



SHIELD SOURCE INCORPORATED

**ENVIRONMENTAL MONITORING PROGRAM
ANNUAL REPORT**

YEAR 2001

Submitted to:

**Canadian Nuclear Safety Commission
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1. INTRODUCTION

1.1 Purpose

This Environmental Monitoring report is to be the environmental monitoring portion of Shield Source Incorporated (SSI) 2001 Annual Report. This report contains a summary of the environmental monitoring results including stack emissions, air, water, milk and vegetation monitoring data. Stack emissions have been compared with the environmental monitoring data and dose to the receptor group has been calculated. In addition, a summary of the local land usage and meteorological data is included.

1.2 Background Information

In 1997, Twin Oaks Consulting (Twin Oaks) was retained by SSI to develop and implement an environmental monitoring program (EMP) and to calculate Derived Release Limits (DRL). Golder Associates reviewed the EMP developed by Twin Oaks and produced a revised EMP including new DRLs for implementation in 2000 (Golder 2000). The CNSC reviewed this report and provided a list of comments and suggestion in a letter to Shield Source (CNSC 2000). Golder incorporated the changes suggested by the CNSC (2000) in the proposed EMP and recalculated the DRLs under separate cover based on the most up-to-date information. These revised documents were submitted to CNSC in July 2001 and are still under review.

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 a second survey in November 2001 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.

A map of the environmental monitoring area is attached in Appendix I.

Table 1
SSI EMP Sampling Locations

STATION	LOCATION	Approximate Distance and Direction from Stack
1	Background Sample (QA/QC)	16000 m northeast
2	Field Sample Transferred to New Container In The Field (QA/QC)	16000 m northeast
3	Well house	120 m northeast
4	Hydro Pole	150 m southeast
5	Tap water Airport Terminal/Environment Canada Fence	240 m southeast
6	Airport Rd culvert	870 m southeast
7	Cavan Creek	1500 m south
8	Fazerville Access	2500 m south
9	Sign at Airport Entrance	210 m southeast
10	Pond and House across from SSI	171 m northeast
11	Chain link fence Mel O'Brien Way	210 m northwest
12	Tree line west of stack	210 m southwest
13	Tree line south west of stack	570 m southwest
14	Sign at corner of Mel O'Brien Way	150 m north
15	Culvert - Mervin Line west	500m northwest
16	Mervin Line - Otonabee River	1625 m northeast
17	Culvert at Hwy 115 access	1250 m north
18	Culvert Beardsmore Rd	1500 m north
19	Worboy Court	1875 m north
20	Monaghan Rd - Otonabee River	5000 m northeast
21	Mahood Line	3110 m east
22	Matchette Line	2560 m east
23	██████████ Farm	2864 m southeast
24	Brealy Drive Apple Tree	4400 m north
25	Lakefield Apple Tree	20800 m northeast
BLANK	Sample Prepared With Same Medium, Carried to Field, Taped and Packaged in Field (QA/QC)	

2. SUMMARY OF ENVIRONMENTAL MONITORING RESULTS

2.1 Samples

Environmental samples were collected monthly by SSI staff and sent to Monserco Laboratories for analysis. Stack emissions were measured continuously from the SSI facility. The sampling program consists of 5 types of samples collected - stack emissions, ambient air samples, ambient water samples, milk and vegetation samples. The sampling results are described below.

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 HTO and HT emissions are then calculated. The weekly and

yearly HTO and HT stack emissions were summarized and compared to the Derived Emissions Limit (DEL) and the Administrative Limit (AL) values originally calculated by Twin Oaks Consulting (TOC 1997) as well as the proposed DEL and AL values calculated by Golder Associates (Golder 2001).

2.2.1 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
Date	Date	Released	Released	Activity
From	To	(Bq)	(Bq)	(Bq)
Dec 20	Jan 22	2.16E+12	1.48E+13	1.69E+13
Jan 23	Feb 25	2.44E+12	1.10E+13	1.34E+13
Feb 26	Mar 20	2.07E+12	6.06E+12	8.13E+12
Mar 21	Apr 19	2.61E+12	1.06E+13	1.32E+13
Apr 20	May 24	3.03E+12	1.05E+13	1.36E+13
May 25	Jun 17	1.92E+12	8.01E+12	9.92E+12
Jun 18	Jul 24	3.03E+12	1.20E+13	1.50E+13
Jul 25	Aug 20	2.20E+12	6.01E+12	8.21E+12
Aug 21	Sep 23	2.29E+12	1.04E+13	1.27E+13
Sep 24	Oct 24	1.94E+12	8.81E+12	1.08E+13
Oct 25	Nov 19	1.67E+12	4.48E+12	6.15E+12
Nov 20	Dec 18	1.68E+12	5.98E+12	7.66E+12
Total		2.70E+13	1.09E+14	1.36E+14

The highest release occurred during the sampling period of December 20, 2000 and January 22, 2001, when an activity of 1.69×10^{13} Bq was recorded. This corresponds with average levels of tritium in ambient air and water monitoring data.

The minimum stack emission was found during the sampling period of October 25 and November 19, 2001 (6.15×10^{12} Bq). This corresponds with higher levels of tritium in ambient air and water monitoring data.

No discernable variation with season was observed in the data.

2.2.2 DEL and AL

Weekly and yearly HTO and HT emission are summarized and compared to the Derived Emission Limit (DEL) and the Administrative Limit (AL) values originally calculated by Twin Oaks Consulting (TOC 1997) and the DEL and AL values calculated by Golder Associates (Golder 2001). The SSI Radiation Safety Manual-Rev.9 indicates that the AL is 1% of the DEL. However Rev. 11 of the Radiation Safety Manual proposes a more realistic AL of 50% based on the revised DELs. A summary of the weekly and yearly DEL and AL values (Bq) are included in Table 3.

Table 3
Weekly and Yearly DEL and AL Values

Description	TOC		Golder (Proposed)	
	DEL (Bq)	AL (Bq) (1%)	DEL (Bq)	AL (Bq) (50%)
HTO /Week	9.9E+13	9.9E+11	2.3E+12	1.2E+12
HT/Week	5.7E+15	5.7E+13	9.2E+18	4.6E+18
HTO/Year	5.2E+15	5.2E+13	1.2E+14	6.0E+13
HT/Year	3.0E+17	3.0E+15	4.8E+20	2.4E+20

2.2.3 Exceedences of DEL and AL

Yearly Stack Emissions

The total HTO and HT stack emissions for 2001 did not exceed the yearly DELs or ALs calculated by TOC or by Golder. (Table 4)

Table 4
Annual Stack Emission Compared with DEL and AL

YEAR	TRITIUM OXIDE (HTO) PER YEAR (Bq)					TRITIUM GAS (HT) PER YEAR (Bq)				
	STACK EMISSION	TWIN OAKS		GOLDER		STACK EMISSION	TWIN OAKS		GOLDER	
		DEL	AL	DEL	AL		DEL	AL	DEL	AL
		5.2E+15	5.2E+13	1.2E+14	6.0E+13		3.0E+17	3.0E+15	4.8E+20	2.4E+20
Exceedance of DEL or AL (% exceeded by)					Exceedance of DEL or AL (% exceeded by)					
2001	2.7E+13	--	--	--	--	1.0E+14	--	--	--	--

Weekly Stack Emissions

The weekly HTO and HT stack emissions for 2001 did not exceed the weekly DELs or ALs calculated by TOC or by Golder.

Table 5
Weekly Stack Emissions Compared with DEL and AL

DATE	TRITIUM OXIDE (HTO) PER 7 ⁽¹⁾ DAYS (Bq)					TRITIUM GAS (HT) PER 7 ⁽¹⁾ DAYS (Bq)				
	STACK EMISSION	TWIN OAKS		GOLDER		STACK EMISSION	TWIN OAKS		GOLDER	
		DEL	AL	DEL	AL		DEL	AL	DEL	AL
		9.9E+13	9.9E+11	2.3E+12	1.2E+12		5.7E+15	5.7E+13	9.2E+18	4.6E+18
Exceedance of DEL or AL (%exceeded by)					Exceedance of DEL or AL (%exceeded by)					
Jan 02 -										
Jan 09 -	8.1E+11	--	--	--	--	2.2E+12	--	--	--	--
Jan 16 -	4.6E+11	--	--	--	--	3.6E+12	--	--	--	--
Jan 23 -	4.6E+11	--	--	--	--	3.3E+12	--	--	--	--
Jan 30 -	3.9E+11	--	--	--	--	2.8E+12	--	--	--	--
Feb 06 -	3.8E+11	--	--	--	--	2.9E+12	--	--	--	--

Table 5
Weekly Stack Emissions Compared with DEL and AL (Cont'd)

DATE	TRITIUM OXIDE (HTO) PER 7 ⁽¹⁾ DAYS (Bq)					TRITIUM GAS (HT) PER 7 ⁽¹⁾ DAYS (Bq)				
	STACK EMISSION	TWIN OAKS		GOLDER		STACK EMISSION	TWIN OAKS		GOLDER	
		DEL 9.9E+13	AL 9.9E+11	DEL 2.3E+12	AL 1.2E+12		DEL 5.7E+15	AL 5.7E+13	DEL 9.2E+18	AL 4.6E+18
Exceedance of DEL or AL (%exceeded by)					Exceedance of DEL or AL (%exceeded by)					
Apr 24 -	6.2E+11	--	--	--	--	2.3E+12	--	--	--	--
May 01 -	5.8E+11	--	--	--	--	1.3E+12	--	--	--	--
May 08 -	4.0E+11	--	--	--	--	3.0E+12	--	--	--	--
May 15 -	4.5E+11	--	--	--	--	3.4E+12	--	--	--	--
May 22 -	9.8E+11	--	--	--	--	1.4E+12	--	--	--	--
May 29 -	6.3E+11	--	--	--	--	2.2E+12	--	--	--	--
Jun 05 -	5.3E+11	--	--	--	--	3.0E+12	--	--	--	--
Jun 12 -	4.6E+11	--	--	--	--	2.0E+12	--	--	--	--
Jun 19 -	6.8E+11	--	--	--	--	2.0E+12	--	--	--	--
Jun 26 -	6.0E+11	--	--	--	--	2.8E+12	--	--	--	--
Jul 03 -	6.3E+11	--	--	--	--	1.9E+12	--	--	--	--
Jul 10 -	6.1E+11	--	--	--	--	2.8E+12	--	--	--	--
Jul 17 -	5.0E+11	--	--	--	--	1.7E+12	--	--	--	--
Jul 24 -	5.0E+11	--	--	--	--	2.2E+12	--	--	--	--
Jul 31 -	6.4E+11	--	--	--	--	1.6E+12	--	--	--	--
Aug 07 -	7.0E+11	--	--	--	--	1.7E+12	--	--	--	--
Aug 14 -	3.8E+11	--	--	--	--	1.6E+12	--	--	--	--
Aug 21 -	5.6E+11	--	--	--	--	1.2E+12	--	--	--	--
Aug 28 -	5.7E+11	--	--	--	--	2.3E+12	--	--	--	--
Sep 04 -	4.6E+11	--	--	--	--	2.0E+12	--	--	--	--
Sep 11 -	5.5E+11	--	--	--	--	2.4E+12	--	--	--	--
Sep 18 -	2.9E+11	--	--	--	--	1.9E+12	--	--	--	--
Sep 25 -	4.8E+11	--	--	--	--	2.5E+12	--	--	--	--
Oct 02 -	4.4E+11	--	--	--	--	1.7E+12	--	--	--	--
Oct 09 -	4.1E+11	--	--	--	--	2.0E+12	--	--	--	--
Oct 16 -	5.1E+11	--	--	--	--	1.4E+12	--	--	--	--
Oct 23 -	3.7E+11	--	--	--	--	2.2E+12	--	--	--	--
Oct 30 -	4.8E+11	--	--	--	--	2.3E+12	--	--	--	--
Nov 06 -	6.2E+11	--	--	--	--	1.3E+12	--	--	--	--
Nov 13 -	2.8E+11	--	--	--	--	9.3E+11	--	--	--	--
Nov 20 -	4.1E+11	--	--	--	--	8.7E+11	--	--	--	--
Nov 27 -	3.2E+11	--	--	--	--	7.6E+11	--	--	--	--
Dec 04 -	3.2E+11	--	--	--	--	7.6E+11	--	--	--	--
Dec 11 -	5.5E+11	--	--	--	--	2.2E+12	--	--	--	--
Dec 18 -	4.0E+11	--	--	--	--	1.7E+12	--	--	--	--
Dec 25 -	2.2E+11	--	--	--	--	1.4E+12	--	--	--	--
Jan 01 -	2.2E+11	--	--	--	--	1.0E+12	--	--	--	--
Jan 03 -	6.4E+10	--	--	--	--	3.0E+11	--	--	--	--

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 2001 with those from 2000, shows no observable repetition of annual trends.

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 II.

2.3.2 Results

The ambient air monitoring data collected from January 2001 to December 2001 is provided in Table 6.

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 were 0.78 and 0.79 Bq/m³, collected from sample stations 3 and 10, respectively. Sample stations 3 and 10 are located 120 and 171 meters northeast of the SSI stack, respectively.

In general the tritium activity estimates in air decrease with progressive distance from the SSI stack.

Table 6
Ambient Air Monitoring Data (Bq/m³)

Date	Stn 1	Stn 3	Stn 4	Stn 5	Stn 7	Stn 8	Stn 9	Stn 10	Stn 11	Stn 12	Stn 13	Stn 14	Stn 21	Stn 22	Blank	Avg/mo
	A1	A3	A4	A5	A7	A8	A9	A10	A11	A12	A13	A14	A21	A22		
20-Dec-00																
Jan 23, 01	-	0.72	-	0.56	0.27	-	0.54	-	0.27	0.42	0.82	0.27	0.27	0.27	-	0.44
Feb 26, 01	-	0.27	-	0.27	0.27	0.27	0.27	3.63	0.27	0.27	0.27	0.27	0.27	0.27	-	0.55
Mar 21, 01	-	0.39	-	0.39	0.39	0.39	0.39	0.66	0.39	0.39	0.39	0.39	0.39	0.39	-	0.42
Apr 20, 01	0.30	0.30	0.50	0.30	0.30	0.30	0.30	-	0.32	0.30	0.30	1.01	0.30	0.30	0.30	0.37
May 25, 01	0.26	0.67	0.26	0.26	-	0.26	0.26	0.26	0.41	0.34	0.26	0.49	0.26	0.26	0.26	0.32
Jun 18, 01	0.38	0.84	1.12	0.38	0.38	0.38	-	0.45	0.38	0.38	0.38	-	0.38	0.38	0.38	0.48
Jul 25, 01	0.25	1.12	0.85	-	0.25	0.25	0.33	0.35	0.25	0.25	0.25	0.64	0.25	0.25	0.25	0.39
Aug 21, 01	0.34	1.49	0.90	0.45	0.44	0.34	0.39	0.65	0.35	0.34	0.34	0.85	0.34	0.34	0.34	0.52
Sep 24, 01	0.27	1.21	0.37	0.27	0.27	0.27	0.27	0.29	0.27	0.27	0.27	0.81	0.27	-	0.27	0.38
Oct 25, 01	0.29	0.35	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.37	0.29	0.29	0.29	0.30
Nov 20, 01	0.35	1.14	-	1.19	-	1.03	0.35	0.74	0.35	0.35	0.35	0.82	0.35	0.35	0.35	0.59
Dec 18, 01	0.32	0.89	0.94	0.32	0.32	0.19	0.32	0.58	0.38	0.41	0.48	0.34	0.32	0.32	0.32	0.43
Average	0.31	0.78	0.65	0.43	0.32	0.36	0.34	0.79	0.33	0.33	0.37	0.57	0.31	0.31	0.31	0.43
Maximum	0.38	1.49	1.12	1.19	0.44	1.03	0.54	3.63	0.41	0.42	0.82	1.01	0.39	0.39	0.38	0.59
Distance from Stack m	16000	120	150	240	1500	2500	210	171	210	210	570	150	3110	2560		
Direction	NE	NE	SE	SE	S	S	SE	NE	NW	SW	SW	N	E	E		

- no sample collected or analyzed

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 Results

The ambient water monitoring data collected from January 2001 to December 2001 is provided in Table 7.

The highest monthly tritium activities were detected in samples from stations 3 and 10. Sample stations 3 and 10 are located 120 and 171 meters northeast of the SSI stack, respectively. The ground water (WG) monthly measurements from stations 3 and 10 tend to be greater than at other stations. In addition to ground water (WG) samples, SSI began taking well water (WW) samples at these two locations in August and in October 2001, respectively. The tritium activities in the well water samples at these stations were below detection limit.

There is moderate variability among the monthly measurements in the samples collected from the same location. However there does not appear to be a monthly tritium activity trend among these locations.

Overall there is a distinct trend of decreasing activity in water with distance from the SSI stack. Tritium activity in most samples collected from locations greater than 900 meters from the SSI stack was less than the detection limit.

Table 7
Ambient Water Monitoring Data (Bq/L)

	Stn 1	Stn 2	Stn 3		Stn 5	Stn 6	Stn 7	Stn 8	Stn 10		Stn 12	Stn 13	Stn 15	Stn 16	Stn 17	Stn 18	Stn 19	Stn 20	Stn 22	Stn 23	Blank	Avg/ mo	
DATE	W1	W2	WW3	WG3	W5	W6	W7	W8	WW10	WG10	W12	W13	W15	W16	W17	W18	W19	W20	W22	W23			
23-Jan-01	<50	<50	-	1515	<50	<50	<50	<50	-	365	717	151	<50	<50	64	<50	<50	<50	<50	<50	<50	n/a	192
26-Feb-01	<50	<50	-	1088	<50	<50	<50	<50	-	556	104	97	<50	<50	<50	<50	<50	<50	<50	<50	-	n/a	146
21-Mar-01	<50	<50	-	1272	<50	<50	<50	<50	-	733	232	70	<50	<50	<50	<50	<50	<50	<50	<50	-	n/a	173
20-Apr-01	<50	<50	-	1059	<50	94	<50	<50	-	814	257	185	<50	<50	<50	<50	<50	<50	<50	<50	-	<50	169
25-May-01	<50	<50	-	985	<50	66	<50	<50	-	527	163	81	109	<50	<50	<50	<50	<50	<50	<50	-	<50	140
18-Jun-01	<50	<50	-	966	<50	<50	<50	<50	-	493	-	148	70	<50	<50	<50	<50	<50	<50	<50	-	<50	136
25-Jul-01	<50	<50	-	-	<50	-	<50	<50	-	559	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	85
21-Aug-01	<50	<50	<50	-	<50	-	<50	<50	-	793	-	-	-	<50	-	64	<50	<50	<50	<50	-	58	108
24-Sep-01	<50	<50	<50	-	<50	<50	<50	<50	-	851	-	<50	-	<50	<50	<50	<50	<50	<50	<50	-	<50	99
03-Oct-01	-	-	-	-	-	-	-	-	<50	-	-	-	-	-	-	-	-	-	-	-	-	-	49
26-Oct-01	<50	<50	<50	942	<50	<50	<50	<50	<50	1602	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-	<50	171
20-Nov-01	<50	<50	<50	2003	<50	<50	<50	<50	<50	1101	292	<50	93	<50	<50	<50	<50	<50	<50	<50	-	<50	214
18-Dec-01	<50	<50	<50	3098	<50	98	<50	<50	<50	1605	566	224	75	<50	<50	66	<50	<50	<50	<50	-	<50	318
Average	49	49	49	1437	49	60	49	49	49	833	297	110	66	49	50	52	49	49	49	49	49	50	154
Maximum	49	49	49	3098	49	98	49	49	49	1605	717	224	109	49	64	66	49	49	49	49	49	58	318
Distance from Stack m	16000	16000	120		240	870	1500	2500	171		210	570	500	1625	1250	1500	1875	5000	2560	2864			
Direction	NE	NE	NE		SE	SE	S	S	NE		SW	SW	NW	NE	N	N	N	NE	E	SE			

- no sample collected or analyzed

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 is provided in Table 8.

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; therefore results correspond to air and water monitoring data for this location area.

Table 8
Milk Monitoring Data (Bq/L)

	Stn 23
DATE	M23
Jan 23, 01	<200
Oct 3, 01	<200
Oct 25, 01	<200
Nov 20, 01	<200
Dec 18, 01	<200
Distance from Stack m	2864
Direction	SE

2.6 Vegetation Samples

2.6.1 Sampling Method

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

2.6.2 Results

The vegetation monitoring data collected is provided in Table 9.

The highest tritium activities were detected in samples from station 10. Sample station 10 is located 171 meters northeast of the SSI stack. These higher values correspond to the water and air monitoring results for this location.

Table 9
Vegetation Monitoring Data (Bq/L)

	Stn 1	Stn 8	Stn 10	Stn 16	Stn 21	Stn 23	Stn 24	Stn 25
DATE	V1	V8	V10	V16	V21	V23	V24	V25
Jan 23, 01						200		
Aug 21, 01		<200	2640				<200	<200
Sep 24, 01	<200	<200	2300	330				<200
Oct 25, 01			2260	<200	<200			
Nov 20, 01				360				
Distance from Stack m	16000	2500	171	1625	3110	2864	4400	20800
Direction	NE	S	NE	NE	E	SE	N	NE

3. CALCULATED DOSES TO THE CRITICAL RECEPTOR

The model used to estimate doses to the critical receptor is presented in the Shield Source Inc. Proposed Environmental Monitoring Program. 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. In the updated model, the doses are calculated based on average activities determined in the monitoring program, at the location that approximates the nearest residential dwelling (station 10). The average dose calculations assume that 50% of the vegetable and animal produce consumed originates from the vicinity of the Shield Source facility. The methodology is outlined in Appendix III.

Doses of tritium to the critical receptor are presented in Table 10. Potential exposure to tritium through the consumption of local vegetation and animal produce is based on uptake modelling using the activities in air and water.

Table 10
Estimated Doses of Tritium (HT) and Tritium Oxide (HTO) to the Critical Receptor Based on Average Monitored Activity in Air and Water at the Nearest Residential Location

Form of Tritium	Activity in Water (Bq/L)	Activity in Air (Bq/m ³) ^a	Dose to Child (mSv/yr)	Monitoring Sample Location	Assumptions
HTO	833	0.21	0.029	Station 10, 171 m northeast of the stack	-50% of vegetable and animal produce from vicinity of site -Based on uptake modelling to vegetation and animals
HT	-	0.58	0.000000013		

^abased on total activity of 0.79 Bq/m³ using 27% HTO and 73% HT based on average stack emissions

The calculated long-term doses to the critical receptor do not exceed the annual public dose limit of 1 mSv per year.

For comparative purposes the estimated doses to the critical receptor were also calculated based on the average activities measured in vegetation (apples) in addition to air and water (Table 11).

Table 11
Estimated Doses of Tritium (HT) and Tritium Oxide (HTO) to the Critical Receptor Based on Average Monitored Activity in Air, Water and Vegetation at the Nearest Residential Location

Form of Tritium	Activity in Water (Bq/L)	Activity in Air (Bq/m ³) ^a	Activity in Vegetation (Bq/kg)	Dose to Child (mSv/yr)	Monitoring Sample Location	Assumptions
HTO	833	0.21	2400*	0.039	Station 10, 171 m northeast of the stack	-50% of vegetable and animal produce from vicinity of site -based on average activities measured in vegetation samples
HT	-	0.58	-	0.000000013		

based on total activity of 0.79 Bq/m³ using 27% HTO and 73% HT based on average stack emissions

* represents tritium oxide (HTO) and organically bound tritium (OBT)

The calculated long-term doses to the critical receptor using activities measured in vegetation samples also do not exceed the annual public dose limit of 1 mSv per year.

A survey of the monitoring area indicated that at no time has a vegetable garden or livestock been observed at the critical receptor residence. The vegetation samples collected from this location were apples from a tree on the property. Although the estimated doses in Table 11 indicate that consumption of apples would not result in unacceptable exposure, residents of this property have confirmed that the apples are not consumed.

The contribution of each exposure pathway to total dose to the critical receptor is presented in Table 12, and is based on monitored values. As expected, the majority of the dose is contributed by ingestion of food and water. The inhalation pathway contributes a very small proportion of the total dose.

Table 12
Relative Tritium Oxide (HTO) Dose to the Critical Receptor Resulting from Each Exposure Pathway: Air, Water and Vegetation

Form of Tritium	Dose to Child (mSv/yr)	Dose from Water		Dose from Air		Dose from Vegetation*		Dose from Animal Produce*	
		(mSv/yr)	% of Total	(mSv/yr)	% of Total	(mSv/yr)	% of Total	(mSv/yr)	% of Total
HTO	0.039	0.014	36.9%	0.000047	0.12%	0.0095	24.3%	0.015	38.9%

* represents tritium oxide (HTO) and organically bound tritium (OBT)

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 13 shows the Field Blank results for 2001.

Tritium activity was below detection limit, therefore contamination of samples during sample sessions was not suspected.

Table 13
Field Blank Data (Bq/L)

	Stn 2
DATE	W2
Jan 23, 01	<50
Feb 26, 01	<50
Mar 21, 01	<50
Apr 20, 01	<50
May 25, 01	<50
Jun 18, 01	<50
Jul 25, 01	<50
Aug 21, 01	<50
Sep 24, 01	<50
Oct 26, 01	<50
Nov 20, 01	<50
Dec 18, 01	<50

4.2 Travel Blanks

Travel blanks detect sample contamination during storage and transport. Travel blanks consist of pre-filled bottles provided by the analytical laboratory. 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 14 shows the Travel Blank results for 2001.

Table 14
Travel Blanks Data (Bq/L)

	Water	Air
DATE	Travel Blank	Travel Blank
Jan 23, 01	-	-
Feb 26, 01	-	-
Mar 21, 01	-	-

	Water	Air
DATE	Travel Blank	Travel Blank
Apr 20, 01	<50	<50
May 25, 01	<50	<50
Jun 18, 01	<50	<50
Jul 25, 01	<50	<50
Aug 21, 01	58	<50
Sep 24, 01	<50	<50
Oct 26, 01	<50	<50
Nov 20, 01	<50	<50
Dec 18, 01	<50	<50

Tritium activity was below detection limit with exception to the August 21, 2001 sampling session. A reading occurred in the water travel blank slightly above detection limit indicating some contamination may have occurred during storage and transport. The higher value corresponds with slightly elevated results in ambient air and ambient water monitoring data for that sampling session. However contamination cannot be confirmed from these results therefore error is not assumed.

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 labeled individually and are submitted separately to the analytical laboratory.

4.3.1 Results

Table 15 shows the Replicate Sample results for ambient air monitoring data and Table 16 shows the Replicate Sample results for ambient water monitoring data.

Table 15
Ambient Air Replicate Sample Data (Bq/L)

DATE	Station	Replicate 1	Replicate 2	Replicate 3
Jan 23, 01	Stn 11	-	-	-
Feb 26, 01	Stn 11	-	-	-
Mar 21, 01	Stn 11	-	-	-
Apr 20, 01	Stn 11	59	<50	<50
May 25, 01	Stn 11	99	<50	82
Jun 18, 01	Stn 11	<50	<50	<50
Jul 25, 01	Stn 11	<50	<50	<50
Aug 21, 01	Stn 11	56	<50	<50
Sep 24, 01	Stn 11	<50	<50	<50
Oct 26, 01	Stn 11	<50	<50	<50
Nov 20, 01	Stn 11	<50	<50	<50
Dec 18, 01	Stn 11	<50	74	<50

Table 16
Ambient Water Replicate Sample Data (Bq/L)

DATE	Station	Replicate 1	Replicate 2	Replicate 3
Jan 23, 01	Stn 16	<50	<50	<50
Feb 26, 01	Stn17	<50	<50	<50
Mar 21, 01	Stn22	<50	<50	<50
Apr 20, 01	Stn5	<50	<50	<50
May 25, 01	Stn16	<50	<50	<50
Jun 18, 01	Stn 22	<50	<50	<50
Jul 25, 01	-	-	-	-
Aug 21, 01	Stn 3	<50	<50	<50
Sep 24, 01	Stn 3	<50	<50	<50
Oct 26, 01	Stn 3	<50	<50	<50
Nov 20, 01	Stn 3	<50	<50	<50
Dec 18, 01	Stn 3	<50	<50	<50

Note: laboratory misplaced replicate samples sent July 2001.

5. SUMMARY

The monitoring program conducted from January 2001 to December 2001 and discussed in this report was based on TOC (1997 EMP) in order to comply with permit requirements. However, it should be noted that changes to the current DELs and monitoring program have been suggested by SSI's July 2001 proposal (Golder Associates 2001). Therefore results in this report were also compared to the proposed DELs and EMP (Golder 2001).

Stack emissions did not exceed DELs or ALs at any time during the year.

The maximum monthly stack emission of tritium (1.69×10^{13} Bq in January, 2001) corresponded with average levels of tritium in both the water monitoring data and the ambient air monitoring data. Therefore, a correlation between the stack emissions and environmental results could not be made with the current data.

Overall there is a trend of decreasing activity in all types of samples with distance from the SSI stack. Tritium activity in most samples collected from locations greater than 900 meters from the SSI stack was less than the detection limit.

Both modelled and measured tritium concentrations in vegetation produce estimated doses that are well below the regulatory dose limit for the general public. The estimated dose to a child living at the nearest residential dwelling at the point of maximum average monitored air, water and vegetation activity was 0.039 mSv/year. The apples sampled and analysed for the monitoring program are not consumed by residents of this dwelling. The estimated dose based on vegetation uptake modelling using monitored air and water data was 0.029 mSv/year. Both of the exposure estimates to the critical receptor are less than the regulatory dose limit of 1mSv/year for airborne tritium emission to the public.

SSI's environmental monitoring program is currently in a state of being improved and redefined. It is SSI's desire to have an acceptable and technically sound program and to be directly involved to ensure it is maintained.

APPENDIX I

ENVIRONMENTAL MONITORING SITE LOCATIONS

APPENDIX II
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.

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

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:

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

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:

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

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 III
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 modeled; 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 III 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 III Tables prepared by Golder Associates for data.

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