Canada's Nuclear Regulator

# Report on the Clean-up and Abandonment of Shield Source Inc.



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**Report on the Clean-up and Abandonment of Shield Source Inc.**


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Canadian Nuclear Safety Commission
280 Slater Street
P.O. Box 1046, Station B
Ottawa, Ontario K1P 5S9
CANADA

Tel.: 613-995-5894 or 1-800-668-5284 (in Canada only)
Facsimile: 613-995-5086
Email: info@cnsc-ccsn.gc.ca
Website: nuclearsafety.gc.ca
Facebook: facebook.com/CanadianNuclearSafetyCommission
YouTube: youtube.com/cnscccsn

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## Cover images

From left to right:
Aerial photo of Shield Source Inc.
Exit sign made with tritium
Local waterway

# EXECUTIVE SUMMARY

This report, written by Canadian Nuclear Safety Commission (CNSC) staff for the public, describes the clean-up and abandonment of the Shield Source Inc. (SSI) facility, and the results of past and ongoing site monitoring activities. SSI was established in 1986 and was a manufacturer of gaseous tritium light sources (GTLSs) used in the production of self-illuminating signs (e.g., emergency exit signs) at their facility located in Peterborough, Ontario. In March 2013, SSI notified the CNSC and the public of its intention to cease operations and seek the release of the facility from CNSC regulatory control. SSI was required by CNSC staff to develop a plan for clean-up and decontamination of its facility. Detailed planning ensured the public, workers and the environment were protected during all clean-up and decontamination activities.

Clean-up and decontamination work was planned and carried out by qualified SSI and third party (RadSafe) staff under the regulatory oversight of CNSC inspectors. In addition to SSI monitoring and reporting, the CNSC also conducted independent sampling of air, soil and water, and verified all regulatory requirements and clean-up criteria were met. Following all clean-up and decontamination activities, CNSC staff concluded that the building was safe and there is no health risk to the community or the environment; therefore, the building was released for unrestricted industrial use.

The CNSC announced its decision on March 28, 2014 [1] to issue a Licence to Abandon to SSI for its facility located in Peterborough. As of April 1, 2014, SSI was no longer subject to CNSC regulatory control, and the facility was released for unrestricted industrial use.

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# 1.0 INTRODUCTION

On March 28, 2014 the Canadian Nuclear Safety Commission (CNSC) issued a Licence to Abandon [1] to Shield Source Inc. (SSI) for its nuclear substance processing facility located in Peterborough, Ontario. As of April 1, 2014, SSI was no longer subject to the CNSC's regulatory requirements.

The purpose of this report is to provide information concerning the clean-up and abandonment of the SSI facility, and the results of past and ongoing site monitoring activities.

This report is based on information submitted by SSI and work completed by CNSC staff, and includes the following:

- regulatory requirements for clean-up (section 2)
- summary of clean-up activities (section 3)
- status of the current environment (section 4)
- future monitoring and site use (section 5)

## 1.1 Background

Shield Source Inc. was established in 1986 and was a manufacturer of gaseous tritium light sources (GTLSs) used in the production of self-illuminating signs (e.g., emergency exit signs). The SSI facility was located on the Peterborough Municipal Airport property. Up until May 2012, SSI was licensed to receive and process tritium gas which was used to fill glass tubes to produce GTLSs. These light sources were then used to manufacture signs.

In May 2012, the Commission amended SSI's licence to suspend GTLS production due to a discrepancy in reported tritium gas emissions from the facility. Monitoring of tritium gas emissions was conducted by SSI; however, environmental monitoring samples (e.g., air, surface water, groundwater and vegetation) were routinely analyzed by an independent third party laboratory contracted by SSI. Therefore, the SSI environmental monitoring data, discussed in section 3 and presented in Appendix A of this report, was not affected by the reporting discrepancy of tritium gas emissions, and environmental monitoring data was reviewed annually by CNSC staff.

On March 4, 2013, SSI notified the CNSC and the public that it did not intend to resume operations, and that it would not request a renewal of its operating licence. Following this announcement, the CNSC reviewed SSI's preliminary decommissioning plan (PDP) [2, 3] which contained the general approach to closure of the facility, the steps involved, the acceptable criteria and the expected timelines. Following the review, CNSC staff requested more details related to the clean-up of the tritium fill room (TFR), where GTLS production occurred. A supplemental plan [4] to remove the tritium fill machines and all the TFR components was subsequently submitted to the CNSC. The PDP and supplemental plan were approved by CNSC staff.

In October 2013, SSI began the facility clean-up. All clean-up and decontamination activities were completed and there are no nuclear substances or radiation devices left in the facility. CNSC staff analyzed samples collected in the facility, and verified that all regulatory requirements and clean-up criteria have been met. CNSC staff concluded that SSI has made

adequate provisions to protect the health and safety of the public and the environment. The site can now be used for other industrial purposes.

Clean-up and decontamination work was carried out by qualified staff under the regulatory oversight of CNSC inspectors. In addition to SSI monitoring and reporting, the CNSC also conducted independent sampling of air, soil and water, and verified all regulatory requirements and clean-up criteria were met. CNSC staff concluded that the building was safe and there would be no health risk to the community or the environment.

# 2.0 REGULATORY REQUIREMENTS

CNSC staff ensured the clean-up of the SSI facility met all applicable regulatory requirements for the protection of human health and the environment, before recommending to the Commission to issue a licence to abandon the facility [1]. This section provides an explanation of the CNSC's regulatory requirements for the SSI facility clean-up.

Section 5.1(1) of the *Nuclear Substances and Radiation Devices Regulations* provides the regulatory requirements for conditional and unconditional clearance that would be used to determine if a facility could be released from regulatory control. The concept of "clearance from regulatory control" implies a removal of restrictions, so that the cleared materials can be treated without any consideration of their radiological properties. The specific clearance levels applied to the SSI clean-up activities are described in section 2.1.

Unconditional clearance is the concentration of a radionuclide, such as tritium, below which regulatory control is not required (since there are no radiation hazards). Conditional clearance applies to bulk quantities of material, such as mixed waste, in which the radioactive substance is evenly distributed and at a level deemed to not pose a risk for human health and the environment.

Conditional clearance means that, once the clean-up is complete, any remaining tritium will not result in a dose to an individual greater than 0.01 mSv in a year. This dose is equivalent to an individual undergoing a single dental x-ray. Conditional clearance is often associated with contamination that cannot be completely removed, such as residual contamination in building materials.

Furthermore, where an unconditional or conditional clearance level for tritium is not defined in regulations, the CNSC considers 30 $Bq/cm^2$ to be an acceptable level for releasing a laboratory or workspace from regulatory control. This value is derived from International Atomic Energy Agency (IAEA) [5] and is also based on an individual receiving a dose no greater than 0.01 mSv in a year. This limit is also consistent with the American National Standards Institute recommendations for tritium [6].

## 2.1 Clean-up criteria

To meet the regulatory requirements discussed above, SSI was required to meet the following clean-up criteria:

1) For building materials, in which the tritium was uniformly distributed prior to disposal, SSI was required to achieve an unconditional clearance level of 100 Bq/g.

2) For air (meaning the concentration of tritium in air in the facility, as a result of past operations), SSI was required to achieve limit of 150 Bq/$m^3$. This is equivalent to a dose of 0.01 mSv per year for occupancy during a normal work week (8 hours/day, 5 days/week).
3) For the remaining surfaces, such as walls and floors, where no specific conditional or unconditional clearance levels for tritium apply, the CNSC considers 30 Bq/$cm^2$ to be acceptable. SSI proposed a limit of 0.34 Bq/$cm^2$, almost 100 times lower than the CNSC level for these remaining surfaces.

## 3.0 SUMMARY OF CLEAN-UP ACTIVITIES

SSI conducted planning, clean-up and decontamination activities in a four-phased approach, as described below. Detailed planning ensured the public, workers and the environment were protected during all activities.

**Phase 1 – Planning**

This phase consisted of the development of a detailed work-plan [4, 7] by a qualified third party - RadSafe Canada Ltd. (RadSafe) - for the tritium fill room (TFR) and the associated structures (stack and ductwork). The plan included categorization of material, to establish waste reduction and disposal strategies, the clean-up criteria, and the overall cost and schedule of the clean-up.

**Phase 2 – Clean-up and decontamination of the TFR**

As a result of manufacturing gaseous tritium light sources (GTLSs), the TFR and its components contained the bulk of the tritium contamination. All the work conducted during clean-up and decontamination activities was performed according to the health and safety measures defined in the detailed work plans, including the use of personal protective equipment. The following activities were completed during this phase:

- dismantling and packaging of the tritium fill machines
- dismantling and removal of the supporting infrastructure (e.g., ventilation) in the TFR
- clean-up and decontamination of all room contents (e.g., equipment and furniture) in the TFR
- removal of the concrete floor, the drywalls and the ceiling in the TFR, to minimize any residual amounts of tritium left in the room
- preparation and packaging of all waste, for disposal at a CNSC-licensed waste management facility

**Phase 3 – Removal of stack and ductwork**

This phase involved the removal and packaging of the remaining internal ductwork (e.g., ventilation), the outside stack, and any associated components. Waste was packaged and sent for disposal at a CNSC-licensed waste management facility.

**Phase 4 – Final report**

The last phase consisted of the preparation of the final closure report [8]. Although CNSC staff reviewed monitoring results as they became available, SSI was provided time to prepare a final submission, summarizing all the work that had been completed to meet CNSC regulatory requirements. The final closure report included:

- a description of the facility's end-state (after clean-up and decontamination activities)

- final monitoring results
- summary of releases to the environment that occurred during the work
- summary of personnel doses received during the work
- summary of operating experience gained during the work

The final closure report was submitted as part of SSI's Annual Compliance Report [9] for 2013. This report is available on SSI's website (shieldsource.com/public-information/annual-reports.php), or can be requested from the CNSC (email to info@cnsc-ccsn.gc.ca).

## 3.1 Waste management

Waste was generated from several activities performed on-site throughout the clean-up.

Tritium-contaminated liquid effluents resulted from the clean-up of the GTLSs and associated parts, the laundering of personnel protective equipment, air conditioning condensation, and the general cleaning of the TFR and decontamination room. These effluents were captured in holding tanks and tested prior to being released.

Low-level tritium-contaminated solid waste material was generated from past sign assembly operations and during the facility cleaning. This included disposable cleaning materials, disposable personnel protective equipment, glass waste from light source generation and expired device waste.

Higher level tritium-contaminated waste was generated from broken and damaged tritium light sources and signs, and contaminated machine parts.

The largest source of solid contaminated waste came from the return and replacement program for safety devices. SSI was responsible for disassembling returned devices, and removing the GTLS.

Any item that exceeded 50 Bq/g was packaged and sent to Chalk River Laboratories, a CNSC-licensed facility owned by Canadian National Laboratories, for radioactive waste disposal. All non-radioactive hazardous waste was disposed at a hazardous waste facility or returned to the supplier. All waste below the regulatory limit of 100 Bq/g (and SSI's internal limit of 50 Bq/g) was sent to the municipal landfill.

All the waste shipments were packaged, stored and shipped in accordance with the *Transport of Dangerous Goods Regulations* and the *Packaging and Transport of Nuclear Substances Regulations*.

## 3.2 CNSC monitoring and verification of clean-up activities

CNSC staff reviewed and accepted all the detailed work-plans required to carry out clean-up and decontamination activities. This ensured SSI made adequate provisions for the protection of the environment and the health and safety of workers and the public.

Furthermore, a CNSC inspector was present at SSI during all clean-up activities to ensure compliance with all regulatory requirements, and to perform independent sampling and verification. During Phase 2, CNSC radiation protection and environmental protection staff were

present for the dismantling of the tritium fill machines to observe and document the clean-up and decontamination procedures.

SSI conducted sampling in the facility during clean-up and decontamination activities, and reported the results to the CNSC. Random samples were submitted to the CNSC laboratory for verification purposes and CNSC analysis confirmed the accuracy of SSI's results.

CNSC staff conducted air sampling for tritiated water (HTO; aerosolized tritium) and surface swipe sampling of tritium throughout the entire facility during the clean-up and decontamination process. This was done to collect independent data from that obtained directly by SSI and its consultants. The results of the sampling performed by the CNSC during March 2014 are provided in tables 1 and 2. A CNSC Sample Analysis Report [10], which provides all verification samples, as well as detailed diagrams showing the location of each sample taken, is available from the CNSC upon request (email to info@cnsc-ccsn.gc.ca).

**Table 1: Results of CNSC surface swipe samples taken at the SSI facility in March 2014 (Clean-up criteria is 30 Bq/cm$^2$)**

| Sample locations | Tritium concentration (Bq/cm$^2$) |
|---|---|
| Decontamination and brightness testing area | 0.07 – 0.2 |
| Assembly and packaging area | 0.2 – 0.7 |
| Administrative area | * |
| Laboratory | 0.07 – 0.47 |
| Entrance hallway | * |
| Back workshop | 0.17 – 0.76 |
| Tritium fill room | 0.2 – 0.3 |

*No samples above detection limit

**Table 2: Results of CNSC air monitoring of HTO (aerosolized tritium) samples taken at the SSI facility in March 2014 (Clean-up criteria is 150 Bq/m$^3$)**

| Sample location | HTO concentration (Bq/m$^3$) |
|---|---|
| Tube washdown room | 45 |
| Potting room | 63 |
| Tritium fill room | 81 |
| Assembly room | 44 |
| Aircraft assembly room | 83 |
| Back workshop | 79 |
| Warehouse | 61 |

The CNSC analyzed samples on a regular basis. The most recent results from March 2014 (summarized in table 1), after the completion of all clean-up and decontamination activities, confirmed that the tritium concentration in air and all surface swipes are below the clean-up

criteria of 150 Bq/m$^3$ and 30 Bq/cm$^2$, respectively, in all areas of the facility. Although some surface swipe samples were marginally above (e.g., 0.47 – 0.76 Bq/cm$^2$) the SSI-proposed limit of 0.34 Bq/cm$^2$, all samples were well below the CNSC limit of 30 Bq/cm$^2$. It should also be noted that table 1 only shows the range in tritium concentrations of surface swipe samples above the detection limit; however, the majority of samples were below the detection limit. In November 2013, CNSC staff also collected 14 soil samples around the SSI facility where the highest level of organically-bound tritium was expected (i.e., around the stack). The results of 13 of the samples ranged from 0.353 to 91.47 Bq/g, as presented in Appendix B, table B1; these results were below the 100 Bq/g unconditional clearance level. One sample exceeded this limit, with a concentration of 139.81 Bq/g. As demonstrated in section 4.6.4, this concentration would result in a dose less than 0.01 mSv per year, meeting the conditional clearance criteria.

Using the CNSC's independent monitoring results from air and soil, the dose to members of the public (including new occupants of the facility) was determined to be well below the regulatory limit, as outlined in section 4.6.4.

Based on extensive sampling and verification activities, CNSC staff concluded that the clean-up and decontamination of the facility met all regulatory requirements, and the facility could be released from regulatory control, as it posed no risk to future occupants or the public.

# 4.0 STATUS OF THE ENVIRONMENT

Under its operating licence as a Class IB facility, SSI was required to have an environmental monitoring program (EMP). SSI submitted environmental monitoring results from their EMP, in its annual compliance reports to the CNSC. The results from the most recent report [11] are publicly available on the SSI website (shieldsource.com/public-information/annual-reports.php), with selected aspects discussed here. Diagrams or descriptions of each sample location can also be found in SSI's report. The report is also available from the CNSC upon request (email to info@cnsc-ccsn.gc.ca).

This section also summarizes the independent monitoring and verification activities conducted by CNSC staff. Overall, air, surface water, groundwater and vegetation samples collected as part of the EMP and CNSC independent monitoring were below regulatory limits for tritium.

## 4.1 Atmospheric

SSI's environmental monitoring program included 21 air monitoring stations around the SSI facility and on the airport property. These stations were used to monitor tritium concentrations in air. The SSI air monitoring results from 2011-14 are provided in Appendix A, table A1.

The results showed significant decreases in the concentration of tritium in air since the facility reduced its operations in 2012; further reductions appeared in 2013, when SSI focused on clean-up and decontamination activities. This illustrated that the removal of the source (manufacturing activities) caused ambient air concentrations to decrease to very low levels.

In 2013, SSI's monitoring of tritium in air showed results either below detection limits or extremely low. The highest maximum value was 4.63 Bq/m$^3$ at the A4 sampler, and did not appear to follow the generally decreasing trend. This specific increase was attributed to the removal of the tritium fill machines from the facility at the end of October 2013. In December

2013, following the removal of the tritium fill machines, all air samplers were below detectable level, as was the case for samples taken in 2014.

Overall, tritium concentrations are decreasing with time, and are expected to further reduce in the future. CNSC staff concluded that there is no risk to the environment or the health and safety of people posed by tritium in air.

## 4.2 Surface water

Tritium released into the atmosphere exchanges with surface water through various mechanisms, including washout by precipitation. SSI monitored the concentration of tritium in surface water at several locations around the SSI facility and the airport. Samples were also taken from the Peterborough Water Treatment Plant (WTP). The results of SSI's surface water monitoring from 2011-14 are provided in Appendix A, table A2. All samples were below the current Ontario drinking water standard of 7000 Bq/L. Furthermore, the average activity of samples taken from potential drinking water locations (WW5, W17, W19, W25 and WTP) all remained below detectable levels. The maximum activity from potential drinking water locations W17 and WTP were 11 Bq/L and 9.4 Bq/L, respectively. These samples are over 1,000 times below the value prescribed by the *Ontario Drinking Water Quality Standards*, and below the 2009 Ontario Drinking Water Advisory Council's proposed limit of 20 Bq/L.

Overall, average concentrations have decreased since operations were reduced in 2012, and are expected to decrease further in the future, as tritium is no longer being released to air from SSI.

## 4.3 Groundwater

The environmental monitoring program included 10 groundwater monitoring wells around the SSI facility and on the airport property. These wells were used to monitor the tritium concentration in groundwater. The wells are not, and will never be used as a source of drinking water because of the presence of a landfill with historic waste where SSI was located. The results of SSI groundwater monitoring from 2011-14 are provided in Appendix A, table A3. Due to freezing in the wells, only results for wells 1, 2 and 3 were obtained in 2014.

Overall, tritium concentrations are decreasing with time, and are expected to further diminish in the future. Only well 3, located immediately adjacent to the facility, shows a concentration of tritium that is above the 7,000 Bq/L Ontario drinking water standard. Tritium levels in this monitoring well have fallen from approximately 15,400 Bq/L in 2012 to about 8,300 Bq/L in 2014, and are expected to decrease below the Ontario drinking water standard value in one or two years. As described in section 5.1, well 3 will continue to be monitored by CNSC staff until the concentration of tritium is below the *Ontario Drinking Water Quality Standards*. CNSC staff will also continue to monitor well 1 and 2.

Additional monitoring was done at a resident's well, located across the road from SSI. Monitoring indicated that the well is not contaminated with tritium; the results were below the detection limit of 7 Bq/L. Section 5.1 describes the future monitoring and decommissioning of this well.

## 4.4 Vegetation

Vegetation samples of apples, grapes and reeds, were collected by SSI and analyzed for tritium. Appendix A, table A4 provides the results of the vegetation sampling performed from 2011-13.

Tritium concentrations were below regulatory limits and are decreasing with time. It is expected that concentrations will reduce further in the future. The results of vegetation monitoring are used in determining doses to the public as discussed in section 4.6.2.

## 4.5 CNSC monitoring and verification of results

CNSC staff conducted environmental monitoring activities in 2013 [12] and 2014, to independently verify the levels of contaminants in the environment. These activities were completed in addition to the monitoring performed throughout the clean-up and decontamination activities.

CNSC staff monitoring activities focused on surface water, soil, air, and fruits. These were determined to be the most likely exposure pathways to the public. Results from CNSC independent monitoring in 2013 are presented in table 3 below. Samples from monitoring activities conducted in 2014 are being analyzed and results will be made publicly available on the CNSC website. Through the independent monitoring activities, CNSC staff verified SSI's monitoring data.

**Table 3: Results from CNSC independent monitoring inside and around the SSI facility in 2013**

| Sampling | Description | Results |
|---|---|---|
| Sampling of air inside SSI | HTO (Tritiated water) | 4 Bq/$m^3$ |
| | HT (Tritium gas) | 30 Bq/$m^3$ |
| Sampling of water | Pond across from SSI (HTO) | 460 Bq/L |
| | Otonabee River (HTO) | < 5 Bq/L |
| Sampling of soil | On Brealey Drive (HTO) | 16 Bq/L |
| | By Otonabee River (HTO) | < 5 Bq/L |
| Sampling of fruits | Apples across from SSI (HTO) | 165 Bq/L |
| | Apples from Brealey Drive (HTO) | < 5 Bq/L |

Note: Minimum detection concentration is 5 Bq/L

CNSC staff made the following conclusions based on the independent environmental monitoring results from 2013, and sampling conducted inside the SSI facility in March 2014 (described in section 3.2):

- At the end of all clean-up and decontamination activities, tritium releases were 1,000-10,000 lower than during operation, and any residual releases from the premises are now negligible.
- Tritium in the environment is similar to natural background levels less than 5 km from the SSI facility.
- Tritium in air close to SSI facility is approximately 10 times higher than background, but should approach natural levels in a few years, as residual tritium disperses and decays. There is no risk to the environment or the public as discussed in section 4.6.
- Tritium in soils and groundwater is only elevated near and to the east of the SSI facility. These levels are also safe, and will decline gradually to background.

The CNSC has also completed many initiatives under the Tritium Studies Project, to enhance the information used in the regulatory oversight of tritium processing and tritium releases in Canada. More information on these CNSC initiatives can be found on the CNSC website at: nuclearsafety.gc.ca/eng/resources/health/tritium/tritium_studies.cfm

## 4.6 Human health

### 4.6.1 CNSC regulatory dose limits

The CNSC's *Radiation Protection Regulations* set dose limits on the amount of radiation the public and nuclear energy workers (NEWs) can receive. These regulations require every licensee to implement a radiation protection program that keeps the amount of exposure to ionizing radiation "as low as reasonably achievable" (ALARA). Radiation dose limits are set in accordance with recommendations of the International Commission on Radiological Protection, as well as IAEA standards and guides.

In Canada, the CNSC sets the dose limits for NEWs and the public. The effective dose limit for members of the public is 1 mSv/year. The effective dose for NEWs is 50 mSv/year and 100 mSv/5 years.

Canadians are exposed to many sources of natural and artificial (man-made) radiation in their everyday lives. Natural radiation accounts for approximately 60% of an average Canadian's annual dose, while artificial radiation (mostly from medical procedures) accounts for the other 40% of the annual radiation exposure. There is no difference between the effects caused by natural or artificial radiation. Table 4 provides a comparison of natural and artificial sources of radiation to the regulatory dose limits set by the CNSC.

**Table 4: A comparison of CNSC regulatory dose limits to natural and man-made sources of radiation**

| Dose (mSv) | Limit or type of exposure |
|---|---|
| 30-100 | Radiation dose from a full body computed axial tomography (CAT) scan |
| 100 | 5-year radiation dose limit for nuclear energy workers |
| 50 | Annual radiation dose limit for nuclear energy workers |
| 1.3-4.1 | Range of annual Canadian background dose (e.g., cosmic, terrestrial, inhalation, ingestion) |
| 1 | Annual public radiation dose limit |
| 0.1-0.12 | Dose from lung X-ray |
| 0.01 | Dose from dental X-ray |
| 0.01 | Average dose due to air travel |

More information on radiation and radiation doses can be found on the CNSC website at: nuclearsafety.gc.ca/eng/resources/radiation/index.cfm

### 4.6.2 Dose to the public from 2013 operations

SSI considered six scenarios representing people (receptors) within the public who could potentially receive a dose from activities at the SSI facility. The scenarios evaluated and the corresponding doses are provided in table 4. Depending on the assumptions of each scenario (e.g., diet, distance from facility, time spent at the facility, etc.) monitoring results collected by SSI were taken into consideration when calculating potential dose.

As shown in table 5, the highest potential dose was for an infant living at a cattle farm less than 1 kilometer north of SSI. This dose was calculated to be 0.00523 mSv, representing 0.52% of the allowable dose limit to the public of 1.0 mSv.

**Table 5: Public dose assessment results for 2013**

**(Annual public radiation dose limit is 1 mSv/year)**

| Receptor | Description | Age group | Dose (mSv/year) |
|---|---|---|---|
| Airport worker | Works at the airport<br>Lives elsewhere | Adult | 0.000171 |
| Airport worker | Works at the airport<br>Lives near the airport | Adult | 0.000174 |
| Airport maintenance worker | Lawn mower at the airport | Adult | 0.000517 |
| Airport Road resident near | Living across Airport Road from SSI | Adult | 0.000570 |
| | | Child | 0.000531 |
| | | Infant | 0.000489 |
| Airport Road resident far | Living approximately 500 m south of SSI | Adult | 0.000451 |
| | | Child | 0.000422 |
| | | Infant | 0.000395 |
| Cattle farm resident | Cattle farm north of SSI (less than 1 km away) | Adult | 0.00194 |
| | | Child | 0.00240 |
| | | Infant | 0.00523 |

### 4.6.3 Dose to workers during clean-up

Clean-up and decontamination activities were performed by SSI and RadSafe personnel, and were observed by a CNSC inspector. SSI and RadSafe carefully planned all decontamination activities, to ensure that appropriate worksite layout (e.g., barriers to prevent the spread of contamination), contamination control and personal protective equipment were implemented to reduce worker exposure to tritium. For example, activities associated with the tritium fill

machines were carried out by workers in full Tyvek suits with full-face respirators, Tyvek boots and multiple layers of gloves. This ensured doses to workers remained ALARA.

Worker exposure to tritium was assessed twice daily, once in the morning and again in the evening. The average and maximum dose to the six individuals (five SSI and RadSafe personnel, plus one CNSC inspector) associated with clean-up and decontamination activities were 0.01 mSv and 0.02 mSv, respectively. This is over 1,000 times below the regulatory dose limit for workers of 50 mSv/year.

### 4.6.4 Dose to the public from current and future site use

CNSC staff completed an assessment [13] of doses to members of the public resulting from localized residual tritium in soil around the SSI facility, as well as residual tritium in the former SSI facility. These dose assessments were completed to provide a conservative estimate of dose to the public from current and future use of the site. The following two receptors were considered to be representative of individuals inside and outside the facility:

1) New occupants of the former SSI facility.
2) Individuals (including the public) outside the former SSI facility.

For new occupants of the former SSI facility, individuals were considered to work on a full-time basis; therefore, the assessment assumed that an occupant would spend 2,000 hours per year in the facility.

Doses were assessed for both the maximum and minimum tritium concentrations observed in air, assuming the residual tritium in air remains constant throughout 2014. The resulting expected range in annual dose would be 0.003 to 0.006 mSv, as shown in table 6.

For individuals outside the former SSI facility, four exposure scenarios were considered:

1) A worker excavating a trench in soil located at the well 3 sampling location.
2) A child ingesting soil located at the well 3 sampling location.
3) An adult exposed to tritium in air directly outside the facility.
4) A child exposed to tritium in air directly outside the facility.

The doses to the worker and child receptors consist of three pathways: inhalation, absorption through intact skin, and inadvertent soil ingestion. For the soil ingestion pathway, aside from inadvertent soil ingestion, the dose to a child with pica (a condition where an individual ingests non-nutritive substances, such as clay, chalk, dirt, or sand) was also considered.

**Table 6: Summary of doses associated with residual tritium at the former SSI facility (Annual public radiation dose limit is 1 mSv/year)**

| Receptor | Dose by exposure pathway (mSv/year) | | Total dose (mSv/year) |
|---|---|---|---|
| | Inhalation and absorption through skin | Ingestion | |
| **New occupant of the facility** | | | |
| Worker (adult) | 0.003 – 0.006 | – | 0.003 – 0.006 |
| **Individual outside the facility** | | | |
| **Soil** | | | |
| Adult (Scenario 1) | 0.002 | 0.00001 | 0.002 |
| Child (Scenario 2) | 0.002 | 0.00005 | 0.002 |
| **Air** | | | |
| Adult (Scenario 3) | 0.0004 | – | 0.0004 |
| Child (Scenario 4) | 0.0004 | – | 0.0004 |

Excavation work at the site of the highest tritium-in-soil measurement would yield a dose of approximately 0.002 mSv, as shown in table 6. This scenario is considered to be very conservative (and less likely than the others in this assessment), since these doses would only be expected if a mechanism of exposure to tritiated water vapour in air at a concentration equal to that in soil pore water existed.

Based on air monitoring carried out next to the SSI building, the dose from tritium in air outside of the facility is expected to be 0.0004 mSv per year. This is more than 1,000 times below the public dose limit of 1 mSv/year.

CNSC staff concluded that the dose from tritium to both new occupants and individuals outside the facility is well below the regulatory dose limit, and poses no risk to the environment or the health and safety of people.

## 5.0 FUTURE SITE USE

Clean-up and decontamination activities were planned and executed based on the assumption that the SSI facility would be left as an unrestricted use commercial facility. The facility is zoned for commercial use, and the airport management company confirmed that the facility will never be zoned for residential or recreational use.

## 5.1 Future monitoring

Although monitoring results have indicated that there is no risk to the environment or the health and safety of people, the CNSC will continue to monitor the environment around the SSI facility. Monitoring will be done to provide confidence that tritium concentrations in the environment will decrease over time.

Monitoring of the residential well across the street from SSI will continue until the well is decommissioned. The property where this well is located has been purchased by the Peterborough Airport, who plans to demolish the house and decommission the well. Tritium levels in the well have been routinely monitored, showing levels well below detection limits and applicable drinking water standards.

CNSC staff has committed to monitor groundwater well 3 until the tritium concentration decreases below the 7000 Bq/L Ontario drinking water standard. Groundwater well 1 and 2 will also continue to be monitored by CNSC staff. CNSC staff will assess the need to continue groundwater monitoring on an annual basis. As discussed in section 4.3, these groundwater sources are not used for drinking water, and do not pose a risk to the environment or the health and safety of persons.

A comprehensive sampling campaign was conducted in September 2014 to collect samples of air, water, vegetation and soil for CNSC analysis. The CNSC met with the Airport Authority, the Ontario Ministry of the Environment, the municipality and Safe and Clean Energy to discuss future site monitoring. The CNSC will make monitoring results publicly available on the CNSC website.

# 6.0 CONCLUSION

The CNSC concluded that there are no nuclear substances and radiation devices left in the facility. Based on CNSC staff's independent monitoring, and the review of submissions from SSI and its consultants, CNSC staff concluded that SSI made adequate provisions for the protection of the environment, and the health and safety of persons.

# 7.0 ACRONYMS

| | |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| CNSC | Canadian Nuclear Safety Commission |
| DL | Detection Limit |
| GTLS | Gaseous Tritium Light Source |
| HT | Tritium Gas |
| HTO | Tritiated Water Vapour |
| IAEA | International Atomic Energy Agency |
| NEW | Nuclear Energy Worker |
| PDP | Preliminary Decommissioning Plan |
| RadSafe | RadSafe Canada Ltd. |
| SSI | Shield Source Incorporated |
| TFR | Tritium Fill Room |
| WTP | Water Treatment Plant |

# 8.0 REFERENCES

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[9] Shield Source Incorporated. *Annual Compliance Report 2013/2014*. March 31, 2014.

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[12] Canadian Nuclear Safety Commission. *Independent Environmental Monitoring Program Lab Report at Shield Source Inc*. August 2013. eDoc 4198010.

[13] Canadian Nuclear Safety Commission. *SSI Dose Assessment*. April 2014. eDoc 4416802

# Appendix A. SSI Annual Compliance Monitoring Report Results

**Table A1: Results of atmospheric monitoring performed by SSI**

| Location | Average tritium concentration ($Bq/m^3$) | | | | Maximum tritium concentration ($Bq/m^3$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 |
| A1 | 5.45 | 2.06 | 1.53 | <DL | 12.01 | 3.59 | 2.43 | <DL |
| A2 | 3.78 | 2.32 | 1.04 | <DL | 10.25 | 4.63 | 1.54 | <DL |
| A3 | 10.66 | 2.91 | 1.22 | <DL | 41.57 | 8.64 | 2.02 | <DL |
| A4 | 3.53 | 2.39 | 1.38 | <DL | 7.14 | 4.32 | 4.63 | <DL |
| A5 | 6.36 | 2.94 | 1.17 | <DL | 16.48 | 11.27 | 1.69 | <DL |
| A6 | 9.28 | 2.11 | 1.03 | <DL | 46.16 | 4.63 | 1.91 | <DL |
| A7 | 3.51 | 1.68 | 1.00 | <DL | 8.33 | 3.27 | 1.50 | <DL |
| A8 | <DL | <DL | 0.91 | <DL | <DL | 0.82 | 1.17 | <DL |
| A9 | <DL | 0.92 | 0.97 | <DL | <DL | 1.03 | 1.31 | <DL |
| A10 | <DL | 0.94 | 1.06 | <DL | <DL | 1.25 | 1.69 | <DL |
| A11 | <DL | <DL | 0.95 | <DL | <DL | <DL | 1.10 | <DL |
| A12 | <DL | <DL | 0.89 | <DL | <DL | 1.16 | 0.87 | <DL |
| A13 | <DL | <DL | 1.02 | <DL | <DL | 1.01 | 1.85 | <DL |
| A14 | <DL | 1.62 | 1.02 | <DL | <DL | 2.41 | 1.64 | <DL |
| A15 | <DL | 1.41 | 1.01 | <DL | <DL | 2.59 | 2.17 | <DL |
| A17 | <DL | 1.57 | 1.02 | <DL | <DL | 1.91 | 1.79 | <DL |
| A21 | 5.28 | 2.01 | 1.15 | <DL | 16.61 | 3.60 | 1.48 | <DL |
| A22 | 3.94 | 1.95 | 1.12 | <DL | 6.50 | 3.70 | 1.63 | <DL |
| A23 | 4.34 | 2.10 | 1.21 | <DL | 7.74 | 4.32 | 1.85 | <DL |
| A24 | 5.44 | 2.14 | 1.12 | <DL | 11.62 | 4.94 | 1.51 | <DL |
| A25 | -- | 2.14 | 1.19 | <DL | -- | 7.20 | 3.07 | <DL |
| A28 | -- | <DL | 0.94 | <DL | -- | 0.99 | 1.81 | <DL |

Note: Ontario background is < DL of 0.2 $Bq/m^3$

**Table A2: Results of surface water monitoring samples taken by SSI**

| Location | Average tritium concentration (Bq/L) | | | | Maximum tritium concentration (Bq/L) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2014 | 2011 | 2012 | 2013 | 2014 |
| W2 | <DL | -- | -- | -- | <DL | -- | -- | -- |
| W3 | 912 | 800 | 719 | -- | 1,570 | 950 | 1,400 | -- |
| W4 | 392 | 314 | 118 | -- | 665 | 412 | 180 | -- |
| WW5* | <DL | <DL | <DL | -- | <DL | <DL | <DL | -- |
| WG5 | 849 | 784 | 456 | -- | 1,050 | 990 | 620 | -- |
| W8 | 115 | 79 | 34 | -- | 334 | 110 | 78 | -- |
| W9 | <DL | 20 | <DL | -- | <DL | 41 | 16 | -- |
| W10 | <DL | 20 | <DL | -- | <DL | 41 | 17 | -- |
| W11 | <DL | 54 | 24 | -- | <DL | 90 | 69 | -- |
| W12 | <DL | 25 | 18 | -- | <DL | 54 | 38 | -- |
| W13 | <DL | 42 | <DL | -- | <DL | 61 | <DL | -- |
| W14 | 139 | 128 | 39 | -- | 326 | 200 | 56 | -- |
| W15 | <DL | <DL | <DL | -- | <DL | <DL | <DL | -- |
| W17* | <DL | <DL | <DL | <DL | <DL | 11 | <DL | <DL |
| W19* | <DL | -- | -- | -- | <DL | -- | -- | -- |
| W25* | -- | <DL | <DL | <DL | -- | <DL | <DL | <DL |
| W28 | -- | <DL | <DL | <DL | -- | <DL | 18 | <DL |
| WTP | -- | -- | <DL | -- | -- | -- | 9 | -- |

* Drinking Water Sample

WTP = Peterborough Waste Water Treatment Facility

**Table A3: Results of groundwater monitoring samples taken by SSI**

| Location | Average tritium concentration (Bq/L) | | | | Maximum tritium concentration (Bq/L) | | | |
|---|---|---|---|---|---|---|---|---|
| | **2011** | **2012** | **2013** | **2014** | **2011** | **2012** | **2013** | **2014** |
| Well 1 | 628 | 470 | 120 | 1,187 | 1,340 | 1,420 | 989 | 2,070* |
| Well 2 | 8,324 | 7,142 | 5,113 | 3,840 | 13,400 | 9,700 | 6,750 | 4,200 |
| Well 3 | 15,664 | 12,211 | 9,896 | 8,288 | 22,900 | 15,400 | 11,200 | 8,320 |
| Well 4 | 1,711 | 1,522 | 1,066 | -- | 2,470 | 1,980 | 1,480 | -- |
| Well 5 | 725 | 1,117 | 629 | -- | 1,450 | 2,160 | 741 | -- |
| Well 6 | 1,262 | 1,807 | 1,555 | -- | 1,860 | 1,970 | 1,670 | -- |
| Well 7A | 68 | 29 | 31 | -- | 278 | 112 | 156 | -- |
| Well 7B | 2,214 | 1,543 | 1,387 | -- | 3,010 | 2,300 | 2,000 | -- |
| Well 8 | 1,892 | 3,468 | 3,603 | -- | 2,250 | 4,440 | 4,840 | -- |
| Well 10 | <DL | 50 | 48 | -- | <DL | 94 | 77 | -- |

* The maximum tritium concentration measured in 2014, although higher than previous 3 years, is still within the range of variations observed annually, and the overall trend is declining. Furthermore, the groundwater monitoring wells are not used as a source of drinking water.

**Table A4: Results of vegetation sampling taken by SSI**

| Sample | Location | Average tritium concentration (Bq/L) | | | | Maximum tritium concentration (Bq/L) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2010 | 2011 | 2012 | 2013 |
| Apple (from ground) | Brealey Drive | 223 | 48 | 31 | <DL | 284 | 130 | 50 | 30 |
| Apple (from tree) | Brealey Drive | -- | 60 | 68 | <DL | -- | 160 | 120 | 25 |
| Grapes | Brealey Drive | -- | 48 | 213 | 7.4 | -- | 100 | 720 | 10.2 |
| Grapes | Mervin Line | -- | 297 | 111 | 32.3* | -- | 390 | 170 | 32.3* |
| Grapes | Beardsmore Road | -- | 173 | 33 | 15.7 | -- | 210 | 60 | 12.8 |
| Apple (from ground) | Airport Road | 2,565 | 1,478 | 1,345 | 203.4 | 2,630 | 2,470 | 2,490 | 211 |
| Apple (from tree) | Airport Road | -- | 1,205 | 640 | 216.9 | -- | 1,430 | 930 | 258.5 |

*Only one sample was collected in 2013; not statistically valid.

# Appendix B. CNSC Soil Sample Independent Monitoring Results

**Table B1: Results of CNSC soil samples taken around the SSI facility in November 2013**

| Sample location | Organically-bound tritium concentration (Bq/g fresh) |
|---|---|
| A | 70.97 |
| B | 91.47 |
| C | 21.94 |
| D | 139.8 |
| E | 24.08 |
| F | 2.208 |
| G | 20.33 |
| H | 23.53 |
| I | 1.976 |
| J | 1.551 |
| K | 1.037 |
| L | 0.805 |
| M | 0.353 |
| N | 2.789 |

*Organically-bound tritium concentrations were considered in calculating the potential dose to the public in section 4.6.4.