps to improve the automatic software algorithms will continue to be explored in 2004/2005 through funding to be provided by Health Canada.

The dose rates measured from ^{41}Ar , ^{133}Xe , ^{135}Xe , and ^{192}Ir were not uniformly distributed throughout each month, but appeared as occasional spikes. See Figure 4.8.7 in Section 4.8.5 for an example of an ^{41}Ar spike observed.

The total noble gas and skyshine air kerma dose in 2003 at the PN boundary (average of all 9 monitoring location results) was approximately 333 nGy. This is about 7 times higher than that in 2002 and is due mainly to two events:

- (a) The start-up of PN Unit 4 in the second half of 2003 and a chronic release of ^{41}Ar from PN Unit 4 starting in September, 2003. The source of ^{41}Ar is in-leakage of air into and subsequent release of ^{41}Ar from the moderator cover gas system. The location of the in-leakage was identified and the problem will be addressed during the April 2004 Unit 4 outage.
- (b) The July 2003 radiography work described in more detail below.

Radiography is performed a number of times each year outside the powerhouse in the north east corner of the PN site using a collimated beam of ^{192}Ir .

On July 29 and again on July 31, 2003, unusually long duration radiography shots were required to be performed above ground level on the building stacks where the Training and Mockup Building joins the Warehouse on the east side of the PN site. During the radiography procedure, the collimated beam was pointing towards air monitoring station 6. This combination of events resulted in significantly higher than usual dose rates being measured at that monitoring location.

Normally, the beam is pointed towards the ground in such circumstances and the shots are of relatively short duration. Under these conditions there is not a direct line of sight to air monitoring stations 2 and 6, which are the two closest detector locations. However, skyshine radiation scattered off the atmosphere in the range of 2 to 10 nGy/h can be detected at these stations while the radiography is being performed.

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The total dose measured at air monitoring station 6 was about 465 nGy as a result of radiography procedure. See Figure 3.1.5d. This corresponds to an effective dose to the C1 Correctional Institute Critical Group about 50 metres away of about 0.1 μSv which is very low in relation to the public legal limit of 1,000 $\mu\text{Sv}/\text{year}$ and public background doses from naturally occurring and human-made radiation of about 1,840 $\mu\text{Sv}/\text{year}$.

Calibration of Exploranium Monitors for ^{131}I

Iodine-131 is potentially an important radionuclide (in terms of health impact) that could be released in significant quantities in the unlikely event of a serious reactor accident combined with a breach of containment.

In late 2001, the Exploranium GR150 Spectrometers were calibrated to provide a direct and continuous measurement of ^{131}I concentrations in air. The calibration procedure was developed by Dr. R.L. Grasty of Gamma-Bob Inc. [R-14] and approved for use by the CNSC. [R-15] Dr. J. Hovgaard of Exploranium G.S. Ltd. subsequently updated the monitoring network software so that the ^{131}I dose rates could be displayed. This new measurement capability will provide additional confidence that OPG has a sufficient understanding of its operational impact on the surrounding communities at all times.

Iodine-131 was not detected by any of the monitors at the Pickering and Darlington sites in 2003, based on visual examination of the detectors' spectral data.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**3.2 Airborne Tritium and ^{14}C**

The results of monitoring for airborne tritium in 2003 using the molecular sieve monitors at the DN and PN sites are summarized in Tables 3.2.1 and 3.2.4. Each table is followed by a series of bar charts showing the month by month concentration at each monitoring location. Note that the vertical scales on the bar charts for each station have been adjusted to maximize the presentation of the data. Figures 3.2.1i and 3.2.2m illustrate the historical trends in the average annual indicator measurements. Sampling locations are shown in Figures C2 and C3 in Appendix C.

Air is sampled for tritiated water vapour by passing air at a continuous steady rate through a drying material (molecular sieve). The water is extracted and analyzed monthly.

Results are obtained by multiplying the specific activity of tritium in the extracted water (Bq/g- H_2O) by the average absolute humidity (g- $\text{H}_2\text{O}/\text{m}^3$ air) measured for the sampling period. The average absolute humidity is determined by dividing the mass of water collected on the molecular sieve (the weight gain of the sieve plus container) by the volume of air sampled as measured by an integrating flow meter.

Airborne tritium monitoring data may be unavailable due to failure of the sampling pump, loss of power to the monitoring site, or other causes. Where data for a particular month have been lost, no information is shown for that month in the bar charts. The results of the quality assurance program for tritium-in-water (the analytical technique used in this case) are reported in Section 5.0 of this document.

New, passive tritium air sampler technology was employed at the PN site starting in 2001 on a trial basis, as part of the upgraded monitoring program at that site. **[R-1]** The passive tritium samplers have a diffusion head fitted on top of a liquid scintillation counting vial that contains a 50/50 mixture of "dead water" (tritium free) and ethylene glycol. Scintillation cocktail is added in the laboratory at the conclusion of the sampling period and the sample is analyzed by liquid scintillation counting. The passive samplers are replaced and analyzed quarterly. These samplers have been placed at PN critical group locations as well as at the same location as a number of the molecular sieve tritium monitors (sites 2, 6, and 10) to allow a comparison of the two technologies over a 2-year period. See Table 3.2.5. They have also been placed at a number of Provincial background locations. See Table 3.2.7. The advantage in using the passive samplers is that an electrical power source is not required and the samplers, which are placed on the properties of private residents, are unobtrusive.

Also new in 2001 at the PN site was the implementation of the capability to monitor ^{14}C -in-air through adding an extra molecular sieve canister to the tritium in air monitor. This third canister removes the CO_2 from the air stream. In the lab, at the end of each month, the CO_2 is removed from the canister by a helium purge through a liquid nitrogen cold trap. The CO_2 collected is then analyzed by liquid scintillation counting.

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New passive ^{14}C -in-air sampler technology was also employed at the PN site starting in 2001 on a trial basis as part of the upgraded monitoring program at that site. The ^{14}C passive sampler contains mixed hydroxide pellets to absorb CO_2 from air at a controlled rate. At the end of the sampling period (quarterly), the CO_2 is released from the pellets in the laboratory and analyzed by liquid scintillation counting.

These passive ^{14}C samplers have been placed at PN critical group locations as well as at the same location as the modified molecular sieve tritium monitors (sites 2, 6, and 10) to allow a direct comparison of the two technologies over a 2-year period. See Table 3.2.6. These samplers have also been placed at a number of Provincial background locations. See Table 3.2.8.

Passive tritium-in-air and ^{14}C -in-air samplers have also been recently installed at those DN critical group locations where an active molecular sieve is not already present. They have been located together with the molecular sieve tritium and ^{14}C monitors (sites 1, 2, and 6) to allow a direct comparison of the two technologies over a two year period. See Tables 3.2.2 and 3.2.3. This was new in 2003 and was a result of the upgrade to the DN site radiological environmental monitoring program. **[R-2]**

Table 3.2.1 Darlington Nuclear Site - Tritium-in-Air - 2003

Sites	Annual Average Tritium-in-Air Concentration (Bq/m^3) ¹
INDICATOR SITES:	
1. Southeast Fence	1.2
2. East Fence	0.8
3. Maple Grove	0.5
4. Park Road	0.4
5. Knight Road	0.4
6. Provincial Park	0.4
Average	0.6
AREA SITES:	
7. Oshawa	0.2
8. Bowmanville	0.3

¹ Results from active molecular sieve monitors shown in Table 3.2.1 and in Figures 3.2.1a through 3.2.1h.

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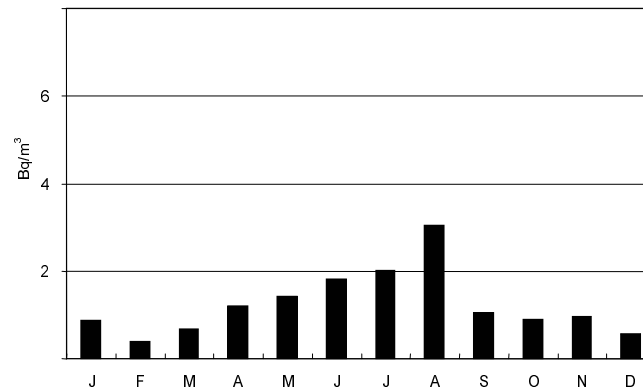


Figure 3.2.1a Darlington Nuclear Site Tritium-In-Air - 1. Southeast Fence

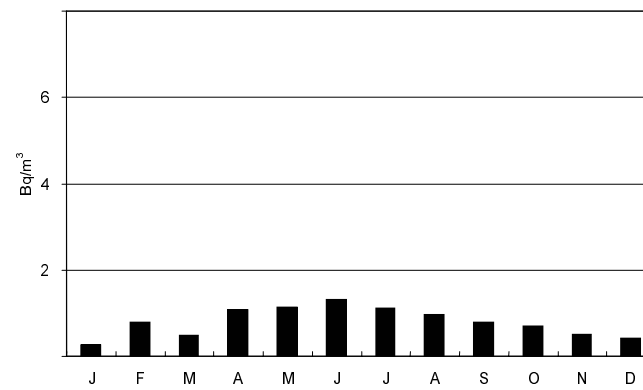


Figure 3.2.1b Darlington Nuclear Site Tritium-In-Air - 2. East Fence

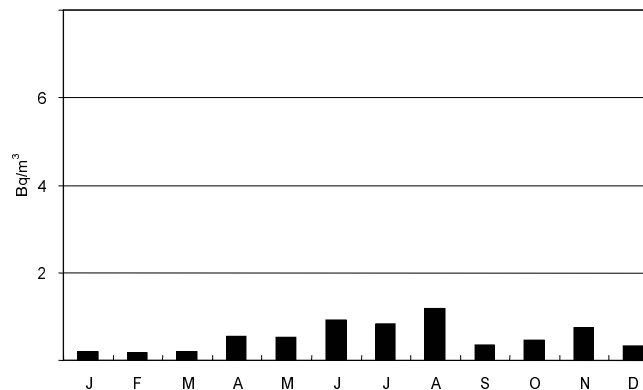


Figure 3.2.1c Darlington Nuclear Site Tritium-In-Air - 3. Maple Grove

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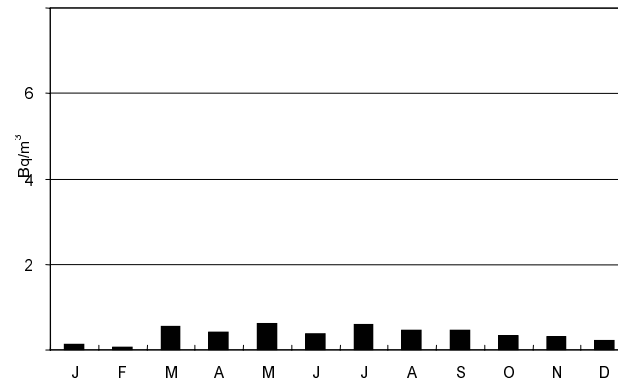


Figure 3.2.1d Darlington Nuclear Site Tritium-In-Air - 4. Park Road

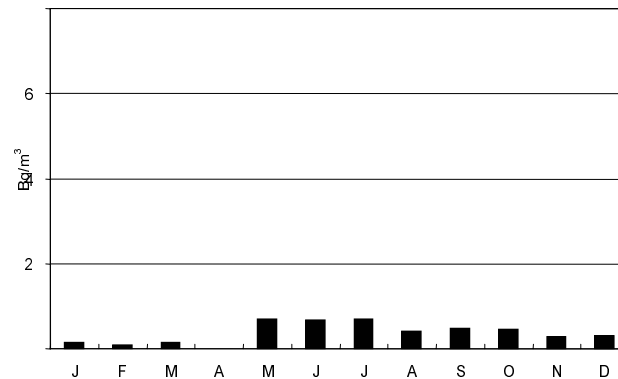


Figure 3.2.1e Darlington Nuclear Site Tritium-In-Air - 5. Knight Road

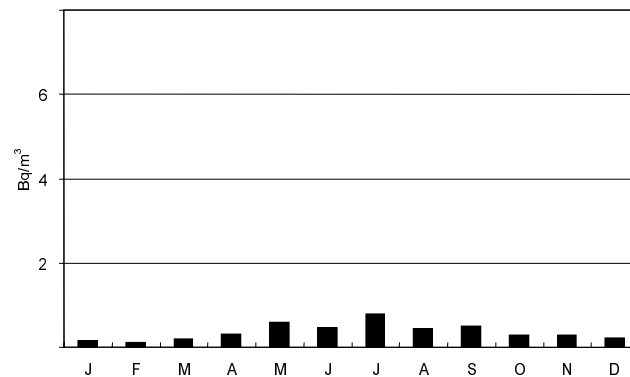


Figure 3.2.1f Darlington Nuclear Site Tritium-In-Air - 6. Provincial Park

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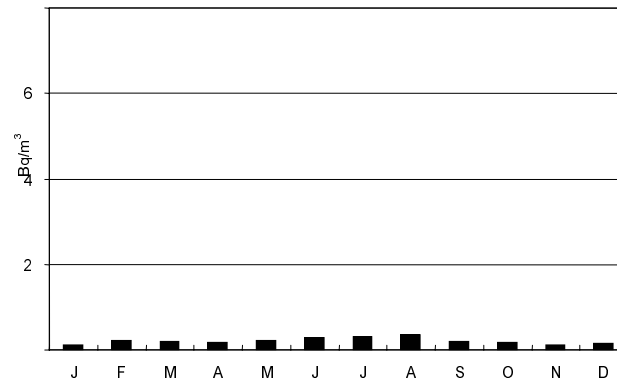


Figure 3.2.1g Darlington Nuclear Site Tritium-In-Air - 7. Oshawa

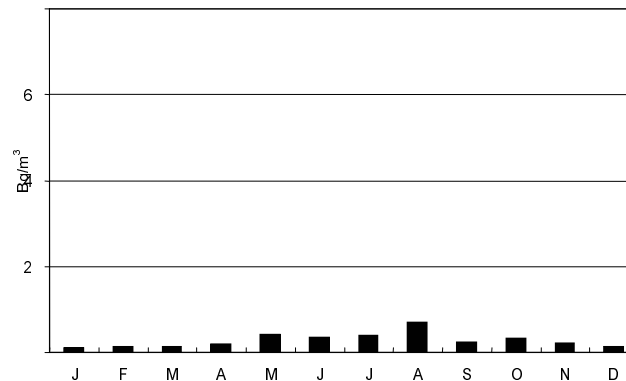


Figure 3.2.1h Darlington Nuclear Site Tritium-In-Air - 8. Bowmanville

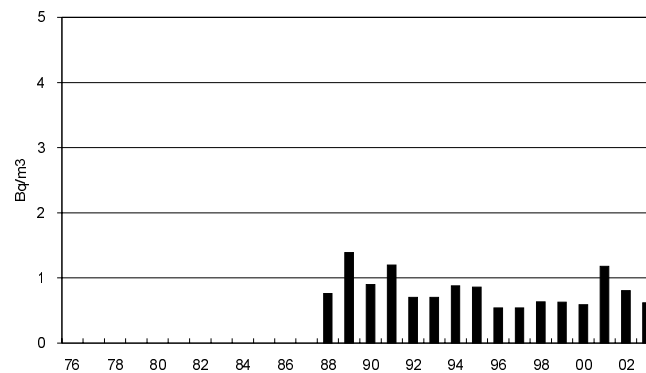


Figure 3.2.1i¹ Darlington Nuclear Site Tritium-In-Air Trends - Indicator Average

¹ Molecular sieve active sampler results.

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Table 3.2.2 Darlington Nuclear Site Tritium-in-Air Passive Samplers - 2003

Air Monitoring Sites ¹	Molecular Sieve Tritium –in Air (Bq/m ³)	Passive Sampler Tritium-in-Air (Bq/m ³)
INDICATOR AND AREA SITES:		
1. Southeast Fence	1.4	3.7
2. East Fence	0.9	2.0
6. Provincial Park	0.4	0.9
CRITICAL GROUP LOCATIONS		
R1	NA	0.5
R27	NA	0.7
R275	NA	1.6
F1	NA	1.2
F7	NA	0.8
DF3	NA	0.2
DF5	NA	0.3
DF7	NA	0.2
DF8	NA	0.3
DF9	NA	0.3

Table 3.2.3 Darlington Nuclear Site – ¹⁴C-in-Air Passive Samplers - 2003

Air Monitoring Sites ¹	Molecular Sieve ¹⁴ C–in-Air (Bq/kg-C)	Passive Sampler ¹⁴ C -in-Air (Bq/kg-C)
INDICATOR AND AREA SITES:		
1. Southeast Fence	311	299
2. East Fence	295	311
6. Provincial Park	252	258
CRITICAL GROUP LOCATIONS		
R2	NA	270
R27	NA	262
R275	NA	244
F1	NA	284
F7	NA	236
DF3	NA	246
DF5	NA	222
DF7	NA	239
DF8	NA	261
DF9	NA	238

¹ Sites 1, 2 and 6 correspond to molecular sieve monitor locations for comparing the two technologies. See map C2 in Appendix C for locations.

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Table 3.2.4 Pickering Nuclear Site – Tritium-in-Air - 2003

Sites	Annual Average Tritium-in-Air Concentration (Bq/m ³) ¹
INDICATOR SITES:	
2. Montgomery Park Road	13.5
3. Sandy Beach Road	2.7
4. Liverpool Road	1.4
6. East Boundary	6.7
7. Central Maintenance – West	6.6
8. Frenchman's Bay	2.0
9. Petticoat Creek	2.5
10. Central Maintenance – East ²	13.7
11. Alex Robertson Park ²	3.7
Average	5.9
AREA SITES:	
5. Highway 7	0.2
Ajax Hospital	1.2
HPL ³	0.5

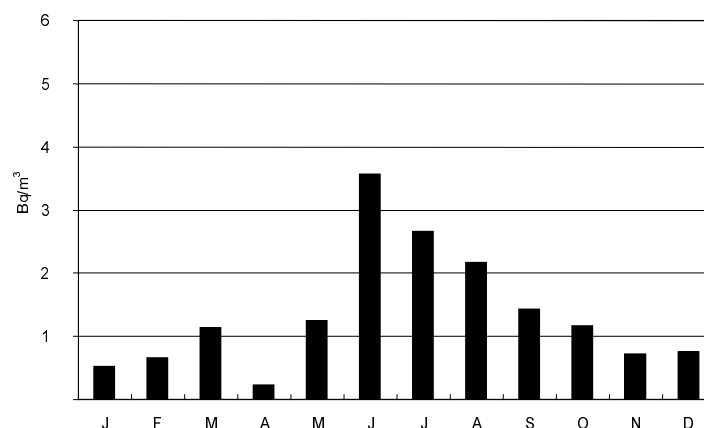


Figure 3.2.4a Pickering Nuclear Site Tritium-In-Air - 2. Montgomery Park Road

¹ Results from active molecular sieve monitors shown in Table 3.2.4 and in Figures 3.2.4a through 3.2.4l.

² New locations added in 2001 as part of the updated radiological environmental monitoring program at the PN site.

³ OPG Health Physics Laboratory is located at 1549 Victoria Street East, Whitby.

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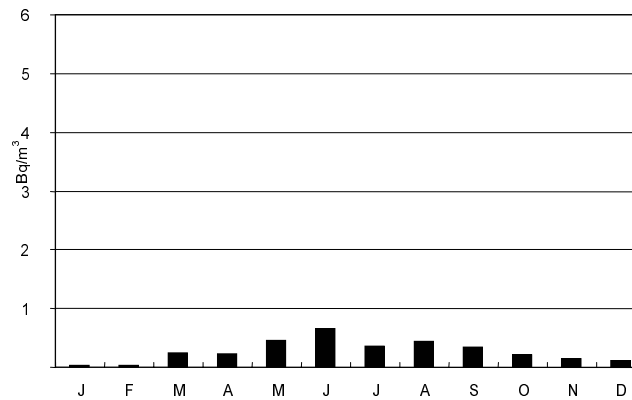


Figure 3.2.4b Pickering Nuclear Site Tritium-In-Air - 3. Sandy Beach Road

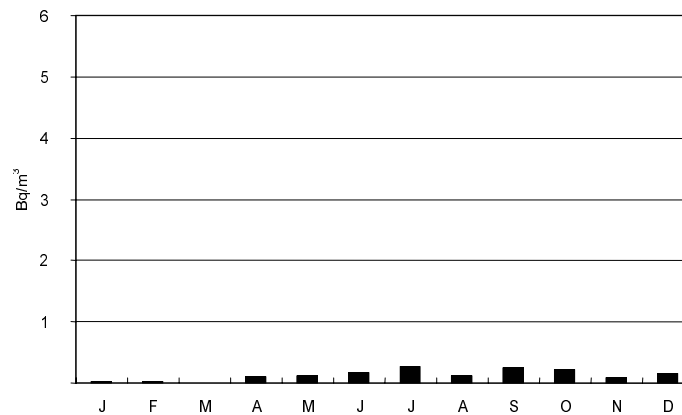


Figure 3.2.4c Pickering Nuclear Site Tritium-In-Air - 4. Liverpool Road

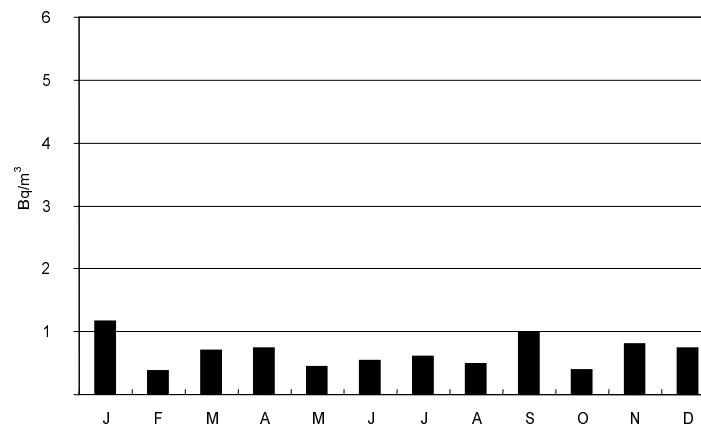


Figure 3.2.4d Pickering Nuclear Site Tritium-In-Air - 6. East Boundary Road

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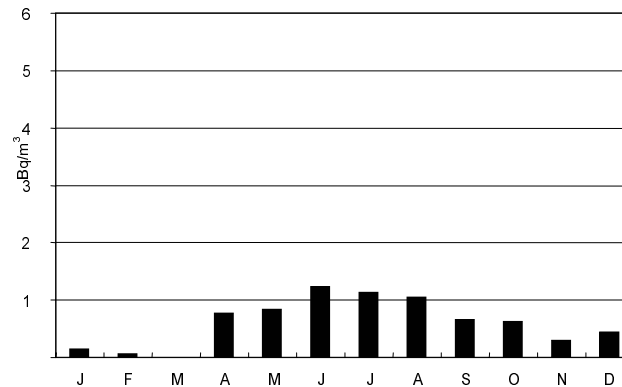


Figure 3.2.4e Pickering Nuclear Site Tritium-In-Air - 7. Central Maintenance West

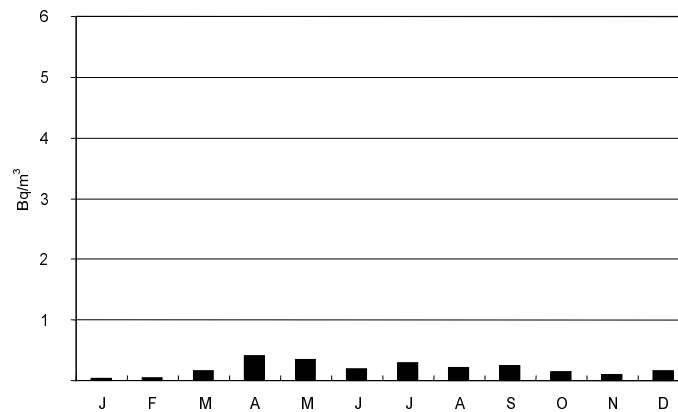


Figure 3.2.4f Pickering Nuclear Site Tritium-In-Air - 8. Frenchman's Bay

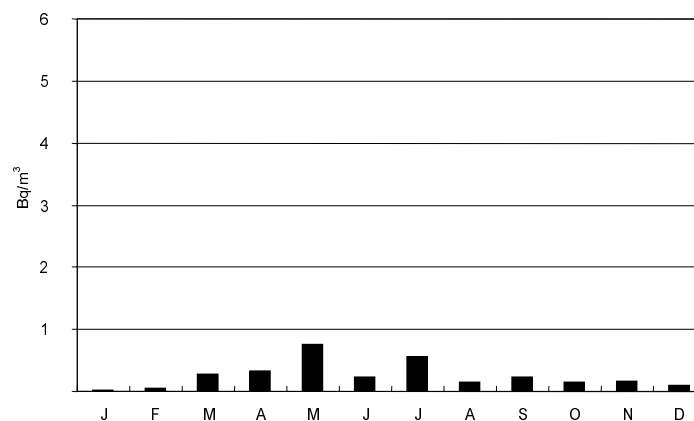


Figure 3.2.4g Pickering Nuclear Site Tritium-In-Air - 9. Petticoat Creek Conservation Area

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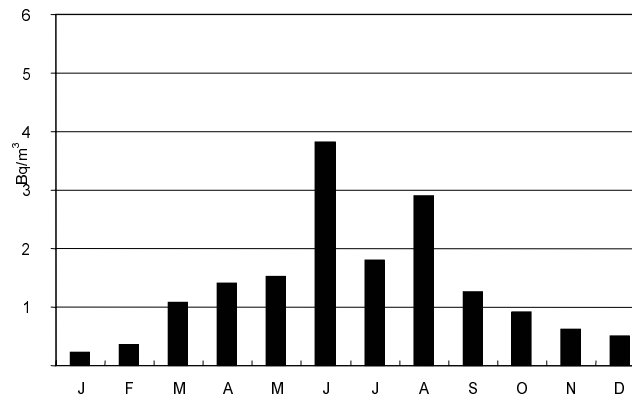


Figure 3.2.4h Pickering Nuclear Site Tritium-In-Air - 10. Central Maintenance – East

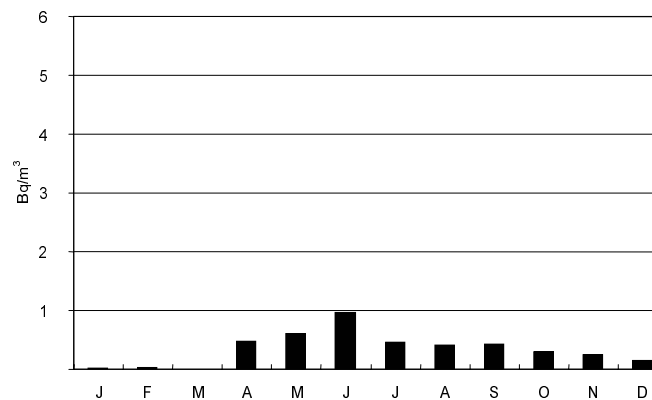


Figure 3.2.4i Pickering Nuclear Site Tritium-In-Air - 11. Alex Robertson Park



Figure 3.2.4j Pickering Nuclear Site Tritium-In-Air - 5. Highway 7

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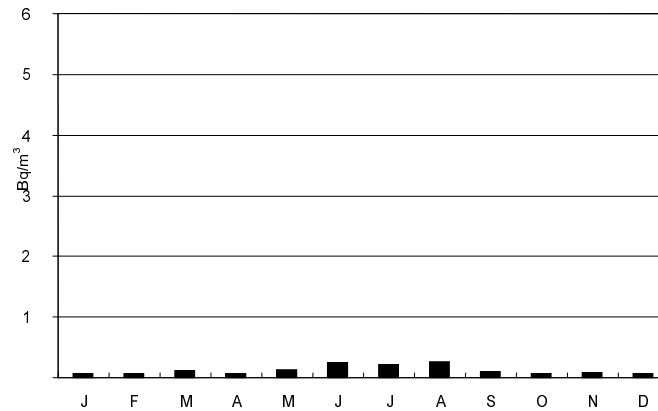


Figure 3.2.4k Pickering Nuclear Site Tritium-In-Air - Ajax Hospital

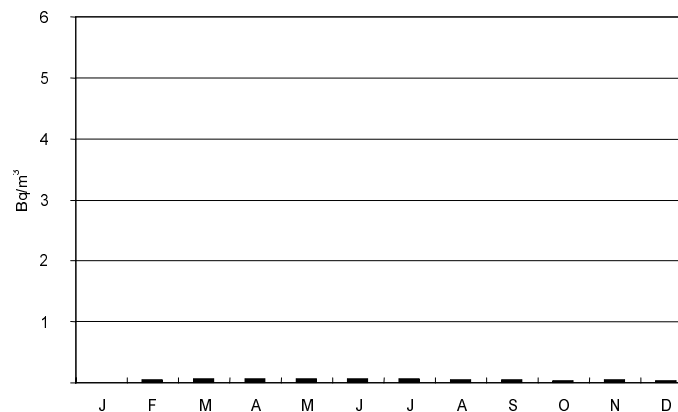


Figure 3.2.4l Pickering Nuclear Site Tritium-In-Air - EHPL - Victoria Street East, Whitby

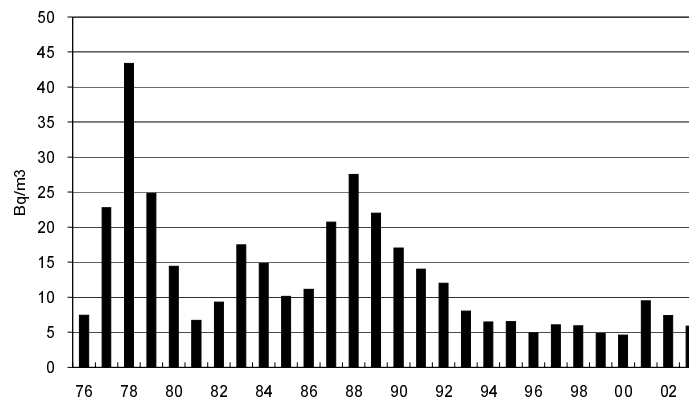


Figure 3.2.4m¹ Pickering Nuclear Site Tritium-In-Air Trends - Indicator Average

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Table 3.2.5 Pickering Nuclear Site Tritium-in-Air Passive Samplers – 2003

Air Monitoring Sites ¹	Molecular Sieve Tritium-in-Air (Bq/m ³)	Passive Sampler Tritium-in-Air (Bq/m ³)
INDICATOR AND AREA SITES:		
2. Montgomery Park Road	13.5	26.5
6. East Boundary	6.7	12.7
10. Central Maintenance – East	13.7	26.0
CRITICAL GROUP LOCATIONS:		
R83 ²	NA	2.4
R120	NA	6.9
F31 ³	NA	1.2
DF1	NA	0.7
DF8	NA	1.1
DF11	NA	1.3
C2	NA	5.9
R145	NA	2.4

Table 3.2.6 Pickering Nuclear Site - ¹⁴C-in-Air Passive Samplers - 2003

Air Monitoring Sites ¹	Molecular Sieve ¹⁴ C-in-Air (Bq/kg-C)	Passive Sampler ¹⁴ C-in-Air (Bq/kg-C)
INDICATOR AND AREA SITES:		
2. Montgomery Park Road	606	567
6. East Boundary	421	430
10. Central Maintenance – East	556	523
CRITICAL GROUP LOCATIONS:		
R83 ²	NA	282
R120	NA	327
F31	NA	244
DF1	NA	263
DF8	NA	248
DF11	NA	259
C2	NA	331
R145	NA	254

¹ Sites 2, 6, and 10 correspond to molecular sieve monitor locations for comparing the two technologies. See map C3 in Appendix C for locations.

² R83 property sold April 30, 2003 and made into a commercial property. January to March Q1 value shown.

³ F31 replaced F27

NA Not Analysed

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Table 3.2.7 Provincial Background Sites - Tritium-in-Air - 2003

Background Sites	Molecular Sieve Tritium-in-Air (Bq/m ³)	Passive Sampler Tritium-in-Air (Bq/m ³)
Lambton	0.03	NA
Nanticoke	0.03	NA
Lakefield	NA	0.12
Bancroft	NA	0.09
Barrie	NA	0.10
Belleville	NA	0.08
Picton	NA	0.07
Lambton	NA	0.12
Average	0.03	0.10

NA Not Analysed

Table 3.2.8 Provincial Background Sites - ¹⁴C-in-Air - 2003

Background Sites	Molecular Sieve ¹⁴ C-in-Air (Bq/kg-C)	Passive Sampler ¹⁴ C-in-Air (Bq/kg-C)
Lambton	247	NA
Nanticoke	250	NA
Lakefield	NA	236
Bancroft	NA	228
Barrie	NA	223
Belleville	NA	227
Picton	NA	229
Lambton	NA	248
Average	249	232

NA Not Analysed

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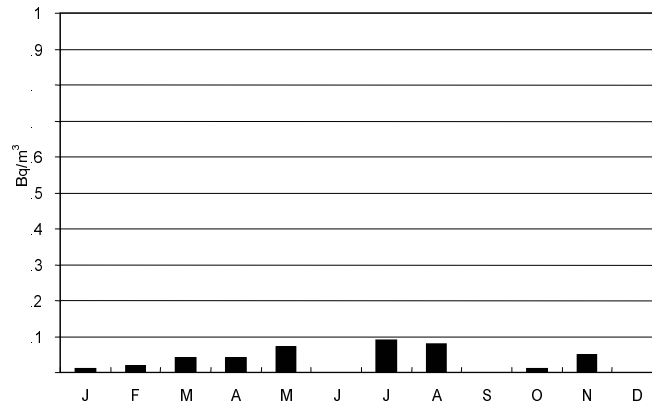


Figure 3.2.5a Provincial Background Sites Tritium-In-Air - Lambton

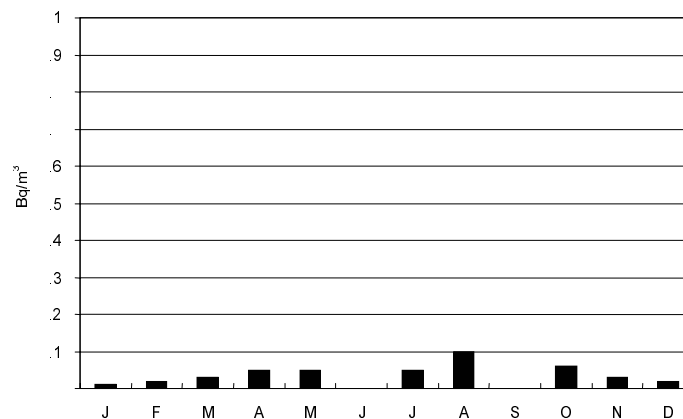


Figure 3.2.5b Provincial Background Sites Tritium-In-Air – Nanticoke

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Discussion of Airborne Tritium and ^{14}C Measurements

Results of measurements throughout 2003 showed higher average airborne tritium oxide concentrations in the vicinity of OPG nuclear stations compared with the provincial background locations.

At many sites, a seasonal variation in airborne tritium is observed with peak values normally reported in the summer. This is consistent with the seasonal variation in humidity, which contains increased levels of evapo-transpired tritiated moisture from the ground during warm months, and does not necessarily reflect variations in station emissions.

At the DN site, the average indicator tritium in air concentration decreased from 0.8 Bq/m^3 in 2002 to 0.6 Bq/m^3 in 2003. This is consistent with an 11 percent decrease in tritium to air emissions and an increase of 13 percent in atmospheric dilution due to wind dispersion in 2003 compared to 2002. Figure 3.2.1i shows the long-term trend plot of indicator average tritium in air concentrations. There was a downward trend in the long-term trend data up until 2000. The increase in 2001 and 2002 was due to reduced atmospheric dilution due to wind dispersion. See Figure 3.9.1.

At the PN site, the highest tritium in air concentrations were measured at air monitoring stations 10 and 2 (NNE and NE wind sectors respectively) reflecting the dominance of the wind frequency for landward wind sectors in that general direction (see Section 3.9). The average indicator airborne tritium concentration decreased from 7.4 Bq/m^3 in 2002 to 5.9 Bq/m^3 in 2003. The decrease in 2003 compared to 2002 was due to a 22 percent increase in atmospheric dilution due to wind dispersion which more than off-set a 3 percent increase in site tritium to air emissions. See Figure 3.9.2. Figure 3.2.4m shows the long-term trend plot of indicator average tritium-in-air concentrations. Tritium-in-air indicator average concentrations had been decreasing since 1988 and appeared to have leveled off in recent years up until 2000. The increase in 2001 and 2002 was due to reduced atmospheric dilution due to wind dispersion. See Figure 3.9.2. PN1-4 units were all placed in lay-up state in December 1997. PN Unit 4 was returned to service in September of 2003.

A two-year trial to compare the results of the new tritium and ^{14}C in air passive sampling technology (introduced during the PN site REMP upgrade) to the traditional molecular sieve technology was completed in 2002. Biases were observed in the comparison data, which led to further work and testing by the Health Physics Laboratory in 2003.

Changes were made to the passive ^{14}C sample analysis procedure that reduced the previously observed biases to acceptable levels. **[R-16]** Thus, passive ^{14}C monitoring will remain in place for routine environmental radiological monitoring at current locations at both the PN and DN sites, and the active and passive results will continue to be compared to ensure they are consistent within acceptable levels.

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The passive ^{14}C -in-air sampler results were on average about 4 percent lower than the molecular sieve ^{14}C -in-air results in 2003 representing good agreement at the three PN site locations. This is similar to 6 percent lower results in 2002 and 5 percent higher results in 2001. See Table 3.2.6 for results at these and other critical group locations.

Passive ^{14}C -in-air samplers were installed for the first time in 2003 at the Darlington site. The passive results in 2003 were on average about 1 percent lower than the molecular sieve ^{14}C results at three DN site locations, again representing good agreement. See Table 3.2.3 for results at these and other critical group locations.

At the Provincial background locations, the molecular sieve results averaged 246 Bq/kg-C in 2003, matching the Provincial ^{14}C background of 246 ± 1 Bq/kg-C as determined by the Geological Survey of Canada in maple leaves in the Ottawa area. The passive sampler results at six Provincial background locations were about 7 percent lower on average at 232 Bq/kg-C. There is an error of about ± 20 Bq/kg-C on all OPG ^{14}C measurements.

At the PN site, the passive tritium-in-air sampler results were on average about 1.9 times than the molecular sieve tritium-in-air measurements performed at the same location (air monitoring stations 2, 6 and 10) in 2003. This is similar to 1.9 times results in 2002 and 1.7 times higher results in 2001. See Table 3.2.5 for results at these and other critical group locations.

Passive tritium-in-air samplers were installed for the first time in 2003 at the Darlington site. The passive results in 2003 were on average about 2.4 times higher than the molecular sieve tritium-in-air measurements performed at the same location (air monitoring stations 1, 2 and 6). See Table 3.2.2 for results at these and other critical group locations.

At the Provincial background locations, the molecular sieve results averaged 0.03 Bq/m^3 in 2003, matching the Provincial background measured in Ottawa by Health Canada of 0.05 Bq/m^3 also using a molecular sieve monitor. The passive tritium-in-air monitors gave an average of 3 times higher values at 6 background locations. This large positive bias was also seen in 2002 where the passive tritium-in-air results were 5 times higher than the OPG and Health Canada molecular sieve results at background locations.

A special study performed at the PN site over a six-month period in 2003 confirmed the positive biases (on average about a factor of 2) seen in the passive tritium-in-air samplers during the previous two-year period. The study also revealed that the passive tritium samplers were providing results that were highly variable and un-reproducible from data obtained by multiple passive samplers at the same location. **[R-17]** OPG will continue using this technology on a special study basis, at all current locations and perform additional testing in 2004 in an effort to better understand the cause of the biases noted.

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3.3 Precipitation (Dry/Wet Fallout)

Dry/wet fallout, which includes precipitation, is collected monthly and analyzed for tritium and gross beta activity. Measurement results at the nuclear sites are presented in Tables 3.3.1 and 3.3.2. Sampling locations are shown in Appendix C, Figures C2 and C3. Figures 3.3.1 and 3.3.2 illustrate the historical trends in the average annual boundary tritium measurements at each OPG nuclear site.

Dry/wet fallout monitoring data are not used in the calculation of public dose. These results are only used as a gross indication of other more direct measurements such as tritium in air and biota, and tritium in drinking water.

In the 1950s and early 1960s, atmospheric weapons testing significantly increased the tritium concentration in all rainwater around the world. Tritium monitoring in precipitation in the Ottawa Valley was initiated during this period. The results from 1962 through 2001 are shown in Figure 3.3.3. **[R-18] [R-19]**

Starting in 1999, OPG has upgraded its Provincial Background Monitoring Program to fund the collection and analyses of monthly precipitation samples from the following locations:

- (a) Calgary, Alberta
- (b) Saskatoon, Saskatchewan
- (c) Fredericton, New Brunswick

See Table 3.3.3 for 2003 annual average results at these locations.

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Table 3.3.1 Darlington Nuclear Site Tritium and Gross Beta in Precipitation - 2003

Sites	Average Tritium Concentration in Precipitation (Bq/L)	Average Gross Beta Deposition Rate (Bq·m ⁻² ·month ⁻¹)
INDICATOR SITES:		
1. SE Fence	54	18
2. E Fence	33	26
3. Maple Grove	17	21
4. Park Road	17	20
5. Knight Road	25	15
6. Provincial Park	15	20
Average	27	20
AREA SITES:		
7. Oshawa-Bond St. TS	9	14
8. Bowmanville TS	13	18
R1	33	NA
R29	13	NA
R47	16	NA
R65	17	NA
R275	19	NA
F1	38	NA
F8	14	NA
F15	11	NA
DF3	7	NA
DF5	10	NA
DF7	6	NA
DF8	7	NA
DF9	7	NA

NA Not Analysed.

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Table 3.3.2 Pickering Nuclear Site Tritium and Gross Beta in Precipitation - 2003

Sites	Average Tritium Concentration in Precipitation (Bq/L)	Average Gross Beta Deposition Rate (Bq·m ⁻² ·month ⁻¹)
INDICATOR SITES:		
2. Montgomery Park Road	594	20
3. Sandy Beach Road	176	14
4. Liverpool Road	167	22
6. East Boundary	199	18
7. Central Maintenance - West	293	12
8. Frenchman's Bay	116	19
9. Petticoat Creek	142	17
10. Central Maintenance ¹	395	19
11. Alex Robertson Park ¹	127	19
Average	245	18
AREA SITES:		
5. Highway 7	11	20
R83 ¹	51	NA
R122	138	NA
R143	92	NA
DF8	26	NA
F10	22	NA
F25	12	NA
F27 ²	46	NA
F31 ²	14	NA

Table 3.3.3 Background Tritium in Precipitation - 2003

Background Sites	Average Tritium Concentration in Precipitation (Bq/L)
Calgary, Alberta	1.3
Saskatoon, Saskatchewan	2.3
Fredericton, New Brunswick	1.8
Average	1.8

NA Not Analysed.

¹ R83 property sold April 2003 and made into a commercial property. January to April average shown.² F31 replaced F27 who withdraw from the program in May 2003. F31 results for June to December only.

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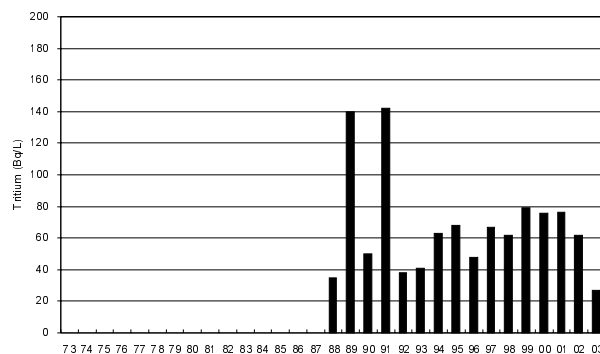


Figure 3.3.1 Darlington Nuclear Site Tritium-in-Precipitation Trends - Indicator Average

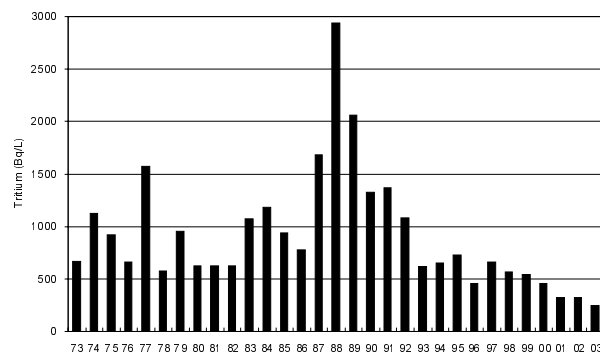


Figure 3.3.2 Pickering Nuclear Site Tritium-in-Precipitation Trends - Indicator Average

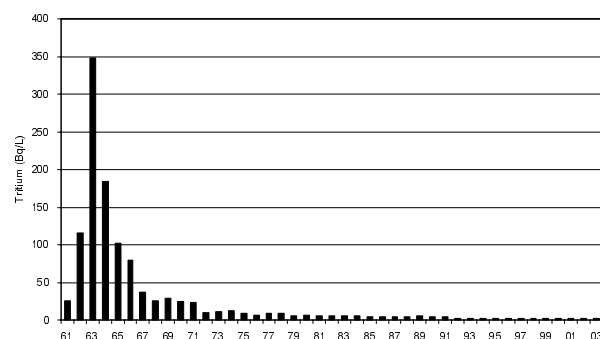


Figure 3.3.3 Ottawa Valley Tritium-in-Precipitation Trends

Note: The vertical scales on the bar charts for each location have been adjusted to maximize the presentation of the data.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**Discussion of Precipitation Measurements**

Tritium in precipitation tends to be correlated with tritium in air trends over the long term. This can be seen by comparing the annual trend plots of precipitation (Figures 3.3.1 and 3.3.2) with those of tritium in air (Figures 3.2.1i and 3.2.2m). All values measured at the Darlington and Pickering nuclear sites were well above the average Canadian background value of 1.8 Bq/L as per Table 3.3.3.

Monthly comparisons, however, often show poor correlation due to the infrequent nature of precipitation and changes in tritium concentrations between precipitation events. The highest average annual tritium in precipitation concentration was measured at the PN site, Site 2 – Montgomery Park Road location, at 594 Bq/L. This value is within the Ministry of the Environment (MOE) drinking water standard of 7,000 Bq/L¹ for tritium.

New rain gauges with an oil layer to prevent the transfer of tritium to and from the air were installed at all air monitoring stations at the PN site in May 2001. Previously, open containers collecting dry/wet fallout were used to obtain samples for tritium in precipitation analysis. Eliminating the exchange of tritium in the precipitation sample with the outside air has resulted in more accurate and representative results.

Similar rain gauges were installed at DN site air monitoring stations in late 2002 as part of the environmental monitoring program upgrade on going at that site. Results obtained using these rain gauges are reported starting in the 2003 assessment.

Measurements of gross beta activity are reported in units of Bq·m⁻²·month⁻¹. This measurement represents the total fallout as a result of deposition of airborne radionuclides both as dry deposition and that carried down in precipitation. Gross beta in fallout in North America normally averages from 5 to 100 Bq·m⁻²·month⁻¹ on an annual basis due to radioactive fallout from both natural sources (⁷Be, ⁴⁰K, and U and Thorium series radionuclides in dust from surface soil and other natural sources) and atmospheric nuclear weapon testing. The 2003 averages for the DN and PN sites were within this range.

The long term trend at the DN site saw tritium in precipitation levels increasing in general up to 1999 and trend downwards to 2003. The large drop in 2003 is due to reduced tritium to air emissions and increased measured atmospheric dilution due to

¹ The MOE implemented an interim tritium Ontario Drinking Water Objective (ODWO) of 7,000 Bq/L in December 1994, pending review of the Canadian drinking water guidelines and the ongoing federal government review of acceptable risks for radionuclides and industrial chemicals. In late 1996, the Federal Minister of Health published the results of a review of the Canadian drinking water guidelines and adopted an annual average maximum permissible concentration of tritium in drinking water of 7,000 Bq/L. [R-20] The ongoing federal government review of acceptable risks for radionuclides and industrial chemicals was published in 1998. [R-21]

The MOE issued a proposal to adopt the Canadian Drinking Water Quality Guideline for Radiological Characteristics as an Ontario Drinking Water Objective on August 26, 1999 (EBR Registry No. PA9E0006). In August 2001, after a review of public comments, the value of 7,000 Bq/L for tritium was adopted as an official drinking water standard. Ontario Power Generation has made a commitment to the MOE (coincident with the introduction of the 7,000 Bq/L interim ODWO) to maintain drinking water concentrations below 100 Bq/L at local water treatment plants around each nuclear site on an annual average basis.

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wind dispersion in 2003. Also, the effect of the oil layer provided a more accurate indication of levels. See Figure 3.3.1.

The long term trend at the PN site saw tritium in precipitation levels peak in the late 1980's and trend downwards to the present. See Figure 3.3.1.

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3.4 Milk

Milk samples are collected weekly from farms near the DN and PN sites and quarterly at background locations in the Province of Ontario. The samples are analyzed for tritium, ^{14}C , and gamma-emitters. Calculated annual average values of measurement results are provided in Tables 3.4.1, 3.4.2 and 3.4.3.

**Table 3.4.1 Darlington Nuclear Site: Milk - ^3H , ^{131}I , and ^{14}C
Annual Average Concentrations - 2003**

Farm ¹	Distance and Direction from Station (km)	$^3\text{H}^2$ (Bq/L)	$^{131}\text{I}^{3,4}$ (Bq/L)	^{14}C (Bq/kg-C)
DF3	11 km NW	8.0		243
DF5	3 km N	2.9		256
DF7	9 km NNE	2.4		242
DF8	10 km NW	5.2		251
DF9	13 km ENE	4.5		245
Average Values of all Farms		4.6	<0.11	247

**Table 3.4.2 Pickering Nuclear Site: Milk - ^3H , ^{131}I , and ^{14}C
Annual Average Concentrations - 2003**

Farm	Distance and Direction from Station (km)	$^3\text{H}^2$ (Bq/L)	$^{131}\text{I}^3$ (Bq/L)	^{14}C (Bq/kg-C)
DF1	12 km WNW	18.6		250
DF8 ⁵	10 km NNE	27.5		249
DF11	10 km NE	26.4		250
Average Values of all Farms		24.2	<0.11	250

**Table 3.4.3 Provincial Background Sites: Milk - ^3H , ^{131}I , and ^{14}C
Annual Average Concentrations - 2003**

Farm ⁶	Location	$^3\text{H}^2$ (Bq/L)	$^{131}\text{I}^3$ (Bq/L)	^{14}C (Bq/kg-C)
1	Belleville	4.0	<0.12	234
2	London	0.6	<0.10	237
Average Values of all Farms		2.3	<0.11	235

¹ DF3, DF5, DF7, and DF8 were previously labeled Farm 2, 1, 3, and 5 in previous published reports. DF9 is new in 2003.

² Weekly samples are used to form a monthly composite sample for tritium oxide analysis.

³ Radioiodines not detected in any sample in 2003. Detection limit shown.

⁴ All farm weekly samples are used to produce a weekly composite sample for iodine analysis.

⁵ Organically Bound Tritium (OBT) was measured in all monthly DF8 milk samples. The annual average OBT concentration was 29.0 Bq/L water equivalent (w.e.).

⁶ Provincial location milk samples collected and analysed quarterly.

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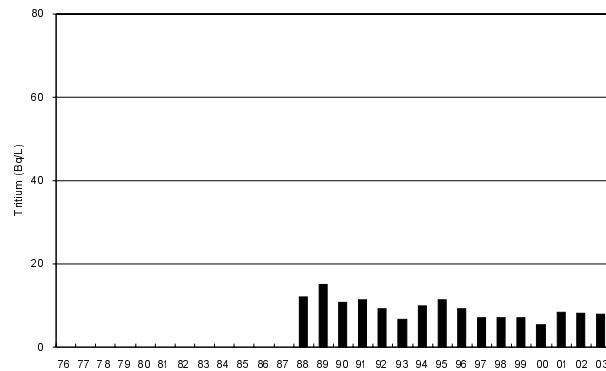


Figure 3.4.1 Darlington Nuclear Site Tritium-in-Milk Trends

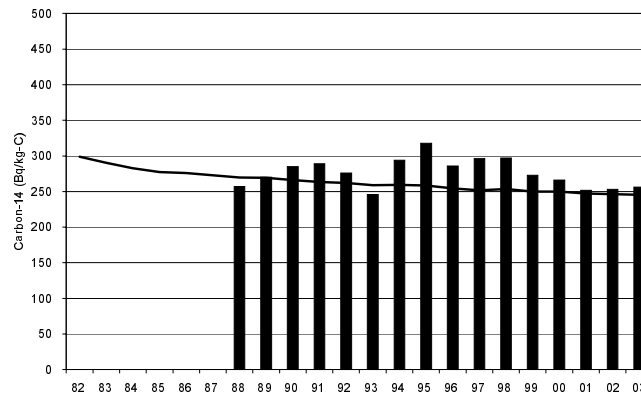


Figure 3.4.2 Darlington Nuclear Site ¹⁴C-in-Milk and Background Trends¹

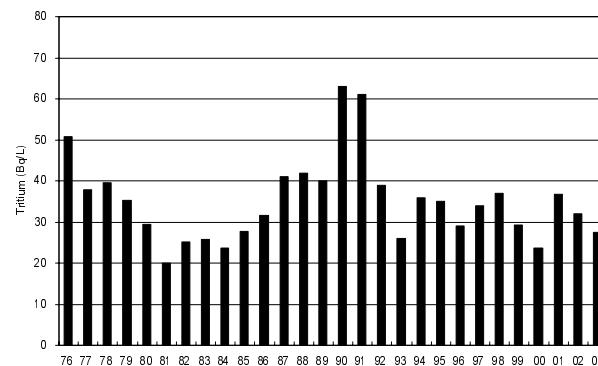


Figure 3.4.3 Pickering Nuclear Site Tritium-in-Milk Trends

¹ Background ¹⁴C concentrations in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ¹⁴C bar charts above.

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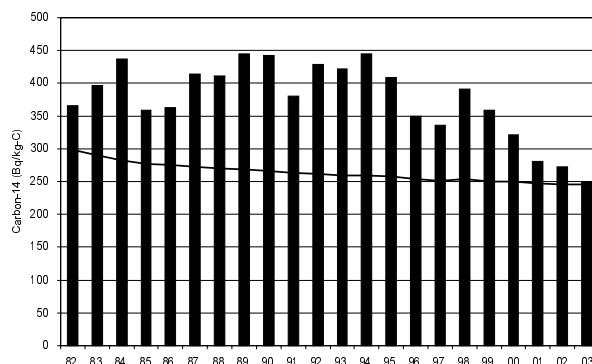
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Figure 3.4.4 Pickering Nuclear Site ^{14}C -in-Milk and Background Trends¹

Discussion of Milk Measurements

In 2003, ^{131}I was not detected in any OPG milk samples. The detection limit for ^{131}I averaged approximately 0.11 Bq/L for all samples in 2003.

Annual average trend plots of tritium and ^{14}C concentrations in milk at both nuclear sites are presented in Figures 3.4.1 through 3.4.4. Background ^{14}C concentrations, as measured in maple leaves in Ottawa, Ontario are superimposed as a line in the ^{14}C figures. The values plotted represent the average of actual measurements made each year at each site. The number and location of farms at both sites have changed over the years.

At the DN site, the average level of tritium-in-milk at all five farms decreased from 6.1 Bq/L in 2002 to 4.6 Bq/L in 2003. Tritium to air emissions were 11 percent lower in 2003 compared to 2002. There was also 13 percent higher measured atmospheric dilution due to wind dispersion over the same time period. Carbon-14 concentrations in milk at the DN site decreased slightly from 250 Bq/Kg-C in 2002 to 247 Bq/Kg-C in 2003. It should be noted that DN site milk concentrations in 1988 and 1989, prior to reactor operation, averaged 270 Bq/kg-C. The error on ^{14}C measurements at these levels is approximately ± 20 Bq/kg-C. One dairy farm (DF9) was added in 2003 as a result of the upgrade to the overall monitoring program that took place in late 2002. **[R-2]** See Figure C2 in Appendix C for locations.

Since the late 1980s, tritium-in-milk concentrations at the DN site are trending lower. The longer-term ^{14}C concentration has continued to decrease from 1995 to the present.

The PN monitoring program now includes three dairy farms (previously one) being sampled in 2001 and beyond as a result of the upgrade to the PN site radiological environmental monitoring program. **[R-1]** See Figure C3 in Appendix C for locations.

¹ Background ^{14}C concentrations in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ^{14}C bar charts above.

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Tritium levels in milk at the PN site have decreased on average from 27.9 Bq/L in 2002 to 24.2 Bq/L in 2003. Total tritium emissions to air at the PN site increased 3 percent over the same time period but there was a 22 percent increase in measured atmospheric dilution due to wind dispersion which off-set the increase in emissions. Carbon-14 levels in milk have decreased from 263 Bq/kg-C in 2002 to 250 Bq/kg-C in 2003. This decrease occurred despite a 90 percent increase in ^{14}C emissions to air in 2003 compared to 2002. There was an increase in atmospheric dilution due to wind dispersion measured near the site boundary but not enough to explain the decrease. Over the long term, tritium-in-milk at the PN site is stable. There has been a notable decrease in ^{14}C -in-milk concentrations since the early 1990s that continued through 2003.

The Provincial background location farms gave ^{14}C and tritium averages of 235 Bq/kg-C and 2.3 Bq/L in milk respectively.

Atomic Energy of Canada performed a study on a large number of foodstuffs to determine the naturally occurring ratio of OBT/TFWT (Organically Bound Tritium/Tissue Free Water Tritium). The ratio observed ranged from 0.3 to 4.2 with an overall average of 1.25 ± 0.75 when concentrations are expressed as Bq/L water equivalent. **[R-22]** Measured ratios substantially outside of this range could potentially identify anomalies for further investigation.

OBT was measured in all monthly composite DF8 milk samples and averaged 29.0 Bq/L (w.e.). The OBT/TFWT ratio in 2003 is 1.1. The ratio was 1.0 in 2002 and 1.1 in 2001.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**3.5 Drinking Water**

Drinking water samples are taken from three DN area Water Supply Plants (WSPs), four PN area WSPs and local wells near each site.

The locations of these WSPs relative to the nearest nuclear station discharge are as follows:

	Distance from Site
DARLINGTON NUCLEAR SITE	
Bowmanville WSP	5 km ENE of DN
Newcastle WSP	11 km E of DN
Oshawa WSP	9 km W of DN
PICKERING NUCLEAR SITE	
R.C. Harris WSP	21km WSW of PN
Horgan WSP	10 km SW of PN
Ajax WSP	6 km ENE of PN
Whitby WSP	13 km ENE of PN

WSPs at Ajax, Whitby, and Oshawa supply water to the Region of Durham water supply network, which serves the urban areas of Pickering, Ajax, Whitby, and Oshawa.

The R.C. Harris WSP and the Horgan WSP supply water to the Metropolitan Toronto water supply network.

The Bowmanville and Newcastle WSPs supply water to their respective urban communities.

Samples of lake water are taken three times daily at the R.C. Harris WSP and Horgan WSP. All other water supply plants in the DN and PN areas are sampled twice daily. Weekly composite samples are used for tritium analysis, and monthly composite samples are used for gross beta analysis.

Quarterly "grab" samples are also taken from drinking water supplies throughout the province and analyzed for tritium and gross beta activity. These results indicate the range of background concentrations experienced during the year. See Table 3.5.3.

Tables 3.5.1 and 3.5.2 provide the 2003 average annual concentrations measured at the DN and PN sites area water supply plants respectively. See Figures 3.5.1a through 3.5.2h as well.

Monthly well water samples are also collected from farms and residents near the DN and PN sites. Average annual concentrations measured are reported in Table 3.5.1 and Table 3.5.2.

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The detection limit¹ (Ld) for tritium in water was approximately 3.7 Bq/L in 2003. This is the level of tritium required to say with 95 percent confidence that it can be detected. The current counting systems cannot distinguish actual values from background noise below the critical level of 1.8 Bq/L. The Ld for gross beta in water was approximately 0.05 Bq/L in 2003.

¹ The critical level is approximately half the detection limit and is the value that distinguishes detection from non-detection. The detection limit is the true value which would be detected (i.e., give a measured result greater than the critical level) 95% of the time, or 19 times out of 20. < Denotes less than the critical level of 1.8 Bq/L for tritium and 0.03 for gross beta.

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Table 3.5.1 Darlington Nuclear Site - Area Drinking Water Tritium and Gross Beta - 2003

Drinking Water Supply Plants	Annual Average Tritium Concentration ¹ (Bq/L)	Annual Average Gross Beta Activity ¹ (Bq/L)
Bowmanville WSP	6.2	0.10
Newcastle WSP	6.1	0.10
Oshawa	6.7	0.10
Drinking Water Well Locations ²	Annual Average Tritium Concentration ¹ (Bq/L)	Annual Average Gross Beta Activity ¹ (Bq/L)
DF3	5.7	0.37
DF5	<1.8	0.24
DF7	<1.8	0.27
DF8	<1.8	0.18
DF9	<1.8	0.06
F1	<1.8	0.04
F8	<1.8	0.12
F15	<1.8	0.15
R1	30.3	0.11
R29	<1.8	0.06
R47A	8.2	0.11
R47B	5.1	0.12
R65	19.5	0.27
R279	3.8	0.85
R294	9.8	0.07
R316	10.6	0.09
R320	10.2	0.07
Lake Water Locations	Annual Average Tritium Concentration ¹ (Bq/L)	Annual Average Gross Beta Activity ¹ (Bq/L)
Darlington Provincial Park	8.8	0.14
McLaughlin Bay	28.4	0.25
St. Mary's Cement	5.9	0.10

¹ All values reported are below the current Provincial Drinking Water Standard for tritium and gross beta of 7,000 Bq/L and 1.0 Bq/L respectively. The critical level is approximately half the detection limit and is the value that distinguishes detection from non-detection. The detection limit is the true value which would be detected (i.e., give a measured result greater than the critical level) 95% of the time, or 19 times out of 20. < Denotes less than the critical level of 1.8 Bq/L for tritium and 0.03 for gross beta.

² See Figure C2 in Appendix C for locations.

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Table 3.5.2 Pickering Nuclear Site - Area Drinking Water Tritium and Gross Beta - 2003

Drinking Water Supply Plants	Annual Average Tritium Concentration (Bq/L)	Annual Average Gross Beta Activity (Bq/L)
Ajax	6.7	0.11
Scarborough Horgan	5.5	0.10
Toronto Harris	5.5	0.10
Whitby	6.4	0.10
Drinking Water Well Locations¹	Annual Average Tritium Concentration (Bq/L)	Annual Average Gross Beta Activity (Bq/L)
R11a (April – November)	64.0	0.16
R11b ² (April – November)	80.7	0.13
R115	20.6	0.11
R116 (January – August)	6.3	0.10
R120	74.1	0.11
R122	14.9	0.46
R124	13.7	0.26
R125	77.0	0.10
R127 (September – December)	68.3	NA
R143	17.3	NA
F10	13.1	NA
DF8	18.7	NA
F25	<1.8 ³	NA
F27 (January – May)	26.2	NA
F31 (June to December)	14.0	NA
Lake Water Locations	Annual Average Tritium Concentration (Bq/L)	Annual Average Gross Beta Activity (Bq/L)
Frenchman's Bay	28.8	NA
Beachpoint Promenade	19.0	NA
Squire's Beach	29.3	NA

NA Not Analysed

¹ New in 2001 at the PN site due to upgrade of the PN site radiological environmental monitoring program. See Figure C3 in Appendix C for locations.

² Used for watering property and not for drinking due to high mineral content.

³ The critical level is approximately half the detection limit and is the value that distinguishes detection from non-detection. The detection limit is the true value which would be detected (i.e., give a measured result greater than the critical level) 95% of the time, or 19 times out of 20. < Denotes less than the critical level of 1.8 Bq/L for tritium and 0.03 for gross beta.

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**Table 3.5.3 Provincial Background Sites - Drinking Water
Tritium and Gross Beta – 2003**

Locations	Water Source	Annual Average Tritium Concentration (Bq/L)	Annual Average Gross Beta Concentration (Bq/L)
Bancroft	Clarke Lake	2.1	0.07
Belleville	Bay of Quinte	2.9	0.09
Brockville ¹	Lake Ontario	4.2	0.10
Burlington ¹	Lake Ontario	4.4	0.09
Cobourg ¹	Lake Ontario	5.1	0.09
Goderich ¹	Lake Huron	3.0	0.08
Kingston ¹	Lake Ontario	4.5	0.10
London	Lake Huron	4.0	0.07
Niagara Falls ¹	Niagara River	4.0	0.08
North Bay	Trout Lake	3.0	0.07
Orangeville	Well Water	2.9	0.04
Parry Sound	Georgian Bay	3.5	0.05
Sarnia ¹	Lake Huron	5.0	0.06
St. Catherines	Lake Moodie/Gibson	2.9	0.09
Sudbury	Ramsay Lake	3.3	0.06
Thunder Bay	Lake Superior	<1.8 ²	0.16
Windsor ¹	Lake St. Clair	4.0	0.13
Average		3.5	0.08

¹ New locations added in 2001 as part of the upgrade to the provincial radiological environment monitoring program. See Figure C4 in Appendix C for locations.

² The critical level is approximately half the detection limit and is the value that distinguishes detection from non-detection. The detection limit is the true value which would be detected (i.e., give a measured result greater than the critical level) 95 percent of the time, or 19 times out of 20. < Denotes less than the critical level of 1.8 Bq/L for tritium and 0.03 Bq/L for gross beta.

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Darlington Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants

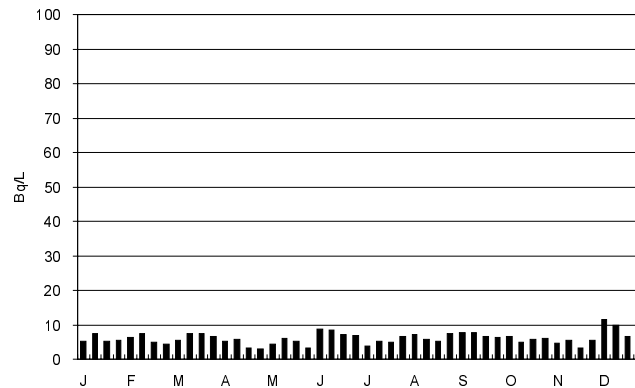


Figure 3.5.1a Bowmanville WSP - Tritium in Water

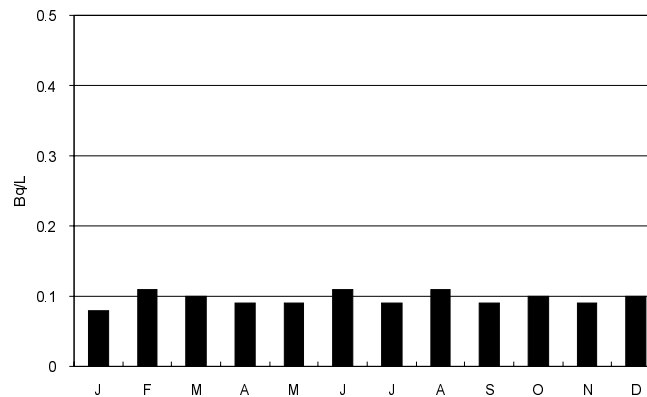


Figure 3.5.1b Bowmanville WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Darlington Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants

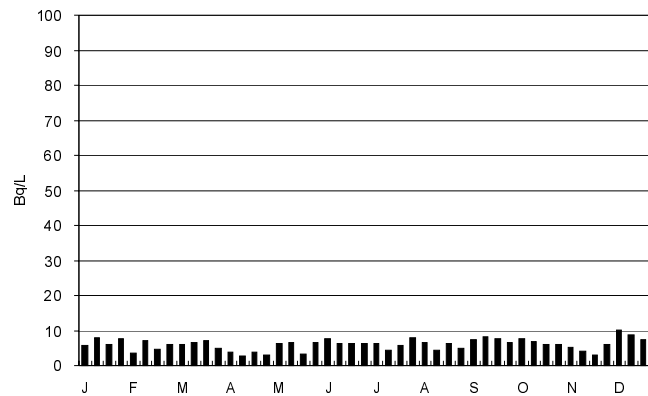


Figure 3.5.1c Newcastle WSP - Tritium in Water

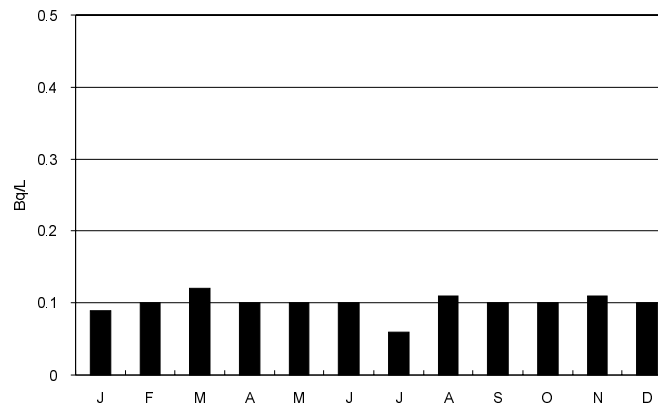


Figure 3.5.1d Newcastle WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Darlington Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants

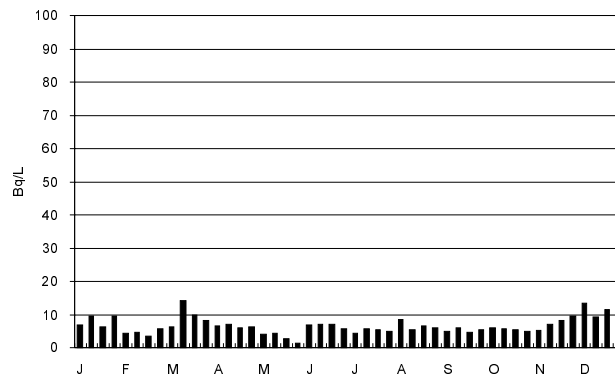


Figure 3.5.1e Oshawa WSP - Tritium in Water

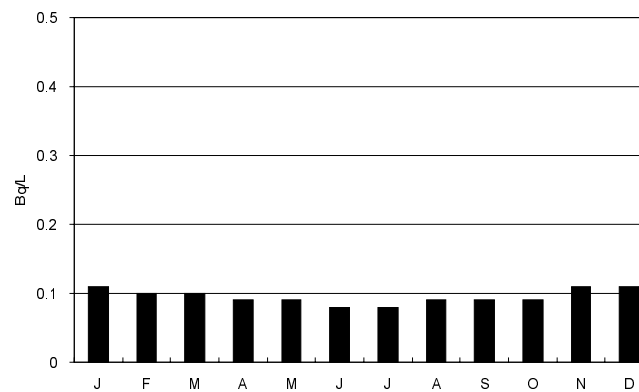


Figure 3.5.1f Oshawa WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Pickering Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants

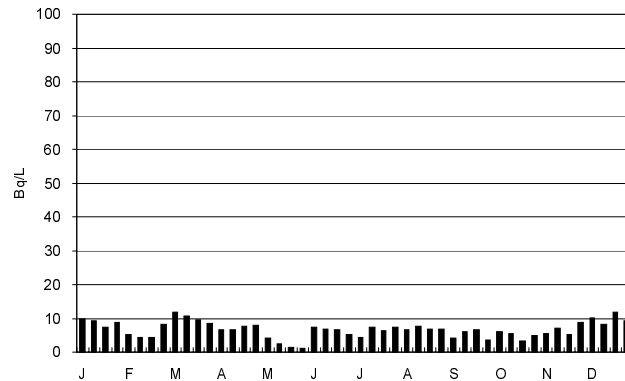


Figure 3.5.2a Ajax WSP - Tritium in Water

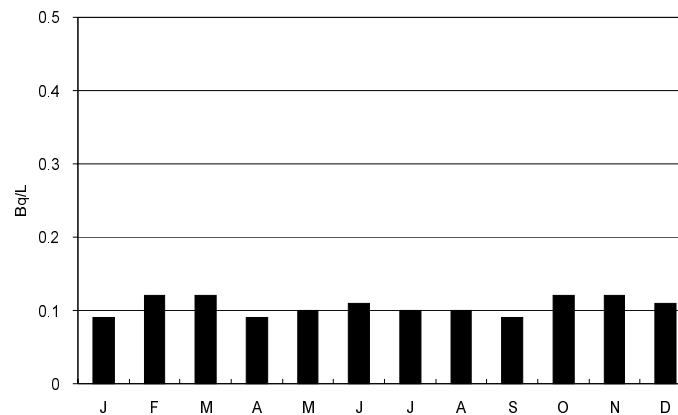


Figure 3.5.2b Ajax WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Pickering Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants

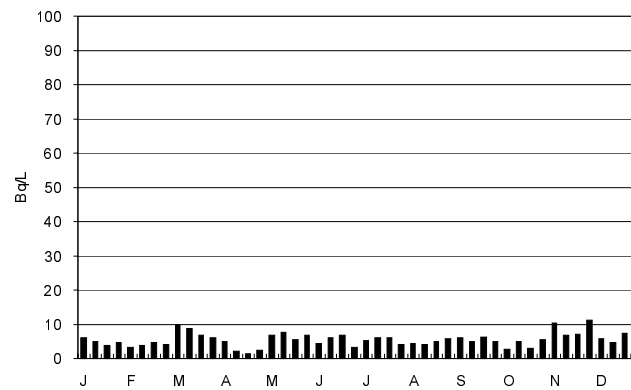


Figure 3.5.2c Scarborough Horgan WSP - Tritium in Water

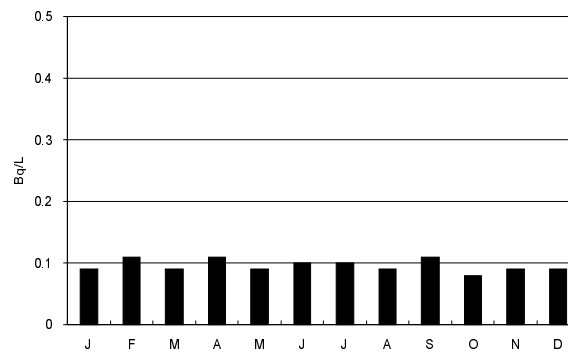


Figure 3.5.2d Scarborough Horgan WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Pickering Nuclear Area Tritium¹ and Gross Beta Concentrations in Water Supply Plants (Continued)

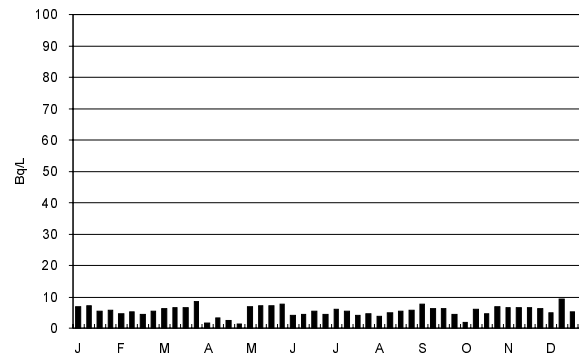


Figure 3.5.2e Toronto R.C. Harris WSP - Tritium in Water

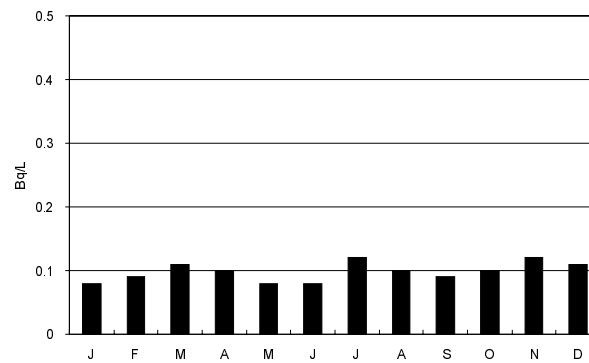


Figure 3.5.2f Toronto R.C. Harris WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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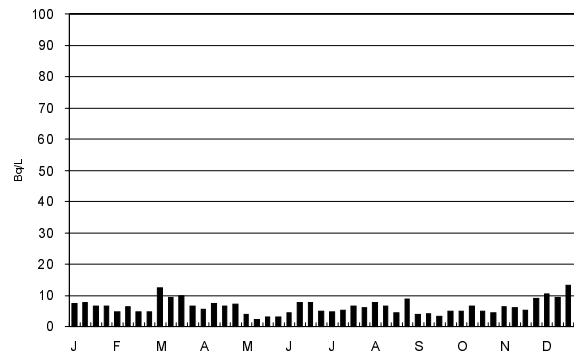


Figure 3.5.2g Whitby WSP - Tritium in Water

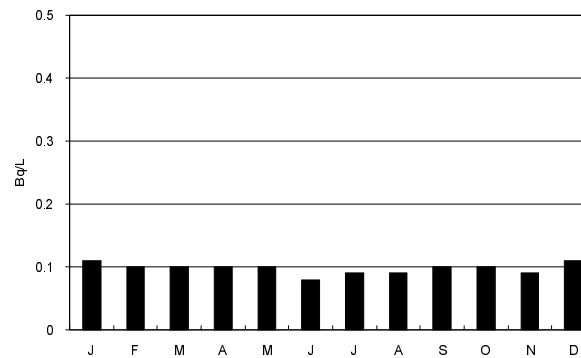


Figure 3.5.2h Whitby WSP - Gross Beta in Water

¹ The y-axis scale maximum value is 100 Bq/L for the tritium charts. Ontario Power Generation has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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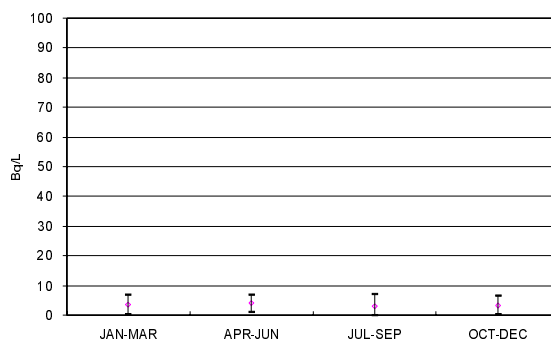
Provincial Background Sites - 2003
Average of All Background Sites $\pm 1\sigma$ 

Figure 3.5.3a Provincial Sites - Tritium in Water

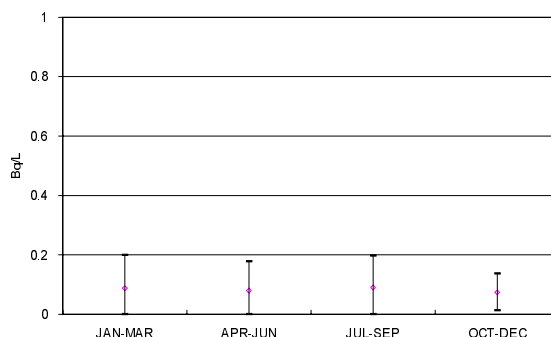


Figure 3.5.3b Provincial Sites - Gross Beta in Water

Discussion of Drinking Water Measurements

Tritium

In general, tritium in drinking water concentrations above background can be attributed to routine emissions from the stations. Background levels are made up of tritium from natural cosmogenic sources and fallout from atmospheric weapons testing. These background levels were determined by Atomic Energy of Canada Limited – Chalk River Laboratories (AECL-CRL) to be 2.5 Bq/L for Lake Ontario and 3.7 Bq/L for Lake Huron in a 1997 study. [R-23] Further development of a Great Lakes Tritium Model has resulted in calculated background levels of 2.0 Bq/L for Lake Huron and 1.9 Bq/L for Lake Ontario in 2003. OPG now has a model for predicting total Great Lakes tritium concentrations as well as the natural, atmospheric weapon test and OPG operational contributions, in any future year using OPG and Bruce Power site tritium emission to air and water data as input. [R-24]

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See Figure 3.5.4h for the model's calculation of Lake Ontario tritium levels from 1953 through to 2025. The model has calculated future lake tritium concentrations (beyond 2003) assuming tritium to air and water emissions at OPG and Bruce Power nuclear sites are at 1996 levels (prior to the lay-up of PN1-4 and BN1-4).

Impacts of station emissions on the nearby water supply plants vary depending upon distance from the station, lake current direction, and general dispersion conditions. Annual average tritium levels at all water supply plants were well within the MOE drinking water standards for radionuclides (see Section 3.3 on MOE drinking water standards). OPG also met its commitment to maintain annual average tritium levels at all water supply plants below 100 Bq/L in 2003. Refer to the historic trend plots from 1983 to present of all seven water supply plants annual tritium in drinking water concentrations (Figures 3.5.4a through 3.5.4g). A discussion of each site follows.

(a) Darlington Nuclear

Tritium concentrations in drinking water taken from Lake Ontario at the Newcastle, Bowmanville and Oshawa Water Supply Plants (Table 3.5.1) were between the measured 1997 Lake Ontario average of 7.1 Bq/L [**R-23**] and the AECL-CRL model-predicted average for 2003 of 5.6 Bq/L due to emissions to air and water at the DN and PN generating stations. The highest annual average tritium concentration in 2003 municipal drinking water (6.7 Bq/L) was measured at the Oshawa WSP.

Well water samples from around DN show tritium concentrations higher and lower than normal background levels. Concentrations of tritium in well water may be below background if the source aquifer contains water that has been separated from natural sources of tritium for long periods of time (years), as the half-life of tritium is 12.3 years. If a well is recharged from precipitation, then the concentrations of tritium would be expected to reflect, to some degree, those found in precipitation.

(b) Pickering Nuclear

Tritium concentrations in drinking water taken from Lake Ontario at the Ajax, Whitby, Horgan and Harris water supply plants (Table 3.5.2) were between the measured 1997 Lake Ontario average of 7.1 Bq/L [**R-23**] and the model-predicted average for 2003 of 5.6 Bq/L due to emissions to air and water at the PN and DN sites. The highest annual average tritium concentration in 2003 municipal drinking water (6.7 Bq/L) was measured at the Ajax WSP.

Residence R11 close to the PN site west boundary uses a shallow well (approximately 3 metres deep) for drinking water purposes that has tritium concentrations somewhat higher than Lake Ontario water and Frenchman's Bay water samples obtained immediately adjacent to the property. The results (see Table 3.5.2 location R11a) indicate that the well water is being impacted by a combination of elevated tritium levels in local precipitation and lake water. This is

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consistent with previous year's results, and the tritium levels are well below the annual average Ontario Drinking Water Standard of 7,000 Bq/L.

In 2001, Dr. Tom Kotzer of AECL-CRL determined the residence time of the water in a second well on the property (R11b in Table 3.5.2) that is used for watering purposes. [R-25] The residence time is the span of time since the water in the well was last on the surface as a result of precipitation. The residence time was determined to be about 2.8 years. The measurement could not be repeated on well R11a due to its shallow depth. Well R11b was measured to be about 27 feet deep. Dr. Kotzer collected water from an unused well about 6 metres deep in Kinsmen Park in 1999, and determined a groundwater residence time of <1 year. [R-26]

Concentrations of deuterium in both wells were measured in 2001 and found comparable to previously measured levels in Lake Ontario waters and in tritium depleted well waters up gradient of the PN site. [R-25] This indicates that the source of the tritium in the well is likely from a mixture of precipitation and water from the lake (due to its close proximity).

Gross Beta

Annual average gross beta activity levels in water at the water supply plants near the DN and PN facilities ranged from 0.10 to 0.11 Bq/L. They were not significantly different than the average of the 4 provincial background Lake Ontario measurements of 0.09 to 0.10 Bq/L (Table 3.5.3). Therefore, it was concluded that the gross beta activity in drinking water supplies is not elevated above the background as a result of station emissions.

Gross beta concentrations in the range 0.005 to 0.2 Bq/L in drinking water are normal and result from naturally occurring radionuclides together with fallout from nuclear weapon tests.

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Annual Average Tritium Concentrations in Area WSPs¹

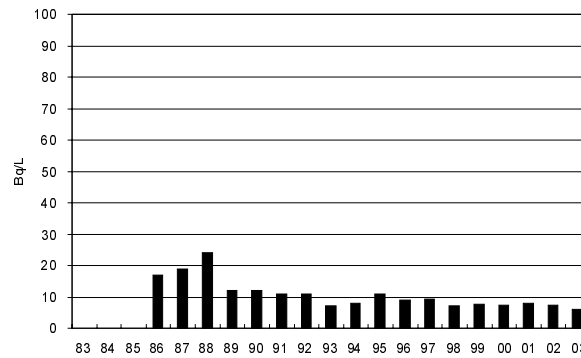


Figure 3.5.4a Bowmanville WSP - Tritium in Water

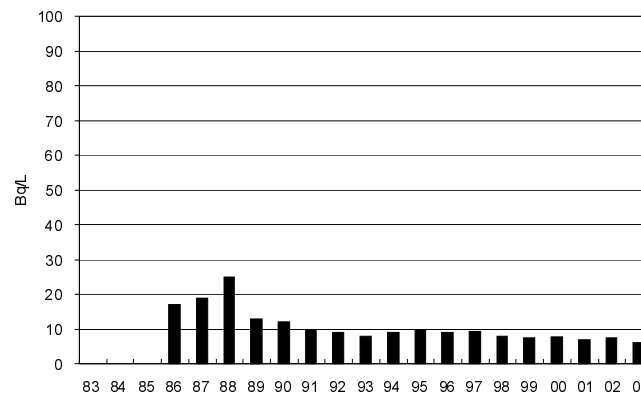


Figure 3.5.4b Newcastle WSP - Tritium in Water

¹ The y-axis scale maximum value is 100 Bq/L. OPG has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Annual Average Tritium Concentrations in Area WSPs (Continued)¹

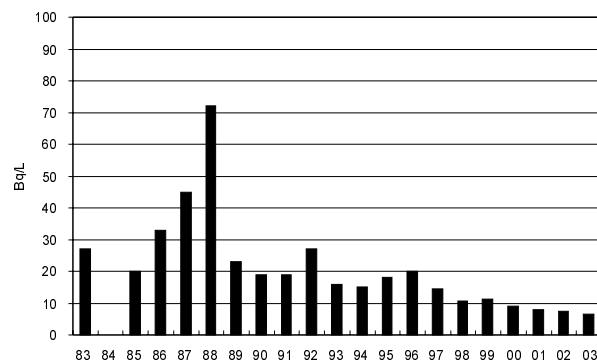


Figure 3.5.4c Ajax WSP - Tritium in Water

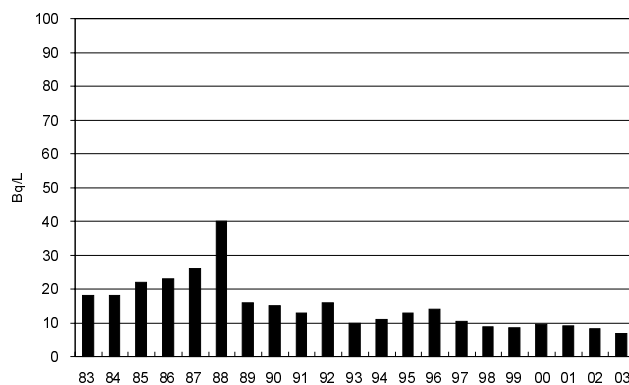


Figure 3.5.4d Oshawa WSP - Tritium in Water

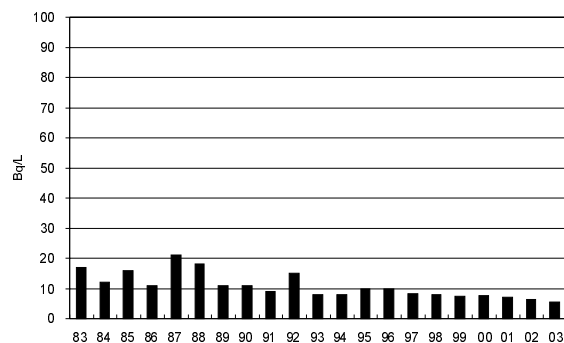


Figure 3.5.4e Scarborough Horgan WSP - Tritium in Water

¹ The y-axis scale maximum value is 100 Bq/L. OPG has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Annual Average Tritium Concentrations in Area WSPs (Continued)¹

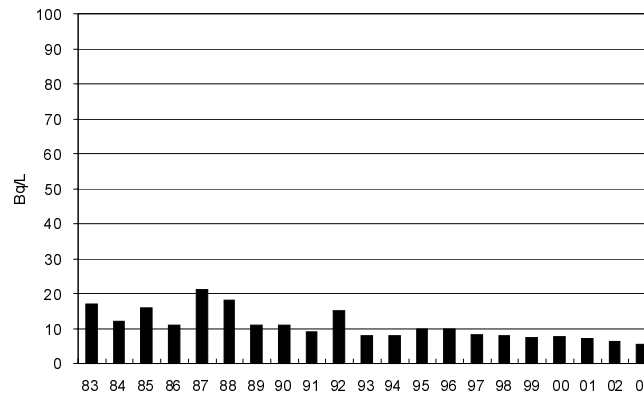


Figure 3.5.4f Toronto Harris WSP - Tritium in Water

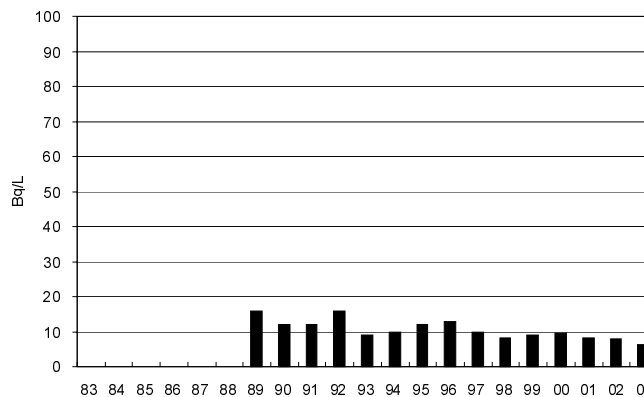


Figure 3.5.4g Whitby WSP - Tritium in Water

¹ The y-axis scale maximum value is 100 Bq/L. OPG has made a commitment to maintain annual average tritium concentrations below this level at local water treatment plants.

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Historic and Projected Lake Ontario Tritium Concentrations

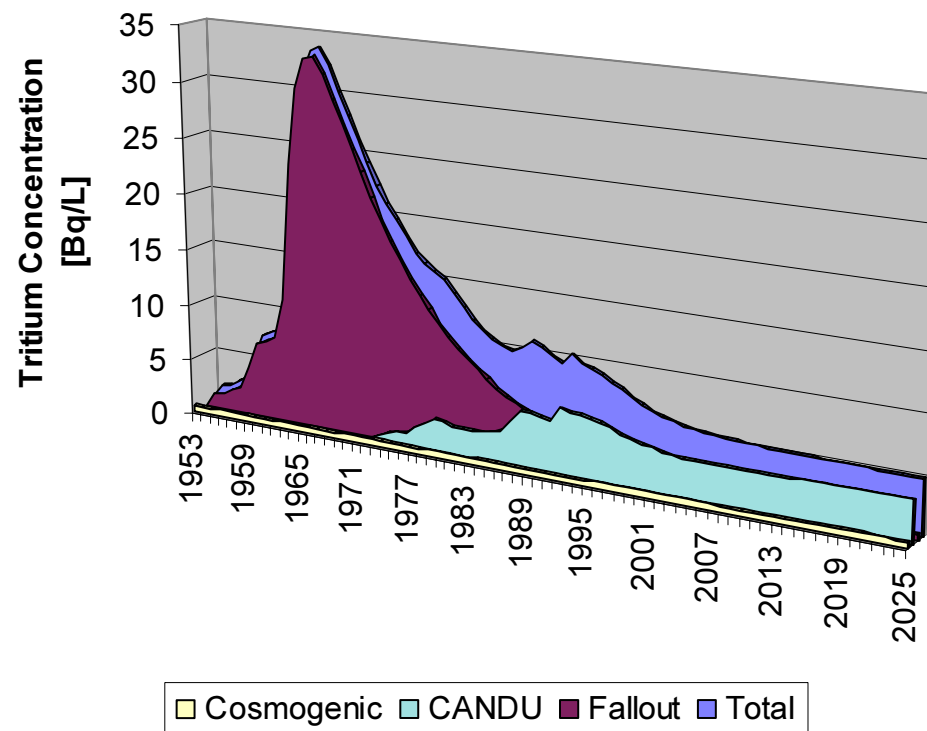


Figure 3.5.4h Historic and Projected Lake Ontario Tritium Concentrations

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3.6 Aquatic Sampling

Samples of sediments and fish are taken annually from the aquatic receiving environment adjacent to the DN and PN sites. The results of this sampling program are given in Tables 3.6.1.1 to 3.6.2.2. The $\pm$ values given in these tables are uncertainties at the 95 percent confidence level (2σ) based on counting statistics. If a particular radionuclide was not detected, the detection limit is presented.

The aquatic sampling procedure was upgraded in 1998 to obtain statistically valid sets of samples in an effort to establish better long-term sampling requirements. The upgrade included:

- Establishing new background locations for fish and sediment samples for both Lake Ontario and Lake Huron. See Figure C4 in Appendix C for identification of new locations.
- Obtaining replicate samples at each location for both sediment and fish.
- Obtaining tritium concentrations from fish flesh. Previously it was assumed the tritium concentration in fish flesh was equal to the concentrations in large volume water samples collected at the same time and location as the fish samples.

The formal statistical analysis of all 1998 fish and sediment samples was completed and sent to the CNSC for review. [R-27] [R-28] A separate report documenting the statistical analysis of the 1999 and 2000 fish and sediment samples was completed and sent to the CNSC in early 2003. [R-29]

Based on feedback received from the CNSC [R-30] and the final recommendations contained in Reference [R-29] the aquatic monitoring program was modified for 2001 and beyond as follows:

- OPG and Bruce Power standardized the target fish species collected at each site and at background locations. Lake Whitefish and White Sucker (bottom feeder) are the target species with Brown Bullhead and Round Whitefish as their respective backup species.
- One location at each site will be sampled. For the DN site this will be over the diffuser. At the PN site this will be in the PN5-8 outfall.
- A minimum of 4 replicate samples of fish and sediments will be collected and analysed at each location. A subsequent statistical analysis of year 2001 results on fish samples indicated that OPG should strive to obtain up to 8 replicate samples for analyses.
- OBT measurements will be performed on composite samples of the target fish species at all locations.

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- The fish flesh ventral to the lateral line has historically been excluded from the analysis as the MOE recommends the public not eat this portion of the fish in their Guide to Eating Ontario Sport Fish issued each year. OPG now includes this portion of the fish in its analysis at the CNSC's request but does not expect it to impact on the results obtained.

The Health Physics laboratory has developed an analysis for ^{14}C in lake bottom sediment samples. These results at indicator and background locations are reported starting in the year 2002 assessment.

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Table 3.6.1.1 Darlington Nuclear Site - Area Lake Ontario Sediment - 2003

Location	Sample Date	Sample Type	¹⁴ C ^{1,2} Bq/kg- C ± 2σ	Gamma Analysis ³ Bq/kg ± 2σ (dry weight)			
				¹³⁷ Cs	¹³⁴ Cs	⁶⁰ Co	⁴⁰ K
Darlington Provincial Park-A	September 13	Sediment	NA	1.57 ± 0.25	<0.4	<0.4	466.4 ± 8.8
Darlington Provincial Park-B	September 13	Sediment		1.72 ± 0.26	<0.3	<0.4	464.2 ± 11.4
Darlington Provincial Park-C	September 13	Sediment		1.46 ± 0.22	<0.3	<0.3	444.9 ± 9.9
Darlington Provincial Park-D	September 13	Sediment		1.19 ± 0.23	<0.3	<0.3	445.6 ± 14.1
Port Darlington-A	July 14	Sediment	NA	3.07 ± 0.56	<0.5	<0.7	465.1 ± 20.9
Port Darlington-B	July 14	Sediment		3.22 ± 0.44	<0.4	<0.4	497.6 ± 15.7
Port Darlington-C	July 14	Sediment		3.11 ± 0.39	<0.3	<0.3	463.9 ± 11.4
Port Darlington-D	July 14	Sediment		3.22 ± 0.32	<0.3	<0.3	446.9 ± 14.7
Diffuser-A	October 2	Sediment	NA	0.81 ± 0.27	<0.4	<0.5	257.6 ± 9.4
Diffuser-B	October 2	Sediment		2.02 ± 0.44	<0.5	<0.6	304.9 ± 11.4
Diffuser-C	October 2	Sediment		2.57 ± 0.40	<0.5	0.6 ± 0.3	415.0 ± 15.3
Diffuser-D	October 2	Sediment		2.56 ± 0.40	<0.6	<0.6	477.3 ± 12.1

NA – Not Analyzed

¹ Result of composite sample made up from 4 replicate samples. Samples were collected for analysis in 2003 but could not be analyzed using the standard technique due to high mussel shell and fine sediment content.

² The total organic carbon content of the diffuser composite sample was determined to be 2,600 ppm (3,100 ppm – replicate analysis).

³ The ± values represent twice the standard deviation of one determination.

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Table 3.6.1.2 Darlington Nuclear Site - Area Lake Ontario Fish – 2003

Sample Location	Fish Type (Composites)	Sample Date	Tritium ¹ (TFWT)	¹⁴ C ¹	Gamma ² Bq/kg ± 2σ (wet weight)			OBT ³	
			Bq/L ± 2σ ²	Bq/kg-C ± 2σ ²	¹³⁷ Cs	¹³⁴ Cs	⁴⁰ K	Bq/L (w.e.) ± 2σ (Composites)	
Darlington Diffuser	White Sucker	-A	July 4	5.7 ± 2.5	245 ± 19	0.16 ± 0.06	<0.08	145.1 ± 3.9	24.4 ± 2.8
		-B	July 4	6.3 ± 2.5	262 ± 19	0.14 ± 0.09	<0.14	156.3 ± 3.9	
		-C	Nov/Dec	5.2 ± 2.5	232 ± 19	0.21 ± 0.12	<0.18	129.6 ± 4.1	
		-D	Nov/Dec	4.5 ± 2.4	244 ± 19	<0.33	<0.27	114.4 ± 6.5	
		-E	Nov/Dec	3.6 ± 2.4	241 ± 19	0.24 ± 0.09	<0.15	141.7 ± 3.6	
		-F	Nov/Dec	3.2 ± 2.3	229 ± 18	0.26 ± 0.13	<0.21	136.3 ± 4.5	
		-G	Nov/Dec	5.1 ± 2.5	245 ± 19	<0.23	<0.22	108.4 ± 5.3	
		-H	Nov/Dec	5.4 ± 2.5	256 ± 20	0.33 ± 0.17	<0.25	86.1 ± 5.1	
Darlington Diffuser	Round Whitefish	-A	Nov/Dec	23.7 ± 3.6	239 ± 18	<0.12	<0.13	72.9 ± 2.4	28.3 ± 2.9
		-B	Nov/Dec	37.3 ± 4.0	257 ± 20	<0.14	<0.15	79.7 ± 2.7	
		-C	Nov/Dec	35.1 ± 4.0	280 ± 20	<0.29	<0.29	96.8 ± 5.6	
		-D	Nov/Dec	23.3 ± 3.4	264 ± 20	<0.20	<0.20	108.2 ± 5.4	
		-E	Nov/Dec	29.1 ± 3.7	274 ± 20	<0.17	<0.17	76.5 ± 3.1	
		-F	Nov/Dec	36.9 ± 4.0	282 ± 22	0.14 ± 0.07	<0.13	96.0 ± 2.9	
		-G	Nov/Dec	25.4 ± 3.6	257 ± 20	0.23 ± 0.11	<0.17	106.5 ± 4.8	
		-H	Nov/Dec	26.5 ± 3.6	248 ± 20	0.16 ± 0.07	<0.14	107.8 ± 3.0	

¹ The $\pm$ values represent twice the standard deviation of the mean of two determinations.

² The $\pm$ values represent twice the standard deviation of one determination.

Comment: Gamma analysis based on wet weight.

³ Organically Bound Tritium concentrations were measured in composite samples of each DN site target species.

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Table 3.6.2.1 Pickering Nuclear Site - Area Lake Ontario Sediment - 2003

Sample Location		Sample Date	Sample Type	Gamma Analysis ³ Bq/kg $\pm$ 2 σ				¹⁴ C ^{1,2}
				¹³⁷ Cs	¹³⁴ Cs	⁶⁰ Co	⁴⁰ K	Bq/kg-C $\pm$ 26
"A" Discharge	-A	July 11	Sediment	2.53 $\pm$ 0.20	<0.26	<0.29	415.0 $\pm$ 7.1	183 $\pm$ 30
	-B	July 11	Sediment	2.45 $\pm$ 0.23	<0.22	<0.22	412.7 $\pm$ 6.2	
	-C	July 11	Sediment	2.50 $\pm$ 0.26	<0.27	<0.30	401.8 $\pm$ 7.1	
	-D	July 11	Sediment	2.93 $\pm$ 0.29	<0.28	<0.31	402.7 $\pm$ 7.6	
"B" Discharge	-A	July 11	Sediment	3.81 $\pm$ 0.31	<0.29	<0.33	469.0 $\pm$ 8.3	183 $\pm$ 28
	-B	July 11	Sediment	3.73 $\pm$ 0.31	<0.27	<0.30	469.3 $\pm$ 7.6	
	-C	July 11	Sediment	2.50 $\pm$ 0.23	<0.22	<0.23	418.0 $\pm$ 6.2	
	-D	July 11	Sediment	2.55 $\pm$ 0.24	<0.22	<0.23	417.4 $\pm$ 11.8	
Liverpool Road Beach	-A	July 21	Sediment	1.07 $\pm$ 0.24	<0.28	<0.35	341.9 $\pm$ 7.7	58 $\pm$ 22
	-B	July 21	Sediment	0.58 $\pm$ 0.13	<0.22	<0.20	288.8 $\pm$ 5.2	
	-C	July 21	Sediment	0.74 $\pm$ 0.20	<0.23	<0.28	276.8 $\pm$ 6.1	
	-D	July 21	Sediment	0.90 $\pm$ 0.28	<0.30	<0.28	314.4 $\pm$ 8.8	
Duffin's Creek	-A	July 11	Sediment	0.43 $\pm$ 0.16	<0.30	<0.29	448.4 $\pm$ 15.0	85 $\pm$ 28
	-B	July 11	Sediment	0.45 $\pm$ 0.22	<0.27	<0.32	459.2 $\pm$ 8.0	
	-C	July 11	Sediment	0.39 $\pm$ 0.16	<0.30	<0.29	461.7 $\pm$ 10.4	
	-D	July 11	Sediment	0.41 $\pm$ 0.21	<0.28	<0.32	457.7 $\pm$ 7.9	

¹ Result of composite sample made up from 4 replicate samples.

² The total organic carbon content of the Pickering A and Pickering B sediment samples were determined to be 900 ppm and 800 ppm respectively.

³ The $\pm$ value represents twice the standard deviation of one determination.

Comment: Determination based on dry weight.

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Table 3.6.2.2 Pickering Nuclear Site - Area Lake Ontario Fish – 2003

Sample Location	Fish Type (Composites)	Sample Date	Tritium ^{1,2} (TFWT) Bq/L ± 2σ	¹⁴ C ^{1,2} Bq/kg-C ± 2σ	Gamma ² Bq/kg ± 2σ (wet weight)			OBT ³ Bq/L (w.e.) ± 2σ (Composites)	
					¹³⁷ Cs	¹³⁴ Cs	⁴⁰ K		
Pickering 5-8 Outfall	White Sucker	-A	July 3	8.5 ± 2.6	262 ± 20	0.23 ± 0.07	<0.10	153.9 ± 4.5	16.4 ± 2.7
		-B	July 3	7.7 ± 2.6	252 ± 19	0.24 ± 0.08	<0.13	146.5 ± 3.6	
		-C	July 4	11.5 ± 2.8	261 ± 20	0.17 ± 0.05	<0.10	123.9 ± 3.3	
		-D	July 4	12.2 ± 2.8	258 ± 20	0.28 ± 0.08	<0.11	136.1 ± 3.1	
		-E	July 11	11.3 ± 2.8	256 ± 20	0.16 ± 0.05	<0.07	127.4 ± 4.7	
		-F	July 11	16.5 ± 3.1	242 ± 19	0.19 ± 0.08	<0.12	134.0 ± 3.3	
		-G	July 11	12.1 ± 2.9	265 ± 19	0.33 ± 0.09	<0.10	124.0 ± 2.8	
		-H	July 11	11.7 ± 2.8	275 ± 20	0.25 ± 0.06	<0.07	125.3 ± 2.4	
Pickering 5-8 Outfall	Round Whitefish	-A	July 11	18.5 ± 3.1	284 ± 21	0.30 ± 0.07	<0.11	137.9 ± 3.1	31.2 ± 3.0
		-B	July 11	23.6 ± 3.3	262 ± 19	0.21 ± 0.09	<0.15	128.6 ± 5.9	
		-C	July 11	22.6 ± 3.3	276 ± 20	0.42 ± 0.21	<0.33	107.7 ± 6.2	
		-D	July 11	27.6 ± 3.5	270 ± 19	0.27 ± 0.13	<0.21	127.9 ± 4.2	
		-E	Nov 26	21.9 ± 3.2	293 ± 21	0.29 ± 0.12	<0.20	141.8 ± 7.4	
		-F	Nov 26	10.6 ± 2.7	263 ± 19	0.18 ± 0.10	<0.15	134.3 ± 3.8	
		-G	Nov 26	7.9 ± 2.6	270 ± 20	0.16 ± 0.09	<0.15	151.1 ± 5.2	
		-H	Nov 26	8.1 ± 2.6	263 ± 20	0.25 ± 0.16	<0.25	130.0 ± 5.9	

¹ The $\pm$ values represent twice the standard deviation of the mean of two determinations.

² The $\pm$ values represent twice the standard deviation of one determinations.

³ Organically Bound Tritium concentrations were measured in composite samples of each PN site target species.

< Indicates detection limit value at 4.66 σ

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Table 3.6.2.3 Darlington Nuclear Site - Area Beach Sand and Soils – 2003

Location	Sample Type	Gamma Analysis ¹ Bq/kg $\pm$ 2 σ (dry weight)			
		¹³⁷ Cs	¹³⁴ Cs	⁶⁰ Co	⁴⁰ K
F1	Soil (open area – not irrigated)	11.04 $\pm$ 0.41	<0.37	<0.35	638.2 $\pm$ 9.2
F1	Garden Soil (irrigated – shallow well water)	6.37 $\pm$ 0.46	<0.42	<0.46	701.1 $\pm$ 10.8
F16	Soil (open area – not irrigated)	10.72 $\pm$ 0.68	<0.61	<0.74	590.9 $\pm$ 15.6
F16	Garden soil (irrigated – shallow well water)	5.65 $\pm$ 0.51	<0.53	<0.66	541.8 $\pm$ 13.8
R1	Garden Soil (irrigated – deep well water)	4.67 $\pm$ 0.37	<0.32	<0.38	493.1 $\pm$ 8.5
F8	Garden Soil (irrigated – deep well water)	6.19 $\pm$ 0.55	<0.34	<0.36	544.6 $\pm$ 14.8
Provincial Park	Beach Sand	<0.24	<0.22	<0.20	281.6 $\pm$ 4.9

< Indicates detection limit value at 4.66 σ .

Table 3.6.2.4 Pickering Nuclear Site - Area Beach Sand and Soils – 2003

Location	Sample Type	Gamma Analysis ¹ Bq/kg $\pm$ 2 σ (dry weight)			
		¹³⁷ Cs	¹³⁴ Cs	⁶⁰ Co	⁴⁰ K
Squires Beach - Field	Soil (open area – not irrigated)	10.65 $\pm$ 0.40	<0.36	<0.34	770.3 $\pm$ 9.7
R116	Garden Soil (irrigated – shallow well water) ¹¹⁴	11.00 $\pm$ 0.80	<0.75	<0.92	731.9 $\pm$ 19.8
R122	Garden Soil (irrigated – deep well water)	5.13 $\pm$ 0.43	<0.43	<0.45	664.8 $\pm$ 15.0
Beach Point Promenade	Beach Sand	1.30 $\pm$ 0.29	<0.40	<0.49	359.7 $\pm$ 10.5
Squires Beach	Beach Sand	0.58 $\pm$ 0.10	<0.27	<0.29	322.8 $\pm$ 6.4
Liverpool Road Beach	Beach Sand	0.58 $\pm$ 0.15	<0.24	<0.25	239.7 $\pm$ 7.2

< Indicates detection limit value at 4.66 σ .

¹ The $\pm$ value represents twice the standard deviation of one determination.

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Table 3.6.3.1 Provincial Background - Lake Sediment, Beach Sand and Inland Soil – 2003

Location ¹		Sample Type	¹⁴ C ^{2,3} Bq/kg-C ± 2σ	Gamma Analysis ⁴ Bq/kg ± 2σ (dry weight)			
				¹³⁷ Cs	¹³⁴ Cs	⁶⁰ Co	⁴⁰ K
Cobourg	-A	Sediment	135 ± 29	1.70 ± 0.27	<0.25	<0.27	462.4 ± 12.7
Cobourg	-B	Sediment		1.45 ± 0.21	<0.25	<0.20	471.1 ± 10.3
Cobourg	-C	Sediment		1.12 ± 0.15	<0.21	<0.20	441.2 ± 6.3
Cobourg	-D	Sediment		1.65 ± 0.22	<0.24	<0.28	447.6 ± 12.5
Cobourg	-A	Beach Sand	NA	0.62 ± 0.16	<0.21	<0.21	430.3 ± 9.0
	-B	Beach Sand		0.60 ± 0.16	<0.24	<0.28	428.8 ± 12.5
Cobourg	-A	Inland Soil	NA	0.39 ± 0.18	<0.27	<0.30	406.5 ± 6.8
	-B	Inland Soil		0.41 ± 0.18	<0.26	<0.30	387.8 ± 6.7
Marie Curtis Park	-A	Sediment	NA	<0.41	<0.35	<0.46	337.9 ± 10.1
	-B	Sediment		<0.22	<0.21	<0.21	367.3 ± 5.7
	-C	Sediment		<0.25	<0.24	<0.25	376.3 ± 9.0
	-D	Sediment		<0.28	<0.27	<0.30	400.8 ± 7.2
Goderich	-A	Sediment	43 ± 23	<0.25	<0.24	<0.25	206.9 ± 5.2
	-B	Sediment		<0.39	<0.34	<0.39	191.0 ± 7.7
	-C	Sediment		0.20 ± 0.12	<0.19	<0.17	187.3 ± 4.0
	-D	Sediment		<0.40	<0.33	<0.40	185.0 ± 7.6
Goderich	-A	Beach Sand	NA	<0.21	<0.19	<0.18	256.1 ± 6.8
	-B	Beach Sand		0.27 ± 0.15	<0.22	<0.24	223.5 ± 9.1
Lakefield	-A	Inland Soil	NA	6.27 ± 0.66	<0.55	<0.73	673.3 ± 22.5
	-B	Inland Soil		6.88 ± 0.46	<0.40	<0.50	734.3 ± 11.4
Goderich	-A	Inland Soil	NA	0.64 ± 0.22	<0.24	<0.30	259.0 ± 5.8
	-B	Inland Soil		1.73 ± 0.41	<0.45	<0.60	356.8 ± 16.8

NA Not Analyzed

< Indicates detection limit value at 4.66σ

¹ See Figure C4 in Appendix C for locations.

² Result of composite made up of 4 replicate samples.

³ The total organic carbon context of the Cobourg and Goderich composite samples were determined to be 1,100 ppm and 500 ppm respectively.

⁴ The ± values represent twice the standard deviation of one determination.

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Table 3.6.3.2 Provincial Background - Fish - 2003

Sample Location	Fish Type (Composites)	Sample Date	Tritium ¹ (TFWT) Bq/L $\pm 2\sigma^2$	¹⁴ C ¹ Bq/kg-C $\pm 2\sigma^2$	Gamma ² Bq/kg $\pm 2\sigma$ (wet weight)			OBT ³ Bq/L (w.e) $\pm 2\sigma$ (Composites)
					¹³⁷ Cs	¹³⁴ Cs	⁴⁰ K	
Lake Ontario-Far Field ⁴	White Sucker	-A Oct. 15	4.0 $\pm$ 2.3	238 $\pm$ 19	1.26 $\pm$ 0.18	<0.22	168.4 $\pm$ 6.4	26.6 $\pm$ 2.8
		-B Oct. 15	5.4 $\pm$ 2.4	242 $\pm$ 19	0.96 $\pm$ 0.18	<0.20	146.5 $\pm$ 4.8	
		-C Oct. 15	12.5 $\pm$ 2.7	233 $\pm$ 19	1.16 $\pm$ 0.18	<0.22	147.3 $\pm$ 4.8	
		-D Oct. 15	4.2 $\pm$ 2.3	221 $\pm$ 19	1.24 $\pm$ 0.18	<0.22	167.3 $\pm$ 6.6	
		-E Oct. 15	2.4 $\pm$ 2.2	241 $\pm$ 19	1.24 $\pm$ 0.12	<0.16	154.0 $\pm$ 3.7	
		-F Oct. 15	3.5 $\pm$ 2.4	241 $\pm$ 19	0.87 $\pm$ 0.26	<0.34	124.9 $\pm$ 6.8	
		-G Oct. 15	2.8 $\pm$ 2.4	260 $\pm$ 19	0.80 $\pm$ 0.18	<0.24	150.0 $\pm$ 4.9	
		-H Oct. 15	3.5 $\pm$ 2.6	238 $\pm$ 19	1.01 $\pm$ 0.18	<0.22	158.0 $\pm$ 4.9	
	White Fish	-A Oct. 15	4.0 $\pm$ 2.6	250 $\pm$ 19	0.46 $\pm$ 0.21	<0.36	120.9 $\pm$ 6.9	26.2 $\pm$ 2.8
		-B Oct. 15	3.1 $\pm$ 2.4	242 $\pm$ 19	0.71 $\pm$ 0.15	<0.24	163.7 $\pm$ 6.6	
		-C Oct. 15	5.3 $\pm$ 2.7	259 $\pm$ 19	1.67 $\pm$ 0.13	<0.16	169.1 $\pm$ 3.8	
		-D Oct. 15	4.5 $\pm$ 2.6	264 $\pm$ 19	0.66 $\pm$ 0.26	<0.34	132.0 $\pm$ 7.1	
		-E Oct. 15	4.3 $\pm$ 2.6	238 $\pm$ 19	0.79 $\pm$ 0.17	<0.23	148.6 $\pm$ 4.8	
		-F Oct. 15	2.7 $\pm$ 2.4	246 $\pm$ 19	1.03 $\pm$ 0.18	<0.24	161.0 $\pm$ 6.7	
		-G Oct. 15	5.0 $\pm$ 2.5	252 $\pm$ 19	0.56 $\pm$ 0.10	<0.15	163.9 $\pm$ 3.8	
		-H Oct. 15	4.2 $\pm$ 2.3	253 $\pm$ 19	0.50 $\pm$ 0.22	<0.32	133.1 $\pm$ 6.8	

NA Not Analyzed

¹ The $\pm$ values represent twice the standard deviation of the mean of two determinations.
² The $\pm$ values represent twice the standard deviation of one determination.
 Comment: Gamma analysis based on wet weight.
³ Organically Bound Tritium concentrations were measured in composite samples of each target species.
⁴ See Figure C4 in Appendix C for locations.
 <MDA value at 4.66.

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Table 3.6.3.2 Provincial Background - Fish – 2003-Continued

Sample Location	Fish Type (Composites)	Sample Date	Tritium ¹ (TFWT) Bq/L ± 2σ ²	¹⁴ C ¹ Bq/kg-C ± 2σ ²	Gamma ² Bq/kg ± 2σ (wet weight)			OBT ³ Bq/L (w.e) ± 2σ (Composites)	
					¹³⁷ Cs	¹³⁴ Cs	⁴⁰ K		
Lake Huron-Far Field ⁴	White Sucker	-A	Sept. 03	7.3 ± 2.4	226 ± 26	0.26 ± 0.06	<0.12	100.7 ± 3.3	4.4 ± 3.2
		-B	Sept. 03	8.5 ± 2.4	366 ± 31	0.29 ± 0.06	<0.11	96.9 ± 3.2	
		-C	Sept. 03	6.7 ± 2.3	211 ± 27	0.30 ± 0.08	<0.17	119.8 ± 4.2	
		-D	Sept. 03	5.3 ± 2.3	220 ± 27	0.36 ± 0.07	<0.13	111.9 ± 3.6	
		-E	Sept. 03	9.5 ± 2.5	224 ± 27	0.25 ± 0.07	<0.14	96.7 ± 3.3	
		-F	Sept. 03	6.0 ± 2.3	228 ± 27	0.15 ± 0.06	<0.14	110.3 ± 3.6	
		-G	Sept. 03	6.2 ± 2.3	222 ± 27	0.35 ± 0.09	<0.16	110.6 ± 3.8	
		-H	Sept. 03	7.5 ± 2.4	215 ± 27	0.46 ± 0.07	<0.14	108.1 ± 3.6	
	Lake Whitefish	-A	Nov. 01	4.0 ± 2.1	266 ± 28	1.07 ± 0.11	<0.19	131.2 ± 4.7	7.4 ± 3.3
		-B	Nov. 01	4.3 ± 2.1	260 ± 28	0.48 ± 0.09	<0.18	130.7 ± 4.7	
		-C	Nov. 01	3.4 ± 1.8	251 ± 29	0.68 ± 0.08	<0.15	126.0 ± 4.1	
		-D	Nov. 01	3.6 ± 2.1	259 ± 28	0.41 ± 0.08	<0.16	121.5 ± 4.1	
		-E	Nov. 01	4.3 ± 2.1	261 ± 28	0.64 ± 0.09	<0.17	134.2 ± 4.7	
		-F	Nov. 01	4.3 ± 2.1	237 ± 27	0.69 ± 0.11	<0.17	129.2 ± 4.6	
		-G	Nov. 01	3.8 ± 2.1	263 ± 29	1.14 ± 0.09	<0.15	121.7 ± 4.0	
		-H	Nov. 01	4.3 ± 2.1	256 ± 28	0.78 ± 0.11	<0.17	128.6 ± 4.4	

¹ The $\pm$ values represent twice the standard deviation of the mean of two determinations.

² The $\pm$ values represent twice the standard deviation of one determination.

Comment: Gamma analysis based on wet weight.

³ Organically Bound Tritium concentrations were measured in composite samples of each target species <MDA value at 4.66.

⁴ See Figure C4 in Appendix C for locations.

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Table 3.6.3.3 Lake Ontario Water – ¹⁴C Specific Activity

Location		Sample Date	¹⁴ C ^{1,2} (Bq/kg – C ± 2σ)
PN-B Outfall	-1	November 21	269 ± 20
	-2	November 21	264 ± 20
	-3	November 21	264 ± 20
	-4	November 21	303 ± 25
DN Diffuser	-1	November 21	196 ± 23
	-2	November 21	208 ± 21
	-3	November 21	198 ± 36
	-4	November 21	No Sample
Cobourg	-1	November 21	260 ± 20
	-2	November 21	254 ± 21
	-3	November 21	266 ± 21
	-4	November 21	240 ± 21

¹ The ± values represent twice the standard deviation of 1 determination.

² Forty litre lake water samples collected for ¹⁴C analysis was introduced in 2002. The data to be used in a three year study to better understand the bioaccumulation of ¹⁴C in fish. Carbon-14 specific activity levels at the PN-B outfall are about 8 percent higher than at the Cobourg background location. The ¹⁴C levels in lake water at the DN diffuser are lower than expected relative to normal background levels seen at the Cobourg background location.

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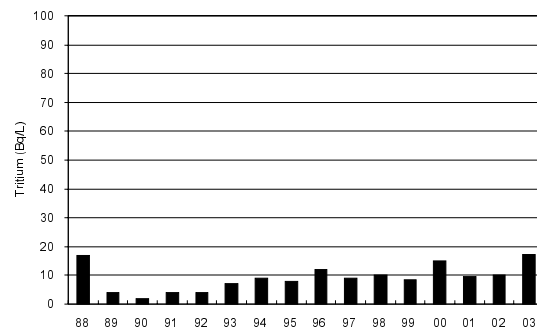


Figure 3.6.1 Darlington Nuclear Site - Tritium-in-Fish Trends

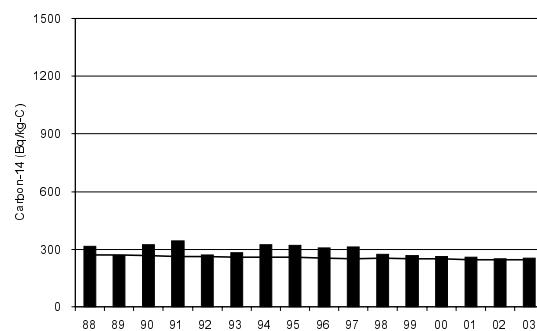


Figure 3.6.2 Darlington Nuclear Site - ¹⁴C-in-Fish and Background Trends¹

Pickering Nuclear¹

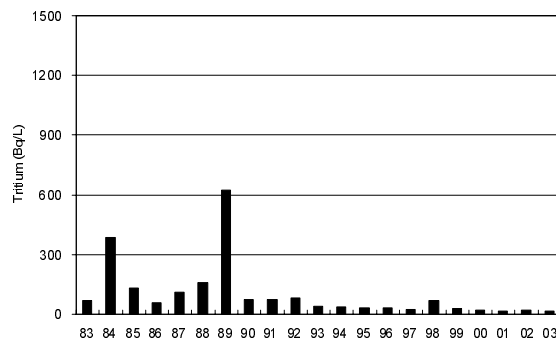


Figure 3.6.3 Pickering Nuclear Site - Tritium-in-Fish Trends

¹ Background ¹⁴C concentrations in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ¹⁴C bar charts above.

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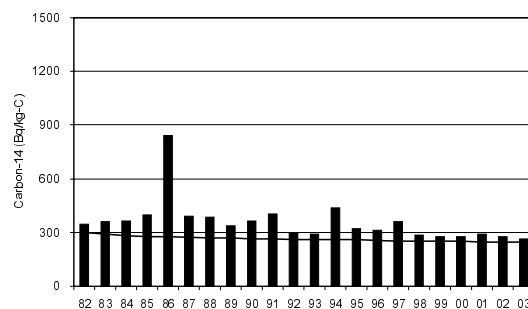


Figure 3.6.4 Pickering Nuclear Site - ^{14}C -in-Fish and Background Trends¹

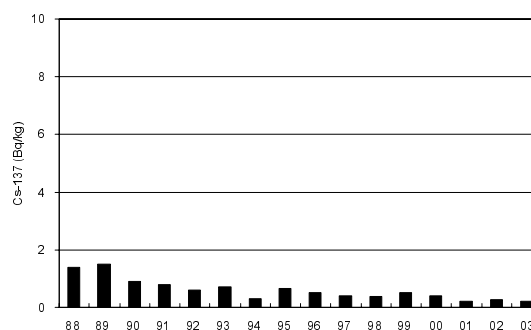


Figure 3.6.5 Darlington Nuclear Site - ^{137}Cs -in-Fish Trends

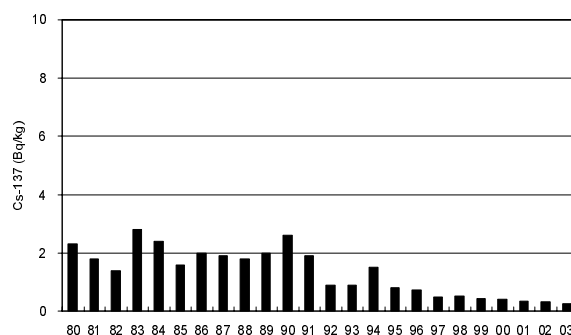


Figure 3.6.6 Pickering Nuclear Site - ^{137}Cs -in-Fish Trends

¹ Background ^{14}C concentrations in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ^{14}C bar charts above.

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Discussion of Aquatic Sampling

Sediment

The major portion of the activity in sediment, in the vicinity of the stations, is due to the naturally occurring radionuclide ^{40}K . Cesium-137 is a product of both nuclear weapon tests and reactor operations and was detected in all site sediment samples at the DN and PN sites with the exception at the Darlington diffuser location (not detected). Cesium-134 and ^{60}Co (which are solely reactor produced) were not detected in any of the sediment samples at both the DN and PN sites in 2003 with one exception at the Darlington diffuser where ^{60}Co was detected slightly above the detection limit. See Tables 3.6.1.1 and 3.6.2.1.

Carbon-14 is a product of both nuclear weapon tests, reactor operations and is produced naturally in the upper atmosphere. Any values observed above 245 Bq/kg-C would indicate the presence of ^{14}C from reactor operations. All values measured for ^{14}C in lake bottom sediments were well below this level in 2003. A number of the results were significantly below 245 Bq/kg-C indicating the presence of low activity inorganic carbon diluting the sample.

Beach Sand/Silt and Soil Samples

Background inland soil and beach sand samples were collected at Lakefield, Cobourg and Goderich to determine the ^{137}Cs concentration in Ontario soils due to atmospheric weapon test fallout. The ^{137}Cs concentrations measured in inland soils ranged from 0.4 to 6.3 Bq/kg, and ranged from 0.2 Bq/kg to 0.6 Bq/kg in beach sand. See Table 3.6.3.1.

The large difference between these two background readings is due to soil type (clay type materials retain more ^{137}Cs than sandy materials) as well as wave action which is continually moving the cesium around and not allowing it to sit undisturbed as originally deposited from the atmosphere.

This range of values, for the reasons just mentioned, make it difficult to determine if ^{137}Cs measured along the shoreline is from OPG operations unless the values measured are significantly higher than background values or other radionuclides such as ^{60}Co or ^{134}Cs are present.

The average ^{137}Cs concentration measured at the three DN site beach and PN site beaches was <0.2 Bq/Kg and 0.8 Bq/kg respectively. This was similar to the background concentrations measured at Cobourg, Ontario of 0.6 Bq/kg. There was no ^{60}Co or ^{134}Cs detected in any of the DN and PN beach sand samples.

Two samples of garden soil as well as an open field sample were obtained from the Squires Beach area east of the PN site. Four samples of garden soils and two open field samples were obtained at local farms and residents close to the DN site. Cesium-137 values ranged from 4.7 to 11.0 Bq/kg in these samples which are higher

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than the range of values seen at the background locations in 2003 but within the range of values seen at the background locations over the last 2 years. See Tables 3.6.2.3, 3.6.2.4, and 3.6.3.1.

It is therefore suspected the ^{137}Cs measured in these garden samples is weapon based and not from OPG operations. Neither ^{134}Cs nor ^{60}Co were detected in either sites soil samples in 2003.

Fish

The major portion of the activity in fish is naturally occurring ^{40}K and ^{14}C . A small amount of ^{137}Cs is usually present due primarily to nuclear weapon testing and to a lesser extent from reactor operation. Cesium-134 and ^{60}Co , which are indicative of reactor operation, were not detected in any fish samples at the DN and PN sites in 2003.

Cesium-137 (above the detection limit) was found in about half the DN area fish samples in 2003. However, values on average were lower than results obtained from the Lake Ontario background locations. Carbon-14 levels in DN fish appeared to be slightly above those in background location samples on average in 2003 (253 Bq/kg-C versus 245 Bq/kg-C). Tritium levels in fish ranged from an average of 5 Bq/L in White Suckers to 30 Bq/L in White Fish.

Long-term levels of radionuclides in fish are increasing for tritium, unchanged to decreasing for ^{14}C and decreasing for ^{137}Cs at DN. The tritium levels in fish change quickly from day to day with changing water tritium levels. Thus, tritium concentrations measured in fish tissue reflect the tritium concentration in the water on the day when they were sampled each year. See Figures 3.6.1, 3.6.2, and 3.6.5 respectively.

Cesium-137 was found above the detection limit in all PN area fish, but at lower levels than the results obtained at the Lake Ontario background locations. Carbon-14, on average, was higher than the Lake Ontario background samples (266 Bq/kg-C versus 245 Bq/kg-C). Tritium levels in fish decreased slightly on average from 20 Bq/L in 2002 to 17 Bq/L in 2003.

Long-term levels of radionuclides in fish at PN are decreasing with time for tritium, ^{14}C , and ^{137}Cs . There are some fluctuations from year to year. See Figures 3.6.3, 3.6.4, and 3.6.6.

OBT measurements were performed on composite samples of each DN and PN site target species. The OBT/TFWT ratio's obtained were 5.0 and 1.0 for the White Sucker and White Fish composite sample respectively at the DN site and 1.4 and 1.8 respectively at the PN site. With the exception of the DN site White Sucker, the ratio's obtained are not substantially different from those obtained by AECL on a wide variety of food stuffs at background locations (see discussion in Section 3.4). The OBT/TFWT ratio is not as meaningful for outfall fish samples as it is for milk and vegetable

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samples, due to the quickly changing TFWT levels in fish from day to day with changing water tritium levels, in lake water near the nuclear sites.

The OBT/TFWT ratio seen in the provincial background fish in Lake Ontario was 6.0 in 2003. A ratio close to unity is expected at background locations where the concentration of TFWT is expected to be fairly uniform. High ratio's were also seen in Provincial background vegetable samples. See discussion of Terrestrial Sampling in Section 3.7. Conversely, the OBT/TFWT ratio seen in the Lake Huron background fish samples was 1.2 as analyzed by the Bruce Power Health Physics Laboratory. See Table 3.6.3.2. OPG will continue to perform OBT measurements on fish samples at the PN site and background locations and will consult with Bruce Power to understand and refine the analytical method to address the high variability seen in the OPG background samples.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**3.7 Terrestrial Sampling**

Samples of terrestrial biota representative of the 2003 growing season were taken from the vicinity of the DN and PN sites. Actual sample locations and the wind sectors in which they were taken at each nuclear site are shown in Appendix C (Figures C2 and C3). Analyses were carried out for tissue-free water tritium and ^{14}C . Where multiple sample types are found (i.e., 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. Honey sampling for gamma-emitters has, therefore, been included in the environmental radiological program for these sites. Nectar is gathered by honey bees over a wide area and is a useful indicator of airborne particulate emissions.

Trend plots of annual average tritium and ^{14}C in vegetation at both nuclear sites are presented in Figures 3.7.1 through 3.7.4. It should be noted that the number of samples and their locations have changed throughout the trend period.

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Table 3.7.1 Darlington Nuclear Site - Area Terrestrial Biota - 2003

Location ¹	Sample Type (Composite)	Tritium (TFWT) ² Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	Gamma ³ Bq/L $\pm 2\sigma$
R2	Chestnut	32.7 $\pm$ 3.7	262 $\pm$ 20	NA
R85	Grape	32.0 $\pm$ 3.8	267 $\pm$ 20	NA
F1	Chestnut, Crab Apple	64.0 $\pm$ 4.9	278 $\pm$ 20	NA
R122	Pear	17.2 $\pm$ 3.2	242 $\pm$ 20	NA
R17	Crab Apple	21.6 $\pm$ 3.3	279 $\pm$ 20	NA
R24	Pear	17.2 $\pm$ 3.2	274 $\pm$ 20	NA
DF3	Crab Apple	14.4 $\pm$ 3.0	230 $\pm$ 19	NA
R27	Apple, Grape, Pear	25.0 $\pm$ 3.5	283 $\pm$ 20	NA
R1	Crab Apple	10.7 $\pm$ 2.8	222 $\pm$ 18	NA
R39	Apple, Pear	19.4 $\pm$ 3.3	250 $\pm$ 20	NA
F18	Apple	8.5 $\pm$ 2.7	242 $\pm$ 19	NA
R47	Apple	27.2 $\pm$ 3.6	256 $\pm$ 19	NA
R63	Crab Apple	12.6 $\pm$ 2.9	244 $\pm$ 19	NA
DF7	Apple	8.7 $\pm$ 2.7	227 $\pm$ 18	NA
R65	Red Berry, Crab Apple	41.1 $\pm$ 4.1	291 $\pm$ 19	NA
R228	Grape	26.3 $\pm$ 3.5	252 $\pm$ 19	NA
F26	Pear, Crab Apple	13.1 $\pm$ 2.9	245 $\pm$ 19	NA
R275	Apple	31.9 $\pm$ 3.8	254 $\pm$ 19	NA
DF9	Crab Apple	14.8 $\pm$ 3.0	235 $\pm$ 19	NA
R2	Tomato, Cucumber, Potato, Carrot, Cabbage	30.5 $\pm$ 3.5	262 $\pm$ 20	NA

¹ See map C2 in Appendix C for locations.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ The $\pm$ values represent twice the standard deviation of one determination.

MDA value at 4.66 σ .

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Table 3.7.1 Darlington Nuclear Site - Area Terrestrial Biota – 2003 (Continued)

Location ¹	Sample Type (Composite)	Tritium (TFWT) ² Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	Gamma ³ Bq/L $\pm 2\sigma$
R77	Tomato, Cucumber, Zucchini, Carrot, Potato, Beet, Beet Leaves, Parsley, Chives	17.3 $\pm$ 3.0	241 $\pm$ 19	NA
F1	Tomato, Green Pepper, Bean, Cucumber, Onion, Beet, Beet Leaf	46.2 $\pm$ 4.1	365 $\pm$ 21	NA
R130	Tomato, Cucumber, Parsley	16.3 $\pm$ 3.0	247 $\pm$ 20	NA
F8	Tomato, Cucumber, Zucchini, Onion, Carrot, Cabbage	14.8 $\pm$ 2.9	279 $\pm$ 20	NA
R141	Tomato, Cucumber, Swiss Chard	14.3 $\pm$ 2.8	260 $\pm$ 19	NA
DF2	Tomato, Cucumber, Zucchini, Potato, Carrot, Beet, Cabbage, Swiss Chard, Beet Leaf	0.2 $\pm$ 2.6	231 $\pm$ 18	NA
F13	Tomato, Pepper, Egg Plant, Swiss Chard	9.3 $\pm$ 2.8	230 $\pm$ 18	NA
F16	Tomato, Cucumber, Zucchini, Bean, Beet, Carrot, Potato, Swiss Chard, Lettuce, Cabbage, Beet Leaf	13.4 $\pm$ 3.0	231 $\pm$ 19	NA
DF6	Tomato, Pepper, Squash, Carrot, Potato, Onion, Carrot Leaf, Lettuce	6.7 $\pm$ 2.6	251 $\pm$ 20	NA
R47	Tomato, Zucchini, Squash, Potato, Rhubarb and Leaf	18.9 $\pm$ 3.3	272 $\pm$ 20	NA
DF7	Apple, Potato, Kale	7.0 $\pm$ 2.7	242 $\pm$ 20	NA
R66	Tomato, Cucumber, Squash, Zucchini, Onion, Carrot, Brussel Sprout and Leaf	14.4 $\pm$ 3.1	287 $\pm$ 21	NA
R228	Tomato, Cucumber, Squash, Onion, Potato, Cabbage Leaf	11.8 $\pm$ 3.0	263 $\pm$ 20	NA
F25	Tomato, Cucumber, Squash	12.1 $\pm$ 3.0	244 $\pm$ 19	NA
R275	Tomato, Cucumber, Onion, Carrot, Lettuce, Ragano	19.4 $\pm$ 3.3	259.0 $\pm$ 19	NA

¹ See map C2 in Appendix C for locations.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ The $\pm$ values represent twice the standard deviation of one determination.

MDA value at 4.66 σ .

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Table 3.7.1 Darlington Nuclear Site - Area Terrestrial Biota – 2003 (Continued)

Location ¹	Sample Type (Composite)	Tritium (TFWT) ² Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	Gamma ³ Bq/L $\pm 2\sigma$
R328	Honey	46.1 $\pm$ 6.4	250 $\pm$ 19	¹³⁷ Cs:<0.1 ¹³⁴ Cs:<0.1 ⁴⁰ K:24.4 $\pm$ 2.0
R327	Honey	39.3 $\pm$ 6.1	251 $\pm$ 19	¹³⁷ Cs:<0.1 ¹³⁴ Cs:<0.1 ⁴⁰ K:23.2 $\pm$ 1.5
R32	Honey	45.5 $\pm$ 6.4	265 $\pm$ 20	¹³⁷ Cs:<0.1 ¹³⁴ Cs:<0.1 ⁴⁰ K:8.7 $\pm$ 0.8
F27	Honey	66.7 $\pm$ 5.0	238 $\pm$ 19	¹³⁷ Cs:<0.1 ¹³⁴ Cs:<0.1 ⁴⁰ K:22.4 $\pm$ 1.5
R326	Honey	37.8 $\pm$ 4.1	280 $\pm$ 20	¹³⁷ Cs:<0.1 ¹³⁴ Cs:<0.1 ⁴⁰ K:20.7 $\pm$ 1.4
DF3	Silage	9.3 $\pm$ 2.6	255 $\pm$ 20	NA
DF5	Hay	36.5 $\pm$ 3.9	267 $\pm$ 20	NA
DF7	Silage	8.8 $\pm$ 2.6	225 $\pm$ 19	NA
DF8	Silage	8.9 $\pm$ 2.6	275 $\pm$ 21	NA
DF9	Corn	18.2 $\pm$ 3.1	256 $\pm$ 20	NA

NA Not Analysed

¹ See map C2 in Appendix C for locations.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ The $\pm$ values represent twice the standard deviation of one determination.

MDA value at 4.66 σ .

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Table 3.7.2 Pickering Nuclear Site - Area Terrestrial Biota - 2003

Location Number ¹	Sample Type (Composite)	Tritium (TFWT) ^{2,3} Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	OBT ⁴ Bq/L (w.e.) $\pm 2\sigma$
7	Apple	99.0 $\pm$ 5.6	320 $\pm$ 21	NA
10	Apple	141.2 $\pm$ 6.5	371 $\pm$ 22	NA
12	Apple	55.7 $\pm$ 4.4	257 $\pm$ 19	NA
22	Apple/Berry	134.4 $\pm$ 6.4	383 $\pm$ 23	169.4 $\pm$ 5.6
29 ⁵	Crab Apple	1197.0 $\pm$ 18.1	1166 $\pm$ 35	NA
32	Apple	160.4 $\pm$ 6.9	325 $\pm$ 21	NA
F10	Apple	28.3 $\pm$ 3.5	248 $\pm$ 19	42.8 $\pm$ 3.3
F18	Apple	27.2 $\pm$ 3.5	269 $\pm$ 20	NA
F31	Apple	32.1 $\pm$ 3.6	236 $\pm$ 19	NA
R120	Apple	231.0 $\pm$ 8.2	302 $\pm$ 21	205.3 $\pm$ 6.1
R152	Apple	108.4 $\pm$ 5.8	250 $\pm$ 19	NA
Indicator Site 2	Onion, Carrots, Cabbage, Zucchini, Tomato, Cucumber, Potato, Zucchini	598.3 $\pm$ 13.6	843 $\pm$ 30	NA
Indicator Site 9	Cabbage, Cucumber, Zucchini, Carrot, Lettuce, Cabbage	129.6 $\pm$ 6.6	254 $\pm$ 20	NA

NA – Not Analyzed

¹ These locations are shown on map C3 in Appendix C.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ TFWT represents Tissue Free Water Tritium or tritium oxide (HTO)

⁴ OBT represents Organically Bound Tritium. The units of OBT can be expressed as Bq/L (water equivalent) or Bq/kg-Hydrogen. Bq/L (w.e.) is more easily understood and represents the OBT concentration expressed in water equivalent units to allow a direct comparison to TFWT values. 1Bq/L (w.e.) is equivalent to 9 Bq/kg-hydrogen.

⁵ Site 29 values (previously Site 6 in 1992 assessment) excluded from the calculation of the average, as it is considered on-site. The apple tree which was previously sampled at this location was damaged in a storm 1996 and had to be removed.

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Table 3.7.2 Pickering Nuclear Site - Area Terrestrial Biota – 2003 (Continued)

Location Number ¹	Sample Type (Composite)	Tritium (TFWT) ^{2,3} Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	OBT ⁴ Bq/L (w.e.) $\pm 2\sigma$
Indicator Site 11	Carrot, Beet, Cabbage, Tomato, Cucumber, Zucchini	123.0 $\pm$ 6.4	354 $\pm$ 22	NA
DF1	Tomato, Bean, Squash, Carrot Potato, Beet, Onion, Swiss Chard, Cabbage	16.6 $\pm$ 3.0	258 $\pm$ 20	NA
DF8	Rhubarb, Tomato, Pepper, Cucumber, Squash, Beet, Onion, Horse Radish, Parsley, Rhubarb Leaf	36.0 $\pm$ 3.9	247 $\pm$ 19	NA
DF8	Silage (Alfalfa, Corn)	58.3 $\pm$ 4.7	259 $\pm$ 20	
F13	Squash, Zucchini, Corn, Onion, Cabbage, Onion, Pepper, Tomato, Egg Plant	20.7 $\pm$ 3.2	248 $\pm$ 19	
16	Tomato, Pumpkin, Pepper, Raspberry, Beet and Leaf	22.0 $\pm$ 3.3	284 $\pm$ 20	31.0 $\pm$ 3.0
F25	Zucchini, Squash, Onion, Tomato, Cucumber, Potato, Bean, Pepper, Beet	24.4 $\pm$ 3.4	275 $\pm$ 20	43.6 $\pm$ 3.3
F31	Cucumber, Tomato, Potato, Beet, Beet Leaf	29.4 $\pm$ 3.6	250 $\pm$ 20	NA

NA Not Analyzed

¹ These locations are shown on map C3 in Appendix C.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ TFWT represents Tissue Free Water Tritium or tritium oxide (HTO)

⁴ OBT represents Organically Bound Tritium. The units of OBT can be expressed as Bq/L (water equivalent) or Bq/kg-Hydrogen. Bq/L (w.e.) is more easily understood and represents the OBT concentration expressed in water equivalent units to allow a direct comparison to TFWT values. 1Bq/L (w.e.) is equivalent to 9 Bq/kg-hydrogen.

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Table 3.7.2 Pickering Nuclear Site - Area Terrestrial Biota – 2003 (Continued)

Location Number ¹	Sample Type (Composite)	Tritium (TFWT) ^{2,3} Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	OBT ⁴ Bq/L (w.e.) $\pm 2\sigma$	Gamma ⁵ Bq/L $\pm 2\sigma$
F36	Tomato, Eggplant, Bean, Pepper, Zucchini, Cucumber, Potato, Lettuce, Cauliflower Leaf, Cabbage	17.3 $\pm$ 3.0	251 $\pm$ 19	NA	
R84	Swiss Chard, Mint, Cabbage, Cucumber, Cherry Tomato, Potato, Beet, Carrot	58.5 $\pm$ 4.7	282 $\pm$ 20	NA	
R69	Tomato	13.3 $\pm$ 2.8	235 $\pm$ 19	NA	
R81	Tomato, Parsley	50.1 $\pm$ 4.4	276 $\pm$ 20	NA	
R109	Tomato, Grape, Rhubarb, Potato, Carrot	65.4 $\pm$ 4.9	265 $\pm$ 20	NA	
R153	Tomato, Pepper, Onion Leaf,	75.1 $\pm$ 5.2	247 $\pm$ 19	NA	
R120	Squash, Tomato, Zucchini, Pepper, Cauliflower Leaf,	155.3 $\pm$ 7.1	284 $\pm$ 20	148.9 $\pm$ 10.9	
R144	Carrot, Tomato, Plum, Kohl Rabi, Artichoke, Turnip and Leaf, Swiss Chard, Onion, Zucchini, Cucumber, Bean, Pepper	180.9 $\pm$ 7.7	347 $\pm$ 22	NA	
NNE Wind Sector	Honey	48.6 $\pm$ 4.5	250 $\pm$ 20	NA	¹³⁴ Cs: <0.1 ¹³⁷ Cs: <0.1, ⁴⁰ K: 72.8 $\pm$ 3.7
WNW Wind Sector	Honey	72.1 $\pm$ 5.2	259 $\pm$ 20	54.3 $\pm$ 3.6	⁴⁰ K: 23.6 $\pm$ 1.8
NE Wind Sector	Honey	84.9 $\pm$ 5.5	254 $\pm$ 19	NA	⁴⁰ K: 10.6 $\pm$ 1.2

¹ These locations are shown on map C3 in Appendix C.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ TFWT represents Tissue Free Water Tritium or tritium oxide (HTO)

⁴ OBT represents Organically Bound Tritium. The units of OBT can be expressed as Bq/L (water equivalent) or Bq/kg-Hydrogen. Bq/L (w.e.) is more easily understood and represents the OBT concentration expressed in water equivalent units to allow a direct comparison to TFWT values. 1 Bq/L (w.e.) is equivalent to 9 Bq/kg-hydrogen.

⁵ The $\pm$ values represent twice the standard deviation of one determination.

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Table 3.7.3 Provincial Background - Terrestrial Biota – 2003

Location Number ¹	Sample Type (Composite)	Tritium (TFWT) ^{2,3} Bq/L $\pm 2\sigma$	¹⁴ C ² Bq/kg-C $\pm 2\sigma$	OBT ⁴ Bq/L (w.e.) $\pm 2\sigma$
Lakefield	Tomato	1.3 $\pm$ 2.4	226 $\pm$ 19	19.1 $\pm$ 2.8
Lakefield	Potato	3.5 $\pm$ 2.5	223 $\pm$ 19	17.0 $\pm$ 2.7
Bancroft	Cucumber, Tomato, Bean, Corn, Pepper	2.5 $\pm$ 2.5	213 $\pm$ 18	19.1 $\pm$ 2.8
Bancroft	Onion, Potato, Carrot, Beet	5.1 $\pm$ 2.6	210 $\pm$ 18	20.3 $\pm$ 2.8
Bancroft	Cauliflower, Cabbage	4.1 $\pm$ 2.6	235 $\pm$ 19	31.2 $\pm$ 3.1
Sarnia	Pepper, Tomato, Squash, Pumpkin	2.1 $\pm$ 2.4	228 $\pm$ 19	31.6 $\pm$ 3.0
Sarnia	Beet, Onion, Potato	1.0 $\pm$ 2.4	249 $\pm$ 20	21.8 $\pm$ 2.7
Sarnia	Cabbage	1.3 $\pm$ 2.4	240 $\pm$ 20	35.0 $\pm$ 3.1
Barrie	Beet Leaf, Rhubarb	3.5 $\pm$ 2.5	265 $\pm$ 22	39.0 $\pm$ 3.2
Barrie	Pears	5.0 $\pm$ 2.6	247 $\pm$ 20	24.9 $\pm$ 2.8
Barrie	Beet, Onion	1.6 $\pm$ 2.4	242 $\pm$ 20	34.4 $\pm$ 3.1
Picton	Pepper, Potato, Cucumber, Bean, Tomato	0.2 $\pm$ 2.3	251 $\pm$ 20	28.1 $\pm$ 2.9
Picton	Onion	3.0 $\pm$ 2.4	224 $\pm$ 19	30.9 $\pm$ 3.0
Picton	Cabbage, Broccoli	0.9 $\pm$ 2.4	241 $\pm$ 20	36.3 $\pm$ 3.2

NA – Not Analyzed

¹ These locations are shown on map C4 in Appendix C.

² The $\pm$ values represent twice the standard deviation of the mean of two determinations.

³ TFWT represents Tissue Free Water Tritium or tritium oxide (HTO)

⁴ OBT represents Organically Bound Tritium. The units of OBT can be expressed as Bq/L (water equivalent) or Bq/kg-Hydrogen. Bq/L (w.e.) is more easily understood and represents the OBT concentration expressed in water equivalent units to allow a direct comparison to TFWT values. 1Bq/L (w.e.) is equivalent to 9 Bq/kg-hydrogen.

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Tritium and ¹⁴C Concentrations in Vegetation

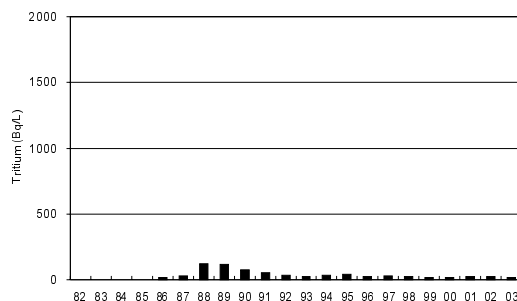


Figure 3.7.1 Darlington Nuclear Site Tritium-in-Vegetation Trends¹

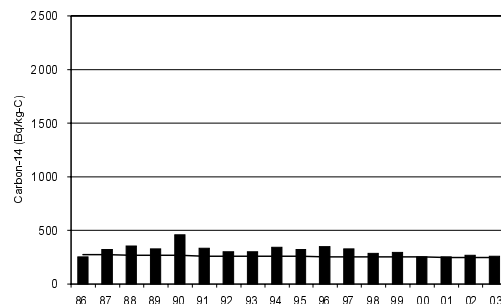


Figure 3.7.2 Darlington Nuclear Site ¹⁴C-in-Vegetation and Background Trends¹

¹ Background ¹⁴C in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ¹⁴C bar charts above. Year 2003 results were not available at the time of publishing this report due to equipment problems. The 2003 samples were collected and the analytical results will be published in the 2003 assessment.

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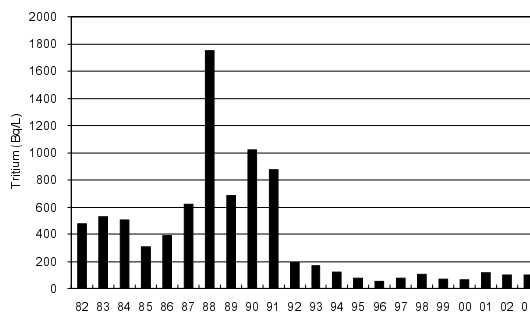


Figure 3.7.3 Pickering Nuclear Site Tritium-in-Vegetation Trends

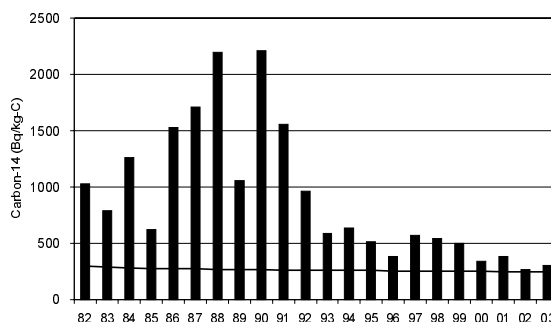


Figure 3.7.4 Pickering Nuclear Site ¹⁴C-in-Vegetation and Background Trends¹

¹ Background ¹⁴C concentrations in the province of Ontario as measured in maple leaves in the Ottawa Region by the Geological Survey of Canada are shown as a line plot on the ¹⁴C bar charts above.

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FOR 2003**Discussion of Terrestrial Sampling**

Experience has shown negligible variability in tritium and ^{14}C uptake in different species of plants from the same location. For dosimetry purposes, nonedible biota may be used as indicators of potential concentrations in locally grown food. [R-31]

Natural ^{14}C concentrations in plants are currently about 245 Bq per kilogram carbon, the same as the natural concentration in atmospheric carbon dioxide involved in photosynthetic processes. Any concentrations significantly in excess of these values are likely due to reactor operation. Carbon-14 background concentrations are currently falling around the world as weapon test ^{14}C is being removed naturally from the environment. Pre-atmospheric weapon test levels were measured at 226 Bq/kg-C. [R-32]

Figure 3.7.5 shows the historic ^{14}C concentrations measured in tree rings and maple leaves obtained from the following locations across Canada.

- (a) Whiteshell Park, Manitoba – White Pine Tree
- (b) Lambton, Ontario – Black Oak Tree
- (c) Kingston, Ontario – Oak Tree
- (d) Fredericton, New Brunswick – Poplar Tree
- (e) Ottawa, Ontario – Maple Leaves (shown as a solid line in Figure 3.7.5)

Samples (a) through (d) were analyzed by AECL-CRL in Chalk River as part of a CANDU Owners Group project. [R-33] The maple leaf samples are collected and analyzed each year by the Geological Survey of Canada. [R-34] [R-35] OPG started funding the work of the Geological Survey of Canada in 1998 to enable them to continue.

The maple leaf data will be used by OPG to determine the background ^{14}C concentration suitable for use each year in determining ^{14}C public doses. The maple leaf data obtained in 2003 averaged 245.7 Bq/kg-C. Since 2001, OPG has used a conservative value of 245 Bq/kg-C as a background subtract value in calculating public dose for ^{14}C ingestion and inhalation pathways. Starting with the 2003 dose assessment this background value will be lowered to 240 Bq/kg-C. This will maintain a small conservatism in the dose calculation recognizing the downward trending background ^{14}C levels in the environment. See Figure 3.7.5 for the historic trend downward in ^{14}C concentrations in maple leaves and tree rings.

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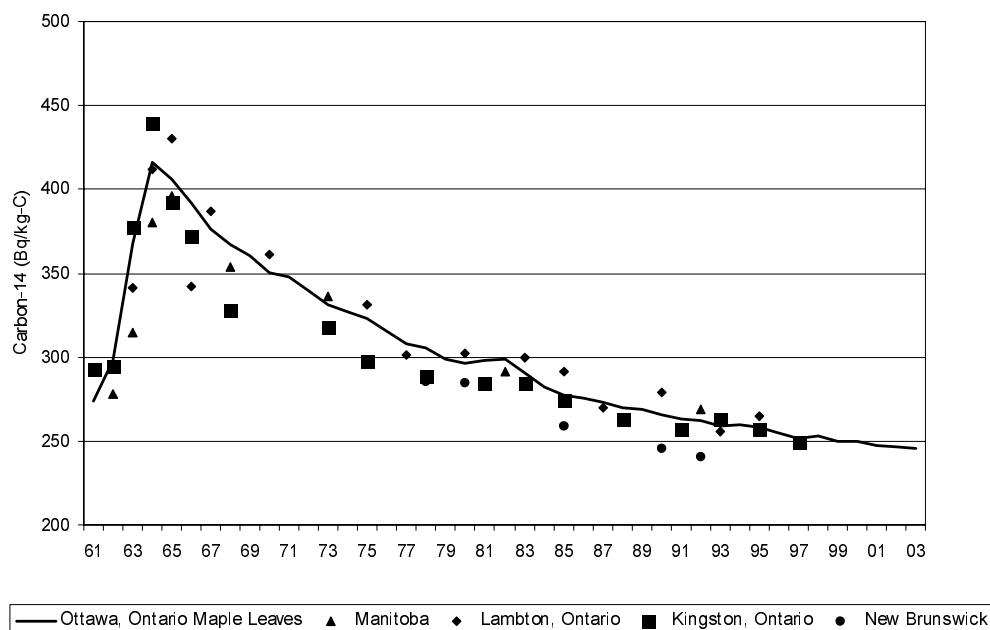


Figure 3.7.5 Historical Background ^{14}C Concentrations in Canada as Measured in Tree Rings and Maple Leaves

Darlington Nuclear Area

The average concentration of tritium in DN terrestrial biota has decreased slightly from 23 Bq/L in 2002 to 20 Bq/L in 2003. Figure 3.7.1 indicates the long-term trend of tritium in vegetation is decreasing with time.

The average concentration of ^{14}C in local fruit and vegetables has decreased slightly from 264 Bq/kg-C in 2002 to 260 Bq/kg-C in 2003. Figure 3.7.2 indicates the long-term trend of ^{14}C in vegetation is neither increasing nor decreasing with time, however current concentrations since 2000 are nearing background levels.

Pickering Nuclear Area

The terrestrial sampling program for the PN area includes samples from local fruit and vegetable producers, as well as OPG-managed garden plots near the Site 2, Site 6, and Petticoke Creek Conservation Area environmental air monitoring stations (Indicator Sites 2, 6, and 9 respectively in Table 3.7.2).

Concentrations of tritium in PN terrestrial biota decreased slightly from 101 Bq/L in 2002 to 97 Bq/L in 2003. Figure 3.7.3 indicates the long-term trend of tritium in vegetation has decreased significantly to 1994 and has remained relatively flat to the present with some fluctuation from year to year.

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The concentration of ^{14}C in local fruit and vegetables increased on average from 269 Bq/kg-C in 2002 to 300 Bq/kg-C in 2003. This is consistent with a 90 percent increase in ^{14}C to air emissions on average in 2003 off set by increased atmospheric dilution due to wind dispersion. Figure 3.7.4 indicates the long-term trend in ^{14}C concentrations in fruits and vegetables peaked in 1988 to 1990 and has been decreasing to the present time, with some fluctuation from year to year.

Provincial Background

New sample locations were established in 2001 for the Provincial background radiological environmental monitoring program. **[R-8]** The results are given in Table 3.7.3. The average tritium oxide concentration measured in all samples was 2.5 Bq/L. The average ^{14}C concentration measured in the same samples was 235 Bq/kg-C. See Figure C4 in Appendix C for sample locations.

Organically Bound Tritium (OBT) Measurements

OBT concentrations have been measured in selected samples of fruits and vegetables at the PN site since 2001. OBT measurements were also performed on selected fruit and vegetable samples gathered from around the Province of Ontario well away from nuclear sources. The results are shown in Tables 3.7.2 and 3.7.3 and are summarized as follows:

- (a) The average OBT/TFWT ratio obtained for the 2003 terrestrial samples collected at background locations was 14.6 ± 10.1 . AECL-CRL performed a similar study in 1997 and obtained a ratio of 0.91 ± 0.37 . **[R-36]**
- (b) The average OBT/TFWT ratio obtained for the 2003 terrestrial samples collected at PN site locations was 1.1 ± 0.3 . AECL-CRL performed a similar study in 1997 and obtained a ratio of 0.97 ± 0.29 . **[R-36]**

The average results of both the 2003 and 1997 studies overlap the OBT/TFWT ratio of 1.25 ± 0.75 found by R.M. Brown at the PN site. However, there was very large variability observed in the 2003 provincial background ratios (14.6 ± 10.1).

This large variability in the 2003 provincial background sample results points out clearly the problems involved in getting accurate results for OBT as experienced by the OPG-HPL laboratory. It is a very difficult analysis to perform. At background locations the concentration of tritium in tissue free water and that which is organically bound should be very low and fairly equal giving an expected ratio close to unity. OPG will continue to perform OBT analyses on selected samples of vegetables, milk and fish at the PN site and background locations and will attempt to understand and refine the analytical procedure to address the high variability seen in the background vegetable samples.

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3.8 Sewage

The York Durham Water Pollution Control Plant (WPCP) is located about 2 km east of the PN site. The WPCP is not a nuclear facility but does receive a sewage stream from the PN site. There are, however, other sources of radioactivity from other sewage paths, mainly from the use of radionuclides in medical diagnosis and treatment. The PN site sewage stream is mixed with these other sewage streams from the York and Durham municipalities and processed at the WPCP and the resulting sludge incinerated. Ash from the incinerator is a secondary product arising from the sewage stream that is handled by the workers.

In 2000, OPG conducted a pathway analysis of all possible pathways of radionuclides in sewage to the WPCP. [R-37] Derived release limits were calculated for tritium, ^{14}C and gross beta for use in controlling releases of radioactivity into PN sewage. In 2001, tritium and gross beta releases were measured in sewage effluent and found to be within station operating targets for tritium and gross beta. An acceptable methodology for measuring ^{14}C in sewage effluent was developed by the HPL in late 2001.

Monitoring of ash at the WPCP was added to the PN site radiological environmental monitoring program in February of 2001. This was to confirm our understanding of the transfer of radioactivity through the WPCP is consistent with our pathway analysis for PN sewage. [R-37] Ash is also being analysed, as it is the form of sewage that has the highest concentration of radionuclides (other than ^{14}C and tritium) and has the potential to cause the highest dose in WPCP workers. Monthly samples of ash were collected and analysed by high resolution gamma spectrometry. The ash was found to have concentrations of ^{131}I ranging from 4.5 Bq/kg to 145.9 Bq/kg with an average value of 29.3 Bq/kg. See Table 3.8.3.

High resolution gamma scans were also carried out on weekly samples of PN sewage collected (prior to discharge to the WPCP) in 2001. Iodine-131 was not detected in any of the samples (< 0.3 Bq/L on average) see Table 3.8.1. These results strongly suggest the ^{131}I detected in the WPCP ash samples (Table 3.8.3) is not from OPG operations. Cobalt-60 was detected in one sewage effluent sample whose origin is the PN site. Quarterly composite samples made up from the weekly samples were also analysed for tritium and ^{14}C . Carbon-14 was not detected in these quarterly composite samples and tritium was measured well above background levels. See Table 3.8.2 for results.

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Table 3.8.1 Pickering Nuclear Site-Sewage Effluent Gamma Scan Results-2003

Date	¹³¹ I (Bq.kg ⁻¹ ±2σ)	¹³⁷ Cs (Bq.kg ⁻¹ ±2σ)	¹³⁴ Cs (Bq.kg ⁻¹ ±2σ)	⁶⁰ Co (Bq.kg ⁻¹ ±2σ)	⁴⁰ K (Bq.kg ⁻¹ ±2σ)
7 Jan	<0.3	<0.3	<0.3	<0.3	8.4 ± 3.7
14 Jan	<0.2	<0.2	<0.2	<0.2	5.8 ± 2.1
21 Jan	<0.3	<0.3	<0.3	<0.3	6.6 ± 3.8
28 Jan	<0.3	<0.2	<0.2	<0.2	12.3 ± 2.3
4 Feb	<0.3	<0.3	<0.3	<0.3	8.2 ± 3.0
11 Feb	<0.3	<0.3	<0.3	<0.3	<4.4
18 Feb	<0.3	<0.3	<0.3	<0.3	7.8 ± 3.4
25 Feb	<0.3	<0.3	<0.3	<0.3	4.7 ± 2.8
5 Mar	<1.2	<0.2	<0.2	<0.2	9.2 ± 1.4
15 Mar	<0.3	<0.2	<0.2	<0.2	9.6 ± 1.8
19 Mar	<0.3	<0.2	<0.2	<0.2	11.9 ± 1.7
26 Mar	<0.2	<0.2	<0.2	<0.2	8.7 ± 2.0
1 Apr	<0.3	<0.3	<0.3	<0.2	15.9 ± 2.6
8 Apr	<0.2	<0.2	<0.2	<0.2	9.7 ± 1.9
16 Apr	<0.2	<0.2	<0.2	<0.2	11.0 ± 2.0
23 Apr	<0.3	<0.3	<0.3	<0.2	16.4 ± 2.6
30 Apr	<0.2	<0.2	<0.2	<0.2	10.4 ± 1.5
6 May	<0.3	<0.2	<0.2	<0.2	9.4 ± 2.0
13 May	<0.3	<0.2	<0.3	<0.2	10.6 ± 2.2
20 May	<0.3	<0.3	<0.3	<0.2	5.9 ± 1.8
27 May	<0.3	<0.3	<0.3	<0.2	13.5 ± 2.5
4 Jun	<0.3	<0.3	<0.3	0.7 ± 0.2	13.7 ± 2.6
11 Jun	<0.3	<0.3	<0.3	<0.2	14.9 ± 2.5
18 Jun	<0.2	<0.2	<0.2	<0.2	9.9 ± 1.9
25 Jun	<0.2	<0.2	<0.2	<0.2	10.6 ± 2.0
3 Jul	<0.4	<0.4	<0.4	<0.4	4.0 ± 1.9
9 Jul	<0.3	<0.3	<0.3	<0.2	14.7 ± 2.5
16 Jul	<0.2	<0.2	<0.2	<0.2	11.1 ± 1.6
23 Jul	<0.2	<0.2	<0.2	<0.2	9.8 ± 2.0
30 Jul	<0.1	<0.1	<0.1	<0.1	8.6 ± 1.4
5 Aug	<0.2	<0.2	<0.2	<0.2	8.4 ± 1.5
12 Aug	<0.3	<0.2	<0.2	<0.2	6.0 ± 1.5
19 Aug	<0.2	<0.2	<0.2	<0.2	10.0 ± 1.5
26 Aug	<0.3	<0.4	<0.3	<0.4	3.7 ± 2.2
2 Sep	<0.3	<0.3	<0.3	<0.2	16.2 ± 2.7
9 Sep	<0.2	<0.2	<0.2	<0.2	9.0 ± 1.9

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Table 3.8.1 Pickering Nuclear Site-Sewage Effluent Gamma Scan Results-2003-Continued

Date	^{131}I (Bq.kg $^{-1}\pm 2\sigma$)	^{137}Cs (Bq.kg $^{-1}\pm 2\sigma$)	^{134}Cs (Bq.kg $^{-1}\pm 2\sigma$)	^{60}Co (Bq.kg $^{-1}\pm 2\sigma$)	^{40}K (Bq.kg $^{-1}\pm 2\sigma$)
16 Sep	<0.3	<0.3	<0.2	<0.3	14.5 $\pm$ 2.5
23 Sep	<0.3	<0.4	<0.4	<0.3	6.0 $\pm$ 1.4
30 Sep	<0.2	<0.3	<0.3	<0.3	4.4 $\pm$ 1.4
7 Oct	<0.4	<0.4	<0.4	<0.4	5.0 $\pm$ 3.3
14 Oct	<0.3	<0.3	<0.4	<0.3	4.7 $\pm$ 1.4
21 Oct	<0.2	<0.2	<0.2	<0.2	11.6 $\pm$ 2.1
28 Oct	<0.3	<0.2	<0.2	<0.2	7.2 $\pm$ 1.9
4 Nov	<0.3	<0.3	<0.3	<0.3	5.0 $\pm$ 2.5
11 Nov	<0.3	<0.3	<0.2	<0.3	4.2 $\pm$ 1.3
18 Nov	<0.3	<0.3	<0.2	<0.3	15.6 $\pm$ 2.6
25 Nov	<0.2	<0.2	<0.2	<0.2	10.2 $\pm$ 2.6
2 Dec	<0.3	<0.2	<0.3	<0.3	5.6 $\pm$ 1.7
9 Dec	<0.3	<0.3	<0.2	<0.3	16.1 $\pm$ 2.6
16 Dec	<0.3	<0.3	<0.3	<0.3	3.4 $\pm$ 1.2
23 Dec	<0.4	<0.3	<0.3	<0.2	6.4 $\pm$ 1.8
30 Dec	<0.4	<0.3	<0.2	<0.3	15.8 $\pm$ 2.6

- Notes:**
- <Indicates limit of Detection (Ld).
 - Summary Report of PN Site Sewage Effluent Sample results. The sewage stream is treated at the York Durham Water Pollution Control Plant.

Table 3.8.2 Pickering Nuclear Site Sewage Effluent Tritium and ^{14}C Concentration Results-2003

Sewage Effluent Sample	^3H (Bq/L)	^{14}C (Bq/L)
Quarter 1	1,007 $\pm$ 18	<2.1
Quarter 2	823 $\pm$ 16	<2.1
Quarter 3	575 $\pm$ 13	<2.1
Quarter 4	721 $\pm$ 15	<2.1

- Notes:**
- Quarterly composite samples made up from samples.
 - Detection Limit (^3H) = 3.7 Bq/L.
 - Detection Limit (^{14}C) = 2.1 Bq/L.
 - The $\pm$ values represent twice the standard deviation of 2 determinations.

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Table 3.8.3 York Durham Water Pollution Control Plant,
Ash Gamma Scan Results-2003

Month	^{131}I (Bq.Kg $^{-1} \pm 2\sigma$)	^{137}Cs (Bq.Kg $^{-1} \pm 2\sigma$)	^{40}K (Bq.Kg $^{-1} \pm 2\sigma$)	^{60}Co (Bq.Kg $^{-1} \pm 2\sigma$)	^{134}Cs (Bq.Kg $^{-1} \pm 2\sigma$)
January	145.9 $\pm$ 5.3	0.4 $\pm$ 0.3	164.9 $\pm$ 7.8	<0.4	<0.5
February	20.3 $\pm$ 0.6	0.5 $\pm$ 0.3	183.9 $\pm$ 8.2	<0.4	<0.6
March	18.9 $\pm$ 0.3	0.6 $\pm$ 0.1	220.8 $\pm$ 4.0	<0.2	<0.5
April	30.1 $\pm$ 0.7	0.9 $\pm$ 0.2	288.3 $\pm$ 10.4	<0.3	<0.3
May	13.3 $\pm$ 3.6	5.4 $\pm$ 0.5	218.6 $\pm$ 9.9	<0.3	<0.2
June	29.9 $\pm$ 0.8	5.7 $\pm$ 0.5	223.8 $\pm$ 4.9	<0.4	<0.2
July	15.8 $\pm$ 2.0	0.5 $\pm$ 0.1	218.0 $\pm$ 8.5	<0.2	<0.2
August	35.4 $\pm$ 7.4	0.9 $\pm$ 0.4	192.9 $\pm$ 8.8	<0.6	<0.5
September	4.5 $\pm$ 0.3	0.5 $\pm$ 0.2	199.8 $\pm$ 8.3	<0.3	<0.5
October	12.5 $\pm$ 4.8	<0.7	177.8 $\pm$ 9.4	<0.6	<0.5
November	13.6 $\pm$ 0.5	0.7 $\pm$ 0.2	195.9 $\pm$ 7.4	<0.3	<0.3
December	11.5 $\pm$ 0.5	1.0 $\pm$ 0.2	216.4 $\pm$ 11.3	<0.3	<0.3

Notes: 1. < Indicates Limit of Detection (Ld).

- The ash samples represent a highly concentrated medium of natural background and medical source radionuclides. These include ^{67}Ga , $^{99\text{m}}\text{Tc}$, ^{201}Tl , ^{131}I , ^{208}Tl , ^{228}Ac , ^{212}Bi , ^{214}Bi , ^{212}Pb , ^{214}Pb , and ^7Be .
- Cobalt-Co, and ^{134}Cs , if detected would indicate the presence of radionuclides from OPG operations.
- The low ^{137}Cs levels detected are believed to be from atmospheric testing of nuclear weapons from the 1960's. Cesium-137 is also potentially released from OPG's reactors during normal operations.

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3.9 Measured Atmospheric Dilution Factors and Meteorological Data

Atmospheric dilution factors provide a measure of the dilution of station radiological stack emissions to air in the atmosphere. Factors influencing the dilution in the atmosphere include wind speed and direction as well as the level of turbulence or stability of the atmosphere.

Atmospheric dilution factors (K_a) are calculated from the measured tritium oxide in air concentrations and station tritium oxide emissions using the relationship:

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

Where C is the annual average tritium oxide in air concentration (Bq/m^3) measured outside the station boundary and Q is the average tritium oxide release rate (Bq/s) for 2003 measured with stack monitors at the point of release. The release rate is determined by dividing the total annual emission of tritium oxide as given in Table 2.1 by 3.16×10^7 seconds per year.

Figures 3.9.1 and 3.9.2 graphically show how these measured K_a values have varied historically at the DN and PN sites.

Wind speed and direction are measured continuously at meteorological towers at each nuclear site. Processing of this data yield annual averages as percent wind direction. Data on wind frequency by speed and direction at the 10 meter height for the DN and PN sites are presented in Tables 3.9.3 and 3.9.4. [R-38]

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Table 3.9.1 Darlington Nuclear Site Annual Average Dilution Factors - 2003

Sites	Measured Average Airborne Tritium Concentration (Bq/m ³)	Measured Ka (s/m ³)
BOUNDARY SITES		
1. South East Fence	1.2	2.4×10^{-7}
2. East Fence	0.8	1.5×10^{-7}
3. Maple Grove	0.5	1.0×10^{-7}
4. Park Road	0.4	7.2×10^{-8}
5. Knight Road	0.4	7.6×10^{-8}
6. Provincial Park	0.4	6.9×10^{-8}
Boundary Average	0.6	1.2×10^{-7}
CONTROL SITES		
7. Oshawa	0.2	4.0×10^{-8}
8. Bowmanville	0.3	5.4×10^{-8}

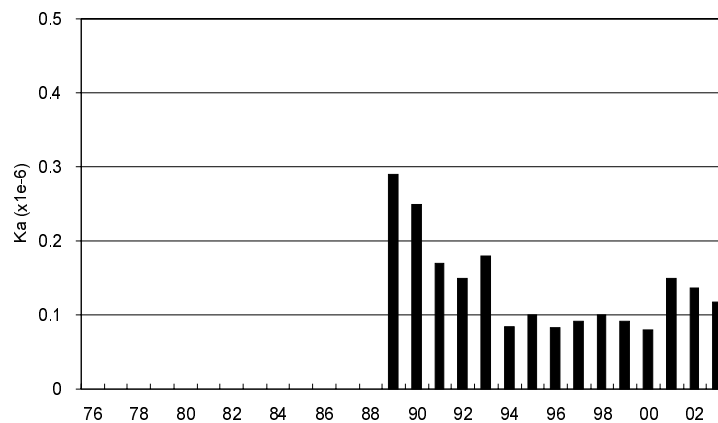


Figure 3.9.1 Darlington Nuclear Site Calculated Ka Values

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Table 3.9.2 Pickering Nuclear Site Annual Average Dilution Factors - 2003

Sites	Measured Average Airborne Tritium Concentration (Bq/m ³)	Measured Ka (s/m ³)
BOUNDARY SITES		
2. Montgomery Park Road	13.6	8.2×10^{-7}
3. Sandy Beach Road	2.8	1.7×10^{-7}
4. Liverpool Road	1.4	8.2×10^{-8}
6. East Boundary	6.7	4.1×10^{-7}
7. Central Maintenance-West	6.6	4.0×10^{-7}
8. Frenchman's Bay	2.0	1.2×10^{-7}
9. Petticoat Creek Conservation Area	2.5	1.5×10^{-7}
10. Central Maintenance-East	13.7	8.3×10^{-7}
11. Alex Robertson Park	3.7	2.2×10^{-7}
Boundary Average	5.9	3.6×10^{-7}
CONTROL SITE		
5. Highway 7	0.2	1.2×10^{-8}
Ajax Hospital	1.2	7.5×10^{-8}
EHPL-Whitby	0.5	2.9×10^{-8}

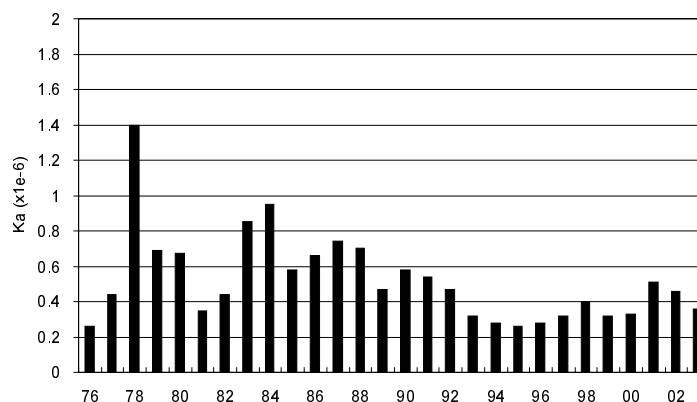


Figure 3.9.2 Pickering Nuclear Site Calculated Ka Values

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Table 3.9.3 Darlington Nuclear Site - Wind Frequency by Direction and Speed - 2003

Direction from	Wind Speed Ranges in km/h								Total
	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	>70	
N	3.4	1.1	0.2	0	0	0	0	0	4.7
NNE	2.4	0.7	0	0	0	0	0	0	3.1
NE	3.7	2.7	0.3	0	0	0	0	0	6.6
ENE	3.9	3.1	0.9	<0.1	0	0	0	0	7.9
E	4.2	4.8	1.0	0	0	0	0	0	9.9
ESE	2.4	0.6	<0.1	0	0	0	0	0	3.0
SE	2.1	0.6	<0.1	0	0	0	0	0	2.7
SSE	1.4	0.5	<0.1	0	0	0	0	0	1.9
S	1.2	0.5	<0.1	0	0	0	0	0	1.8
SSW	2.0	1.7	<0.1	0	0	0	0	0	3.8
SW	2.9	5.9	1.0	<0.1	0	0	0	0	9.9
WSW	4.8	3.4	0.5	0	0	0	0	0	8.7
W	4.6	3.6	0.8	0.1	0	0	0	0	9.2
WNW	3.9	2.5	1.0	0.3	<0.1	0	0	0	7.7
NW	5.6	4.3	1.1	0.1	<0.1	0	0	0	11.1
NNW	4.7	2.6	1.0	<0.1	0	0	0	0	8.3
TOTAL	53.0	38.5	7.8	0.7	<0.1	0	0	0	100.0

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Table 3.9.4 Pickering Nuclear Site - Wind Frequency by Direction and Speed - 2003

Direction from	Wind Speed Ranges in km/h								Total
	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	>70	
N	6.4	1.1	<0.1	0	0	0	0	0	7.5
NNE	2.0	1.3	<0.1	0	0	0	0	0	3.3
NE	2.0	2.8	0.2	0	0	0	0	0	5.0
ENE	2.2	4.5	1.7	<0.1	0	0	0	0	6.4
E	2.3	2.9	0.4	<0.1	0	0	0	0	5.7
ESE	2.3	1.2	<0.1	<0.1	0	0	0	0	3.6
SE	1.1	0.7	<0.1	0	0	0	0	0	1.9
SSE	1.1	0.7	0.2	0	0	0	0	0	2.0
S	3.8	4.5	0.2	<0.1	0	0	0	0	8.5
SSW	4.4	3.9	1.1	0.3	0	0	0	0	9.7
SW	2.4	3.0	1.1	<0.1	0	0	0	0	6.6
WSW	2.7	2.3	0.7	<0.1	0	0	0	0	5.8
W	2.9	3.0	1.0	<0.1	0	0	0	0	7.0
WNW	3.7	3.6	0.6	0.1	0	0	0	0	8.1
NW	4.7	2.9	0.2	0	0	0	0	0	7.8
NNW	7.8	1.3	0.2	0	0	0	0	0	9.2
TOTAL	51.8	39.7	7.8	0.7	0	0	0	0	100

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**4.0 ASSESSMENT OF DOSES TO THE PUBLIC**

An assessment is made of doses to the public resulting from the operation of OPGs nuclear generating stations. These doses are based on measured concentrations of radionuclides in environmental media as much as possible. Where environmental concentrations are not statistically measurable above background, doses are based on measured station emission data and environmental pathway modeling.

4.1 Historic Dose Calculations

Before 2001, the dose to a member of the public was calculated in terms of a Hypothetical Individual. This dose was the most reasonable estimate of the maximum dose that an individual living in the vicinity of the nuclear facility might receive. It was calculated by attributing very conservative characteristics to the individual (e.g., site boundary location, 100 percent consumption of local food and water). Hypothetical Individual doses were calculated for an adult, a 1 year old infant drinking formula, and a 1 year old infant drinking fresh cow's milk. The concept of the Hypothetical Individual was used as a surrogate for actual members of the public because the extent of environmental data collected did not permit the calculation of doses to actual groups of individuals living near the facility.

The PN Radiological Environmental Monitoring Program (REMP) was re-designed, and implemented on January 1, 2001. **[R-1]** The purpose of this update was to bring the program into better compliance with the CSA Standard N288.4. **[R-3]** The updated program provided sufficient environmental data to enable a calculation of dose to a number of groups of members of the public, specifically the seven potential critical groups identified in the 1999 BEAK International Inc. pathway analysis used in the re-design of the PN REMP. **[R-39]**

For 2001 and 2002 doses were calculated for the PN potential critical groups. This calculation was intended to be as realistic as possible by using the information collected in the PN Site Specific Survey **[R-40]** in regard to potential critical group locations and characteristics. Minor pathways which were omitted in the Hypothetical Individual dose calculation were included in these calculations. For each potential critical group, doses were calculated for an adult, a 1 year old infant that drinks formula and a 1 year old that drinks fresh cow's milk. Calculations were made using the IMPACT¹ computer code, version 2.3.5, following the methodology of CSA standard N288.1. **[R-7]** As part of the transition to reporting critical group doses, Hypothetical Individual doses were also calculated as before for both DN and PN.

¹ Integrated Model for Probabilistic Assessment of Contaminated Transport.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**4.2 Current Changes to Dose Calculations**

The DN REMP was updated and implemented at the beginning of 2003. **[R-2]** There are now sufficient environmental data available for the DN site to enable the calculation of doses for DN potential critical groups, as a result, there is no longer a need to continue with the calculation of the Hypothetical Individual dose for either DN or PN.

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, as described in the Derived Release Limit reports for these stations. **[R-41] [R-42]** The calculation of the Hypothetical Individual dose has been discontinued, but historical Hypothetical Individual dose data along with the new critical group dose data can be viewed in trend graphs for the two sites. See Figures 4.7.1 and 4.7.2.

The methodology used in this report for calculating public dose follows that described in OPG's Derived Release Limit (DRL) Guidance document **[R-43]**, which was approved for use by CNSC in February 2003. **[R-44]** The OPG DRL Guidance is an update of the 1987 CSA standard CSA-N288.1 that was used previously. The new methodology introduces additional age groups described below, and now includes a 3 month nursing infant that represents the age span of birth to 12 months. Calculations for the 3 month nursing infant are based on an interim OPG model which will be replaced in future by a model currently being developed by the International Commission on Radiological Protection (ICRP). Some model parameter values used here differ from those of the DRL Guidance document (e.g., food consumption rates) in order to reduce the amount of conservatism in the calculation and provide a more realistic dose estimate. Where different values were used, they are noted and included in this report. Calculations were performed using IMPACT version 4.0.3 software. This version of IMPACT accurately implements the models in OPG's DRL Guidance.

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4.3 Critical Group Dose Calculations

The calculation of public dose in this report is intended to be as realistic as possible using the information collected in the DN and PN Site Specific Surveys [R-45] and [R-40] in regard to potential critical group lifestyles and attributes.

In environmental assessments, “critical groups” are used to estimate the maximum realistic impacts of emissions. Critical groups are actual groups of members of the public generally residing close to the nuclear site. The CSA N288.1 Standard [R-7] defines a critical group as “a fairly homogenous group of people whose location, habits, diet, etc., cause them to receive doses higher than the average received by typical people in all other groups in the exposed population.”

In this report, a single critical group is identified for each nuclear site, DN and PN. This group is the one with the highest total dose estimate. Since it is not apparent beforehand which group this will 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.

The 6 age classes for which doses are calculated are: an adult, a 15 year old child, a 10 year old child, a 5 year old child, a 1 year old infant, and a 3 month nursing infant. The one year old infant is assumed to drink formula for all potential critical groups, except the dairy farm infant who drinks fresh cow's milk. The 3 month old nursing infant encompasses the age span from birth to 12 months, and is also assumed to consume solid foods in addition to mother's milk during some part of this period.

The potential critical group dose calculations use realistic receptor characteristics, based as much as possible on data collected in the DN and PN site-specific surveys, and thus gives rise to more realistic doses. For example, whereas the Hypothetical Individual dose calculation assumed 100 percent consumption of local food and water, critical group calculations make use of known lower contaminated ingestion fractions.

These dose calculations include all pathways of radionuclide uptake or external exposure, unlike the previous Hypothetical Individual dose calculations which omitted some minor pathways. The pathways included are listed below and are described in the OPG DRL Guidance document.

- (a) Air inhalation/Skin absorption
- (b) Air Immersion (external exposure)
- (c) Water Ingestion
- (d) Water immersion (external exposure – swimming and bathing)
- (e) Soil external exposure or soil groundshine
- (f) Terrestrial plant ingestion – fruits and vegetables
- (g) Terrestrial animal product ingestion – milk, meat, eggs
- (h) Aquatic animal ingestion – fish
- (i) Sediment external exposure – beach groundshine
- (j) Incidental soil and sediment ingestion

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The IMPACT version 4.0.3 program was run in a mode which allowed the insertion of actual environmental monitoring data results and site official radiological emission values (Table 2.1) for 2003. The insertion of actual environmental measurements is made through what are known as 'dictator sources'. This enables the program to perform the dose calculation using the actual concentration measured at a potential critical group location when such data are available (and not the concentration calculated from emission measurements), thus obtaining more realistic and accurate doses. Where measured environmental data are not available, doses were modeled from emissions. Table 4.3.1 indicates for each radionuclide and pathway how the dose was calculated with respect to input data.

The IMPACT version 4.0.3 software now calculates Organically Bound Tritium (OBT) concentrations in plants and animal products from tritiated water emissions data. Similarly, the software incorporates conversion of elemental tritium to tritiated water by soil bacteria, and the conversion of the methane form of ^{14}C to $^{14}\text{CO}_2$, by soil bacteria.

Concentrations of iodine and particulates in air were calculated at each potential critical group location using emissions data and an empirical atmospheric dilution factor as determined from the ratio of measured airborne tritium emissions to measured tritium in air at the critical group location.

Noble gas doses were measured directly using Exploranium gamma radiation monitors. These are located near the site boundary in the landward wind sectors. The doses measured at the site boundary were adjusted to the potential critical group locations using modeled atmospheric dilution factors from IMPACT.

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 Groups are spread over much wider geographic areas, and for these the maximum group value was used in order to keep the calculated doses on the conservative side.

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Table 4.3.1 Method (by Radionuclide and Pathway) for Determination of Critical Group Dose

Pathway	Radionuclide	Modeled ⁽¹⁾	Measured
Air	HTO		✓
	HT	✓ ⁽²⁾	
	C-14		✓
	I(mfp)	✓ ⁽²⁾	
	Noble Gas		✓ ⁽³⁾
	Cs-137	✓ ⁽²⁾	
Soil	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137	✓	
Terrestrial Animals	HTO		✓ ⁽⁴⁾
	C-14		✓ ⁽⁴⁾
	I(mfp)	✓	
	Cs-137	✓	
	OBT ⁽⁵⁾	✓	
Terrestrial Plants	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137	✓	
	OBT ⁽⁵⁾	✓	
Aquatic Animals	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137		✓
	OBT ⁽⁵⁾	✓	
Sand	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137		✓
Water	HTO		✓
	C-14	✓	
	I(mfp)	✓	
	Cs-137	✓	

- Note:**
- (1) Modeling is based on emissions or from local air measurements where they are available.
 - (2) Concentrations modeled from emissions and adjusted using empirical atmospheric dilution factors (Ka) determined at 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) Radionuclides are not measured directly in animals, with the exception of tritium and ¹⁴C in dairy milk, therefore the concentration is modeled from measured concentrations in air, water and forage. Carbon-14 in water is modeled from local air measurements.
 - (5) Dose is modeled from emissions and adjusted to reduce conservatism and include measured HTO concentrations in terrestrial plants and aquatic animals.

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4.3.1 Darlington Nuclear Critical Groups

The 9 potential critical groups at Darlington Nuclear for which doses are calculated in this report are listed and described below. They are the same potential critical groups identified in the Darlington Nuclear DRL report. **[R-41]** All of the potential critical groups except the farm group consume some locally caught fish, and all but the Fisher groups are assumed to be exposed to local beach sand.

- (a) The **Oshawa/Courtice** potential critical group consists of urban residents located to the W and WNW of the site starting at about 7 km from the site. These residents obtain almost all their drinking water from the local water supply plant, 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. These residents obtain almost all their drinking water from the local water supply plant, 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 local water supply plant, 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 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 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 supply mostly from wells and use it for drinking, bathing, irrigation, and livestock. 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 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 local water supply plants, and use it for drinking, bathing, and irrigation. They do not

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raise livestock. They obtain a moderate fraction of their annual fruits, vegetables 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. Members of this group are typically at this location about 23 percent of the time. They consume water from the local water supply plant.
- (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 percent 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 local water supply plants, and purchase a small fraction of their annual fruits, vegetables, meat, poultry, and eggs from locally grown sources.

4.3.2 Pickering Nuclear Potential Critical Groups

The 8 potential critical groups at Pickering Nuclear for which doses are calculated in this report are listed and described below. They are the same potential critical groups identified in the Pickering Nuclear DRL reports [R-42], with an additional correctional institution added:

- (a) The **C1** potential critical group consists of residents at a correctional institute approximately 1.25 km ENE of the PN Site. C1 residents obtain drinking water from local water supply plants, and consume no home grown produce. The C1 resident is conservatively assumed to be at this location 100 percent of the time over at least 1 year.
- (b) The **C2** potential critical group consisting of inhabitants at a second correctional institute, located approximately 3 km NNE of the PN Site. The C2 group also obtains drinking water from municipal supplies and does not consume locally produced fruits or vegetables. The C2 resident is conservatively assumed to be at this location 100 percent of the time over at least 1 year.
- (c) 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 percent of the time. They consume water from

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the local water supply plant. The closest location for this group is about 1.1 km NNE of the site.

- (d) **The Urban Residents** potential critical group consists of Pickering and Ajax area residents which surround the PN Site (e.g., Fairport, Fairport Beach, Rose Bank, Liverpool, Pickering Village, etc.). The members of this group consume water from municipal supplies 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.
- (e) The **SB** potential critical group consists of residents of Squires Beach, located approximately 2 km from the PN site in the ENE and NE wind sectors. Residents of Squires Beach obtain water for drinking, bathing, and irrigation from both municipal supplies and from wells, which are influenced by infiltration of precipitation, but not recharged from the nearby lake. Squires Beach residents also consume some locally grown produce and locally caught fish. Members of this potential critical group are also externally exposed to beach sand at local beaches.
- (f) The **Local Farms** 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 a portion of their water supply from wells and consume locally grown produce and animal products, as well as locally caught fish. They are also externally exposed to beach sand at local beaches.
- (g) The **Local Dairy Farms** potential critical group consists of residents of dairy farms within a 20 km radius of the PN Site. This group obtains a portion of their water supply from local wells. They also consume locally grown fruit and vegetables and locally produced animal products, particularly fresh cow's milk. Members of this potential critical group are also externally exposed to beach sand at local beaches.
- (h) 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 percent of their time at the outfall location where atmospheric exposure occurs.

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4.4 Change from Default Calculation Parameters

The assumptions and modeling parameters used in the IMPACT 4.0.3 program for potential critical group calculations at DN and PN are generally the same as those documented in the DN and PN DRL reports. [R-41] [R-42] Where these differ from the DRL report, they are explicitly identified below and values are provided in this report.

(a) Default Food Consumption

The default total food consumption rates given in the OPG DRL Guidance document represent the 90th percentile of the population. These rates are much higher than the average intake rates for the population, and were used to ensure a degree of conservatism in calculating doses used to determine DRLs. For this report, the intent is to provide a realistic estimate of dose, and so the default food intake rates used here are the “reference” values. These are based on the same data as those used in the DRL Guidance document, but are adjusted to reference caloric intake requirements for each age group, as given in ICRP 23 [R-46] and shown in Table G20a of the OPG DRL Guidance report. [R-43] The food intake rates used are shown in Table 4.4.1.

(b) Nursing Infant Milk Intake

The milk intake rate for the nursing infant used in this report is the mean value as given by the United States Environmental Protection Agency (US EPA). [R-47] The DRL Guidance gives the 95th percentile intake rate.

(c) Meteorological Data

Calculations of atmospheric dispersion in the IMPACT software use site-specific meteorological data. The DN and PN DRL reports used 5 year average data. In this report, only 2003 site-specific data are used. [R-38]

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Table 4.4.1 OPG Critical Group Individual Ingestion Rates

Food Sources *	Infant		Child			Adult	
	3 months (Nursing Infant)	1 year	5 years	10 years	15 years	male	Nursing Mother
Reference Fish Intake (kg/a)	0	0.8	1.9	2.1	2.8	5.0	3.4
Reference Honey intake (kg/a)	0.8	0.3	0.6	0.7	0.9	1.4	0.9
Reference Beef intake (kg/a)	19	9.8	13	20	32	45	30
Reference Pork intake (kg/a)	0	3.0	5.3	8	12	19	13
Reference Lamb intake (kg/a)	0	0.009	0.6	0.5	0.5	0.5	0.3
Reference Rabbit intake (kg/a)	0	0.5	0.06	0.09	0.1	0.2	0.1
Reference Deer intake (kg/a)	0	0.02	0.03	0.04	0.06	0.08	0.06
Reference Poultry intake (kg/a)	0	4.1	5.5	6.8	9.1	13	8.9
Reference Egg intake (kg/a)	2.8	7.8	6.9	8	12	20	14
Reference Milk intake (kg/a)**	279***	216	196	212	263	178	121
Total Reference Terrestrial Animal products (kg/a)	301	241	228	256	329	277	188
Grain (kg/a)	32	54	97	112	149	155	105
Fruit and berries (kg/a)	68	61	65	64	73	117	79
Vegetables (kg/a)	25	40	64	79	114	157	106
Mushrooms (kg/a)	0.00	0.1	0.2	0.3	0.5	1.0	0.7
Potatoes (kg/a)	4.6	21	34	44	64	70	48
Total Reference plant intake (kg/a)	129	176	259	299	401	500	339
Water Intake (L/a)	136	402	548	657	730	840	810
Soil and Sediment Intake (kg/d)	0.00025	0.00025	0.0002	0.0002	0.0001	0.0001	0.000025

* Reference ingestion rates are 0.625 of the default values used in the DRL Guidance.

** For 1 yr infant, if on fresh cow's milk, subtract fresh milk intake to get net water intake. If on formula, fresh milk = 0

*** Nursing infant milk intake is the mean intake taken from the EPS 2002 "Child Specific Exposure Factors Handbook".

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**4.5 Critical Group Radionuclide Concentrations, Calculations and Results**

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

4.5.1 Tritium

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

- (a) Tritium in air was measured at each critical group location with background subtracted. At some locations there were two different types of tritium collectors, the standard active molecular sieve collector, and the new passive collector which is part of a trial program. In order to remain conservative in making dose estimates, the higher of the concentrations found was used at each location that had the two monitors even though the trial has not been completed.
- (b) Drinking water is sampled and measured at the local water supply plant as well as at wells where local residents obtain their water. For the water supply plants, the annual average concentration less background is used, and for wells the maximum annual average concentration found at each critical group is used. Tritium concentration in wells used for purposes other than drinking water is modeled.
- (c) Milk from local dairy farms is sampled on a monthly basis and the highest annual average of all the dairy farms is used for the dose calculation with background subtracted. Only dairy farm residents drink local milk since it is illegal to sell unprocessed milk.
- (d) Fruit and vegetable tritium concentrations are measured at each critical group location and the background value is subtracted. The maximum concentration measured at each critical group is used in the dose calculation.
- (e) 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 (>5 km) it is assumed that there is not a large variance in radionuclide concentrations in silage obtained at these locations. Therefore, a silage sample taken at one location can be applied to both the Farm and Dairy Farm critical groups. At Darlington silage samples are obtained only 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 since it is located much closer to the site resulting in a higher radionuclide concentration in silage compared to that obtained at the Dairy Farm. Instead the maximum concentrations obtained in the vegetables sampled at the farm locations are used to represent concentrations in silage. Background values are subtracted.

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- (f) The concentration used in locally caught fish is the average tritium concentration measured in the fish samples with the background value subtracted.

Tables D1 to D15 in Appendix D give the concentrations used at each critical group as determined using the above assumptions.

Pathways not covered by the REMP program are modeled from emissions data using the IMPACT program. See Table 4.3.1.

Organically Bound Tritium (OBT)

In previous years, OBT dose was estimated from Tissue Free Water Tritium (TFWT) measured concentrations [R-48] based on the average ratio of OBT to TFWT concentrations as measured by AECL in a large number of foodstuffs. [R-22] The ratio OBT/TFWT ranged from 0.3 to 4.2 with an overall average of 1.25 ± 0.75 when concentrations are expressed as Bq/L water equivalent.

Starting with the 2003 dose assessment, the IMPACT model will be used to calculate dose from OBT at each critical group locations. Due to some limitations of the program, OBT dose can only be calculated from site Tritium Oxide (HTO) emissions. The following adjustments using measured HTO in fruits, vegetables and fish are then applied to the dose obtained in order to remove some of the conservatism in the model.

- OBT dose obtained from terrestrial plant and animals is adjusted using a ratio of

$$\frac{HTO_{\text{measured_in_plants}}}{HTO_{\text{modeled_in_plants}}}$$

for each critical group according to the fruits and vegetables sampled at the location. At critical group locations where there are no locally grown fruits and vegetables, the OBT dose is adjusted using the ratio obtained for the Farm critical group.

- OBT dose obtained from aquatic animals is adjusted using the ratio

$$\frac{HTO_{\text{measured_in_fish}}}{HTO_{\text{modeled_in_fish}}}$$

based on the fish taken from around the outfall at each nuclear site. The same ratio is then applied to all the critical groups that ingest fish.

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Starting in 1996, an estimate of the elemental tritium dose resulting from emissions at the DN Tritium Removal Facility was introduced. Elemental tritium concentrations in air can be modeled from emissions data and the atmospheric dispersion factor measured from tritium oxide data, as described in Section 4.3. This is the same approach as utilized for noble gas, iodine and particulate dose calculations. The inhalation pathway is the only direct pathway to humans resulting in dose. Elemental tritium converts into tritium oxide through interaction with the microbes in the soil. The resultant tritium oxide is routinely measured in air and local biota around nuclear sites.

4.5.2 Carbon-14

The concentrations of ^{14}C used for the calculations of critical group doses are based on the maximum of the measurements for each sample type obtained at each location minus a background concentration of 240 Bq/kg-C. These concentrations are provided in Tables D1 to D15 in Appendix D for each critical group.

Concentrations of ^{14}C in well water are modeled from measured local air concentrations at each critical group location and concentrations in the water supply plants are modeled from site waterborne emissions.

Currently there are no ^{14}C monitors set up at the PN Urban Residents critical group or the Bowmanville Residents critical group. At these locations the ^{14}C in air is modeled from emissions using the empirical atmospheric dilution factors (Ka) as described in Section 4.3.

4.5.3 Noble Gases and Skyshine

Environmental TLDs are present at the boundary air monitoring stations at all sites and are replaced and read out quarterly (see Section 3.1). Using TLDs to measure environmental gamma dose rates does not allow for detection of contributions from noble gas emissions with statistical certainty at the normal levels of emissions.

Exploranium G.S. Ltd. sodium iodide gamma spectrometers are installed at the boundary around the DN and PN sites. These systems allow continuous monitoring of all natural and human-made gamma dose rates (i.e., noble gases and ^{192}Ir skyshine) in the public domain. The CNSC has reviewed the development and testing of these systems at PN and has given approval for OPG to start using the monitors to measure and report noble gas and ^{192}Ir skyshine public doses starting in 2000. **[R-49]**

The monitors measure the air kerma rate, which is converted to effective dose using appropriate age-specific conversion factors (effective dose/air kerma rate) **[R-50]** and standard occupancy and shielding factors for air immersion dose as described in the DRL Guidance document.

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The air kerma rate at the PN site due to the Used Fuel Dry Storage Area and Re-Tube Components Storage Area was measured in September 2000 over water on Lake Ontario. [R-51] 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 which were identified as the major source. 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 1,000 due to scattering in air (effective half distance of 56 metres for skyshine radiation at 300 keV. [R-52] The skyshine dose from this source is therefore not significant and will not be calculated for any PN site critical group outside the 1 km boundary. The skyshine dose is added to the Fisher Critical Group as it is assumed to be located 500 metres south of the site in Lake Ontario.

4.5.4 Radioiodines

The concentrations used to calculate doses to the critical group individuals from radioiodines are calculated from emissions using the empirical atmospheric dilution factors (Ka) based on HTO in air at each critical group location as described in Section 4.3 or directly modeled from emissions where no local HTO measurements are available. This approach is utilized since the concentrations of radioiodines are too low to be easily detected by measurement in the environment.

The dose from radioiodines is based on mixed fission product radioiodines. This is to account for other shorter lived radioiodines, which may be emitted with ^{131}I . Iodine (mixed fission product) refers to ^{131}I in equilibrium with a mixture of fission product radioiodines with radioactivity in the ratio $^{131}\text{I}: ^{132}\text{I}: ^{133}\text{I}: ^{134}\text{I}: ^{135}\text{I} = 1.00: 1.48: 2.05: 2.29: 1.95$.

The concentrations of radioiodines at each critical group are provided in Tables D1 to D15 in Appendix D.

4.5.5 Particulates

The term "particulates" refers to the remaining group of nuclides not otherwise identified in the initial four groups of nuclides that make up the activity released in airborne effluents. Typically, the measurement of the small concentrations of particulates in the effluent, is based on the gross radioactivity in the sample, and there is no further analysis to determine the specific radionuclides present. To assess a dose on the basis of a particulate measurement, a conservative approach requires the assumption that the radionuclides present are the most limiting, that is, the radionuclides which result in the highest assignment of dose.

Analysis of DRLs and percent composition of different radionuclides in airborne and water borne effluents indicates ^{137}Cs has the highest impact on dose at both DN and PN. Therefore, all gross radioactivity measured in the air or water emissions is counted as ^{137}Cs .

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As with the procedure for radioiodines, the concentrations used to calculate doses to critical group individuals are modeled using the empirical atmospheric dilution factors (Ka) at each critical group location as described in section 4.3. The only pathways in which gross beta gamma activity is detected in environmental samples are fish and beach sand. The gross beta gamma activity is assigned by default to be ^{137}Cs if no other radionuclides are detected in the sample. This results in a conservative dose estimate. If another radionuclide is detected it will be used in the calculation and if the activity is less than the total gross beta gamma activity, the remaining activity is assigned to ^{137}Cs . A background value is always subtracted from all measured concentrations of particulates obtained through environmental sampling.

Cs-137 is present in fish as a result of historic atmospheric weapons testing and also potentially from reactor operation. Cs-137 is routinely measured in fish at OPG sites above the detection limit and for purposes of the dose calculation is conservatively assumed to be entirely from reactor operation.

When particulate concentrations other than ^{137}Cs are found below the detection limit, two approaches can be taken. In the first, the detection limit is taken to be the concentration of the radionuclide present. The second approach involves modeling the concentration of the detected radionuclide from emissions. If this concentration is a value below the detection limit then this value is used in the dose calculations. Otherwise, the detection limit is maintained as the concentration of the detected radionuclide.

The concentrations of radioiodines at each critical group are in Tables D1 to D15 in Appendix D.

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4.6 Critical Group Dose Calculation Procedure and Results

Critical Group doses are calculated according to the methodology described in the DRL Guidance and with the following assumptions:

- Residents live at the location 100 percent of the time.
- The fraction of contaminated food eaten is as determined by the site specific survey.
- Drinking water is consumed from local sources as determined by the site specific survey.
- Only Dairy Farm residents ingest local cow milk.
- No local grain products are consumed by humans.

The doses are calculated using the criteria listed below:

Dose from Air: Based on measured HTO and ^{14}C concentrations and modeled I(mfp) and particulate concentrations as described in Section 4.5.4 and 4.5.5 respectively. Noble Gas dose is measured directly in every wind sector at the site boundary and adjusted to the critical group location using air dispersion factors from the critical group locations to the boundary monitor locations.

The monitor location used is the one in the same wind sector in which the critical group is located. For critical groups that span over several wind sectors, such as the Dairy Farm and Farm, the wind sector with the highest air concentration is used to determine the corresponding ratio. Refer to Section 4.5.3 Noble Gases for more detail.

Dose from Drinking Water: Based on measured HTO from the critical group's water source (WSP or well) and modeled concentrations of ^{14}C , I(mfp) and gross beta gamma in well water and the Water Supply Plant (WSP). The radionuclide concentrations are modeled from the local air concentrations and for WSP's they are modeled from site waterborne effluent values.

Dose from Water Immersion: Based on measured HTO from the critical group's water source (WSP, local beach or well) and modeled concentrations of ^{14}C , I(mfp) and gross beta gamma in well water, WSP and beach water. The radionuclide concentrations are modeled from local air concentrations for the wells and are modeled from site waterborne effluent for the WSP and the beach water.

Dose from Terrestrial Plants: Calculated from measured HTO and ^{14}C in local fruits and vegetables. I(mfp) and particulate are modeled from local concentrations in air. OBT is modeled from emissions of HTO and adjusted to reflect the ratio of measured to modeled HTO in local produce. See Section 4.5.1 OBT for details.

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Dose from Terrestrial Animals: Calculated directly from measured concentrations of HTO and ^{14}C in milk. Dose resulting from the ingestion of terrestrial animal products other than milk are calculated from measured concentrations of HTO and ^{14}C in forage, air and water. The model is used to predict the transfer of HTO and ^{14}C to animals from forage, air and water. The dose resulting from I(mfp) and particulate is modeled from local concentrations in air. OBT is modeled from HTO emissions and adjusted to reflect the ratio of the measured to modeled values of HTO in local produce. See Section 4.5.1 OBT for details.

Dose from Aquatic Animals: Based on measured concentrations of HTO, ^{14}C and ^{137}Cs in local fish. OBT is modeled from emissions of HTO and adjusted to reflect the ratio of measured to modeled HTO in fish.

Dose from Groundshine: Concentrations of radionuclides in soil are modeled at each critical group using local concentrations in air for each radionuclide. Doses are then calculated by standard methods. See Sections 4.5.4 and 4.5.5.

Dose from Beachshine: Concentrations of radionuclides in beach sand are modeled at the local beach from site waterborne emissions for each radionuclide. Doses are then calculated by standard methods.

Exceptions

Fisher Critical Group: Only resides at the location for 1 percent of the time. Since this critical group is located offshore it is impractical to measure radionuclide concentrations in the air, therefore all concentrations except those for fish are modeled at this critical group location.

St. Mary's Cement and Pickering Industrial Area Critical Groups: Considered to be at the location for only 23 percent of the time since they do not reside at the location.

Farm Critical Group (Darlington): This farm maintains one cow on their property and the residents consume its milk, however no milk samples were taken at this location therefore the dose obtained from local cow milk is modeled from the local radionuclide concentrations in air, water and forage.

Appendix D gives doses for each critical group at the DN and PN sites. Doses are provided by radionuclide and by pathway for all the pathways identified in the DRL Guidance. [R-43]

Tables 4.6.1 and 4.6.2 provide a summary of the total doses for each critical group for the DN and PN sites. For a detailed breakdown of all critical group doses by radionuclide and pathway see Tables D16-D32 in Appendix D.

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Table 4.6.1 Total Critical Group Doses at Darlington Nuclear – 2003

Critical Group Doses (uSv)									
	Rural Residents	Bowmanville	Oshawa	St. Mary's	Camper	Farm	Dairy Farm	West/East Beach	Fisher
Adult	0.8	0.4	0.3	0.3	0.4	0.5	0.6	1.0	0.1
15yr. Old	0.6	0.3	0.3	NA	0.3	1.2	0.6	0.9	0.1
10yr. Old	0.7	0.3	0.3	NA	0.3	1.2	0.6	0.9	0.1
5yr. Old	0.6	0.3	0.3	NA	0.3	1.2	0.6	0.8	0.1
1yr. Old	0.7	0.3	0.3	NA	0.3	1.2	0.7	0.8	0.0
Nursing Infant	0.9	0.5	0.5	NA	0.4	1.7	0.7	1.2	0.1

Limiting Critical Group: Farm 3 Month old Nursing Infant

Limiting Critical Group Dose (µSv/a): 1.7

Percent of Legal Limit (%) 0.17

Percent of Canadian Background Radiation (%) 0.09

Table 4.6.2 Total Critical Group Doses at Pickering Nuclear – 2003

Critical Group Doses (uSv)								
	Urban Residents	Squires Beach	Industrial	C1	C2	Dairy Farm	Farm	Fisher
Adult	1.7	3.1	2.0	4.7	NA	1.1	0.9	0.4
15yr. Old	1.6	2.8	NA	4.3	1.9	1.0	0.8	0.3
10yr. Old	1.5	2.8	NA	NA	NA	1.0	0.8	0.3
5yr. Old	1.3	2.4	NA	NA	NA	1.0	0.8	0.3
1yr. Old	1.3	2.4	NA	NA	NA	0.9	0.8	0.2
Nursing Infant	2.2	4.1	NA	NA	NA	1.3	1.1	0.6

Limiting Critical Group: C1 Adult

Limiting Critical Group Dose (µSv/a): 4.7

Percent of Legal Limit (%) 0.47

Percent of Canadian Background Radiation (%) 0.26

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**4.7 Discussion of Critical Group Dose Calculations**

A summary of the total doses calculated for each critical at each site are given in Tables 4.6.1 and 4.6.2. A more detailed breakdown of all critical group doses by radionuclide group and pathway are presented in Tables D16 to D32 in Appendix D.

The total doses are an estimate of what members of a particular potential critical group may be exposed to, however any individual may have somewhat more or less dose than indicated depending on how their lifestyle differs from the weighted averages determined through interviews.

Trends in the dose assessment for the most limiting critical group in PN are plotted for the last 2 years along with the hypothetical dose reported in the past. Since the critical group dose calculation has not been previously calculated for DN the trend represents the hypothetical dose up to 2002 and the critical group dose for 2003. These trends are presented in Figures 4.7.1 and 4.7.2. Two step changes are observed in the PN trend as well as in the DN trend. In 1992 there is a decrease in dose due to the change in dose assessment procedures applied to both sites. A second change in dose is observable in the PN trend in 2000 which reflects the introduction of the new OPG Gamma Ray Monitoring Network which resulted in a significant reduction in the reported noble gas dose.

In 2003, an increase in dose occurred for the DN site from 1.2 μSv for the Hypothetical Adult in 2002 to 1.7 μSv for the 3-month old Farm infant in 2003. This increase is attributable mainly to the introduction of the 3 month old nursing infant age group. The change in dose calculation methodology was implemented to bring OPG public dose reporting in line with CNSC reporting requirements **[R-4]** and to present the public with the most realistic and up-to-date calculation of public dose possible.

At the PN site, the highest critical group dose was obtained by the C1 Correctional Facility adult at 4.7 μSv . The increase in dose compared to the 2002 critical group dose of 4.0 μSv (also at the C1 location) is attributed to the change in dose calculation methodology and increased noble gas and radiography skyshine dose. This result is consistent with the fact that the C1 critical group is the closest of the 8 potential critical groups to the PN site (with the exception of the fisher group which is located 0.5 km offshore but only has a residency factor of 1 percent) and is located in a fairly high frequency wind sector. Air inhalation/skin absorption of tritium in air is the primary pathway of tritium dose uptake accounting for about 90 percent of the total dose, at the C1 location.

The overall totals for the limiting critical group and age group at each site are compared with the legal limit for a member of the public of 1,000 $\mu\text{Sv/a}$ and the estimated background public doses from naturally occurring and human-made radiation of about 1,840 $\mu\text{Sv/year}$. A detailed breakdown of the sources of background doses is given in Table 4.8.1. See Figure 4.7.3 for a graphical representation of this data.

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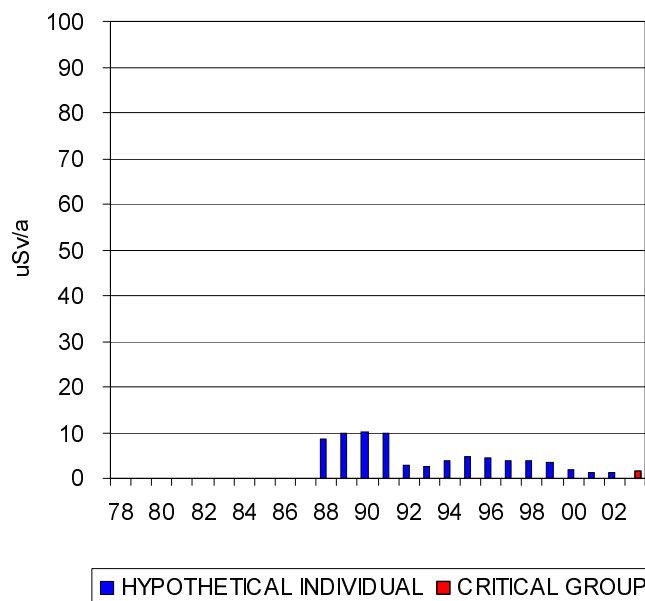


Figure 4.7.1 Darlington Nuclear Site Public Dose Trends

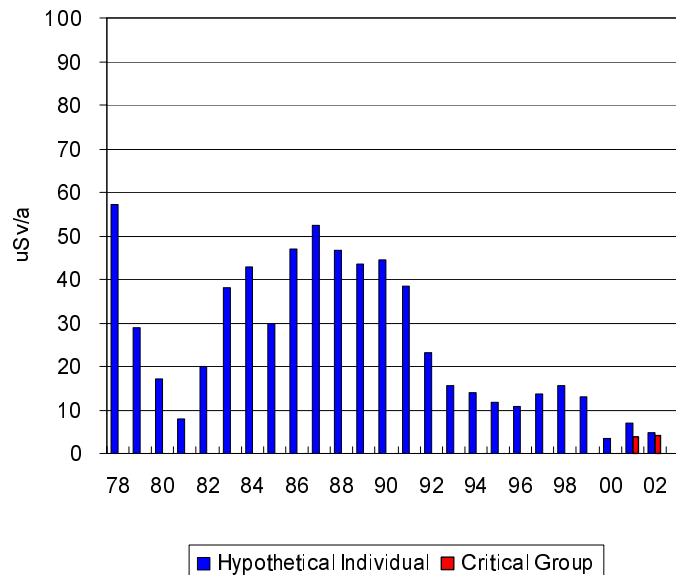


Figure 4.7.2 Pickering Nuclear Site Public Dose Trends

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Figure 4.7.3a¹ Graphical Presentation of 2003 OPG Critical Group Doses in Relation to Canadian Background and Medical Doses

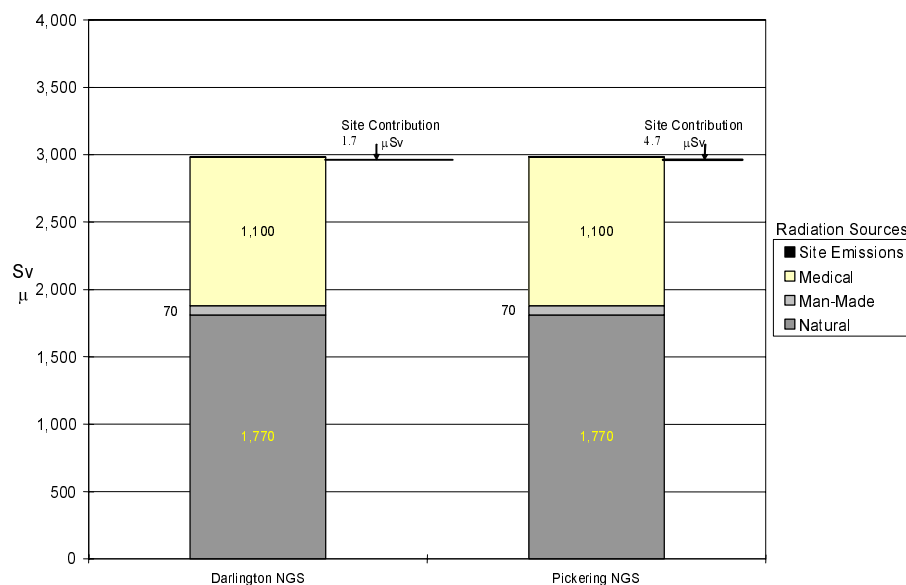


Table 4.7.1 Examples of Typical Natural and Human-Made Doses to the Public in the Range of Calculated Critical Group Doses at OPG Sites

Source of Exposure	Effective Dose (μSv)
Ingestion of one 250 ml glass of milk (⁴⁰ K)	0.06
Ingestion of one Banana (⁴⁰ K)	0.1
Annual External Exposure during Precipitation Events (Gamma Radiation from Naturally Occurring Radon Gas Decay Products)	4
Airplane Travel	3 per half-hour flight
Dental X-ray	10
Chest X-ray	70

¹ Data taken from Tables 4.6.1, 4.6.2 and 4.8.1.

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4.8 Background Public Dose Data

The objective in assessing a dose to an actual public critical group is to calculate the most reasonable estimate of the dose that a group of individuals living in the vicinity of each OPG nuclear site may receive. This calculated dose is then available for use by OPG, the CNSC and the general public as a basis on which to judge the acceptability of the facilities operations. It should be noted that it is not the role of this document to make this judgement beyond simple comparisons with natural and human-made background radiation sources and existing legislative limits to the public.

In late 2002, Dr. R.L. Grasty of Gamma-Bob Incorporated was hired by OPG to update the information available on Canadian public doses from naturally occurring sources.

[R-53] A review of historic information was performed as well as new ground gamma ray surveys carried out over the roads in four major Canadian cities. A scientific paper documenting this work was published in 2004 in the International Journal "Radiation Protection Dosimetry". **[R-54]** A summary of the results contained in these two reports is presented below:

Table 4.8.1 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	1,256	926	757	667	3,225	565	565
External	480	219	178	278	176	154	154
Total	2,422	1,769	1,554	1,564	4,022	1,338	1,338

- Notes:**
- 1 In addition to naturally occurring radiation, the public also receives about 70 μSv effective dose from human-made sources such as nuclear weapon test fallout, and exposures from technological processes and consumer products and services. Thus, the total background dose in Canada from naturally occurring and human-made sources is 1,840 μSv/year.
 - 2 The annual public legal limit in Canada is 1,000 μSv dose from human-made sources.
 - 3 The legal limit of 1,000 μSv per year is over and above the dose the public already receives from the natural environment (Table 4.8.1. above) and from that received from medical treatments (about 1,100 μSv on a per caput basis in Canada) on an annual basis.

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4.8.1 Natural External Terrestrial Dose

The Canadian annual external dose of 219 μSv is considerably lower than the worldwide average of 480 μSv estimated by UNSCEAR. [R-55] In order to put the Canadian results into perspective, it is useful to study the typical North-American ranges in outdoor effective dose due to naturally occurring potassium, uranium and thorium in the ground.

In the period 1975-1983, the United States Department of Energy conducted the National Uranium Resource Evaluation Program. [R-56] This program included airborne gamma ray surveys of most of the United States. Maps of the potassium, uranium and thorium concentration of the ground were compiled from the digital data. [R-57] In the mid-1970's, a similar program called the Uranium Reconnaissance Program was carried out in Canada. [R-58]

The Geological Survey of Canada (GSC) has recently combined the US data with those from Canada and produced maps of the potassium, uranium and thorium concentration of the ground and the outdoor air absorbed dose rate in nano-grays per hour. In order to compare the results of the present study with those from Canada and the United States, the potassium, uranium and thorium concentration data were recompiled to produce a colour map of the annual outdoor effective dose. The resulting map prepared by Sander Geophysics represents the average annual effective doses averaged over areas of 10 km x 10 km. See Figure C7 in Appendix C. The distribution of all the measurements that were used to make the map is presented graphically in Figure 4.8.1.

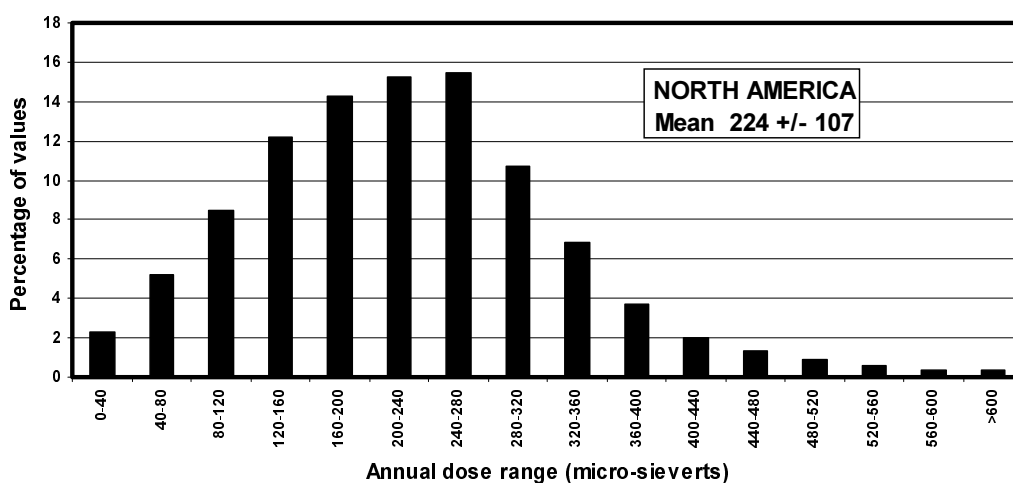


Figure 4.8.1 Distribution of Annual External Terrestrial Dose For North America

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The map for Canada and the US (Figure C7 in Appendix C) shows that there are large variations in annual outdoor effective dose. In Canada, some of the lowest levels of around 20-40 μSv are found in the Athabasca sandstones of northern Saskatchewan, while the highest level of 1,424 μSv is in the Northwest Territories. It should be noted that this maximum value of 1,424 μSv represents an average value for an area of 10 x 10 km but is increased to 2,335 μSv when using the original airborne data that were averaged over an area of 2 x 2 km.

The difference between the minimum and maximum values of the original airborne data represents a variation of more than a factor of one hundred. The highest natural levels found in the Northwest Territories are well above those found by the airborne surveys around major Canadian cities or by the road surveys of the four cities (Figures 4.8.2 through 4.8.5). If this natural level was the result of industry introduced radiation, there would be many places in northern Canada that would exceed the allowable public legal limit set by the Canadian Nuclear Safety Commission of 1,000 μSv .

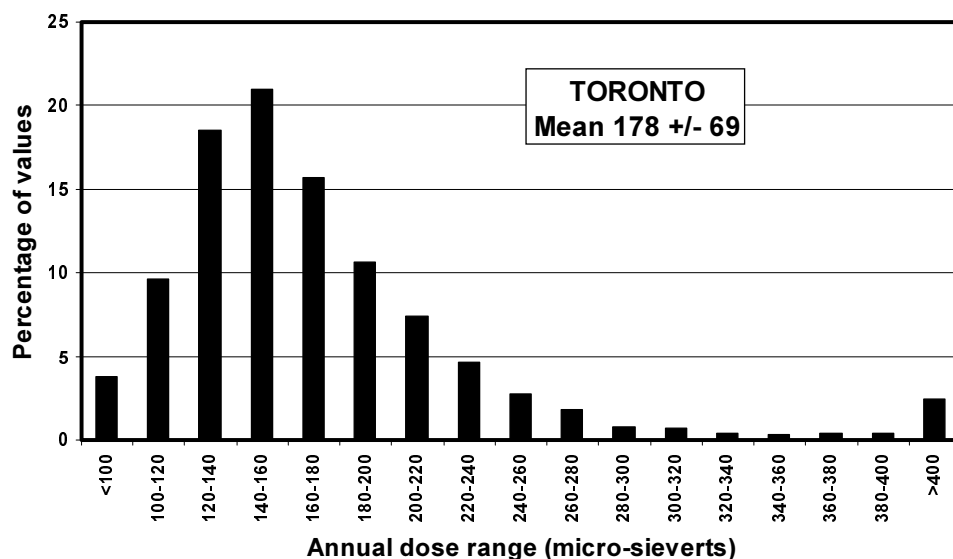


Figure 4.8.2 Distribution of Annual External Terrestrial Dose for Toronto

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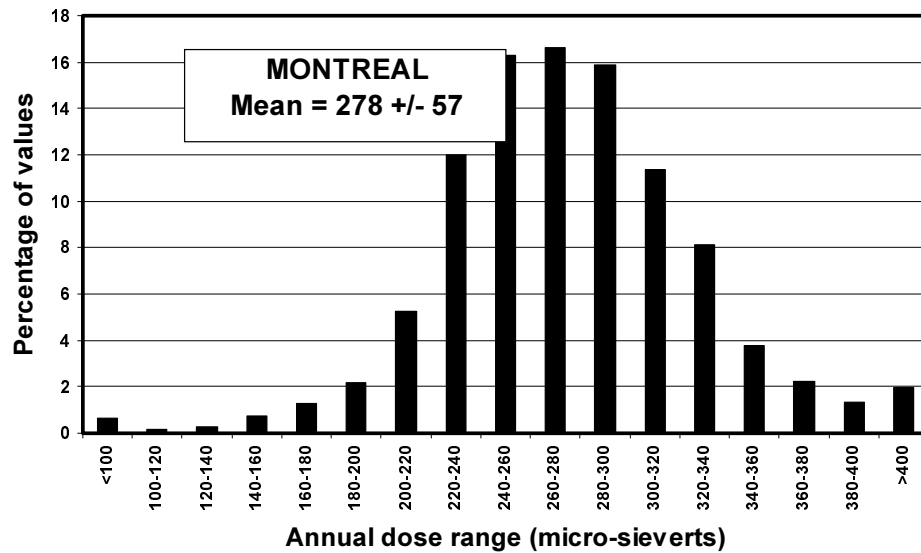


Figure 4.8.3 Distribution of Annual External Terrestrial Dose for Montreal

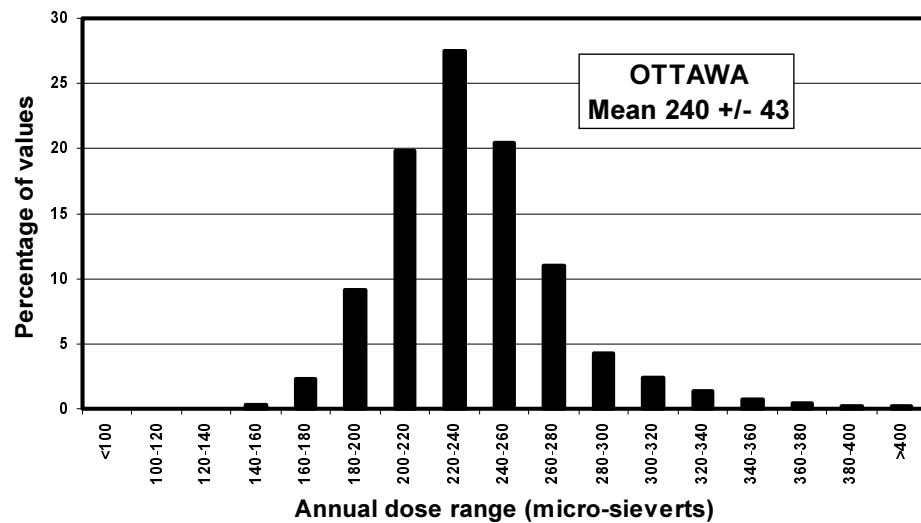


Figure 4.8.4 Distribution of Annual External Terrestrial Dose for Ottawa

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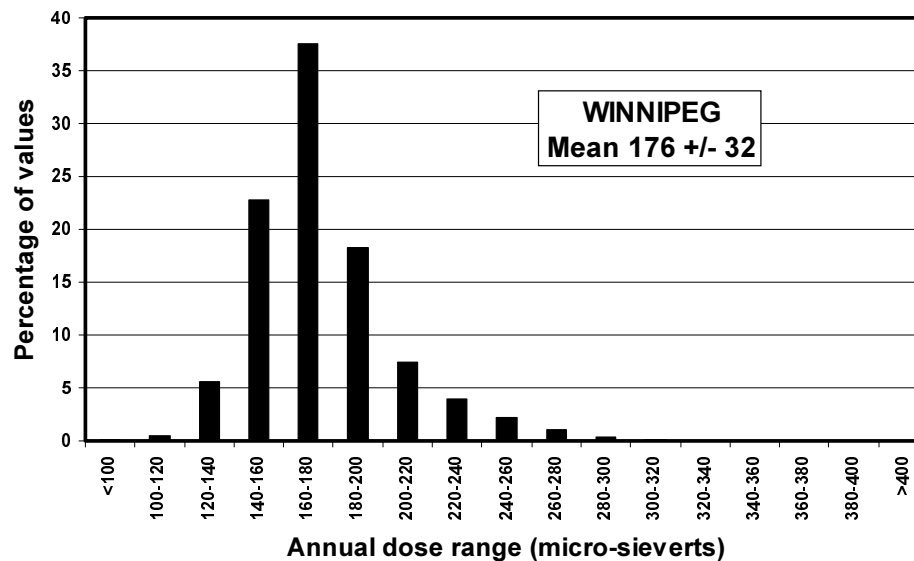


Figure 4.8.5 Distribution of Annual External Terrestrial Dose for Winnipeg

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4.8.2 Natural Radon and Thoron Inhalation Dose in Canada

Radon-222 (^{222}Rn) commonly called radon is an inert radioactive gas produced by the decay of uranium-238 (^{238}U). This radioactive gas can travel through the ground and enter buildings where it decays into radioactive particles. Through normal breathing, these radioactive particles (radioactive decay products) can result in significant dose to the respiratory tract. There is also a small component of dose originating from another radon isotope, ^{220}Rn , commonly called thoron that is produced by the decay of ^{232}Th . The concentration of radon and thoron in a home will depend on the uranium and thorium content of the surrounding soil, the soil porosity, the proportions of ^{222}Rn and ^{220}Rn that escapes from the soil particles and the moisture content of the surrounding soil. It will also depend on the house construction and on people's living habits (e.g. whether windows are kept open or closed, etc.). Consequently, there can be large differences in radon and thoron concentrations in individual homes.

In the summers of 1977 and 1978, the Radiation Protection Bureau of Health Canada, carried out a total of 9999 measurements of radon and radon daughter concentrations in 14 Canadian cities. [R-59] In subsequent years, measurements were made in an additional five cities. [R-60] In this report, the results from the total of approximately 14,000 homes are used to derive an average annual Canadian dose from inhalation of radon.

Both radon isotopes are also present in outdoor air though generally at much lower concentrations than in indoor air. This outdoor component to the total dose must also be considered. The annual radiation dose from this component of natural radiation is estimated from measurements of ^{222}Rn made in 31 communities across Canada. [R-61]

4.8.3 Cosmic Radiation Dose in Canada

A large component of the radiation dose to the human population arises from high-energy cosmic radiation entering earth's atmosphere. A computer program (CARI-6), developed by the Civil Aerospace Medical Institute (CAMI) of the Federal Aviation Administration (FAA) was used to calculate the outdoor cosmic radiation levels for the 21 largest cities in Canada, based on their longitudes, latitudes and elevations above sea level. [R-62]

In order to compensate for variations in cosmic radiation due to the 11-year solar cycle, the values were averaged over 4 solar cycles starting in 1958. These values ranged from a low of 348 μSv for Victoria, British Columbia close to sea level, to a high of 556 μSv for Calgary, Alberta at an elevation of 1,048 m. The population weighted average outdoor annual effective dose for Canada was calculated to 379 μSv .

Buildings provide some shielding against cosmic radiation but the shielding factor will depend on the structure and composition of building materials. UNSCEAR has suggested a shielding factor of 0.8 for cosmic radiation. [R-55] Using this shielding factor and an indoor occupancy factor of 0.8, this lowers the annual total effective dose

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for Canada to 318 μSv . The fact that most of the Canadian population lives close to sea level explains the lower Canadian dose from cosmic radiation compared to the worldwide average of 380 μSv reported by UNSCEAR. **[R-55]** In order to put the Canadian results into perspective, a map of annual outdoor effective dose for cosmic radiation has been produced for Canada and the United States. See Figure C8 in Appendix C.

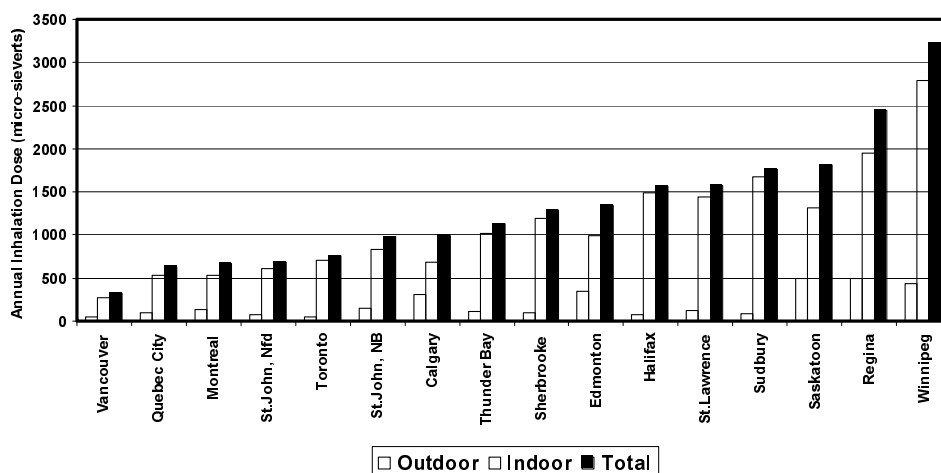


Figure 4.8.6 Annual Inhalation Dose from Radon Gas and its Decay Products in Major Canadian Cities

The total inhalation dose varies considerably from city to city across Canada. Figure 4.8.6 shows the total annual inhalation dose from ^{222}Rn and ^{220}Rn for 16 Canadian cities where both indoor and outdoor radon measurements have been made. This figure shows that the annual inhalation dose for Winnipeg (3,225 μSv) is almost 10 times higher than the value for Vancouver (326 μSv) and more than four times the value for Toronto (757 μSv). As shown in Table 4.8.1, this is primarily due to differences in indoor radon.

The high indoor radon levels for Winnipeg and also for Regina and Saskatoon can be attributed to the generally low rainfall in the Prairie Provinces and the associated low moisture content of the ground. This low moisture content allows radon to migrate easily through the ground and into homes. In addition, Regina and Winnipeg are situated on glacial lake clays. In summer, these clays dry out and produce fractures that act as radon pathways through the ground.

Large variations were also found in summer outdoor radon concentrations across Canada with Winnipeg, Regina and Saskatoon being up to ten times higher than Toronto or Vancouver. The high 1990 outdoor values for the prairies were attributed to the unusually dry summer. Measurements carried out the following year in Calgary, Edmonton and Winnipeg showed that the summer outdoor radon levels in these three cities had decreased as much as seven times.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**4.8.4 Public Terrestrial Dose and Radon Dose Near the DN and PN Sites**

A special study was carried out by Dr. R.L. Grasty of Gamma - Bob in 2001 under contract to OPG to determine public radiological doses from natural sources in the vicinity of the Darlington and Pickering nuclear sites. Two aspects of naturally occurring background radiation were examined, public terrestrial dose from radionuclides in the soil and public dose from exposure to radon gas and its daughter products.

The annual outdoor effective dose from natural sources of radiation in the ground for the Darlington and Pickering area residents was estimated from the airborne gamma ray survey carried out in the fall of 1999 over both OPG nuclear sites. **[R-63] [R-64]**

The outdoor effective dose rates at the time of the survey were calculated from the measured ground activities of ^{40}K and the ^{238}U and ^{232}Th decay series using internationally accepted conversion coefficients.

Maps of the annual outdoor effective dose were generated for both DN and PN sites and are presented in Figures C5 and C6 in Appendix C.

The maps clearly show that the populated areas are lower in radioactivity than the open area of farmland, forests and parks. This is because the materials used in the construction of roads, parking lots and buildings are generally made of low radioactivity limestone. Based on the data it was calculated that the annual adult effective dose from potassium, uranium and thorium in the ground on average was about 152 μSv for urban residents and about 172 μSv for rural residents (e.g., farmers) in the Pickering area.

The same calculations for the Darlington area yield annual effective adult doses from potassium, uranium and thorium in the ground on average at about 154 μSv for urban adults (e.g., towns of Bowmanville, Newcastle, and Oshawa) and 172 μSv for rural adults (e.g., farmers).

There is a very large range of outdoor effective doses in the rural farm areas around both the DN and PN sites as seen in Figures C6 and C7. The largest values of annual effective dose range up to 220-250 μSv over fairly large sections of land, well above the average of 172 μSv .

The annual effective dose from radon (^{222}Rn and ^{220}Rn) for Pickering area residents was estimated from measurements taken in homes in nearby Scarborough in 1993/1994. **[R-65]**

The average basement value at 37 Bq/m^3 was reduced by a factor of 0.6 to allow for differences in the ^{222}Rn concentrations between basements and living areas. Using an equilibrium factor of 0.33 between ^{222}Rn and its decay products, the annual effective dose due to ^{222}Rn was established to be 514 μSv . This value includes a small contribution of 57 μSv from ^{222}Rn in the outdoor air. Based on typical ratios between

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^{222}Rn and ^{220}Rn , it was estimated that the annual effective dose from ^{220}Rn was $43\ \mu\text{Sv}$. Thus, the total radon public annual effective dose in the vicinity of the PN site is estimated to be about $565\ \mu\text{Sv}$. [R-64]

4.8.5 Public Radon Dose due to Precipitation

Radon-222 is a radioactive gas having a relatively long half-life of 3.8 days. It can, therefore, travel considerable distances in air. The radioactive decay products of radon gas present in the air are charged particles and attach to small dust particles (aerosols), also present in the air. These aerosols act as nuclei on which rain can form. When it rains or snows, the small radioactive particles in the precipitation are brought down and deposited on the ground. Consequently, this significantly increases the natural radioactivity levels at the ground level, which is normally due solely to potassium, uranium and thorium decay series radionuclides in the soil.

Figure 4.8.7 is a screen dump from the GR150 network monitoring system and shows the measured increases above background in air kerma dose rate due to typical precipitation events (naturally occurring) and typical noble gas releases (operations based). As shown, measured noble gas peaks are typically an order of magnitude lower than those recorded for radon precipitation events and are much shorter in duration when they occur. The measurements were made by the Exploranium monitor located at air monitoring station #2 at the PN site in November 2001. Normal background levels under dry conditions are in the range of 20-25 nGy/h due to naturally occurring radionuclides in the soil as discussed above. The annual dose resulting from all precipitation events was calculated for 1999 by looking at the area under each precipitation peak recorded throughout the year. It was calculated that in 1999, the annual air kerma dose due to these short-term increases from rain or snow was about 5.6 nGy. This translates into an effective dose of about $4\ \mu\text{Sv}$. [R-64]

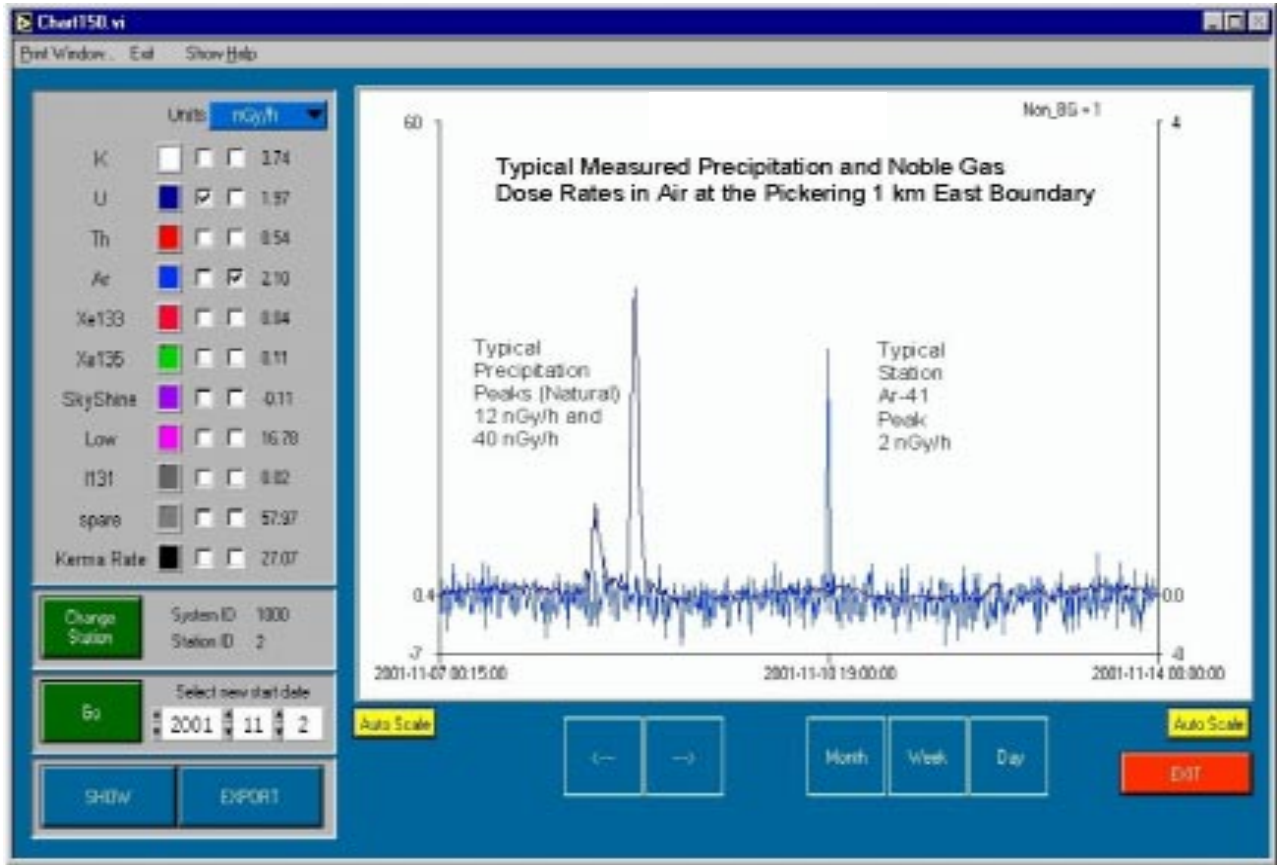
By way of comparison, the public critical group dose at the DN and PN sites in 2003 was $1.7\ \mu\text{Sv}$ and $4.7\ \mu\text{Sv}$, respectively.

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Figure 4.8.7 Typical Measured Precipitation and Noble Gas Dose Rates in Air at the Pickering 1-km East Boundary



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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**5.0 QUALITY ASSURANCE PROGRAMS**

OPG Nuclear is committed to an effective Quality Assurance (QA) program to ensure the REMP is carried out at the highest quality to fulfill the following objectives:

- To meet the CNSC license commitment for the operation of OPG's nuclear generating stations, and,
- To provide best estimates of radiation doses to the public in the vicinity of the OPG generation sites.

The QA program embraces all activities in the laboratory and field involving sample collection, sample availability, laboratory analysis, laboratory quality control, and external laboratory comparison. This section provides an overview of quality assurance activities that are critical to ensure the quality of the REMP data.

5.1 Sample Availability

This indicator is provided to track 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. The following are the types of samples commonly collected in the vicinity of the OPG Nuclear sites:

- (a) Ambient air effluents
- (b) Precipitation and dust fallout
- (c) Environmental Gamma (i.e., TLD's and Exploranium Monitors)
- (d) Water from local drinking water supply plants and wells
- (e) Aquatic samples consisting of lake water, fish and lake sediment
- (f) Terrestrial samples consisting of milk, honey, fruits and vegetables.

The sample availability percentage is determined by dividing the number of valid sample analyses by the number of planned sample analyses for each REMP site. The overall sample availability for year 2003 was 99 percent for PN, and 97 percent for the DN and the Provincial Background REMP's. These are all above the minimum performance target of 90 percent. A historic trend of the sample availability for program years 1999-2003 is provided in Figure 5.1 below.

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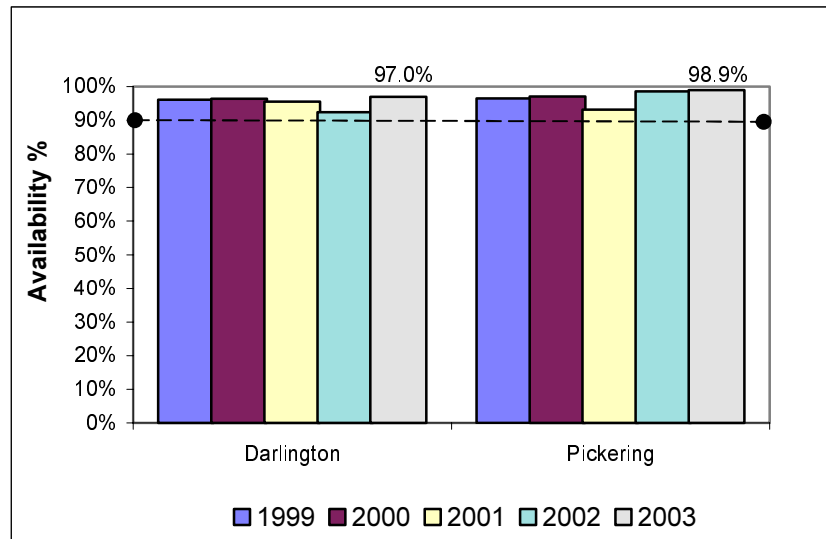


Figure 5.1 REMP Sample Availability for the OPG Sites (1999-2003)

As indicated in Table 5.1 below, the availability of sample types from various environmental pathways vary from 77 percent to 100 percent. Despite some sample types having sample availability under 90 percent (refer to Table 5.1 footnotes for details), the overall sample availability for Darlington Nuclear REMP, Pickering Nuclear REMP, and Provincial Background REMP are all greater than the target of 90 percent, which indicates that the quality of the program is not compromised.

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Table 5.1 Detailed Breakdown of REMP Sample Availability by Sample Types

Sample Types	Collection Frequency	Darlington Nuclear				Pickering Nuclear				Provincial Controls			
		Locations	Plan	Actual	Availability	Locations	Plan	Actual	Availability	Locations	Plan	Actual	Availability
Atmospheric													
Tritium-in-Air and Carbon-14 in Air (Molecular Sieves)	Monthly (H3, C-14)	8	132	124	94%	12	180	177	98%	2	48	44	92%
Tritium-in-Air and Carbon-14 in Air (Passive Samplers)	Quarterly (H3, C-14)	14	104	93	89% ¹	11	82	77	94%	6	48	46	96%
External Gamma (TLD's)	Quarterly (Gamma)	10	40	40	100%	12	48	48	100%	12	48	46	96%
External Gamma (GR150 Monitor))	Monthly (Gamma)	6	72	64	89% ²	9	108	104	96%				
Precipitation	Monthly (H3)	21	200	199	100%	17	169	169	100%	3	33	33	100%
Dry Fallout	Monthly (Gross Beta)	8	96	95	99%	10	120	120	100%				
Drinking Water													
Lake Water (Supply Plants)	Weekly Composite (H3)	2	96	96	100%	5	240	240	100%				
	Monthly Composite (Gross Beta)	2	24	24	100%	5	60	60	100%				
Residents Wells/Cisterns	Monthly (H3)	17	204	200	98%	13	148	148	100%				
	Quarterly Composite (Gross Beta)	17	68	67	99%	8	30	30	100%				
Drinking Water	Quarterly (H3, Gross Beta)									17	136	134	99%

¹ Passive Samplers (Carbon-14 and tritium in Air) for Darlington Nuclear had a sample availability of 89%. During the Upgrade to the Darlington Nuclear (DN) Radiological Environmental Monitoring Program (REMP) the passive samplers were installed late (i.e., Second Quarter 2003). In addition, the analytical procedure used during the first half of 2003 to recover Carbon Dioxide from the samples did not work very well resulting in several poor results (i.e., invalid data). The procedure has since been modified (use of different acid) which has stabilized and increased recovery of Carbon Dioxide.

² Exploranium (GR-150) Monitors for the DN REMP had a sample availability of 89%. Inadequate procedures and staff resources of contractor resulted in long response times to fix/reset intermittent monitor problems. This resulted in lower than acceptable monitor performance for several months. Improved procedures and maintenance support are being incorporated into a revised contract.

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Table 5.1 Detailed Breakdown of REMP Sample Availability by Sample Types-Continued

Sample Types	Collection Frequency	Darlington Nuclear				Pickering Nuclear				Provincial Controls			
		Locations	Plan	Actual	Availability	Locations	Plan	Actual	Availability	Locations	Plan	Actual	Availability
Aquatic													
Fish	Annual (HTO, C-14, Gamma Scan) & Annual Composite (OBT)	2	63	63	100%	1	50	50	100%	2	100	100	100%
Sediments	Annual (Gamma Scan) & Annual Composite (C-14, Organic Carbon, Particle Size Distribution)	3	17	14	82% ³	4	24	24	100%	4	22	22	100%
Lake Water	Monthly (H3) and Quarterly (Gross Beta)	3	36	35	97%	3	27	27	100%				
Terrestrial													
Milk	Weekly Composite (Gamma Scan)	5	52	51	98%	3	52	52	100%				
	Monthly Composite (H3, C14, OBT)	5	120	120	100%	3	84	84	100%				
		Quarterly (H3, C-14, Gamma Scan)									2	24	21
Fruits	Annual & Annual Composite (H3, C-14, OBT), Monthly (OBT)	19	38	38	100%	10	22	22	100%	1	3	3	100%
Vegetables	Annual & Annual Composite (H3, C-14, OBT), Monthly (OBT)	20	42	42	100%	16	37	35	95%	6	47	44	94%
Honey	Annual (H3, C-14, Gamma Scan, OBT)	6	18	15	83% ⁴	4	13	10	77% ⁶				
Sewage and Ash	Weekly (Gamma Scan)					1	52	52	100%				
	Quarterly Composite (H3, C14)					1	8	8	100%				
	Monthly (Gamma Scan)					1	12	12	100%				
Soil and Beach Sand/Silt	Annual (Gamma Scan)	5	8	7	88% ⁵	6	6	6	100%	3	10	10	100%
OVERALL SITE SAMPLE AVAILABILITY			1430	1387	97.0%		1572	1555	98.9%		519	503	96.9%

3 Sample availability for Darlington REMP sediment samples was 82%. The sediment samples obtained near Darlington Nuclear contained a substantial amount of mussel shells. After sample processing the sample was in a form that was not suitable for current lab analysis techniques.

4 Honey sample availability for Darlington REMP was 83% for 2003. The beekeeper mistakenly supplied an incorrect honey sample (i.e., mixture of honey from many apiary locations), instead of the separate honey sample from the apiary of interest. As such the sample was not analysed.

5 Sample availability for Darlington REMP soil and beach sand was 88% for 2003. One sample of beach sand was inadvertently not collected (i.e., missed sample).

6 Honey sample availability for the Pickering REMP was 77% for 2003. The reason is that one of the apiaries and the backup apiary locations did not have honey for 2003. Due to the hot dry summer the bees left the hives.

7 Milk sample availability for the Provincial Background REMP was 88% in 2003. The Dairy Farm in Belleville sold his herd with out notice. As such, a milk sample for the first quarter of 2003 was not obtained from Belleville. A replacement Dairy farm in Belleville was added to the program in the second quarter of 2003.

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5.2 Laboratory Analysis

A total of 3,445 laboratory analyses were reported for the year 2003. The analyses covered tritium, gross beta, ^{14}C , ^{131}I , TLD gamma, OBT, gamma scan, organic carbon, and particle size distribution. The DN site accounted for 40.3 percent of the total number of sample analyses, while PN and Provincial programs accounted for 45.1 percent and 14.6 percent, respectively. The detailed breakdown for the radiological analyses is presented in the Table 5.2 below and as percentage breakdown in Figure 5.2.1.

Table 5.2 Detailed Breakdown of Laboratory Analyses for REMP in 2003

Laboratory Analysis	Number of Sample Analyses for Each REMP Site			
	DN (Upgraded)	PN (Upgraded)	Provincial (Upgraded)	Total Analyses
Tritium	790	850	201	1841
Gross Beta	195	210	67	472
^{14}C	198	162	102	462
^{131}I	51	52	7	110
TLD Gamma / Ext Gamma	104	152	46	302
Gamma Scan – ^{95}Nb , ^{152}Eu ^{134}Cs , ^{137}Cs , ^{40}K , ^{60}Co , ^{95}Zr	44	105	58	207
OBT	3	20	18	41
Organic Carbon and Particle Size Distribution	2	4	4	10
Site Totals	1,387	1,555	503	3,445

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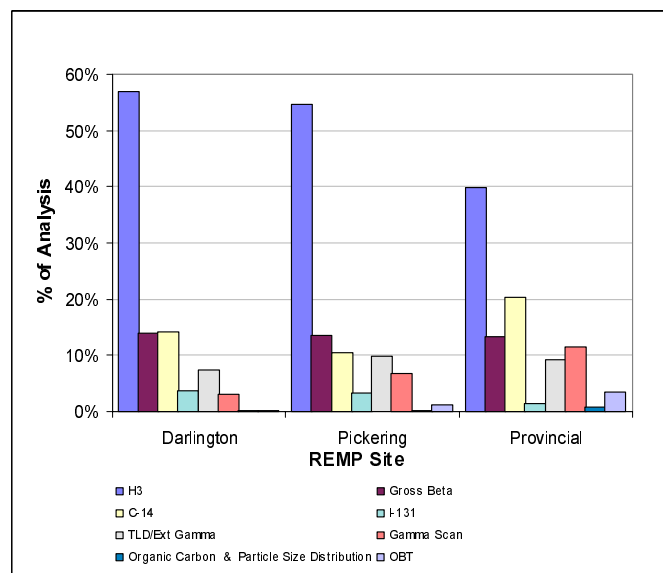


Figure 5.2.1 Percent Breakdown of Analysis for the REMP Sites

A historical trend of the annual number of sample analyses performed for each site is shown in Figure 5.2.2.

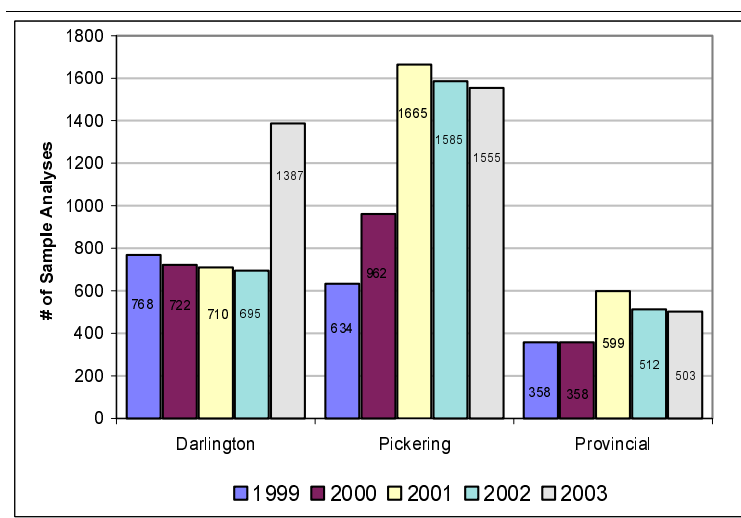


Figure 5.2.2 Annual Number of Sample Analyses for the REMP Site (1999-2003)

- Note:**
- (1) Pickering Nuclear REMP was upgraded in 2001.
 - (2) Provincial Background REMP was upgraded in 2001.
 - (3) Darlington Nuclear REMP was upgraded in 2003.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**5.3 Laboratory Quality Assurance and Quality Control**

The OPG Health Physics Laboratory is in compliance with the requirements for C-106, Technical and Quality Assurance Requirements for Dosimetry Services, CNSC. In addition, the operation of the Laboratory is consistent with the following documentation, which is part of the requirements for a CNSC Category II Dosimetry License application:

- Dosimetry Quality Assurance Program, N-REP-03416.3-0478.
- Dosimetry Quality Assurance Manual, N-MAN-03416.3-0020.
- Analytical Limits and Quality Control in the OHN Health Physics Laboratories, ESD-HPD-95-04.

Details of the Laboratories QA/QC program for the REMP are presented Table 5.3.

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Table 5.3 Laboratory Quality Assurance and Quality Control Plan

Analysis	Medium	Reality Checks		External Benchmarks		Process Control			Quality Control		
		Historical	Relative	Interlab	Audit	Bias	Precision	Bkgd	Acceptance	Spikes	Controls
TLD	Environmental TLD	X	X	NRCC	CNSC	Cals	Cals	Lab Controls	Plaques	X	Shipping
Tritium	OBT				CNSC	80 Bq/L	80 Bq/L	Blank	Cocktail / Blank	80 Bq/L	
	Water	X	X	Analytics	CNSC	Standard	Standard	Blank	Cocktail / Blank	80 Bq/L	Lab
	Air	X	X		CNSC	Standard	Standard	Blank	Cocktail / Blank	X	
Gross Beta	Water	X	X	Analytics	CNSC	Cs-137	Cs-137	Blank	Gas	Cs-137	
C-14	Produce (Milk/Fish/Vegetable)	X	X		CNSC	Coal	Coal	CO ₂		Sawdust	
Gamma Spec	Water	X	X	Analytics	CNSC	Mixed Gamma	Mixed Gamma	Mixed Gamma		Mixed Gamma	
	Sediment / Soil	X	X	Analytics	CNSC						
	I-131 in Milk	X	X	Analytics	CNSC						

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5.3.1 Laboratory Quality Control

Quality control samples are used to estimate the precision and accuracy of analytical results and to examine sources of error introduced by laboratory practices. There are two types of quality control samples used to accompany the analyses of the environmental samples collected for the REMP, process control samples and quality control standards. The process control samples are 'dead water' (radiation free water/blank) samples to be treated as real samples and will go through the same handling process as the real samples. The quality control 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 accompanied quality control samples are within $\pm 20\%$ of the known/expected values.

Based on the analytical results reported for 2003, the results of the quality control samples as shown in Table 5.4 were in the range from 92 percent to 114 percent for Tritium and from 91 percent to 106 percent for ^{14}C measurements. The results provide added confidence in terms of the quality of the data for the program and the consistency of the laboratory measurements.

Table 5.4 Results of Laboratory Quality Control Samples as Reported

Sample Types	Tritium		^{14}C	
	High	Low	High	Low
Air Effluent ¹	114%	88%	106%	91%
Drinking Water	110%	93%	NA	NA
Precipitation	108%	95%	NA	NA
Milk	107%	92%	103%	94%

NA – Not Applicable

¹ QC Percentage not available for ^{14}C in air for the passive ^{14}C samplers. Acceptable reference QC material not available. Health Physics Lab project started to locate/develop new QC material for this analysis.

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5.3.2 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 a laboratory operation including equipment calibration, analytical procedures, data review and internal quality control. These testing programs are a crucial part of the laboratory QA program and 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 2003. [R-66] The organizers of these programs were:

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

These programs involved the testing of tritium, gross alpha, beta, and gamma in water/drinking water, gamma emitters in milk, and in soil, and environmental Gamma measurements using Thermoluminescent Dosimeter (TLD). The results of these laboratory performances testing programs are presented below.

- (a) Analytics, Inc. Program

The test samples are supplied for the laboratory QA program on a quarterly basis. The results for 2003 are provided in Tables 5.5 to 5.10. A summary for each sample type is as follows:

- (1) Tritium in water - results meet test criteria.
- (2) Gross Beta in water – results meet the test criteria. However, the relative difference appears to have a persistent positive bias. This bias was also apparent for 2001 and 2002 test results. This bias is being investigated.
- (3) Gross Alpha in water – results meet test criteria.
- (4) Gamma emitters in milk – results meet test criteria.
- (5) Gamma emitters in water – results meet test criteria.
- (6) Gamma emitters in soil – results meet the test criteria.

The test limits are as follows:

$$\begin{aligned} -25\% \leq \text{Mean Relative Difference} \leq +50\% \\ \text{Relative Precision} \leq 40\% \end{aligned}$$

These test limits correspond to the *in vitro* accuracy specifications of the CNSC's S-106 dosimetry standard document.

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(b) NRCC Environmental Gamma QA Program

The laboratory performance testing program for environmental Gamma measurements is performed on a quarterly basis through independent exposure using TLD devices at irradiation facilities at the NRCC and at Health Physics Laboratory OPG Nuclear. It should be noted that the NRCC uses a different source of radiation (^{60}Co , compared to ^{137}Cs used by the OPG Nuclear) and this resulted in different responses for the measurements (a bias of -18 percent). The difference in response has not been taken into account in the mean relative response values reported in Table 5.11. If it is taken into account (i.e., the mean relative responses are increased by 18 percent), then the results are very good, and well within the performance criteria ANSI-N545-1975) (bias less than ± 30 percent).

Table 5.5 Analytics Test Results for Tritium in Water (pCi/L)

Quarter	Analytics Value	OPG Value	Mean Relative Difference (%)	Relative Precision (%)
Q1/2003	4,463	4,392	-1.5	1.5
Q2/2003	11,953	11,628	-2.7	1.5
Q3/2003	8,000	7,879	-1.5	1.4
Q4/2003	352	371	+5.4	8.1

Table 5.6 Analytics Test Results for Gross Beta in Water (pCi/L)

Quarter	Analytics Value	OPG Value	Mean Relative Difference (%)	Relative Precision (%)
Q1/2003	186	214	+15.0	4.7
Q2/2003	268	313	+16.8	1.0
Q3/2003	246	298	+21.0	2.7
Q4/2003	141	188	+33.3	5.3

Table 5.7 Analytics Test Results for Gross Alpha in Water (pCi/L)

Quarter	Analytics Value	OPG Value	Mean Relative Difference (%)	Relative Precision (%)
Q1/2003	61	70	+14.8	1.4
Q2/2003	49	60	+22.4	18.3
Q3/2003	36	34	-5.6	8.8
Q4/2003	51	50	-2.0	10.0

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Table 5.8 Analytics Test Results for Gamma in Milk (pCi/L)

2003		¹³¹ I	¹⁴¹ Ce	⁵¹ Cr	¹³⁴ Cs	¹³⁷ Cs	⁵⁸ Co	⁵⁴ Mn	⁵⁹ Fe	⁶⁵ Zn	⁶⁰ Co
Q1	Analytics Value	74	173	246	90	200	47	64	47	93	162
	OPG Value	75	169	222	82	209	45	68	52	99	166
	Mean Relative Difference (%)	+1.4	-2.3	-9.8	-8.9	+4.5	-4.2	+6.0	+10.6	+6.5	+2.4
	Relative Precision (%)	6.7	1.8	6.8	7.3	4.8	8.9	1.5	11.5	5.1	1.2
Q2	Analytics Value	103	283	239	103	230	93	186	99	181	132
	OPG Value	111	269	247	95	240	93	197	111	195	135
	Mean Relative Difference (%)	+7.8	-4.9	+3.3	-7.8	+4.3	0.0	+5.9	+12.1	+7.7	+2.3
	Relative Precision (%)	5.4	3.0	4.9	7.4	2.9	2.2	4.1	13.5	5.1	4.4
Q3	Analytics Value	74	86	233	119	88	99	93	79	176	123
	OPG Value	73	84	241	115	96	102	102	82	190	138
	Mean Relative Difference (%)	-1.4	-2.3	+3.4	-3.4	+9.1	+3.0	+9.6	+3.8	+7.9	+12.2
	Relative Precision (%)	2.7	4.8	11.6	3.5	3.1	2.9	4.9	6.1	3.7	3.6
Q4	Analytics Value	90	202	280	135	129	111	173	102	197	155
	OPG Value	ND ¹	192	257	127	133	115	181	110	202	154
	Mean Relative Difference (%)	ND ¹	-4.9	-8.2	-5.9	+3.1	+3.6	+4.6	+7.8	+2.5	-0.6
	Relative Precision (%)	ND ¹	4.7	15.2	3.1	4.5	3.5	2.8	6.4	3.5	3.9

¹ Iodine-131 results for the fourth quarter 2003 were not measured because sample delivery was delayed. By the time the samples were analyzed, the iodine had decayed.

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Table 5.9 Analytics Test Results for Gamma in Water (pCi/L)

2003		¹³¹ I	¹⁴¹ Ce	⁵¹ Cr	¹³⁴ Cs	¹³⁷ Cs	⁵⁸ Co	⁵⁴ Mn	⁵⁹ Fe	⁶⁵ Zn	⁶⁰ Co
Q1	Analytics Value	70	168	238	88	195	42	63	46	90	157
	OPG Value	67	167	238	82	199	45	66	45	97	165
	Mean Relative Difference (%)	-4.3	-0.6	0.0	-6.8	+2.1	+7.1	+4.5	-2.2	+7.7	+5.1
	Relative Precision (%)	17.9	4.7	3.4	4.8	3.0	4.5	6.0	8.9	N/A	3.6
Q2	Analytics Value	81	253	213	92	206	83	166	88	162	118
	OPG Value	97	244	229	90	214	84	172	94	176	119
	Mean Relative Difference (%)	+19.8	-3.6	+7.5	-2.1	+3.8	+1.2	+3.6	+6.8	+8.6	+0.8
	Relative Precision (%)	8.2	1.2	10.4	3.3	2.8	2.4	1.7	6.4	5.7	3.4
Q3	Analytics Value	76	81	221	113	84	94	88	75	166	117
	OPG Value	72	77	225	105	91	99	95	80	184	130
	Mean Relative Difference (%)	-5.3	-4.7	+1.8	-7.5	+8.3	+5.3	+7.9	+6.1	+10.6	+10.8
	Relative Precision (%)	2.0	8.4	12.0	1.3	2.1	8.4	1.7	5.4	4.3	6.1
Q4	Analytics Value	ND¹	61	189	127	121	104	162	96	184	145
	OPG Value	61	184	265	122	126	102	168	100	177	144
	Mean Relative Difference (%)	ND ¹	-2.6	+1.1	-3.9	+4.1	-1.9	+3.7	+4.1	-3.8	-0.7
	Relative Precision (%)	ND ¹	3.8	13.6	5.8	4.8	4.9	1.2	7.0	6.8	0.7

¹ Iodine-131 results for the fourth quarter 2003 were not measured because sample delivery was delayed. By the time the samples were analyzed, the iodine had decayed.

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Table 5.10 Analytics Test Results for Gamma in Soil (pCi/g)

2003		¹⁴¹ Ce	⁵¹ Cr	¹³⁴ Cs	¹³⁷ Cs	⁵⁸ Co	⁵⁴ Mn	⁵⁹ Fe	⁶⁵ Zn	⁶⁰ Co
Q1	Analytics Value	0.358	0.508	0.186	0.497	0.096	0.133	0.098	0.192	0.335
	OPG Value	0.365	0.509	0.174	0.546	0.095	0.156	0.097	0.254	0.359
	Mean Relative Difference (%)	+1.9	+0.2	-6.5	+10.4	-1.0	+17.2	-0.1	+32.3	+7.1
	Relative Precision (%)	5.5	1.7	4.0	3.1	10.5	7.1	5.1	33.5	1.7
Q2	Analytics Value	0.310	0.262	0.113	0.359	0.102	0.204	0.108	0.199	0.145
	OPG Value	0.248	0.212	0.090	0.348	0.086	0.185	0.093	0.180	0.136
	Mean Relative Difference (%)	-20.0	-19.1	-20.3	-3.1	-15.6	-9.3	-13.8	-9.5	-6.2
	Relative Precision (%)	3.2	6.6	4.4	4.0	4.7	2.7	4.3	2.2	5.1
Q3	Analytics Value	0.193	0.525	0.269	0.305	0.222	0.209	0.178	0.395	0.278
	OPG Value	0.165	0.457	0.222	0.305	.197	0.214	0.164	0.379	0.269
	Mean Relative Difference (%)	-14.5	-12.9	-17.5	0.0	-11.3	+2.3	-7.9	-4.1	-3.2
	Relative Precision (%)	4.8	1.8	5.0	3.6	2.0	3.3	3.7	2.4	2.2
Q4	Analytics Value	0.323	0.449	0.217	0.319	0.177	0.277	0.164	0.315	0.248
	OPG Value	0.283	0.373	0.185	0.305	0.162	0.260	0.146	0.291	0.222
	Mean Relative Difference (%)	-12.4	-16.9	-14.7	-4.4	-8.5	-6.3	-11.0	-7.6	-10.5
	Relative Precision (%)	5.3	8.8	2.2	3.3	1.2	5.4	7.5	3.8	1.8

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Table 5.11 Relative Response and Correlation for Environmental Gamma (mR)

Quarter	Source	Exposure Levels	Mean Measured Exposure	Mean Relative Response	Coefficient of Variation
Q1/2003	⁶⁰ Co	35/107	31.5/94.8	-11	6.9
Q2/2003	⁶⁰ Co	34.1/103.4	28.1/84.0	-18	3.2
Q3/2003	⁶⁰ Co	33.3/100	27.6/82.6	-17	4.5
Q4/2003	⁶⁰ Co	32.5/98	27.7/81.4	-16	3.5

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**5.4 Self Assessment of Quality Assurance Program**

The Ontario Power Generation Health Physics Laboratory (HPL) conducted three self-assessments of their quality assurance program in 2003 as follows:

- Self assessment of HPL document control. HPL performed a review of the document control requirements in their quality assurance manual and compliance with provisions. The findings showed improvements were required in four areas, leading to these recommendations:
 - (i) Include requirements for hand written changes in laboratory procedures.
 - (ii) Include procedures for changes to external documents in the quality assurance manual.
 - (iii) Establish well marked location for easy access of laboratory procedures.
 - (iv) Need to link laboratory procedure on procedure maintenance to governance.

A corrective action plan is in place to implement the above recommendations.
- Self assessment of the Change Control process utilized in the Health Physics Laboratory. The assessment concluded that there were several change control processes available, and that there is some uncertainty as to the circumstances which each applies to. A corrective action plan is in place to rationalize business processes used to initiate, assess, and document changes to HPL processes, and that the affected documentation be revised accordingly.
- Assessment of Documentation of Standard Radioisotope Solution. A review of the documentation to establish traceability of radioisotope standards preparations was conducted. The findings determined the need to improve maintenance of records and increase detail in some laboratory procedures. Corrective actions have been completed.

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5.5 Quality Assurance Program Developments

The ENVISTA software, which is a commercial laboratory information management software (LIMS) package containing a QA/QC module, is expected to become operational in 2004.

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Appendix A: Radiological Units

Exposure

1 roentgen (R) = 2.58×10^{-4} coulomb/kg-air (no equivalent SI unit defined but exposure to about 114 roentgen (R) gives an absorbed dose in air of 1 gray (Gy))

Absorbed Dose

1 gray (Gy) = 1 joule/kg absorbed dose

1 gray (Gy) = 100 rad

1 milligray (mGy) = 100 millirad (mrad)

Effective Dose

1 sievert = 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 (s^{-1})

1 curie (Ci) = 3.7×10^{10} disintegration's per second

1 curie (Ci) = 37 gigabecquerel (GBq)

1 becquerel (Bq) = 27 picocurie (pCi)

1 millicurie (mCi) = 37 megabecquerel (MBq)

1 nanocurie (nCi) = 37 becquerel (Bq)

1 picocurie (pCi) = 37 millibecquerel (mBq)

1 mCi·km⁻²·month⁻¹ = 37 Bq·m⁻²·month⁻¹

Dose per Unit Intake

1 mrem per pCi intake = $\frac{1}{3,700} \cdot \text{Sv} \cdot \text{Bq}^{-1}$

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Appendix B: Glossary of Acronyms and Symbols

⁴¹ Ar	- Argon-41
⁷ Be	- Beryllium-7
¹⁴ C	- Carbon-14
¹³⁴ Cs	- Cesium-134
¹³⁷ Cs	- Cesium-137
⁶⁰ Co	- Cobalt-60
CO ₂	- Carbon Dioxide
³ H	- Tritium (Hydrogen-3)
¹³¹ I	- Iodine-131
¹⁹² Ir	- Iridium-192
⁵⁴ Mn	- Manganese-54
⁹⁵ Nb	- Niobium-95
⁴⁰ K	- Potassium-40
²²⁰ Rn	- Radon-220
²²² Rn	- Radon-222
²³² Th	- Thorium-232
²³⁸ U	- Uranium-238
¹³³ Xe	- Xenon-133
¹³⁵ Xe	- Xenon-135
⁶⁵ Zn	- Zinc-65
AECL-CRL	- Atomic Energy of Canada Limited – Chalk River Laboratories
Bq	- Becquerel
BN	- Bruce Nuclear
BP	- Bruce Power
CAMI	- Civil Aerospace Medical Institute
CANDU	- Canadian Deuterium Uranium
CNSC	- Canadian Nuclear Safety Commission, previously known as the Atomic Energy Control Board
CSA	- Canadian Standards Association
DN	- Darlington Nuclear
DN1-4	- Reactors 1 through 4 at the Darlington Nuclear Site
ED	- Environment Division
FAA	- Federal Aviation Administration
GSC	- Geological Survey of Canada
Gy	- Gray
H ₂ O	- Water
HPL	- Health Physics Laboratory (Whitby, Ontario)
HT	- Elemental Tritium
HTO	- Tritium Oxide
ICRP	- International Commission on Radiological Protection
IMPACT	- Integrated Model for Probabilistic Assessment of Contaminated Transport
Ka	- Atmospheric Dilution (or Dispersion) Factor (s/m ³)
Lc	- Critical Level

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Ld	- Detection Limit
LIMS	- Laboratory Information Management Software
MWe	- Megawatts, electrical
MWhe	- Megawatt-hours, electrical
MOE	- Ministry of the Environment (Ontario)
NaI	- Sodium Iodide
NGS	- Nuclear Generating Station
NRCC	- National Research Council of Canada
OBT	- Organically Bound Tritium
ODWO	- Ontario Drinking Water Objective
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
QA	- Quality Assurance
QC	- Quality Control
REMP	- Radiological Environmental Monitoring Program
RPD	- Radiation Protection Division
TFWT	- Tissue Free Water Tritium
TLD	- Thermoluminescent Dosimeter
TRF	- Tritium Removal Facility (DN)
TS	- Transformer Station
UNSCEAR	- United Nations Scientific Committee on the Effects of Atomic Radiation
US	- United States
USEPA	- United States Environmental Protection Agency
WPCP	- Water Pollution Control Plant
WSP	- Water Supply Plant
WWMF	- Western Waste Management Facility

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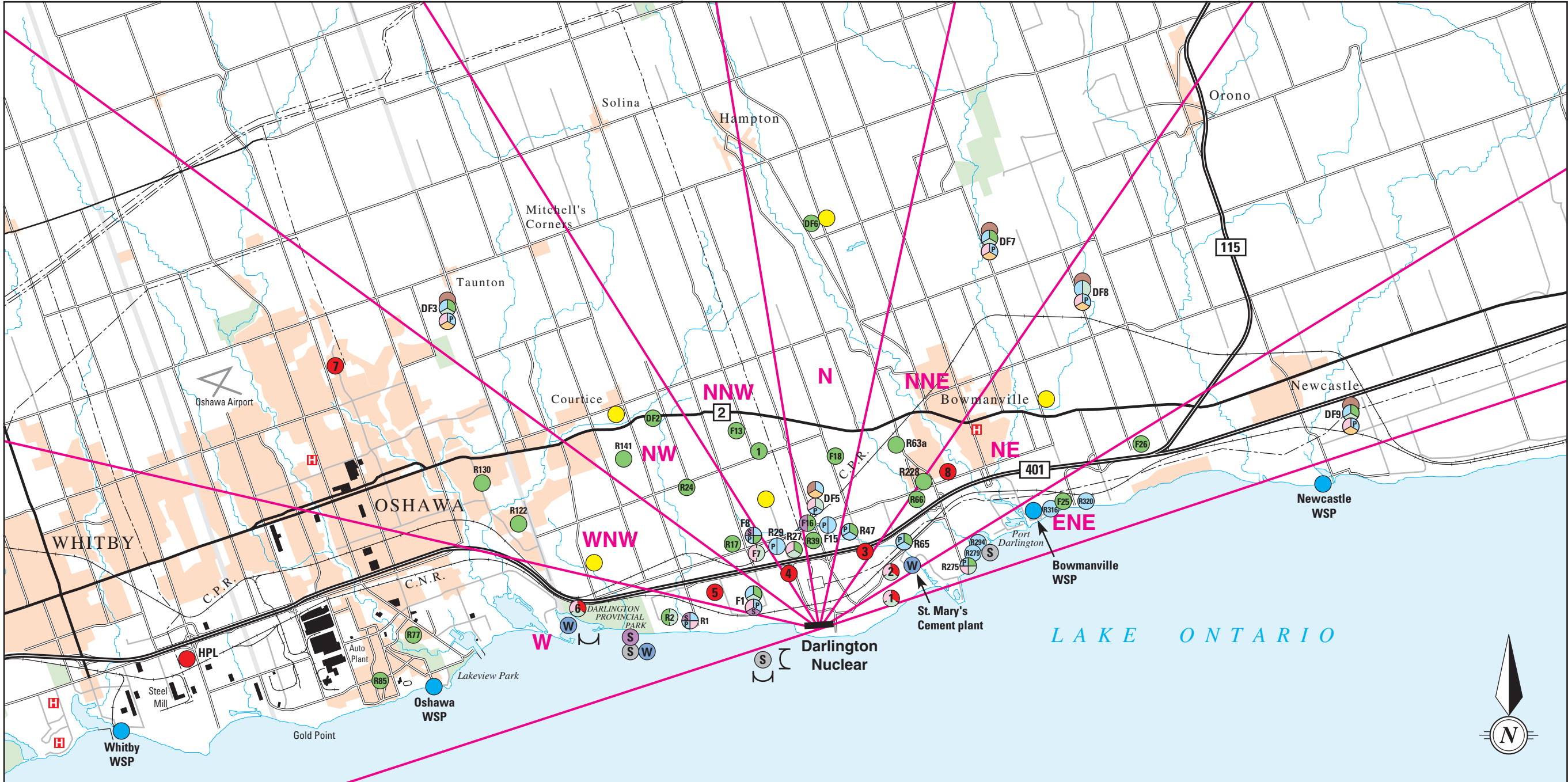
Appendix C: Maps of Environmental Monitoring Locations

Figure C1
Location of Ontario Power Generation Installations



FIGURE G2

DARLINGTON ENVIRONMENTAL MONITORING LOCATIONS



Info. as of March, 2004

LEGEND

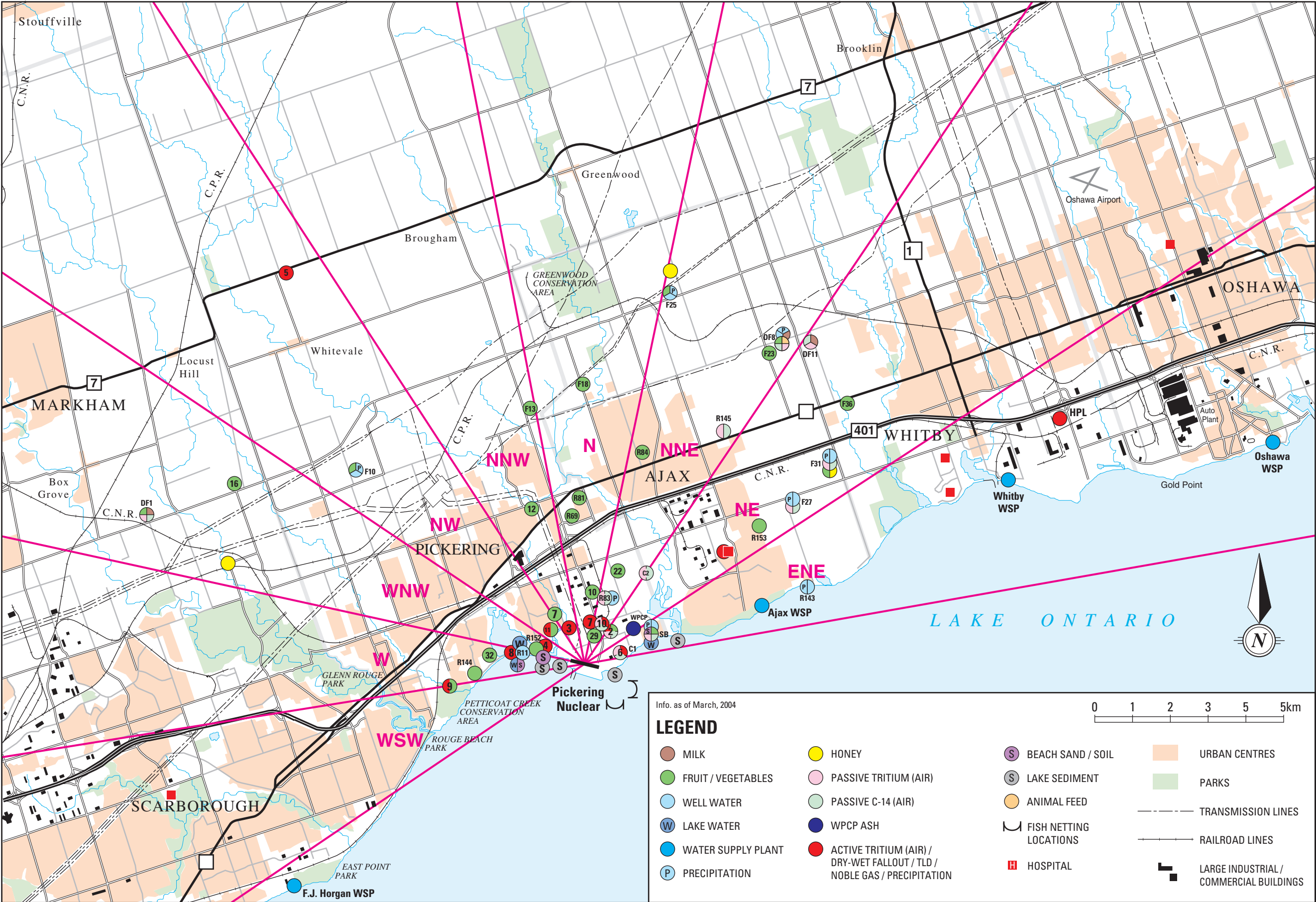
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|--------------------|--|------------------------|---|
| MILK | HONEY | BEACH SAND / SOIL | URBAN CENTRES |
| FRUIT / VEGETABLES | PASSIVE TRITIUM (AIR) | LAKE SEDIMENT | PARKS |
| WELL WATER | PASSIVE C-14 (AIR) | ANIMAL FEED | TRANSMISSION LINES |
| LAKE WATER | WPCP ASH | FISH NETTING LOCATIONS | RAILROAD LINES |
| WATER SUPPLY PLANT | ACTIVE TRITIUM (AIR) / DRY-WET FALLOUT / TLD / NOBLE GAS / PRECIPITATION | HOSPITAL | LARGE INDUSTRIAL / COMMERCIAL BUILDINGS |
| PRECIPITATION | | | |

NOTE: 1) Active Tritium (air) only at HPL Monitoring Site.

3) TLD's at locations R275 and DF5.

FIGURE C3

PICKERING ENVIRONMENTAL MONITORING LOCATIONS



R.C. Harris WSP (21 km WSW of PN site)

NOTE: 1) Active Tritium (air) only at Ajax Hospital and HPL.
2) Noble Gas monitors at Air Monitoring Stations 2 3 4 6 7 8 9 10 and 11

3) TLD's at location SB and C2.
4) Active Carbon-14 (air) at Air Monitoring Stations 2 6 and 10

5) Squires Beach (SB) Sample at R115, R116, R120, R122, R124, R125, and R127.

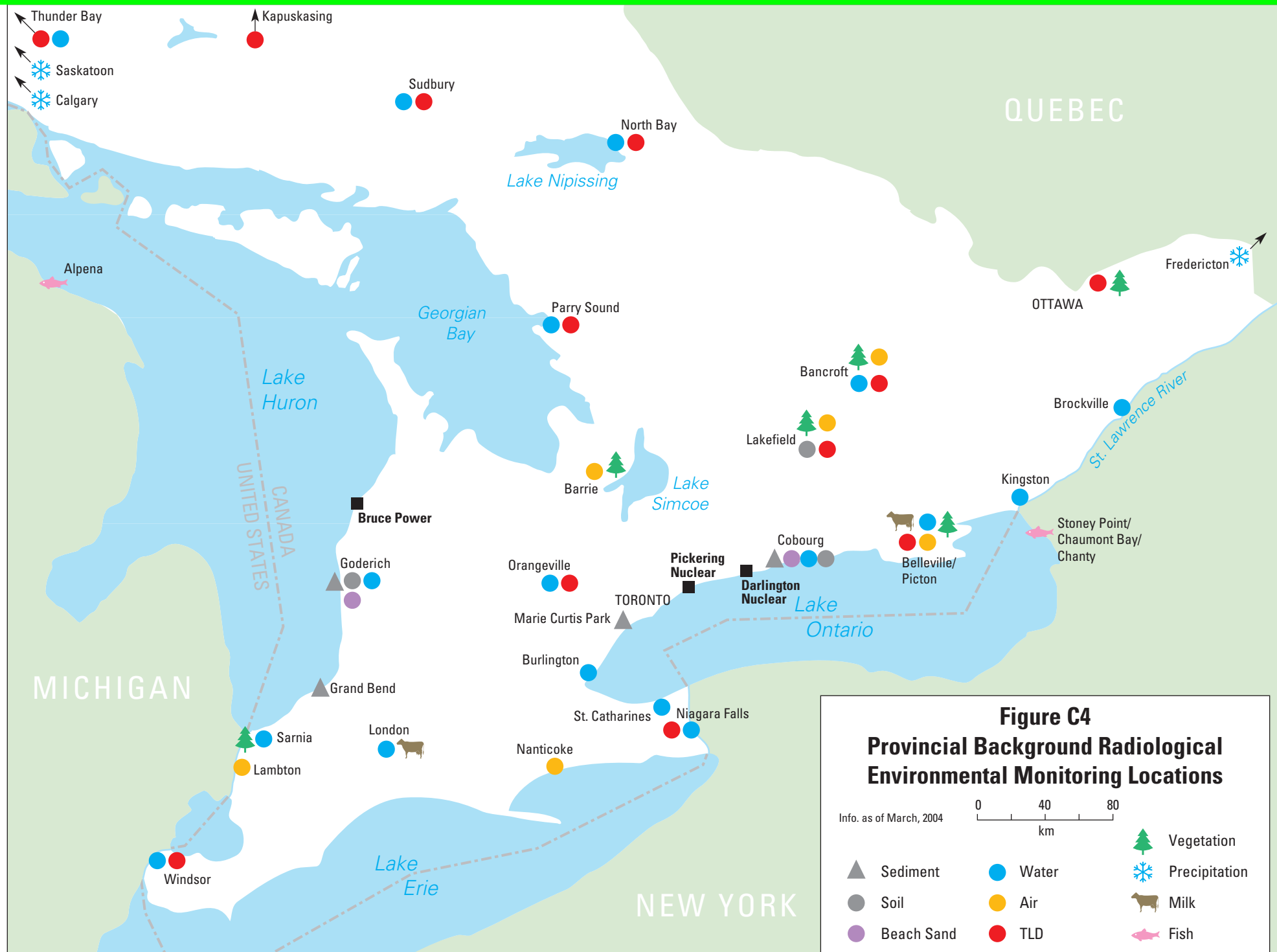


Figure C5

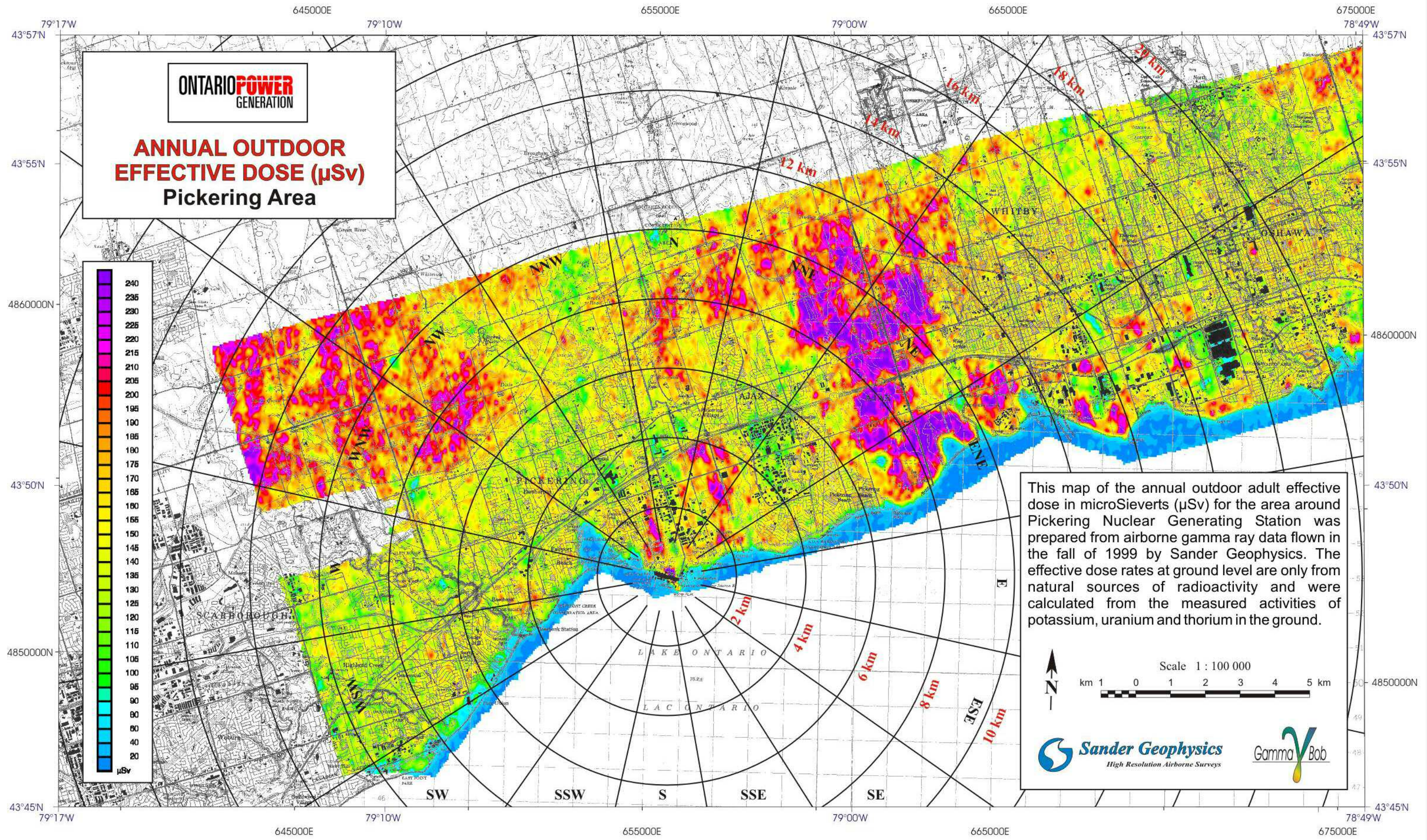
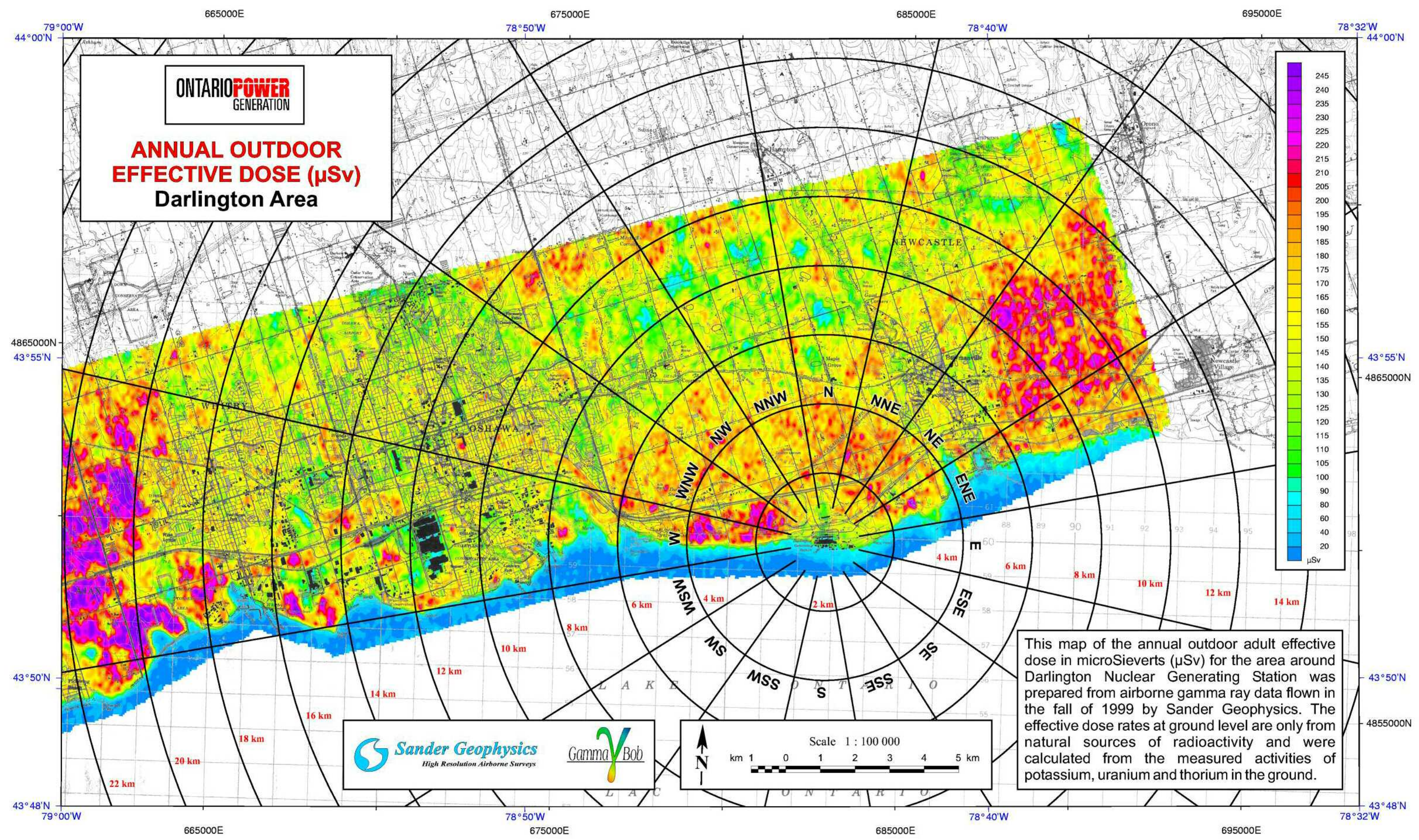
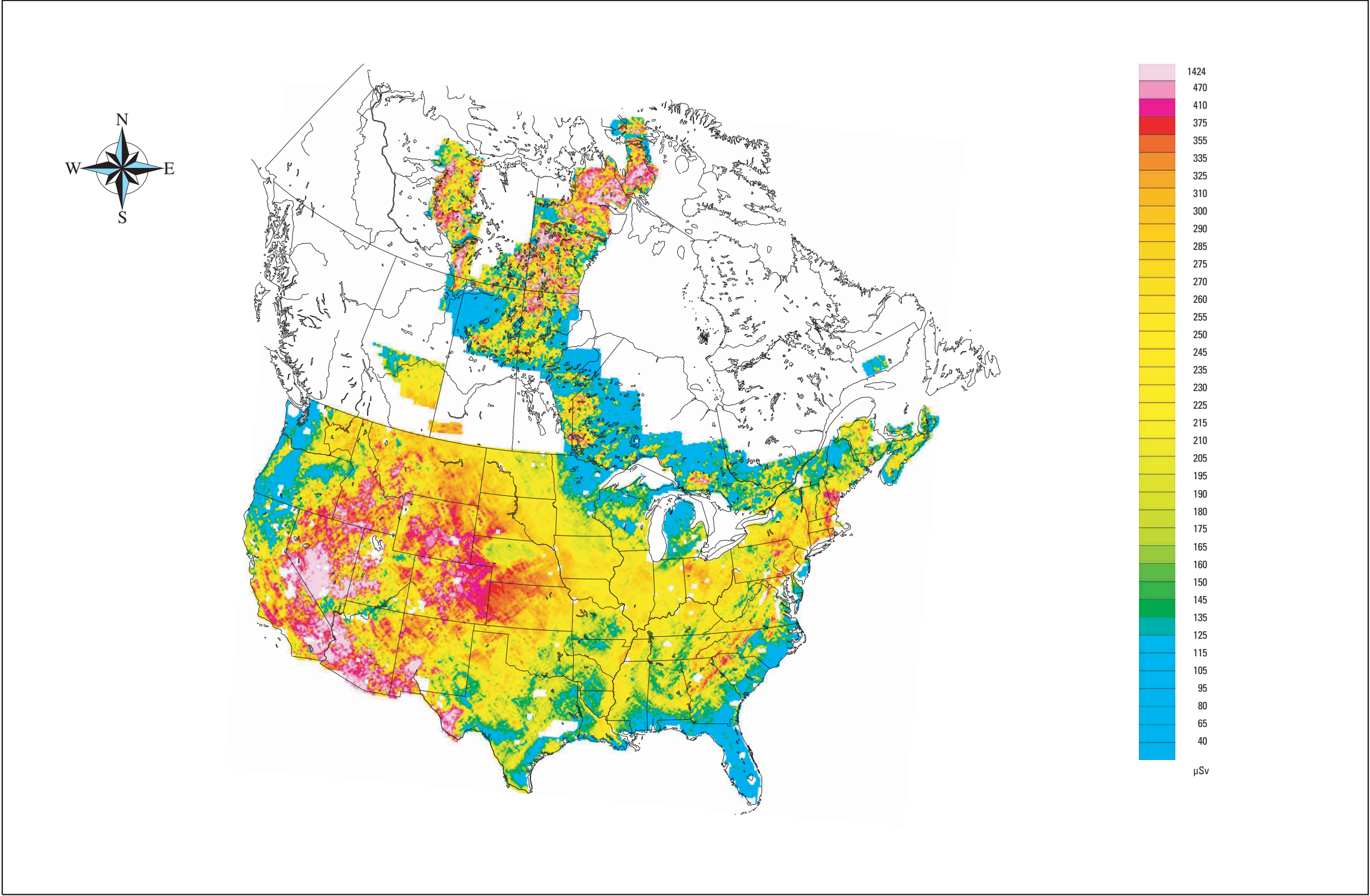


Figure C6



The annual outdoor effective dose for Canada and the United States from available airborne gamma ray survey data.



Gamma Ray Spectrometer Data

Figure C7

Annual Outdoor
Effective Dose
(μSv)

This map of the annual outdoor effective dose for Canada and the United States was derived from ground concentrations of potassium, uranium and thorium, determined by airborne gamma-ray spectrometry. The airborne surveys were conducted in the 1970's under national programs by the Geological Survey of Canada (Uranium Reconnaissance Program) and the US Department of Energy (National Uranium Resource Evaluation program). The data were assembled by the Radiation Geophysics Section, Geological Survey of Canada. The United States data were provided to the GSC by Joseph S. Duval (U.S. Geological Survey). The Canadian data were obtained from the NATGAM database, Natural Resources Canada.



kilometres 5.00 0 10.00 20.00 kilometres

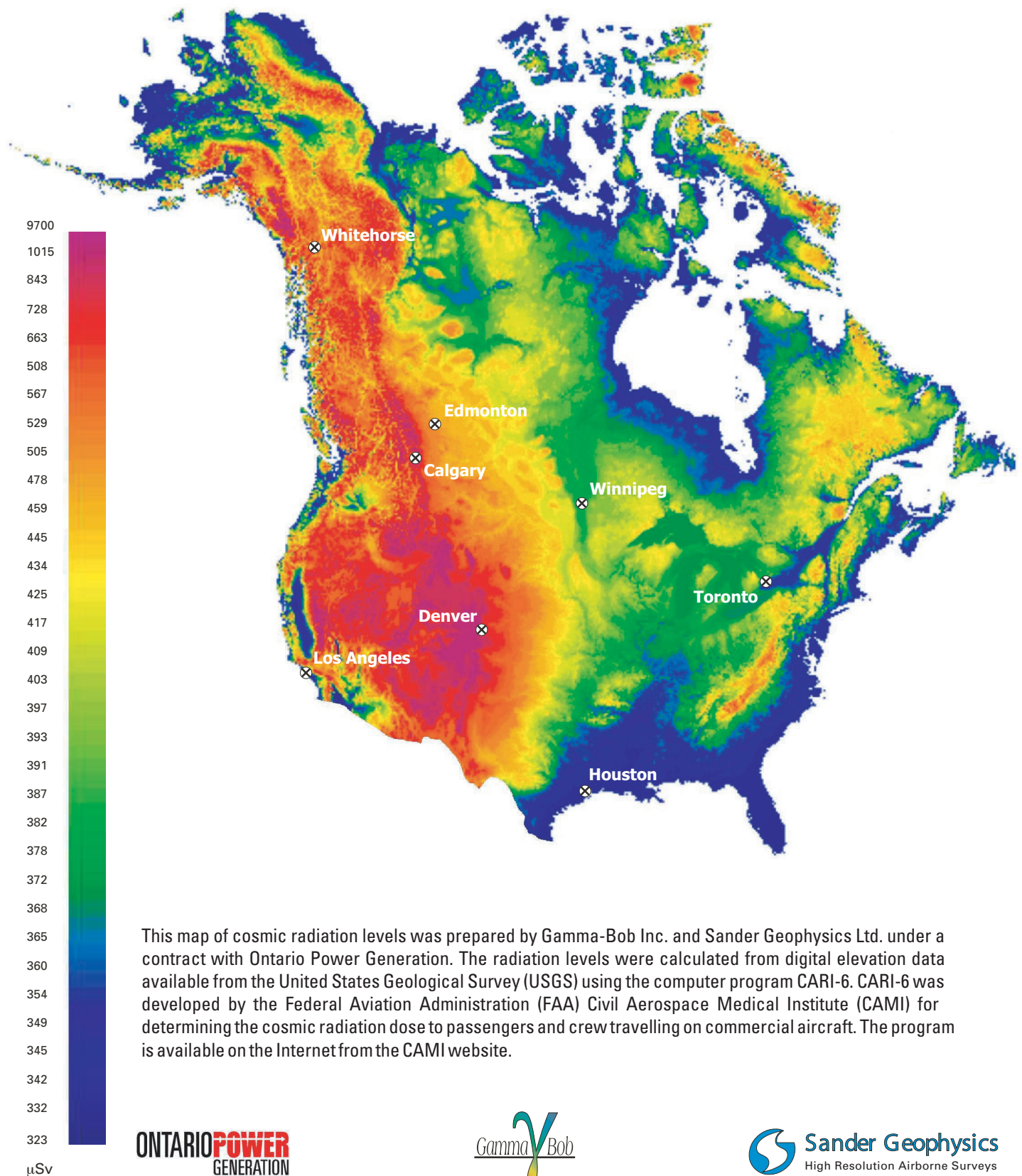
GEOLOGICAL SURVEY OF CANADA



COMMISSION GÉOLOGIQUE DU CANADA



Figure C8
Annual Outdoor Effective Dose from Cosmic Radiation
(microsieverts)



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**Appendix D: Tables of Radionuclide Concentration Data and Public Doses by
Pathway/Radionuclide at DN and PN Critical Group Locations**

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Table D1 Provincial Camper Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	0.88	0.03	0.85	Bq/m ³	Bq/m ³	1	8.50E-01
Air	HT	3.53E-01	0	3.53E-01	Bq/m ³	Bq/m ³	1	3.53E-01
Air	Iodine	7.61E-07	0	7.61E-07	Bq/m ³	Bq/m ³	1	7.61E-07
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	3.67E-07
Air	C-14	258.3	240	18.3	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	1.28E-02
Fruit	Tritium	64	3	61	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	5.49E+01
Fruit	C-14	2.78E+02	240	3.80E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	2.66E+00
Vegetables	Tritium	4.62E+01	2.5	4.37E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	3.93E+01
Vegetables	C-14	365.0	240	125.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	8.75E+00
Lake (Osh WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03
Lake (Beach)	Tritium	8.8	1.9	6.9	Bq/L	Bq/m ³	1000	6.90E+03
Lake (McLaughlin Bay)	Tritium	2.84E+01	1.9	2.65E+01	Bq/L	Bq/m ³	1000	2.65E+04
Fish (McLaughlin Bay)	Tritium	3.33E+01	4.5	2.88E+01	Bq/L (free water)	Bq/kg	0.9	2.59E+01
Fish (McLaughlin Bay)	C-14	253.0	240	13	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	1.63E+00
Fish (McLaughlin Bay)	Cs-137	0.14	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.24	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

***Note:** Camper fruits and vegetables are obtained from farms therefore the same value is used as that for the farm Critical Group.

Footnotes to this table are found at the bottom of Table D15.

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Table D2 Rural Resident Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	0.82	0.03	0.79	Bq/m ³	Bq/m ³	1	7.90E-01
Air	HT	3.29E-01	0	3.29E-01	Bq/m ³	Bq/m ³	1	3.29E-01
Air	Iodine	7.09E-07	0	7.09E-07	Bq/m ³	Bq/m ³	1	7.09E-07
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	3.42E-07
Air	C-14	270	240	30	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	2.10E-02
Fruit	Tritium	41.1	3	38.1	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	3.43E+01
Fruit	C-14	2.91E+02	240	5.10E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	3.57E+00
Vegetables	Tritium	3.03E+01	2.5	2.78E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.50E+01
Vegetables	C-14	287.0	245	42.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	2.94E+00
Well Water	Tritium	30.3	1.8	28.5	Bq/L	Bq/m ³	1000	2.85E+04
Lake (Beach)	Tritium	8.8	1.9	6.9	Bq/L	Bq/m ³	1000	6.90E+03
Lake (Osh WSP)	Tritium	6.70E+00	1.9	4.80E+00	Bq/L	Bq/m ³	1000	4.80E+03
Lake (Bow WSP)	Tritium	6.20E+00	1.9	4.30E+00	Bq/L	Bq/m ³	1000	4.30E+03
Fish	Tritium	37.3	4.5	32.8	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	282	240	42	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.33	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	2.40E-01	0.24	0.00E+00	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

* **Note:** Fruit and vegetables concentrations are used for silage since the rural residents are close to the site.

Footnotes to this table are found at the bottom of Table D15.

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Table D3 St. Mary's Cement Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	3.69	0.03	3.66	Bq/m ³	Bq/m ³	1	3.66E+00
Air	HT	1.48E+00	0	1.48E+00	Bq/m ³	Bq/m ³	1	1.48E+00
Air	Iodine	3.19E-06	0	3.19E-06	Bq/m ³	Bq/m ³	1	3.19E-06
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	1.54E-06
Air	C-14	311.3	240	71.3	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	4.99E-02
Lake (Bow WSP)	Tritium	6.2	1.9	4.3	Bq/L	Bq/m ³	1000	4.30E+03

Footnotes to this table are found at the bottom of Table D15.

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Table D4 Bowmanville Resident Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	0.36	0.03	0.33	Bq/m ³	Bq/m ³	1	3.30E-01
Air	HT	1.42E-01	0	1.42E-01	Bq/m ³	Bq/m ³	1	1.42E-01
Air	Iodine	3.07E-07	0	3.07E-07	Bq/m ³	Bq/m ³	1	3.07E-07
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	1.48E-07
Air	C-14	NA	240	NA	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	7.57E-03
Fruit	Tritium	26.3	3	23.3	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.10E+01
Fruit	C-14	252	240	12	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	8.40E-01
Vegetables	Tritium	11.8	2.5	9.3	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	8.37E+00
Vegetables	C-14	2.63E+02	240	2.30E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	1.61E+00
Lake (Bow WSP)	Tritium	6.20E+00	1.9	4.30E+00	Bq/L	Bq/m ³	1000	4.30E+03
Lake (Beach)	Tritium	8.8	1.9	6.9	Bq/L	Bq/m ³	1000	6.90E+03
Fish	Tritium	37.3	4.5	32.8	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	282	240	42	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.33	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.24	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

* Active sampler #8 used for the radionuclide in air concentrations since there are no passive samplers available at this location. Carbon – 14 based on passives.

Footnotes to this table are found at the bottom of Table D15.

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Table D5 West/East Beach Resident Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	1.6	0.03	1.57	Bq/m ³	Bq/m ³	1	1.57E+00
Air	HT	6.41E-01	0	6.41E-01	Bq/m ³	Bq/m ³	1	6.41E-01
Air	Iodine	1.38E-06	0	1.38E-06	Bq/m ³	Bq/m ³	1	1.38E-06
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	6.67E-07
Air	C-14	243.5	240	3.5	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	2.45E-03
Fruit	Tritium	31.9	3	28.9	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.60E+01
Fruit	C-14	2.54E+02	240	1.40E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	9.80E-01
Vegetables	Tritium	1.94E+01	2.5	1.69E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	1.52E+01
Vegetables	C-14	254.0	240	14.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	9.80E-01
Well Water	Tritium	10.6	1.8	8.8	Bq/L	Bq/m ³	1000	8.80E+03
Lake (Bow WSP)	Tritium	6.2	1.9	4.3	Bq/L	Bq/m ³	1000	4.30E+03
Lake (Beach)	Tritium	8.80E+00	1.9	6.90E+00	Bq/L	Bq/m ³	1000	6.90E+03
Fish	Tritium	3.73E+01	4.5	3.28E+01	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	282.0	240	42	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.33	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.24	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

* Fruit and vegetable concentrations are used for silage since the west/east beach is close to the site.

Footnotes to this table are found at the bottom of Table D15.

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Table D6 Oshawa Resident Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	0.52	0.03	0.49	Bq/m ³	Bq/m ³	1	4.90E-01
Air	HT	2.08E-01	0	2.08E-01	Bq/m ³	Bq/m ³	1	2.08E-01
Air	Iodine	4.51E-07	0	4.51E-07	Bq/m ³	Bq/m ³	1	4.51E-07
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	2.17E-07
Air	C-14	252	240	12	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	8.40E-03
Fruit	Tritium	32	3	29	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.61E+01
Fruit	C-14	2.67E+02	240	2.70E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	1.89E+00
Vegetables	Tritium	1.73E+01	2.5	1.48E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	1.33E+01
Vegetables	C-14	247.0	240	7.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	4.90E-01
Lake (Osh WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03
Lake (Beach)	Tritium	8.8	1.9	6.9	Bq/L	Bq/m ³	1000	6.90E+03
Fish	Tritium	3.73E+01	4.5	3.28E+01	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	2.82E+02	240	4.20E+01	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.3	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.24	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

* Active sampler #7 used for the radionuclide in air concentrations since there are no passive samplers available at this location. Carbon-14

Footnotes to this table are found at the bottom of Table D15.

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Table D7 Dairy Farm Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	0.3	0.03	0.27	Bq/m ³	Bq/m ³	1	2.70E-01
Air	HT	1.20E-01	0	1.20E-01	Bq/m ³	Bq/m ³	1	1.20E-01
Air	Iodine	2.59E-07	0	2.59E-07	Bq/m ³	Bq/m ³	1	2.59E-07
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	1.25E-07
Air	C-14	261	240	21	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	1.47E-02
Fruit	Tritium	14.8	3	11.8	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	1.06E+01
Fruit	C-14	2.35E+02	240	0.00E+00	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	0.00E+00
Vegetables	Tritium	1.02E+01	2.5	7.70E+00	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	6.93E+00
Vegetables	C-14	251.0	240	11.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	7.70E-01
Well Water	Tritium	5.70E+00	1.8	3.90E+00	Bq/L	Bq/m ³	1000	3.90E+03
Lake (Beach)	Tritium	8.80E+00	1.9	6.90E+00	Bq/L	Bq/m ³	1000	6.90E+03
Milk	Tritium	8.0	2.3	5.7	Bq/L	Bq/L	1	5.70E+00
Milk	C-14	256.2	240	16.2	Bq/kg-C	Bq/kg	0.066	1.07E+00
Silage	Tritium	36.5	2.5	34	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	3.06E+01
Silage	C-14	275	240	35	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	2.45E+00
Fish	Tritium	3.73E+01	4.5	3.28E+01	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	2.82E+02	240	4.20E+01	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.3	0.93	0.0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.2	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

Footnotes to this table are found at the bottom of Table D15.

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Table D8 Farm Radionuclide Concentrations – Darlington 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	1.16	0.03	1.13	Bq/m ³	Bq/m ³	1	1.13E+00
Air	HT	4.70E-01	0	4.70E-01	Bq/m ³	Bq/m ³	1	4.70E-01
Air	Iodine	1.00E-06	0	1.00E-06	Bq/m ³	Bq/m ³	1	1.00E-06
Air	Cs-137	0.0	0	0.0	Bq/m ³	Bq/m ³	1	4.84E-07
Air	C-14	284.3	240	44.3	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	3.10E-02
Fruit	Tritium	64	3	61	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	5.49E+01
Fruit	C-14	2.78E+02	240	3.80E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	2.66E+00
Vegetables	Tritium	4.62E+01	2.5	4.37E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	3.93E+01
Vegetables	C-14	365.0	240	125.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	8.75E+00
Well Water	Tritium	3.03E+01	1.8	2.85E+01	Bq/L	Bq/m ³	1000	2.85E+04
Lake (Beach)	Tritium	8.80E+00	1.9	6.90E+00	Bq/L	Bq/m ³	1000	6.90E+03
Fish	Tritium	37.3	4.5	32.8	Bq/L (free water)	Bq/kg	0.9	2.95E+01
Fish	C-14	282	240	42	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	5.25E+00
Fish	Cs-137	0.33	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	0.24	0.24	0	Bq/kg - dry weight	Bq/L	1.615	0.00E+00

* Fruit and vegetable concentrations are used for silage since the farm is close to the site.

Footnotes to this table are found at the bottom of Table D15.

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Table D9 Urban Resident Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	4.37	0.03	4.34	Bq/m ³	Bq/m ³	1	4.34E+00
Air	Iodine	1.37E-06	0	1.37E-06	Bq/m ³	Bq/m ³	1	1.37E-06
Air	Cs-137	3.03E-06	0	3.03E-06	Bq/m ³	Bq/m ³	1	3.03E-06
Air	C-14	NA	240	NA	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	3.10E-02
Fruit	Tritium	160.4	3	157.4	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	1.42E+02
Fruit	C-14	383	240	143	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	1.00E+01
Vegetables	Tritium	1.30E+02	2.5	1.27E+02	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	1.14E+02
Vegetables	C-14	3.54E+02	240	1.14E+02	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	7.98E+00
Well Water	Tritium	64.0	1.8	62.2	Bq/L	Bq/m ³	1000	6.22E+04
Lake (Ajax WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03
Lake (Beach Point Promenade)	Tritium	19	1.9	17.1	Bq/L	Bq/m ³	1000	1.71E+04
Fish	Tritium	2.76E+01	4.5	2.31E+01	Bq/L (free water)	Bq/kg	0.9	2.08E+01
Fish	C-14	2.93E+02	240	5.30E+01	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	6.63E+00
Fish	Cs-137	0.4	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	1.3	0.24	1.06	Bq/kg - dry weight	Bq/L	1.615	1.71E+00

* Active sampler #11 used for the radionuclide in air concentrations since there are no passive samplers available at this location. Carbon-14 based on passives.

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Table D10 Squires Beach Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	6.92	0.03	6.89	Bq/m ³	Bq/m ³	1	6.89E+00
Air	Iodine	2.18E-06	0	2.18E-06	Bq/m ³	Bq/m ³	1	2.18E-06
Air	Cs-137	4.80E-06	0	4.80E-06	Bq/m ³	Bq/m ³	1	4.80E-06
Air	C-14	326.5	240	86.5	Bq/kg-C	Bq/m ³	0.0007⁽¹⁾	6.06E-02
Fruit	Tritium	231	3	228	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.05E+02
Fruit	C-14	302	240	62	Bq/kg-C	Bq/kg	0.07⁽³⁾	4.34E+00
Vegetables	Tritium	1.55E+02	2.5	1.53E+02	Bq/L (free water)	Bq/kg	0.9⁽²⁾	1.38E+02
Vegetables	C-14	2.84E+02	240	4.40E+01	Bq/kg-C	Bq/kg	0.07⁽³⁾	3.08E+00
Well Water	Tritium	77.0	1.8	75.2	Bq/L	Bq/m ³	1000	7.52E+04
Lake (Squires Beach)	Tritium	29.3	1.9	27.4	Bq/L	Bq/m ³	1000	2.74E+04
Fish	Tritium	27.6	4.5	23.1	Bq/L (free water)	Bq/kg	0.9	2.08E+01
Fish	C-14	2.93E+02	240	5.30E+01	Bq/kg-C	Bq/kg	0.125⁽⁴⁾	6.63E+00
Fish	Cs-137	4.20E-01	0.93	0.00E+00	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	1.3	0.24	1.06	Bq/kg - dry weight	Bq/L	1.615	1.71E+00

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Table D11 Correctional Institute C1 Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	12.7	0.03	12.67	Bq/m ³	Bq/m ³	1	1.27E+01
Air	Iodine	4.00E-06	0	4.00E-06	Bq/m ³	Bq/m ³	1	4.00E-06
Air	Cs-137	8.80E-06	0	8.80E-06	Bq/m ³	Bq/m ³	1	8.80E-06
Air	C-14	429.8	240	189.8	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	1.33E-01
Lake (Ajax WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03

Table D12 Correctional Institute C2 Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	5.85	0.03	5.82	Bq/m ³	Bq/m ³	1	5.82E+00
Air	Iodine	1.84E-06	0	1.84E-06	Bq/m ³	Bq/m ³	1	1.84E-06
Air	Cs-137	4.06E-06	0	4.06E-06	Bq/m ³	Bq/m ³	1	4.06E-06
Air	C-14	330.8	240	90.8	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	6.36E-02
Lake (Ajax WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03

Footnotes to this table are found at the bottom of Table D15.

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003**Table D13 Industrial Park Radionuclide Concentrations – Pickering 2003**

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	25.9575	0.03	25.9275	Bq/m ³	Bq/m ³	1	2.59E+01
Air	Iodine	8.20E-06	0	8.20E-06	Bq/m ³	Bq/m ³	1	8.20E-06
Air	Cs-137	1.80E-05	0	1.80E-05	Bq/m ³	Bq/m ³	1	1.80E-05
Air	C-14	522.8	240	282.75	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	1.98E-01
Lake (Ajax WSP)	Tritium	6.7	1.9	4.8	Bq/L	Bq/m ³	1000	4.80E+03

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Table D14 Dairy Farm Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentraions	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	1.28	0.03	1.25	Bq/m ³	Bq/m ³	1	1.25E+00
Air	Iodine	4.03E-07	0	4.03E-07	Bq/m ³	Bq/m ³	1	4.03E-07
Air	Cs-137	8.88E-07	0	8.88E-07	Bq/m ³	Bq/m ³	1	8.88E-07
Air	C-14	263.0	240	23	Bq/kg-C	Bq/m ³	0.0007⁽¹⁾	1.61E-02
Fruit	Tritium	36	3	33	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.97E+01
Fruit	C-14	258	240	18	Bq/kg-C	Bq/kg	0.07⁽³⁾	1.26E+00
Vegetables	Tritium	3.60E+01	2.5	3.35E+01	Bq/L (free water)	Bq/kg	0.9⁽²⁾	3.02E+01
Vegetables	C-14	2.58E+02	240	1.80E+01	Bq/kg-C	Bq/kg	0.07⁽³⁾	1.26E+00
Well Water	Tritium	18.7	1.8	16.9	Bq/L	Bq/m ³	1000	1.69E+04
Milk	Tritium	2.75E+01	2.3	2.52E+01	Bq/L	same	1	2.52E+01
Milk	C-14	2.50E+02	240	1.04E+01	Bq/kg-C	Bq/kg	0.066⁽⁵⁾	6.86E-01
Hay	Tritium	58.3	2.5	55.8	Bq/L (free water)	Bq/kg	0.9⁽²⁾	5.02E+01
Hay	C-14	259	240	19	Bq/kg-C	Bq/kg	0.07⁽³⁾	1.33E+00
Fish	Tritium	27.6	4.5	23.1	Bq/L (free water)	Bq/kg	0.9	2.08E+01
Fish	C-14	2.93E+02	240	5.30E+01	Bq/kg-C	Bq/kg	0.125⁽⁴⁾	6.63E+00
Fish	Cs-137	4.20E-01	0.93	0.00E+00	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	1.3	0.24	1.06	Bq/kg - dry weight	Bq/L	1.615	1.71E+00

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Table D15 Farm Radionuclide Concentrations – Pickering 2003

Medium	Radionuclide	Local Concentrations	Background (Average Value)	Net Value	Reported Units	Required Units	Conversion Factor	Final Value
Air	Tritium	1.18	0.03	1.15	Bq/m ³	Bq/m ³	1	1.15E+00
Air	Iodine	3.71E-07	0	3.71E-07	Bq/m ³	Bq/m ³	1	3.71E-07
Air	Cs-137	8.18E-07	0	8.18E-07	Bq/m ³	Bq/m ³	1	8.18E-07
Air	C-14	243.5	240	3.5	Bq/kg-C	Bq/m ³	0.0007 ⁽¹⁾	2.45E-03
Fruit	Tritium	32.1	3	29.1	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.62E+01
Fruit	C-14	2.69E+02	240	2.90E+01	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	2.03E+00
Vegetables	Tritium	2.94E+01	2.5	2.69E+01	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	2.42E+01
Vegetables	C-14	284.0	240	44.0	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	3.08E+00
Well Water	Tritium	2.62E+01	1.8	2.44E+01	Bq/L	Bq/m ³	1000	2.44E+04
Hay	Tritium	58.3	2.5	55.8	Bq/L (free water)	Bq/kg	0.9 ⁽²⁾	5.02E+01
Hay	C-14	259	240	19	Bq/kg-C	Bq/kg	0.07 ⁽³⁾	1.33E+00
Fish	Tritium	2.76E+01	4.5	2.31E+01	Bq/L (free water)	Bq/kg	0.9	2.08E+01
Fish	C-14	293.0	240	53	Bq/kg-C	Bq/kg	0.125 ⁽⁴⁾	6.63E+00
Fish	Cs-137	0.42	0.93	0	Bq/kg - wet weight	Bq/kg - wet weight	1	0.00E+00
Beach Sand	Cs-137	1.30E+00	0.24	1.06E+00	Bq/kg - dry weight	Bq/L	1.615	1.71E+00

- (1) The amount of kg of carbon in 1m³ of air is 7×10^{-4} based on a 1990 value of CO₂ concentration in air of 354 ppmv.
- (2) The water content of a typical fresh fruit and vegetable diet is – 90% by weight.
- (3) The carbon content of a typical fresh fruit and vegetable diet (excluding wheat) – 7% by weight.
- (4) Average carbon content of edible portion of fish is – 12.5% of fresh weight.
- (5) Average carbon content of milk = 6.6% by weight.

See Table 4.3.1 for indication of which local concentrations are measured and which are modeled.

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Table D16: Darlington Farm Critical Group Doses - 2003

FARM		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	2.34E-06	3.01E-03	1.42E-07	2.94E-08	1.09E-01	4.07E-01	0.00E+00	6.08E-12	9.51E-10	6.50E-10	6.18E-05	5.18E-01
	Cs-137+	3.59E-07	1.80E-05	7.89E-03	8.40E-07	6.06E-04	1.66E-03	0.00E+00	0.00E+00	0.00E+00	2.31E-06	2.12E-05	1.02E-02
	HT	0.00E+00	7.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.62E-06
	HTO	0.00E+00	3.66E-01	0.00E+00	2.13E-06	1.79E-02	8.41E-02	0.00E+00	0.00E+00	0.00E+00	9.29E-03	3.83E-01	8.61E-01
	Noble Gases	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-02	1.52E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-02
	I(mfp)	1.91E-05	2.50E-04	7.32E-05	1.14E-08	9.86E-04	6.42E-04	0.00E+00	0.00E+00	0.00E+00	1.28E-07	3.33E-06	1.97E-03
	Total (uSv)	2.55E-02	3.70E-01	7.96E-03	3.02E-06	1.54E-01	5.08E-01	0.00E+00	6.08E-12	9.51E-10	9.29E-03	3.83E-01	1.46E+00
15yr. Old	C-14	2.34E-06	2.96E-03	1.42E-07	2.89E-08	8.32E-02	3.09E-01	0.00E+00	6.08E-12	9.34E-10	6.50E-10	5.28E-05	3.96E-01
	Cs-137+	3.59E-07	1.56E-05	7.89E-03	8.40E-07	4.46E-04	1.24E-03	0.00E+00	0.00E+00	0.00E+00	2.31E-06	1.85E-05	9.61E-03
	HT	0.00E+00	6.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-06
	HTO	0.00E+00	3.32E-01	0.00E+00	2.13E-06	1.43E-02	6.19E-02	0.00E+00	0.00E+00	0.00E+00	8.19E-03	3.33E-01	7.49E-01
	Noble Gases	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-02	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-02
	I(mfp)	1.91E-05	3.50E-04	7.32E-05	1.77E-08	1.25E-03	7.40E-04	0.00E+00	0.00E+00	0.00E+00	1.28E-07	4.48E-06	2.44E-03
	Total (uSv)	2.55E-02	3.35E-01	7.96E-03	3.02E-06	1.19E-01	3.85E-01	0.00E+00	6.08E-12	9.34E-10	8.19E-03	3.33E-01	1.21E+00
10yr. Old	C-14	2.34E-06	3.12E-03	1.42E-07	8.10E-08	7.96E-02	3.04E-01	0.00E+00	6.08E-12	2.62E-09	6.50E-10	6.67E-05	3.87E-01
	Cs-137+	3.59E-07	1.00E-05	7.89E-03	1.29E-06	2.28E-04	6.77E-04	0.00E+00	0.00E+00	0.00E+00	2.31E-06	1.28E-05	8.82E-03
	HT	0.00E+00	6.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.56E-06
	HTO	0.00E+00	3.16E-01	0.00E+00	5.33E-06	1.25E-02	5.73E-02	0.00E+00	0.00E+00	0.00E+00	7.74E-03	3.75E-01	7.68E-01
	Noble Gases	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-02	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-02
	I(mfp)	1.91E-05	4.11E-04	7.32E-05	5.40E-08	1.41E-03	8.01E-04	0.00E+00	0.00E+00	0.00E+00	1.28E-07	6.15E-06	2.72E-03
	Total (uSv)	2.55E-02	3.19E-01	7.96E-03	6.76E-06	1.11E-01	3.75E-01	0.00E+00	6.08E-12	2.62E-09	7.74E-03	3.75E-01	1.22E+00
5yr. Old	C-14	2.34E-06	2.17E-03	1.42E-07	1.00E-07	7.38E-02	3.06E-01	0.00E+00	6.08E-12	3.25E-09	6.50E-10	6.88E-05	3.82E-01
	Cs-137+	3.59E-07	5.55E-06	7.89E-03	1.24E-06	1.55E-04	5.39E-04	0.00E+00	0.00E+00	0.00E+00	2.31E-06	1.02E-05	8.60E-03
	HT	0.00E+00	5.09E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E-06
	HTO	0.00E+00	2.45E-01	0.00E+00	7.25E-06	1.34E-02	6.73E-02	0.00E+00	0.00E+00	0.00E+00	6.78E-03	4.25E-01	7.57E-01
	Noble Gases	2.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-02	1.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-02
	I(mfp)	1.91E-05	4.74E-04	7.32E-05	1.05E-07	2.26E-03	1.29E-03	0.00E+00	0.00E+00	0.00E+00	1.28E-07	9.94E-06	4.13E-03
	Total (uSv)	2.55E-02	2.47E-01	7.96E-03	8.70E-06	1.05E-01	3.88E-01	0.00E+00	6.08E-12	3.25E-09	6.78E-03	4.25E-01	1.21E+00
Infant	C-14	3.04E-06	2.22E-03	1.85E-07	2.02E-07	1.07E-02	3.31E-01	0.00E+00	7.90E-12	6.56E-09	2.03E-10	8.16E-05	3.44E-01
	Cs-137+	4.67E-07	4.92E-06	1.03E-02	1.94E-06	1.61E-05	4.61E-04	0.00E+00	0.00E+00	0.00E+00	3.84E-09	9.38E-06	1.07E-02
	HT	0.00E+00	4.69E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.69E-06
	HTO	0.00E+00	2.26E-01	0.00E+00	1.41E-05	2.06E-03	7.85E-02	0.00E+00	0.00E+00	0.00E+00	1.46E-03	4.85E-01	7.93E-01
	Noble Gases	3.11E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-03	1.51E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-02
	I(mfp)	2.48E-05	5.01E-04	9.52E-05	2.36E-07	3.63E-04	1.59E-03	0.00E+00	0.00E+00	0.00E+00	8.78E-09	1.32E-05	2.59E-03
	Total (uSv)	3.11E-02	2.28E-01	1.03E-02	1.65E-05	1.53E-02	4.27E-01	0.00E+00	7.90E-12	6.56E-09	1.46E-03	4.86E-01	1.20E+00
Nursing Infant	C-14	3.04E-06	1.23E-03	1.85E-07	1.77E-07	2.14E-01	1.70E-01	0.00E+00	7.90E-12	5.74E-09	2.03E-10	2.42E-05	3.85E-01
	Cs-137+	4.67E-07	4.45E-06	1.03E-02	3.39E-06	8.11E-04	5.45E-04	0.00E+00	0.00E+00	0.00E+00	3.84E-09	5.56E-06	1.16E-02
	HT	0.00E+00	3.44E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.44E-06
	HTO	0.00E+00	1.65E-01	0.00E+00	1.87E-05	6.75E-01	8.13E-02	0.00E+00	0.00E+00	0.00E+00	1.18E-03	2.17E-01	1.14E+00
	Noble Gases	3.11E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-01	1.07E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-01
	I(mfp)	2.48E-05	2.82E-04	9.52E-05	2.38E-07	8.15E-03	1.08E-03	0.00E+00	0.00E+00	0.00E+00	8.78E-09	4.49E-06	9.64E-03
	Total (uSv)	3.11E-02	1.67E-01	1.03E-02	2.25E-05	1.05E+00	2.63E-01	0.00E+00	7.90E-12	5.74E-09	1.18E-03	2.17E-01	1.74E+00

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D17: Darlington Dairy Farm Critical Group Doses - 2003

DAIRY FARM		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.11E-06	1.43E-03	6.75E-08	1.39E-08	1.47E-01	1.53E-01	2.00E-04	6.08E-12	9.51E-10	3.07E-10	3.99E-05	3.02E-01
	Cs-137+	9.27E-08	4.66E-06	1.66E-03	1.77E-07	5.30E-04	7.72E-04	0.00E+00	0.00E+00	0.00E+00	1.05E-06	4.18E-07	2.97E-03
	HT	0.00E+00	1.95E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E-06
	HTO	0.00E+00	8.75E-02	0.00E+00	5.10E-07	2.78E-02	5.26E-02	3.84E-05	0.00E+00	0.00E+00	2.37E-03	8.90E-02	2.59E-01
	Noble Gases	5.84E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E-02	1.04E-02	1.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.41E-02
	I(mfp)	4.93E-06	6.47E-05	1.77E-05	2.76E-09	1.74E-03	3.03E-04	0.00E+00	0.00E+00	0.00E+00	3.10E-08	1.58E-06	2.13E-03
Total (uSv)		5.84E-03	8.90E-02	1.68E-03	7.04E-07	2.00E-01	2.17E-01	2.49E-04	6.08E-12	9.51E-10	2.37E-03	8.90E-02	6.06E-01
15yr. Old	C-14	1.11E-06	1.40E-03	6.75E-08	1.37E-08	1.67E-01	1.12E-01	1.10E-04	6.08E-12	9.34E-10	3.07E-10	3.41E-05	2.81E-01
	Cs-137+	9.27E-08	4.04E-06	1.66E-03	1.77E-07	5.59E-04	5.51E-04	0.00E+00	0.00E+00	0.00E+00	1.05E-06	3.64E-07	2.78E-03
	HT	0.00E+00	1.76E-06	0.00E+00	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-06
	HTO	0.00E+00	7.92E-02	0.00E+00	5.10E-07	3.18E-02	3.60E-02	2.15E-05	0.00E+00	0.00E+00	2.09E-03	7.74E-02	2.26E-01
	Noble Gases	5.84E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.47E-02	7.35E-03	5.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-02
	I(mfp)	4.93E-06	9.06E-05	1.77E-05	4.27E-09	3.38E-03	3.35E-04	0.00E+00	0.00E+00	0.00E+00	3.10E-08	2.13E-06	3.83E-03
Total (uSv)		5.84E-03	8.07E-02	1.68E-03	7.05E-07	2.28E-01	1.56E-01	1.37E-04	6.08E-12	9.34E-10	2.09E-03	7.74E-02	5.52E-01
10yr. Old	C-14	1.11E-06	1.48E-03	6.75E-08	3.84E-08	1.80E-01	1.15E-01	1.18E-04	6.08E-12	2.62E-09	3.07E-10	4.31E-05	2.97E-01
	Cs-137+	9.27E-08	2.58E-06	1.66E-03	2.73E-07	3.22E-04	3.18E-04	0.00E+00	0.00E+00	0.00E+00	1.05E-06	2.52E-07	2.31E-03
	HT	0.00E+00	1.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-06
	HTO	0.00E+00	7.54E-02	0.00E+00	1.27E-06	3.05E-02	3.61E-02	2.05E-05	0.00E+00	0.00E+00	1.97E-03	8.70E-02	2.31E-01
	Noble Gases	5.84E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.53E-02	7.96E-03	6.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.32E-02
	I(mfp)	4.93E-06	1.06E-04	1.77E-05	1.31E-08	4.11E-03	3.82E-04	0.00E+00	0.00E+00	0.00E+00	3.10E-08	2.92E-06	4.62E-03
Total (uSv)		5.84E-03	7.70E-02	1.68E-03	1.60E-06	2.41E-01	1.60E-01	1.44E-04	6.08E-12	2.62E-09	1.97E-03	8.71E-02	5.74E-01
5yr. Old	C-14	1.11E-06	1.03E-03	6.75E-08	4.75E-08	1.95E-01	1.22E-01	2.08E-04	6.08E-12	3.25E-09	3.07E-10	4.44E-05	3.19E-01
	Cs-137+	9.27E-08	1.43E-06	1.66E-03	2.62E-07	2.62E-04	2.69E-04	0.00E+00	0.00E+00	0.00E+00	1.05E-06	2.01E-07	2.20E-03
	HT	0.00E+00	1.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-06
	HTO	0.00E+00	5.84E-02	0.00E+00	1.73E-06	3.62E-02	4.58E-02	3.98E-05	0.00E+00	0.00E+00	1.73E-03	9.86E-02	2.41E-01
	Noble Gases	5.84E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E-02	9.32E-03	1.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.65E-02
	I(mfp)	4.93E-06	1.23E-04	1.77E-05	2.53E-08	7.20E-03	6.53E-04	0.00E+00	0.00E+00	0.00E+00	3.10E-08	4.72E-06	8.00E-03
Total (uSv)		5.84E-03	5.96E-02	1.68E-03	2.07E-06	2.66E-01	1.78E-01	2.59E-04	6.08E-12	3.25E-09	1.73E-03	9.87E-02	6.12E-01
Infant	C-14	1.44E-06	1.05E-03	8.77E-08	9.60E-08	3.28E-01	1.46E-01	1.50E-04	7.90E-12	6.56E-09	9.50E-11	7.47E-06	4.75E-01
	Cs-137+	1.21E-07	1.27E-06	2.16E-03	4.09E-07	3.31E-04	2.57E-04	0.00E+00	0.00E+00	0.00E+00	8.49E-10	2.62E-08	2.75E-03
	HT	0.00E+00	1.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-06
	HTO	0.00E+00	5.39E-02	0.00E+00	3.38E-06	5.92E-02	6.04E-02	2.77E-05	0.00E+00	0.00E+00	2.97E-04	1.60E-02	1.90E-01
	Noble Gases	7.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.47E-02	1.26E-02	7.96E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-02
	I(mfp)	6.41E-06	1.30E-04	2.30E-05	5.71E-08	1.35E-02	8.98E-04	0.00E+00	0.00E+00	0.00E+00	2.23E-09	8.86E-07	1.46E-02
Total (uSv)		7.13E-03	5.51E-02	2.18E-03	3.94E-06	4.46E-01	2.20E-01	1.86E-04	7.90E-12	6.56E-09	2.97E-04	1.60E-02	7.47E-01
Nursing Infant	C-14	1.44E-06	5.83E-04	8.77E-08	8.40E-08	1.35E-01	9.71E-02	0.00E+00	7.90E-12	5.74E-09	9.50E-11	1.56E-05	2.33E-01
	Cs-137+	1.21E-07	1.15E-06	2.16E-03	7.15E-07	5.14E-04	3.81E-04	0.00E+00	0.00E+00	0.00E+00	8.49E-10	1.09E-07	3.06E-03
	HT	0.00E+00	8.77E-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	8.77E-07
	HTO	0.00E+00	3.95E-02	0.00E+00	4.46E-06	2.12E-01	7.75E-02	0.00E+00	0.00E+00	0.00E+00	2.40E-04	5.04E-02	3.79E-01
	Noble Gases	7.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.17E-02	1.18E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.35E-02
	I(mfp)	6.41E-06	7.29E-05	2.30E-05	5.75E-08	7.29E-03	7.61E-04	0.00E+00	0.00E+00	0.00E+00	2.23E-09	2.13E-06	8.16E-03
Total (uSv)		7.13E-03	4.01E-02	2.18E-03	5.32E-06	4.36E-01	1.88E-01	0.00E+00	7.90E-12	5.74E-09	2.40E-04	5.05E-02	7.24E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D18: Darlington Bowmanville Resident Critical Group Doses - 2003

BOWMANVILLE		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	6.87E-07	8.85E-04	4.18E-08	8.62E-09	3.43E-03	1.56E-01	5.35E-05	6.08E-12	9.51E-10	2.40E-11	1.64E-06	1.60E-01
	Cs-137+	1.10E-07	5.52E-06	3.55E-03	3.79E-07	1.47E-05	6.63E-04	0.00E+00	0.00E+00	0.00E+00	2.68E-06	2.15E-04	4.46E-03
	HT	0.00E+00	2.30E-06	0.00E+00	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-06
	HTO	0.00E+00	1.07E-01	0.00E+00	6.23E-07	1.12E-03	3.50E-02	1.03E-05	0.00E+00	0.00E+00	1.28E-03	5.67E-02	2.01E-01
	Noble Gases	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-04	6.46E-03	2.77E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-03
	I(mfp)	5.92E-06	7.76E-05	2.27E-05	3.56E-09	4.25E-05	2.56E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.04E-04
Total (uSv)		1.78E-02	1.08E-01	3.58E-03	1.01E-06	5.40E-03	1.98E-01	6.65E-05	6.08E-12	9.51E-10	1.28E-03	5.69E-02	3.91E-01
15yr. Old	C-14	6.87E-07	8.68E-04	4.18E-08	8.47E-09	2.25E-03	1.18E-01	2.94E-05	6.08E-12	9.34E-10	2.40E-11	1.40E-06	1.21E-01
	Cs-137+	1.10E-07	4.78E-06	3.55E-03	3.79E-07	9.93E-06	4.92E-04	0.00E+00	0.00E+00	0.00E+00	2.68E-06	1.87E-04	4.25E-03
	HT	0.00E+00	2.08E-06	0.00E+00	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-06
	HTO	0.00E+00	9.69E-02	0.00E+00	6.23E-07	7.27E-04	2.54E-02	5.74E-06	0.00E+00	0.00E+00	1.12E-03	4.93E-02	1.73E-01
	Noble Gases	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-04	4.88E-03	1.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.40E-03
	I(mfp)	5.92E-06	1.09E-04	2.27E-05	5.50E-09	4.21E-05	2.93E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.73E-04
Total (uSv)		1.78E-02	9.78E-02	3.58E-03	1.02E-06	3.55E-03	1.49E-01	3.67E-05	6.08E-12	9.34E-10	1.13E-03	4.95E-02	3.22E-01
10yr. Old	C-14	6.87E-07	9.15E-04	4.18E-08	2.38E-08	2.07E-03	1.17E-01	3.15E-05	6.08E-12	2.62E-09	2.40E-11	1.77E-06	1.20E-01
	Cs-137+	1.10E-07	3.06E-06	3.55E-03	5.83E-07	5.01E-06	2.71E-04	0.00E+00	0.00E+00	0.00E+00	2.68E-06	1.29E-04	3.97E-03
	HT	0.00E+00	1.98E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-06
	HTO	0.00E+00	9.22E-02	0.00E+00	1.56E-06	5.96E-04	2.39E-02	5.47E-06	0.00E+00	0.00E+00	1.06E-03	5.54E-02	1.73E-01
	Noble Gases	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.66E-04	4.96E-03	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.42E-03
	I(mfp)	5.92E-06	1.28E-04	2.27E-05	1.68E-08	4.52E-05	3.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.21E-04
Total (uSv)		1.78E-02	9.32E-02	3.58E-03	2.18E-06	3.18E-03	1.46E-01	3.85E-05	6.08E-12	2.62E-09	1.06E-03	5.56E-02	3.20E-01
5yr. Old	C-14	6.87E-07	6.37E-04	4.18E-08	2.94E-08	1.89E-03	1.18E-01	5.56E-05	6.08E-12	3.25E-09	2.40E-11	1.83E-06	1.21E-01
	Cs-137+	1.10E-07	1.70E-06	3.55E-03	5.60E-07	3.42E-06	2.18E-04	0.00E+00	0.00E+00	0.00E+00	2.68E-06	1.03E-04	3.88E-03
	HT	0.00E+00	1.54E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-06
	HTO	0.00E+00	7.14E-02	0.00E+00	2.12E-06	6.35E-04	2.86E-02	1.06E-05	0.00E+00	0.00E+00	9.30E-04	6.28E-02	1.64E-01
	Noble Gases	1.78E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.46E-04	5.43E-03	2.94E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-03
	I(mfp)	5.92E-06	1.47E-04	2.27E-05	3.26E-08	7.26E-05	5.21E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.69E-04
Total (uSv)		1.78E-02	7.22E-02	3.58E-03	2.74E-06	3.05E-03	1.53E-01	6.92E-05	6.08E-12	3.25E-09	9.33E-04	6.29E-02	3.14E-01
Infant	C-14	8.94E-07	6.51E-04	5.43E-08	5.94E-08	2.61E-04	1.30E-01	4.01E-05	7.90E-12	6.56E-09	4.97E-12	2.17E-06	1.31E-01
	Cs-137+	1.43E-07	1.51E-06	4.62E-03	8.74E-07	3.44E-07	1.90E-04	0.00E+00	0.00E+00	0.00E+00	5.55E-07	9.48E-05	4.91E-03
	HT	0.00E+00	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-06
	HTO	0.00E+00	6.59E-02	0.00E+00	4.13E-06	9.89E-05	3.44E-02	7.39E-06	0.00E+00	0.00E+00	2.41E-04	7.18E-02	1.72E-01
	Noble Gases	2.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.83E-05	6.68E-03	2.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.75E-03
	I(mfp)	7.69E-06	1.56E-04	2.96E-05	7.35E-08	1.05E-05	6.55E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.58E-04
Total (uSv)		2.17E-02	6.67E-02	4.65E-03	5.14E-06	4.39E-04	1.72E-01	4.96E-05	7.90E-12	6.56E-09	2.42E-04	7.19E-02	3.37E-01
Nursing Infant	C-14	8.94E-07	3.61E-04	5.43E-08	5.20E-08	4.11E-02	7.01E-02	0.00E+00	7.90E-12	5.74E-09	4.97E-12	6.42E-07	1.12E-01
	Cs-137+	1.43E-07	1.36E-06	4.62E-03	1.53E-06	2.40E-04	2.35E-04	0.00E+00	0.00E+00	0.00E+00	5.55E-07	5.62E-05	5.16E-03
	HT	0.00E+00	1.04E-06	0.00E+00	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-06
	HTO	0.00E+00	4.82E-02	0.00E+00	5.45E-06	1.60E-01	3.78E-02	0.00E+00	0.00E+00	0.00E+00	1.95E-04	3.21E-02	2.78E-01
	Noble Gases	2.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.51E-02	5.08E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-02
	I(mfp)	7.69E-06	8.75E-05	2.96E-05	7.40E-08	1.18E-03	4.66E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-03
Total (uSv)		2.17E-02	4.87E-02	4.65E-03	7.11E-06	2.47E-01	1.14E-01	0.00E+00	7.90E-12	5.74E-09	1.95E-04	3.22E-02	4.69E-01

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Table D19: Darlington St. Mary’s Cement Critical Group Doses - 2003

ST.MARY’S CEMENT		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	8.67E-07	1.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.81E-07	1.12E-03
	Cs-137+	2.63E-07	1.32E-05	5.77E-03	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.29E-05	5.85E-03
	HT	0.00E+00	5.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-06
	HTO	0.00E+00	2.73E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-02	2.89E-01
	Noble Gases	7.29E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.29E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	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)	1.39E-05	1.83E-04	5.36E-05	8.39E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-04
Total (uSv)		7.31E-03	2.74E-01	5.82E-03	6.23E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-02	3.04E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D20: Darlington West/East Beach Critical Group Doses - 2003

WEST/EAST BEACH		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.85E-07	2.38E-04	1.12E-08	2.32E-09	1.07E-03	1.83E-01	6.48E-04	6.08E-12	9.51E-10	6.79E-11	2.75E-06	1.85E-01
	Cs-137+	4.95E-07	2.49E-05	1.10E-02	1.17E-06	5.01E-06	8.78E-04	0.00E+00	0.00E+00	0.00E+00	2.46E-06	7.92E-05	1.19E-02
	HT	0.00E+00	1.04E-05	0.00E+00	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-05
	HTO	0.00E+00	5.09E-01	0.00E+00	2.96E-06	5.54E-04	4.21E-02	1.24E-04	0.00E+00	0.00E+00	1.29E-02	2.19E-01	7.84E-01
	Noble Gases	1.48E-02	0.00E+00	0.00E+00	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-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-04	4.68E-03	3.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.01E-03
	I(mfp)	2.63E-05	3.44E-04	9.93E-05	1.55E-08	2.41E-05	3.40E-04	0.00E+00	0.00E+00	0.00E+00	1.89E-07	7.71E-06	8.42E-04
Total (uSv)		1.48E-02	5.10E-01	1.10E-02	4.15E-06	1.96E-03	2.31E-01	8.06E-04	6.08E-12	9.51E-10	1.29E-02	2.19E-01	1.00E+00
15yr. Old	C-14	1.85E-07	2.34E-04	1.12E-08	2.28E-09	6.77E-04	1.39E-01	3.56E-04	6.08E-12	9.34E-10	6.79E-11	2.35E-06	1.40E-01
	Cs-137+	4.95E-07	2.15E-05	1.10E-02	1.17E-06	3.36E-06	6.52E-04	0.00E+00	0.00E+00	0.00E+00	2.46E-06	6.89E-05	1.17E-02
	HT	0.00E+00	9.41E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.41E-06
	HTO	0.00E+00	4.61E-01	0.00E+00	2.96E-06	3.56E-04	3.06E-02	6.95E-05	0.00E+00	0.00E+00	1.14E-02	1.91E-01	6.94E-01
	Noble Gases	1.48E-02	0.00E+00	0.00E+00	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-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-04	3.54E-03	1.88E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E-03
	I(mfp)	2.63E-05	4.83E-04	9.93E-05	2.40E-08	2.34E-05	3.91E-04	0.00E+00	0.00E+00	0.00E+00	1.89E-07	1.04E-05	1.03E-03
Total (uSv)		1.48E-02	4.62E-01	1.10E-02	4.16E-06	1.25E-03	1.74E-01	4.44E-04	6.08E-12	9.34E-10	1.14E-02	1.91E-01	8.65E-01
10yr. Old	C-14	1.85E-07	2.46E-04	1.12E-08	6.40E-09	6.83E-04	1.37E-01	3.81E-04	6.08E-12	2.62E-09	6.79E-11	2.97E-06	1.38E-01
	Cs-137+	4.95E-07	1.38E-05	1.10E-02	1.80E-06	1.89E-06	3.58E-04	0.00E+00	0.00E+00	0.00E+00	2.46E-06	4.77E-05	1.14E-02
	HT	0.00E+00	8.95E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.95E-06
	HTO	0.00E+00	4.38E-01	0.00E+00	7.41E-06	3.09E-04	2.87E-02	6.63E-05	0.00E+00	0.00E+00	1.08E-02	2.14E-01	6.93E-01
	Noble Gases	1.48E-02	0.00E+00	0.00E+00	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-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-04	3.59E-03	1.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.79E-03
	I(mfp)	2.63E-05	5.66E-04	9.93E-05	7.33E-08	2.68E-05	4.24E-04	0.00E+00	0.00E+00	0.00E+00	1.89E-07	1.42E-05	1.16E-03
Total (uSv)		1.48E-02	4.39E-01	1.10E-02	9.29E-06	1.20E-03	1.70E-01	4.67E-04	6.08E-12	2.62E-09	1.08E-02	2.14E-01	8.62E-01
5yr. Old	C-14	1.85E-07	1.72E-04	1.12E-08	7.92E-09	7.12E-04	1.39E-01	6.74E-04	6.08E-12	3.25E-09	6.79E-11	3.06E-06	1.41E-01
	Cs-137+	4.95E-07	7.64E-06	1.10E-02	1.72E-06	1.47E-06	2.87E-04	0.00E+00	0.00E+00	0.00E+00	2.46E-06	3.82E-05	1.13E-02
	HT	0.00E+00	6.94E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.94E-06
	HTO	0.00E+00	3.40E-01	0.00E+00	1.01E-05	3.49E-04	3.43E-02	1.29E-04	0.00E+00	0.00E+00	9.42E-03	2.43E-01	6.27E-01
	Noble Gases	1.48E-02	0.00E+00	0.00E+00	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-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-04	3.92E-03	3.56E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.15E-03
	I(mfp)	2.63E-05	6.53E-04	9.93E-05	1.42E-07	4.53E-05	6.89E-04	0.00E+00	0.00E+00	0.00E+00	1.89E-07	2.30E-05	1.54E-03
Total (uSv)		1.48E-02	3.41E-01	1.10E-02	1.20E-05	1.30E-03	1.79E-01	8.39E-04	6.08E-12	3.25E-09	9.42E-03	2.43E-01	8.00E-01
Infant	C-14	2.41E-07	1.75E-04	1.46E-08	1.60E-08	9.98E-05	1.53E-01	4.85E-04	7.90E-12	6.56E-09	1.33E-11	3.63E-06	1.54E-01
	Cs-137+	6.43E-07	6.78E-06	1.42E-02	2.69E-06	1.56E-07	2.48E-04	0.00E+00	0.00E+00	0.00E+00	1.73E-07	3.50E-05	1.45E-02
	HT	0.00E+00	6.40E-06	0.00E+00	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-06
	HTO	0.00E+00	3.13E-01	0.00E+00	1.96E-05	5.40E-05	4.12E-02	8.95E-05	0.00E+00	0.00E+00	2.37E-03	2.78E-01	6.35E-01
	Noble Gases	1.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-05	4.80E-03	2.58E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.86E-03
	I(mfp)	3.42E-05	6.91E-04	1.29E-04	3.21E-07	5.88E-06	8.61E-04	0.00E+00	0.00E+00	0.00E+00	3.23E-08	3.05E-05	1.75E-03
Total (uSv)		1.81E-02	3.14E-01	1.44E-02	2.27E-05	1.91E-04	2.00E-01	6.01E-04	7.90E-12	6.56E-09	2.37E-03	2.78E-01	8.28E-01
Nursing Infant	C-14	2.41E-07	9.72E-05	1.46E-08	1.40E-08	4.47E-02	8.26E-02	0.00E+00	7.90E-12	5.74E-09	1.33E-11	1.08E-06	1.27E-01
	Cs-137+	6.43E-07	6.13E-06	1.42E-02	4.71E-06	4.52E-04	3.01E-04	0.00E+00	0.00E+00	0.00E+00	1.73E-07	2.07E-05	1.50E-02
	HT	0.00E+00	4.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.68E-06
	HTO	0.00E+00	2.30E-01	0.00E+00	2.59E-05	6.19E-01	4.49E-02	0.00E+00	0.00E+00	0.00E+00	1.92E-03	1.24E-01	1.02E+00
	Noble Gases	1.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.55E-02	3.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-02
	I(mfp)	3.42E-05	3.88E-04	1.29E-04	3.23E-07	2.43E-03	6.01E-04	0.00E+00	0.00E+00	0.00E+00	3.23E-08	1.04E-05	3.60E-03
Total (uSv)		1.81E-02	2.30E-01	1.44E-02	3.10E-05	7.02E-01	1.32E-01	0.00E+00	7.90E-12	5.74E-09	1.92E-03	1.24E-01	1.22E+00

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D21: Darlington Rural Resident Critical Group Doses - 2003

RURAL RESIDENTS		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.59E-06	2.04E-03	9.64E-08	1.99E-08	4.88E-03	1.42E-01	4.51E-04	6.08E-12	9.51E-10	4.34E-10	2.68E-05	1.49E-01
	Cs-137+	2.54E-07	1.28E-05	5.68E-03	6.05E-07	1.45E-05	7.47E-04	0.00E+00	0.00E+00	0.00E+00	2.35E-06	4.99E-05	6.51E-03
	HT	0.00E+00	5.33E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-06
	HTO	0.00E+00	2.56E-01	0.00E+00	1.49E-06	1.82E-03	3.61E-02	8.65E-05	0.00E+00	0.00E+00	7.40E-03	2.52E-01	5.54E-01
	Noble Gases	3.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-03	5.84E-03	2.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.18E-03
	I(mfp)	1.35E-05	1.77E-04	5.18E-05	8.10E-09	1.21E-04	2.89E-04	0.00E+00	0.00E+00	0.00E+00	9.30E-08	1.74E-06	6.54E-04
Total (uSv)		3.45E-02	2.58E-01	5.73E-03	2.13E-06	8.15E-03	1.85E-01	5.61E-04	6.08E-12	9.51E-10	7.40E-03	2.52E-01	7.52E-01
15yr. Old	C-14	1.59E-06	2.00E-03	9.64E-08	1.95E-08	3.08E-03	1.07E-01	2.48E-04	6.08E-12	9.34E-10	4.34E-10	2.29E-05	1.12E-01
	Cs-137+	2.54E-07	1.10E-05	5.68E-03	6.05E-07	9.61E-06	5.56E-04	0.00E+00	0.00E+00	0.00E+00	2.35E-06	4.34E-05	6.30E-03
	HT	0.00E+00	4.83E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.83E-06
	HTO	0.00E+00	2.32E-01	0.00E+00	1.49E-06	1.14E-03	2.65E-02	4.84E-05	0.00E+00	0.00E+00	6.52E-03	2.20E-01	4.86E-01
	Noble Gases	3.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E-04	4.48E-03	1.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.35E-03
	I(mfp)	1.35E-05	2.48E-04	5.18E-05	1.25E-08	1.18E-04	3.32E-04	0.00E+00	0.00E+00	0.00E+00	9.30E-08	2.34E-06	7.66E-04
Total (uSv)		3.45E-02	2.34E-01	5.73E-03	2.13E-06	5.19E-03	1.39E-01	3.09E-04	6.08E-12	9.34E-10	6.52E-03	2.20E-01	6.45E-01
10yr. Old	C-14	1.59E-06	2.11E-03	9.64E-08	5.49E-08	2.96E-03	1.06E-01	2.65E-04	6.08E-12	2.62E-09	4.34E-10	2.89E-05	1.11E-01
	Cs-137+	2.54E-07	7.07E-06	5.68E-03	9.31E-07	4.80E-06	3.04E-04	0.00E+00	0.00E+00	0.00E+00	2.35E-06	3.00E-05	6.03E-03
	HT	0.00E+00	4.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.59E-06
	HTO	0.00E+00	2.21E-01	0.00E+00	3.73E-06	9.28E-04	2.46E-02	4.61E-05	0.00E+00	0.00E+00	6.16E-03	2.47E-01	4.99E-01
	Noble Gases	3.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.53E-04	4.48E-03	1.36E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.25E-03
	I(mfp)	1.35E-05	2.91E-04	5.18E-05	3.83E-08	1.35E-04	3.60E-04	0.00E+00	0.00E+00	0.00E+00	9.30E-08	3.21E-06	8.54E-04
Total (uSv)		3.45E-02	2.23E-01	5.73E-03	4.75E-06	4.78E-03	1.36E-01	3.25E-04	6.08E-12	2.62E-09	6.17E-03	2.47E-01	6.57E-01
5yr. Old	C-14	1.59E-06	1.47E-03	9.64E-08	6.79E-08	2.99E-03	1.08E-01	4.69E-04	6.08E-12	3.25E-09	4.34E-10	2.98E-05	1.13E-01
	Cs-137+	2.54E-07	3.92E-06	5.68E-03	8.94E-07	3.45E-06	2.42E-04	0.00E+00	0.00E+00	0.00E+00	2.35E-06	2.40E-05	5.95E-03
	HT	0.00E+00	3.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.56E-06
	HTO	0.00E+00	1.71E-01	0.00E+00	5.07E-06	1.05E-03	2.88E-02	8.97E-05	0.00E+00	0.00E+00	5.40E-03	2.80E-01	4.86E-01
	Noble Gases	3.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.59E-04	4.82E-03	2.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.60E-03
	I(mfp)	1.35E-05	3.35E-04	5.18E-05	7.42E-08	2.28E-04	5.80E-04	0.00E+00	0.00E+00	0.00E+00	9.30E-08	5.19E-06	1.21E-03
Total (uSv)		3.45E-02	1.73E-01	5.73E-03	6.11E-06	5.03E-03	1.42E-01	5.83E-04	6.08E-12	3.25E-09	5.40E-03	2.80E-01	6.46E-01
Infant	C-14	2.06E-06	1.50E-03	1.25E-07	1.37E-07	4.07E-04	1.20E-01	3.38E-04	7.90E-12	6.56E-09	1.21E-10	3.53E-05	1.22E-01
	Cs-137+	3.30E-07	3.48E-06	7.38E-03	1.40E-06	3.77E-07	2.06E-04	0.00E+00	0.00E+00	0.00E+00	6.63E-08	2.20E-05	7.62E-03
	HT	0.00E+00	3.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.28E-06
	HTO	0.00E+00	1.58E-01	0.00E+00	9.88E-06	1.79E-04	3.37E-02	6.23E-05	0.00E+00	0.00E+00	1.55E-03	3.20E-01	5.13E-01
	Noble Gases	4.21E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-04	5.75E-03	1.79E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.89E-03
	I(mfp)	1.75E-05	3.54E-04	6.73E-05	1.68E-07	2.80E-05	7.15E-04	0.00E+00	0.00E+00	0.00E+00	9.29E-09	6.87E-06	1.19E-03
Total (uSv)		4.21E-02	1.60E-01	7.45E-03	1.16E-05	7.39E-04	1.60E-01	4.18E-04	7.90E-12	6.56E-09	1.55E-03	3.20E-01	6.92E-01
Nursing Infant	C-14	2.06E-06	8.33E-04	1.25E-07	1.20E-07	3.93E-02	6.56E-02	0.00E+00	7.90E-12	5.74E-09	1.21E-10	1.05E-05	1.06E-01
	Cs-137+	3.30E-07	3.14E-06	7.38E-03	2.44E-06	3.46E-04	2.42E-04	0.00E+00	0.00E+00	0.00E+00	6.63E-08	1.31E-05	7.99E-03
	HT	0.00E+00	2.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-06
	HTO	0.00E+00	1.16E-01	0.00E+00	1.31E-05	4.27E-01	3.48E-02	0.00E+00	0.00E+00	0.00E+00	1.25E-03	1.43E-01	7.22E-01
	Noble Gases	4.21E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E-02	4.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.97E-02
	I(mfp)	1.75E-05	1.99E-04	6.73E-05	1.69E-07	2.17E-03	4.83E-04	0.00E+00	0.00E+00	0.00E+00	9.29E-09	2.34E-06	2.94E-03
Total (uSv)		4.21E-02	1.17E-01	7.45E-03	1.58E-05	5.15E-01	1.05E-01	0.00E+00	7.90E-12	5.74E-09	1.25E-03	1.43E-01	9.30E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D22: Darlington Provincial Park Camper Critical Group Doses - 2003

CAMPER		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	4.83E-07	6.22E-04	0.00E+00	0.00E+00	2.18E-03	1.09E-01	4.97E-03	6.08E-12	9.51E-10	1.46E-11	7.52E-07	1.17E-01
	Cs-137+	1.36E-07	6.84E-06	5.98E-03	6.37E-07	5.63E-06	4.43E-04	0.00E+00	0.00E+00	0.00E+00	1.63E-06	9.84E-05	6.54E-03
	HT	0.00E+00	2.86E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-06
	HTO	0.00E+00	1.38E-01	0.00E+00	0.00E+00	8.63E-04	2.18E-02	1.38E-03	0.00E+00	0.00E+00	9.08E-04	4.03E-02	2.03E-01
	Noble Gases	2.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-04	3.97E-03	7.84E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-02
	I(mfp)	7.23E-06	9.49E-05	5.56E-05	8.70E-09	5.92E-05	1.71E-04	5.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.88E-04
Total (uSv)		2.43E-02	1.39E-01	6.03E-03	6.46E-07	3.63E-03	1.35E-01	1.42E-02	6.08E-12	9.51E-10	9.09E-04	4.04E-02	3.63E-01
15yr. Old	C-14	4.83E-07	6.10E-04	0.00E+00	0.00E+00	1.36E-03	8.32E-02	2.73E-03	6.08E-12	9.34E-10	1.46E-11	6.43E-07	8.79E-02
	Cs-137+	1.36E-07	5.92E-06	5.98E-03	6.37E-07	3.64E-06	3.32E-04	0.00E+00	0.00E+00	0.00E+00	1.63E-06	8.56E-05	6.41E-03
	HT	0.00E+00	2.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E-06
	HTO	0.00E+00	1.25E-01	0.00E+00	0.00E+00	5.37E-04	1.62E-02	7.70E-04	0.00E+00	0.00E+00	8.00E-04	3.50E-02	1.78E-01
	Noble Gases	2.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E-10	3.07E-09	4.39E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.78E-09
	I(mfp)	7.23E-06	1.33E-04	5.56E-05	1.35E-08	5.72E-05	1.98E-04	4.57E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.52E-04
Total (uSv)		2.43E-02	1.25E-01	6.03E-03	6.51E-07	1.96E-03	9.99E-02	3.50E-03	6.08E-12	9.34E-10	8.02E-04	3.51E-02	2.97E-01
10yr. Old	C-14	4.83E-07	6.43E-04	0.00E+00	0.00E+00	1.33E-03	8.14E-02	2.93E-03	6.08E-12	2.62E-09	1.46E-11	8.12E-07	8.63E-02
	Cs-137+	1.36E-07	3.79E-06	5.98E-03	9.80E-07	1.85E-06	1.80E-04	0.00E+00	0.00E+00	0.00E+00	1.63E-06	5.92E-05	6.23E-03
	HT	0.00E+00	2.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.46E-06
	HTO	0.00E+00	1.19E-01	0.00E+00	0.00E+00	4.39E-04	1.48E-02	7.34E-04	0.00E+00	0.00E+00	7.57E-04	3.94E-02	1.75E-01
	Noble Gases	2.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-04	3.04E-03	4.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.92E-03
	I(mfp)	7.23E-06	1.56E-04	5.56E-05	4.11E-08	6.60E-05	2.13E-04	5.32E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.98E-04
Total (uSv)		2.43E-02	1.20E-01	6.03E-03	1.02E-06	2.13E-03	9.97E-02	8.24E-03	6.08E-12	2.62E-09	7.58E-04	3.95E-02	3.00E-01
5yr. Old	C-14	4.83E-07	4.48E-04	0.00E+00	0.00E+00	1.36E-03	8.18E-02	5.17E-03	6.08E-12	3.25E-09	1.46E-11	8.37E-07	8.88E-02
	Cs-137+	1.36E-07	2.10E-06	5.98E-03	9.41E-07	1.36E-06	1.43E-04	0.00E+00	0.00E+00	0.00E+00	1.63E-06	4.74E-05	6.18E-03
	HT	0.00E+00	1.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-06
	HTO	0.00E+00	9.20E-02	0.00E+00	0.00E+00	5.01E-04	1.73E-02	1.43E-03	0.00E+00	0.00E+00	6.62E-04	4.47E-02	1.57E-01
	Noble Gases	2.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E-04	3.27E-03	8.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-02
	I(mfp)	7.23E-06	1.80E-04	5.56E-05	7.97E-08	1.12E-04	3.42E-04	1.47E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.99E-04
Total (uSv)		2.43E-02	9.26E-02	6.03E-03	1.02E-06	2.29E-03	1.03E-01	1.49E-02	6.08E-12	3.25E-09	6.64E-04	4.47E-02	2.88E-01
Infant	C-14	6.28E-07	4.58E-04	0.00E+00	0.00E+00	1.88E-04	8.78E-02	3.73E-03	7.90E-12	6.56E-09	1.79E-12	9.92E-07	9.22E-02
	Cs-137+	1.77E-07	1.87E-06	7.77E-03	1.47E-06	1.54E-07	1.21E-04	0.00E+00	0.00E+00	0.00E+00	2.00E-07	4.34E-05	7.94E-03
	HT	0.00E+00	1.76E-06	0.00E+00	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-06
	HTO	0.00E+00	8.48E-02	0.00E+00	0.00E+00	8.69E-05	2.00E-02	9.91E-04	0.00E+00	0.00E+00	1.35E-04	5.11E-02	1.57E-01
	Noble Gases	2.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-05	3.86E-03	6.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.93E-03
	I(mfp)	9.40E-06	1.90E-04	7.23E-05	1.80E-07	1.37E-05	4.19E-04	1.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-04
Total (uSv)		2.96E-02	8.55E-02	7.84E-03	1.65E-06	3.42E-04	1.12E-01	1.07E-02	7.90E-12	6.56E-09	1.35E-04	5.11E-02	2.97E-01
Nursing Infant	C-14	6.28E-07	2.54E-04	0.00E+00	0.00E+00	2.97E-02	4.41E-02	0.00E+00	7.90E-12	5.74E-09	1.79E-12	2.94E-07	7.40E-02
	Cs-137+	1.77E-07	1.69E-06	7.77E-03	2.57E-06	6.51E-04	1.40E-04	0.00E+00	0.00E+00	0.00E+00	2.00E-07	2.58E-05	8.59E-03
	HT	0.00E+00	1.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-06
	HTO	0.00E+00	6.21E-02	0.00E+00	0.00E+00	1.64E-01	2.00E-02	0.00E+00	0.00E+00	0.00E+00	1.09E-04	2.29E-02	2.69E-01
	Noble Gases	2.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-02
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-02	2.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-02
	I(mfp)	9.40E-06	1.07E-04	7.23E-05	1.81E-07	1.19E-03	2.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.65E-03
Total (uSv)		2.96E-02	6.25E-02	7.84E-03	2.75E-06	2.24E-01	6.72E-02	0.00E+00	7.90E-12	5.74E-09	1.09E-04	2.29E-02	4.14E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D23: Darlington Oshawa Resident Critical Group Doses - 2003

OSHAWA		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	6.35E-07	8.17E-04	3.86E-08	7.95E-09	1.73E-04	7.19E-02	9.93E-04	6.08E-12	9.51E-10	1.99E-11	1.25E-06	7.39E-02
	Cs-137+	1.61E-07	8.09E-06	4.36E-03	4.64E-07	3.73E-07	3.38E-04	0.00E+00	0.00E+00	0.00E+00	2.22E-06	1.64E-04	4.87E-03
	HT	0.00E+00	3.37E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.37E-06
	HTO	0.00E+00	1.59E-01	0.00E+00	9.25E-07	1.14E-04	1.71E-02	1.91E-04	0.00E+00	0.00E+00	1.37E-03	6.72E-02	2.45E-01
	Noble Gases	3.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.15E-05	1.21E-02	5.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-02
	I(mfp)	8.55E-06	1.12E-04	3.28E-05	5.13E-09	3.35E-06	1.30E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.87E-04
Total (uSv)		3.52E-03	1.60E-01	4.39E-03	1.40E-06	3.52E-04	1.02E-01	1.24E-03	6.08E-12	9.51E-10	1.37E-03	6.74E-02	3.40E-01
15yr. Old	C-14	6.35E-07	8.01E-04	3.86E-08	7.82E-09	1.04E-04	5.43E-02	5.46E-04	6.08E-12	9.34E-10	1.99E-11	1.07E-06	5.58E-02
	Cs-137+	1.61E-07	7.01E-06	4.36E-03	4.64E-07	2.28E-07	2.51E-04	0.00E+00	0.00E+00	0.00E+00	2.22E-06	1.43E-04	4.76E-03
	HT	0.00E+00	3.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E-06
	HTO	0.00E+00	1.44E-01	0.00E+00	9.25E-07	6.94E-05	1.25E-02	1.07E-04	0.00E+00	0.00E+00	1.21E-03	5.85E-02	2.16E-01
	Noble Gases	3.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.76E-05	9.14E-03	2.88E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.21E-03
	I(mfp)	8.55E-06	1.57E-04	3.28E-05	7.94E-09	3.16E-06	1.50E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-04
Total (uSv)		3.52E-03	1.45E-01	4.39E-03	1.41E-06	2.14E-04	7.64E-02	6.81E-04	6.08E-12	9.34E-10	1.21E-03	5.86E-02	2.90E-01
10yr. Old	C-14	6.35E-07	8.45E-04	3.86E-08	2.19E-08	9.44E-05	5.39E-02	5.84E-04	6.08E-12	2.62E-09	1.99E-11	1.35E-06	5.54E-02
	Cs-137+	1.61E-07	4.48E-06	4.36E-03	7.14E-07	1.14E-07	1.38E-04	0.00E+00	0.00E+00	0.00E+00	2.22E-06	9.88E-05	4.60E-03
	HT	0.00E+00	2.90E-06	0.00E+00	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-06
	HTO	0.00E+00	1.37E-01	0.00E+00	2.31E-06	5.62E-05	1.17E-02	1.02E-04	0.00E+00	0.00E+00	1.14E-03	6.58E-02	2.16E-01
	Noble Gases	3.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E-05	9.29E-03	3.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.35E-03
	I(mfp)	8.55E-06	1.84E-04	3.28E-05	2.43E-08	3.13E-06	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-04
Total (uSv)		3.52E-03	1.38E-01	4.39E-03	3.07E-06	1.87E-04	7.51E-02	7.16E-04	6.08E-12	2.62E-09	1.15E-03	6.59E-02	2.89E-01
5yr. Old	C-14	6.35E-07	5.88E-04	3.86E-08	2.72E-08	1.00E-04	5.47E-02	1.03E-03	6.08E-12	3.25E-09	1.99E-11	1.40E-06	5.64E-02
	Cs-137+	1.61E-07	2.49E-06	4.36E-03	6.86E-07	9.35E-08	1.10E-04	0.00E+00	0.00E+00	0.00E+00	2.22E-06	7.90E-05	4.55E-03
	HT	0.00E+00	2.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-06
	HTO	0.00E+00	1.06E-01	0.00E+00	3.15E-06	6.56E-05	1.38E-02	1.98E-04	0.00E+00	0.00E+00	1.00E-03	7.45E-02	1.96E-01
	Noble Gases	3.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.63E-05	1.01E-02	5.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-02
	I(mfp)	8.55E-06	2.12E-04	3.28E-05	4.70E-08	5.19E-06	2.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-04
Total (uSv)		3.52E-03	1.07E-01	4.39E-03	3.91E-06	2.07E-04	7.91E-02	1.29E-03	6.08E-12	3.25E-09	1.00E-03	7.46E-02	2.71E-01
Infant	C-14	8.25E-07	6.01E-04	5.01E-08	5.49E-08	1.91E-05	6.00E-02	7.44E-04	7.90E-12	6.56E-09	3.58E-12	1.66E-06	6.14E-02
	Cs-137+	2.09E-07	2.21E-06	5.66E-03	1.07E-06	1.38E-08	9.51E-05	0.00E+00	0.00E+00	0.00E+00	4.00E-07	7.25E-05	5.84E-03
	HT	0.00E+00	2.08E-06	0.00E+00	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-06
	HTO	0.00E+00	9.78E-02	0.00E+00	6.13E-06	1.20E-05	1.64E-02	1.37E-04	0.00E+00	0.00E+00	2.69E-04	8.52E-02	2.00E-01
	Noble Gases	4.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.96E-06	1.24E-02	3.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02
	I(mfp)	1.11E-05	2.25E-04	4.27E-05	1.06E-07	1.10E-06	3.28E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.08E-04
Total (uSv)		4.29E-03	9.86E-02	5.71E-03	7.36E-06	3.92E-05	8.93E-02	9.21E-04	7.90E-12	6.56E-09	2.70E-04	8.53E-02	2.84E-01
Nursing Infant	C-14	8.25E-07	3.33E-04	5.01E-08	4.80E-08	1.78E-02	3.22E-02	0.00E+00	7.90E-12	5.74E-09	3.58E-12	4.91E-07	5.04E-02
	Cs-137+	2.09E-07	1.99E-06	5.66E-03	1.88E-06	4.69E-04	1.15E-04	0.00E+00	0.00E+00	0.00E+00	4.00E-07	4.30E-05	6.30E-03
	HT	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06
	HTO	0.00E+00	7.16E-02	0.00E+00	8.10E-06	1.96E-01	1.76E-02	0.00E+00	0.00E+00	0.00E+00	2.69E-04	8.52E-02	3.70E-01
	Noble Gases	4.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.38E-02	9.36E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.31E-02
	I(mfp)	1.11E-05	1.26E-04	4.27E-05	1.07E-07	7.98E-04	2.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-03
Total (uSv)		4.29E-03	7.21E-02	5.71E-03	1.01E-05	2.98E-01	5.95E-02	0.00E+00	7.90E-12	5.74E-09	2.70E-04	8.52E-02	5.25E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D24 Darlington Sport Fisher Critical Group Doses - 2003

FISHER		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	2.15E-07	2.77E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-02
	Cs-137+	4.17E-08	2.10E-06	0.00E+00	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-06
	HT	0.00E+00	8.78E-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	8.78E-07
	HTO	0.00E+00	4.42E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.71E-02
	Noble Gases	2.30E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.91E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.91E-04
	I(mfp)	2.13E-06	2.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E-05
Total (uSv)		2.30E-03	4.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.58E-02
15yr. Old	C-14	2.15E-07	2.72E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.67E-03
	Cs-137+	4.17E-08	1.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-06
	HT	0.00E+00	7.95E-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	7.95E-07
	HTO	0.00E+00	4.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.17E-02
	Noble Gases	2.30E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-04
	I(mfp)	2.13E-06	4.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-05
Total (uSv)		2.30E-03	4.03E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.31E-02
10yr. Old	C-14	2.15E-07	2.86E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.28E-03
	Cs-137+	4.17E-08	1.16E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-06
	HT	0.00E+00	7.56E-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	7.56E-07
	HTO	0.00E+00	3.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.96E-02
	Noble Gases	2.30E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-04
	I(mfp)	2.13E-06	4.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.98E-05
Total (uSv)		2.30E-03	3.84E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E-02
5yr. Old	C-14	2.15E-07	2.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-02
	Cs-137+	4.17E-08	6.44E-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	6.86E-07
	HT	0.00E+00	5.86E-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	5.86E-07
	HTO	0.00E+00	2.95E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.04E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-02
	Noble Gases	2.30E-03	0.00E+00	0.00E+00	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-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.39E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.39E-04
	I(mfp)	2.13E-06	5.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.72E-05
Total (uSv)		2.30E-03	2.98E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.18E-02
Infant	C-14	2.80E-07	2.04E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-02
	Cs-137+	5.42E-08	5.72E-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	6.26E-07
	HT	0.00E+00	5.41E-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	5.41E-07
	HTO	0.00E+00	2.72E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-02
	Noble Gases	2.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.07E-04
	I(mfp)	2.77E-06	5.82E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.09E-05
Total (uSv)		2.80E-03	2.75E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.44E-02
Nursing Infant	C-14	2.80E-07	1.13E-04	0.00E+00	0.00E+00	3.74E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.85E-03
	Cs-137+	5.42E-08	5.17E-07	0.00E+00	0.00E+00	5.25E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.25E-03
	HT	0.00E+00	3.96E-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	3.96E-07
	HTO	0.00E+00	1.99E-02	0.00E+00	0.00E+00	3.88E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-02
	Noble Gases	2.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-03
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.75E-06
	I(mfp)	2.77E-06	3.27E-05	0.00E+00	0.00E+00	1.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-04
Total (uSv)		2.80E-03	2.01E-02	0.00E+00	0.00E+00	4.79E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.08E-02

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D25 Pickering Farm Critical Group Doses - 2003

FARM		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.85E-07	2.38E-04	1.12E-08	2.32E-09	1.22E-02	1.58E-01	9.08E-04	7.70E-10	1.21E-07	1.89E-09	1.97E-05	1.72E-01
	Cs-137+	6.07E-07	3.05E-05	1.33E-02	1.42E-06	7.45E-04	2.90E-03	0.00E+00	5.02E-03	9.95E-05	3.26E-05	3.35E-04	2.25E-02
	HTO	0.00E+00	3.73E-01	0.00E+00	2.17E-06	9.11E-03	4.47E-02	9.87E-05	0.00E+00	0.00E+00	9.76E-03	2.59E-01	6.96E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.64E-03	7.47E-03	2.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-02
	Noble Gases I(mfp)	1.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-02
Total(uSv)		7.05E-06	9.25E-05	2.71E-05	4.24E-09	4.44E-04	2.46E-04	0.00E+00	0.00E+00	0.00E+00	4.74E-08	7.26E-07	8.17E-04
15yr. Old	C-14	1.85E-07	2.34E-04	1.12E-08	2.28E-09	8.08E-03	1.21E-01	4.99E-04	7.70E-10	1.18E-07	1.89E-09	1.69E-05	1.29E-01
	Cs-137+	6.07E-07	2.64E-05	1.33E-02	1.42E-06	5.11E-04	2.19E-03	0.00E+00	5.02E-03	9.95E-05	3.26E-05	2.91E-04	2.15E-02
	HTO	0.00E+00	3.38E-01	0.00E+00	2.17E-06	6.12E-03	3.43E-02	5.52E-05	0.00E+00	0.00E+00	8.60E-03	2.26E-01	6.12E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-03	5.94E-03	1.65E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-02
	Noble Gases I(mfp)	1.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-02
Total(uSv)		7.05E-06	1.30E-04	2.71E-05	6.56E-09	4.40E-04	2.87E-04	0.00E+00	0.00E+00	0.00E+00	4.74E-08	9.77E-07	8.91E-04
10yr. Old	C-14	1.85E-07	2.46E-04	1.12E-08	6.40E-09	7.52E-03	1.18E-01	5.34E-04	7.70E-10	3.32E-07	1.89E-09	2.13E-05	1.27E-01
	Cs-137+	6.07E-07	1.69E-05	1.33E-02	2.19E-06	2.54E-04	1.17E-03	0.00E+00	5.02E-03	1.53E-04	3.26E-05	2.02E-04	2.02E-02
	HTO	0.00E+00	3.21E-01	0.00E+00	5.43E-06	5.01E-03	3.02E-02	5.26E-05	0.00E+00	0.00E+00	8.14E-03	2.54E-01	6.18E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-03	5.73E-03	1.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-02
	Noble Gases I(mfp)	1.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-02
Total(uSv)		7.05E-06	1.52E-04	2.71E-05	2.00E-08	5.16E-04	3.05E-04	0.00E+00	0.00E+00	0.00E+00	4.74E-08	1.34E-06	1.01E-03
5yr. Old	C-14	1.85E-07	1.72E-04	1.12E-08	7.92E-09	6.56E-03	1.19E-01	5.89E-04	7.70E-10	4.11E-07	1.89E-09	2.20E-05	1.26E-01
	Cs-137+	6.07E-07	9.37E-06	1.33E-02	2.10E-06	1.64E-04	9.13E-04	0.00E+00	5.02E-03	1.47E-04	3.26E-05	1.61E-04	1.98E-02
	HTO	0.00E+00	2.49E-01	0.00E+00	7.38E-06	4.87E-03	3.37E-02	6.38E-05	0.00E+00	0.00E+00	7.12E-03	2.88E-01	5.82E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.55E-03	5.92E-03	1.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02
	Noble Gases I(mfp)	1.55E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-02
Total(uSv)		7.05E-06	1.75E-04	2.71E-05	3.88E-08	8.33E-04	4.82E-04	0.00E+00	0.00E+00	0.00E+00	4.74E-08	2.17E-06	1.53E-03
Infant	C-14	1.85E-07	1.75E-04	1.12E-08	1.60E-08	7.31E-04	1.26E-01	4.25E-04	1.00E-09	8.31E-07	5.19E-11	2.60E-05	1.28E-01
	Cs-137+	7.89E-07	8.32E-06	1.73E-02	3.28E-06	1.46E-05	7.44E-04	0.00E+00	6.52E-03	2.30E-04	6.84E-07	1.48E-04	2.50E-02
	HTO	0.00E+00	2.30E-01	0.00E+00	1.44E-05	6.05E-04	3.55E-02	4.43E-05	0.00E+00	0.00E+00	1.14E-03	3.29E-01	5.96E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.37E-04	6.54E-03	1.41E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.09E-03
	Noble Gases I(mfp)	1.89E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.89E-02
Total(uSv)		9.17E-06	1.85E-04	3.52E-05	8.77E-08	8.07E-05	5.67E-04	0.00E+00	0.00E+00	0.00E+00	3.23E-09	2.87E-06	8.80E-04
Nursing Infant	C-14	1.89E-02	2.30E-01	1.74E-02	1.78E-05	1.97E-03	1.70E-01	4.83E-04	6.52E-03	2.30E-04	1.14E-03	3.29E-01	7.75E-01
	Cs-137+	2.41E-07	9.72E-05	1.46E-08	1.40E-08	4.94E-02	6.24E-02	0.00E+00	1.00E-09	7.27E-07	5.19E-11	7.71E-06	1.12E-01
	HTO	7.89E-07	7.52E-06	1.73E-02	5.74E-06	6.03E-03	7.74E-04	0.00E+00	6.52E-03	4.02E-04	6.84E-07	8.76E-05	3.12E-02
	OBT	0.00E+00	1.68E-01	0.00E+00	1.90E-05	5.48E-01	2.85E-02	0.00E+00	0.00E+00	0.00E+00	9.23E-04	1.47E-01	8.92E-01
	Noble Gases I(mfp)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.72E-02	3.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.08E-02
Total(uSv)		1.89E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.89E-02
Total(uSv)		9.17E-06	1.04E-04	3.52E-05	8.82E-08	4.01E-03	3.41E-04	0.00E+00	0.00E+00	0.00E+00	3.23E-09	9.79E-07	4.51E-03
Total(uSv)		1.89E-02	1.68E-01	1.74E-02	2.48E-05	6.74E-01	9.56E-02	0.00E+00	6.52E-03	4.02E-04	9.24E-04	1.47E-01	1.13E+00

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D26 Pickering Dairy Farm Critical Group Doses - 2003

DAIRY FARM		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animal	Terrestrial plant	Aquatic animal	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.22E-06	1.57E-03	7.39E-08	1.52E-08	7.81E-02	6.62E-02	0.00E+00	7.70E-10	1.21E-07	1.50E-09	3.44E-05	1.46E-01
	Cs-137+	6.59E-07	3.31E-05	1.25E-02	1.33E-06	3.44E-03	2.74E-03	0.00E+00	5.02E-03	9.95E-05	2.09E-05	1.28E-06	2.38E-02
	HTO	0.00E+00	4.05E-01	0.00E+00	2.36E-06	7.95E-02	5.30E-02	0.00E+00	0.00E+00	0.00E+00	1.00E-02	2.69E-01	8.17E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.99E-02	8.36E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.83E-02
	Noble Gases	8.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.46E-03
	I(mfp)	7.68E-06	1.01E-04	2.80E-05	4.38E-09	2.44E-03	2.57E-04	0.00E+00	0.00E+00	0.00E+00	5.00E-08	1.02E-06	2.84E-03
Total(uSv)		8.47E-03	4.07E-01	1.25E-02	3.71E-06	2.53E-01	1.31E-01	0.00E+00	5.02E-03	9.96E-05	1.00E-02	2.69E-01	1.10E+00
15yr. Old	C-14	1.22E-06	1.54E-03	7.39E-08	1.50E-08	8.58E-02	5.13E-02	0.00E+00	7.70E-10	1.18E-07	1.50E-09	2.94E-05	1.39E-01
	Cs-137+	6.59E-07	2.87E-05	1.25E-02	1.33E-06	3.53E-03	2.10E-03	0.00E+00	5.02E-03	9.95E-05	2.09E-05	1.11E-06	2.33E-02
	HTO	0.00E+00	3.67E-01	0.00E+00	2.36E-06	9.64E-02	4.18E-02	0.00E+00	0.00E+00	0.00E+00	8.82E-03	2.34E-01	7.48E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.92E-02	6.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.61E-02
	Noble Gases	8.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.46E-03
	I(mfp)	7.68E-06	1.41E-04	2.80E-05	6.77E-09	4.53E-03	3.04E-04	0.00E+00	0.00E+00	0.00E+00	5.00E-08	1.37E-06	5.02E-03
Total(uSv)		8.47E-03	3.69E-01	1.25E-02	3.71E-06	2.79E-01	1.02E-01	0.00E+00	5.02E-03	9.96E-05	8.84E-03	2.34E-01	1.02E+00
10yr. Old	C-14	1.22E-06	1.62E-03	7.39E-08	4.21E-08	9.19E-02	4.93E-02	0.00E+00	7.70E-10	3.32E-07	1.50E-09	3.71E-05	1.43E-01
	Cs-137+	6.59E-07	1.84E-05	1.25E-02	2.05E-06	2.03E-03	1.10E-03	0.00E+00	5.02E-03	1.53E-04	2.09E-05	7.69E-07	2.08E-02
	HTO	0.00E+00	3.49E-01	0.00E+00	5.90E-06	9.37E-02	3.58E-02	0.00E+00	0.00E+00	0.00E+00	8.34E-03	2.63E-01	7.50E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.01E-02	6.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.66E-02
	Noble Gases	8.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.46E-03
	I(mfp)	7.68E-06	1.66E-04	2.80E-05	2.07E-08	5.44E-03	3.17E-04	0.00E+00	0.00E+00	0.00E+00	5.00E-08	1.88E-06	5.96E-03
Total(uSv)		8.47E-03	3.51E-01	1.25E-02	8.01E-06	2.83E-01	9.29E-02	0.00E+00	5.02E-03	1.53E-04	8.36E-03	2.63E-01	1.02E+00
5yr. Old	C-14	1.22E-06	1.13E-03	7.39E-08	5.20E-08	9.90E-02	4.87E-02	0.00E+00	7.70E-10	4.11E-07	1.50E-09	3.83E-05	1.49E-01
	Cs-137+	6.59E-07	1.02E-05	1.25E-02	1.96E-06	1.64E-03	8.52E-04	0.00E+00	5.02E-03	1.47E-04	2.09E-05	6.15E-07	2.02E-02
	HTO	0.00E+00	2.71E-01	0.00E+00	8.02E-06	1.13E-01	3.89E-02	0.00E+00	0.00E+00	0.00E+00	7.30E-03	2.98E-01	7.28E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.56E-02	6.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-01
	Noble Gases	8.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.46E-03
	I(mfp)	7.68E-06	1.91E-04	2.80E-05	4.01E-08	9.47E-03	4.97E-04	0.00E+00	0.00E+00	0.00E+00	5.00E-08	3.05E-06	1.02E-02
Total(uSv)		8.47E-03	2.72E-01	1.25E-02	1.01E-05	3.19E-01	9.54E-02	0.00E+00	5.02E-03	1.47E-04	7.32E-03	2.98E-01	1.02E+00
Infant	C-14	1.58E-06	1.15E-03	9.61E-08	1.05E-07	1.65E-01	5.02E-02	0.00E+00	1.00E-09	8.31E-07	1.01E-10	6.43E-06	2.16E-01
	Cs-137+	8.56E-07	9.03E-06	1.62E-02	3.07E-06	2.03E-03	6.74E-04	0.00E+00	6.52E-03	2.30E-04	8.24E-09	7.99E-08	2.57E-02
	HTO	0.00E+00	2.50E-01	0.00E+00	1.56E-05	1.87E-01	3.86E-02	0.00E+00	0.00E+00	0.00E+00	1.39E-03	4.83E-02	5.25E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-01	6.72E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-01
	Noble Gases	1.03E-02	0.00E+00	0.00E+00	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-02
	I(mfp)	9.98E-06	2.02E-04	3.64E-05	9.05E-08	1.78E-02	5.69E-04	0.00E+00	0.00E+00	0.00E+00	4.57E-09	5.72E-07	1.86E-02
Total(uSv)		1.03E-02	2.51E-01	1.62E-02	1.88E-05	5.07E-01	9.62E-02	0.00E+00	6.52E-03	2.30E-04	1.39E-03	4.83E-02	9.36E-01
Nursing Infant	C-14	1.58E-06	6.39E-04	9.61E-08	9.20E-08	6.24E-02	2.19E-02	0.00E+00	1.00E-09	7.27E-07	1.01E-10	1.34E-05	8.49E-02
	Cs-137+	8.56E-07	8.16E-06	1.62E-02	5.37E-06	2.34E-03	6.44E-04	0.00E+00	6.52E-03	4.02E-04	8.24E-09	3.34E-07	2.61E-02
	HTO	0.00E+00	1.83E-01	0.00E+00	2.07E-05	6.48E-01	2.54E-02	0.00E+00	0.00E+00	0.00E+00	1.12E-03	1.53E-01	1.01E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-01	2.88E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-01
	Noble Gases	1.03E-02	0.00E+00	0.00E+00	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-02
	I(mfp)	9.98E-06	1.13E-04	3.64E-05	9.11E-08	9.53E-03	3.15E-04	0.00E+00	0.00E+00	0.00E+00	4.57E-09	1.37E-06	1.00E-02
Total(uSv)		1.03E-02	1.83E-01	1.62E-02	2.62E-05	8.54E-01	5.11E-02	0.00E+00	6.52E-03	4.02E-04	1.12E-03	1.53E-01	1.28E+00

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Title:	ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003
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Table D27 Pickering Squires Beach Resident Critical Group Doses - 2003

SQUIRES BEACH		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animal	Terrestrial plant	Aquatic animal	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	4.58E-06	5.89E-03	2.78E-07	5.74E-08	0.00E+00	2.24E-02	1.10E-05	6.58E-10	1.03E-07	2.86E-09	1.13E-04	2.84E-02
	Cs-137+	3.56E-06	1.79E-04	7.82E-02	8.33E-06	0.00E+00	1.94E-03	0.00E+00	5.02E-03	9.95E-05	3.03E-05	7.07E-04	8.62E-02
	HTO	0.00E+00	2.23E+00	0.00E+00	1.30E-05	0.00E+00	2.89E-02	1.20E-06	0.00E+00	0.00E+00	1.61E-02	6.06E-01	2.88E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-03	3.58E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-03
	Noble Gases	1.09E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01
	I(mfp)	4.13E-05	5.45E-04	1.59E-04	2.49E-08	0.00E+00	1.65E-04	0.00E+00	0.00E+00	0.00E+00	3.08E-07	2.30E-05	9.33E-04
Total(uSv)		1.09E-01	2.24E+00	7.84E-02	2.14E-05	0.00E+00	5.90E-02	1.26E-05	5.02E-03	9.96E-05	1.62E-02	6.07E-01	3.11E+00
15yr. Old	C-14	4.58E-06	5.78E-03	2.78E-07	5.64E-08	0.00E+00	1.71E-02	6.07E-06	6.58E-10	1.01E-07	2.86E-09	9.67E-05	2.30E-02
	Cs-137+	3.56E-06	1.55E-04	7.82E-02	8.33E-06	0.00E+00	1.47E-03	0.00E+00	5.02E-03	9.95E-05	3.03E-05	6.15E-04	8.56E-02
	HTO	0.00E+00	2.02E+00	0.00E+00	1.30E-05	0.00E+00	2.24E-02	6.71E-07	0.00E+00	0.00E+00	1.42E-02	5.27E-01	2.59E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.50E-03	2.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.50E-03
	Noble Gases	1.09E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01
	I(mfp)	4.13E-05	7.63E-04	1.59E-04	3.86E-08	0.00E+00	1.93E-04	0.00E+00	0.00E+00	0.00E+00	3.08E-07	3.09E-05	1.19E-03
Total(uSv)		1.09E-01	2.03E+00	7.84E-02	2.14E-05	0.00E+00	4.56E-02	6.94E-06	5.02E-03	9.96E-05	1.42E-02	5.28E-01	2.81E+00
10yr. Old	C-14	4.58E-06	6.09E-03	2.78E-07	1.58E-07	0.00E+00	1.67E-02	6.49E-06	6.58E-10	2.84E-07	2.86E-09	1.22E-04	2.29E-02
	Cs-137+	3.56E-06	9.92E-05	7.82E-02	1.28E-05	0.00E+00	7.81E-04	0.00E+00	5.02E-03	1.53E-04	3.03E-05	4.26E-04	8.47E-02
	HTO	0.00E+00	1.92E+00	0.00E+00	3.25E-05	0.00E+00	1.95E-02	6.39E-07	0.00E+00	0.00E+00	1.34E-02	5.93E-01	2.55E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-03	2.09E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-03
	Noble Gases	1.09E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01
	I(mfp)	4.13E-05	8.95E-04	1.59E-04	1.18E-07	0.00E+00	2.04E-04	0.00E+00	0.00E+00	0.00E+00	3.08E-07	4.25E-05	1.34E-03
Total(uSv)		1.09E-01	1.93E+00	7.84E-02	4.56E-05	0.00E+00	4.15E-02	7.34E-06	5.02E-03	1.53E-04	1.35E-02	5.94E-01	2.77E+00
5yr. Old	C-14	4.58E-06	4.24E-03	2.78E-07	1.96E-07	0.00E+00	1.68E-02	7.16E-06	6.58E-10	3.52E-07	2.86E-09	1.26E-04	2.12E-02
	Cs-137+	3.56E-06	5.50E-05	7.82E-02	1.23E-05	0.00E+00	6.06E-04	0.00E+00	5.02E-03	1.47E-04	3.03E-05	3.40E-04	8.44E-02
	HTO	0.00E+00	1.49E+00	0.00E+00	4.42E-05	0.00E+00	2.17E-02	7.75E-07	0.00E+00	0.00E+00	1.18E-02	6.72E-01	2.20E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-03	2.37E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-03
	Noble Gases	1.09E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01
	I(mfp)	4.13E-05	1.03E-03	1.59E-04	2.28E-07	0.00E+00	3.21E-04	0.00E+00	0.00E+00	0.00E+00	3.08E-07	6.86E-05	1.62E-03
Total(uSv)		1.09E-01	1.50E+00	7.84E-02	5.70E-05	0.00E+00	4.37E-02	8.17E-06	5.02E-03	1.47E-04	1.18E-02	6.73E-01	2.42E+00
Infant	C-14	5.95E-06	4.34E-03	3.62E-07	3.96E-07	0.00E+00	1.79E-02	5.16E-06	8.56E-10	7.10E-07	3.88E-10	1.49E-04	2.24E-02
	Cs-137+	4.63E-06	4.88E-05	1.02E-01	1.92E-05	0.00E+00	4.87E-04	0.00E+00	6.52E-03	2.30E-04	9.97E-07	3.12E-04	1.09E-01
	HTO	0.00E+00	1.38E+00	0.00E+00	8.62E-05	0.00E+00	2.25E-02	5.39E-07	0.00E+00	0.00E+00	3.54E-03	7.68E-01	2.17E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-03	1.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-03
	Noble Gases	1.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-01
	I(mfp)	5.37E-05	1.09E-03	2.07E-04	5.15E-07	0.00E+00	3.72E-04	0.00E+00	0.00E+00	0.00E+00	5.77E-08	9.09E-05	1.82E-03
Total(uSv)		1.33E-01	1.38E+00	1.02E-01	1.06E-04	0.00E+00	4.60E-02	5.87E-06	6.52E-03	2.30E-04	3.54E-03	7.69E-01	2.44E+00
Nursing Infant	C-14	5.95E-06	2.40E-03	3.62E-07	3.46E-07	7.41E-03	8.85E-03	0.00E+00	8.56E-10	6.22E-07	3.88E-10	4.43E-05	1.87E-02
	Cs-137+	4.63E-06	4.41E-05	1.02E-01	3.37E-05	7.96E-04	4.87E-04	0.00E+00	6.52E-03	4.02E-04	9.97E-07	1.85E-04	1.10E-01
	HTO	0.00E+00	1.01E+00	0.00E+00	1.14E-04	2.34E+00	1.74E-02	0.00E+00	0.00E+00	0.00E+00	2.85E-03	3.44E-01	3.71E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.87E-02	2.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.11E-02
	Noble Gases	1.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-01
	I(mfp)	5.37E-05	6.14E-04	2.07E-04	5.19E-07	2.77E-03	2.16E-04	0.00E+00	0.00E+00	0.00E+00	5.77E-08	3.10E-05	3.89E-03
Total(uSv)		1.33E-01	1.01E+00	1.02E-01	1.48E-04	2.44E+00	2.93E-02	0.00E+00	6.52E-03	4.02E-04	2.85E-03	3.44E-01	4.06E+00

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Title:
ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D28 Pickering Industrial Park Resident Critical Group Doses - 2003

INDUSTRIAL		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	3.44E-06	4.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-05	4.46E-03
	Cs-137+	3.07E-06	1.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.77E-04	7.35E-04
	HTO	0.00E+00	1.93E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-02	1.95E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Noble Gases	7.86E-02	0.00E+00	0.00E+00	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-02
	I(mfp)	3.60E-05	4.72E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E-04
Total(uSv)		7.87E-02	1.94E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-02	2.04E+00

Table D29 Pickering Correctional Institute C1 Critical Group Doses – 2003

C1		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	1.01E-05	1.29E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-10	1.21E-04	1.31E-02
	Cs-137+	6.53E-06	3.28E-04	1.37E-01	1.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-06	2.51E-03	1.40E-01
	HTO	0.00E+00	4.11E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E-04	8.06E-02	4.19E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Noble Gases	3.78E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E-01
	I(mfp)	7.62E-05	9.98E-04	2.88E-04	4.50E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-03
Total(uSv)		3.78E-01	4.12E+00	1.37E-01	1.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E-04	8.32E-02	4.72E+00
15yr. Old	C-14	1.01E-05	1.27E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-10	1.04E-04	1.28E-02
	Cs-137+	6.53E-06	2.84E-04	1.37E-01	1.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-06	2.18E-03	1.39E-01
	HTO	0.00E+00	3.72E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E-04	7.01E-02	3.79E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Noble Gases	3.78E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E-01
	I(mfp)	7.62E-05	1.40E-03	2.88E-04	6.96E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-03
Total(uSv)		3.78E-01	3.73E+00	1.37E-01	1.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04	7.24E-02	4.32E+00

Table D30 Pickering Correctional Institute C2 Critical Group Doses - 2003

C2		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
15yr. Old	C-14	4.80E-06	6.07E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-10	1.04E-04	6.17E-03
	Cs-137+	3.01E-06	1.31E-04	5.70E-02	6.08E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-06	2.18E-03	5.93E-02
	HTO	0.00E+00	1.71E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E-04	7.01E-02	1.78E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Noble Gases	6.25E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.25E-02
	I(mfp)	3.49E-05	6.45E-04	1.28E-04	3.09E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-04
Total(uSv)		6.26E-02	1.71E+00	5.71E-02	6.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04	7.24E-02	1.91E+00

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D31 Pickering Sport Fisher Critical Group Doses - 2003

FISHER		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	5.61E-07	7.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-02
	Cs-137+	5.32E-07	2.67E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.73E-05
	HTO	0.00E+00	3.36E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.38E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-04
	Noble Gases	2.07E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-02
	I(mfp)	5.95E-06	8.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-05
Total(uSv)		2.07E-02	3.37E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-01
15yr. Old	C-14	5.61E-07	7.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-02
	Cs-137+	5.32E-07	2.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E-05
	HTO	0.00E+00	3.05E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
	Noble Gases	2.07E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-02
	I(mfp)	5.95E-06	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04
Total(uSv)		2.07E-02	3.05E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.38E-01
10yr. Old	C-14	5.61E-07	7.46E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-02
	Cs-137+	5.32E-07	1.48E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-05
	HTO	0.00E+00	2.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E-04
	Noble Gases	2.07E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-02
	I(mfp)	5.95E-06	1.33E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-04
Total(uSv)		2.07E-02	2.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.24E-01
5yr. Old	C-14	5.61E-07	5.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-02
	Cs-137+	5.32E-07	8.22E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.75E-06
	HTO	0.00E+00	2.25E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.26E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.08E-04
	Noble Gases	2.07E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-02
	I(mfp)	5.95E-06	1.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-04
Total(uSv)		2.07E-02	2.25E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-01
Infant	C-14	7.29E-07	5.31E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.43E-03
	Cs-137+	6.91E-07	7.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.98E-06
	HTO	0.00E+00	2.07E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-04
	Noble Gases	2.57E-02	0.00E+00	0.00E+00	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-02
	I(mfp)	7.73E-06	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-04
Total(uSv)		2.57E-02	2.08E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-01
Nursing Infant	C-14	7.29E-07	2.95E-04	0.00E+00	0.00E+00	4.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E-03
	Cs-137+	6.91E-07	6.59E-06	0.00E+00	0.00E+00	1.02E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-01
	HTO	0.00E+00	1.52E-01	0.00E+00	0.00E+00	2.84E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-04
	Noble Gases	2.57E-02	0.00E+00	0.00E+00	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-02
	I(mfp)	7.73E-06	9.14E-05	0.00E+00	0.00E+00	3.42E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.41E-04
Total(uSv)		2.57E-02	1.52E-01	0.00E+00	0.00E+00	3.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.69E-01

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ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 2003

Table D32 Pickering Urban Residents Critical Group Doses - 2003

URBAN RESIDENT		Air external	Air inhalation	Soil external	Soil ingestion	Terrestrial animals	Terrestrial plants	Aquatic animals	Sediment ext.	Sediment ingest	Water external	Water ingestion	Total (uSv)
Adult	C-14	2.34E-06	3.01E-03	1.42E-07	2.94E-08	3.26E-06	3.24E-02	1.26E-05	7.70E-10	1.21E-07	2.03E-09	1.01E-04	3.55E-02
	Cs-137+	2.25E-06	1.13E-04	5.53E-02	5.90E-06	3.40E-08	7.06E-04	0.00E+00	5.02E-03	9.95E-05	3.59E-05	2.08E-03	6.34E-02
	HTO	0.00E+00	1.39E+00	0.00E+00	8.12E-06	2.35E-06	1.56E-02	1.37E-06	0.00E+00	0.00E+00	2.21E-03	7.53E-02	1.49E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-06	2.86E-03	4.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-03
	Noble Gases	1.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-01
	I(mfp)	2.62E-05	3.42E-04	9.70E-05	1.51E-08	5.71E-07	6.27E-05	0.00E+00	0.00E+00	0.00E+00	2.81E-10	0.00E+00	5.29E-04
Total(uSv)		1.51E-01	1.40E+00	5.54E-02	1.41E-05	8.44E-06	5.16E-02	1.43E-05	5.02E-03	9.96E-05	2.24E-03	7.74E-02	1.74E+00
15yr. Old	C-14	2.34E-06	2.96E-03	1.42E-07	2.89E-08	1.92E-06	2.44E-02	6.90E-06	7.70E-10	1.18E-07	2.03E-09	8.65E-05	2.75E-02
	Cs-137+	2.25E-06	9.78E-05	5.53E-02	5.90E-06	2.07E-08	5.35E-04	0.00E+00	5.02E-03	9.95E-05	3.59E-05	1.81E-03	6.29E-02
	HTO	0.00E+00	1.26E+00	0.00E+00	8.12E-06	1.46E-06	1.19E-02	7.63E-07	0.00E+00	0.00E+00	1.95E-03	6.54E-02	1.34E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-06	2.27E-03	2.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E-03
	Noble Gases	1.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-01
	I(mfp)	2.62E-05	4.80E-04	9.70E-05	2.34E-08	5.26E-07	7.35E-05	0.00E+00	0.00E+00	0.00E+00	2.81E-10	0.00E+00	6.77E-04
Total(uSv)		1.51E-01	1.27E+00	5.54E-02	1.41E-05	5.28E-06	3.92E-02	7.89E-06	5.02E-03	9.96E-05	1.98E-03	6.73E-02	1.59E+00
10yr. Old	C-14	2.34E-06	3.12E-03	1.42E-07	8.10E-08	2.14E-06	2.43E-02	7.39E-06	7.70E-10	3.32E-07	2.03E-09	1.09E-04	2.75E-02
	Cs-137+	2.25E-06	6.26E-05	5.53E-02	9.07E-06	1.19E-08	2.86E-04	0.00E+00	5.02E-03	1.53E-04	3.59E-05	1.25E-03	6.21E-02
	HTO	0.00E+00	1.20E+00	0.00E+00	2.03E-05	1.22E-06	1.06E-02	7.28E-07	0.00E+00	0.00E+00	1.84E-03	7.36E-02	1.29E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-06	2.20E-03	2.38E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-03
	Noble Gases	1.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-01
	I(mfp)	2.62E-05	5.63E-04	9.70E-05	7.15E-08	6.67E-07	7.80E-05	0.00E+00	0.00E+00	0.00E+00	2.81E-10	0.00E+00	7.65E-04
Total(uSv)		1.51E-01	1.20E+00	5.54E-02	2.95E-05	5.40E-06	3.74E-02	8.35E-06	5.02E-03	1.53E-04	1.88E-03	7.50E-02	1.53E+00
5yr. Old	C-14	2.34E-06	2.17E-03	1.42E-07	1.00E-07	2.36E-06	2.48E-02	8.15E-06	7.70E-10	4.11E-07	2.03E-09	1.13E-04	2.71E-02
	Cs-137+	2.25E-06	3.47E-05	5.53E-02	8.71E-06	1.02E-08	2.24E-04	0.00E+00	5.02E-03	1.47E-04	3.59E-05	1.00E-03	6.18E-02
	HTO	0.00E+00	9.31E-01	0.00E+00	2.76E-05	1.48E-06	1.20E-02	8.82E-07	0.00E+00	0.00E+00	1.61E-03	8.34E-02	1.03E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-06	2.29E-03	2.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-03
	Noble Gases	1.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-01
	I(mfp)	2.62E-05	6.49E-04	9.70E-05	1.39E-07	1.15E-06	1.23E-04	0.00E+00	0.00E+00	0.00E+00	2.81E-10	0.00E+00	8.97E-04
Total(uSv)		1.51E-01	9.34E-01	5.54E-02	3.65E-05	6.54E-06	3.94E-02	9.30E-06	5.02E-03	1.47E-04	1.65E-03	8.45E-02	1.27E+00
Infant	C-14	3.04E-06	2.22E-03	1.85E-07	2.02E-07	2.08E-07	2.74E-02	5.88E-06	1.00E-09	8.31E-07	2.87E-10	1.34E-04	2.98E-02
	Cs-137+	2.92E-06	3.08E-05	7.19E-02	1.36E-05	8.73E-10	1.83E-04	0.00E+00	6.52E-03	2.30E-04	4.99E-06	9.20E-04	7.98E-02
	HTO	0.00E+00	8.58E-01	0.00E+00	5.38E-05	2.22E-07	1.30E-02	6.13E-07	0.00E+00	0.00E+00	4.26E-04	9.54E-02	9.67E-01
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-07	2.56E-03	1.95E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.56E-03
	Noble Gases	1.84E-01	0.00E+00	0.00E+00	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-01
	I(mfp)	3.41E-05	6.86E-04	1.26E-04	3.13E-07	9.41E-08	1.46E-04	0.00E+00	0.00E+00	0.00E+00	3.66E-10	0.00E+00	9.92E-04
Total(uSv)		1.84E-01	8.61E-01	7.20E-02	6.79E-05	7.09E-07	4.33E-02	6.68E-06	6.52E-03	2.30E-04	4.31E-04	9.64E-02	1.26E+00
Nursing Infant	C-14	3.04E-06	1.23E-03	1.85E-07	1.77E-07	8.78E-03	1.51E-02	0.00E+00	1.00E-09	7.27E-07	2.87E-10	3.96E-05	2.52E-02
	Cs-137+	2.92E-06	2.78E-05	7.19E-02	2.38E-05	9.24E-04	1.92E-04	0.00E+00	6.52E-03	4.02E-04	4.99E-06	5.45E-04	8.06E-02
	HTO	0.00E+00	6.29E-01	0.00E+00	7.10E-05	1.24E+00	1.13E-02	0.00E+00	0.00E+00	0.00E+00	3.44E-04	4.27E-02	1.92E+00
	OBT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-02	1.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-02
	Noble Gases	1.84E-01	0.00E+00	0.00E+00	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-01
	I(mfp)	3.41E-05	3.86E-04	1.26E-04	3.15E-07	1.60E-03	8.82E-05	0.00E+00	0.00E+00	0.00E+00	3.66E-10	0.00E+00	2.23E-03
Total(uSv)		1.84E-01	6.30E-01	7.20E-02	9.53E-05	1.27E+00	2.82E-02	0.00E+00	6.52E-03	4.02E-04	3.49E-04	4.32E-02	2.24E+00

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