Radiation Safety Manual

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Office of the Chief Risk Officer

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Contents

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Purpose of Document

The Radiation Safety Manual (RSM) serves to outline uOttawa (hereafter referred to as 'uOttawa' or "the University") expectations and mandatory requirements for the management of radiation safety. The RSM sets out requirements establishing that individuals working with radioactive materials will have the required knowledge and training to safely perform their work and to establish compliance with relevant legislation.

The RSM applies to uOttawa employees and is extended to serve as a reference for interested parties at uOttawa.

The RSM defines the responsibilities for uOttawa employees and when managing relationships and safety performance expectations between uOttawa and other entities work with and at uOttawa.

Users must also comply with the minimum requirements and procedures outlined in the General OHS Program Manual and Laboratory Safety Program Manual. This manual serves as a standard for radiation safety specific matters.

Non-compliance from the requirements outlined in this manual and associated procedure or violation of the respective permits, are subject to evaluation against Policy 2d (Disciplinary Measures for Reprehensible Acts) and Policy 115 (Responsible Conduct of Research). Prior to working with radioactive materials, individuals working with radioactive materials shall verify that the proper permitting is acquired by the associated supervisor through the Office of the Chief Risk Officer (OCRO).

Chapeter 1 Corporate Oversight

1.1 RADIATION SAFETY PROGRAM

The ultimate purpose of the Radiation Safety Program (RSP) is to ensure that users have the knowledge and training so that they may safely perform their duties. They also must comply with the Canadian Nuclear Safety Commission (CNSC) Nuclear Safety and Control Act (NSCA) and its regulations.

1.1.1 CNSC Licence

uOttawa has been issued a consolidated licence (NSRD Licence) by the CNSC. This licence incorporates numerous conditions relating to radioactive material possession, use, disposal, importation and exportation.

The A. E. Lalonde accelerator mass spectrometry (AEL AMS) facility at uOttawa also holds a CNSC Class II Nuclear Facility Licence for the use and service of their High Voltage Engineering B.V. (HVE) 3MV accelerator. An AEL AMS Radiation Safety Manual has been created under the uOttawa RSP and implemented at the AEL AMS facility.

To maintain these licences, the University must ensure that activities involving radioactive substances and equipment are carried out in accordance with the CNSC NSCA and its regulations and applicable conditions.

1.1.2 CNSC - Obligations of Licensees and Workers

The CNSC's General Nuclear Safety and Control Regulations outline the obligations of the Licensees and the Workers. With regards to ensuring security and reporting any potential breaches or threats, there are three significant sections: Sections12 - Obligations of the Licensee, Section 17 - Obligation of the Worker, and Section 29 - General Reports.

Summary of Key Clauses are:

Section 12 - Obligations of the Licensee

(c) take all reasonable precautions to protect the environment and the health and safety of persons and to maintain the security of nuclear facilities and of nuclear substances;

(h) implement measures for alerting the licensee to acts of sabotage or attempted sabotage anywhere at the site of the licensed activity;

(j) instruct the workers on the physical security program at the site of the licensed activity and on their obligations under that program;

Section 17 - Obligation of the Worker

(b) comply with the measures established by the licensee to protect the environment and the health and safety of persons, maintain security, control the levels and doses of radiation, and control releases of radioactive nuclear substances and hazardous substances into the environment;

(c) promptly inform the licensee or the worker's supervisor of any situation in which the worker believes there may be

(i) a significant increase in the risk to the environment or the health and safety of persons,

(ii) a threat to the maintenance of the security of nuclear facilities and of nuclear substances or an incident with respect to such security,

(iii) a failure to comply with the Act, the regulations made under the Act or the licence,

(iv) an act of sabotage, theft, loss or illegal use or possession of a nuclear substance, prescribed equipment or prescribed information, or

(v) a release into the environment of a quantity of a radioactive nuclear substance or hazardous substance that has not been authorized by the licensee;

Section 29 - General Reports

(1) Every licensee who becomes aware of any of the following situations shall immediately make a preliminary report to the CNSC of the location and circumstances of the situation and of any action that the licensee has taken or proposes to take with respect to it:

(c) a release, not authorized by the licence, of a quantity of radioactive nuclear substance into the environment;

(d) a situation or event that requires the implementation of a contingency plan in accordance with the licence;

(e) an attempted or actual breach of security or an attempted or actual act of sabotage at the site of the licensed activity;

(f) information that reveals the incipient failure, abnormal degradation or weakening of any component or system at the site of the licensed activity, the failure of which could have a serious adverse effect on the environment or constitutes or is likely to constitute or contribute to a serious risk to the health and safety of persons or the maintenance of security;

(g) an actual, threatened or planned work disruption by workers;

(h) a serious illness or injury incurred or possibly incurred as a result of the licensed activity;

(i) the death of any person at a nuclear facility.

(2) Every licensee who becomes aware of a situation referred to in subsection (1) the report shall contain the following information:

(a) the date, time and location of becoming aware of the situation;

(b) a description of the situation and the circumstances;

(c) the probable cause of the situation;

(d) the effects on the environment, the health and safety of persons and the maintenance of security that have resulted or may result from the situation;

(e) the effective dose and equivalent dose of radiation received by any person as a result of the situation; and

(f) the actions that the licensee has taken or proposes to take with respect to the situation.

1.1.3 Structure of Radiation Safety Program

The Radiation Safety Program (RSP) is managed in a tiered approach. The management structure in order of responsibility is:

1. Radiation Safety Committee (RSC)
2. Assistant Director – Environment, Radiation and Biosafety
3. Radiation Safety Specialist (RSS) / Radiation Safety officer (RSO)
4. Permit Holders
5. Users

1.1.4 Roles and Responsibilities

At uOttawa, responsibilities for several roles are detailed in Administrative Procedure 14-1 (Internal Responsibility Procedure for Health and Safety Issues); please refer to the Procedure 14-1 for detailed responsibilities.

In addition to the roles and responsibilities outlined in Procedure 14-1, additional roles and responsibilities applicable to the RSP include:

Radiation Safety Committee
The Radiation Safety Committee (RSC) oversees the entire program and is responsible for oversight and directional support of the program. The RSC acts as the University's decision-maker in areas pertaining to the use of radioactive materials. The RSC establishes and verifies that the University follows the regulations and license conditions set out by the CNSC. Members of the RSC are appointed by the Vice-President (VP) Research.

The Radiation Safety Officer (RSO) and Office of the Chief Risk Officer (OCRO) shall monitor compliance to verify that necessary steps are taken for the continued health and safety of radioisotope users and non-users alike and communicates the results to the RSC. The RSC confirms compliance based on reporting and reviews and approves recommendations made by the RSO. The RSC has the authority to suspend Internal Radioisotope Permits.

Additional information regarding RSC, including scope, membership, responsibilities and authority, meetings, voting, and confidentiality is detailed in the *Radiation Safety Committee Terms of Reference*.

Assistant Director – Environment, Radiation and Biosafety
The OCRO's Assistant Director – Environment, Radiation and Biosafety works directly with the RSO, ensures adequate resources are allocated for the implementation and oversight of an effective RSP, reports to the RSC, oversees and supports the development of policies and programs that aid the safe handling of radioisotopes.

Radiation Safety Specialist (RSS) / Radiation Safety Officer (RSO)
The OCRO's Radiation Safety Specialist (RSS) acts as the University's Radiation Safety Officer (RSO). The RSO reports to the Assistant Director – Environment, Radiation and Biosafety, develops policies and programs that aid the safe handling of radioisotopes to ensure the day-to-day operations are in compliance with the requirements set out by the CNSC and the RSC. The RSO also liaises with federal, provincial and municipal governments to ensure the University is in compliance with all applicable regulations regarding radioisotope use. The RSO derives their authority through the Vice Rector (Research) and the RSC.

The day-to-day operations of the RSP include:

- Providing radiation safety training
- Implementing and monitoring dosimetry and bioassay programs
- Monitoring the purchase, use, storage and disposal of radioactive material
- Inspecting the facilities (labs) to ensure compliance with regulations
- Ensuring the as low as reasonably achievable (ALARA) principle is practiced

Permit Holders/Principal Investigators

Principal Investigators (PI) must attain an approved Internal Radioisotope Permit through the OCRO prior to working with radioactive materials. Upon receiving an approved permit, the Permit Holder is responsible for the safety of the radiation users (students, workers) and for the continued security of their permitted radioactive material. They are responsible for ensuring that the acquisition, use, and disposal of radioactive material under their supervision comply with relevant legislation and uOttawa's policies and procedures (Permit Holders are requested to thoroughly familiarize themselves with these conditions).

Internal Radioisotope Permit Holders are required to ensure that:

- They are aware of any changes in uOttawa policies and procedures
- Radioisotopes are only used and stored in areas listed on the permit
- Only authorized users are allowed to work with radioisotopes
- The Internal Radioisotope Permits are up to date
- Each user is adequately trained and follows safe laboratory practices
- The RSM is accessible to all users
- Contamination monitoring is performed according to uOttawa's requirements
- Leak testing of sealed sources with activities greater than 50 MBq are performed according to uOttawa's requirements
- The inventory of radioactive materials is properly controlled
- Experimental procedures follow the ALARA principle
- Authorized users, if required, wear dosimeters

The Permit Holder must also provide immediate supervision to individuals who are inexperienced in the use of radioisotopes. The RSC must be consulted regarding any request for an underage individual to work or be present in a radioisotope laboratory.

Proposed new purchases and/or disposal of instruments containing radioactive materials must be brought to the attention of the RSO to ensure compliance with all regulations relating to possession and disposal of these instruments. This includes liquid scintillation counters and other instruments with internal radioactive sources, such as gas chromatograph detectors.

Any purchase of hand-held survey meters must also be brought to the attention of RSO who will assist the selection of the appropriate equipment and add any acquired equipment to the RSP's equipment database. An inventory of equipment is retained by the RSO for calibration purposes and for reports to the CNSC.

Permit Holders are responsible for ensuring that radioisotope laboratories are properly decommissioned prior to departure from uOttawa or when the research performed no longer

requires the use of radioactive materials. The RSO will facilitate this process and ensure criteria requirements have been met.

When a Permit Holder finds themselves holding a different view in comparison to the RSO, they are required to discuss this matter with the Dean of their Faculty who is a member of the RSC. In this way, the Dean may elect to further discuss the issue with the RSC. Should resolution not be found at this level, the most senior levels of management (Board of Governors Committee - Health Safety and the Environment) maybe requested for their assessment of risk and liability.

Users

The users (students, workers) are responsible for working in compliance with legislation, requirements of the uOttawa, and the RSP. Users are responsible for their own health and safety and the health and safety of others, as well as they share responsibility for the safe and environmentally responsible handling, transport, storage, and disposal of radioactive materials. Users must understand and comply with the safe practices outlined in this program. Specifically, users must familiarize themselves with permit conditions and comply with the RSP (procedures, plans, work instructions, etc.). In case of doubt regarding any aspect of the program, verification must be sought from the OCRO. If users have any concerns or issues related to the effective control of radioactive materials, they should inform their supervisors or alternatively, the RSO.

New users should request appropriate supervision until such time as they feel comfortable with the procedures they are using and can demonstrate the required competencies to proficiently carry out the procedures and activities related to radioactive materials that they have been permitted to perform.

1.1.5 Facilities and Equipment

Facilities and equipment should be verified by the OCRO to ensure compliance with uOttawa's policies and procedures, as well as the CNSC regulations. This includes the design of new or renovated facilities, personal protective equipment (PPE), monitoring equipment and emergency supplies.

1.1.6 Training

Individuals working with radioactive materials or related equipment should receive training that aligns with the minimum training requirements and training courses outlined in the General OHS Program Manual, Laboratory Safety Program Manual, and Laboratory Safety Training Framework (provided by OCRO).

The Radiation Safety Training (RST) is the central component of the University's RSP and a mandatory requirement for all users. The RST consists of a 3-hour theoretical course provided by the RSO, a post-course quiz, and in-lab practical training provided by the Permit Holder or their lab delegate.

General awareness training may be provided by the RSO to other uOttawa employees who need to handle radioactive material packages/containers at work according to the employee's job/task risk assessment.

Personnel appointed as RSO are required to receive RSO training in radiation safety and regulatory requirements before filling the position. To maintain their qualifications, the RSO must take refresher training every 5 years.

1.1.7 Procedures

Permit holders and users are informed of clearly defined procedures through the RSM, uOttawa Radiation Safety website and training sessions. The procedures outlined in the manual are specific to uOttawa's RSP and will enable permit holders and users to comply with the CNSC regulations. These procedures include:

- Safety training and emergency response
- Dose monitoring
- Acquisition and inventory control
- Shipping and receiving
- Contamination control
- Waste management
- Decommissioning
- Record management
- Security requirements for storage and use locations

1.1.8 Program Monitoring

In order to ensure the University is in compliance with regulatory requirements, the OCRO has been mandated to establish and monitor the RSP. OCRO reports their findings to the RSC and those individual directly involved. In recognition of the primary role of the principal investigator to conduct research, OCRO has designed its monitoring activities to minimize the number of interruptions into the research and academic laboratory. To limit these intrusions, OCRO uses a variety of tools to assess compliance, which include the program element review, documentation review, inspections, and investigations.

Procedure and Policy Review
Procedures and policies covered by the RSM are reviewed periodically to ensure they are accurate and up to date. Applicable sections are reviewed when there are changes in the regulatory requirements, the research needs and directions, or the University's standards and services. A full review of the RSM is conducted every 3 years.

Program Element Review
To ensure that each program elements meets a specific goal without becoming an unnecessary burden to the research community; each element is assessed in terms of regulatory requirements, effectiveness, efficiency, necessity and burden on all parties. Program elements include issues such as permits, inventory, security, dosimetry, training, transportation, waste, etc. This review may engage an assessment of the faculty/department support, as well as other services involved.

Documentation/Records Review
By reviewing the completeness and accuracy of records submitted to OCRO, trends and possible oversights can be detected. The adherence of the ALARA principle can be assessed by reviewing dosimetry records. Inventory and disposal records are used not only to address laboratory performance, but to ensure the CNSC Licence conditions are adhered to. Documents and records are also used in the preparations of the annual compliance report which is subsequently submitted to the CNSC.

Inspections
Inspections are a tool whereby a picture of a laboratory's performance can be assessed. The way the RSP is implemented in a lab may vary; some labs identify specific individuals who are delegated the task to monitor and ensure compliance, in other labs, the responsibility is shared. The strengths and weaknesses of each system are assessed.

OCRO has adopted a performance rating scale to assess performance over time (file review) and a specific inspection and is both objective and subjective in nature. The sole purpose is to identify labs having the greatest difficulty reaching and maintaining a state of compliance and provide the necessary support to help identify root causes and the necessary remedial action. High risks observed during the inspections are brought to the attention of the Dean. Inspections or equivalent compliance monitoring activities are undertaken by OCRO at a frequency of 4 labs per month.

Investigations
Periodically, there is a need to investigate a specific incident be it a spill, dose, etc. or cases that trigger the uOttawa's action levels. These opportunities are also used to address the root causes and other influencing factors. As a result, laboratory performance may be examined in greater detail or even a full RSP element, e.g., training.

1.2 INTERNAL AUTHORIZATION

1.2.1 Internal Radioisotope Permits

In order to work with radioactivity at uOttawa, first and foremost, an internal Radioisotope Permit is required. The internal Radioisotope Permits are the method by which the OCRO ensures compliance with the CNSC Acts, Regulations and Licence conditions. There are four main types of permits:

1. Unsealed (Open) Source
2. Sealed Source
3. Sealed Source in Device
4. Exempt Activity

To apply for a permit, the Principal Investigator (PI) must complete the Permit Application Form. Critical requirements including laboratory space that meets radiation work requirements (refer to *Section 2.3 Laboratory Requirement*), detection equipment for contamination monitoring (refer to *Section 2.8 Radiation Detection and Measurement*), dosimetry (refer to *Section 2.7.1 Personnel Monitoring*) and training will be dealt with during the permit application process. If RSO determines that approval from the CNSC is required for a proposed project (e.g., if use of a radioisotope at a single time is greater than 10,000 times its exemption quantity), the RSO will assist submitting an application to the CNSC and only issue an internal Radioisotope Permit once written CNSC approval is received.

The Radioisotope Permits are usually issued for 4 years. Information on the permits covers the major aspects of radioactive usage in the laboratory. It identifies the permit/radioactive material type, the radioisotope(s) that are permitted to be used, the radioisotope activity that can be used at any one single time (Use Limit), the use and storage locations, and the authorized personnel who may work with the material.

All users must comply with the permit and the Permit Conditions (attached to the permit application), the requirements outlined in the RSM, and the procedures associated with the RSP. Non-compliance could result in the loss in uOttawa's Nuclear Substances and Radiation Devices (NSRD) Licence and thus have detrimental implications on the University's teaching and research activities.

See *Section 2.12 Forms* to find the Permit Application Forms

1.2.2 Radiation Safety Training

To work with radioactivity under a specific Internal Radioisotope Permit, users (including but are not limited to professors, students, post-doc fellows, technicians, research assistants, visitors, etc.) must fulfill the uOttawa mandatory training requirement (Laboratory Safety Training Framework) and the RSP training requirement. Upon approval by the RSO, the user may start working with radioactive materials.

The RST is a central component of the RSP, and it is mandatory for all individuals who work with radioactive materials. A 3-hour theoretical course (Radiation Safety Training – For Users) is held 3 times a year at the beginning of each semester. It is followed by a post-course online quiz that must be completed within 2 weeks. A training certificate will be issued to individual who pass the quiz (75%). This theoretical course covers the topics including

- Physical and biological characteristics of radiation
- Regulatory and internal requirements
- Radiation safety principles and risk analysis
- Operational procedures and safe work practices

Before working with radioactive material, individuals must also complete a New User Registration Form, which registers a user under a permit, records the type of radioactive materials to be used, and documents the in-lab practical training provided by the Permit Holder or their informed delegate.

The refresher training is typically required when the permit is renewed (every 4 years).

Click here to register for the Radiation Safety Training – For Users

See *Section 2.12 Forms* to find the New User Registration Form

1.2.3 Planning and Procedures

The following procedural steps **must be followed** when planning for or performing work in which procurement, storage, or disposal of radioactive materials and associated equipment is involved:

1. Conduct a hazard identification and risk assessment (HIRA) using the ALARA principle and obtain the appropriate permit
2. Implement a dosimetry program as necessary
3. Identify and procure radioactive materials as necessary, referencing existing inventory and minimizing the amount of radioactive materials procured, where feasible
4. Transport radioactive materials with proper authorization, documentation, communication, and controls

5. Design and implement safe transport, lab storage, use, signage, and disposal
6. Properly dispose of radioactive waste and decommission relevant equipment
7. Monitor radiation fields and potential contamination and leaks
8. Maintain and store, as prescribed, proper records and documentation of radioactive materials, waste, and equipment

Additional steps may be required based on the project or work scope. Details for these procedural steps can be found in *Chapter 2 Operational Practices*.

Chapeter 2 Operational Practices

2.1 ALARA

ALARA is an acronym for "as low as reasonably achievable". It is a fundamental radiation safety principle for minimizing radiation exposure and releases of radioactive material, while taking into consideration economic and social factors. Not only is it a sound safety principle, but it is also a regulatory requirement for all radiation safety programs. At uOttawa over 20-year period, the RSP has been based on the ALARA principle. Inventory control has kept the quantity and activity of radioisotopes to a minimum, users are knowledgeable, procedures are followed, and no individual has ever received a dose close to the regulatory limit.

2.1.1 ALARA Implementation

An effective ALARA based RSP is only possible when a commitment to safety is made by all those involved, and the principle should be used in all laboratory operations. Holistically as the RSP, ALARA is ensured by the issuing of internal permits, training and authorizing users, approval of radioisotope purchases, assessing use and disposition records, contamination monitoring and radiation surveys, reviewing dosimetry exposure records, and decommissioning of permits, rooms and equipment.

In the laboratory, the ALARA principle can be followed by

1. Designing the experiment/procedure so the lowest possible amount of radioactive material is used and length of time in the radiation field is minimized
2. Wearing dosimeters, if applicable, when working with radioactivity
3. Providing bioassay samples when required
4. Reporting incidents or unsafe practices to their supervisors and, if appropriate, the RSO
5. Being aware of potential radiation hazards, exposure levels and safety controls in the laboratory
6. Knowing the operating and emergency procedures

2.1.2 External Radiation Exposure Mitigation

There are three principles that can be used to limit exposure to radiation:

1. **Time** – minimizing the time or exposure directly reduces the radiation dose
2. **Distance** – doubling the distance between your body and the radiation source will divide the radiation exposure by a factor of 4

3. **Shielding** – using an absorber such as Plexiglas for beta particles and lead for X-rays and gamma rays is an effective way to reduce radiation exposures

2.1.3 Internal Radiation Exposure Mitigation

The following practices are effective for reducing potential internal exposures:

1. Good hygiene techniques that prohibit the consumption of food and drink in the laboratory, and the control of personal gestures that involve "hand-to-mouth" contacts
2. Frequent wipe tests and radiation surveys of work areas, refrigerators, hoods, sinks, phones and computer keyboards, etc.
3. Control contamination with absorbent paper and spill trays, properly labelled waste containers, equipment, etc. and prompt decontamination of any detected contamination
4. Use fume hoods for materials which could become airborne (e.g., vapours, dust, aerosols, etc.) and present an inhalation hazard to workers
5. Use proper personal protective equipment (PPE) such disposable gloves, safety glasses, lab coats, etc.

2.1.4 Action Levels

To achieve ALARA, personnel dose and radiation fields are monitored, and action levels have been determined by the RSP. The CNSC defines an action level as "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for a specific action to be taken".

At uOttawa, action levels are atypical doses or atypical radiation fields. They are:

- A dose of 0.3 mSv* over a 3-month dosimetry wearing period
- Atypical radiation fields (usually 5 times above background)

*If this dose was to continue, the individual could exceed uOttawa's (public exposure limit) of 1 mSv in a year.

If an action level is reached, it will trigger an investigation by the RSO to determine why the action level was reached, and then preventive measures are determined to remediate the situation so that the action level is not reached in the future. Preventative measures are achieved by following the ALARA principle, adhering to procedures, being knowledgeable (trained) and planning for unusual situations.

Meanwhile, the RSO will determine if the CNSC must be immediately notified as per reporting criteria outlined in *Section 1.1.2 CNSC - Obligations of Licensees and Workers*.

2.2 EMERGENCY RESPONSE

Emergencies related to laboratory radioactive material and device handling could be a sealed source leak, a radioactive spill, personal contamination, fire emergencies, etc. It is important to plan the actions to be taken for different accident scenarios before any accident occurs. Thinking of how an accident might happen can help reduce the likelihood of such an event.

All emergencies related to radioactive material must be reported to the Permit Holder and OCRO/RSO must be informed by:

- Calling Protection Service at ext. 5411
- Sending an email to rad.safety@uottawa.ca
- Submitting a uOttawa Accident/Incident Reporting Form

2.2.1 Sealed Source

Any incident/accident involving a radioactive sealed source must be reported to RSO immediately. Any malfunctions of equipment that contain a sealed source must also be reported to RSO.

For sealed sources that require leak-testing (activity > 50 MBq), if the leak testing results indicate a leakage of 200 Bq or more, the following steps must be taken:

1. Discontinue using the sealed source or shielding
2. Discontinue using the radiation device in which the sealed source or shielding is located or may have been located
3. Take measures to limit the spread of radioactive contamination from the sealed source or shielding
4. Immediately after complying with paragraphs (1) to (3), notify the RSO who will notify the CNSC
5. The RSO will arrange an inspection of the sealed source to determine whether it can safely return to regular use or must be transferred for disposal

2.2.2 Spill Response

Since the scenarios of a spill are numerous and the potential impact broad ranging, each scenario must be assessed independently. General guidelines can be found in Table 1 Radioactive Material Spill Response Procedures and in the CNSC poster "Radioisotope Safety – Spill Procedures". The poster should be posted in the laboratory with the name and phone number for the responsible contact person in the space provided.

Table 1. Radioactive Material Spill Response Procedures

	SPILL RESPONSE PROCEDURE
	For major spills (> 100 times exemption quantity, contamination of personnel, or release of volatile), immediately inform OCRO/RSO (ext. 5411; rad.safety@uottawa.ca)
1.	Notify all individuals in the immediate area that a spill has occurred
2.	Increase distance from the spill. If the spill is severe, this may require evacuating the area
3.	If evacuation is required, lock and sign door. The warning sign should include your name, as well as a location of spill and time of return
4.	Limit access to only those individual responding to the spill
5.	If personal (skin) contamination has occurred, gently wash skin with mild soap and tepid water
6.	If personal (skin) contamination has occurred, immediately report it to the RSO

If safe to clean up:	
1.	Contain the spill with absorbent material (paper towels)
2.	Obtain any additional supplies and/or personal protective equipment (overalls, shoe coverings)
3.	Push spill toward its center. Clean from outside to inside. Collect all contaminated material in one appropriately labelled bag
4.	Decontaminate area with appropriate solutions (keep in mind biological or chemical hazards)
5.	If fixed contamination above twice background remains, contact OCRO
Leaving the scene after cleaning up:	
1.	Monitor self (especially feet, hands and lab coat) for contamination
2.	Leave lab coat behind if contaminated. Remove and take dosimetry badge to avoid erroneous readings
3.	Complete a uOttawa Accident/Incident Reporting Form

OCRO provides additional support by addressing spills during training sessions and private consultation. Major spills involve more than 100 exemption quantities (EQ), or contamination of personnel, or release of volatile radioactive material. Any major spill must immediately be reported to the Protection Services (Tel: ext. 5411) and the RSO (rad.safety@uottawa.ca) who will then make a report to the CNSC.

2.2.3 Personal Exposure

uOttawa RSP has set a dose of 0.3 mSv over a 3-month dosimetry wearing period as action level, which if reached, will trigger an investigation and implementation of preventive measures to ensure the person's annual dose will not exceed the CNSC dose limit for members of the public (see *Section 2.7.1.1 CNSC Dose Limits*).

In the event that a person is suspected to receive a dose that exceeds the dose limit, the person and the CNSC must be notified of the dose, and the RSO will conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure. Preventive actions must be taken to prevent the recurrence of the incident. The RSO must submit a full report to the CNSC within 21 days after becoming aware that the dose limit has been exceeded.

2.2.4 Fire

In the event of a fire, users are recommended to secure the radioactive material that they are working with and then follow procedures from uOttawa Emergency Services and in the uOttawa Lab Safety Program Manual. If sealed sources or radiation devices are involved in a fire, users or Permit Holders must contact the Protection Services (Tel: ext. 5411) and the RSO (rad.safety@uottawa.ca) immediately.

2.2.5 Other Hazards

There are often other hazards associated with laboratory ratiocinative material and device handling. In the case of using sealed sources and radiation devices, there may be electrical or physical hazards. In the case of using unsealed sources, there may be biological or chemical hazards. When planning for or responding to an emergency, users must keep different types of hazards in mind.

2.3 LABORATORY REQUIREMENT

2.3.1 CNSC Room Classification

Laboratories, areas or enclosures that contain more than one exemption quantity (EQ) of an unsealed sources are classified by the CNSC as basic, intermediate, or high level. The classification is based on the amounts of radioactivity of a radioisotope used at a single time.

- Basic Level laboratory: the quantity of unsealed nuclear substance used at a single time does not exceed 5 times its corresponding annual limit on intake (ALI)
- Intermediate level laboratory: the quantity of unsealed nuclear substance used at a single time does not exceed 50 times its corresponding ALI
- High Level laboratory: The quantity of unsealed nuclear substance used at a single time does not exceed 500 times its corresponding ALI
- Containment Level laboratory: the quantity of unsealed nuclear substance used at a single time exceeds 500 times its corresponding ALI

Annual Limit on Intake (ALI) is the amount of a radionuclide that will deliver an effective dose of 20 mSv during the 50-year period after the radionuclide is taken into the body of a person 18 years old or older, or during the period beginning at intake and ending at age 70 after it is taken into the body of a person less than 18 years old. EQ and ALI are specific to each radioisotope. Table 2 lists common radioisotopes used at uOttawa and their corresponding EQ and the Basic Level criteria (</= 5ALI).

Table 2. EQ and Basic Level Criteria of Common Radioisotopes

Radioisotopes	Exemption Quantity (EQ)		Basic Level Criteria (</=5ALI)	
	MBq	mCi	MBq	mCi
H-3	1000	27	5000	135.13
C-14	10	0.27	170	4.59
Na-22	1	0.027	31.5	0.85
P-32	0.1	0.0027	34.5	0.93
S-35	100	2.7	90	2.43
Cl-36	1	0.027	19.5	0.527
K-42	1	0.027	500	13.51
Ca-45	10	0.27	43.5	1.176
Cr-51	10	0.27	2650	71.62
Co-57	1	0.027	165	4.459
Co-60	0.1	0.0027	6	0.162
I-125	1	0.027	6.5	0.176
Ba-133	1	0.027	55	1.486
Cs-137	10	0.27	15	0.405
Pb-210	0.01	0.00027	0.0455	0.00123
Ra-226	0.01	0.00027	0.0455	0.00123

Room classification of a laboratory is determined when a new Internal Radioisotope Permit is applied or Permit amendment is requested. Laboratory level is indicated on the Permit, and users must follow all the requirements that are applicable to the room level their laboratory falls under. If a new laboratory is classified as intermediate level or above, the RSO must submit a Design Assessment Form (DAF) or equivalent and the dose calculations to the CNSC for their review and authorization.

2.3.2 Laboratory Physical Requirement

The physical requirements of radioisotope laboratories are extensive. A basic overview of theses physical requirements is provided in this section.

Ventilation

Any use of radioactive materials should be performed in a designated remote area of the laboratory. The laboratory should be at negative pressure. The airflow should be from areas of minimum likelihood of airborne radioactive contamination to areas where such contamination is more likely. In laboratories likely to generate radioactive aerosols or fumes, all air should be vented through a fume hood. There are extensive requirements for fume hood certification.

Finishing and Fixtures

Finishing and fixtures should be chemical resistant, smooth, washable, with all joints sealed. Cleanliness is paramount.

Plumbing
Sinks designated for use with radioactive materials should be clearly labelled. Sink traps should be accessible. Back flow prevention devices should be used on vacuum or cooling lines.

Storage
Access to radioactive material storage areas must only be issued to authorized personnel, and measures must be in place to ensure that the CNSC dose limit (1mSv/year) is not exceeded as a result of radioactive material storage. These areas must be secure and designed to address the requirements of the samples. This may involve meeting specific temperatures, secondary containment, additional shielding. Radiation levels outside storage areas should not exceed 2.5 µSv/h. The storage area must minimize risk of contamination and be easily decontaminated.

Security
Security elements must be incorporated into the design of the laboratory and should include access control, monitoring capacity, and be located away from public areas. Radioisotope laboratories should have a solid lock on the door.

Miscellaneous
Coat hooks should be provided close to the exit of the lab. No food or drink is permitted in the lab. Radioactive materials are not to be located near desks. Intermediate level labs should install an appropriate radiation-monitoring device.

Incidental Radiation
Radioisotope laboratories should be designed to minimize incidental radiation. Storage locations should be shielded (if necessary) on all sides. Radiation can pose a hazard to individuals in rooms abutting the radioisotope laboratory.

The possibility of incidental exposure to others should be taken into account when designing work areas. Avoid using center benches when working with radioisotopes, especially those which require shielding. When using isotopes that emit gamma radiation, try to work near an outside wall.

2.3.3 Security

The security of radioactive material is of concern to uOttawa, the public and the CNSC. Measures have been implemented to ensure radioactive material (including radioactive waste) is appropriately stored and access is only allowed to authorized individuals. As with all risk management strategies, a balance must be achieved between ensuring a secure environment while facilitating research activities.

2.3.3.1 Access Control

Access control is accomplished by ensuring an integrated approach between research laboratory procedures and the infrastructure support of the faculties and departments in which they work. This process must address before, during and after hour activities.

Means of access control can be achieved through physical barriers, psychological barriers, and conducting monitoring activities. Requirements for access control include:

- Laboratory doors must be locked when the room is unoccupied for extended periods of time.
- Radioactive samples must be stored in a locked enclosure or container.
- A security culture must be established to ensure only authorized access to radioactive material and appropriate use of radioactive material.
- An authorized person must be aware at all times of any unauthorized persons entering the laboratory and intervene when someone could be exposed to or could potentially steal radioactive material.
- Non-laboratory personnel, such as engineering or maintenance personnel, contractors or commercial service representatives must be accompanied by authorized personnel at all times.

2.3.3.2 Personnel Clearance

Personnel clearance is achieved by only allowing authorized individuals into the laboratory and only authorized users on the Radioisotope Permit (approved by OCRO) are permitted to work with radioactive material.

2.3.3.3 Inventory Control

Security control can also be accomplished by minimizing and tracking inventory of radioactive material in the lab. Any radioisotope that is no longer useful, has insufficient activity or whose chemical integrity is questionable should be disposed. Keeping only radioisotopes that are in use will decrease the security risk. The radioisotope inventory should be checked regularly and when requested by OCRO, the inventory must be compared to the OCRO inventory listing for the permit holder. OCRO must be informed of any inconsistencies.

2.3.3.4 Storage of Radioactive Material

All radioactive material must be stored in a secure area. The secure area is normally a locked cabinet/side room, a locked fridge/freezer or a lockbox which attached to the wall of the fridge/freezer.

In addition to keeping the radioactive material secure, users must be vigilant and monitor the radioactive inventory for any missing radioactive material. If any radioactive material is missing or thought to be stolen, lab personnel must inform Protection Service (ext. 5411) and report to the RSO (rad.safety@uottawa.ca) immediately, and the RSO will also notify the CNSC immediately. If any radioactive material is deemed stolen, local police will be contacted. Along with the notification, details concerning the circumstance and any actions taken or proposed actions taken the following information must be provided. Information needed are listed below:

1. Radioisotope
2. Current activity
3. Purchase order (PO) number for unsealed source, model and serial number for sealed source, brand, model and serial number for device
4. Date and time where the situation occurred or, if unknown, the approximate date and time
5. Last known location
6. Any action taken or action planned
7. Actions that will be put in place to prevent a future loss or theft

2.4 SIGNAGE, LABELING AND POSTING

The purpose of posting radiation signage and labeling is to inform individuals of potential risk of radiation exposure and the presence of radioactive material. All rooms where radioactive materials will be used or stored will require a variety of postings. The use of signage and labeling also distinguishes experimental equipment, work and storage areas that are dedicated to radioactive material or activities. Care must be taken to ensure proper postings and labelling since invalid posting of radiation warning signs or labels is prohibited by federal legislation.

2.4.1 Radiation Warning Sign

The CNSC prescribes the use of the "Radiation Warning Symbol" in its Radiation Protection Regulations. The design of this radiation trefoil symbol is shown as the Figure 1. The three blades and the central disk of the symbol shall be magenta or black; and located on a yellow background.

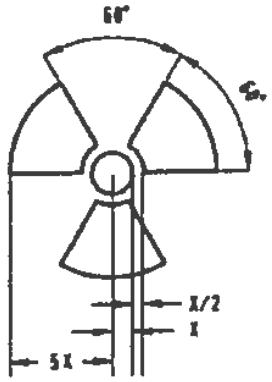

Figure 1. Radiation Warning Symbol

The CNSC has set specific criteria which the "radiation warning symbol" and prescribed wording should or should not be used. If this signage was used when criteria was not met, the University risks being cited of frivolous use of signage.

The CNSC specific signage is the trefoil symbol coloured magenta or black on yellow background with the wording "RAYONNEMENT-DANGER-RADIATION" (see Figure 2).

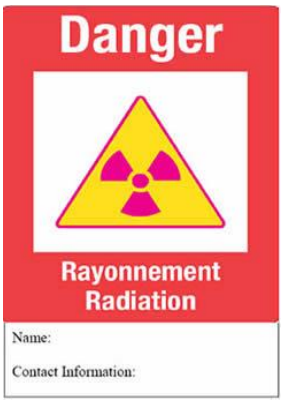

Figure 2. CNSC Specific Radiation Signage

The CNSC specific signage must be posted at boundary of and every point of access if

- There is a radioactive nuclear substance in a quantity greater than 100 times its exemption quantity (EQ), and/or
- Where there is reasonable probability that a person might be exposed to an effective dose rate of greater than 25 µSv/h.

All laboratories that have nuclear substances or radiation emitting devices that meet the CNSC criteria shall post the CNSC specific signage at each entrance to the lab or at each boundary point.

2.4.2 Internal Radioisotope Permits

Internal Radioisotope Permits must be posted in a visible location inside all locations listed on Permit. If the Permit is an Unsealed (Open) Source Permit, a current "Users List" with all authorized users' names must accompany the Permit.

2.4.3 CNSC Posters

Various posters were available from the CNSC and are required to be posted in the labs where radioactive material is handled. Hard copies of these posters may be obtained from the OCRO.

Use of Unsealed Nuclear Substances
The appropriate CNSC room classification poster with the Permit Holder's name and 24-hour contact information (telephone number) should be posted in a visible location in all rooms where all unsealed radioactive material is used or stored. The Use of Unsealed Nuclear Substances posters (Basic Level or Intermediate Level) must include the 24-hour emergency contact information.

Spill Procedures
The Spill Procedures poster must be posted in a room in which unsealed radioisotopes are used and handled.

Guidelines for Handling Packages Containing Nuclear Substances
The Guidelines for Handling Packages Containing Nuclear Substances poster should be posted in all locations where radioisotopes are packaged or opened.

Proper Care and Use of Personal Dosimeters
The Proper Care and Use of Personal Dosimeters poster should be posted in all rooms where dosimeters are worn.

2.4.4 Other Signage and Labeling Requirements

Radiation Use Areas
Signage for counter tops or areas where radioactivity is dependent on work practices and nature of radioactive material involved. The areas may be identified by marking area off with tape and tape can be labelled as "Radioactive Use Area". Note, if area is free of radioactive after use, labelling of use area is not a requirement.

Figure 3. Various Labels for Radiation Use Area

Radiation Storage Areas
Cupboards, cabinets, refrigerators, and other containers used to store more than one EQ of a nuclear substance must be identified with radiation symbol and appropriate wording such as “Radiation Storage Area”. Storage areas that do not contain one EQ of a radioisotope must not have the radiation symbol.

Sample Containers
Stock vials must be identified with a radiation symbol, the name of the radioisotope, its purchase order (PO) number if applicable, and information respecting the nature, quantity, date of assay of the nuclear substance contained within and lot number if applicable. If stock solution is aliquoted into smaller quantities for future use, container holding vials or vials must be labelled with same signage as stock vial.

Sealed Source, Sealed Source in Device
Sealed source, sealed source in device and instruments such as liquid scintillation counters that contain more than one EQ of a radioisotope must be labelled with a radiation symbol, the name of the radioisotope, the activity and date of calibration (or a reference date).

A label containing the 24-hour emergency contact information for the person responsible for the sealed source or the device must be attached to the storage container or the device.

Waste Containers
The radioactive waste containers must have affixed to it a “For Radioactive Decay” label or a "Liquid Scintillation" Label. See Figure 5 for images of waste labels. These labels can be modified to more detailly describe the waste. If other hazards apply to the waste, such as a chemical hazard, the “uOttawa Hazardous Waste” label must also be attached to the pail.

Other Tools and Equipment
Survey meters used for contamination monitoring must have a sticker with its calibration/verification date on it. Tools such as pipettors or equipment such as centrifuges may be labelled to identify their use in radioactive work. Signage is dependent on work practices and nature of radioactive material involved. If tool or equipment are free of radioactivity after use, they should not be labelled as radioactive. Instead, they can be labelled as "for radioactive use".

Table 3. Summary Requirements for Laboratory Signs Location, Information and Type of Posting

Location	Information, type of posting and criteria
Entrance of laboratory use/storage area	**CNSC Specific Radiation Signage** if a radioactive nuclear substance in a quantity greater than 100 EQ is stored or used, and/or there is reasonable probability that a person might be exposed to an effective dose rate of greater than 25 µSv/h

Inside the lab	• **uOttawa internal permit**
	• **Current list of authorize users**
	• **CNSC posters (if applicable)**
	  ○ Use of unsealed nuclear substances poster (Basic or Intermediate Level)
	  ○ Spill procedure poster
	  ○ Proper care & use of personal dosimeters poster
	  ○ Guidelines for handling packages containing nuclear substances poster

Work/storage area	• Labelling **"radioactive work area"** if radioactivity below EQ is used or stored • Labelling **"radioactive work area" + a radiation symbol** if more than one (1) EQ of radioactivity is used or stored
Sample containers	Labelling with **a radiation symbol**, **name of the radioisotope**, **purchase order (PO) number** if applicable, and information respecting **the nature, quantity, date of assay** of the nuclear substance contained within and **lot number** if applicable
Sealed source and sealed source in device	• Labelling with **a radiation symbol**, **name of the radioisotope**, **activity and date of calibration (or a reference date)** if more than one EQ of radioactivity is contained • **24-hour emergency contact information** if more than one EQ of radioactivity is contained
Waste container	**"Radioactive Decay" label** or **"Liquid Scintillation" label** or a modified version of these labels and other applicable label, such as "uOttawa Hazardous Waste" label
Other tools and equipment	• A sticker with "date of calibration/verification" on survey meters used for contamination monitoring • Signage is dependent on work practices and nature of radioactive material involved

2.5 INVENTORY MANAGEMENT

Inventory control is one of the CNSC's primary requirements. Management and users must maintain accurate up-to-date records of all radioactive material and ensure that the material is held in a secure fashion.

Radioactive material inventory must be from purchase to disposal to establish and maintain effective inventory control. This tracking is termed a "cradle to grave" management process. The procurement, transfer, usage and disposal records of each type of radioactive source (unsealed

source, sealed source or sealed source in device) must be maintained. Table 4 below outlines the key forms required for each stage of the radioactive materials lifecycle.

Table 4. Required Documentation for Radioactive Materials Inventory Control.

Radioactive materials Lifecycle Stage	Required Documentation
Procurement	Purchase Requisition Form
Transfer	Transfer Form
Usage	Use and Disposition Form
Disposal	Use and Disposition Form Waste Logs
Decommissioning	Decommissioning Form

Inventory tracking for all radioactive materials begins with the Purchase Requisition Form. All purchase forms must be processed through a designated purchasing department (e.g., Science Store at the Faculty of Science, MedPurch at the Faculty of Medicine, etc.) so that the purchase order is approved by OCRO.

It is also important that OCRO is informed of any transfers so that inventory records are adjusted to ensure accuracy.

Once a year at minimum, unsealed source Permit Holders must physically verify their inventory with the OCRO inventory. Information on each stock vial must be compared to the information listed on the OCRO inventory listing. The purchase order (PO) number must be written or attached to the stock vial since it is the unique identifier for the radioactive substance.

For unsealed (open) sources, a dedicated inventory form – Use and Disposition Form (UDF) is used to track each sample from start of use to completion. A UDF must be started upon the receipt of the sample. Each usage and disposal are logged on this form. Records can be hard copies that are kept in the radiation records binder or electronic copies kept in the lab's radiation record's files. Once the sample is used up ("finished") or transferred to a different Permit/Licence Holder, its electronic excel UDF must be sent to the RSO, who will update the OCRO's central database and remove the sample from the Permit Holder's inventory.

For sealed sources and sealed sources in devices, inventory is tracked by incorporating the serial number of each source into the internal Radioisotope Permit. To dispose of a sealed source, OCRO must be contacted, and a Transfer Form is completed to document the method of disposal (e.g., transfer to a third party such as a licensed radiation disposal company).

2.6 PURCHASING, SHIPPING, RECEIVING AND TRANSPORTING

Purchasing shall reference and follow the requirements and procedures defined by and managed through Procurement. The RSM outlines additional requirements relevant to the procurement of radioactive materials.

The RSO shall verify that only those individuals who have been approved by OCRO are authorized to purchase radioactive materials; and only those radioisotopes and activities authorized may be purchased. Radioactive materials may only be purchased in accordance with internal permit

conditions and with authorization by the RSO. Radioactive materials, including both new, transfers, and waste, must also only be offered for shipment once approved by the RSO.

Inherently the successful receipt/delivery of your purchase or transfer of radioactive material is dependent upon the awareness level of those individuals involved, to the factors which determine or influence travel arrangements.

Regulatory Control Factor

The CNSC control the purchase, possession and transfer of radioactive material within Canada through the issuance of a NSRD Licence, the NSCA and associated regulations. The CNSC has delegated the University the responsibility of regulating individual Permit Holders as to what they may purchase and transfer. Hence, of radioactive material and radiation devices may only be purchased in accordance with internal Radioisotope Permit conditions and with authorization by RSO, who ensures that inventory of radioactive material and radiation devices does not exceed the NSRD Licence limits. In addition, radioactive material must only be offered for shipment once approved by the RSO.

Additional transportation regulations should also be reviewed to verify compliance, including those from Transport Canada (TC), International Atomic Energy Association (IAEA), and for air carriers, the International Air Transport Association (IATA). Finally, most countries have their own national agencies which regulate radioactive material and may dictate the terms of transfer.

Should radioactive materials be shipped to uOttawa from other countries, it is necessary to review any relevant national agencies that regulate radioactive materials. Contact OCRO for support to identify any relevant agencies and regulations to consider.

A contingency plan must be in place should an incident occur in transit, or at the point of receipt.

Contract Factor

The contract term plays a critical role in the receipt of the radioactive material and the level of compliance achieved. In addition to defining the material that is to be purchased, there is often a reference to the International Chamber of Commerce - Incoterms 2020. These international procurement rules clearly state what are the roles and responsibilities of the buyer and seller. Specifically referenced are those who are responsible for: obtaining insurance (liability and product), receiving importation authorization, and paying duty and freight forwarding costs. The time when the buyer officially takes possession of the goods and accepts all risk and liability is also defined. It is important to note under some Incoterms 2020, that “time” could be at the airport where the supplier releases the goods to the carrier. The need for specific documentation such as quality assurance, source integrity verification (leak testing), etc. must also be stated at the time of contract negotiation.

When setting up contracts for the purchase and shipment of radioactive material, Procurement must be engaged to establish the proper contracting and monitoring of such contracts.

Shipping and Receiving Factor

When goods enter Canada there is a need to have the goods clear customs. uOttawa has engaged a brokerage company to facilitate the clearance of the majority of shipments through customs. They require specific information to be provided by the seller, such as commercial invoices/Proforma invoices, bill of lading. In addition, Canada Border Services Agency (CBSA) will require documentation that the receiver is authorized by the CNSC to possess the radioactive material.

Should the shipment be sent from uOttawa to another party (transferred), the same need for verification of authorizations must be fulfilled. OCRO must ensure that the recipient institution and the individual are authorized, aware of the travel arrangements, and will confirm receipt of shipment. In preparing the actual shipment, the radioactive material must be assessed using a variety of criteria (radioisotope, activity, dose rate, contamination limits etc.) to determine its packaging, labeling, and documentation requirements set by regulatory bodies (CNSC, TC, IAEA, IATA). International shipments may also engage additional requirements set by the recipient country (i.e., USA - Department of Homeland Security).

Finally, the ultimate control over shipping lies with the carrier. The carrier will route or reroute any of its transport vehicles, as it deems necessary. Thus, a direct flight may actually be a multiple stage travel route, with a number of different carriers (and travel forms) being used, through a number of different countries. It is important to be aware these possible changes, as it increases the risk of the package being held up in transit; especially as an individual pilot has final say on what he is prepared to transport.

2.6.1 Purchasing

To ensure inventory control and compliance, all radioactive material be pre-approved by the RSO prior to being ordered. The CNSC expects the purchase control of unsealed (open) sources, sealed sources, and sealed sources incorporated in a device (i.e., gas chromatographs and liquid scintillation counters).

Roles and responsibilities in purchasing radioactive material are outlined as following:

Permit Holders

- Ensure the current permit authorizes the purchase of the radioactive material and the requested activity
- Complete the Purchase Requisition Form
- Follow the procedures outline in this section

OCRO/RSO

- Ensures that the radioactive material purchase process is in compliance with regulations
- Approves purchases that meet necessary criteria by signing Purchase Requisition Forms and notify purchasing departments by agreed upon timelines

Purchasing Department

- Assigns PO numbers to purchase orders
- Places the approved purchases and receives packages.

The following procedures must be followed when purchasing radioactive material:

1. All radioactive material (unsealed/open sources, sealed sources and sealed sources incorporated in a device) must be ordered using the Purchase Requisition Form.
2. Should multiple companies be involved in the ordering, production and transfer of the radioactive material, all companies must be listed in the form, with their addresses, and the name and telephone/fax/email of the contact person. This situation occasionally occurs when

ordering sealed sources, i.e., the company selling the material may be in one country, yet the material is produced and shipped from another.

3. Purchase Requisition Form must be signed by the Permit Holder or delegate.
4. Once the Purchase Requisition Form is completed, it must be sent to the purchasing department.
5. Purchasing department assigns a PO number and then forwards Purchase Requisition Form to the RSO by email (rad.safety@uottawa.ca) for approval.
6. If the order is in compliance with the Radioisotope Permit and the NSRD License, it will be approved. Purchase requisitions for a radioisotope not listed, or in excess of the associated use limit on an individual permit will not be processed. If this occurs the Permit Holder will be informed of the problem.
7. Upon approval by the RSO, the Purchase Requisition Form will be emailed back to the purchasing department and the Permit Holder. Therefore, the material will be ordered.

IMPORTANT: The PO number is used as the unique identifier for the unseal sources to track the source from "cradle to grave". Once the source is received in the laboratory, a Use and Disposition Form (UDF) must be started for the source and its PO number must be inserted on this form.

Note, due to the complexity of international shipments and the multiple regulations that must be considered, the time associated with international purchases can be considerably longer than standard shipments.

2.6.2 Shipping

To establish and maintain regulatory compliance and effectively manage the complexity of the radioactive materials shipping process, OCRO (rad.safety@uottawa.ca) must be consulted 3 weeks at minimum prior to shipment. Examples of regulations/regulators include the CNSC's Packing and Transport of Nuclear Substances Regulations (PTNSR), TC's Transportation of Dangerous Goods (TDG) Regulations, IATA and IAEA.

Inherently, the primary concern for the shipping of radioactive material is to ensure the design and integrity of the radioactive material and associated packaging is such that it will not result in a release of radioactive material or an unexpected exposure during transit. Appropriate documentation and labeling are required to inform others of any potential risk. Activities associated with the shipping of radioactive material (packaging and transporting) must be undertaken by personnel who is certified for the TDG, Class 7.

2.6.3 Receiving

Radioactive packages are first received by the Shipping and Receiving Department and then picked up by or delivered to the authorized radioactive material user. Should any damage of the packaging occur during transit, it is the responsibility receiver to monitor the package and report any incident to the CNSC. Therefore, OCRO (rad.safety@uottawa.ca) must be contacted immediately should a damaged package be received. The RSO will investigate and inform the CNSC if required.

The RSM includes receiving procedures for both the Shipping and Receiving Department and Users followed by reporting requirement:

Procedures for Shipping and Receiving Department

1. Verify that individuals receiving radioactive material have been trained in TDG for Class 7 Radioactive Packages
2. Verify deliveries are scheduled during working hours. If for an exceptional circumstance, a shipment is to arrive after working hours, have a specific storage location that is secure and prevents unnecessary exposure
3. Check integrity of package. If the package is damaged, do not sign for receipt and inform OCRO and lab
4. Sign for the received package. If upon close examination package deemed to be damage, contact OCRO and lab
5. Informs lab personnel and OCRO of receipt of package if previously instructed to do so
6. Verify that the package being received corresponds to an order previously approved by OCRO
7. Verify the packing slip. Note the packing slip may not be readily available. Make sure not to handle radioactive material and follow the steps below:
    a. Take the packaging slip if it is located on the outside, do not open the package. IF NOT, GO TO NEXT STEP
    b. If the packaging slip is inside the outer package, open the package and retrieve the packaging slip if located on top. IF NOT, GO TO NEXT STEP
    c. If the packaging slip is not visible on the surface, send package to lab and ask that the packing slip be returned once they have opened the package
8. Minimize personal exposure to radiation by using ALARA principle and taking into account information provided by the TDG safety mark
9. Ensure all radioactive material is stored in a secure location once received

Note: A dosimeter will be issued to Shipping and Receiving personnel, if an approved order may present a potential exposure risk.

Procedures for Radioactive Material Users

Only authorized users, those who are working under a radiation permit, may open a package containing radioactive material. Users must always confirm the material received is the purchase that was ordered and monitor the package for contamination and ensure there has been no loss of containment during transit. (Note: assume the package may be contaminated until you have proven otherwise.)

1. Preparation:
    - Wear a lab coat and deposable gloves while handling the package
    - Wear a dosimeter, if applicable
    - Use a cart (with edges to prevent items from falling off) to transport package from the Shipping and Receiving Department to the lab (using a cart also minimizes radiation exposure by increasing the distance between transporter and package)
    - Place the package in a fume hood if contents are volatile

2. Inspection:
    - Inspect packages for damage or leakage immediately upon receipt

- Inspect the package for radioactive labeling applied. Interpret labeling and transport index value used to assess personal exposure risk. Refer to the CNSC Poster - "Guidelines for Handling Packages Containing Nuclear Substances"

3. Opening Packages:

Unsealed (Open) Sources

- Open the package (while wearing lab coat and gloves) and verify the contents with the packing slip and order placed
- Monitor all packaging materials for presence of contamination (See *Section 2.7.4. Package Monitoring*)

Outer package

- Inspect the outer package and check for damage to the contents such as a broken seal or discoloration of packaging materials
- Remove the storage container ("pig") from the box and use direct monitoring (survey meter) to measure any contamination in the box or on the storage container
- Deface all radioactive warnings and symbols on the packaging prior to safely disposing of this packaging

Inner package

- Open the storage container ("pig") and verify the radioisotope, its activity and other details with the information on the vial match the purchase order
- Use indirect monitoring to determine if any removable contamination is present: wipe the vial with a moistened filter paper. Depending on energy or radiation emission, analyze the paper by either using a survey meter or a liquid scintillation counter

Sealed Sources

- Open the package (while wearing lab coat and gloves) and verify the contents with the packing slip and order placed
- Check for damage to sealed source
- If sealed source has an activity of greater than 50 MBq, ensure leak testing paperwork is present
- Deface all radioactive warnings and symbols on the packaging prior to safely disposing of this packaging

Sealed Source in Device

- If device such as a liquid scintillation counters or gas chromatograph is to be installed by service technician, do not open package
- If sealed source has an activity of greater than 50 MBq, ensure leak testing paperwork is present
- Once the device is installed and packing material is to be discarded, ensure all radioactive warnings and symbols are defaced

4. Keeping Records:

   Unsealed (Open) Sources
   - Start a Use and Disposition Form (UDF) for the source
   - Document the package contamination monitoring results in Bq/cm^2 in the upper right corner of the UDF

   Sealed Sources and Sealed Source in Device
   - File and send source calibration certificate OCRO, if applicable
   - File and send instruments model and serial number to OCRO

5. Storage:
   - Store the sources/devices in the designated secure area of the laboratory

Reporting Requirement
The Shipping and Receiving Department and users must report to OCRO (rad.safety@uottawa.ca) immediately for any

- Discrepancy in the purchase order and the goods as defined on packaging slip
- Circumstance where the integrity of the package is questioned
- Circumstance where exposure to radiation is a concern
- Circumstance where radioactive material is lost, stolen or no longer under the control of a person

The RSO will investigate and determine if the case must be reported to the regulators (e.g., the CNCS, TC, etc.).

2.6.4 Transfers

Transferring radioactive material refers to taking or giving radioactive material from one authorized party to another. Transferring can be within the university from one Permit Holder to another, or external to the university from one licensed entity to another. All transfers of radioactive material must be notified to OCRO beforehand and approved by the RSO prior to actual shipping/transportation.

Transfer Within the University
Transfers of radioactive material between Permit holders must be approved by RSO. In addition, the radioisotope and activity must be within permit limitations of the Permit Holder who is receiving the material. If the radioisotope is not on the permit, or the activity exceeds the Permit limits, the transfer is still possible, but the permit must be amended before the transfer is permitted.

To initiate a transfer, an Internal Transfer Form (see *Section 2.12 Forms*) must be completed and sent to the RSO for approval.

For unsealed (open) source transfers, once the transfer is approved, the transferring Permit Holder must complete the UDF for the source being transferred by placing the activity transferred in the "Other" column and a note who (Permit Holder name with permit number) the source is transferred to. The receiving Permit Holder then starts a new UDF for the transferred source using the activity

being transferred and tombstone information (PO number, purchase date, radioisotope, etc.) obtained from the original owner.

Transfer Outside the University
Transfers of radioactive material or device outside the University require approval of RSOs from both the shipper's (consignor) and receiver's (consignee) sides.

To initiate a transfer, either receiving or sending radioactive material or device, an External Transfer Form (see *Section 2.12 Forms*) must be completed and sent to the RSO for approval. For radioactive material and device that are above EQ, the RSO must verify with the consignee that the radioactive material or device is present on the consignee's CNCS Licence before transfer.

For unsealed (open) source transfers, where the source is being sent to another organization, the Permit Holder must complete the UDF for the source being transferred by placing the activity transferred in the "Other" column and a note saying who (name of individual and organization) the material was transferred to.

For unsealed (open) source transfers, where the material is being received, the Permit Holder must start a UDF just as they would when purchasing radioactive material.

2.6.5 Transporting

Transporting is normally for movement of radioactive materials within the university, and shipping is normally reserved for transport outside of the university. OCRO must be informed and approve any re-location or transfer of radioactive material.

For transport within the University, if no public roads are crossed, only uOttawa procedures are applicable. If public road is crossed, (e.g., King Edward), or the radioactive material is to be transported to other campuses, then the CNSC Packing and Transport Nuclear Substance Regulation (PTNSR) and possibly TC's TDG Regulations are applicable as relevant.

Before any radioactive material is transported, the selection of the method and route shall be based on keeping the potential exposures to both the users and the public to a minimum (with reference to ALARA).

Please note, personally owned vehicles are NOT covered by the University's auto liability coverage. Personal vehicle should not be used to transport dangerous goods/samples.

Transporting Unsealed (Open) Sources
When transporting unsealed (open) source radioactive materials, including waste, users must

- Ensure that caps and lids are tight
- Use an appropriate shielding box, with four sides, a lid and a bottom, and constructed of lead for gamma radiation and plexiglass for beta radiation
- Carry the box on a leak proof tray
- Use the elevators (not stairwells) to reduce the possibility of trips or falls which may lead to spills or injury
- Use a laboratory cart when possible, to increase the distance between the transporter and the radioactive material itself
- Minimize exposure of other workers and the public
- Wear appropriate PPE, such as gloves - this may require an assistant to open doors

- Have a plan to deal with accidental spills
- Clean up and decontaminate any spill that occurs

Transporting Sealed Sources
When transporting a sealed source, the user must

- Inform the RSO with the new location and update the Permit if the sealed source is moving to permanent location
- Ensure that adequate shielding is maintained, so the level of radiation from a properly shielded source does not exceed 2.5 µSv/h
- Conduct a leak test if the sealed source is dropped or damaged during transit and report the incident to the Permit Holder and RSO

Transporting Sealed Source in Device
When transporting devices that contain sealed sources, such as liquid scintillation counters or gas chromatographs, the user must

- Inform the RSO with the new location and update the Permit if the device is moving to permanent location
- Conduct wipe test before transport to ensure no contamination is present
- Report any incident or possible damage to the equipment occurring during transport immediately to the Permit Holder and RSO

2.7 MONITORING

Monitoring is a general term that encompasses a wide scope of activities from detection of radiation fields to dosimetry. Since radiation cannot be detected by any of the human senses, monitoring is essential to safe work environment. Good work practices and frequent monitoring of work and storage areas are used to ensure exposure risk to radiation is minimized. Dosimetry is used to ensure personal doses are kept as low as possible. Leak testing of sealed sources and contamination monitoring of radiation work areas are used to ensure leaking sources are removed from service, and work areas are free of radiation contamination. Due to the importance of monitoring, the CNSC has specific requirements for each type of monitoring activity.

2.7.1 Personnel Monitoring

2.7.1.1 CNSC Dose Limits

Exposure to radiation must be closely monitored to ensure that no one receives an exposure which could have a potentially adverse health effect. In recognition of this, the CNSC has set dose limits for members of the nuclear energy workers (NEW) and the general public (non-NEW). See Table 5 Dose Limits Assigned by the CNSC.

Table 5-1. Equivalent Dose Limits Assigned by the CNSC

Organ or tissue	Person	Period	Equivalent Dose Limit (mSv)
Lens of Eye	NEW	One-year dosimetry period	50
Lens of Eye	Non-NEW	One calendar year	15
Skin	NEW	One-year dosimetry period	500
Skin	Non-NEW	One calendar year	50
Hands and Feet	NEW	One-year dosimetry period	500
Hands and Feet	Non-NEW	One calendar year	50

Table 5-2. Effective Dose Limits Assigned by the CNSC

Person	Period	Effective Dose Limit (mSv)
NEW	One-year dosimetry period	50
NEW	Five-year dosimetry period	100
Pregnant NEW	Balance of the pregnancy starting from the date on which the licensee has been informed of the pregnancy	4
Non-NEW	One calendar year	1

A NEW is defined as any individual in the course of their work who would exceed the dose limit (1 mSv per calendar year) of a member of the public. At the Radioisotope Permit application stage, the following information will be assessed to identify whether the users will be a NEW or not: research design, historical records and anticipated dose. If deemed as a NEW, the user will be formally required to sign the appropriate documentation. It is important that the RSO be informed of any change in experimental design that could result in an exposure above the public dose limits.

Under the CNSC criteria, employees at uOttawa are classified as members of the public.

2.7.1.2 Dosimetry

At uOttawa, individuals who are exposed to radiation and who may receive a dose will be issued a dosimeter. Individuals who register to work with radioactive material and fill out the New User Registration Form will automatically be issued a dosimeter if required. The RSO may also elect to monitor (short or long term) individuals who do not directly work with radiation but may be in proximity to radioactive sources. These individuals include support staff, contractors and trades personnel.

Dosimetry Service, Type of Dosimeters and Wearing Period

At uOttawa, personnel doses are recorded on dosimeters provided by Health Canada's National Dosimetry Service (NDS). Through the NDS, an individual's dose is tracked for life. To enroll in the NDS, the following information must be submitted to the NDS: name, sex, date of birth, place of birth and social insurance numbers. This information will allow the doses to be correctly assigned to the individuals.

Dosimeters provided by the NDS are the optically stimulated luminescence dosimeters (OSLD) or thermoluminescence dosimeters (TLD). They can be whole body badges, wrist extremity badges or rings. The shielding incorporated into the dosimeters is intentionally designed to mimic the natural shielding provided by human skin, fat and other organs. Thus, a dosimeter will not be assigned to users who use radioisotopes emitting weak beta particles (H-3, C-14, S-35 or Ca-45) that cannot penetrate the shielding of the dosimeters to be detected.

Users who work with radioisotopes of which emission can be detected by the dosimeters are provided with a whole body dosimeter and an arm dosimeter for exposure monitoring. Personnel who need to access a radioactive material storage area may also be provided with a body dosimeter depending on the level of radiation emission and the amount of time spent in the area. Dosimetry requirements for authorized users and the type of dosimeter are listed on the Users List attached to the internal Radioisotope Permit.

The dosimeter wearing period is 3 months. At the end of each wearing period, the dosimeters are returned to Health Canada NDS for dose analysis (reading).

Exposure Reports and Monitoring

Exposure Reports are generated and sent by Health Canada to the RSO every 3 months. If an individual receives an atypical dose (0.3 mSv), the RSO will notify the individual by email and follow-up with the individual to determine if the exposure reading represents a personal dose due to the experimental design, a singular incident, or a non-personal dose due to storage practices or damage. If an individual's dose approaches the CNSC dose limits, the experimental design and work schedule will be reviewed and modified if necessary.

An individual can contact the RSO to know their accumulative dose, or contact the NDS and complete the Employee's Dose History Summary (EDHS) Request Form to request their complete dose histories.

Proper Care and Use of Dosimeters

The CNSC's poster Proper Care and Use of Personal Dosimeters assists in storing and wearing dosimeters properly. This poster should be posted in the laboratory where users are required to wear dosimeters.

Dosimeters must not be worn outside the work environment such as when undergoing medical procedures involving radiation, as this may cause the dosimeter to register a non-occupational exposure.

2.7.1.3 Pregnancy

All workers at uOttawa are considered to be members of the public with regards to the maximum permissible radiation dose. There is no difference between the maximum amounts of radioactivity a pregnant work can receive versus a non-pregnant worker.

It's the worker's personal decision to advise their supervisor and/or RSO about their pregnancy and/or breastfeeding status. If necessary, the RSO will keep this information in confidence. However, once declared, the regulatory requirements will apply. Depending on the exposure risk in the laboratory, the worker may be re-assigned tasks and offered participation in a special monthly dosimetry service. Specific concerns can be brought to the attention of the RSO or their supervisor.

2.7.1.4 Thyroid Monitoring

Radioiodine is a health risk since it can easily concentrate in the thyroid if the appropriate containment procedures are not used. In the CNSC REGDOC-2.7.2, the thyroid monitoring requirements are focused on volatile (unbound) radioiodine due to the high risk of this form to concentrate in the in the thyroid. Currently, uOttawa's NSRD Licence does not differentiate between bound or unbound iodine. It requires thyroid screening of individuals who

- use iodine-125 (I-125) in a single 24-hour period,
    - more than 2 MBq (0.054 mCi) in an open room,
    - more than 200 MBq (5.41 mCi) in a fume hood, or
    - more than 20 GBq (541 mCi) in a glove box.
- are involved in a spill of greater than 2 MBq, or
- has external (skin) contamination.

With the external (skin) contamination, no quantity of radioactivity (MBq) is specified, hence, procedures for thyroid monitoring must be in place for any use of I-125.

Screening for internal I-125 will be performed using a direct measurement of the thyroid with an instrument that can detect 1 kBq of I-125. If thyroid screening detects more than 10 kBq of I-125 in the thyroid, a report will be made by the RSO to the CNSC immediately and have bioassay performed within 24 hours by a person approved by the CNSC to provide internal dosimetry.

To ensure best practice, radioiodine users that will use greater than 2 MBq of I-125 in an open room, more than 200 MBq in a fume hood and more than 20 GBq in a glove box, a baseline thyroid reading will be taken before the work, being followed by a thyroid monitoring taken the day after handling and 5 days after handling.

All users who are involved in a spill or have external (skin) contamination of I-125 must contact the RSO immediately (rad.safety@uottawa.ca; call ext. 5411). Thyroid monitoring will be arranged for the following day and 5 days after handling.

Laboratories who plan to use I-125 should contact the RSO, so a thyroid monitoring program will need to be re-instated; otherwise, purchases will not be approved until the program is established.

2.7.2 Radiation Field Monitoring

The CNSC regulations require that radiation fields in occupied areas outside storage area must not exceed **2.5 µSv/hr**. In practical terms, it means the perimeter of fridges and storage rooms must not exceed this limit.

Survey meters are used to detect radiation fields, and the right type of survey meter has to be chosen for the particular radiation field. The laboratories radioactive inventory and waste are indicators of the type of radiation and the type of survey meter required. (Refer to *Section 2.8.1, Instrument Selection* to choose the appropriate meter.)

Users must use a calibrated survey meter when monitoring radiation field. A calibrated meter is a meter that has met the CNSC calibration requirements and has been calibrated in the current year (see *Section 2.8.2 Instrument Check and Calibration*). The OCRO has several calibrated survey meters that may be borrowed.

Radiation exposure in a radioactive material storage area may also be monitored by an area dosimeter. Like personal dosimeters, the area dosimeters are exchanged every three months, and

the results on the exposure report are reviewed by the RSO to ensure the CNSC dose limit for members of the public (1 mSv/year) is not exceeded as a result of radioactive material storage.

2.7.3 Contamination Monitoring

Contamination monitoring is done to ensure radioactive material after being used or stored, has not contaminated the work environment. The CNSC regulations stipulate when contamination monitoring is required and the permissible limits. The requirements are dependant on the type of radioisotope and activity.

It is important to note that two types of radioactive contamination may be found: fixed contamination and non-fixed (loose) contamination. Each of these have different requirements that must be met.

2.7.3.1 Fixed Contamination

Fixed contamination is defined as radioactive material found in a location for which it is not intentionally or naturally found and can not be removed even after multiple cleansings. Therefore, fixed contamination can only be detected by conducting direct measurement (see *Section 2.8.5 Direct Measurement*). Fixed contamination may be a result of a spill/release in which the radioactivity has become absorbed/adsorbed onto a surface, and it may occur due to the chemical properties of the radioactive material or the structure and composition of the material in/on to which the radioactive material has been absorbed/adsorbed.

It is not possible to remove fixed contamination, therefore, users must ensure the contamination is appropriately shielded to minimize personal exposure. If the half-life is short (<90 days), users should wait until the material has decayed away.

Note, OCRO must be informed of all fixed contamination and the action that has been taken to minimize personal exposure.

2.7.3.2 Non-fixed (Loose) Contamination

The CNSC has set out criteria which defines the acceptable level of non-fixed contamination based upon the classification of the radionuclides and the nature of the area being monitored. Non-fixed contamination limits for selected classes of a radionuclide at two specific types of areas are listed in Table 6. These values must be averaged over an area not exceeding 100 cm^2.

Table 6. The CNSC's Contamination Criteria for Non-fixed Contamination

Non-Fixed Contamination	Class A* radionuclides	Class B* radionuclides	Class C* radionuclides
In all areas, rooms or enclosures where unsealed nuclear substances are used, or stored	3 Bq/cm^2	30 Bq/cm^2	300 Bq/cm^2
In all other areas and packaging	0.3 Bq/cm^2	3 Bq/cm^2	30 Bq/cm^2

*When using more than one radioisotope (or radionuclide) in an area, the radioisotope with the lowest contamination limit must be used to determine the limit for the area. For classes of radioisotopes, refer to the CNSC – Classes of Nuclear Substances.

Non-fixed contamination can be either detect by conducting either direct or indirect measurement (see *Section 2.8.5 Direct Measurement* and *Section 2.8.6 Indirect Measurement*). To achieve the best practices and adhere to the ALARA principle, uOttawa RSP has set the contamination monitoring criteria of **0.3 Bq/cm^2** for all radioscopes.

2.7.3.3 Contamination Monitoring Requirement

Contamination monitoring should be done in all areas where contamination could exist such as work bench, sink taps, and fridge handle. The following requirements must be followed:

- The instrument/method used for contamination monitoring must be capable of detecting the radioisotope(s) to be detect.
- A map must be created to identify all locations to be contamination monitored.
- For Basic Level laboratories, the contamination monitoring is done **weekly**, and results must be recorded on the Contamination Monitoring Monthly Log; for Intermediate Level laboratories, contamination monitoring is done **after every use** and method of documenting must be determined by the lab.
- For all laboratories, if radioactivity is not used, monitoring is not required. A note must be inserted on the Contamination Monitoring Monthly Log that radioactivity was not used.
- If contamination is found, it must be cleaned and re-measured until the activity is below the uOttawa contamination criteria (0.3 Bq/cm^2). The cleaning method will depend on the chemical properties of the radioactive substance and the type of surface such as a non-porous countertop. Detergents such as Decon 75 or Alconox may be used for stubborn contamination.
- All contamination monitoring results must be documented in the unit of Bq/cm^2 (see *Section 2.8.3 Relating Measurement Readings to Regulatory Criteria*).
- If contamination cannot be cleaned to activities below the uOttawa contamination criteria, it is considered fixed contamination. See *Section 2.7.3.1 Fixed Contamination*, for actions required.
- Contamination monitoring records must be kept by the Permit Holder infinitely until their Radioisotope Permit is decommissioned and all records are filed with OCRO.

2.7.4 Package Monitoring

All packages containing radioactive material must be monitored for contamination to ensure there has been no loss of containment during transit. Note, if a package is damaged or there is evidence of leakage such as broken seals or discoloured packing, the RSO must be notified (refer to the CNSC's poster "Guidelines for Handling Packages Containing Nuclear Substances" for more information).

External Package Surfaces

Monitoring of the external surfaces of packages containing radioisotopes that are detectable by a survey meter (Geiger counter) should be done and any anomalies such as radiation levels in excess of the package labelling, incorrect transport index, contamination, leakage, short or wrong shipment must be reported to OCRO.

Inner Package or Primary Container

Either direct (survey meter) or indirect monitoring (wipe tests) must be done on the inner package or primary container of all received packages containing radioactive materials. The method used may depend on the type of radioisotope received. For example, H-3, C-14, Ca-45 and S-35 samples will require indirect contamination monitoring using wipe tests by a liquid scintillation counter since the radiation from these radioisotopes is too weak to be detected by a contamination monitor.

If contamination is detected, all packaging and, if appropriate, all locations in contact with the package, must be monitored for contamination. Users must contain the contamination, decontaminate, and dispose in accordance with procedures outlined in the RSM and report the contamination to OCRO.

The results from the contamination monitoring in Bq/cm^2 (e.g., units cpm or cps must be converted to Bq/cm^2) must be documented on the UDF that is created for the new unsealed source.

2.7.5 Leak Testing of Sealed Sources

The CNSC requires that all sealed sources that are not exempt for licensing and that contain 50 MBq or greater of radioactive material, be monitored to assess the integrity of the material housing the source. By definition, a sealed source provides a level of assurance that the radioactive material can not escape and result in contamination or an inadvertent exposure. However, due to age, use or damage, the integrity of the housing material can be compromised resulting in a potential serious situation. In evaluating the risk verses the probability of an incident, the CNSC has set a graduated leak test frequency schedule that takes into consideration whether the sources are in storage, incorporated into devices, or in use.

The frequency of leak testing is as follows:

- Immediately after an event which may have resulted in the sealed source or shielding being damaged
- Immediately before using a source that had been in storage for a period of 12 consecutive months or greater
- Every 6 months for sealed sources in use and not incorporated into a device
- Every 12 months for sealed sources incorporated into a device
- Every 24 months when a source is in storage

It is the responsibility of the Permit Holder to ensure all the sealed sources in their possession that require leak testing are monitored at the designated frequency. Additional requirements for leak testing of a sealed source are

- Leak testing measuring and sampling procedures must be made in accordance with the CNSC's expectations outlined in in REGDOC-1.6.1.
- Instrument used must be able to detect 200 Bq or less of the radioisotope in the sealed source.
- The interval between sampling and measuring should be as short as possible.
- The leak testing results must be recorded on dedicated forms.

Permit Holders may leak test their own sources independently or coordinate the leak test sampling and measuring with other Permit Holders to allow for a more effective and efficient process. Leak testing can also be conducted by an external service provider (e.g., Noremtech, Uni-Vert Tech, etc.).

Regardless of the process, Permit Holders must send a copy of the sampling and measuring certificates to OCRO and retain these records for at least 3 years.

Response to a Leaking Source
Should a source be found to be leaking 200 Bq or greater, the following action must be taken:

1. Discontinue the use of the sealed source or sealed source incorporated into a device
2. Minimize the risk of contamination
3. Immediately notify the RSO, who will notify the CNSC of the leakage
4. In consultation with OCRO to determine the remedial actions to be undertaken to minimize exposure to the radiation and to decontaminate where necessary

2.8 RADIATION DETECTION AND MEASUREMENT

2.8.1 Instrument Selection

Radiation monitoring instrument is used to monitor exposure doses to individuals, locate contamination and monitor radiation fields. There are many types of radiation detection instruments. Some instruments are made to detect the presence or radioactivity (cps, cpm), whereas some are designed to measure dose rates (µSv/hr or mrem/hr) rather than contamination. Some instruments can measure both radioactivity and dose rates. It is important that the instrument chosen can detect the radiation type of interest and accurately detect radiation levels (sensitivity) required by the regulatory limits.

Hand-held survey meters are suited to detect moderate to high energy beta, gamma and x-ray radiation, and they have very low efficiencies to measure low-energy radioisotopes such as H-3, C-14, Ca45, Fe55 and S-35. To detect these low-energy beta emitters, a liquid scintillation counter must be used.

The ability of radiation detection instruments to detect radioisotopes of interest varies with the types of instruments and their manufacturers. Guidance on the selection of instruments can be found in Table 7 summarized from the CNSC regulatory document, REGDOC-1.6.1 version 2 and Radionuclide Information Booklet. Note, for specific information on a particular make or model of an instrument, the manufacturer should be contacted.

Table 7-1. The CNSC's Recommendation on Radiation Detection Instrument Selection

Code	Hand-held contamination monitoring instrument	Recommended applications
1	Thin-window G-M detector	Beta emitters, alpha emitters
2	Gas-filled proportional detector	Variable, refer to manufacturer's specifications
3	Thin-crystal sodium iodide scintillation detector	Low-energy gamma emitters (<200 keV)
4	Thick-crystal sodium iodide scintillation detector	High-energy gamma emitters (>200 keV)
5	Organic/plastic scintillation detector	Generally specifically designed for alpha and beta detection with low background. Gamma detection is variable; refer to manufacturer's specifications.
6	Zinc sulphide scintillation detector	Alpha emitters
7	Thick zinc sulphide scintillator with proprietary discrimination	Beta emitters, alpha emitters, gamma emitters
Code	**Non-portable monitoring instruments (wipe counters)**	**Recommended applications**
A	Liquid scintillation counter	Alpha and beta wipe samples, especially for very low-energy beta emitters such as H-3, Ni-63, and C-14
B	Sodium iodide well counter	Gamma wipe samples, allows for spectroscopic analysis of different isotopes if multiple isotopes are being used
C	Gas-flow proportional counter	Alpha and beta wipe samples
D	Semiconductor gamma spectrometer (High Purity Germanium)	Gamma wipe samples, allows for high-resolution spectroscopic analysis of different isotopes if multiple isotopes are being used

Table 7-1. Common Radioisotopes and Suggested Radiation Detection Instrument

Radioisotope	Principle Emission	Energy (keV)	Detection Instrument	
			Hand-held	Non-portable
H-3	beta	5.7	5	A
C-14	beta	49	1, 2, 5, 7	A, C
Na-22	beta	545.41 (90%)	1, 2, 4, 5, 7	A, B, C
P-32	beta	695	1, 2, 5, 7	A, C
S-35	beta	49	1, 2, 5, 7	A, C
Ca-45	beta	77	1, 2, 5, 7	A, C
Cr-51	photon	320 (10%)	1, 2, 4, 5, 7	B
Fe-55	photon	5.9 (25%)	5	A, B
Co-57	Photon	122 (86%)	1, 2, 3, 5, 7	A, B
Co-60	photon	1170, 1330	1, 2, 4, 5, 7	A, B, C
Sr-90	beta	196	1, 2, 5, 7	A, C
Tc-99m	photon	141 (89%)	1, 2, 3, 5, 7	A, B
I-125	Photon	35 (6.5%)	1, 2, 3, 5, 7	A, B
I-131	photon	364	1, 2, 4, 5, 7	A, B, C
Ba-133	photon	356 (60%)	1, 2, 4, 5, 7	A, B
Cs-137	photon	662	1, 2, 4, 5, 7	A, B, C

2.8.2 Instrument Check and Calibration

Instrument check and calibration must be performed to ensure radiation detection measurements are accurate. This accuracy is especially important with regards to regulatory criteria such as the CNSC contamination and radiation field limits.

Non-portable instruments used for counting wipes, such as liquid scintillation counters and gamma counters, should be routinely serviced according to the manufacturer's instructions or when there are issues with the instrument. Instrument owners must maintain a record of the service information and the dates. It is also important to run an operational check to ensure the instrument is operating correctly. Running a standard as a sample and comparing the measured results with the accepted results is one common operational check. For each set of measurements, a blank must also be run. The results from operational checks should be recorded. When performing the measurements, a background reading of area away from sources of radioactivity should also be done and recorded.

Survey meters are a type of hand-held instrument used for radiation survey. Their measurement is normally in mR/hr or mSv/h. Survey meters are required by the CNSC to be calibrated within the 12 months preceding its use. This is to assure persons using the survey meter that the unit is functioning properly and that the readings obtained are representative of the actual conditions.

OCRO arranges annual survey meter calibration service with a service provider (e.g., Nuclear Services Canada Inc.). Once calibration is done, the service provider will issue a calibration certificate to the meter owner and put a sticker with calibration date and due date on the meter. The calibration certificate will be reviewed by the RSO to ensure that the calibration of the meter is done in accordance with the CNSC regulatory expectations for calibration of survey meter.

Contamination meters are a type of hand-held instrument used for contamination monitoring. Their measurement is in cpm, cps or Bq/cm^2. A survey meter can be a contamination meter if it can conduct measurement in these units. Before using a contamination meter, users must conduct precheck of the meter by following the manufacturer's procedures and recommendations.

Instruments that are not operating within the parameters of the operational checks or which show anomalous background, blank or standard measurements, should not be used until their operation can be verified.

2.8.3 Relating Measurement Readings to Regulatory Criteria

The CNSC regulatory contamination limits are in the International System of Units (SI), becquerels per centimeter squared (Bq/cm^2) and the readings from most contamination meters are in counts per second (cps) or counts per minute (cpm). Therefore, there are needs to be a means to converting the cpm or cps to Bq/cm^2. This conversion can be done if the efficiency of the instrument for a specific radioisotope is known.

Due to detection capabilities, instruments do not detect all radioisotopes equally, and their ability to detect or efficiencies can vary dramatically depending on the radioisotope being detected. Some instruments are unable to accurately detect some radioisotopes. For example, hand-held survey meters cannot detect H-3 and C-14 accurately.

Instrument efficiencies for specific radioisotopes can be obtained from the manufacturer or determined using an appropriate standard of known activity (see *Section 2.8.4 Counting Efficiency* for a description of instrument counting efficiency). The following equations can be used to convert the monitoring results in the unit of cpm into Bq/cm^2:

- Wipe test results (from a liquid scintillation counter or gamma counter):

$$Result\ in\ \mathrm{Bq/cm^2} = (Reading\ in\ \mathrm{cpm} - bkg)/(E_c \times E_w \times 60 \times A)$$

  where bkg = counts per minute of the background,

  E_c = counter efficiency (refer to vendor's manual),

  E_w = wipe efficiency, assume 10% (0.1), and

  A = area wiped in cm^2.

- Survey meter results:

$$Result\ in\ \mathrm{Bq/cm^2} = (Reading\ in\ \mathrm{cpm} - bkg)/(E_c \times 60 \times A)$$

  Where bkg = counts per minute of the background,

  E_c = survey meter efficiency (refer to vendor's manual), and

  A = area scanned in cm^2 (e.g., 19.6 cm^2 for a pancake probe).

As a rule of thumb, when the counter efficiency (E_c) is unknown, the following efficiencies can be used for the purpose of counting wipes:

- 100% (1) for P-32, C-14, S-35
- 75% (0.75) for I-125
- 50% (0.5) for H-3 and unknowns

Note, for mixtures of radioisotopes, calculation must be done using the radioisotope for which the instrument has the lowest detection efficiency.

2.8.4 Counting Efficiency

According to the CNSC's REGDOC-1.6.1 version 2, the counting efficiency of a detector depends on:

- The type of detection equipment (e.g., Geiger Muller, NaI Scintillation, plastic scintillation, proportional)
- The detector's size and shape
- The distance from the detector to the radioactive material
- The radioisotope and the type of radiation measured (alpha, beta, gamma radiations and their energies
- The backscatter of the radiation toward the detector
- The absorption of the radiation before it reaches the detector (by air and by the detector's covering)

Some decay products may interact with the detector to give false readings.

The detector efficiency can be found by either counting standard source of known activity with the detector in use (see the efficiency equation below) or referring to the documentation supplied by the vendor for specific radioisotope(s) (if not specified, contact the vendor for the required information).

$$Efficiency = \frac{detector\ count\ rate - background\ count\ rate}{known\ activity\ of\ standard\ source}$$

The factors affecting the efficiency are shown in Figure 4.

1. Some radiation goes directly from the radioactive material P, into the detector.
2. Some radiation will backscatter off the surface, into the detector.
3. Some radiation is absorbed by the detector covering.
4. Most radiation doesn't even get detected.
5. If the detector was closer, this radiation would be detected.

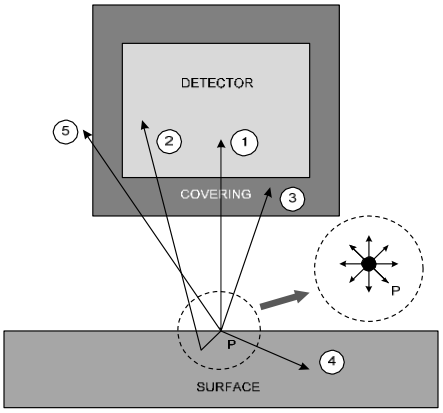

Figure 4. Factors affecting counting efficiency

2.8.5 Direct Measurement

Radiation survey meter is composed of a probe to detect radioactivity, the base containing the electronics, and the meter face. Conducting measurement by using a survey meter is a direct measurement technique, and it is convenient when monitoring large areas. The readings are a sum of both fixed and non-fixed contamination. Steps below can be followed when using a survey meter to monitor contamination:

1. Ensure instrument is capable of detecting the radioisotope you are using
2. Check for a calibration sticker: calibration date or verification date is within the current year
3. Check the battery
4. Check tightness and integrity of cable connections
5. Check audible response (if available) is working
6. If instrument has an integral check source, check the response
7. Record results from operational checks (steps 1 to 6)
8. Turn the on/off switch to the lowest multiplication scale and ensure the unit is on the "F" position, if there is a F/S (fast/slow) switch
9. Allow the instrument to warm up 15 to 20 seconds. Measure and record background radiation (this should be done away from sources of radioactivity)
10. Pass the meter probe slowly over each area identified on the contamination monitoring map
11. Keep the probe face towards the surface being monitored and keep the distance between the probe and the surface as small as possible without touching the probe
12. Record the highest measurement for each area, convert the measurement unit from cpm or cps into Bq/cm^2 (see *Section 2.8.3 Relating Measurement Readings to Regulatory Criteria*) and document the results on the Contamination Monitoring Monthly Log
13. If the contamination is greater than 0.3 Bq/ cm^2, decontaminate the area until the measurement is below the criteria. A reading in excess of regulatory limit after repeated cleaning is an indication of fixed contamination or a high radiation background. If a fixed contamination is identified, report to the RSO
14. Document the final measurement in Bq/cm^2 after decontamination
15. Turn off the meter once the work is completed

Note, meters that are not operating within the parameters of the operational checks or which show anomalous background, blank or standard measurements, should not be used until their operation can be verified.

2.8.6 Indirect Measurement

Measurement of contamination using wipes is an indirect measurement method. It detects removable radioactive contamination. Wipes can be a filter paper, wipe or cotton swab lightly moistened with alcohol or waster, and they are analyzed, depending on radioisotope, by liquid scintillation counter, gamma counter or survey meter.

Steps below can be followed when conducting indirect measurement using wipes:

1. Swipe an area of 100 cm^2 by pressuring the wipe against the surface. Use one wipe for each location identified from the contamination monitoring map
2. If the wipes are measured by using a liquid scintillation counter:
    a. Fold the wipe and insert it into a liquid scintillation vail.
    b. Add scintillation fluid into the vial
    c. Use a wide-open window and perform measurement
3. If the wipes are counted by using a survey meter:
    a. The wipe should be smaller than or equal to the sensitive area of the detector
    b. Count the wipes in a low-background area
4. Record the measurement for each area, convert the measurement unit from cpm or cps into Bq/cm^2 and document the results on the Wipe Test Form or/and Contamination Monitoring Monthly Log
5. If the result is greater than 0.3 Bq/cm^2, decontaminate the area until the measurement is below the criteria
6. Document the final measurement in Bq/cm^2 after decontamination

2.9 RADIOACTIVE WASTE MANAGEMENT

Radioactive waste is essentially radioactive material that is no longer needed by the Permit Holder or the laboratory personnel. There are many types of radioactive waste: remnants in the stock vial, waste associated with experimental or contamination monitoring procedures, sealed sources that have decayed to a level that is no longer useful, sealed sources in a device that has failed or sealed sources in a device that has become obsolete.

The RSP has established a “cradle to grave” monitoring and tracking system. Radioactive material is tracked from the point of generation (purchase) right through to its disposal. For unsealed (open) sources, OCRO has implemented a series of wastes tracking logs or waste disposal forms. These waste logs normally accompany the waste containers and are sent to OCRO for approval when the waste is ready for disposal. Disposal of radioactive sealed sources, sealed sources incorporated in a device and biological samples containing radioactivity must be addressed on a case-by-case basis. OCRO must be contacted to determine the procedural steps must be followed.

The main waste disposal streams associated with uOttawa are

1. Waste for direct landfill disposal

2. Non-aqueous waste (liquid scintillation waste)
3. Water-soluble waste
4. Radioactive material requiring off-site disposal
5. Radioactive carcass waste

Roles and responsibilities, waste disposal criteria, packaging and labeling, records and storage requirements defined in this section are applicable to all waste streams. Specific management practices pertain to individual waste stream are also described in the RSM. The radioactive waste management procedures may be revised periodically by OCRO due to the changes in the regulatory criteria or in-house procedures.

Addition information related to these procedures such as instructions on decay calculation, unit conversion and radioisotope characterization can also be found on the OCRO Radiation Safety Web Page – Operational Hub.

2.9.1 Roles and Responsibilities

Principal Investigators (Permit Holders)

- Ensure relevant lab staff/students are following the RSP radioactive waste management procedures
- Ensure the lab is equipped with appropriate waste containers and labels
- Ensure all documentation and inventory requirements are met

Users (students, technicians, visitors, etc.)

- Practice due diligence and the ALARA principles when handling radioactive waste to ensure compliances and minimize exposures
- Follow the RSP radioactive waste management procedures and ensure regulatory requirements are met
- Correctly and completely document all activities associated with waste management on appropriate forms

OCRO

- Review pertinent regulatory documents and the CNSC license conditions to ensure compliance
- Develop, implement, review and revise procedures to ensure the appropriate measures are in place to ensure compliance and minimize the risk of exposure
- Monitor the level of compliance and ensure the appropriate action is taken when non-compliance is noted
- Maintain records regarding the amount of waste generated
- Arrange for transfer of the waste to central decay storage areas
- Ensure decay storage areas are controlled, managed and associated documentation is accurate
- Review documentation associated with the waste to be transferred prior to authorizing the transfer

Faculty Representatives

- May be involved in providing access to the central decay storage area in their faculty. They must ensure access is controlled and no unauthorized transfer will occur
- Will only facilitate the transfer of waste if authorization has been previously provided by the RSC

2.9.2 Disposal Criteria

The University's NSRD Licence has set specific disposal limits for each radioisotope. The disposal limits for the radioisotopes on each Radioisotope Permit are listed on the second page of the Permit.

Waste disposed via the municipal garbage must be in solid form and uniformly distributed in the waste. Its limit is quantity per kilogram (Bq/kg) and there is a limit of not more than three tonnes per building per year. Liquid waste disposal limit is per building per year. For all, solid, liquid and gas waste streams, when more than one nuclear substance is disposed of at one time, the sum of the quotients obtained by dividing the quantity of each substance by its disposal limit shall not exceed one.

In addition to the CNSC's disposal criteria, other regulatory requirements also apply to the radioactive waste. For example, the City of Ottawa has limitations for what may be transferred to the municipal sewer; TC in conjunction with the CNSC regulates the transport of radioactive material, so the radioactive waste must be shown to meet TGD/PTNSR regulations before transfer to a radioactive waste disposal company. Accurate detailed waste records must be kept ensuring compliance with these regulations.

Additional criteria associated with waste streams includes

- Waste containing infectious agents must be disinfected by chemical or physical means prior to disposal.
- Aqueous solutions containing toxic material will have the disposal procedure decided upon based on the type of toxic material, its concentration and the radionuclide involved. OCRO must be contacted to determine an appropriate disposal procedure.
- Unbound Iodine 125 (I-125) with an activity greater than 100 µCi presents an inhalation hazard, therefore, unbound I-125 must be treated (e.g., by adding excess protein) prior to disposal to eliminate the inhalation hazard.

2.9.3 Records and Waste Logs

Radioactive waste disposal must be recorded on the Use and Disposition Form (UDF), and the transfer of radioactive waste to waste containers must be recorded on the appropriate Waste Log:

- Solid Decay Waste Log – for solid waste containing a short-lived radioisotope
- Liquid Decay Waste Log – for liquid waste containing a short-lived radioisotope
- Liquid Scintillation Waste Log – for liquid scintillation waste
- Solid Waste Log – for solid waste containing a long-lived radioisotope
- Liquid Waste Log – for liquid waste containing a long-lived radioisotope

UDF and waste logs must be sent to OCRO (rad.safety@uottawa.ca) immediately upon the final use of a radioactive material. It is through the continual inputting of this information that OCRO can

track disposal activity totals for each radioisotope and ensure limits have not been exceeded. Should activity totals approach the limits, laboratories will be informed to hold their waste for decay, or off-site disposal will be arranged.

See *Section 2.12 Forms* to find the UDF and Waste Logs

2.9.4 Packaging and Labeling

Approved radioactive waste containers are

- 20L plastic pail with lid and double lined with plastic bags,
- Leak-proof bottle/bin with lid for liquid waste, and
- Sharps container for contaminated sharps.

There are two types of radioactive waste labels (Figure 5), they are

- The red “For Radioactive Decay” label, and
- The blue “Liquid Scintillation Waste” label.

Waste containers and labels can be requested from OCRO via the Hazardous Waste Program.

Figure 5. Radioactive waste label: “For Radioactive Decay” label (left) and “Liquid Scintillation Waste” label (middle); and “uOttawa Hazardous Waste” label (right).

The radioactive waste packaging and labelling requirements are

- A “For Radioactive Decay” label or “Liquid Scintillation Waste” label must be affixed to the waste container. These labels can be modified to fully describe the waste. For example, the “Liquid Scintillation Waste” label can be used for liquid waste if "Scintillation" is crossed off (defaced).
- Sharp objects such as needles, Pasteur pipettes and broken glass must be placed into a sharps container prior to disposal. A “For Radioactive Decay” label must be affixed to the container. If the material is not for decay, cross-off "Decay" (deface) from label.
- All waste pails must have two plastic inner liners/bags. The liner/bag must be strong enough to support the waste when it is removed. Under no circumstances are waste to be placed in

unlined waste pails. Biohazards (autoclave) bags may be used if the waste contains biohazardous components.

- The container must be identified with a specific container identification code, which will be referenced on the corresponding Waste Log.
- Liquids must be stored in a chemically compatible container with a secure leak-proof lid. The container must be placed in a secondary container which will contain the total volume of the liquid should a container leak or break.
- If the waste contains other types of hazards (e.g., chemical, biological, etc.), a "uOttawa Hazardous Waste" label must be attached to the waste container.

2.9.5 Waste Storage

The radioactive waste storage requirements are

- All waste must be stored in the approved waste container with appropriate labelling.
- The radiation field strength must be assessed to determine if there is a risk of personal exposure to those occupying the room. The RSO can be consulted to assess this risk.
- Radioactive waste must be stored in an area of low traffic flow or shielding material must be used to minimize radiation field and exposure.
- Other potential hazards/risks must be considered in determining storage requirements. For example, harm of organic vapours associated with liquid scintillation cocktails must be considered to ensure proper ventilation is available.
- The corresponding Waste Log must accompany the waste container, or a note must be attached to the container indicating where to find the Waste Log if it is stored at a different location.

2.9.6 Procedures for Waste Management and Disposal

Procedures for each of the waste streams are outlined below and must be undertaken in addition to all other requirements stated above.

Waste for Direct Landfill Disposal

In recognition that some radioisotopes pose minimal risk, the CNSC has set disposal limits (DL) under which the material may be sent directly to landfill. These limits are set out on the second page of the Permit Holder's permit. Waste with quantities below the DL can be placed in the regular garbage. The following actions must be taken prior to disposal:

1. Ensure all record documentation requirements are met (see *2.9.2 Records and Waste Logs*)
2. If applicable, scan waste with a survey meter to ensure activity is comparable to background radiation
3. Deface all radioactive symbols and warnings from the waste
4. If possible, place the waste in the central regular garbage pick-up area

Waste Held for Decay

Radioactive material held for decay is usually waste whose half-life is sufficiently short enough (no longer than 3 months). The waste will be held until it decays to an activity below the DL, so it may be disposed of to landfill. Liquid waste will be held for the radioactivity to decay below the CNSC

exemption quantity (EQ), after which the waste will be disposed of according to it characteristics. Should the waste emit a high radiation field additional, precautions will be required. In addition, if the waste contains solvent, the waste will need to be stored in climate control room with sufficient ventilation.

The following actions must be taken to manage the waste held for decay:

1. Ensure all record documentation requirements are met (see *2.9.2 Records and Waste Logs*)
2. Store each radioisotope in a separate waste container
3. When the pail is full, seal the inner bag with taped, place the lid on such that the waste will remain contained even if the pail be tipped. Waste containers must not be over filled
4. Waste container may either be held for decay in lab space or in the central decay facility. The RSO can be contacted to discuss restrictions for each option
5. Once the waste has been decayed, deface all radioactive labeling, symbols, and written warnings on any items prior to final disposal
    a. For solid waste, unless other waste components prohibit disposal to landfill (i.e., chemical hazards), the waste bags can be removed from the pail and disposed of as regular garbage; otherwise, the waste will be treated as regular hazardous waste, and a "uOttawa Hazardous Waste" label must be attached to the container
    b. For non-aqueous liquid waste, the waste will be treated as regular hazardous waste, and a "uOttawa Hazardous Waste" label must be attached to the container
6. Permit Holders must keep an inventory of the number of waste containers sent to the central decay and the date on which they should be retrieved for disposal. Once the waste has been decayed, the Permit Holder must retrieve the pail from the decay facility
7. If applicable, waste should be surveyed using a survey meter to confirm the waste has decayed below the DL and the activity of the waste is comparable to the background

Liquid Scintillation Waste (LSW)

Liquid scintillation cocktail is an organic based solvent used to enhance the detection efficiency of an experimental or monitoring sample. Biodegradable cocktails may also be used. Depending upon the activity of the radioactive material associated with the liquid scintillation cocktail, the liquid scintillation waste (LSW) may be subsequently sent off-site either as radioactive material or chemical waste. Consequently, detailed records are required to determine which disposal route is applicable.

The following actions must be taken to manage the LSW:

1. Ensure all record documentation requirements are met (see *2.9.2 Records and Waste Logs*)
2. Ensure the lid of each vial is securely tightened
3. Multiple radioisotopes may be held in the same waste container
4. When the pail is ¾ full, seal the inner bag with tape or tie off, place the lid on such that the waste will remain contained should the pail be tipped
5. Send the LSW Waste Log to OCRO for analysis and approval to transfer. The RSO will determine the classification of the waste as either radioactive waste or declassified LSW
6. Once waste is declassified, deface all radioactive labeling, symbols and written warnings on any items prior to disposal

7. Declassified LSW will be treated as regular hazardous waste. Users should follow the guidelines in *Appendix A - Declassification of Radioactive Waste for Hazardous Waste Pick-up* to request waste pickup through the uOttawa hazardous waste program

Water Soluble Waste (WSW)
The definition of "water soluble waste" (WSW) is the laboratory generated liquid waste that contains low level radioactivity (radioisotopes) and is free of chemical/biological hazards. The University's NSRD Licence has set the sewer system disposal limits for each radioisotope; however, the City of Ottawa does not permit such discharge. Users must follow the guideline in *Appendix B – Procedures for Water Soluble Waste Management* to manage the WSW.

Radioactive Material Requiring Off-site Disposal
Some radioactive waste needs to be sent off-site for disposal due to the type of radioisotope involved, radioactivity, or characteristics of the waste. This type of waste includes but are not limited to

- Radioactive material not authorized for disposal as part of the University's NSRD Licence
- Sealed sources that were purchased for experimental purposes or sealed sources that were extracted from instruments (liquid scintillation counters, gas chromatographs)
- Radioactive material that does not qualify for in-house decay (i.e., long half-life)
- Natural occurring radioactive material (NORM), e.g., uranium rocks, mining products, etc.
- Depleted uranium, uranyl acetates and nitrate compounds

OCRO must be consulted to assess the circumstances and determine the needs for storage, transport, documentation and disposal, and Permit Holders must provide the following information to the RSO for an assessment:

- Radioisotope(s) in the waste
- Radioactivity in Bq or specific activity in Bq/kg
- Total volume or weight of the waste
- Chemical compounds in the waste

Radioactive Carcass Waste
For the disposal of waste contained within an animal carcass, users can refer to *Appendix C – Procedures for Radioactive Carcass Waste Disposal* for details.

2.10 RADIATION DECOMMISSIONING

Radiation decommissioning can apply to a Radioisotope Permit when the research involving the use of radioactive material is to be terminated, a room (use/storage location) when radioactive material is to be removed or relocated, or a piece of equipment when it is to be sent for repair or disposal. Three essential exercises are involved in the radiation decommissioning process:

1. Removal of all radioactive material, including waste,
2. Monitoring for contamination and performing decontamination, if required, and
3. Removal of all radiation warning signs and symbols.

The Permit Holder must follow *Appendix D – Radiation Decommissioning Guide* and complete the Decommissioning Form (see *Section 2.12 Forms*). The RSO will verify the appropriate measures have been taken and approve the decommissioning form.

2.11 RECORD MANAGEMENT

The RSP requires that records associated with internal approval, training, radioactive material handling and monitoring must be kept. These records may be reported to or inspected by the CNSC to prove regulatory requirements and licence conditions are met. Both OCRO and Permit Holders must implement a record management system to ensure

- Inventory is accurate and does not exceed the NSRD License limits
- Radioactive waste disposal is within regulatory limits
- Users are trained and competent to work under their PI's Radioisotope Permit
- Radioactive contamination is verified and mitigated

OCRO keeps central records of acquisition and transfer, inventory, waste disposal, training, dosimetry results, calibration, incident and accident, inspections, decommissioning, etc. as per CNSC's Record Retention Period Summary. The CNSC must be notified in writing at least 90 days before any of these records are going to be disposed.

Permit Holders are responsible for keeping records associated with their own laboratory activities (either hard copies or electronic copies). These records include:

Training records
uOttawa Procedure 14-1, Internal Responsibility Procedure for Health and Safety Issues specifies the requirement for supervisors to maintain up to date training records. Permit Holders must keep the current users' training records including the names of users, the date on which Radiation Safety Training or refresher training was given, and their New User Registration Forms. Training records must be made available for inspection.

Inventory records
Inventory records include Purchase Requisition Forms, Transfer Forms, and UDF for unsealed (open) sources. These records must be kept indefinitely since the CNSC stipulates that all inventory records must be kept until 1 year after the expiry of uOttawa's NSRD Licence. Once a Permit Holder decommissions their Radioisotope Permit, these records are kept by OCRO.

Waste records
Each unsealed (open) source Permit Holder must keep all Waste Logs until the waste is disposed. The UDF which contain the waste profile for each source must be kept indefinitely since the CNSC stipulates records must be kept for 1 year after the expiry of uOttawa's NSRD Licence. Once a Permit Holder decommissions their Radioisotope Permit, these records are kept by OCRO.

Contamination monitoring records
Each unsealed (open) source Permit Holder must maintain accurate contamination monitoring records and keep the record infinitely until the Permit Holder decommissions their Radioisotope Permit. These records must be transferred to OCRO when their Permit is decommissioned, and the records will then be kept by OCRO.

All Wipe Test Forms and Contamination Monitoring Monthly Logs must be kept in an organized manner, and it is also advisable to keep any raw data, such as printouts from liquid scintillation or gamma counters.

Leak testing records
Each sealed source Permit Holder or sealed source in device Permit Holder whose sealed source requires leak testing must maintain accurate leak testing records. The leak testing procedure must also be available. All records must be kept for 3 years.

2.12 FORMS

The RSP uses numerous forms within the program. These forms are intrinsic to the program and are designed for use by users and Permit Holders. The forms are reviewed and modified periodically by the RSO to adapt to the current practices and regulatory requirements. The forms are listed below under their related subject. If the online link is not available or assistance is needed to fill out any forms, please send an email to rad.safety@uottawa.ca.

Permit Application
- Internal Radioisotope Permit Application (Unsealed/Open Source)
- Internal Radioisotope Permit Application (Sealed Source)
- Internal Radioisotope Permit Application (Sealed Source in Device)

Personnel Authorization/Registration
- New Radioisotope User Registration Form
- Request to Access Radioactive Storage Room

Acquisition and Transfer
- Purchase Requisition Form
- Internal Transfer Form
- External Transfer Form
- Permit Transfer Form

Use and Disposition
- Use and Disposition Form

Monitoring
- Wipe Test Analysis Form
- Contamination Monitoring Monthly Log
- Sampling Certificate (Sealed Source)
- Measuring Certificate (Sealed Source)

Waste Management
- Solid Waste Decay Log
- Liquid Waste Decay Log
- Water Soluble Waste Log
- Liquid Scintillation Waste Log
- Non-Aqueous Liquid Waste Log
- Radioactive Solid Waste Log

- Radioactive Carcass Waste Log

Radiation Decommissioning

- Radiation Decommissioning Form

Program Monitoring

- Laboratory Radiation Safety Inspection Checklist

Appendix A – Declassification of Radioactive Waste for Hazardous Waste Pick-up

Low activity radioactive waste that contains hazardous chemicals such as liquid scintillation waste, can be declassified as radioactive and then disposed via the uOttawa hazardous waste collection program.

Here are the steps to request waste declassification for hazardous waste pick-up:

1. Send the electronic waste log by email to rad.safety@uottawa.ca for assessment.
2. If waste can be declassified, the radiation safety specialist will return a pdf. file of the waste log sheet with declassification information completed. This file is a declassification documentation and must accompany the waste to prove that it is not radioactive.
3. If waste has been declassified, verify the radioactivity is comparable to background levels by using a contamination monitoring meter. Be sure to document the survey result and meter information on the log sheet.
4. Attach the declassification documentation to the waste pail.
5. Deface radioactive waste label (e.g., “Liquid Scintillation Waste” label) and adhere the “uOttawa Hazardous Waste” label over the radioactive waste label.
6. At the bottom of the hazardous waste label, in the “Special Information”, insert the declassification documentation “Approval Number”.
7. For declassified liquid scintillation waste, request a hazardous waste pick-up using the Hazardous Materials Technical Services – Special Request online form*: complete the request and attach a copy of the declassification documentation received from the Radiation Safety Specialist. Please be sure to keep the same file name as it can be used to track the waste.
8. Keep a copy of the declassification documentation to record the waste disposal and a record of the contamination monitoring survey.

*Note, the above link for a special request must be used, as it allows the attachment of a document.

Appendix B – Procedures for Water-Soluble Waste Management

Background and Purpose

uOttawa holds a CNSC Licence which sets the sewer system disposal limits for each radioisotope, while the City of Ottawa no longer permits such discharge. Therefore, water-soluble waste* (WSW) has now to be collected in a liquid waste container and picked up from your lab via the Hazardous Waste Collection Service. This document aims at assisting you manage such waste and ensuring records are kept for future risk assessment.

**Definition of "water soluble waste": laboratory generated liquid waste that contains low level radioactivity (radioisotopes) and is free of chemical/biological hazards.*

Declassification Criteria

Water soluble waste (WSW), if meets the criteria: the total radioactivity in per waste container does not exceed the radioisotope's CNSC Exemption Quantity (EQ), will be declassified and can be picked up from the lab via the Hazardous Waste Collection Service. The EQ for commonly used radioisotopes are listed in the table below:

Radioisotopes	CNSC EQ	
	(MBq)	(mCi)
C-14	10	0.27
Ca-45	10	0.27
H-3	1000	270
I-125	1	0.027
P-32	0.1	0.0027
S-35	100	2.7

If the criteria cannot be met, the waste is considered as radioactive material, of which the disposal can be more complicated. Check Radiation Safety Manual *Section 2.9.3 Radioactive Waste Management* for details about radioactive material disposal.

WSW Management Procedures

1. Request a liquid waste container (10 L or 20 L) through the hazardous waste program or prepare a smaller container yourself and use it only for WSW.
2. For long-lived radioisotopes and short-lived radioisotopes that do not require to be held for decay:
    - Use a Water-Soluble Waste Log to track the radioisotope quantity (µCi/MBq) and the liquid volume (mL) collected in the waste container. This log compares the total activity of each radioisotope with its EQ. If the total quantity is below EQ, the log will indicate the waste is declassified by showing "Yes" at the bottom. Be aware of the total quantity when adding waste to the container to ensure your waste is always declassified.
    - Put a uO "Hazardous Waste Label" on the container and list all chemical compounds on the label.
3. For short-lived radioisotopes that need to be held for decay:

- Use a Liquid Decay Waste Log to track the radioisotope quantity (µCi/MBq) and the liquid volume (mL) collected in the waste container. This log tells the "Expected Date of Disposal" on top of the log and "xxx Days Held" at the bottom of the log.
- Put a "Radioactive Decay Label" on the container while holding the waste for decay.
- Once pass the "Expected Date of Disposal", cover the "Radioactive Decay Label" with a uO "Hazardous Waste Label" and list all chemical compounds on the label.

4. When the waste is ready for pickup, submit the waste log along with your request via the Hazardous Materials Technical Services – Special Request online form. The OCRO's Environmental Specialist will review your waste log and schedule a waste pickup for you.

   Note: a hardcopy waste log must be attached to the waste container for pickup.

5. When filling out the Inventory of *Use and Disposition Form*, put the quantity in "Other" column. See attached picture below.

	Disposal Profile (µCi)								
	Activity (µCi)			Landfill		✗	Offsite		✓
	Available	Used	Remaining	Direct	Decay Prior	Drain	LSC	Carcass	Other
	250	150	100		135	15			
	100	48.96	51.04		44.064	4.896			
	51.04								
		0			Decay				
TOTAL DISPOSAL PER WASTE STREAM:				0	179.064	19.896	0	0	0	µCi
				0	6.625368	0.736152	0	0	0	MBq
				Ensure appropriate additional log forms are completed						

Contact Information

If you have any questions, please don't hesitate to consult the Radiation Safety Specialist by sending emails to rad.safety@uottawa.ca.

Appendix C – Procedures for Radioactive Carcass Waste Disposal

This section outlines the requirements for the handling and disposal of radioactive animal carcass. All carcasses and tissues that contain or are contaminated with radioactive materials must be disposed of separately from regular biomedical waste in compliance with federal, provincial and municipal regulations, by-laws and consultative documents.

Roles and Responsibilities

Principal Investigators (Permit Holders)

- Ensure relevant lab staff/students are following the procedures for the disposal of radioactive animal carcasses.
- Ensure labs are equipped with the proper bags and Incineration Tags (Necropsy).

Users (students, lab or clinic personnel)

- Practice due diligence at all times when handling radioactive animal carcass waste.
- Follow the procedures for proper disposal of radioactive animal carcasses or tissues.
- Ensure that radioactive carcasses and tissues are discarded in the designated area or properly stored in the laboratory until disposal.
- Ensure any bedding, litter or food that has been contaminated with radioactivity is disposed of appropriately.
- Correctly document all waste information on the Incineration Tag (Necropsy) and in the Radioactive Carcasses Disposal Log.
- Radioactive Carcass Disposal logs are contained in the Radioactive Carcass Disposal Log located at the disposal site (DRO 012 or RGN 1129B1B).
- Inform OCRO when container is close to being full.

Animal Care and Veterinary Services (ACVS)

- Ensure that Incineration Tags (Necropsy) and disposal bags are always available in DRO 012 and RGN 1237
- Train users on the disposal of radioactive animal carcasses by following procedures outlined in this section.
- Assist in transport of waste to designated storage areas, when applicable.
- All waste must be in a designated radioactive waste container with the radioactive trefoil and the words ‘Radioactive’ as well as the Biohazard symbol and an Anatomical waste sticker assigned only for the disposal of radioactive animal carcasses and tissues.
- Contact OCRO to arrange for pickup of full containers.

Office of the Chief Risk Officer (OCRO)

- Assist pick up all radioactive biomedical waste from designated storage areas and arrange for off-site disposal.
- Maintain records regarding the amount of waste generated.
- Ensure Principal Investigators, users, and representatives are complying with procedures, guidelines and regulations.

- Provide guidance regarding the handling, treatment or disposal of biomedical and radioactive waste.
- Ensure that individuals receiving Radiation Safety Training are aware of this procedure the procedures and the necessity of compliance.

Requirements for Waste Preparation
Requirements for safe handling, storing and transporting radioactive carcass waste are

- Radioactive carcasses or tissues should be handled as little as possible.
- A dosimeter, if applicable and proper Personal Protective Equipment (gloves, lab coat and safety glasses) must be worn when handling radioactive animal carcass or tissue.
- Care must be taken in order to avoid any potential biological and radioactive contamination.
- Items contaminated with biohazardous materials must be decontaminated properly with a suitable disinfectant.
- Items that could potentially enter in contact with the radioactive animal carcasses and tissue must be monitored for potential radioactive contamination by direct survey or wipe test and decontaminated
- Ensure any bedding, litter or food that has been contaminated with radioactivity is disposed of appropriately.
- To avoid possible contamination, carcass waste must be double bagged in black garbage bags.
- If any radioactive contamination is found, OCRO must be notified as soon as possible.
- Plastic bags containing the radioactive carcasses must be taped shut during transport.
- Secondary containers should be used when transporting waste. The secondary containers should be decontaminated after use.
- Whenever possible use carts with raised sides for transport.

Requirements for Labelling and Records Keeping
uOttawa has the legal responsibility to document the disposal of radioactive and medical waste generated on its premise. In the case of radioactive animal carcasses and tissues, the radioisotope's *Use and Disposition Form*, the "Incineration Tag" (Necropsy) and the Radioactive Carcass Disposal Log (see Radiation Safety Manual *Section 2.12 Forms*) fulfill these requirements.

All fields on the Incineration Tag (Necropsy) and the Radioactive Animal Carcasses Disposal Log must be completed if applicable.

Table 1. Information required on Incineration Tag and Radioactive Animal Carcasses Disposal Log

Incineration Tag (Necropsy)		**Radioactive Animal Carcasses Disposal Log**
• Tag Identification (Permit Holders initials + lab assigned number) • Date of death • Species • Quantity • Investigator Name • Building • Department	Quantity of Radioisotope (total activity in µCi/kg) • Type of Toxic Material (if applicable) • Type of Biohazard (if applicable) • Other Contaminants (if applicable)	• Date • Lab Representative • PI Name • Species • Number of Carcasses • Weight in kilograms • Radioisotope

• Room Number • Type of Radioisotope	• Comments (if applicable) • Date • Signature	• Total Activity per bag (µCi/kg)

It is critical that the type of radioisotope and the total activity in uCi per kilogram of animal be written on the Incineration Tag (Necropsy) that accompanies the radioactive animal carcasses. Note radioactive carcasses with incomplete and/or unreadable information will be sent back to the waste generator.

Waste Disposal Procedures

The following describe the proper steps for the safe disposition of radioactive animal carcasses or tissue. All radioactive animal carcasses or tissue must be discarded as promptly as possible.

1. Radioactive carcasses or tissues must be placed in two black plastic bags and each bag properly sealed with unlabeled tape.
2. Items that could potentially enter in contact with the radioactive animal carcasses and tissue must be monitored for potential radioactive contamination by direct survey or wipe test.
3. Any bedding, litter or food that has been contaminated with radioactivity is disposed of appropriately.
4. Radioactive carcasses or tissue must be tagged with a yellow University of Ottawa Incineration Tag (Necropsy). All requested information on the Incineration Tag (Necropsy) must be filled out.
5. The radioactive carcasses or tissue can then be transported to designated waste container for storage located in:
    - DRO 012: chest freezer
    - RGN 1129B1B (CTE1.4): clear plastic container on shelves

The waste container must be labeled with the radioactive trefoil and the words 'Radioactive' as well as the Biohazard symbol and an Anatomical waste sticker.

6. For each sealed bag, a Radioactive Carcass Waste Log must be completed.
7. ACVS representatives will contact the OCRO to arrange for waste assessment and a waste pick-up from the storage area.

Table 2. ACVS representative contact information for radioactive carcass waste disposal

DISPOSAL SITE	Name	Office	Extension	E-mail
DRO – Room 012	Ethan Ramsey	DRO 023E	2570	eramsey@uottawa.ca
RGN – Room 1129B1B (CTE1.4)	Tami Janveau Joshua Lavigne	RGN 1313	8069	tgarloug@uottawa.ca jlavign2@uottawa.ca

Appendix D – Radiation Decommissioning Guide

This guide provides an overview for the decommissioning process, including instructions for completion of the Radiation Decommissioning Form.

The decommissioning process is comprised of verifying:

(1) All inventory has been accounted for and has either been used, disposed of or transferred to an authorized person
(2) Waste is appropriately managed (disposed of or transferred to an authorized person)
(3) Contamination Monitoring has been conducted using equipment that is calibrated and can detect the energy and activity to the limits set by the CNSC
(4) All personnel have either left the lab or will continue under another person's permit
(5) Radiation symbol, signage and wording are removed

PART A – SCOPE OF DECOMMISSIONING

Decommission can apply to either internal Radioisotope Permits, use and/or storage locations, and/or equipment.

- To decommission a Permit: complete Table I of the Radiation Decommissioning Form
- To decommission a location (room/area): complete Table II of the Radiation Decommissioning Form
- To decommission a piece of equipment: complete Table III of the Radiation Decommissioning Form

PART B – INVENTORY & WASTE

Inventory is considered any material (stock, aliquot, or samples) that remain in the possession of the permit holder. The Office of the Chief Risk Officer (OCRO) will provide the Permit Holder with the list of radioisotopes that have not yet been recorded as being disposed of. This list will identify each radioactive material and its current activity as of the date listed (decay is accounted for). Depending upon the age of the material, it may have decayed to below regulated levels.

- For unsealed source inventory, complete Table IV of the Radiation Decommissioning Form

Note: All Use and Disposition Forms (UDF) must report radioisotope use and disposal quantities in the SI units as required by the CNSC. Waste Logs must be available and accurate.

PART C – CONTAMINATION MONITORING

Contamination monitoring requirements during radiation decommissioning are

- Contamination monitoring must be performed when decommissioning a Permit, a location where unsealed and sealed sources are used/stored and/or a piece of equipment that is used with unsealed sources or contains a sealed source
- Only results using calibrated instrument which has been approved for monitor the specific radioisotope energies will be accepted

- All areas where radioactive contamination may exist must be monitored. These areas include but are not limited to bench tops, sinks, sink drains, fume hoods, fume hood ducts, floors near waste and use areas, refrigerators or other surfaces that may have become contaminated
- A map must be submitted indicating use, storage and wipe test locations
- Results for each area monitored must be recorded as Bq/cm^2; results documented in the unit of cpm alone will not be accepted
- Monitoring instrument used must be able to detect the limits prescribed by the CNSC
- If monitoring instrument (e.g., liquid scintillation counter, contamination meter) has not been calibrated within the past month, either complete the Operational Check or prove by some method that the instrument is functioning properly, and the results are accurate
- Complete Table V - Contamination Monitoring in the Radiation Decommissioning Form

Operational Check Example:

Calibration Standard	Activity of Standard (dpm)	Activity Measured (cpm)	Counting Efficiency for Radioisotope	Calculated Activity*	In Agreement (Yes/No)
H-3	254300	120395	50%	127150	Yes

*Calculated activity = Activity of Standard x Efficiency = 254300 x 0.5 = 127150

CNSC Contamination Monitoring Criteria
Non-fixed contamination (averaged over an area not exceeding 100 cm^2) does not exceed:

- 0.3 Bq/cm^2 for all class A radionuclides,
- 3 Bq/cm^2 for all class B radionuclides,
- 30 Bq/cm^2 for all class C radionuclides, or
- or the most stringent limit may be used.

To achieve the best practices and adhere to the ALARA principle, uOttawa RSP has set the contamination monitoring criteria of 0.3 Bq/cm^2 for all radioscopes.

Fixed contamination must be reported to the Radiation Safety Specialist who then must inform the CNSC.

Contamination Monitoring Records
The CNSC has stipulated in the regulations that record retention period for contamination monitoring results is 1 year after the expiry of the NSRD Licence. If you are decommissioning your Permit, you should submit all your contamination monitoring record (either original or scanned copies) to OCRO, who will retain these records. If you are decommissioning a location, you are still responsible for keeping all your contamination monitoring records.

PART D – PERSONNEL

All personnel listed on the Permit Users List must be removed as an authorized user or transferred to another Permit.

- Complete Table VI - Status of Authorized Users in the Radiation Decommissioning Form

PART E – SIGNAGE

All signs and symbols must be removed from all locations listed on your permit. Signage includes permits, CNSC poster, labels on waste containers etc. For all decommissioning types, respond to questions.

PART G – APPROVAL

Personnel who undertake decommissioning activities and the Permit Holder must put their signatures at the bottom of the Radiation Decommissioning Form, and the form must be sent to OCRO rad.safety@uottawa.ca for final approval.