



SHIELD SOURCE INCORPORATED

2004
ENVIRONMENTAL MONITORING PROGRAM
ANNUAL COMPLIANCE REPORT

CNSC LICENCE NSPFOL-12.00/2009

**Shield Source Incorporated
CNSC Licence NSPFOL-12.00/2009**

**Environmental Monitoring Program
Annual Compliance Report**

Year 2004

Submitted to:

**Canadian Nuclear Safety Commission
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**ENVIRONMENTAL MONITORING PROGRAM
ANNUAL REPORT
YEAR 2004**

Submitted to:

**Canadian Nuclear Safety Commission
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1. INTRODUCTION

1.1 Purpose

This Environmental Monitoring report is the environmental monitoring portion of Shield Source Incorporated (SSI) 2004 Annual Report. This report contains a summary of the environmental monitoring results including stack emissions, air, water, milk, precipitation and vegetation monitoring data. Stack emissions have been compared with the environmental monitoring data and dose to the receptor group has been calculated.

1.2 Background Information

In 2000 Golder Associates was retained by SSI to produce a revised EMP including new DRLs. SSI and Golder worked together to attain a quality program. The revised EMP was approved in August 2003 and the DRLs in April 2003.

1.3 Land Use Within the Monitoring Program Area

On January 30, 2001, [REDACTED] of Golder Associates' Whitby Office accompanied by the Production Supervisor of SSI, conducted a land use survey within the monitoring program area. Specifically, the land use survey was conducted in the eastern end of North Monaghan Township, adjacent to the SSI facility, and in the western end of Otonabee Township, within a 10 km radius of the SSI facility. The portions of the two townships included in the survey are located in the prevailing down-wind direction from the SSI facility. The description of the land use within the monitoring area was given in SSI's report entitled "2000 Annual Report On Environmental Monitoring Program" submitted by Golder in April 2001.

SSI conducted additional surveys in November 2001, December 2002, December 2003 and December 2004 finding no changes from the initial survey.

1.4 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	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	Mel O'Brien Rd. at end of chain fence	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

2. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

2.1 Samples

Ambient Air, Water and Milk samples were collected monthly by SSI staff and sent to Monserco Laboratories for analysis. Vegetation Samples were collected during harvest time (August through to November) and Precipitation samples were collected April through November. Stack emissions were measured continuously from the SSI facility.

The 2004 sampling program consists of 6 types of samples collected - stack emissions, ambient air samples, ambient water samples, milk, precipitation and vegetation samples. The sampling results are described in the following sections.

2.2 Stack Emissions

SSI monitors both Tritium Gas (HT) and Tritium Oxide (HTO) continuously. Total (HT+HTO) stack emissions are recorded daily and HTO activity readings are measured on the last day of a seven-day interval. The weekly, monthly and yearly stack emissions are then calculated. The Derived Release Limits (DRLs) calculated by Golder Associates were approved by CNSC in August 2003. Therefore, HTO and HT emission are compared to the DRL values in this report.

2.2.1 Stack Emission Results

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

Table 2: Monthly Tritium Stack Emissions

Date		HTO	HT	Total
From	To	Released TBq	Released TBq	Activity TBq
18-Dec	20-Jan	1.6E+12	4.7E+12	6.2E+12
20-Jan	24-Feb	8.5E+11	4.4E+12	5.2E+12
24-Feb	30-Mar	1.4E+12	6.1E+12	7.5E+12
30-Mar	21-Apr	1.2E+12	3.1E+12	4.2E+12
21-Apr	26-May	2.5E+12	4.0E+12	6.5E+12
26-May	23-Jun	1.6E+12	5.5E+12	7.2E+12
23-Jun	27-Jul	1.7E+12	1.2E+13	1.4E+13
27-Jul	24-Aug	1.7E+12	1.2E+13	1.4E+13
24-Aug	28-Sep	2.5E+12	1.5E+13	1.8E+13
28-Sep	27-Oct	1.1E+12	6.8E+12	7.9E+12
27-Oct	24-Nov	9.2E+11	7.9E+12	8.8E+12
24-Nov	21-Dec	1.1E+12	8.8E+12	9.9E+12
Total		1.8E+13	9.1E+13	1.1E+14
Average		1.5E+12	7.6E+12	9.1E+12
Maximum		2.5E+12	1.5E+13	1.8E+13
Minimum		8.5E+11	3.1E+12	4.2E+12

The maximum release of HTO occurred during the sampling periods of April 21 to May 26, 2005 and August 24 to September 28, 2004, when an activity of $2.5\text{E}+12$ Bq was recorded for each period. The April 21 to May 26, 2005 sampling period corresponds with below monthly average of tritium in ambient air and above monthly average of tritium in ambient water. The August 24 to September 28, 2004 sampling period corresponds with maximum monthly average of tritium in ambient air and ambient water samples.

The maximum release of HT and consequently the maximum total activity released occurred during the sampling period of August 24 to September 28, 2004, when an activity of $1.5\text{E}+13$ Bq (HT) and $1.8\text{E}+13$ Bq (Total Activity) was recorded. Maximum monthly average tritium results in ambient air and ambient water occurred at this time.

The minimum stack emission for HTO was found during the sampling period of January 20 to February 24, 2004 ($8.5\text{E}+11$ Bq). This corresponds with below average levels of tritium in ambient air and ambient water monitoring data.

The minimum stack emission for HT was found during the sampling period of March 30 to April 21, 2005 ($3.1\text{E}+12$ Bq). This corresponds with below average levels of tritium in ambient air monitoring data and maximum average levels of tritium in ambient water monitoring data.

No discernable variation with season was observed in the data.

2.2.2 DRL and AL

SSI's current licence requires that if stack emissions exceed 50% of the DRL per year or 5% of the DRL per week for HTO and 0.0005% of the DRL per year or 0.00005% of the DRL per week for HT (Action Levels), as calculated by Golder Associates, the CNSC is to be notified and specific actions must be taken.

SSI has also set Administrative Limits (AdminL) to alert SSI prior to Action Levels being reached in order to meet Radiation Protection requirements. If stack emissions exceed 35% of the DRL per year or 1% of the DRL per week for HTO and 0.00035% of the DRL per year or 0.00001% of the DRL per week for HT, SSI must implement procedures to prevent reoccurrence and reduce risk to persons and/or the environment. The DRLs and the Weekly and Yearly AL and AdminL are given in Table 3.

Table 3: DRL and Weekly and Yearly AL and Admin Values

Description	HTO (Bq)	HT (Bq)
DRL	$1.00\text{E}+14$	$3.40\text{E}+19$
Action		
Yearly	$5.00\text{E}+13$	$1.70\text{E}+15$
Weekly	$5.00\text{E}+12$	$1.70\text{E}+14$
AdminL		
Yearly	$3.50\text{E}+13$	$1.19\text{E}+15$
Weekly	$1.00\text{E}+12$	$3.40\text{E}+13$

2.2.3 Exceedences of DRL and AL

2.2.3.1 Yearly Stack Emissions

The total HTO and HT stack emissions for 2004 did not exceed the yearly DRLs calculated by Golder or the SSI ALs or AdminL. (Table 4).

Table 4: Annual Stack Emission Compared with DRL, AL and AdminL

YEAR	TRITIUM OXIDE (HTO) PER YEAR (Bq)				TRITIUM OXIDE (HT) PER YEAR (Bq)			
	STACK EMISSION	DRL	ACTION LIMIT	ADMINISTRATIVE LIMIT	STACK EMISSION	DRL	ACTION LIMIT	ADMINISTRATIVE LIMIT
		1.00E+14	5.00E+13	3.50E+13		3.40E+19	1.70E+15	1.19E+15
(Bq)	Exceedence of DRL, AL or AdminLimit (% Exceedence By)			(Bq)	Exceedence of DRL, AL or AdminLimit (% Exceedence By)			
2004	1.73E+13	--	--	--	9.07E+13	--	--	--

2.2.3.2 Weekly Stack Emissions

The weekly HTO and HT stack emissions for 2004 did not exceed the weekly AL or AdminL (Table 5).

Table 5: Weekly Stack Emissions Compared with DRL, AL and AdminL

DATE	TRITIUM OXIDE (HTO) PER 7 ⁽¹⁾ DAYS (Bq)				TRITIUM GAS (HT) PER 7 ⁽¹⁾ DAYS (Bq)			
	STACK EMISSION	GOLDER MODELLED DRL	ACTION LIMIT	ADMIN. LIMIT	STACK EMISSION	GOLDER MODELLED DRL	ACTION LIMIT	ADMIN. LIMIT
		1.00E+14	5.0E+12	1.0E+12		3.40E+19	1.7E+14	3.4E+13
	Exceedence of DRL, AL or AdminL (% Exceeded By)			Exceedence of DRL, AL or AdminL (% Exceeded By)				
6-Jan	1.7E+11	--	--	--	3.6E+11	--	--	--
13-Jan	1.6E+11	--	--	--	9.4E+11	--	--	--
20-Jan	1.0E+11	--	--	--	7.1E+11	--	--	--
27-Jan	1.1E+11	--	--	--	7.9E+11	--	--	--
3-Feb	2.7E+11	--	--	--	8.3E+11	--	--	--
10-Feb	1.1E+11	--	--	--	8.6E+11	--	--	--
17-Feb	1.5E+11	--	--	--	9.7E+11	--	--	--
24-Feb	2.2E+11	--	--	--	9.2E+11	--	--	--
2-Mar	2.1E+11	--	--	--	9.9E+11	--	--	--
9-Mar	3.4E+11	--	--	--	1.2E+12	--	--	--
16-Mar	2.7E+11	--	--	--	1.5E+12	--	--	--
23-Mar	2.3E+11	--	--	--	1.4E+12	--	--	--
30-Mar	3.9E+11	--	--	--	1.0E+12	--	--	--
6-Apr	3.6E+11	--	--	--	1.0E+12	--	--	--

Table 5: Weekly Stack Emissions Compared with DRL, AL and AdminL (Cont'd)

DATE	TRITIUM OXIDE (HTO) PER 7 ⁽¹⁾ DAYS (Bq)				TRITIUM GAS (HT) PER 7 ⁽¹⁾ DAYS (Bq)			
	STACK EMISSION	GOLDER MODELLED DRL	ACTION LIMIT	ADMIN. LIMIT	STACK EMISSION	GOLDER MODELLED DRL	ACTION LIMIT	ADMIN. LIMIT
		1.00E+14	5.0E+12	1.0E+12		3.40E+19	1.7E+14	3.4E+13
	Exceedence of DRL, AL or AdminL (% Exceeded By)				Exceedence of DRL, AL or AdminL (% Exceeded By)			
13-Apr	3.9E+11	--	--	--	1.2E+12	--	--	--
20-Apr	4.2E+11	--	--	--	8.5E+11	--	--	--
27-Apr	5.1E+11	--	--	--	9.1E+11	--	--	--
4-May	4.9E+11	--	--	--	8.9E+11	--	--	--
11-May	4.7E+11	--	--	--	7.5E+11	--	--	--
18-May	5.5E+11	--	--	--	5.9E+11	--	--	--
25-May	5.0E+11	--	--	--	8.8E+11	--	--	--
1-Jun	5.6E+11	--	--	--	1.1E+12	--	--	--
8-Jun	3.9E+11	--	--	--	7.0E+11	--	--	--
15-Jun	3.2E+11	--	--	--	1.9E+12	--	--	--
22-Jun	3.4E+11	--	--	--	1.9E+12	--	--	--
29-Jun	3.5E+11	--	--	--	4.0E+12	--	--	--
6-Jul	3.3E+11	--	--	--	1.5E+12	--	--	--
13-Jul	3.0E+11	--	--	--	9.2E+11	--	--	--
20-Jul	3.8E+11	--	--	--	2.4E+12	--	--	--
27-Jul	3.0E+11	--	--	--	3.1E+12	--	--	--
3-Aug	4.2E+11	--	--	--	1.9E+12	--	--	--
10-Aug	4.3E+11	--	--	--	4.5E+12	--	--	--
17-Aug	4.2E+11	--	--	--	3.0E+12	--	--	--
24-Aug	4.7E+11	--	--	--	3.1E+12	--	--	--
31-Aug	6.4E+11	--	--	--	2.9E+12	--	--	--
7-Sep	4.9E+11	--	--	--	3.7E+12	--	--	--
14-Sep	4.2E+11	--	--	--	3.4E+12	--	--	--
21-Sep	4.2E+11	--	--	--	3.2E+12	--	--	--
28-Sep	5.8E+11	--	--	--	2.0E+12	--	--	--
5-Oct	3.3E+11	--	--	--	1.5E+12	--	--	--
12-Oct	3.2E+11	--	--	--	2.4E+12	--	--	--
19-Oct	2.4E+11	--	--	--	1.4E+12	--	--	--
26-Oct	2.2E+11	--	--	--	1.5E+12	--	--	--
2-Nov	2.7E+11	--	--	--	2.1E+12	--	--	--
9-Nov	2.5E+11	--	--	--	2.3E+12	--	--	--
16-Nov	2.0E+11	--	--	--	1.7E+12	--	--	--
23-Nov	2.1E+11	--	--	--	1.8E+12	--	--	--
30-Nov	2.8E+11	--	--	--	1.8E+12	--	--	--
7-Dec	2.1E+11	--	--	--	1.7E+12	--	--	--
14-Dec	2.0E+11	--	--	--	1.5E+12	--	--	--
21-Dec	3.7E+11	--	--	--	3.9E+12	--	--	--
28-Dec	1.4E+11	--	--	--	1.8E+12	--	--	--

2.2.4 Data Trends

Stack emission data did not show an identifiable correlation with seasonal change. A comparison of monthly HTO and HT stack emission values in 2004 with those from 2003, 2002, 2001 and 2000 shows no observable repetition of annual trends (Table 6).

Table 6: Yearly HTO & HT Comparison

MONTH	HTO EMISSIONS					HT EMISSIONS				
	2004	2003	2002	2001	2000	2004	2003	2002	2001	2000
January	7.0E+11	8.6E+11	1.2E+12	2.2E+12	2.3E+12	3.3E+12	9.3E+12	4.3E+12	1.5E+13	1.3E+12
February	7.4E+11	9.6E+11	1.4E+12	2.4E+12	2.3E+12	3.8E+12	9.6E+12	1.0E+13	1.1E+13	6.6E+12
March	1.3E+12	8.6E+11	1.3E+12	2.1E+12	1.8E+12	5.4E+12	1.1E+13	1.1E+13	6.1E+12	2.1E+12
April	1.9E+12	1.7E+12	1.9E+12	2.6E+12	3.4E+12	4.4E+12	6.4E+12	1.2E+13	1.1E+13	7.8E+12
May	2.2E+12	1.9E+12	1.5E+12	3.0E+12	2.8E+12	3.5E+12	5.4E+12	8.8E+12	1.1E+13	5.8E+12
June	1.6E+12	1.6E+12	2.0E+12	1.9E+12	3.8E+12	8.8E+12	5.9E+12	7.9E+12	8.0E+12	3.5E+12
July	1.5E+12	2.6E+12	1.6E+12	3.0E+12	2.5E+12	9.0E+12	2.8E+12	6.4E+12	1.2E+13	2.7E+12
August	2.1E+12	2.2E+12	2.6E+12	2.2E+12	4.0E+12	1.4E+13	3.2E+12	1.3E+13	6.0E+12	1.9E+12
September	1.9E+12	3.7E+12	2.3E+12	2.3E+12	3.1E+12	1.2E+13	5.0E+12	8.3E+12	1.0E+13	9.3E+12
October	1.3E+12	2.5E+12	2.3E+12	1.9E+12	2.3E+12	8.3E+12	3.9E+12	1.2E+13	8.8E+12	1.1E+13
November	1.0E+12	1.8E+12	2.2E+12	1.7E+12	2.0E+12	8.2E+12	3.8E+12	9.4E+12	4.5E+12	1.3E+13
December	1.0E+12	1.3E+12	2.9E+12	1.7E+12	1.3E+12	9.7E+12	3.7E+12	9.9E+12	6.0E+12	1.7E+13
TOTAL:	1.7E+13	2.2E+13	2.3E+13	2.7E+13	3.2E+13	9.1E+13	7.0E+13	1.1E+14	1.1E+14	8.2E+13
AVERAGE:	1.4E+12	1.8E+12	1.9E+12	2.3E+12	2.6E+12	7.6E+12	5.8E+12	9.4E+12	9.1E+12	6.8E+12
MAX:	2.2E+12	3.7E+12	2.9E+12	3.0E+12	4.0E+12	1.4E+13	1.1E+13	1.3E+13	1.5E+13	1.7E+13
MIN:	7.0E+11	8.6E+11	1.2E+12	1.7E+12	1.3E+12	3.3E+12	2.8E+12	4.3E+12	4.5E+12	1.3E+12

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 scintillation vials 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 meter above the ground by attaching them to an available surface (post, tree). The sampler is attached so that it always faces the SSI facility. A small plastic plant pot 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.

The passive air monitoring data must be converted from Bq/L in sampling liquid to Bq/m³ 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 calculation and the assumptions made are presented in Appendix I.

2.3.2 Sample Availability

There were 192 planned ambient air sample collections in 2004 and 179 actual collections performed. Therefore 93% of valid ambient air sample collection was achieved compared to planned collection.

2.3.3 Results

The ambient air monitoring data collected from January 2004 to December 2004 are provided in Table 7. Please note that Station A1 has moved location between the 2003 annual report and now. This change occurred because the structure on which the sampler was located has been demolished. The new location is 74 m northeast of the stack. A comparison of average and maximum ambient air monitoring results for each sample location for 2003 and 2004 is given in Table 8.

Based on the assumptions used to convert the passive sampling data from Bq/L in sampling liquid to Bq/m³ in air, tritium activity in air averaged over the sampling period was estimated to be less than 1 Bq/m³ at all sample locations.

The highest annual average tritium activities in ambient air were 4.36 Bq/m³, 1.47 Bq/m³ and 1.28 Bq/m³, collected from sample locations A1, A4 and A5, respectively. Sample locations A1, A4 and A5 are located 120 meters northeast, 250 meters north and 220 meters northeast of the SSI stack, respectively.

The maximum monthly average occurred from August 24, 2004 to September 28, 2004 with a maximum average activity of 1.49 Bq/m³. This corresponds with the maximum monthly HTO emissions (2.5E+12 Bq) and above average monthly ambient water monitoring results (336 Bq/L).

The average activities from 2003 and 2004 appear comparable, except at the site closest to the stack (A1). The average activity in 2004 was approximately 3.4 times higher than the average in 2003. However, the trend of decreasing activity with increasing distance from the stack was consistent in both 2003 and 2004.

The maximum activities from 2003 and 2004 also appear comparable, except at the site closest to the stack (A1). The maximum activity in 2004 was approximately 5 times higher than the maximum in 2003. However, the trend of decreasing activity with increasing distance from the stack was consistent in both 2003 and 2004.

A comparison of the average monthly ambient air activity for 2003 and 2004 is given in Table 9. Average monthly activity from 2003 and 2004 appears comparable. There do not appear to be monthly tritium activity trends over the sampling periods. Activity levels appear to follow production levels and do not appear to have a seasonal variation. Variation observed in activity levels at a station between years could be caused by changes in wind direction.

Table 7: 2004 Ambient Air Monitoring Data (Bq/m³)

Date Sampled	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A17	Avg/ Month
Jan-04	--	0.40	0.70	0.80	1.09	--	0.38	0.30	0.38	0.41	0.31	0.33	0.23	0.24	0.37	0.23	0.44
Feb-04	0.99	0.47	0.79	0.54	0.89	0.84	0.26	0.26	0.26	0.26	0.27	0.29	0.26	0.26	0.26	0.26	0.45
Mar-04	3.47	0.61	1.11	1.42	1.56	0.52	0.97	0.27	0.26	0.50	0.29	0.46	0.32	--	0.26	0.26	0.82
Apr-04	0.78	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.35	0.31	0.31	0.31	--	0.31	0.31	0.35
May-04	3.05	0.45	1.26	1.51	1.15	0.42	0.37	0.26	0.26	0.26	--	0.26	0.26	--	--	0.26	0.75
Jun-04	8.51	0.26	1.12	1.89	0.99	0.31	0.47	1.96	4.10	0.48	0.26	0.26	0.26	0.26	0.26	0.26	1.35
Jul-04	8.42	0.41	--	2.33	1.78	0.30	0.39	0.27	0.27	0.30	0.27	0.27	--	--	0.27	0.27	1.20
Aug-04	3.18	0.26	0.31	0.74	0.40	0.26	0.26	0.26	0.26	0.26	0.26	0.26	--	0.26	0.26	0.26	0.50
Sep-04	8.55	1.23	1.71	3.14	1.85	0.80	0.98	0.41	0.28	0.42	0.53	--	--	0.39	0.28	0.28	1.49
Oct-04	5.67	1.13	1.09	2.12	1.66	1.21	0.88	0.49	0.44	0.61	0.47	0.31	0.31	0.34	0.31	0.31	1.08
Nov-04	3.06	1.04	1.19	2.02	2.42	1.26	1.23	0.90	0.68	0.89	1.66	0.67	0.53	0.43	0.40	0.32	1.17
Dec-04	2.31	0.91	1.31	0.81	1.21	1.34	0.69	0.34	0.90	0.48	0.78	0.47	0.49	0.51	0.34	0.00	0.80
Average	4.36	0.62	0.99	1.47	1.28	0.69	0.60	0.50	0.70	0.43	0.49	0.35	0.33	0.34	0.30	0.25	0.87
Maximum	8.55	1.23	1.71	3.14	2.42	1.34	1.23	1.96	4.10	0.89	1.66	0.67	0.53	0.51	0.40	0.32	1.49
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	

Note: "--" no sample collected or analyzed

Table 8: Annual Comparison of Average and Maximum Ambient Air Monitoring Results for each Sample Location

Location	Average (Bq/L)		Maximum (Bq/L)	
	2003	2004	2003	2004
A1	1.30	4.36	1.72	8.55
A2	0.66	0.62	1.40	1.23
A3	0.91	0.99	1.68	1.71
A4	1.49	1.47	3.38	3.14
A5	1.54	1.28	3.57	2.42
A6	1.08	0.69	2.73	1.34
A7	1.00	0.60	4.18	1.23
A8	0.38	0.50	0.74	1.96
A9	0.40	0.70	0.60	4.10
A10	0.50	0.43	1.00	0.89
A11	0.43	0.49	0.86	1.66
A12	0.37	0.35	0.60	0.67
A13	0.38	0.33	0.65	0.53
A14	0.38	0.34	0.51	0.51
A15	0.44	0.30	0.90	0.40
A17	0.39	0.25	1.08	0.32

Table 9: Annual Comparison of Monthly Average Ambient Air Monitoring Results

Location	Average	
	2003	2004
January	0.42	0.44
February	0.50	0.45
March	0.45	0.82
April	0.64	0.35
May	0.52	0.75
June	0.71	1.35
July	0.95	1.20
August	0.72	0.50
September	1.25	1.49
October	0.92	1.08
November	0.44	1.17
December	0.52	0.80

2.4 Ambient Water Monitoring

2.4.1 Sampling Method

Water samples were collected and analyzed on a monthly basis. Water samples were collected in suitable bottles and triple rinsed with the sample water. The water samples were analyzed by scintillation counting.

2.4.2 Sample Availability

There were 204 planned water sample collections scheduled for 2004 with 151 actual collections performed. Therefore 74% of valid water sample collections were achieved compared to planned collection.

2.4.3 Results

The ambient water monitoring data collected from January 2004 to December 2004 are provided in Table 10. A comparison of average and maximum ambient air monitoring results for each sample location for 2003 and 2004 is given in Table 11.

The highest annual average tritium activities detected in ambient water samples were 1,305 Bq/L and 675 Bq/L from sample locations WG5 and W3. Sample locations 5 and 3 are located 220 meters northeast and 170 meters east of the SSI stack, respectively. A monthly well water sample was also taken at location 5 (WW5) with results below detection limit.

The maximum monthly average tritium activity occurred from February 24 to March 30, 2004 with an average activity of 395 Bq/L across all sampling stations. The February 24 to March 30, 2004 sampling period corresponds with below average monthly HTO emissions ($1.4E+12$ Bq/L) and ambient air monitoring results (0.82 Bq/m³).

The average activity in 2003 and 2004 appears comparable. Some variability exists for stations between 2003 and 2004, but overall HTO activity levels are generally lower in 2004. This is consistent with reduced HTO levels in stack emissions (Table 6).

The maximum activity in 2003 and 2004 also appears comparable. Some variability exists for stations between 2003 and 2004, but overall HTO activity levels are generally lower in 2004. This is consistent with reduced HTO levels in stack emissions (Table 6).

A comparison of the average monthly ambient water activity for 2003 and 2004 is given in Table 12. The average monthly activity appears comparable from 2003 to 2004. There does not appear to be monthly tritium activity trends over the sampling periods. Variations in activity levels at each station could be caused by changes in wind direction and precipitation events.

Collection of ambient water samples during the winter months is considerably reduced due to the formation ice over most water sampling sources. Collections are also reduced during the summer months due to peak temperatures causing drought.

Table 10: Ambient Water Monitoring Data (Bq/L)

DATE	W1	W2	W3	W4	WW5	WG5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W17	Avg/ Month
Jan 20, 04	-	49	-	-	49	-	-	-	-	-	-	-	-	-	-	-	49	49
Feb 24, 04	-	49	-	-	49	-	-	-	-	-	-	-	-	-	-	-	49	49
Mar 30, 04	-	49	746	645	-	1710	717	1378	137	97	116	49	49	82	49	49	49	395
Apr 21, 04	474	49	328	158	49	432	206	298	53	49	49	49	49	49	49	49	49	143
May 26, 04	-	49	1058	440	49	2376	444	898	121	93	49	49	49	49	-	49	49	388
Jun 23, 04	-	49	745	723	49	1408	49	49	49	49	49	49	49	49	49	49	49	220
Jul 27, 04	49	49	843	518	49	1264	320	635	108	49	49	49	52	49	49	49	49	249
Aug 24, 04	-	49	158	218	-	406	128	159	49	49	49	49	49	49	49	49	49	104
Sep 28, 04	-	52	793	878	-	1397	425	737	197	49	108	49	56	65	128	57	49	336
Oct 27, 04	-	49	748	913	62	1426	597	668	158	53	112	49	53	58	98	49	49	321
Nov 24, 04	-	49	654	733	49	1324	486	782	123	49	80	49	150	49	49	49	49	295
Dec 21, 04	-	49	-	-	49	-	-	-	-	-	-	-	-	-	-	-	49	49
Average	262	49	675	581	50	1305	375	623	111	60	73	49	62	55	65	50	49	217
Maximum	474	52	1058	913	62	2376	717	1378	197	97	116	49	150	82	128	57	49	395
Distance	120	240	170	250	220	220	210	200	870	1500	1500	1200	1000	1000	1000	2500	16000	
Direction	NE	SE	E	N	NE	NE	SW	NW	SE	S	N	E	NW	W	SW	S	NE	

Note: “-“ no sample collected or analyzed; Detection Limit is 50 Bq/L

Table 11: Annual Comparison of Average and Maximum Ambient Water Monitoring Results for each Sample Location (Bq/L)

Location	Average		Maximum	
	2003	2004	2003	2004
W1	49	262	49	474
W2	49	49	52	52
W3	828	675	1155	1058
W4	2444	581	9803	913
WW5	49	50	53	62
WG5	1651	1305	1875	2376
W6	630	375	763	717
W7	768	623	1340	1378
W8	123	111	168	197
W9	60	60	92	97
W10	82	73	102	116
W11	49	49	49	49
W12	72	62	126	150
W13	66	55	88	82
W14	80	65	145	128
W15	49	352	52	2768
W17	51	49	68	49

Table 12: Annual Comparison of Monthly Average Ambient Water Results (Bq/L)

Location	Average	
	2003	2004
January	49	49
February	49	49
March	49	395
April	319	143
May	335	388
June	292	389
July	234	249
August	156	104
September	863	336
October	337	321
November	367	295
December	122	49

2.5 Milk Samples

2.5.1 Sampling Method

Milk samples are collected from an area dairy farm in the prevailing wind direction and at locations closest to the SSI facility. Milk samples were collected in suitable sample bottles and analyzed for tritium by liquid scintillation counting.

2.5.2 Results

The milk monitoring data collected are provided in Table 13.

A survey of the surrounding area indicated that the closest dairy farm in the easterly wind direction is over 2800 m from the SSI stack. Tritium activity was below the detection limit (200 Bq/L).

Table 13: Milk Monitoring Data (Bq/L)

DATE	M16
Jan 20, 04	<200
Feb 24, 04	<200
Mar 30, 04	<200
Apr 21, 04	<200
May 26, 04	<200
Jun 23, 04	<200
Jul 27, 04	<200
Aug 24, 04	<200
Sept 28, 04	<200
Oct 27, 04	<200
Nov 24, 04	<200
Dec 21, 04	<200
Distance	2860
Direction	NE

2.6 Precipitation Samples

2.6.1 Sampling Method

Precipitation samples are collected from two locations, P3 and P17, 210 meters southeast and 16000 northeast of the stack. Precipitation samples were collected in suitable sample bottles and analyzed for tritium by liquid scintillation counting.

2.6.2 Results

The precipitation monitoring data collected are provided in Table 14.

Table 14: Precipitation Monitoring Data (Bq/L)

DATE	P3	P17
Apr 21, 04	49	49
May 26, 04	66	49
Jun 23, 04	63	49
Jul 27, 04	118	49
Aug 24, 04	49	49
Sep 28, 04	72	49
Oct 27, 04	172	53
Nov 24, 05	61	49
Average	81	49
Maximum	172	53
Distance	210	16000
Direction	SE	NE

These results are consistent with the trend of decreasing activity with increased distance from the stack.

2.7 Vegetation Samples

2.7.1 Sampling Method

Vegetation samples such as wild apples and berries were collected. Samples were sealed in freezer bags and analyzed for tritium by liquid scintillation counting.

2.7.2 Results

The vegetation monitoring data collected are provided in Table 15.

Vegetation sample locations included sites V4, V5, V7, V9, V10, V13 and V15. Sample locations V5, V7 and V10 were the only locations where vegetation was found. Locations V5, V7 and V10 are located 220 meters northeast, 200 meters northwest and 1,623 meters northeast of the SSI stack, respectively. The higher activity levels found in the samples from location V5 corresponds with maximum average activity in ambient air and ambient water monitoring results.

Table 15: Vegetation Monitoring Data (Bq/L)

	V4	V5	V7	V9	V10	V13	V15
DATE		APPLES	GRAPES		GRAPES		
Aug 24, 04		2800					
Sep 28, 04		2020	680				
Oct 27, 05		1600			<200		
DISTANCE	250	220	200	1500	1625	1000	2500
DIRECTION	N	NE	NW	SW	NE	W	S

Table 16 compares vegetation monitoring results for 2003 and 2004 for the sampling locations V5, V7 and V10.

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

DATE	V5		V7		V10	
	2003	2004	2003	2004	2003	2004
	APPLES	GRAPES	GRAPES	GRAPES	GRAPES	GRAPES
August		2800				
September	1240	2020	6190	680	360	
October		1600			230	<200
DISTANCE	220	220	200	200	200	200
DIRECTION	NE	NE	NW	NW	NW	NW

The monitored tritium activity in vegetation for 2003 and 2004 (September) is comparable at site V5 although the samples were collected from different vegetation types (apples and grapes, respectively). However, monitored activity at site V7 was an order of magnitude lower in 2004 compared with 2003 activity levels for the same vegetation (grapes). The decrease in activity at site V7 from 2003 to 2004 does not appear to correlate to a significant decrease in tritium activity from ambient air sampling. Changes in prevalent wind strength and direction and/or a difference in precipitation events could be contributing factors to this observed decrease.

3. CALCULATED DOSES TO THE CRITICAL RECEPTOR

The model used to estimate doses to the critical receptor is presented in the Shield Source Inc. Derived Release Limits for Tritium Based on Air Dispersion and Environmental Pathway Modeling (Golder 2002). 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 (Golder 2004). Comments from CNSC to the Golder (2004) report have recently been responded to (Golder 2005).

Historically, the dose to the critical receptor has been reported based on either maximum or average monitoring results obtained at the nearest residence (Station 5), which coincided with areas of maximum monitored activity. In 2004, the area of maximum monitored activity in ambient air samples was not observed at the closest residence but at a different location (Station 1). In order to provide a basis for comparison between years, the dose to the critical receptor was calculated based on the nearest residence. However, since the nearest residence no longer coincided with the maximum monitored activity in air, dose to the critical receptor was also calculated based on Stations 1 and 5 (with the highest tritium activity in air and water, respectively).

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

The average and maximum measured activities in air and water at Station 5 (the closest residence) and at Stations 1 and 5 (the sites with highest air and water activity, respectively) are presented in Tables 17 and 18.

Table 17: Average Activities of Tritium in Air and Water Measured During the 2004 Monitoring Program

Location	Form of Tritium	Activity in Water Bq/L	Activity in Air Bq/m ³	Monitoring Sample Locations
Highest Activity	HTO	1,305	1.2 ^(a)	WG5, A1
	HT	-	3.2 ^(a)	
Closest Residence	HTO	1,305	0.3 ^(b)	WG5, A5
	HT	-	0.9 ^(b)	

- a) based on total activity of 4.36 Bq/m³ using 27% HTO and 73% HT based on maximum stack emissions
 b) based on total activity of 1.28 Bq/m³ using 27% HTO and 73% HT based on maximum stack emissions

Table 18: Maximum Activities of Tritium in Air and Water Measured During the 2004 Monitoring Program

Location	Form of Tritium	Activity in Water Bq/L	Activity in Air Bq/m ³	Monitoring Sample Locations
Highest Activity	HTO	2,376	2.3 ^(a)	WG5, A1
	HT	-	6.2 ^(a)	
Closest Residence	HTO	2,376	0.7 ^(b)	WG5, A5
	HT	-	1.8 ^(b)	

- a) based on total activity of 8.55 Bq/m³ using 27% HTO and 73% HT based on maximum stack emissions
 b) based on total activity of 2.42 Bq/m³ using 27% HTO and 73% HT based on maximum stack emissions

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

Estimated doses of tritium, tritium oxide and organically bound tritium were derived using average or maximum concentrations of tritium in air and water measured at the site with the highest activity (Station 1 and 5, respectively) and at the closest residence to the source (Station 5).

Table 19: Estimated Doses of Tritium Oxide (HTO), Tritium (HT) and Organically Bound Tritium (OBT) to the Critical Receptor Based on Average Monitored Activity in Air and Water at the Highest Activity (Station 1 and 5) and the 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	2.3E-02	2.6E-04	1.9E-03	5.7E-03	WG5, A1	50% of vegetables and animal produce from vicinity of site
	HT	NA	7.3E-08	NA	NA		
	OBT	NA	NA	2.6E-03	1.3E-02		
Closest Residence	HTO	2.3E-02	7.6E-05	1.8E-03	5.6E-03	WG5, A5	
	HT	NA	2.1E-08	NA	NA		
	OBT	NA	NA	2.5E-03	1.3E-02		

Table 20: Estimated Doses of Tritium Oxide (HTO), Tritium (HT) and Organically Bound Tritium (OBT) to the Critical Receptor Based on Maximum Monitored Activity in Air and Water at the Highest Activity (Station 1 and 5) and the 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	4.1E-02	5.1E-04	3.4E-03	1.0E-02	WG5, A1	50% of vegetables and animal produce from vicinity of site
	HT	NA	1.4E-07	NA	NA		
	OBT	NA	NA	4.7E-03	2.3E-02		
Closest Residence	HTO	4.1E-02	1.4E-04	3.3E-03	1.0E-02	WG5, A5	
	HT	NA	4.0E-08	NA	NA		
	OBT	NA	NA	4.5E-03	2.3E-02		

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

The contribution of each exposure pathway to total dose to the critical 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 (<5.7%) of the total dose.

The calculated long-term doses to the critical 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) using Average Concentrations to the Critical Receptor Resulting from Each Exposure Pathway: Air, Water, Vegetation, and Animal

Location	Annual Dose Limit (mSv/yr)	Total Dose to Child (mSv/yr)	Dose from Water (mSv/yr)	% of Total	Dose from Air (mSv/yr)	% of Total	Dose from Vegetation (mSv/yr)	% of Total	Dose from Animal (mSv/yr)	% of Total
Maximum Activity	1	0.05	0.02	49.5	0.0003	0.6	0.004	9.7	0.02	40.3
Closest Residence	1	0.05	0.02	50.0	0.00008	0.2	0.004	9.4	0.02	40.4

Table 22: Total Tritium Dose (All Forms) using Maximum Concentrations to the Critical Receptor Resulting from Each Exposure Pathway: Air, Water, Vegetation, and Animal

Location	Annual Dose Limit (mSv/yr)	Total Dose to Child (mSv/yr)	Dose from Water (mSv/yr)	% of Total	Dose from Air (mSv/yr)	% of Total	Dose from Vegetation (mSv/yr)	% of Total	Dose from Animal (mSv/yr)	% of Total
Maximum Activity	1	0.08	0.04	49.4	0.0005	0.6	0.008	9.4	0.03	40.6
Closest Residence	1	0.08	0.04	49.8	0.0001	0.2	0.008	9.4	0.03	40.4

A comparison of modelled average and maximum tritium activities in milk with measured activities in milk shows that the model overestimated milk activities (Tables 23 and 24). This comparison shows that the model predictions are conservative and that doses are not underestimated.

Monitored activity in vegetation (grapes and apples) was higher than modelled activity in 2004 in all cases. The elevated activity in grape and 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 grapes and apples, which would be expected to accumulate some HTO via air deposition or rainfall on the surface of the fruit.

The maximum activity level in vegetation was observed at V5 located 220m northeast of the stack at the closest residence. When the dose modelling is re-run using monitored data for vegetation, the estimated dose from vegetation to a child receptor from the area of highest activity either remained unchanged or increased by 0.01 mSv/yr above modelled results (Table 25). The estimated dose at the closest residence also either remained unchanged or increased by 0.01 mSv/yr above modelled results (Table 25). The estimated dose to a child receptor using monitored or modelled activity in vegetation is lower than the annual dose limit of 1 mSv/yr in all cases.

Table 23: Measured versus Modelled Average Tritium Activity in Milk Based on Average and Maximum Activity in Air and Water

Location	Average		Maximum	
	Measured Mean Bq/L	Modelled (Total HTO and OBT) Bq/L	Measured Mean Bq/L	Modelled (Total HTO and OBT) Bq/L
Highest Activity	<200	1,596	<200	2,908
Closest Proximity	<200	1,587	<200	2,890

Table 24: Measured versus Modelled Average Tritium Activity in Vegetation Based on Average and Maximum Activity in Air and Water

Location	Average		Maximum	
	Measured Mean Bq/L	Modelled (Total HTO and OBT) Bq/L	Measured Mean Bq/L	Modelled (Total HTO and OBT) Bq/L
Highest Activity	2,140	1,115	2,800	2,039
Closest Proximity	2,140	1,074	2,800	1,956

Table 25: Comparison of Estimated Dose Using Modelled Versus Monitored Activity in Vegetation

Location		Annual Dose Limit (mSv/yr)	Total Dose to Child Using Modelled Vegetation Activity (mSv/yr)	Total Dose to Child Using Monitored Activity in Vegetation (mSv/yr)
Average	Highest Activity	1	0.05	0.05
	Closest Residence	1	0.05	0.05
Maximum	Highest Activity	1	0.08	0.09
	Closest Residence	1	0.08	0.09

4. SSI QA/QC

SSI'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. SSI 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 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 26 shows the Field Blank results for 2004.

Table 26: Field Blank Data (Bq/L)

DATE	AMBIENT AIR	AMBIENT WATER	MILK
	Field Blank	Field Blank	Field Blank
Jan 20, 04	67	<50	<50
Feb 24, 04	<50	<50	<50
Mar 30, 04	<50	<50	<50
Apr 21, 04	69	<50	<50
May 26, 04	<50	<50	<50
Jun 23, 04	<50	<50	<50
Jul 27, 04	<50	<50	<50
Aug 24, 04	<50	<50	<50
Sep 28, 04	<50	66	58
Oct 27, 04	86	64	95
Nov 24, 04	121	<50	<50
Dec 21, 04	<50	<50	<50

Ambient air, ambient water and milk activity levels in the field blanks are below or close to the method detection limit of 50 Bq/L, except for the field blank submitted on October 27, 2004 and the ambient air field blank submitted on November 24, 2004. The monitored ambient air, water and milk data does not appear to be significantly higher during these two sampling months. However, data collected on October 27 and November 24, 2004 should be interpreted with caution as the results may be biased upwards by contamination.

4.2 Trip Blanks

Trip blanks detect sample contamination during storage and transport. Travel blanks consist of bottles provided by a laboratory equipment supplier and filled by SSI 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 analytical laboratory to be analyzed along with the collected samples.

4.2.1 Results

Table 27 shows the travel blank results for 2004.

Table 27: Trip Blanks Data (Bq/L)

DATE	AMBIENT AIR	AMBIENT WATER
	Trip Blank	Trip Blank
Jan 20, 04	<50	<50
Feb 24, 04	<50	<50
Mar 30, 04	<50	<50
Apr 21, 04	<50	<50
May 26, 04	<50	<50
Jun 23, 04	<50	<50
Jul 27, 04	<50	<50
Aug 24, 04	<50	<50
Sep 28, 04	<50	<50
Oct 27, 04	122	78
Nov 24, 04	111	<50
Dec 21, 04	<50	<50

Ambient air and water activity levels in the trip blanks are below the method detection limit of 50 Bq/L, except for the trip blank submitted on October 27, 2004 and the ambient air field blank submitted on November 24, 2004. The monitored ambient air and water data does not appear to be significantly higher during these two sampling months. However, data collected on October 27 and November 24, 2004 should be interpreted with caution as the results may be biased upwards by contamination.

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 analytical laboratory.

4.3.1 Results

Table 28 shows the Replicate Sample results for ambient air monitoring data and Table 29 shows the Replicate Sample results for ambient water monitoring data.

Table 28: Ambient Air Replicate Sample Data (Bq/m³)

DATE	LOCATION	REPLICATE 1	REPLICATE 2	REPLICATE 3	Mean	Standard Deviation	Coefficient of Variation (%)
20-Jan-04	A7	0.40	0.28	0.45	0.38	0.09	23.2
24-Feb-04	A7	0.26	0.26	0.26	0.26	3.7E-09	0
30-Mar-04	A7	0.60	0.69	1.61	0.97	0.6	57.8
21-Apr-04	A7	0.31	0.31	0.31	0.31	5.3E-09	0
26-Jun-04	A7	0.35	0.37	0.39	0.37	0.02	5.4
23-Jun-04	A7	0.39	0.56	0.47	0.47	0.09	18.0
27-Jul-04	A7	0.29	0.43	0.45	0.39	0.09	22.4
24-Aug-04	A7	0.26	0.26	0.26	0.26	3.7E-09	0
28-Sep-04	A7	0.82	1.01	1.12	0.98	0.2	15.4
27-Oct-04	A7	0.85	0.78	1.02	0.88	0.1	14.0
24-Nov-04	A7	1.15	1.06	1.46	1.22	0.2	17.2
24-Dec-04	A7	0.86	0.88	0.34	0.69	0.3	44.2

Table 29: Ambient Water Replicate Sample Data (Bq/L)

DATE	LOCATION	REPLICATE 1	REPLICATE 2	REPLICATE 3	Mean	Standard Deviation	Coefficient of Variation (%)
20-Jan-04	-	-	-	-	-	-	-
24-Feb-04	W2	<50	<50	<50	-	-	-
30-Mar-04	W8	125	157	136	139	16.3	11.7
21-Apr-04	W9	<50	<50	<50	-	-	-
26-Jun-04	W6	416	439	478	444	31.3	7.1
23-Jun-04	W3	743	753	738	745	7.6	1.0
27-Jul-04	W12	<50	<50	56	56	-	-
24-Aug-04	W2	<50	<50	<50	-	-	-
28-Sep-04	W10	117	108	99	108	9.0	8.3
27-Oct-04	W12	<50	<50	58	58	-	-
24-Nov-04	W10	76	58	105	80	23.7	29.8
24-Dec-04	-	-	-	-	-	-	-

The replicate air samples reflect within-site variability plus laboratory precision. Variation between replicates was noted during most air sampling events (January, March, twice in June, July, September, October, November and December) and five water sampling occasions (March, twice in June, September and November). The air sampling sessions in July, September and December correspond to higher stack emissions (HT) while the within site variability from the other sampling sessions does not appear to correspond to higher stack emissions. The water sampling sessions in June and September correspond to higher stack emissions (HTO and HT) while the within site variability from the March, and November sampling sessions does not appear to correspond to higher stack emissions.

The replicate air samples show a coefficient of variation between 5.4 and 44.2%. This range of variability is not unexpected for passive air sampling results as minute variations in location and direction of samplers, degree of exposure of samplers and other factors can significantly affect air flow through the samplers.

The coefficient of variation for water samples ranged from 1.0 to 29.8%. This within-site variability and laboratory precision appears to be reasonable since precision at activity levels close to the detection limit is often $\pm 50 - 100\%$. The replicate data lend additional confidence to the interpretation of field-collected data.

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 interlaboratory comparison results are within acceptable limits (Appendix III).

6. INCIDENTS

There were no incidents to report during 2004. HTO and HT emissions remained below administrative and regulatory levels.

7. SUMMARY

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

The estimated dose to the critical receptor (infant) living at the nearest residential dwelling (Station A5 and WG5) based on the average and maximum monitored activities in air and water was 0.05 mSv/yr and 0.08 mSv/yr, respectively. The estimated dose to the critical receptor at the site with the highest measured activity (Station A1 and WG5) based on the average and maximum monitored activities in air and water was 0.05 mSv/yr and 0.08 mSv/yr, respectively. All cases are below the annual dose limit to the general public of 1 mSv/yr.

A comparison of modelled and monitored activities in milk and vegetation showed that the model overestimated milk activities and underestimated vegetation activities for this sampling year. However, when the model was re-run using monitored activity in vegetation, the resulting estimated dose was either the same or increased by 0.01 mSv/yr at the closest residence and the highest activity site when the maximum concentrations were used. Estimated doses using modelled, monitored average or maximum activity levels in vegetation were all lower than the annual dose limit of 1 mSv/yr. Higher stack emissions at the time of vegetation sampling may be responsible for higher monitored vegetation activities than observed in previous years (Station V5). Changes in predominant wind direction or precipitation may be responsible for lower monitored vegetation activities than observed in previous years (V7 and V10).

APPENDIX I
CONVERSION CALCULATIONS

CONVERSION FROM BQ/L TO BQ/M3 IN PASSIVE SAMPLERS

The laboratory analysis results for the air monitoring stations have been provided to SSI 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 SSI by Ontario Power Generation (OPG).

To illustrate how the conversion would be applied to SSI, 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:

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

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

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

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

$$5000 \frac{\text{dpm}}{\text{DAC} \times \text{hr} \times \text{mL}}$$

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:

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

According to the OPG memorandum, each DAC unit is equal to 10 uCi/m³. By substituting this value into the above formulae and converting to Becquerels, the airborne concentration was calculated as:

$$5.00 \times 10^{-6} \text{ DAC} \times 10 \frac{\text{uCi}}{\text{m}^3} \times 37000 \frac{\text{Bq}}{\text{uCi}} = 1.852 \frac{\text{Bq}}{\text{m}^3}$$

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

APPENDIX II

DOSE CALCULATION METHOD

MODEL METHODOLOGY

Three forms of tritium were evaluated: HTO, HT and OBT (organically-bound tritium). The dose conversion factors used in the calculations were:

HTO: 5.8×10^{-11} (CAN/CSA 1987)

HT: 1.2×10^{-14} (CAN/CSA 1987)

OBT: 1.2×10^{-10} (ICRP 1995)

The pathways evaluated were as follows:

1. HTO inhalation and immersion:

- air-to-receptor

2. HT inhalation:

- air-to-receptor

3. HTO ingestion via drinking water:

- water-to-receptor

NOTE: Air-to-water was not modelled; rather, the maximum water activity from the monitoring data was used.

4. HTO ingestion via consumption of plants and animals:

- air-to-plant, water-to-plant, plant-to-receptor;
- air-to-animal; water-to-animal, plant-to-animal; animal-to-receptor

NOTE: Air-to-soil was not estimated because uptake by plants from the soil surface is not applicable to tritium (CAN/CSA 1987). Soil water activity was assumed to be equal to groundwater activity.

5. OBT ingestion via consumption of plants and animals:

- HTO-to-OBT in plant, OBT in plant-to-receptor
- OBT in plant-to-animal, HTO-to-OBT in animal, total OBT in animal-to-receptor

The input parameters and results of the calculations for each of the above pathways are presented in the Appendix II tables.

HTO Inhalation and Immersion; HT Inhalation

The critical receptor (infant in the critical group) was assumed to have a total air volume intake of 1900 m³ per year (CNSC 2000). A 100% occupancy factor was assumed (i.e. the infant would spend 100% of the time in the immediate vicinity of the SSI facility).

Dose from immersion was estimated by multiplying the dose from inhalation by 2. This accounts for skin exposure due to immersion in airborne HTO.

HTO Ingestion via Drinking Water

The total yearly water intake by the critical receptor was assumed to be 300L/yr (CAN/CSA 1987). It was assumed that 100% of drinking water was obtained from the immediate vicinity of the SSI facility.

HTO Ingestion from Consumption of Plants and Animals

(1) Plants: Two pathways leading to plants were evaluated: HTO deposition onto plants from the atmosphere and HTO uptake into plants from soil water. Uptake of tritium from the soil surface was not estimated, since tritium is rapidly incorporated into soil water.

The deposition of HTO onto plants was estimated using the specific activity approach given in CAN/CSA (1987):

$$\text{Transfer parameter (air-to-plant)} = \frac{f_v}{H_a}$$

Where f_v = ratio of specific activity of HTO in soil water to that in air moisture

H_a = absolute humidity of air (kg/m³).

The resulting transfer parameter used was 50 m³/kg. Therefore, plant tissue concentration from air-to-plant was:

$$\text{Bq/kg in plant tissue from air uptake (P}_a\text{)} = \text{air concentration (Bq/m}^3\text{)} \times 50 \text{ (kg/m}^3\text{)}.$$

The uptake of HTO from soil water into plants was estimated using the specific activity approach given in CAN/CSA (1987):

$$\text{Bq/kg in plant tissue } (P_w) = \frac{\text{Water concentration (Bq/L)} \times f_v}{G_w \text{ (kg/L)}}$$

Where f_v = ratio of specific activity of HTO in vegetation water to that in soil water

G_w = distribution factor for tritium in vegetation (Bq/L of water per Bq/kg fresh weight of vegetation)

$$\text{Total activity in plants} = P_a + P_w$$

- (2) Animals: Three pathways leading to animals were evaluated: air-to animal; water-to-animal; and, plant-to-animal.

Transfer parameters for air-to-animal from CAN/CSA (1987) were used. These transfer parameters in m^3/kg are:

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

Therefore, animal HTO concentration (Bq/kg) from air (A_a) = air concentration x transfer parameter.

Transfer parameters for water-to-animal from CAN/CSA (1987) were used. These transfer parameters in L/kg are:

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

Therefore, animal HTO concentration (Bq/kg) from water (A_w) = water concentration x transfer parameter.

Transfer parameters for plant-to-animal from CAN/CSA (1987) were used. These transfer parameters in kg/kg are:

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

Therefore, animal HTO concentration (Bq/kg) from plant uptake (A_p) = plant concentration x transfer parameter.

$$\text{Total HTO activity in animals} = A_a + A_w + A_p$$

(3) Ingestion of plants and animals by the critical receptor

An intake rate of 96 kg/yr was assumed for intake of plants by the infant critical receptor (CAN/CSA 1987). It was assumed that 50% of plant produce consumed by the critical receptor would be from the immediate vicinity of the SSI facility.

Intake rates for animal products from CAN/CSA (1987) are as follows:

Milk: 220 kg/yr

Meat: 24 kg/yr

Eggs: 5 kg/yr

Poultry: 10 kg/yr

It was assumed that 50% of animal produce consumed by the critical receptor would be from the immediate vicinity of the SSI facility.

OBT Ingestion from Consumption of Plants and Animals

The conversion of HTO to OBT in plant tissues was estimated by using a ratio of OBT/HTO of 0.4 (Brown 1995). Therefore, 40% of the total HTO taken in by the plant was assumed to be converted to OBT. The same intake plant intake rate as that used for HTO (96 kg/yr) was used to estimate OBT intake by the critical receptor.

The activity of OBT in animals was estimated by applying the same transfer parameters for plant-to-animal as used for HTO (see above) and multiplying these transfer parameters by the concentration of OBT in plants. In addition, 50% of HTO taken in via air and water by animals was assumed to be converted to OBT (Okada and Momoshina 1993). Therefore, total OBT in animals was the sum of OBT uptake from plants plus 50% of the HTO uptake from air and from water.

The same ingestion rates for plants and animals as those used for HTO were used to estimate OBT uptake by the critical receptor.

Total Estimated Dose to the Critical Receptor

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.

See Attached Appendix II Tables prepared by Golder Associates for data.

References

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- Okada, S. and N. Momoshima 1993. Overview of tritium: characteristics, sources and problems. Health Physics 65(6): 595-609.
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APPENDIX III

LABORATORY QA/QC DATA