SHIELD SOURCE INCORPORATED

2007
ENVIRONMENTAL MONITORING PROGRAM
ANNUAL COMPLIANCE REPORT

CNSC LICENCE NSPFOL-12.02/2009

Shield Source Incorporated
CNSC Licence NSPFOL-12.02/2009

Environmental Monitoring Program Annual Compliance Report

2007

Submitted to:

Canadian Nuclear Safety Commission
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1. INTRODUCTION

1.1 Purpose

This report is the Environmental Monitoring Program portion of the 2007 Annual Compliance Report for Shield Source Incorporated. A summary of the 2007 environmental monitoring results including stack emissions, air, water, milk and vegetation monitoring data is contained within this report. Stack emissions have been compared with the environmental monitoring data and dose to the receptor group has been calculated.

1.2 Land Use within the Monitoring Program Area

A description of the land use within the Shield Source Incorporated monitoring area was given in Shield Source Incorporated's report entitled "2000 Annual Report on Environmental Monitoring Program Shield Source Inc." (Golder Associates) and submitted to the Canadian Nuclear Safety Commission in April 2001. Shield Source Incorporated conducted an additional survey in November 2005 and found that much of the wooded area within the Peterborough Airport property has been cleared and marsh lands within the property have been filled in to support future commercial development as reported in the Environmental Monitoring Program Annual Report Year 2005. No further changes have occurred since this time.

1.3 Environmental Monitoring Locations

The sampling locations and distances from the stack are summarized in Table 1.

Table 1: SSI EMP Sampling Locations

Sampling Location Numbers	Location	Approximate Distance from Stack (m)	Direction from Stack
A1	Airport Beacon Tower	74	NE
~~W1~~	NO LONGER ACTIVE (Culvert At SSI Parking Lot)	120	NE
A2	Fence at Environment Canada weather station	240	SE
W2	Water from washroom tap at airport	240	SE
A3	Sign across from airport entrance	210	SE
W3	Pond just to the north-east of the sign	170	SE
P3	Sign across from Airport Entrance	210	SE
A4	Along Airport Road at creek north of Mel O'Brien Way	250	N
W4	Along Airport Road at creek north of Mel O'Brien Way	250	N
V4	Along Airport Road at creek north of Mel O'Brien Way	250	N
A5	Tree at house opposite SSI	220	NE
WG5	Pond at house opposite SSI	220	NE
WW5	Well water from house opposite SSI	220	NE
V5	Apple tree near pond and residence east of SSI	220	NE
A6	Tree at wetland west of SSI	210	SW
W6	Wetland at tree line west of SSI	210	SW
A7	Mel O'Brien Rd. at end of chain fence	200	NW
~~W7~~	NO LONGER ACTIVE (Flooded land filled in)	200	NW
V7	Mel O'Brien Rd. at end of chain fence	200	NW
A8	Pond/creek at west side of Airport Rd just prior to bend	870	SE
W8	Pond/creek at west side of Airport Rd just prior to bend	870	SE
A9	Cavan Creek	1500	SW
W9	Cavan Creek	1500	SW
V9	Cavan Creek	1500	SW
A10	Culvert at Beardsmore Road	1500	N
W10	Culvert at Beardsmore Road	1500	N
V10	End of Mervin Line (at Otonabee River)	1625	NE
A11	Marshy area east of SSI adjacent to Otonabee River	1200	E
W11	Standing Water	1200	E
A12	Airport Road near tributary to Otonabee River	1000	NW
W12	Pond adjacent to Airport Road	1000	NW
A13	Mervin Line, swampy area	1000	W
W13	Mervin Line, swampy area	1000	W
V13	Mervin Line, swampy area	1000	W
A14	Adjacent to main runway, at pond	1000	SW
W14	Adjacent to main runway, at pond	1000	SW
A15	Fraserville access to Otonabee River	2500	S
W15	Fraserville access to Otonabee River	2500	S
V15	Fraserville access to Otonabee River	2500	S
M16	Dairy Farm east of Stewart Hall and North of Crystal Springs	2860	SE
A17	Background sample 16 km NE of stack	16000	NE
W17	Background sample 16 km NE of stack	16000	NE
P17	Background sample 16 km NE of stack	16000	NE
W19	AirTech Well	196	SW

2. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

2.1 Samples

The 2007 sampling program consisted of five types of samples collected - stack emissions, ambient air samples, ambient water samples, milk sample and vegetation samples.

Stack emissions were measured continuously from the Shield Source Incorporated facility. Ambient air and ambient water samples were collected monthly from sample locations within 1 km of the Shield Source Incorporated stack and quarterly for sample locations greater than 1 km. A milk sample was collected in January 2007; however the dairy farm from which the milk sample was collected sold their dairy quota and cattle at the end of January 2007. Further investigation found no other dairy farms in the surrounding area. Vegetation samples were collected during harvest time (July through to September).

The sampling results are described in the following sections.

2.2 Stack Emissions

Shield Source Incorporated monitors both Tritium Gas (HT) and Tritium Oxide (HTO) continuously. Total HT+HTO stack emissions are recorded daily and HTO activity readings are calculated weekly. The weekly, monthly and yearly stack emissions are then calculated. The current Derived Release Limits (DRLs) calculated by Golder Associates were approved by the Canadian Nuclear Safety Commission in August 2003 and are used in this report to create the basis for all Action and Administrative Limits. The HTO and HT emissions in this report are monitored based on the limits from these DRL values.

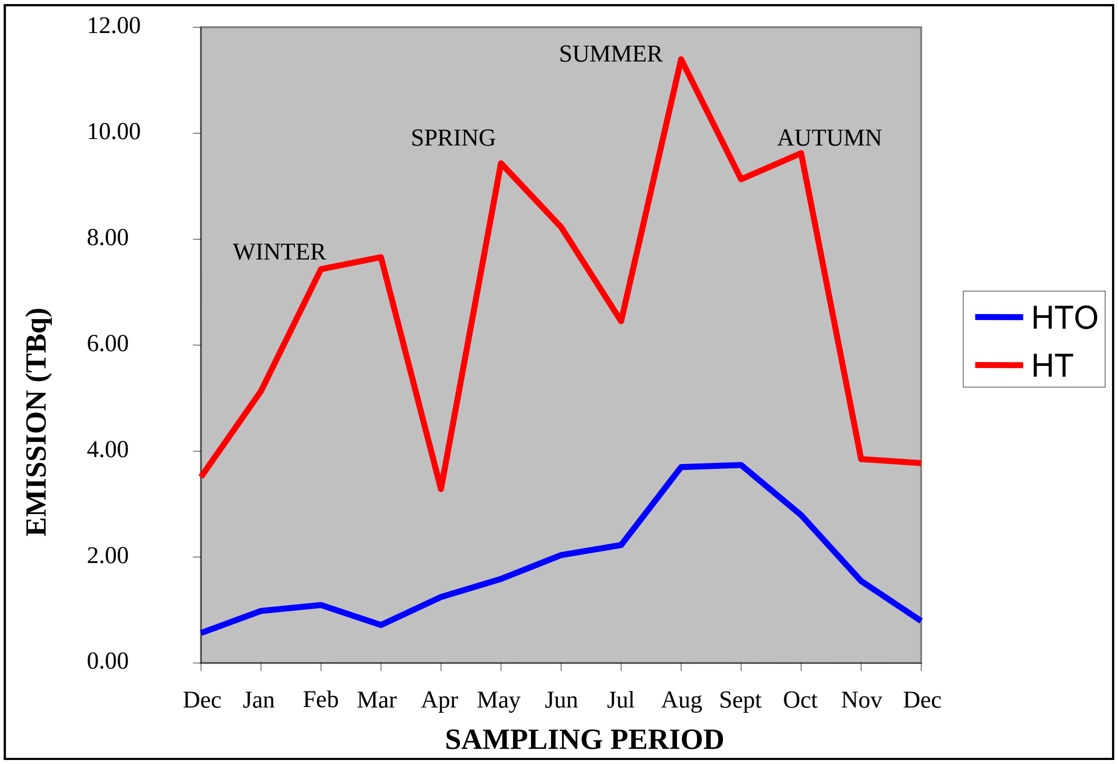
2.2.1 Stack Emission Results

Monthly tritium stack emissions for the period between environmental monitoring sampling dates are presented in Table 2 and illustrated in Figure 1.

Table 2: 2007 Monthly Tritium Stack Emissions for EMP Sampling Periods

Sampling Period		HTO Released TBq	HT Released TBq	Total Activity TBq
From	To			
19-Dec-06	23-Jan-07	0.88	5.26	6.14
23-Jan-07	27-Feb-07	1.11	7.45	8.56
27-Feb-07	27-Mar-07	0.71	7.67	8.38
27-Mar-07	24-Apr-07	1.26	3.28	4.54
24-Apr-07	30-May-07	1.58	9.44	11.02
30-May-07	26-Jun-07	2.05	8.24	10.29
26-Jun-07	24-Jul-07	2.21	6.47	8.68
24-Jul-07	28-Aug-07	3.69	11.4	15.09
28-Aug-07	27-Sep-07	3.73	9.12	12.85
27-Sep-07	31-Oct-07	3.64	8.77	12.41
31-Oct-07	27-Nov-07	1.55	3.86	5.41
27-Nov-07	18-Dec-07	0.79	3.78	4.57
Total		23.20	84.74	107.94
Average		1.87	7.06	9.00
Maximum		3.73	11.4	15.09
Minimum		0.71	3.28	4.54

Figure 1: 2007 Monthly Tritium Stack Emissions



The maximum release of HTO occurred during the sampling period from August 28 to September 27, 2007, when an activity of 3.73 TBq was recorded. The maximum release of HT and consequently the maximum HT + HTO released occurred during the sampling period from July 24 to August 28, 2007, when an activity of 11.40 TBq of HT and 15.09 TBq of HT+ HTO were recorded.

The minimum stack emission for HTO was found during the sampling period from February 27 to March 27, 2007, when 0.71 TBq was recorded and the minimum stack emission of HT during the sampling period from March 27 to April 24, 2007 was 3.28 TBq.

Maximum release of HTO and HT occurred during the months July to October. These emission peaks are a result of normal seasonal higher volume of production, and varying weather conditions.

2.2.2 DRL, Action and Administrative Limits

Shield Source Incorporated's current licence requires the Canadian Nuclear Safety Commission to be notified and specific actions to be taken if at any time the HTO emissions exceed 50% of the DRL per year or 5% of the DRL per week, or if the HT emissions exceed 0.0005% of the DRL per year or 0.00005% of the DRL per week. These limits are known as Action Limits.
Shield Source Incorporated has also set Administrative Limits to alert the company prior to Action Limit levels being reached in order to meet Radiation Protection requirements. If HTO emissions exceed 35% of the DRL per year or 1% of the DRL per week, or if the HT emissions exceed 0.00035% of the DRL per year or 0.00001% of the DRL per week, Shield Source Incorporated implements procedures to prevent reoccurrence and reduce risk to persons and/or the environment. The Derived Release Limits and the Weekly and Yearly Action Limits and Administrative Limits are given in Table 3.

Table 3: DRL and Yearly and Weekly Action and Administrative Limits Values

Description	HTO (TBq)	HT (TBq)
DRL		
Yearly	100	34E+6
Action Limits		
Yearly	50	1700
Weekly	5	1700
Administration Limits		
Yearly	35	1190
Weekly	1	34

2.2.3 DRL and Action Limit Exceedances

2.2.3.1 Yearly Stack Emissions

The total HTO and HT stack emissions for 2007 did not exceed the yearly DRL's or the Shield Source Incorporated yearly Action or Administrative Limits. (Table 4).

Table 4: Annual Stack Emission Compared with DRL, Action and Administrative Limits

YEAR	TRITIUM OXIDE (HTO) PER YEAR (TBq)				TRITIUM OXIDE (HT) PER YEAR (TBq)			
	STACK EMISSION	DRL 100	ACTION LIMIT 50	ADMINISTRATIVE LIMIT 35	STACK EMISSION	DRL 34E+6	ACTION LIMIT 1700	ADMINISTRATIVE LIMIT 1190
	(TBq)	Exceedance of DRL, Action or Administrative Limits (% Exceedance By)			(TBq)	Exceedance of DRL, Action or Administrative Limits (% Exceedance By)		
2007	23.3	--	--	--	87.7	--	--	--

2.2.3.2 Weekly Stack Emissions

The HTO stack emissions in 2007 did not exceed the weekly or yearly Action Limits. However between September 25, 2007 and October 2, 2007 the HTO emission did exceed the Administrative Limit by 2%. (Table 5). Verification was made during that time period that all machines and equipment were operating properly, all departments were functioning within the allowable parameters and all employee bioassays were typical for the jobs performed. The yearly HTO administrative limits were not exceeded in 2007.

The weekly or yearly HT stack emissions in 2007 did not exceed the Action or Administrative Limits.

Table 5: Weekly Stack Emissions Compared with DRL, Action and Administrative Limits

DATE	2007 TRITIUM OXIDE (HTO) PER 7[1] DAYS (TBq)				2007 TRITIUM GAS (HT) PER 7[1] DAYS (TBq)			
	STACK EMISSION	DRL 100	ACTION LIMIT 5	ADMIN. LIMIT 1	STACK EMISSION	DRL 34E+6	ACTION LIMIT 170	ADMIN. LIMIT 34
		Exceedance of DRL, Action or Administrative Limits (% Exceeded By)				Exceedance of DRL, Action or Administrative Limits (% Exceeded By)		
9-Jan	0.23	--	--	--	1.20	--	--	--
16-Jan	0.22	--	--	--	1.25	--	--	--
23-Jan	0.16	--	--	--	1.34	--	--	--
30-Jan	0.19	--	--	--	0.86	--	--	--
6-Feb	0.30	--	--	--	0.53	--	--	--
13-Feb	0.25	--	--	--	1.70	--	--	--
20-Feb	0.18	--	--	--	1.80	--	--	--
27-Feb	0.19	--	--	--	2.56	--	--	--
6-Mar	0.16	--	--	--	2.15	--	--	--
13-Mar	0.14	--	--	--	2.01	--	--	--
20-Mar	0.16	--	--	--	0.90	--	--	--
27-Mar	0.24	--	--	--	2.61	--	--	--
3-Apr	0.34	--	--	--	1.72	--	--	--
10-Apr	0.27	--	--	--	0.68	--	--	--
17-Apr	0.33	--	--	--	0.50	--	--	--
24-Apr	0.32	--	--	--	0.39	--	--	--
1-May	0.32	--	--	--	0.93	--	--	--
8-May	0.20	--	--	--	2.20	--	--	--
15-May	0.18	--	--	--	2.17	--	--	--
22-May	0.31	--	--	--	2.12	--	--	--
29-May	0.58	--	--	--	2.03	--	--	--
5-Jun	0.33	--	--	--	2.04	--	--	--
12-Jun	0.59	--	--	--	2.56	--	--	--
19-Jun	0.60	--	--	--	1.71	--	--	--
26-Jun	0.53	--	--	--	1.93	--	--	--
3-Jul	0.52	--	--	--	1.89	--	--	--
10-Jul	0.61	--	--	--	1.78	--	--	--
17-Jul	0.57	--	--	--	1.36	--	--	--
24-Jul	0.52	--	--	--	1.44	--	--	--
31-Jul	0.50	--	--	--	2.02	--	--	--
7-Aug	0.59	--	--	--	1.44	--	--	--
14-Aug	0.88	--	--	--	1.10	--	--	--
21-Aug	0.73	--	--	--	0.48	--	--	--
28-Aug	1.00	--	--	--	6.39	--	--	--
4-Sep	0.95	--	--	--	2.92	--	--	--
11-Sep	0.95	--	--	--	2.62	--	--	--
18-Sep	0.87	--	--	--	1.83	--	--	--
25-Sep	0.96	--	--	--	1.76	--	--	--

Table 5 cont'd: Weekly Stack Emissions Compared with DRL, Action and Administrative Limits

DATE	TRITIUM OXIDE (HTO) PER 7(1) DAYS (TBq)				TRITIUM GAS (HT) PER 7(1) DAYS (TBq)			
	STACK EMISSION	DRL 100	ACTION LIMIT 5	ADMIN. LIMIT 1	STACK EMISSION	DRL 34E+6	ACTION LIMIT 170	ADMIN LIMIT 34
		Exceedance of DRL, Action or Administrative Limit (% Exceeded By)				Exceedance of DRL, Action or Administrative Limit (% Exceeded By)		
2-Oct	1.02	--	--	2	1.64	--	--	--
9-Oct	0.97	--	--	--	1.17	--	--	--
16-Oct	0.85	--	--	--	2.52	--	--	--
23-Oct	0.46	--	--	--	2.23	--	--	--
30-Oct	0.35	--	--	--	1.21	--	--	--
6-Nov	0.42	--	--	--	1.04	--	--	--
13-Nov	0.26	--	--	--	1.29	--	--	--
20-Nov	0.32	--	--	--	0.82	--	--	--
27-Nov	0.54	--	--	--	0.71	--	--	--
4-Dec	0.25	--	--	--	1.06	--	--	--
11-Dec	0.30	--	--	--	1.70	--	--	--
18-Dec	0.24	--	--	--	1.02	--	--	--
25-Dec	0.23	--	--	--	3.40	--	--	--
1-Jan	0.10	--	--	--	0.96	--	--	--

2.2.4 Data Trends

Table 6: Five Year Comparison of Monthly HTO & HT Emissions for EMP Sampling Periods

	HTO EMISSIONS (TBq)					HT EMISSIONS TBq)				
Sampling Period	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Dec-Jan	1.20	1.60	0.92	1.64	0.88	10.00	4.70	6.19	11.40	5.26
Jan-Feb	0.91	0.85	0.63	0.75	1.11	9.20	4.40	5.04	10.00	7.45
Feb-Mar	0.88	1.40	0.77	0.83	0.71	9.90	6.10	6.35	10.50	7.67
Mar-Apr	1.50	1.20	1.26	0.48	1.26	8.50	3.10	5.55	7.74	3.28
Apr-May	2.40	2.50	1.28	0.38	1.58	6.20	4.00	6.99	4.61	9.44
May-Jun	0.85	1.60	1.94	0.84	2.05	4.50	5.50	7.26	3.37	8.24
Jun-Jul	1.90	1.70	1.98	1.44	2.21	2.00	12.00	6.05	3.04	6.47
Jul-Aug	2.20	1.70	1.41	1.64	3.69	1.90	12.00	8.84	7.69	11.40
Aug-Sep	4.00	2.50	2.64	2.12	3.73	5.90	15.00	14.20	15.10	9.12
Sep-Oct	2.20	1.10	1.57	1.49	3.64	4.20	6.80	13.00	12.50	8.77
Oct-Nov	2.20	0.92	1.62	1.07	1.55	4.10	7.90	11.80	7.98	3.86
Nov-Dec	1.00	1.10	0.98	0.55	0.79	3.20	0.88	13.60	3.51	3.78
TTL:	21.24	18.17	17.00	13.23	23.20	69.60	82.38	104.87	97.44	84.74
AVG:	1.77	1.51	1.42	1.10	1.87	5.80	6.87	8.74	8.12	7.06
MAX:	4.00	2.50	2.64	2.12	3.73	10.00	15.00	14.20	16.10	11.40
MIN:	0.85	0.85	0.63	0.38	0.71	1.90	0.88	5.04	3.04	3.28

Figure 2: Five Year Monthly HTO Comparison

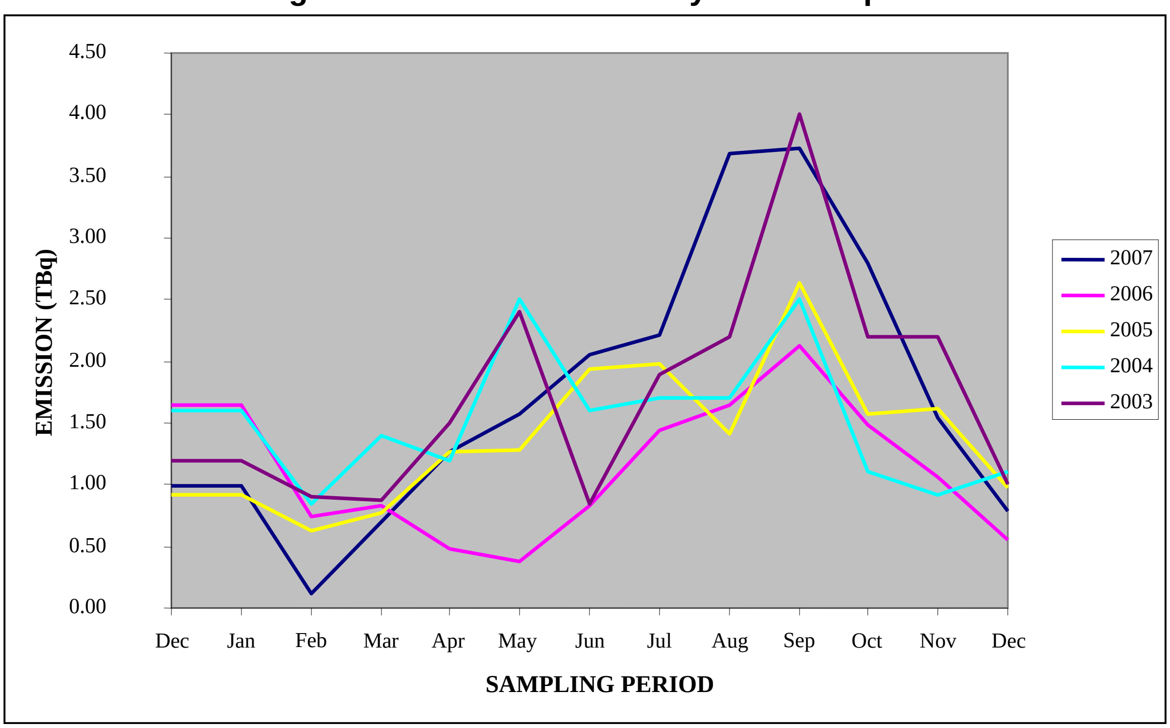
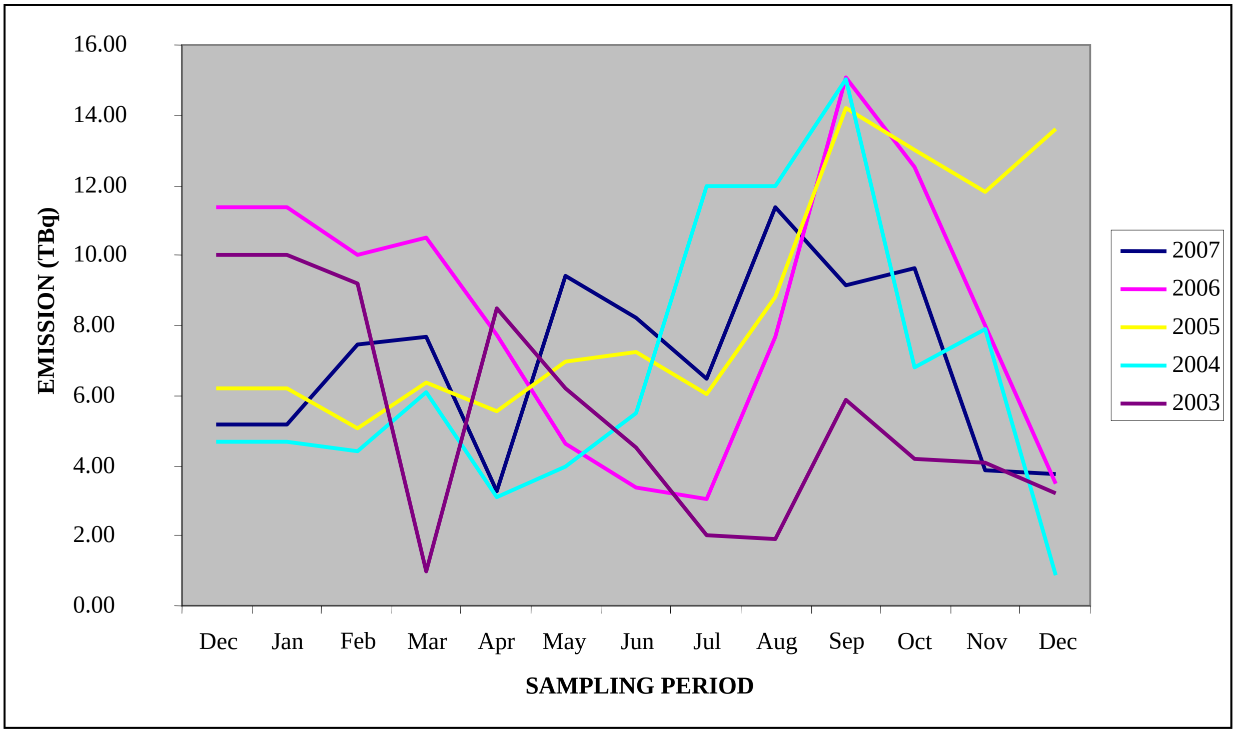


Figure 3: Five Year Monthly HT Comparison



The maximum release of HTO occurred in August to September for each year from 2003 to 2007 (Figure 2). There was no discernable maximum release trend for HT over 5 years, however it is seen from Figure 3 that for most years the maximum release of HT occurred between August and September. These trends observed for the emissions generally follow production levels over the same time period.

Table 7: Five Year Comparison of Seasonal HTO & HT Emissions between EMP Sampling Periods

Sampling Period	HTO EMISSIONS (TBq)					HT EMISSIONS (TBq)				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
WINTER	1.00	1.28	0.77	1.07	0.60	9.70	5.07	5.86	10.60	6.76
SPRING	1.58	1.77	1.49	0.56	1.63	6.40	4.20	6.60	5.24	6.99
SUMMER	2.70	1.97	2.01	1.73	3.21	3.27	13.00	9.70	8.61	9.00
AUTUMN	1.80	1.04	1.39	1.04	1.71	3.83	5.19	1.28	8.00	5.75
MAX:	2.70	1.97	2.01	1.73	3.21	9.70	13.00	12.80	10.60	9.00
MIN:	1.00	1.04	0.77	0.56	0.6	3.27	4.20	5.86	5.24	5.75

Figure 4: Five Year Seasonal HTO Comparison

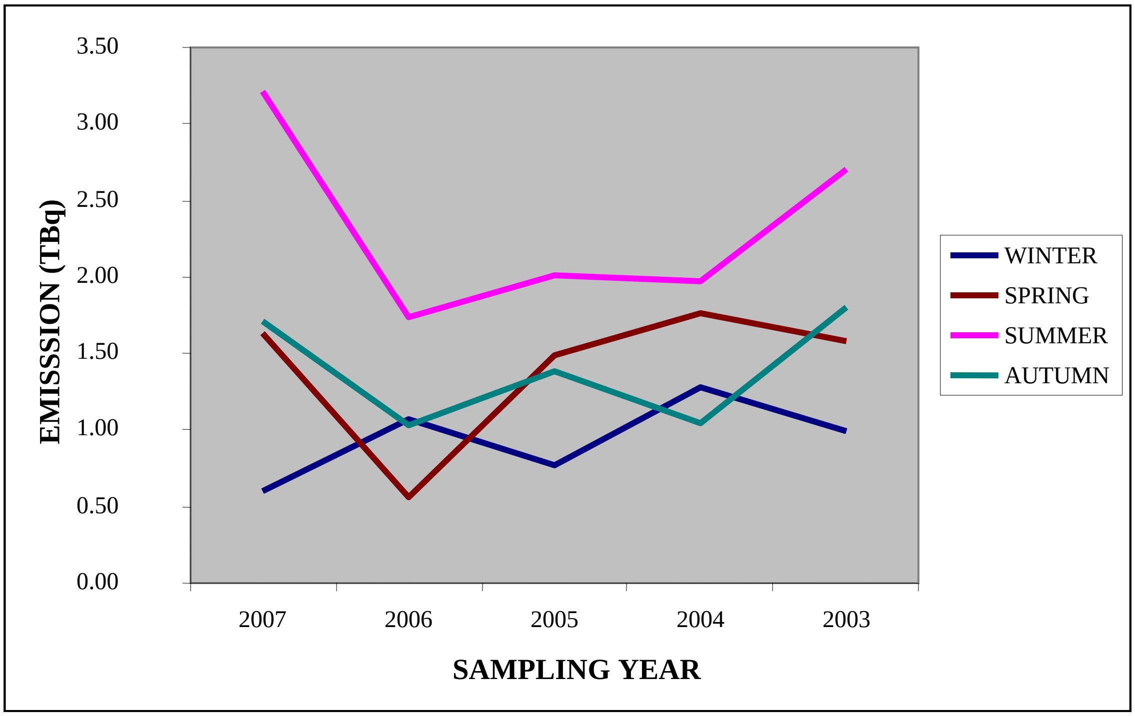
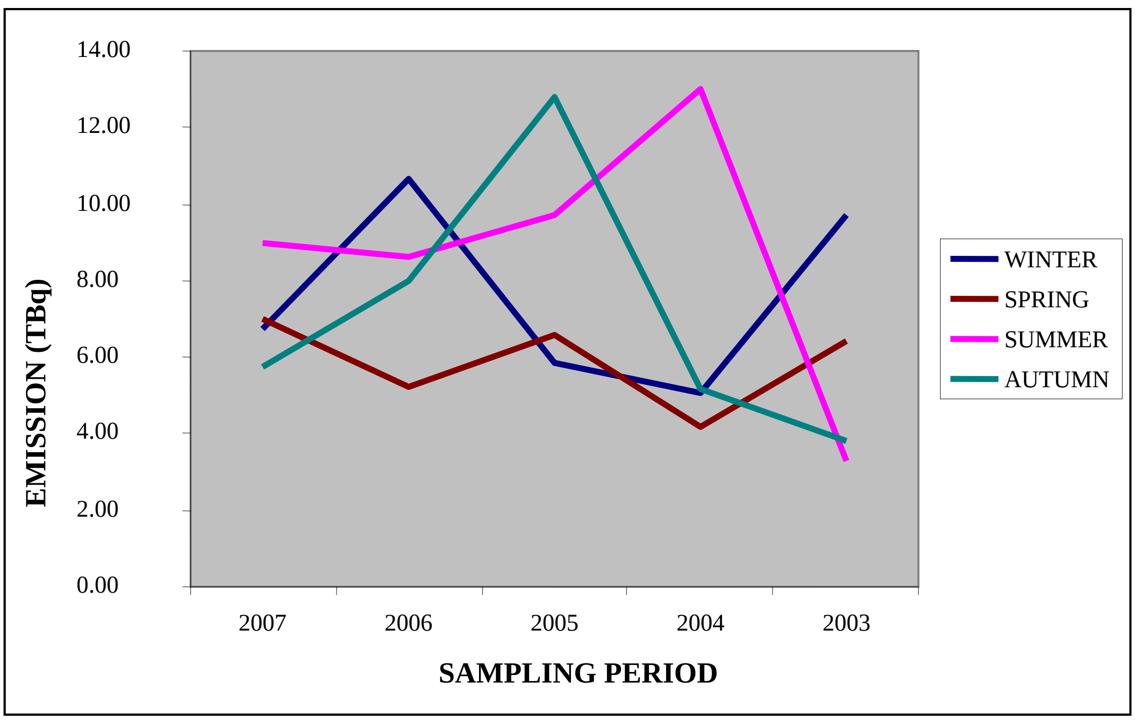


Figure 5: Five Year Seasonal HT Comparison



Maximum release values of HT and HTO generally occurs in the summer months. This maximum corresponds to a higher volume of production during June, July, August and September.

2.3 Ambient Air Data

2.3.1 Sampling Method

Passive air monitors were used to assess tritium activity in air. The samplers consist of containers filled with distilled water and capped with a diffusion cap (designed by Ontario Hydro Technologies). Tritium oxide and tritium gas diffuse into the vial and dissolve in the distilled water. Ethylene glycol is added to the distilled water during the winter months to prevent freezing. The samplers are deployed one metre above the ground by attaching them to an available surface (post, tree). The sampler is attached so that it always faces the Shield Source Incorporated facility. A small plastic container with air holes is suspended in the inverted position over the sampler to protect it. The sampler is left for a one month period and then retrieved for analysis. The sampling liquid is analyzed by scintillation counting through the independent third party.

Monserco Limited was contracted by Shield Source Incorporated to perform the analyses on the samples collected in 2007 and is the independent third party referred to throughout this report.

The passive air monitoring data must be converted from Bq/L in sampling liquid to Bq/m^3 in air. There is no standardized and accepted calculation for this conversion. Numerous assumptions must be made in order to estimate the volume of air sampled by a passive device. The conversion calculations and the assumptions made are presented in Appendix I.

2.3.2 Sample Availability

There were 128 planned ambient air sample collections in 2007 and 121 actual collections performed. The missing samples were due to inaccessibility of samples (i.e. flooding or missing sample due to severe weather). Therefore 95% of valid ambient air sample collection was achieved compared to planned collection.

2.3.3 Results

The ambient air monitoring data collected from January 2007 to December 2007 are provided in Table 8. A comparison of average and maximum ambient air monitoring results for each sample location for 2003, 2004, 2005, 2006 and 2007 are given in Table 9. A monthly comparison of average ambient air activity over the past five years can be found in Table 10.

Based on the assumptions used from Appendix I to convert the passive sampling data from Bq/L in sampling liquid to Bq/m^3 in air, the tritium activity in air averaged over the sampling period was estimated to be 2.3 Bq/m^3 at all sample locations. The highest annual average tritium activity in ambient air was 7.22 Bq/m^3 collected from sample locations A1 which is located 74 metres NE of the Shield Source Incorporated stack. The maximum monthly average occurred from August 28, 2007 to September 27, 2007 with a maximum average activity of 3.52 Bq/m^3. These values correspond to the maximum emission levels observed in 2007.

In 2007 a change in our ventilation stack fan system occurred. The fan speed remained at high speed during both production and non-production hours whereas previous years the fan speed would be lowered during non-production hours. This change has contributed to higher tritium activities found throughout our 2007 data.

Table 8: 2007 Ambient Air Monitoring Data (Bq/m^3)

Date Sampled	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A17	Avg/ Month
Jan-07	3.80	0.78	1.87	3.06	2.85	1.23	0.82	0.73	--	--	--	--	--	--	--	--	1.89
Feb-07	2.14	1.38	3.81	1.75	3.08	1.21	0.94	0.98	--	--	--	--	--	--	--	--	1.91
Mar-07	2.50	2.00	2.50	2.35	1.64	0.80	0.68	<DL	0.38	0.65	--	0.57	0.71	0.45	0.44	<DL	1.08
Apr-07	5.10	2.17	1.79	2.78	3.78	2.13	1.60	0.43	--	--	--	--	--	--	--	--	2.47
May-07	10.61	1.54	4.24	4.52	3.33	0.95	0.95	0.51	--	--	--	--	--	--	--	--	3.33
Jun-07	14.21	2.10	4.56	5.82	3.83	1.22	1.71	0.98	0.58	1.71	0.64	0.93	0.69	--	--	0.46	2.82
Jul-07	9.58	1.59	3.83	--	3.45	0.92	1.01	0.36	--	--	--	--	--	--	--	--	2.96
Aug-07	10.34	1.44	3.55	5.10	2.82	2.14	2.20	0.56	--	--	--	--	--	--	--	--	3.52
Sep-07	14.52	1.99	4.71	6.36	3.26	1.15	1.37	0.79	0.58	1.57	0.73	0.68	0.30	0.52	<DL	<DL	2.45
Oct-07	8.42	--	3.78	3.53	3.00	1.51	2.10	0.75	--	--	--	--	--	--	--	--	3.30
Nov-07	4.17	<DL	1.08	1.36	--	<DL	0.57	<DL	--	--	--	--	--	--	--	--	1.17
Dec-07	1.24	<DL	0.91	<DL	1.56	<DL	<DL	<DL	<DL	<DL	1.63	<DL	<DL	--	<DL	<DL	0.66
Average	7.22	1.43	3.05	3.37	2.96	1.17	1.20	0.59	0.49	1.08	1.00	0.65	0.53	0.48	0.39	0.37	2.30
Maximum	14.52	2.17	4.71	6.36	3.83	2.14	2.20	0.98	0.58	1.71	1.63	0.93	0.71	0.52	0.44	0.46	3.52
DISTANCE	74	240	210	250	220	210	200	870	1500	1500	1200	1000	1000	1000	2500	16000	
DIRECTION	**NE**	**SE**	**SE**	**N**	**NE**	**SW**	**NW**	**SE**	**SW**	**N**	**E**	**NW**	**W**	**SW**	**S**	**NE**	

Notes: (--) indicates no sample collected or analyzed
All results were reported in Bq/L and then converted to Bq/m3 (See Appendix I).
<DL indicates measured level is below detection limit (DL). In statistical summary calculations, values that were <DL were set to DL-1 in Bq/L and then converted to Bq/m3.
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

Table 9: Annual Comparison of Average and Maximum Ambient Air Monitoring Results for each Sample Location

	Average (Bq/L)					Maximum (Bq/L)				
Location	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
A1	1.30	4.36	4.23	4.94	7.22	1.72	8.55	8.62	9.19	14.52
A2	0.66	0.62	1.28	0.86	1.43	1.40	1.23	3.79	1.64	2.17
A3	0.91	0.99	1.44	2.20	3.05	1.68	1.71	2.13	3.75	4.71
A4	1.49	1.47	1.68	1.87	3.37	3.38	3.14	2.86	3.71	6.36
A5	1.54	1.28	2.03	1.79	2.96	3.57	2.42	3.82	3.17	3.83
A6	1.08	0.69	0.78	0.81	1.17	2.73	1.34	1.86	1.57	2.14
A7	1.00	0.60	0.61	0.98	1.20	4.18	1.23	0.94	1.46	2.20
A8	0.38	0.50	0.45	0.76	0.59	0.74	1.96	0.84	2.46	0.98
A9	0.40	0.70	0.50	0.66	0.49	0.60	4.10	1.61	1.22	0.58
A10	0.50	0.43	0.47	0.64	1.08	1.00	0.89	0.91	1.14	1.71
A11	0.43	0.49	0.40	0.63	1.00	0.86	1.66	0.87	1.02	1.63
A12	0.37	0.35	0.36	0.69	0.65	0.60	0.67	0.81	1.15	0.93
A13	0.38	0.33	0.43	0.58	0.53	0.65	0.53	0.84	1.03	0.71
A14	0.38	0.34	0.41	0.57	0.48	0.51	0.51	0.93	0.95	0.52
A15	0.44	0.30	0.41	0.42	0.39	0.90	0.40	0.93	0.59	0.44
A17	0.39	0.25	0.28	0.60	0.37	1.08	0.32	0.43	0.95	0.46
Maximum	A5	A1	A1	A1	A1	A7	A1	A1	A1	A1

Table 10: Annual Comparison of Monthly Average Ambient Air Monitoring Results

	Average				
Month	2003	2004	2005	2006	2007
Jan	0.42	0.44	0.98	0.32	1.89
Feb	0.5	0.45	0.61	1.22	1.91
Mar	0.45	0.82	0.42	0.63	1.08
Apr	0.64	0.35	0.61	0.73	2.47
May	0.52	0.75	0.88	1.14	3.33
Jun	0.71	1.35	1.15	1.67	2.82
Jul	0.95	1.2	1.1	2.11	2.96
Aug	0.72	0.5	1.35	2.59	3.52
Sep	1.25	1.49	1.31	0.95	2.45
Oct	0.92	1.08	2.04	2.21	3.30
Nov	0.44	1.17	1.99	2.29	1.17
Dec	0.52	0.8	1.21	1.93	0.66

2.4 Ambient Water Monitoring

2.4.1 Sampling Method

Water samples were collected and analyzed by liquid scintillation counting, conducted by an independent third party on a monthly basis. Water samples were collected in suitable laboratory supplier purchased containers and triple rinsed with the sample water.

2.4.2 Sample Availability

There were 128 planned water sample collections scheduled for 2007 with 77 actual collections performed. Most samples which were not collected were due to either drought in the summer months or frozen sample locations in the winter months. Therefore 60% of valid water sample collections were achieved compared to planned collection.

2.4.3 Results

The ambient water monitoring data collected from January 2007 to December 2007 are provided in Table 11. A comparison of average and maximum ambient water monitoring results for each sample location for 2003 through 2007 is given in Table 12.

The highest annual average tritium activity detected from Table 11 in ambient water samples was 1872 Bq/L from sample location W3 that is located 170 metres SE of the Shield Source Incorporated stack. As found in Table 11, the maximum monthly average tritium activity occurred from March 27, 2007 to April 24, 2007 with an average activity of 657 Bq/L. A comparison of the average and maximum activities for each sample location from 2003 through 2007 is given in Table 12. The average and maximum activity in 2003 through 2007 from Table 13 appears comparable.

In 2007 a change in our ventilation stack fan system was implemented. The fan speed was increased, to remain at high speed during both production and non-production hours, whereas previous years the fan speed would be lowered during non-production hours. This change has contributed to higher tritium activities found throughout Shield Source Incorporated's 2007 environmental data.

Table 11: Ambient Water Monitoring Data (Bq/L)

`` 2007 DATE	W2	W3	W4	WW5	WG5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W17	WW19	Avg/ Month
Jan	<DL	--	--	<DL	--	--	--	171	--	--	--	--	--	--	--	--	<DL	80
Feb	<DL	--	--	<DL	--	--	--	--	--	--	--	--	--	--	--	--	<DL	44
Mar	<DL	2296	939	<DL	1716	594	--	180	144	155	--	166	63	47	50	47	<DL	435
Apr	<DL	1449	587	--	1552	687	--	237	--	--	--	--	--	--	--	--	<DL	657
May	63	--	1655	<DL	1586	677	--	201	--	--	--	--	--	--	--	--	<DL	612
Jun	51	--	--	--	1553	--	--	142	53	299	<DL	84	130	--	<DL	<DL	<DL	228
Jul	<DL	--	--	<DL	1574	--	--	109	--	--	--	--	--	--	--	--	<DL	362
Aug	55	--	--	<DL	1803	--	--	--	--	--	--	--	--	--	--	--	<DL	388
Sep	<DL	--	--	<DL	1845	--	--	--	<DL	--	<DL	--	--	--	<DL	<DL	<DL	243
Oct	51	--	--	--	2301	--	--	215	--	--	--	--	--	--	--	--	<DL	654
Nov	<DL	--	1172	<DL	2068	--	--	221	--	--	--	--	--	--	--	--	<DL	601
Dec	<DL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<DL	<DL	49
Average	49	1872	1088	46	1778	652	--	148	82	227	50	125	96	47	50	49	47	363
Maximum	63	2296	1655	50	2301	687	--	237	144	299	50	166	130	47	50	50	50	657
DISTANCE	240	170	250	220	220	210	200	870	1500	1500	1200	1000	1000	1000	2500	16000	196	
DIRECTION	SE	SE	N	NE	NE	SW	NW	SE	SW	N	E	NW	W	SW	S	NE	SW	

Notes: (--) indicates no sample collected or analyzed
<DL indicates measured level is below detection limit (DL). In statistical summary calculations, values that were <DL were set to DL-1.
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

Table 12: Annual Comparison of Average and Maximum Ambient Water Monitoring Results for each Sample Location (Bq/L)

Location	Average					Maximum				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
W1	<DL	262	--	--	--	<DL	474	--	--	--
W2	<DL	<DL	52	<DL	49	52	52	84	<DL	63
W3	828	675	1307	1251	1872	1155	1058	2196	1734	2296
W4	2444	581	783	705	1088	9803	913	1403	1110	1655
WW5	<DL	50	56	81	<DL	53	62	83	302	<DL
WG5	1651	1305	1770	1490	1778	1875	2376	2494	1888	2301
W6	630	375	626	721	652	763	717	716	1248	687
W7	768	623	1079	--	--	1340	1378	1079	--	--
W8	123	111	185	106	148	168	197	340	168	237
W9	60	60	55	136	82	92	97	91	372	144
W10	82	73	76	176	227	102	116	135	436	299
W11	<DL	<DL	52	<DL	<DL	<DL	<DL	68	<DL	<DL
W12	72	62	<DL	<DL	125	126	150	<DL	<DL	166
W13	66	55	61	68	96	88	82	74	106	130
W14	80	65	74	61	47	145	128	134	78	47
W15	<DL	352	<DL	<DL	50	52	2768	<DL	<DL	50
W17	51	<DL	57	<DL	49	68	<DL	101	<DL	50
WW19	--	--	--	<DL	<DL	--	--	--	<DL	<DL

Note: (--) indicates no sample collected or analyzed
<DL indicates measured level is below detection limit (DL). In statistical summary calculations, values that were <DL were set to DL-1
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

Table 13: Annual Comparison of Monthly Average Ambient Water Results (Bq/L)

Location	Average				
	2003	2004	2005	2006	2007
Jan	<DL	<DL	<DL	489	80
Feb	<DL	<DL	<DL	<DL	44
Mar	<DL	395	284	514	435
Apr	319	143	367	676	657
May	335	388	319	604	612
Jun	292	389	186	245	228
Jul	234	249	278	674	362
Aug	156	104	265	782	388
Sep	863	336	251	274	243
Oct	337	321	1418	691	654
Nov	367	295	836	560	601
Dec	122	<DL	103	368	<DL

Note: <DL indicates measured level is below detection limit (DL). In statistical summary calculations, values that were <DL were set to DL-1.
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

2.5 Milk Samples

2.5.1 Sampling Method

A milk sample was collected from the dairy farm in January 2007. This farm was chosen because it is the closest to Shield Source Incorporated's facility in the direction of the prevailing winds. The milk sample was collected in a suitable sample container and analyzed by an independent third party for tritium by liquid scintillation counting.

In late January 2007, the dairy farm from which the milk sample was collected sold their dairy quota and cattle. Further investigation found no other dairy farms in the surrounding area. No further milk sampling occurred in 2007 for this reason.

2.5.2 Results

The milk monitoring data collected is provided in Table 14.

A survey of the surrounding area indicated that the closest dairy farm and the one that Shield Source Incorporated has used in the NE wind direction is over 2800 m from the Shield Source Incorporated stack. Tritium activity in the milk sample was below the detection limit.

Table 14: Milk Monitoring Data (Bq/L)

DATE	DL	M16
Jan 23, 07	51	<DL
DISTANCE	2860 m	
DIRECTION	NE	

Note: <DL indicates measured level is below detection limit (DL).

2.6 Vegetation Samples

2.6.1 Sampling Method

Vegetation samples (wild apples and grapes) were collected during the 2007 harvest season. Samples were sealed in plastic bags and analyzed by an independent third party for tritium by liquid scintillation counting.

2.6.2 Results

The vegetation monitoring data collected are provided in Table 15.

Vegetation sample locations were sites V5, V8 and V10. These samples were the only vegetation found at Shield Source Incorporated's site locations. Locations V5, V8 and V10 are located 220 meters NE, 200 meters NW and 1625 meters NE of the Shield Source Incorporated stack, respectively. The higher activity levels found in the samples from location V5 corresponds with maximum HTO and HT emissions during the summer months (June to September).

Table 15: Vegetation Monitoring Data (Bq/L)

DATE	DL	V5 APPLES	V8 GRAPES	V10 GRAPES
Jul 24/07	44	4879	-	-
Aug 28/07	42	4691	-	<DL
Sep 21/07	50	3632	2964	-
Sep 27/07	50	2773	-	-
DISTANCE		220	200	1625
DIRECTION		NE	NW	NE

Note: <DL indicates measured level is below detection limit (DL).

Table 16 compares vegetation monitoring results for 2003 through 2007 for the sampling location V5.

Table 16: Annual Comparison of Vegetation Monitoring Results (Bq/L)

DATE	V5 APPLES				
	2003	2004	2005	2006	2007
Jul	-	-	-	-	4879
Aug	-	2800	2080	-	4691
Sep	1240	2020	2140	3091	3632
Oct	-	1600	-	-	2773
DISTANCE	220				
DIRECTION	NE				

3. CALCULATED DOSES TO THE CRITICAL RECEPTOR

3.1 Selection of Monitored Data for Dose Calculation

The model used to estimate doses to the critical receptor is presented in the Shield Source Incorporated. Derived Release Limits for Tritium Based on Air Dispersion and Environmental Pathway Modeling (SSI 2005). This model was submitted to REPD for review in May 2000, and was updated based on feedback from Mr. Michael James of the CNSC on July 16, 2002. This model uses conservative assumptions regarding the percent of vegetables, fruits, milk, eggs, poultry and meat obtained from the immediate area. A comparison of the conservative model with one using more realistic assumptions was submitted to CNSC in 2004.

Historically, the dose to the critical receptor has been reported based on monitoring results obtained at the nearest residence (Station 5), which coincided with areas of maximum monitored activity. Since 2005, the highest monitored activity in ambient air samples was not observed at the closest residence but at a different location (Station 1). Furthermore in 2007, the highest average monitoring activity in water was observed in Station 3. However, Station 5 still contained the maximum monitored activity in water.

In order to provide a basis for comparison to previous annual reports, the dose to the critical receptor was calculated based on the nearest residence. However, since the nearest residence no longer coincided with the highest monitored activity in air or highest average monitored activity in water, dose to the critical receptor was also calculated based on Stations 1 and 3 (highest average tritium activity in air and highest average activity in water, respectively) and Stations 1 and 5 (highest maximum tritium activity in air and highest maximum activity in water, respectively).

The average monitored activities in air and water at Station 5 (the closest residence) and at Stations 1 and 3 (sites with highest air and water activity, respectively) is presented in Table 17.

Table 17: Average Activities of Tritium in Air and Water Measured During the 2007 Monitoring Program

Location	Form of Tritium	Activity in Water Bq/L	Activity in Air Bq/m^3	Monitoring Sample Locations
Highest Activity	HTO	1,872	7.22	W3, A1
	HT	-	-	
Closest Residence	HTO	1,778	2.96	WG5, A5
	HT	-	-	

The maximum monitored activities in air and water at Station 5 (the closest residence) and at Stations 1 and 5 (sites with highest air and water activity, respectively) is presented in Table 18.

Table 18: Maximum Activities of Tritium in Air and Water Measured During the 2007 Monitoring Program

Location	Form of Tritium	Activity in Water Bq/L	Activity in Air Bq/m^3	Monitoring Sample Locations
Highest Activity	HTO	2,301	14.52	WG5, A1
	HT	-	-	
Closest Residence	HTO	2,301	3.83	WG5, A5
	HT	-	-	

3.2 Dose Calculation Methodology

The methodology for calculating doses to the critical receptor is outlined in Appendix II.

The International Commission on Radiological protection recommends the use of three age categories for estimating the annual dose to the representative individual in the prospective assessments. These categories are 0 to <6 years (infant), 6 to <16 years (child) and 16 to 70 years (adult). It is recommended that dose coefficients and habitat data for the 1-year old infant, 10-year-old-child and the adult should be used as representing the three age categories (ICRP 2005). Therefore, doses were estimated for these three age categories.

The method to calculate doses uses assumptions regarding the annual consumption of vegetables, milk, eggs, poultry and meat, intake of water and inhalation rates. The annual consumption of milk, eggs, poultry and meat were derived using food consumption information from two references (US EPA 1991 and Richardson 1997). The annual consumption of vegetables and intake of water were taken from EHAS 2004. The inhalation rates were taken from ICRP 71 (ICRP 1995b). It should be noted that the present methodology uses the same conservative assumptions regarding the percent of vegetables, fruits, milk, eggs, poultry and meat obtained from the immediate area as in the dose calculations in the 2005 SSI Report.

Potential exposure to tritium through the consumption of local vegetation and animal produce was based on uptake modelling using both the average and maximum observed activities in air and water.

As per CNSC comments (CNSC letter from Gerald Crawford to Peggy Hirst, dated June 18, 2007), the air monitoring values were used 'as is' for dose calculations due to tritium oxide (HTO) in air (i.e., HTO released from the stack, plus a small amount of HTO converted from HT releases that then deposit on soil and diffuse out of the soil to surrounding air). In past models, the monitored air values were adjusted as percentages of HTO and HT releases. However, it was noted that passive diffusion monitors only measure HTO in air and not the total activity attributable to the presence of tritium. Also, since the dose conversion factor for HT is extremely low, the HT dose calculation was not performed in obtaining an estimate to the critical receptors.

Estimated doses due to HTO and organically bound tritium (OBT) were derived using both the average and maximum concentrations of HTO in air and water measured at the selected sites for 1-year-old Infant, 10-year-old Child and Adult and are presented in Sections 3.2.1, 3.2.2 and 3.2.3, respectively.

3.2.1 Dose Calculations for the 1-year-old Infant Receptor

Estimated doses of HTO and OBT were derived for the 1-year-old Infant using both the average (Table 19) and maximum concentrations (Table 20) of HTO in air and water measured at the site with the highest activity and at the closest residence to the source.

Table 19: Estimated Doses to the 1-year-old Infant from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Average* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.020	0.00131	0.0017	0.0062	W3, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0028	0.017		
Closest Residence	HTO	0.019	0.00054	0.0014	0.0058	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0024	0.016		

Table 20: Estimated Doses to the 1-year-old Infant from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Maximum* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.024	0.00262	0.0023	0.0078	WG5, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0039	0.022		
Closest Residence	HTO	0.024	0.00069	0.0019	0.0076	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0031	0.021		

A survey of the monitoring area indicated that at no time had a vegetable garden or livestock been observed at the nearest residence. The vegetation samples collected from this location were wild apples. Although the estimated doses in Tables 19 and 20 indicate that consumption of wild apples would not result in unacceptable exposure, residents of this property have confirmed that wild apples from the property are not consumed.

The contribution of each exposure pathway to total dose to the 1-year-old Infant receptor is presented in Tables 21 and 22. As expected, the majority of the dose is contributed by ingestion of food and water. The inhalation pathway contributes a very small proportion (<3%) of the total dose.

The calculated long-term doses to the 1-year-old Infant receptor do not exceed the annual public dose limit of 1 mSv per year (Tables 21 and 22).

Table 21: Total Tritium Dose (All Forms) to the 1-year-old Infant using *Average* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Infant [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.049***	0.020	40.16%	0.00131	2.66%	0.0045	9.27%	0.0235	47.91%
Closest Residence	1	***0.045***	0.019	41.66%	0.00054	1.19%	0.0038	8.56%	0.0218	48.59%

Table 22: Total Tritium Dose (All Forms) to the 1-year-old Infant using *Maximum* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Infant [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.063***	0.024	38.61%	0.00262	4.19%	0.0063	10.00%	0.0296	47.20%
Closest Residence	1	***0.058***	0.024	41.66%	0.00069	1.19%	0.0050	8.56%	0.0282	48.59%

As shown in Table 23, a comparison of modelled average and maximum tritium activities in milk with measured activities in milk shows that the model overestimates activities in milk. This comparison shows that the model predictions are conservative and that doses are not underestimated.

Table 23: Measured versus Modelled Tritium Activity in Milk

Location	Average		Maximum	
	Measured Mean Bq/L	***Modelled (HTO+OBT) Bq/L***	***Measured Mean Bq/L***	***Modelled (HTO+OBT) Bq/L***
Highest Activity	< 51	2,350	< 51	2,950
Closest Residence	< 51	2,190	< 51	2,833

Note: Tritium activity in milk is independent of the receptor

A comparison of modelled average and maximum tritium concentrations in vegetation with measured activities in vegetation (apples) shows that the model agrees with the monitored vegetation activity within a factor of 2. However, it underestimates vegetation activities (Table 24). Monitored activity in vegetation (apples) was higher than modelled activity in 2007 in all cases. The elevated activity in apple samples coincides with higher stack emissions at the time of collection than in other months. Consequently, stack emission variations during sampling periods may have a direct link to resulting monitored activities in vegetation, particularly in items such as apples which would be expected to accumulate some HTO via air deposition or rainfall on the surface of the fruit.

Table 24: Measured versus Modelled Tritium Activity in Vegetation

Location	Average		Maximum	
	Measured (Apples) Bq/L	***Modelled (HTO+OBT) Bq/L***	***Measured (Apples) Bq/L***	***Modelled (HTO+OBT) Bq/L***
Highest Activity	3,993	1,876	4,879	2,589
Closest Residence	3,993	1,587	4,879	2,054

Note: Tritium activity in vegetation is independent of the receptor

The maximum activity level in vegetation was observed at V5 located 220 m northeast of the stack at the closest residence. When the dose modelling was re-run using monitored data for vegetation along with monitored air and water data, the total estimated dose using monitored vegetation data to a 1-year-old infant receptor increased by about 17% to 21% (Table 25). In the average activity scenario, the total dose using monitored data increased by 0.010 mSv/yr at the closest residence and by 0.009 mSv/yr at the highest activity area when compared to the modelled dose. The total estimated dose in the maximum activity scenario increased by 0.012 mSv/yr at the closest residence and by 0.009 mSv/yr at the highest activity area when compared to the modelled dose. However, the total estimated dose to a 1-year-old infant receptor using monitored or modelled activity in vegetation was still seen to be lower than the annual dose limit of 1 mSv/yr in all cases.

Table 25: Comparison of Estimated Dose Using Modelled Versus Monitored Activity in Vegetation (1-year-old Infant)

Location		Annual Dose Limit (mSv/yr)	Dose using *Modelled* Vegetation Activity (mSv/yr)	Dose using *Monitored* Vegetation Activity (mSv/yr)
Average	Highest Activity	1	0.049	0.058
	Closest Residence	1	0.045	0.055
Maximum	Highest Activity	1	0.063	0.072
	Closest Residence	1	0.058	0.070

3.2.2 Dose Calculations for the 10-year-old Child Receptor

Estimated doses of HTO and OBT were derived for the 10-year-old Child using both the average (Table 26) and maximum concentrations (Table 27) of tritium oxide in air and water measured at the site with the highest activity and at the closest residence to the source.

Table 26: Estimated Doses to the 10-year-old Child from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Average* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.013	0.00185	0.0012	0.0031	W3, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0020	0.009		
Closest Residence	HTO	0.012	0.00076	0.0010	0.0029	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0017	0.008		

Table 27: Estimated Doses to the 10-year-old Child from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Maximum* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.015	0.00373	0.0017	0.0039	WG5, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0028	0.011		
Closest Residence	HTO	0.015	0.00098	0.0013	0.0038	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0022	0.010		

A survey of the monitoring area indicated that at no time had a vegetable garden or livestock been observed at the nearest residence. The vegetation samples collected from this location were wild apples. Although the estimated doses in Tables 26 and 27 indicate that consumption of wild apples would not result in unacceptable exposure, residents of this property have confirmed that wild apples from the property are not consumed.

The contribution of each exposure pathway to total dose to the 10-year-old Child receptor is presented in Tables 28 and 29. As expected, the majority of the dose is contributed by ingestion of food and water. The inhalation pathway contributes a small proportion (<10%) of the total dose.

The calculated long-term doses to the 10-year-old Child receptor do not exceed the annual public dose limit of 1 mSv per year (Tables 28 and 29).

Table 28: Total Tritium Dose (All Forms) to the 10-year-old Child using *Average* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Child [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.029***	0.013	42.71%	0.00185	6.30%	0.0033	11.08%	0.0117	39.91%
Closest Residence	1	***0.026***	0.012	45.28%	0.00076	2.88%	0.0028	10.47%	0.0109	41.37%

Table 29: Total Tritium Dose (All Forms) to the 10-year-old Child using *Maximum* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Child [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.038***	0.015	40.15%	0.00373	9.69%	0.0045	11.69%	0.0148	38.46%
Closest Residence	1	***0.034***	0.015	45.28%	0.00098	2.88%	0.0036	10.46%	0.0141	41.37%

The maximum activity level in vegetation was observed at V5 located 220 m northeast of the stack at the closest residence. When the dose modelling was re-run using monitored data for vegetation along with monitored air and water data, the total estimated dose using monitored vegetation data to a 10-year-old Child receptor increased by about 18% to 27% (Table 30). In the average activity scenario, the total dose using monitored data increased by 0.007 mSv/yr at the closest residence and by 0.006 mSv/yr at the highest activity area when compared to the modelled dose. The total estimated dose in the maximum activity scenario increased by 0.008 mSv/yr at the closest residence and by 0.007 mSv/yr at the highest activity area when compared to the modelled dose. However, the total estimated dose to a 10-year-old Child receptor using monitored or modelled activity in vegetation was still seen to be lower than the annual dose limit of 1 mSv/yr in all cases.

Table 30: Comparison of Estimated Dose Using Modelled Versus Monitored Activity in Vegetation (10-year-old Child)

Location		Annual Dose Limit (mSv/yr)	Dose using *Modelled* Vegetation Activity (mSv/yr)	Dose using *Monitored* Vegetation Activity (mSv/yr)
Average	Highest Activity	1	0.029	0.035
	Closest Residence	1	0.026	0.033
Maximum	Highest Activity	1	0.038	0.045
	Closest Residence	1	0.034	0.042

3.2.3 Dose Calculations for the Adult Receptor

Estimated doses of tritium, tritium oxide and organically bound tritium were derived for the Adult Receptor using both the average (Table 31) and maximum concentrations (Table 32) of tritium oxide in air and water measured at the site with the highest activity and at the closest residence to the source.

Table 31: Estimated Doses to the Adult Receptor from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Average* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.018	0.00211	0.0012	0.0014	W3, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0019	0.004		
Closest Residence	HTO	0.018	0.00086	0.0010	0.0013	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0016	0.003		

Table 32: Estimated Doses to the Adult Receptor from Exposure to Tritium Oxide (HTO) and Organically Bound Tritium (OBT) Based on *Maximum* Monitored Activity in Air and Water at the Highest Activity (Station 1 and 3, respectively) and Closest Residence (Station 5)

Location	Form of Tritium	Total Water Dose [mSv/yr]	Total Air Dose [mSv/yr]	Total Vegetation Dose [mSv/yr]	Total Animal Dose [mSv/yr]	Monitoring Sample Locations	Assumptions
Highest Activity	HTO	0.023	0.00424	0.0017	0.0018	WG5, A1	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0026	0.005		
Closest Residence	HTO	0.023	0.00112	0.0013	0.0017	WG5, A5	50% of vegetables and animal produce from vicinity
	OBT	-	-	0.0021	0.004		

A survey of the monitoring area indicated that at no time had a vegetable garden or livestock been observed at the nearest residence. The vegetation samples collected from this location were wild apples. Although the estimated doses in Tables 31 and 32 indicate that consumption of wild apples would not result in unacceptable exposure, residents of this property have confirmed that wild apples from the property are not consumed.

The contribution of each exposure pathway to total dose to the Adult receptor is presented in Tables 33 and 34. As expected, the majority of the dose is contributed by ingestion of food and water. The inhalation pathway contributes a small proportion (<12%) of the total dose.

The calculated long-term doses to the Adult receptor do not exceed the annual public dose limit of 1 mSv per year (Tables 33 and 34).

Table 33: Total Tritium Dose (All Forms) to the Adult Receptor using *Average* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Adult [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.029***	0.018	64.21%	0.00211	7.32%	0.0031	10.71%	0.0051	17.75%
Closest Residence	1	***0.026***	0.018	68.14%	0.00086	3.35%	0.0026	10.13%	0.0047	18.38%

Table 34: Total Tritium Dose (All Forms) to the Adult Receptor using *Maximum* Tritium Concentrations in Each Exposure Pathway: Air, Water, Vegetation and Animal

Location	Annual Dose Limit [mSv/yr]	*Total Dose to Adult [mSv/yr]*	Total Water Dose [mSv/yr]	% of Total	Total Air Dose [mSv/yr]	% of Total	Total Vegetation Dose [mSv/yr]	% of Total	Total Animal Dose [mSv/yr]	% of Total
Highest Activity	1	***0.038***	0.023	60.31%	0.00424	11.26%	0.0043	11.30%	0.0064	17.14%
Closest Residence	1	***0.033***	0.023	68.14%	0.00112	3.35%	0.0034	10.13%	0.0061	18.38%

The maximum activity level in vegetation was observed at V5 located 220 m northeast of the stack at the closest residence. When the dose modelling was re-run using monitored data for vegetation along with monitored air and water data, the total estimated dose using monitored vegetation data to an Adult receptor increased by about 10% to 19% (Table 35). In the average activity scenario, the total dose using monitored data increased by 0.005 mSv/yr at the closest residence and by 0.004 mSv/yr at the highest activity area when compared to the modelled dose. The total estimated dose in the maximum activity scenario increased by 0.006 mSv/yr at the closest residence and by 0.004 mSv/yr at the highest activity area when compared to the modelled dose. However, the total estimated dose to an Adult receptor using monitored or modelled activity in vegetation was still seen to be lower than the annual dose limit of 1 mSv/yr in all cases.

Table 35: Comparison of Estimated Dose Using Modelled Versus Monitored Activity in Vegetation (Adult Receptor)

Location		Annual Dose Limit [mSv/yr]	Dose using *Modelled* Vegetation Activity [mSv/yr]	Dose using *Monitored* Vegetation Activity [mSv/yr]
Average	Highest Activity	1	0.029	0.033
	Closest Residence	1	0.026	0.031
Maximum	Highest Activity	1	0.038	0.042
	Closest Residence	1	0.033	0.039

4. SSI QA/QC

Shield Source Incorporated's Quality Assurance (QA) program refers to a detailed protocol used to collect high quality environmental monitoring samples. Quality Control refers to the process by which this protocol is tested to ensure that the final samples are of the specified quality. Shield Source Incorporated included field blanks, travel blanks and replicate samples in their sampling program in order to meet the requirements of the QA/QC program.

4.1 Field Blanks

Fields blanks are used to detect incidental or accidental contamination of a sample during sample preparation, sampling, handling, storage, transport and/or analysis. A water sample field blank is prepared using the same sampling sink matrix used for collection of the environmental samples. At one randomly selected sampling location, the field blank is opened and transferred to an empty sampling container, sealed, placed in a plastic bag and placed in the transport carrier.

4.1.1 Results

Table 17 shows the Field Blank results for 2007.

Table 17: Field Blank Data (Bq/L)

DATE	DETECTION LIMIT (DL)	AMBIENT AIR Field Blank	AMBIENT WATER Field Blank	MILK Field Blank
Jan-07	51	130	<DL	<DL
Feb-07	45	56	<DL	-
Mar-07	46	71	<DL	-
Apr-07	44	<DL	<DL	-
May-07	51	<DL	<DL	-
Jun-07	51	75	<DL	-
Jul-07	44	60	<DL	-
Aug-07	42	57	56	-
Sep-07	50	<DL	<DL	-
Oct-07	50	<DL	<DL	-
Nov-07	50	<DL	<DL	-
Dec-07	50	228	<DL	-

4.2 Travel Blanks

Travel blanks detect sample contamination during storage and transport. Travel blanks consist of containers acquired from a laboratory equipment supplier and filled by Shield Source Incorporated off-site. They accompany empty sample bottles to the field site, where they are left intact and unopened inside the shipping container. The unopened travel blanks are then returned to the independent analytical laboratory to be analyzed along with the collected samples.

4.2.1 Results

Table 18 shows the travel blank results for 2007.

Table 18: Travel Blanks Data (Bq/L)

DATE	DETECTION LIMIT (DL)	AMBIENT AIR Trip Blank	AMBIENT WATER Trip Blank
Jan-07	51	144	<DL
Feb-07	45	54	<DL
Mar-07	46	96	<DL
Apr-07	44	104	<DL
May-07	51	85	<DL
Jun-07	51	80	50
Jul-07	44	<DL	<DL
Aug-07	42	<DL	71
Sep-07	50	<DL	<DL
Oct-07	50	<DL	<DL
Nov-07	50	<DL	<DL
Dec-07	50	228	<DL

4.3 Replicate Samples

Replicate samples are used to measure precision variation throughout the sampling and analysis process. Replicate samples are collected by filling multiple containers at a single site. They are labelled individually and are submitted separately to the independent analytical laboratory.

4.3.1 Results

Table 19 shows the Replicate Sample results for ambient air monitoring data and Table 20 shows the Replicate Sample results for ambient water monitoring data.

Table 19: Ambient Air Replicate Sample Data (Bq/m^3)

DATE	LOCATION	REPLICATE 1	REPLICATE 2	REPLICATE 3	Mean	Standard Deviation
Jan-07	A7	0.84	0.86	0.76	0.82	0.05
Feb-07	A7	0.93	0.87	1.03	0.94	0.08
Mar-07	A7	0.77	0.76	0.50	0.68	0.15
Apr-07	A7	1.86	1.23	1.70	1.60	0.33
May-07	A7	0.97	0.91	0.97	0.95	0.03
Jun-07	A7	1.59	1.81	1.72	1.71	0.11
Jul-07	A7	1.13	0.89	1.00	1.01	0.12
Aug-07	A7	2.21	2.10	2.29	2.20	0.10
Sep-07	A7	1.25	1.36	1.49	1.37	0.12
Oct-07	A7	2.04	2.06	2.19	2.10	0.08
Nov-07	A7	0.57	0.34	0.34	0.42	0.13
Dec-07	A7	0.41	0.41	0.41	0.41	0.00

Notes: (--) indicates no sample collected or analyzed
All results were reported in Bq/L and then converted to Bq/m3 (See Appendix I).
In statistical summary calculations, values that were <DL were set to DL-1 in Bq/L and then converted to Bq/m3.
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

Table 20: Ambient Water Replicate Sample Data (Bq/L)

DATE	LOCATION	REPLICATE 1	REPLICATE 2	REPLICATE 3	Mean	Standard Deviation
Jan-07	W2	<DL	<DL	<DL	50	0.0
Feb-07	W2	<DL	<DL	<DL	44	0.0
Mar-07	W9	105	147	179	144	37.1
Apr-07	W6	677	693	691	687	8.7
May-07	WG5	1603	1561	1595	1586	22.3
Jun-07	W9	59	<DL	<DL	59	5.2
Jul-07	W2	<DL	<DL	<DL	43	0.0
Aug-07	W2	68	<DL	55	55	13.5
Sep-07	W9	<DL	<DL	<DL	49	0.0
Oct-07	W2	54	<DL	<DL	51	2.9
Nov-07	WG5	2043	2113	2047	2068	39.3
Dec-07	W2	<DL	<DL	<DL	49	0.0

Notes: (--) indicates no sample collected or analyzed
All results were reported in Bq/L and then converted to Bq/m3 (See Appendix I).
In statistical summary calculations, values that were <DL were set to DL-1 in Bq/L and then converted to Bq/m3.
The Detection Limits were Jan – 50.6 Bq/L, Feb – 45.0 Bq/L, Mar – 46.4 Bq/L, Apr – 44.0 Bq/L, May – 50.8 Bq/L, Jun – 51.0 Bq/L, Jul – 44.4 Bq/L, Aug – 41.9 Bq/L, Sep – 50.0 Bq/L, Oct – 50.0 Bq/L, Nov – 50.0 Bq/L, Dec – 50.0 Bq/L.

5. LABORATORY QA/QC

Monserco Limited has indicated that the laboratory QA/QC data is within their upper and lower confidence limits, and that their inter-laboratory comparison results are within acceptable limits. A copy of the certificate from Monserco Limited indicating the successful participation in the 2007 Tritium Urinalysis Intercomparison Program for 2007 from the National Calibration Reference Centre is on file at Shield Source Incorporated.

6. INCIDENTS

The Administrative Limit for emissions of 1.0x10 TBq was exceeded by 2% on Oct. 2, 2007. This was the only incident in 2007. The Action Levels were not exceeded in 2007.

7. SUMMARY

Emissions

Emissions of HT and HTO from the stack at the Shield Source Incorporated facility were monitored continuously over 2007. The total emissions during the 2007 EMP sampling period from Dec 19, 2006 to Dec 18, 2007 of HT was 84.74 TBq and the total HT emission for the calendar year 2007 was 87.7 TBq, which were below the Administrative Limit of 1190 TBq and subsequently below the Action limit of 1700 TBq. Emissions of HT from Shield Source Incorporated during the 2007 EMP sampling period were 7.1% of the Administrative Limit and 5.0% of the Action Limit and for the calendar year of 2007 HT emissions were 7.37% of the Administrative Limit and 5.16% of the Action Limit.

The total emission of HTO from Shield Source Incorporated during the 2007 EMP sampling period from Dec 19, 2006 to Dec 18, 2007 was 23.20 TBq and the total HTO emissions for the calendar year 2007 was 23.30 TBq, which were below the Administrative Limit of 35 TBq and subsequently below the Action Limit of 50 TBq. Emissions of HTO from Shield Source Incorporated during the 2007 EMP sampling period were 66.4% of the Administrative Limit and 46.4% of the Action Limit and for the calendar year 2007 HTO emissions were 66.6% of the Administrative Limit and 46.6% of the Action Limit.

The weekly Administrative and Action Limits for HT were not exceeded during the EMP sampling period from Dec 19, 2006 to Dec 18, 2007. The Administrative Limit for HTO was exceeded by 2.0% during the week of September 25, 2007. The Action Limit for HTO was not exceeded during the same sampling period.

Maximum emissions of HT and HTO were observed during August and September, which corresponds to an increase of production during these months.

Ambient Air Sampling

Ambient air was monitored throughout 2007 for HT and HTO activity at locations relative to Shield Source Incorporated's operations. An average of 2.3 Bq/m^3 was found over all sample locations, with a maximum value of 14.52 Bq/m^3 at A1. Air sampling locations such as A1 are closer to the stack and showed higher HT and HTO activity levels. The maximum activities found in the air samples over 2007 corresponded with rises in productivity, and the subsequent increase of emissions. The increase of HT and HTO in ambient air at the peak production times was therefore predictable.
The air samples collected in 2007 were generally higher in activity than samples in the previous 4 years. This was due to a change of the way the fan from the stack was operated. In previous years there were different fan speeds during production and non-production hours, in 2007 the fan speed maintained the production speed (high speed) at all times.
Samples collected in the direction NE of the stack showed higher levels of tritium, which indicates that emissions from the stack are windborne, as the prevailing winds are NE in direction.

Ambient Water Monitoring

Water samples, when available, were collected monthly at locations relevant to Shield Source Incorporated's operations.
The maximum reported value at Shield Source Incorporated was 2301 Bq/L at W5, located 220 m NE of the stack. The maximum monthly average occurred April 2007 with a value of 657 Bq/L. This maximum does not correspond to production increases but can be contributed to increased precipitation during that time.
The activity levels for each sampling location are generally consistent through a five year period, with slight variations from year to year. There was no general increase or decrease observed in the activity levels of sampled ambient water between 2003 and 2007.

Milk Sampling

One milk sample was collected at a distance of 2860m NE of the stack in 2007. The result was below the detection limit of 51 Bq/L. As there was only one sample collected, results from this section are inconclusive. Future sampling of milk will not be performed unless a new farm can be found within the field of study as the only farm is no longer in operation.

Vegetation Sampling

Vegetation collected during the summer of 2007 consisted of wild grapes and apples from 3 locations. Maximum results were found in sample V5 which was 220m NE from the stack. The results of V5 also peaked during July and August 2007, which corresponds with the maximum HT and HTO emissions during these months.
Furthermore, at location V5, there is an increase in activity levels over the five year period of 2003-2007, with the maximum levels in 2007. In 2007 a change in our ventilation stack fan system was implemented. The fan speed remained at high speed during both production and non-production hours whereas previous years the fan speed would be lowered during non-production hours. This change has contributed to higher tritium activities found throughout our 2007 data.

Dose to the Critical Receptor

Overall there is a decreasing trend in the activity in all types of samples with increased distance from the SSI stack.

Historically, the dose to the critical receptor has been reported based on monitoring results obtained at the nearest residence (Station 5), which coincided with areas of maximum monitored activity. Since 2005, the highest monitored activity in ambient air samples was not observed at the closest residence but at a different location (Station 1). Furthermore in 2007, the highest average monitoring activity in water was observed in Station 3. However, Station 5 still contained the maximum monitored activity in water.

The estimated doses to the 1-year-old Infant, 10-year-old Child and Adult receptors were below the annual dose limit of 1 mSv/yr. The estimated dose to the 1-year-old Infant was the highest of all the age categories.

The estimated dose to the 1-year-old Infant living at the nearest residential dwelling (Station A5 and WG5) based on the average and maximum monitored activities in air and water was 0.045 mSv/yr and 0.058 mSv/yr, respectively. The estimated dose to the 1-year-old Infant living at the site with the highest activity based on the average (Station A1 and W3) and maximum (Stations A1 and WG5) monitored activities in air and water was 0.049 mSv/yr and 0.063 mSv/yr, respectively.

The estimated dose to the 10-year-old Child living at the nearest residential dwelling (Station A5 and WG5) based on the average and maximum monitored activities in air and water was 0.026 mSv/yr and 0.034 mSv/yr, respectively. The estimated dose to the 10-year-old Child living at the site with the highest activity based on the average (Stations A1 and W3) and maximum (Stations A1 and WG5) monitored activities in air and water was 0.029 mSv/yr and 0.038 mSv/yr.

The estimated dose to the Adult living at the nearest residential dwelling (Station A5 and WG5) based on the average and maximum monitored activities in air and water was 0.026 mSv/yr and 0.033 mSv/yr. The estimated dose to the Adult living at the site with the highest activity based on the average (Station A1 and W3) and maximum (Station A1 and WG5) monitored activities in air and water was 0.029 mSv/yr and 0.038 mSv/yr.

A comparison of modeled and monitored milk and vegetation showed that the model overestimated milk activities (compared to monitored levels below the detection limit) and somewhat underestimated vegetation activities. Monitored activity in vegetation samples was seen to greatly increase in 2007 when compared to data from 2006.

When the model was re-run using monitored activity in vegetation, the resulting total dose increased by approximately 0.009 mSv/yr and 0.010 mSv/yr in the average activity scenario at the highest activity area and closest residence, respectively and by 0.009 mSv/yr and 0.012 mSv/yr in the maximum activity scenario at the highest activity area and closest residence, respectively, for the 1-year-old Infant. The resulting total dose increased by approximately 0.006 and 0.007 mSv/yr in the average activity scenario at the highest activity area and closest residence, respectively and by 0.007 mSv/yr and 0.008 mSv/yr in the maximum activity scenario at the highest activity area and closest residence, respectively, for the 10-year-old Child. The resulting total dose increased by approximately 0.004 and 0.005 mSv/yr in the average activity scenario at the highest activity area and closest residence, respectively and by 0.004 mSv/yr and 0.006 mSv/yr in the maximum activity scenario at the highest activity area and closest residence, respectively, for the Adult.

However, it is noted that vegetation samples were collected during a precipitation event and the apples at location V5 were collected from the ground. All calculated doses using the updated methodology were below the annual dose limit of 1 mSv/yr.

General

There was a general increase of HT and HTO emissions in 2007. This increase was observed in ambient air samples and vegetation samples. This was attributed to an increase of speed in our ventilation stack fan system. The fan speed remained at high speed during both production and non-production hours whereas in previous years, the fan speed would be lowered during non-production hours. Shield Source Incorporated has verified that the amount of tritium processed did not increase in 2007 and thus did not contribute to the increase of HT and HTO emissions.

Shield Source Incorporated has shown that the company is operating well within our Limits.

APPENDIX I

CONVERSION CALCULATIONS

CONVERSION FROM Bq/L TO Bq/m^3 IN PASSIVE SAMPLERS

The laboratory analysis results for the air monitoring stations have been provided to Shield Source Incorporated on the basis of the tritium activity in the liquid from the collection vials. However, these results must be converted to concentration activities before they can be used. The method used for the conversion has been derived from the approach provided to Shield Source Incorporated by Ontario Power Generation (OPG).

To illustrate how the conversion would be applied to Shield Source Incorporated, it has been applied to a worked example. In the example, a sample collected over a period of 15 days was found to have a tritium level of 150.2 Bq/L in the sample vial liquid.

The conversion includes several steps, the first of which is the conversion of the laboratory disintegrations per minute per millilitre (ml), as follows:

$$150.2\ ^{Bq}/_{L} \times 0.001\ ^{L}/_{mL} \times 60\ ^{dpm}/_{Bq} = 9.012\ ^{dpm}/_{mL}$$

This activity level was then converted to an activity per unit of time by incorporating the duration of the sampling in the following manner.

$$\frac{9.012\ \text{dpm/mL}}{15\ \text{days} \cdot 24\ \text{hr/day}} = 0.025\ \text{dpm/(hr} \cdot \text{mL)}$$

Based on the OPG methodology, the sampling vials should pick up tritium activity at a rate of:

5000 dpm/(DAC · hr · mL)

The derived air concentration (DAC) to which the vial was exposed can be calculated by taking the ratio of the activity in the vial and the OPG reference level:

$$\frac{0.025\ \text{dpm/ (hr} \cdot \text{mL)}}{5000\ \text{dpm/ (DAC} \cdot \text{hr} \cdot \text{mL)}} = 5.00 \times 10^{-6}\ \text{DAC}$$

According to the OPG memorandum, each DAC unit is equal to 10 µCi/m^3. By substituting this value into the above formulae and converting to Becquerel, the airborne concentration was calculated as:

$$5.00 \times 10^{-6}\ \text{DAC} \times 10\ \frac{\mu\text{Ci/m}^3}{\text{DAC}} \cdot 37000\ \text{Bq/}\mu\text{Ci} = 1.852\ \text{Bq/ m}^3$$

This conversion was applied to all the laboratory results from the Shield Source Incorporated air monitoring stations. The results from these calculations are presented in Table 2.

APPENDIX II

DOSE CALCULATION METHOD

1. MODEL METHODOLOGY BASED ON SHIELD SOURCE INCORPORATED (2005)

The three forms of tritium evaluated, (tritium gas, HT, tritium oxide, HTO and organically bound tritium, OBT) all followed pathways for the transport of radioactive concentrations among five compartments (Air, Water, Plants, Animal Produce and the Receptor) as shown on Figure II-1.

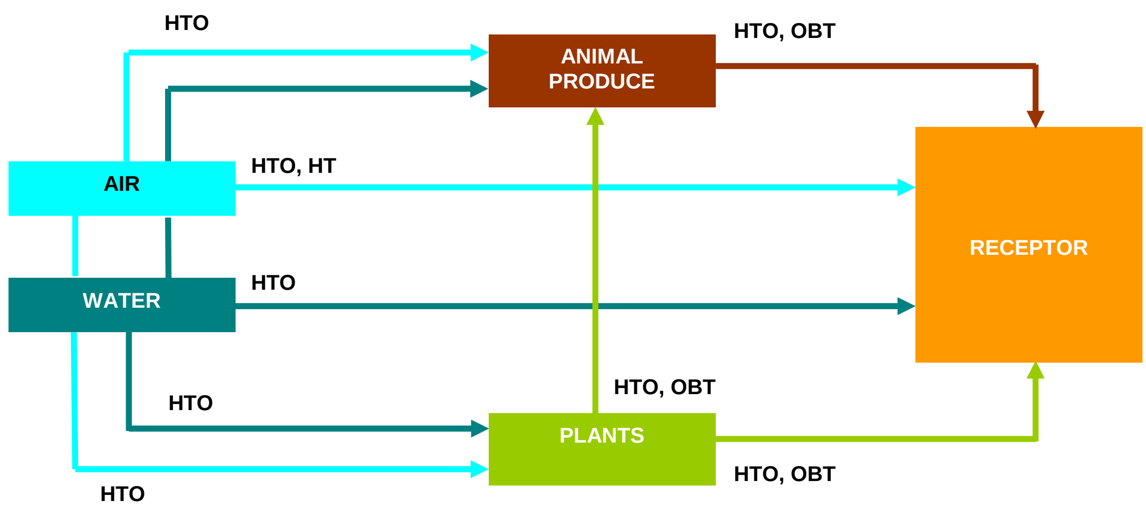


Figure II-1: Environmental Transfer of Three Forms of Tritium

Dose Calculations for HTO and HT

For the radioactive dose calculation of HTO in the receptor it was assumed that receptor would receive its dosage from multiple sources through:

1. Direct Inhalation and Immersion in Air
2. Direct Water Intake
3. Ingestion of Plants and Vegetation
4. Ingestion of Animal Produce

It was assumed that the intake of HT would occur only through air inhalation.

Air → Receptor

The transfer of ***HTO***, *as well as* ***HT****,* through inhalation directly from air to the receptor can be calculated. All transfer parameters are written in the standard form as documented in the CAN/CSA, 1987:

$$Dose_{air\rightarrow} = C_{air}\, P(i)19$$

where, $P(i)19 = i_a \,.\, OF \,.\, DCF$

i_a: annual inhalation rate of air [m^3/yr]

OF: occupancy factor

DCF: dose conversion factor of the specific type of tritium [Sv/Bq]

The critical receptor (infant in the critical group) was assumed to have a total air volume intake of 1900 m^3 (CNSC, 2000) of air per year with a 100% occupancy near the contaminated source. The dose through immersion is calculated using the dose through inhalation, which is multiplied by a factor of 2. The dose through immersion is taken to be the total dose through air for HTO.

The DCF for HTO and HT are given below (CAN/CSA 1987):

HTO: 5.8×10^{-11} [Sv/Bq]

HT: 1.2×10^{-14} [Sv/Bq]

Water → Receptor

Similarly for the dose calculation of HTO in the receptor through direct water ingestion:

$$Dose_{water\rightarrow} = C_{water}\, P(i)29$$

Where, $P(i)29 = \rho \,.\, k \,.\, i_w \,.\, DCF$

ρ: removal factor (by treatment plants)

k: fraction of total water from contaminated source

i_w: annual water intake [L/yr]

The total yearly water intake by the critical receptor (infant) was assumed to be 300L/yr (CAN/CSA, 1987). It was assumed that 100% of the drinking water was obtained from the contaminated source.

Air, Water → Plant

For the transfers of radioactive HTO from air and water to plant the following transfer equations were used converting activity in air and water to [Bq/kg] of plant matter:

$$P_{air\rightarrow} = C_{air}\, P14$$

where, $P14 = f_v / H_a$

f_V: ratio of specific activity of HTO in soil to that of air moisture

H_a: absolute humidity [kg/m^3]

A default value of 50 kg/m^3 (CAN/CSA '87) was used for *P14* above.

$$P_{water\rightarrow} = C_{water}\, P24$$

where, $P24 = f_v / G_w$

f_V: ratio of specific activity of HTO in soil to that of air moisture

G_w: distribution factor for tritium in vegetation [kg/L]

A default value of 0.81 was used for *P24* above.

$P_{air\rightarrow} + P_{water\rightarrow}$ would then be the total amount, C_{plant} carried on to the receptor or animals next in the pathway.

Plant → Receptor

To calculate the dose [Sv/yr] of HTO received from plant matter consumption the transfer function, P49 is used:

$$Dose_{plant\rightarrow} = C_{plant}\, P49$$

where, $P49 = i_p\, g\, DCF$

i_p: annual consumption rate of plant matter [kg/yr]

g: fraction of plant matter arising from contaminated source

It was assumed that vegetation consumption of the critical receptor was 96 kg/yr with 50% arising from the contaminated source.

Air, Water, Plant → Animal

The radioactivity of HTO in animals was assumed to occur through transfers from air, water and plant consumption and is given as the sum of all these three contributing sources in units of [Bq/kg] of animal produce. The animal products considered were milk, meat (Beef+Pork), eggs and poultry. Default transfer parameters were taken from CAN/CSA '87 to calculate the activity of HTO transferred through air, water and plants for all products, *i*:

$A_{air \rightarrow i} = C_{air} P15_i$

$A_{water \rightarrow i} = C_{water} P25_i$

$A_{plant \rightarrow i} = C_{plant}\ P45_i$

where *P15*, *P25* and *P45* were default transfer parameter values for a certain animal produce. The sum of $A_{air \rightarrow}$, $A_{water \rightarrow}$, $A_{plant \rightarrow}$ for each product *i* or $C_{animal,i}$ would be carried onto the receptor.

The transfer parameters for $P15_i$ [m^3/kg] from CAN/CSA (1987) used were:

Milk:	3.9	Eggs:	3.5
Beef:	1.4	Poultry:	6.7
Pork:	2.2		

The transfer parameters for $P25_i$ [L/kg] from CAN/CSA (1987) used were:

Milk	1.1	Eggs:	0.66
Beef:	0.9	Poultry:	1.1
Pork:	0.52		

The transfer parameters for $P45_i$ [kg/kg] from CAN/CSA (1987) used were:

Milk	0.14	Eggs:	0.22
Beef:	0.18	Poultry:	0.35
Pork:	0.22		

Animal → Receptor

The radioactive dose of HTO though the ingestion of a specific animal product, *i* was calculated using:

$Dose_{animal,i \rightarrow,} = C_{animal,i}\ P59$

where, $P59 = i_a\ g\ DCF$

i_a: annual consumption rate of the respective animal produce (e.g. milk, meat etc) [kg/yr]

g: fraction of animal produce arising from contaminated source

It was also assumed that 50% of all consumed produce matter would come from the affected area. The total dose from animal produces was found by summing the dose values arising from all produce matter. Consumption rates for each product were derived from CAN/CSA '87:

Milk:	220 kg/yr	Meat:	24 kg/yr
Eggs:	5 kg/yr	Poultry:	10 kg/yr

Dose Calculations for OBT

OBT was assumed to transfer to the receptor only by the means of consumption of plants and animal produce.

Plant → Receptor

The conversion of HTO to OBT in plant tissues was estimated by using a ratio of 0.4 (Brown 1995). Thus, 40% of the HTO in plants was to converted to OBT. This amount was then transferred to the receptor through the same transfer function used for HTO, however the *DCF* for OBT was used in this step instead.

Plant → Animal → Receptor

50% of the HTO in animal produce acquired through air, water and plants was considered to be converted to OBT (Okada and Momoshima, 1993; ICRP, 1989), using the same transfer parameters for HTO as before. This was added to the amount of OBT transferred to animal produce from plants, once again using the same transfer parameters for HTO. A further transfer parameter (same as HTO) for each animal produce consumed was then applied to the total OBT in animal produce to find the final dose of OBT in the receptor.

The same ingestion rates for plants and animals as those used for HTO were used to estimate OBT uptake by the critical receptor. The DCF for OBT was taken as: 1.2×10^{-10} (ICRP, 1995a)

Total Estimated Dose

Total estimated dose to the infant critical receptor was the sum of the doses from HTO and HT inhalation, HTO immersion, HTO in drinking water, consumption of HTO and OBT in plant produce and consumption of HTO and OBT in animal products.

2. Updates to the 2005 Methodology

Parameters used for the updated methodology include inhalation and ingestion dose conversion factors, consumption vegetables, eggs, poultry and meat, intake of water and inhalation rates. This appendix provides the value used for these parameters and a brief description of the assumptions used to derive some of these parameters.

The daily air volumes inhaled were taken from ICRP Publication 71 (ICRP 1995b) for each age category and multiplied by 365 days per year to get the total volume of air inhaled. The annual total air volume intake for each age category are as follows:

1-year-old Infant:

Annual Total Air Volume Intake: 1883 m^3

10-year-old Child:

Annual Total Air Volume Intake: 5585 m^3

Adult:

Annual Total Air Volume Intake: 8103 m^3

The DCFs for HTO and HT for each age category are as follows (ICRP 1995a):

1-year-old Infant:

HTO: 4.8×10^{-11} [Sv/Bq] (Ingestion and Inhalation)

HT: 4.8×10^{-15} [Sv/Bq] (Inhalation)

OBT: 1.2×10^{-10} (Ingestion)

10-year-old Child:

HTO: 2.3×10^{-11} [Sv/Bq] (Ingestion and Inhalation)

HT: 2.3×10^{-15} [Sv/Bq] (Inhalation)

OBT: 5.7×10^{-11} (Ingestion)

Adult:

HTO: 1.8×10^{-11} [Sv/Bq] (Ingestion and Inhalation)

HT: 1.8×10^{-15} [Sv/Bq] (Inhalation)

OBT: 4.2×10^{-11} (Ingestion)

The annual consumption of milk, eggs, poultry and meat were derived using food consumption data from the *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors"* (US EPA 1991) and the *Compendium of Canadian Human Exposure Factors for Risk Assessment* (Richardson 1997). Richardson (1997) provides daily consumption of 10 composite food categories with a list of the foods incorporated into each category. Since the milk and dairy products includes the dairy products, it was necessary to find the relative contributions milk and dairy products. Therefore, US EPA (1991) was used since it provides daily consumption of the foods for individual foods for the 10 composite groups in Richardson (1997). A sum of the daily consumption rates for the foods included in the milk and dairy products composite category available in US EPA (1991) was calculated and the relative contributions of the each food was determined. The relative contribution of the parameter required (in this case milk) was multiplied by the daily consumption rate for the milk and dairy products composite category from Richardson (1997). The derived daily consumption rates were multiplied by 365 days per year to obtain the annual consumption of each food. Similarly, the eggs, poultry and meat (beef and pork) were derived using the same method as for milk. Eggs, poultry and meat (beef and pork) are part of the same composite group (meat and eggs from Richardson 1997). The relative contributions for eggs, poultry and meat (beef and pork) were derived using daily consumption rates of foods included in the meats and eggs composite category from US EPA 1991. The annual consumption rates for each food and age category are as follows:

1-year-old Infant:

Milk: 208 kg/yr	Meat: 14 kg/yr
Eggs: 9 kg/yr	Poultry: 5 kg/yr

10-year-old Child:

Milk: 211 kg/yr	Meat: 22 kg/yr
Eggs: 8 kg/yr	Poultry: 7 kg/yr

Adult:

Milk: 93 kg/yr	Meat:	34 kg/yr
Eggs: 12 kg/yr	Poultry:	8 kg/yr

The daily consumption rates of vegetables (sum of root vegetables and other vegetables) and intake of water for each age category taken from the *Federal Contaminated Site Risk Assessment in Canada Part 1: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)* (EHAS 2004) and multiplied by 365 days per year to derive the annual vegetation consumption and annual intake of water. The annual vegetation consumption for each age category is as follows:

1-year-old Infant:

Vegetation: 63 kg/yr

10-year-old Child:

Vegetation: 95 kg/yr

Adult:

Vegetation: 119 kg/yr

The annual intake of water for each age category is as follows:

1-year-old Infant:

Water: 219 kg/yr

10-year-old Child:

Water: 292 kg/yr

Adult:

Water: 548 kg/yr

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