RADIATION SAFETY MANAGEMENT PLAN – CHW

POLICY©

DOCUMENT SUMMARY/KEY POINTS

- This Radiation Safety Management Plan provides information about ionising radiation, basic radiation safety, implementation of radiation safety, and how ionising radiation is utilised within The Children's Hospital at Westmead (CHW).
- Outlines the education, training and licensing requirements for users and operators of ionising radiation apparatus and unsealed radioactive substances within CHW.
- At SCH, Radiation Safety is covered by a SLA with POW/SESLHD, refer to the following SESLHD policies: https://www.seslhd.health.nsw.gov.au/policies-and-publications/functional-group/93
- To be read in conjunction with **Local Work Procedures**:
  - Radiation and Pregnancy
  - Radiation Incidents and Special Procedures
  - Exposure of Humans to Ionizing Radiation for Research Purposes
  - Radiation Safety In Laboratories
  - Radiation Safety in Medical Imaging
  - Radiation Safety in Nuclear Medicine
  - Radiation Safety in Haematology
  - Radiation Safety in Dentistry

Approved by:	SCHN Policy, Procedure and Guideline Committee	CHW Radiation Safety Committee
Date Effective:	1st March 2022	**Review Period**: 3 years
Team Leader:	Radiation and Laser Safety Officer	**Area/Dept**: Radiation Safety

CHANGE SUMMARY

- Updated to reflect updated Australian Standards, the use of EMR and clarification of sections to greater understanding for the reader.
- Updated to include information for the Block K (shared services with Westmead Adults Hospital)
- Removal of sections and creation of **new Local Work Procedures** to streamline easier access to relevant information.

READ ACKNOWLEDGEMENT

Email notification of release of this document to the following, with their discretion to distribute to their staff:

- Chief Radiographer
- Chief Nuclear Medicine Scientist
- Director of Nursing - CHW
- NUM – Camperdown Ward
- NUM – Commercial Travellers Ward
- NUM – Operating Suite
- HOD – Dentistry
- HOD – Emergency Department
- HOD – Haematology
- HOD – Gastroenterology
- HOD - Maintenance
- HOD – Speech Pathology
- Laboratory Manager – Endocrinology
- Manager – Security
- Operations Manager – Kids Research (KR)
- Operations Manager – Pathology
- Members of the Radiation Safety Committee

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1 Glossary of Abbreviations

ALARA	As Low As Reasonably Achievable
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
Bq	Becquerel
CT	Computed Tomography
EPA	Environmental Protection Authority (NSW)
EPD	Electronic Personal Dosimeter
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IMS+	Incident Management System
MBS	Modified Barium Swallow
NCRP	Nation Committee on Radiation Protection (USA)
OSLD	Optically Stimulated Luminescent Dosimetry
pQCT	peripheral Quantitative Computed Tomography
RRM	Radiation Regulated Material
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RWS	Radiation Waste Store
TLD	Thermoluminescent Dosimetry
VFSS	Videofluoroscopic Swallow Studies

2 Introduction

This plan is a guide for workers involved, directly or indirectly, with the use of ionising radiation apparatus and / or radioactive materials. Further information may be obtained from the Radiation Safety Officer, Nuclear Medicine Department.

3 Roles and Responsibilities

Radiation safety at CHW is structured such that there is an appointed Radiation Safety Officer who reports to the Radiation Safety Committee and provides regular updates to the CHW WHS Committee Meeting. The overall responsibility for radiation safety at CHW rests with the Radiation Safety Committee.

3.1 Responsibilities of the Employer (SCHN-CHW)

- The Network has obligations under the NSW Work Health and Safety Act (2011) to ensure, so far as is reasonably practicable:
    - The health and safety of its workers;
    - The health and safety of workers whose activities in carrying out work are influenced or directed by the Network; and
    - The health and safety of other persons i.e. patients and visitors, is not put at risk from work carried out as part of the conduct of the Network.
- The Network must ensure that each occupationally exposed person in the employ of the employer is not exposed to ionising radiation that exceeds the dose limits for occupationally exposed persons under the NSW Radiation Control Regulation (2013).

3.2 Responsibilities of Workers and Others

- While at work, a worker must:
    - Take reasonable care for their own health and safety;
    - Take reasonable care that their acts or omissions do not adversely affect the health and safety of other persons;
    - Comply, so far as the worker is reasonably able, with any reasonable instruction that is given by the Network to allow the Network to comply with NSW Work Health and Safety Act (2011); and
    - Co-operate with any reasonable policy or procedure of the Network relating to health or safety at the workplace that has been notified to workers.
- All persons at a workplace must:
    - Take reasonable care for their own health and safety;
    - Take reasonable care that their acts or omissions do not adversely affect the health and safety of other persons; and

- Comply, so far as the person is reasonably able, with any reasonable instruction that is given by the Network to allow the Network to comply with NSW Work Health and Safety Act (2011).

3.3 Radiation Safety Officer (RSO)

The NSW Radiation Control Regulation (2013) provides for the appointment of a Radiation Safety Officer to advise and assist an employer in fulfilling their responsibilities for radiation safety where ionising radiation is in routine use. The EPA has a guideline for RSOs and Radiation Safety Committees available on their website.

3.4 Radiation Safety Committee (RSC)

The Radiation Safety Committee is comprised of members from the radiation-based specialities within CHW: including wards where radiation is used routinely, research facilities and the Radiation Safety Officer. The Committee reports to the SCHN Quality Safety Committee on a biannual basis. The Committee's terms of reference cover ionising and non-ionising radiation safety, and its activities include receiving regular reports from the RSO, considering research proposals involving radiation or radioactive material, investigating incidents involving radiation, and approving procedures for uses of radiation.

4 General Information

4.1 Ionising Radiation

Ionising radiation is defined as radiation capable of producing ions in its passage through matter. Examples of ionising radiation are:

- **Alpha (α) particles** consist of a helium nuclei; two protons and two neutrons. These four particles are tightly bound and behave like a fundamental particle with a charge of +2 (positive charge).

  Alpha particles are usually emitted by heavy radioactive atoms such as uranium and radium. Being large and relatively slow, they quickly dissipate their energy by colliding with the atoms of the material through which they travel causing ionisation to take place. Alpha particles thus have very little power of penetration and are stopped completely by a thin sheet of paper, the outer layer of human skin, or a few centimetres of air. Alpha emitters are most damaging when incorporated into the body, and are not normally used unless securely sealed.

- **Beta (β) particles** consists of high-speed electrons which originate in the nucleus. They have identical properties to atomic electrons with a -1 charge (negative charge).

  Being light weight and emitted with a speed close to that of light, beta particles have greater penetrating ability than alpha particles of the same energy, but still will be stopped by a few millimetres of aluminium, a centimetre or so of human tissue, or a few metres of air, dependent on their energy. Beta emitters are also most hazardous when ingested, but can also be hazardous externally; especially to the cornea.

- **Positrons (β^+)** have the same mass as an electron but carry a positive charge instead of a negative charge. They have the same properties as beta particles however they eventually combine with an electron which results in the emission of two gamma rays. Radioactive substances which emit positrons are used in positron emission tomography (PET scans).

- **Gamma (γ) rays** are electromagnetic in nature, travelling at the speed of light (3x108 m/s) and having both particle and wave-like properties. Gamma rays result from changes in the nucleus and do not have any mass or charge.

  They have a high penetration power and can pass through several hundred metres of air or many centimetres of dense materials such as iron or lead. Gamma emitters are hazardous internally and externally, although less damaging than the particles sources.

- **X-rays** are physically identical to gamma rays and differ only in their means of production, which is usually by means of electrons striking a dense material as occurs in a common diagnostic x-ray machine.

- **Neutrons** are subatomic particles with no net energy charge and a mass slightly larger than that of a proton. They are high speed nuclear particles that have an ability to penetrate other materials. Neutrons can make objects radioactive via a process called neutron activation.

4.2 Radiation Units and Quantities

- **Energy (eV):** the energy gained by an electron in passing through an electric potential of 1 Volt. This is a very small amount of energy, we generally talk in terms of kilo (k) or mega (M) electron volts.
- **Activity (Becquerel, Bq):** the number of nuclear disintegrations occurring in a given quantity of material per unit time. The scientific unit is the Becquerel (Bq); and is defined as one nuclear disintegration per second.
- **Half-life**
  - The physical half-life is the time for half the amount of a substance to undergo radioactive decay
  - The biological half-life is the time for half the amount of a substance to be eliminated from the body following absorption.
  - The effective half-life is the time taken for the radiological effect of the substance absorbed into the body to be reduced by half by biological elimination and radioactive decay.
- **Exposure (C/kg):** the measurement of the amount of ionisation produced in air by a given radiation source. It is measured in coulombs per kilogram of air at normal temperature and pressure and is directly related to the number of radioactive particles or gamma rays per unit area incident on a given body of mass.
- **Absorbed Dose (Gray, Gy):** the measure of energy deposition in any medium by any type of ionising radiation. The SI unit is the Gray (Gy) and is defined as an energy deposition of 1 J/kg:
- **Equivalent Dose (Sievert, Sv)**: Different ionising radiations have different radiobiological effectiveness. To determine the doses of different radiations and to obtain the total biologically effective dose, the absorbed dose of each type of radiation is multiplied by a radiation weighting factor, w_R, which reflects the ability of the particular type of radiation to cause damage.
- **Effective Dose (Sievert, Sv)**: Different organs and tissues have differing sensitivities to radiation. Effective dose is obtained by summing the equivalent doses to all tissues and organs of the body multiplied by a weighting factor, w_T, for each tissue or organ.

4.3 Sources of Ionising Radiation

Radiation exposure may be experienced in the workplace (occupational exposure), by members of the public (general exposure), or by patients (medical exposure). Only occupational and general exposures are limited by regulations. The nature of the exposure may be intentional or accidental.

The majority of the average annual radiation dose to the population is from natural sources of radiation. In Australia the background radiation dose equivalent is of the order 1.5 mSv. The sources of this radiation are varied, refer to **Error! Reference source not found.** below, but the largest component is natural radon, which arises from the decay of trace amounts of uranium in the ground.

Medical sources are the largest man-made component of background. Cosmic radiation arises mainly from the sun, and increases quickly with altitude above sea level, as the earth's atmosphere is a natural radiation shield. Ingestion of radiation from food and drink, world-wide, is largely natural and thus almost impossible to reduce.

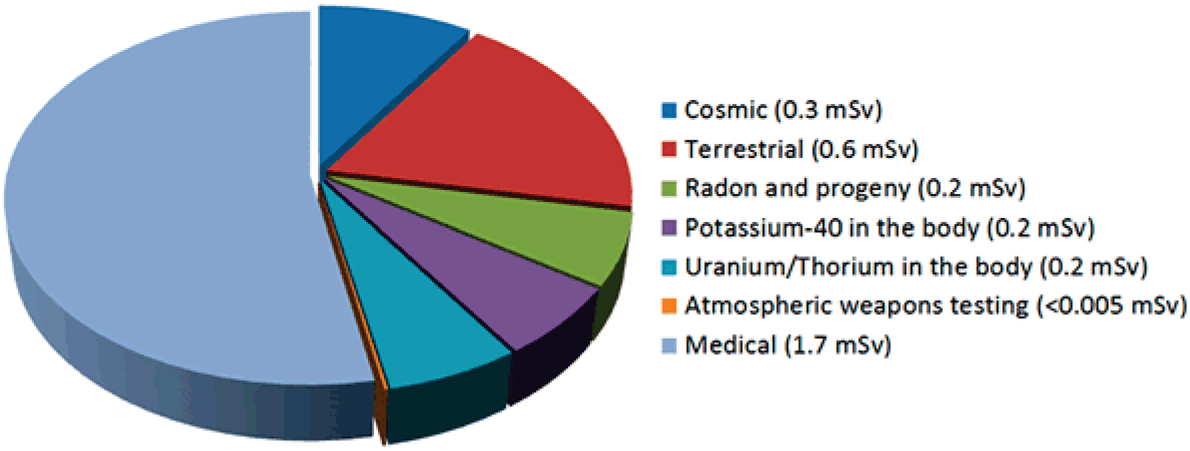

Figure 1: Average yearly radiation exposure in Australia (*source: ARPANSA website accessed June 2021*)

4.4 Radiological Risk

When risk has a benefit to an individual as does the medical use of ionising radiation to patients, the risk may be justified with respect to the benefit. The ICRP 103 (2007) publication is the latest international review of the health risks attributable to ionising radiation. They use life-span study data from the Hiroshima-Nagasaki atomic bomb survivors and other biological and epidemiological information, and assume a linear response at low doses, with the combined detriment due to excess cancer and heritable effects remains approximately 5% per Sievert.

Communication of this risk and how individual people perceive risk is important, especially within the paediatric setting. The use of ionising radiation for diagnosis, assistance in medical interventional procedures and therapy, the benefits need to be weighed relative to the potential risks, and also against the risk of not performing the exam/intervention or therapy.

4.5 Radiation Protection Principles

Radiation effects are divided into two groups and defined as follows:

- Stochastic Effects: malignant disease and heritable effects for which the probability of an effect occurring, but not its severity, is regarded as a function of dose without threshold.
- Tissue Reactions (previously called Deterministic Effects): injury in populations of cells, characterised by a threshold dose and an increase in the severity of the reaction as the dose is increased further.

The objective of radiation protection is to prevent harmful tissue reactions (deterministic effects), and to limit the occurrence of stochastic effects to acceptable levels.

This objective is achieved by a philosophy based on:

- Justification: the process of determining whether either (1) a planned activity involving radiation is, overall, beneficial, i.e. whether the benefits to individuals and to society from introducing or continuing the activity outweigh the harm (including radiation detriment) resulting from the activity; or (2) a proposed remedial action in an emergency or existing exposure situation is likely, overall, to be beneficial, i.e., whether the benefits to individuals and society (including reduction in radiation detriment) from introducing or continuing the remedial action outweigh its cost and any harm or damage it causes.
- Optimisation: the process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, **A**s **L**ow **A**s **R**easonably **A**chievable (the **ALARA** principle), economic and societal factors being taken into account.
- Dose and Risk Limitation: setting limits to the equivalent dose, not including natural or medical radiation, which can be received in any year by workers and the general public.

Dose limits are treated as just that, and not a permitted maximum. For patients, the lowest radiation dose which provides the diagnostic information or medical therapy should always be aimed for, utilising the ALARA principle.

The occupational and general dose limits are set by the International Commission on Radiological Protection (ICRP; Publication 103 (2007)) and have been incorporated into the NSW Radiation Control Regulation (2013).

5 Legislative Requirements

5.1 Overview of the Act and Regulation

The NSW Environmental Protection Authority (EPA), through its Hazardous Materials, Chemicals and Radiation section is responsible for administering the NSW Radiation Control Act 1990 (the Act) and the NSW Radiation Control Regulation 2013 (the Regulation). The Act and Regulation control all uses of radiation apparatus and radioactive materials in NSW.

The objectives of the Act are:

- to secure the protection of persons and the environment from exposure to ionising and harmful non-ionising radiation to the maximum extent that is reasonably practicable, taking into account social and economic factors and recognising the need for the use of radiation for beneficial purposes
- to protect security-enhanced sources from misuse that may result in harm to people or the environment
- To promote the radiation protection principles.

5.2 NSW EPA Publications

The NSW EPA has mandatory requirements for all ionising radiation apparatus used in diagnostic imaging (mandated from 5th April 2021). These are outlined in Radiation Standard 6, and parts relevant to CHW are listed below:

- Part 2: Radiography (medical) and bone mineral densitometry
- Part 3: Dentistry (including maxillofacial)
- Part 4: Fluoroscopy
- Part 5: Computed tomography

These documents outline the compliance tests required for ionising radiation apparatus to be listed on a valid NSW EPA issued Radiation Management Licence (RML) and aim to contribute to dose reduction by:

- ensuring that adequate safety measures are provided to protect patients, occupationally exposed workers and the public from unnecessary radiation exposure
- improving the standard of radiation apparatus in use
- ensuring better monitoring of apparatus performance
- providing reference dose levels as a guide to patient exposure.

5.3 Relevant Codes of Practice and Standards

The Act allows for the adoption of documents forming part of the National Directory for Radiation Protection. The following have been gazetted, and are relevant to this Radiation Management Plan:

- RPS 2 – Code of Practice for the Safe Transport of Radioactive Material (2008)

- RPS 8 – Code of Practice: Exposure of Humans to Ionising Radiation for Research Purposes (2005)
- RPS 10. Code of Practice and Safety Guide for Radiation Protection in Dentistry (2005)
- RPS 11 – Code of Practice: Security of Radioactive Sources (2019)
- RPS 14 – Code of Practice: Radiation Protection in the Medical Applications of Ionising Radiation (2008)

In addition, the following three Safety Guides are available to assist in meeting the requirements of RPS 14:

- RPS 14.1 Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology
- RPS 14.2 Safety Guide for Radiation Protection in Nuclear Medicine
- RPS 14.3 Safety Guide for Radiation Protection in Radiotherapy

Several other ARPANSA publications are available and provide guidance and may be gazetted in the future:

- RFS 1 - Fundamentals for Protection Against Ionising Radiation (2014*)*
- RPS C-1 (Rev. 1)- Code for Radiation Protection in Planned Exposure Situations (2020)
- RPS C-5 – Code For Radiation Protection in Medical Exposure (2019)

There are significant penalties for both the employer (SCHN-CHW) and the individual for breaches of the Act and its associated subordinate legislative documents, in the form of fines, imprisonment or both.

5.4 Licences

The EPA issues two different types of radiation licence, as per the Regulation (2013):

- **Radiation User Licence**

A radiation user licence may have one or more conditions attached to it. These conditions are determined by the work proposed under the licence, as well as the qualifications and experience the applicant must have to be eligible to be granted a user licence. Licence conditions form part of the licence and must be adhered to by the licensee. It is the responsibility of each person using radiation to acquire and maintain their own radiation user licence. A copy must be given to their Department Head, and the RSO.

- **Radiation Management Licence**

CHW maintains a Radiation Management Licence (RML); the purpose is defined by the EPA as “to regulate, restrict or prohibit the possession, sale, storage, giving away, and disposal of regulated material to protect the community and the environment from exposure to radiation.”

The Radiation Safety Officer (RSO) is responsible for maintaining the Radiation Management Licence for CHW. The RSO will maintain a record of all regulated materials and premises to ensure that the RML is current, and of the radiation users and their licence conditions.

It is the responsibility of the regulated material owner (department, laboratory or research facility) to ensure that a valid EPA Certified Radiation Expert (CRE) Compliance Certificate, where applicable, is maintained and a copy provided to the RSO.

5.4.1 Radiation User Licence Exemptions

The Regulation allows for a person to be exempt from having to hold a user licence for specific regulated material, provided that a defined level of supervision is maintained. Persons exempt from holding a radiation user licence include:

- A medical registrar in training in nuclear medicine, diagnostic radiology, ophthalmology, dermatology, rheumatology, or a discipline which uses fluoroscopy,
- Students in any subspecialty of medical radiation science,
- Undergraduate or postgraduate students whose coursework or research requires them to use radioactive substances or radiation apparatus,
- Registered nurses who are required to administer radiopharmaceuticals

Exemptions can only be granted by an appropriately licensed person who is entitled to grant exemptions by a condition of their licence, and all exempted persons are subjected to supervision by appropriately licenced persons. The valid exemption notice must be either displayed at each place in which the regulated material to which the approval relates are proposed to be, or given to each person to whom it relates. The notice must:

- specify the regulated material to which it relates
- set out any additional conditions to which it is subject
- identify each person, or class of persons, to whom it relates
- Identify the person or persons, or class or classes of persons who are to supervise each person, or class of persons, to whom it relates. For example, radiographers are to supervise student radiographers undertaking clinical experience or use the individuals' names.

5.5 Dose Limits and Constraints

All persons, including hospital staff, who are exposed to ionising radiation as part of their employment are deemed to be occupationally exposed, and therefore are subject to legal radiation dose limits. The limits are set out in Schedule 5 of the Regulation.

6 Education and Training

As CHW utilises radiation for various diagnostic and therapeutic purposes it is important that education and training is provided to all radiation workers and relevant workers. By providing training and education to workers it ensures radiation safety of themselves, patients and members of the public.

HETI/My Health Learning has a basic Radiation Protection Awareness course (course code 332428814) available to all staff and managers. It is not CHW-specific and is not mandatory but can be used as a basic introduction to radiation protection and awareness of hazards for all workers within CHW.

6.1 Local Induction and Hazard Identification

Within each department, work area or ward, a local Work, Health and Safety Induction should be completed which outlines the hazards, location of SWP, procedures, personal protective equipment (PPE) and risk registers. If radiation is used, administered or there is the potential for exposure then the local induction should include a relevant section on radiation safety and protection. Please contact the Radiation Safety Officer for assistance in setting up the relevant information or to run the session for you.

6.2 User Training

6.2.1 Medical Imaging Department

The Medical Imaging department performs diagnostic and interventional radiology procedures using various imaging modalities.

Radiologists, radiographers and specialists other than radiologists who utilise the Medical Imaging department apparatus must hold a valid NSW EPA Radiation User licence and professional accreditation, as appropriate for their role. The relevant managers should maintain a register of all workers, licence expiries, any licence conditions and training.

Medical Imaging nurses must be provided with radiation safety training relevant to their position and their integral role within the department.

All workers within Medical Imaging should have suitable knowledge of radiation safety in order to create a safe working environment for themselves, colleagues and patients.

- Interventional Apparatus

ICRP Publication 121 summarises that interventional procedures should be performed by experience paediatric interventional staff due to the potential for high patient radiation dose exposure, and additional training in radiological protection is recommended to protect both patients and staff. Complex interventional procedures have been shown to impart high absorbed doses to the exposed organs and tissues in children.

The Interventional Radiologists and Cardiac Specialists that perform these procedures must provide adequate information to patients, parents/carers and referring doctors including potential radiation effects from these complex procedures. An infosheet or factsheet is an appropriate communication pathway used at SCHN/CHW.

- CT apparatus

Site-specific CT training should be completed for users of the apparatus by the manufacturer. Specific consideration should be taken when creating and optimising protocols for the paediatric population, be it weight-based or age-based, the protocol selected for the patient should be optimised for that patient. The Senior Radiographer and the CT Radiologist should routinely reviewed and optimise the protocols for the CT apparatus, submit DRLs to ARPANSA on an annual basis for comparison to the national DRL.

6.2.2 Nuclear Medicine Department

The Nuclear Medicine department performs diagnostic and therapeutic nuclear medicine procedures using various imaging modalities.

Nuclear medicine physicians, nuclear medicine scientists, hospital scientists and radiopharmacists who utilise the Nuclear Medicine department apparatus and laboratory must hold a valid NSW EPA Radiation User licence and professional accreditation, as appropriate for their role. The relevant managers should maintain a register of all workers, licence expiries, any licence conditions and training.

Radiation safety training around the correct use, administration and disposal of radioactive substances and apparatus is covered in the majority of the specific undergraduate/postgraduate qualifications that workers have. Site-specific training is performed at induction and whenever there are changes to the department.

For hybrid equipment, for example a SPECT/CT, site-specific CT training should be completed for users of the apparatus by the manufacturer. Specific consideration should be taken when creating and optimising protocols for the paediatric population, be it weight-based or age-based, the protocol selected for the patient should be optimised for that patient.

6.2.3 Laboratory, Kids Research and Pathology Departments

For those working with radioactive substances or ionising radiation apparatus a valid NSW EPA radiation user licence may be required, and radiation safety training is required prior to commencement of new starters (at induction), or at routine intervals (refresher sessions). In order to obtain a NSW EPA radiation user licence completion of a radiation safety course is required. CHW specific radiation safety training can be provided by the CHW RSO.

All workers are responsible for performing all procedures in accordance with their specific department, centre or laboratory’s written standard protocols/procedures or policies and in compliance with the radiation safety information outlined in **Error! Reference source not found.**. There should be a documented procedure or scientific method for all uses of radioactive substances. Radioactive substances must only be handled and stored in designated areas and are listed on the CHW Radiation Management Licence.

Laboratory Managers or Supervisors are responsible for ensuring that all procedures are performed safely, that workers are trained appropriately for working with radioactive substances or ionising radiation apparatus, and where appropriate are issued with personal radiation monitoring devices.

Each laboratory or department must maintain a training record for all workers, including any students which can be provided to the CHW RSO or SCHN WHS during routine audits.

7 Radiation Monitoring

7.1 Personal Monitoring Requirements

The Regulation (2013) imposes responsibilities on CHW to record and monitor all occupationally exposed persons in their employ who are involved in the use of ionising radiation for any one of the purposes listed in the following:

- Nuclear medicine
- Diagnostic or interventional radiology (other than dentistry, veterinary and chiropractic applications)
- Scientific research in laboratories classified as medium or high level laboratories where radioactive substances not contained in a sealed source device are used.

Other departments and/or research areas may be monitored as well, but it is not a mandatory requirement. Workers issued with a personal radiation monitoring device (OSLD or TLD) by their employer are required under the legislation to wear the personal monitoring device/dosimeter while at work. A worker may be fined for not wearing the dosimeter/device when working with ionising radiation.

If a worker is required to wear a lead gown during the course of their duties, the dosimeter/device should be worn under the gown. If an employee is issued with two badges, one is to be worn under the gown (labelled IN) and the other worn on the collar of the gown (labelled OUT).

Most monitoring devices are issued on a quarterly (12 week basis), for high dose rate procedures monitors may be issued monthly (Cardiac Cath Lab operators) as required.

- **New Staff**

When a new staff member is recruited to an area that requires personal radiation monitoring either the designated officer within that department or the Radiation Safety Officer can arrange for a personal badge. If the staff member previously worked in a facility that issued a radiation badge that staff member needs to provide their exit dosimetry letter to the Radiation Safety Officer and Department Head.

- **Exiting Staff**

Under the Radiation Control Regulation when a staff member leaves CHW, CHW must provide a copy of the radiation exposure record relating to their employment. These are provided by the Radiation Safety Officer, each department liaison should contact the Radiation Safety Officer prior to the staff member leaving.

Monitoring of radiation exposure is carried out by the relevant individual departments, with different measuring techniques used, dependent on the type of ionising radiation used. The results are held by a designated officer within each relevant department and held centrally with the Radiation Safety Officer in the Historion database. If any results are abnormally high, these are reported to the Radiation Safety Officer and the Department Head.

An abnormally high result is as outlined below:

- Monthly Monitoring Period: 500 μSv or greater
- Quarterly Monitoring Period: 1 mSv or greater

7.2 Types of Monitoring Devices

7.2.1 Optically Stimulated Luminescent Dosimetry (OSLD)

These dosimeters use aluminium oxide crystals dispersed in plastic wafers as the detector material, and behave in a similar way to TLDs. The amount of radiation exposure captured on the crystals is measured by applying a green light (from either a laser or a light-emitting diode (LED)) and measuring the amount of blue light emitted. The amount of blue light emitted is proportional to the radiation exposure

7.2.2 Thermoluminescent Dosimetry (TLD)

Thermoluminescence dosimeters use the electron trapping process; when ionising radiation interacts with a thermoluminescent material, electrons are energised and caught in traps (imperfections/impurities within the crystal structure) in the forbidden band. To determine the dose received the thermoluminescent material is heated to a known temperature (usually 200°C) which enables the electrons to move back into the excitation band and then return to the valence band (ground state) by the emission of a light photon. This light output is measured using a photomultiplier tube and is proportional to the initial radiation dose captured by the dosimeter.

7.2.3 Electronic Personal Dosimeters

An Electronic Personal Dosimeter (EPD) is a “real-time” dosimeter which provides a direct display of either accumulated dose or dose rate. Generally EPD’s use miniature Geiger-Müller as the detectors but new generations are implementing solid-state detectors. Generally these are used within the Nuclear Medicine department with therapy procedures but can be issued to other staff on an as required basis via the Radiation Safety Officer.

8 Facilities (Shielding Design, Signage and Storage)

8.1 Signage

A radiation warning sign is described within the Regulation, Schedule 6. The correct dimensions and colours must be used when signage is displayed within CHW. The specific requirements for signage for radiation apparatus and radioactive substances are outlined in the subsections below.

8.1.1 Radiation Apparatus

A radiation warning sign complying with Schedule 6 of the Regulation must be displayed on the outside of the entry doors to any:

a) room in which a fixed radiography apparatus is installed, or

b) dedicated room in which a mobile or portable apparatus is permanently used.

A radiation warning light must be positioned at the entry doors to all radiography rooms, or where a CRE has determined that it would not pose a risk to the safety of any person if there were no warning light.

Where a radiation warning light is provided, the light must remain illuminated for the duration of the exposure and must bear the words 'X-RAYS—DO NOT ENTER' or similar. Immediate illumination must be ensured.

8.1.2 Laboratories/Premises where radioactive substances are used

A sign must be conspicuously placed either in or near the entry to all registered labs listing the Occupier (person in charge of the lab), the EPA registration number for the premises, the registration expiry date and the name and telephone number of the person to contact in the event of an emergency affecting the premises.

8.2 Shielding

New installations and upgraded equipment areas should be sent to the Radiation Safety Officer for review against compliance with regulatory documents and local policies and procedures. All shielding should be in line with the NSW EPA Guideline 7, or any subsequent published revision of this document.

Reference documents for shielding include:

- Sutton, D. G., Martin, C. J., Williams, J. R., & Peet, D. J. (2012). *Radiation shielding for diagnostic radiology*. London: British Institute of Radiology, 74-7
- National Committee on Radiation Protection (US). (2004). Structural shielding design for medical x-ray imaging facilities (No. 147). NCRP.

A local dose constraints of 25% of the regulatory limits (members of the public and occupationally exposed persons) should be used for CHW facility design.

8.3 Personal Protective Equipment

Mobile lead shields, leaded-glass shields and lead-equivalent aprons/vest/skirts/thyroid collars are available across CHW. All must be labelled with appropriate kVp lead equivalence and tested annually.

All workers wearing lead PPE must comply with the lead apparel risk assessment and SWP for that area

8.4 Storage

For the correct storage of radioactive materials, please contact the Radiation Safety Officer and refer to the AS/NZS 2243.4:2018 with section 5.1 outlining the requirements for storage of radioactive materials.

9 Death Procedures – Bodies containing radioactive material

If a patient dies during treatment with radioactive materials, the nuclear medicine specialist managing the patient's care should ensure, after consultation with the radiation safety officer, that exposure to radiation of any persons handling the body is minimised. At the time of death, the body should have a label attached clearly documenting the radionuclide, form and estimated residual activity. The body should be handled as little as possible. The Radiation Safety Officer or delegated person should be consulted before any procedures, such as laying out or post-mortem are commenced and before the body is released for embalming, burial or cremation. If a patient dies shortly after undergoing a diagnostic nuclear medicine procedure, no special precautions are required.

	Half-life (days)	Indicative maximum activity administered (MBq)	Autopsy / Embalming (MBq)	Burial (MBq)	Cremation (MBq)
P-32	14.3	200	100	2 000	30
Sr-89	50.7	200	50	2 000	20
Y-90	2.7	2 000	200	2 000	70
I-131	8.0	10 000	10	400	400

Table 1: Maximum activities proposed for autopsy, embalming, burial or cremation of the body of a patient who has died during treatment with unsealed radioactive substances (IAEA 2007)

All corpses released for autopsy, embalming, cremation or burial above the limits stated in Table 1 should have a label attached, identifying the radionuclide and its activity at the time of release, together with a release statement signed by the radiation safety officer or qualified expert.

9.1 Post-mortem or embalming

Radioactive material remaining in the corpse can be a hazard through two main pathways; external radiation exposure and radioactive contamination. External exposure to penetrating radiation emanating from a radioactive source occurs at a distance from the source, and can be partially shielded by the corpse itself. Radioactive contamination is associated with actual contact with the radioactive material and spread of the material, similar to chemical contamination.

- Prevention of Contamination: for unsealed radioactive material, standard precautions similar to those used for infection control should be used, including gloves, mask, goggles and gown. Most unsealed radioactive material is either taken up by the target organ and/or eliminated by excretion in the first few days of treatment. The most significant post-death risk of contamination from radioactive material may remain in the body fluids, tissues or organs. Further advice concerning precautionary actions can be obtained from the Nuclear Medicine Physician or the Radiation Safety Officer where the patient was treated.

It is highly unlikely that a patient at CHW will be treated with sealed sources, but if they have been the following will be relevant:

- Reduction of external exposure: the working distance from the sealed source implant site should be maximised while dealing with the corpse. If an organ containing radioactive material needs to be handled, suitable tools such as tongs or forceps should be used to maximise the distance of the hands from the radioactive material, and the time spent carrying out the procedure kept as short as possible.

9.2 Cremation

When the radioactive treatment involves unsealed radioactive material that has been incorporated into bone, or permanently implanted sealed sources (rarely used with paediatric patients) encapsulated in metal that survives the combustion process, some radioactivity will remain in or amongst the skeletal remains. Contact the Radiation Safety Officer for advice in regard to this.

Where the radioactive treatment involves radioactive materials which have not been incorporated into the bone of the deceased and which are expelled into the cremation furnace and flue during combustion, the remains will not be radioactive and so do not require handling and storage precautions.

9.3 Handling of the coffin

No restrictions are normally needed in dealing with the closed coffin following the death of a patient that has been recently released from a hospital after treatment with radioactive material.

9.4 Direct burial or mausoleum entombment

No restrictions are normally needed for direct burial or mausoleum entombment following death of a patient recently treated with radioactive material.

10 Radiation Dosimetry of Patient Procedures

The radiation dosimetry of diagnostic x-ray procedures differs from that of Nuclear Medicine procedures as the dose received is mainly a function of the imaging equipment characteristics and the number of views/projections that are taken. For medical imaging procedures the radiation dose is limited mainly to the field of view being imaged, whereas in Nuclear Medicine procedures an appreciable dose may be received by organs other than those being imaged, due to the uptake of the radiopharmaceutical.

10.1 Diagnostic Medical Imaging

The main parameters which affect patient radiation exposure, and hence radiation absorbed dose are:

- **i.** X-ray tube operating voltage (kV)
- **ii.** X-ray tube operating current (mA)
- **iii.** X-ray tube operating wave form
- **iv.** Radiographic field size
- **v.** Patient shape and size
- **vi.** Number of projections per examination
- **vii.** Source to image distance
- **viii.** Beam quality (HVL)

For CT scans and fluoroscopic procedures there are further variable machine operating characteristics which affect radiation dose. The radiation dose from any given radiological procedure may vary greatly, depending on the technique used.

The skin receives the greatest radiation dose in radiological procedures and is thus the critical organ. In some cases, other, more radiosensitive tissues in the field of view may receive an appreciable dose and so become the critical organ.

Estimation of radiation dose for radiological procedures may be done directly using radiation monitoring devices. Most publicised radiation doses are average values only, and any one individual examination the dose to the patient may be considerably greater or smaller than the publicised value. For patient specific dosimetry please contact the Radiation Safety Officer to provide an estimation of their dose.

10.2 Nuclear Medicine

The absorbed dose from a nuclear medicine procedure is dependent on the radionuclide used, its chemical form, the administered activity and also the physiological clearance mechanisms. Each patient will have a slightly different absorbed dose due to the variations on age, weight and physiological parameters

At CHW the administered activities are predominantly determined on a weight basis, but may be administered on an estimated surface area basis when required. Each different nuclear medicine procedure has an accompanying internal written procedure which outlines the administration procedures.

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Appendix A: Disaster procedures

Please refer to the Disaster Response Plan CHW Healthplan

Appendix B – Glossary

	Definition
Absorbed dose	The measure of the energy deposited in any medium by any type of ionising radiation. SI unit is the Gray.
Absorption	When radiation imparts some or all of its energy to any material through which it passes.
Activity	The number of nuclear transformations occurring in a given quantity of material per unit time. The SI unit is the Becquerel.
Alpha Particles	A strongly ionising particle emitted from the nucleus during radioactive decay having a mass and charge equal in magnitude to the helium nucleus consisting of 2 protons and 2 neutrons with a double positive charge.
Background Radiation	Ionizing radiation from natural sources, such as terrestrial radiation due to radionuclides in the soil or cosmic radiation originating in outer space.
Becquerel	The SI unit for radioactivity defines as the amount of radionuclide decaying at a rate of one transformation per second. (1 Bq = 1 transformation/ second)
Beta Particles	Charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude to that of the electron.
Bremsstrahlung	X-rays that are produced when charged particles, usually electrons, moving with a very high velocity are slowed down rapidly by striking a target.
Curie	The former unit of radioactivity, equal to 3.7×10^{10}Bq
Decay	Transformation of an unstable atomic nucleus into a more stable one, usually accompanied by the emission of charged particles and gamma rays.
Dose Limit	The value of effective dose or equivalent dose to individuals from planned exposure situations that shall not be exceeded.
Equivalent Dose	A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit is the Sievert, which is numerically equal to the absorbed dose in Grays multiplied by the radiation weighting factor.
Electron Volt	Energy gained by an electron in passing through an electric potential of 1 volt.
Exposure	A measure of the ionisation produced in air by x-ray or gamma radiation. The unit of exposure is Coulomb per kilogram.
Gamma Ray	Gamma photons are the most energetic photons in the electromagnetic spectrum. Gamma rays (gamma photons) are emitted from the nucleus of some unstable (radioactive) atoms.
Gray	The SI unit of absorbed dose, equal to one joule per kilogram.
Half-life, biological	The time required, in the absence of further input, for a biological system or compartment to eliminate, by biological processes, half the amount of a substance that has entered it.
Half-life, effective	The time required, as a result of the combined action of radioactive decay and biological elimination, for a system to reduce by half the amount of the substance that has entered it.
Half-life, physical	The time required for a radioactive substance to reduce by half its activity by decay. Each radionuclide has a specific half-life.
Half Value Layer	The thickness of a particular shielding material required to reduce the intensity to one-half its incident value.

ICRP	International Commission on Radiological Protection
Ionising Radiation	Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.
Monitoring	Periodic or continuous determination of the amount of ionising radiation or radioactive contamination present or incident on any part of an individual or his/her clothing.
Neutron	Elementary particle with mass approximately the same as that of a hydrogen atom and electrically neutral.
Non-Ionising Radiation	Radiation that has lower energy levels and longer wavelengths than ionising radiation. It is not strong enough to affect the structure of atoms it contacts but is strong enough to heat tissue and can cause harmful biological effects. Examples include radio waves, microwaves, visible light, and infrared from a heat lamp.
OSLD	Optically Stimulated Luminescence Dosimeter
Radiation	Encompasses the entire Electromagnetic Spectrum; containing both ionising and non-ionising radiation.
Radiological Survey	The evaluation of radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation under a specific set of conditions.
Radionuclide	A nuclide with an unstable ratio of neutrons to protons placing the nucleus in a state of stress. It may undergo various types of rearrangement that involve the release of radiation, in order to reorganise into a more stable state.
Sievert	The name of the SI unit of equivalent dose, effective dose. The unit is joule per kilogram ($J\ kg^{-1}$).
Specific Activity	The total radioactivity of a given nuclide per gram of a compound, element or radioactive nuclide.
TLD	Thermoluminescence Dosimeter;
X-rays	Penetrating electromagnetic radiations having wavelengths shorter than those of visible light. They are generally produced by bombarding a metallic target with fast electrons in a high vacuum.

Appendix C – Radiation Unit Conversion Table

The International System (SI) units are a consistent set of units for use in all branches of science. The General Conference on Weights and Measures acting on the recommendation of the International commission on Radiation Units and Measurements (ICRU) has adopted special unit names for SI units in connection with radioactivity.

Factor Prefix	Symbol		Factor Prefix	Symbol	
10^{18}	Exa	E	10^{-3}	Milli	m
10^{15}	Peta	P	10^{-6}	Micro	µ
10^{12}	Tera	T	10^{-9}	Nano	n
10^{9}	Giga	G	10^{-12}	Pico	p
10^{6}	Mega	M	10^{-15}	Femto	f
10^{3}	Kilo	k	10^{-18}	Atto	a

Table 2: Prefixes for SI Units

Radiation Units

Physical Quantity	SI Unit	Non SI Unit	Relationship
Activity	Becquerel (Bq)	Curie (Ci)	1 Bq = 2.7 x10^{-11} Ci = 27.0 pCi 1 Ci = 3.7 x 10^{10} Bq =37 GBq
Absorbed Dose	Gray (Gy)	Rad	1 Gy = 100 rads 1 Gy = 1 J/kg 1 rad = 0.01 Gy = 10 mGy
Equivalent Dose	Sievert (Sv)	Rem	1 Sv -= 100 rem 1 Sv = 1 J/kg 1 rem = 0.01 Sv = 10 mSv
Exposure	Coulomb/kilogram	Roentgen (R)	1 C/kg = 3876 R =3.876 kR 1 R = 2.58 x 10^{4} C/kg =258 C/kg

Table 3: Relationship between SI and non SI Units for Radiation Quantities

Appendix D – Radioactive Waste Holding Tanks

Within the undercroft of the Main Building CHW owns and operates two 9000 litre concrete holding tanks. These are connected to the toilet in room 14 within Camperdown Ward only. These tanks are used to allow for delay and decay of radionuclide waste from patients undergoing therapeutic nuclear medicine prior to discharge through the hospital sewage system. The two tanks are connected in series, with only one tank in operation at any one time. There are recirculation and out-flow pumps and pipes connected to the tanks. The other tank is used as a back-up only in the event of a discharge pump failure.

The purpose of this system is to prevent the sudden discharge of large quantities of radioactive material into the hospitals sewage system, and to accumulate and dilute radioactive material, allow it to decay to a safe level and only then to discharge the waste over a reasonable period into the sewage system.

The tank system is connected to an alarm panel which activates at both low level and high level filling. At low level, water is added to the tank to remove the alarm and to dilute any waste within the tank. At high level the contents of the decay tank are discharged into the normal sewage system.

Access to the holding tank area is restricted, but the tanks are adequately shielded and monitored by the Radiation Safety Officer on a regular basis. A radiological survey is performed by the Radiation Safety Officer prior to entry, and prior to the removal of the observation lid. This observation lid can be removed using a custom tool held by the maintenance department. This allows for a visual water/waste level check. If the tank is greater than half full, and sufficient decay has occurred since the last therapeutic patient, the tank can be discharged into the normal sewage system.

The Radiation Safety Officer maintains a record of Room 14 usage, radiological surveys of the holding tank area, and also the date of discharge of the tanks to the normal sewage system.

A risk assessment and SWP are available for reference from the Nuclear Medicine Department.

Appendix E – Legislative Dose Limits

As taken from Schedule 5 of the Regulation (2013).

Application	Dose limit	Dose limit
	Occupationally exposed persons	**Members of public (other than patients)**
Effective dose	20 mSv per year averaged over a period of 5 consecutive calendar years[4, 5, 6]	1 mSv in a year[7]
Equivalent dose to:		
(a) lens of the eye	20 mSv per year averaged over a period of 5 consecutive calendar years[4, 5, 6]	15 mSv in a year
(b)skin[8]	500 mSv in a year	50 mSv in a year
(c)the hands and feet	500 mSv in a year	No limit specified

Table 4: Dose Limits for Exposure to Ionising Radiation

Note 1. The limits apply to the sum of the relevant doses from external exposure in the specified period and the committed dose from intakes in the same period. In this Note, ***committed dose*** means the dose of radiation, arising from the intake of radioactive material, accumulated by the body over 50 years following the intake (except in the case of intakes by children, where it is the dose accumulated until the age of 70).

Note 2. Any dose resulting from medical diagnosis or treatment should not be taken into account.

Note 3. Any dose attributable to normal naturally occurring background levels of radiation should not be taken into account.

Note 4. With the further provision that the effective dose must not exceed 50mSv in any single year.

Note 5. When a female employee declares a pregnancy, the embryo or foetus should be afforded the same level of protection as required for members of the public.

Note 6. When, in exceptional circumstances, a temporary change in the dose limitation requirements is approved by the Authority, one only of the following conditions applies:

(a) The effective dose limit must not exceed 50mSv per year for the period, that must not exceed 5 years, for which the temporary change is approved,

(b) The period for which the 20mSv per year average applies must not exceed 10 consecutive years and the effective dose must not exceed 50mSv in any single year.

Note 7. In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1mSv per year.

Note 8. The equivalent dose limit for the skin applies to the dose averaged over any 1 square centimetre of skin, regardless of the total area exposed.

Appendix G – Quality Management in Radiation Safety

1. Research involving Ionising Radiation Declaration
1. Radioactive Spill Clean Up Instructions
2. Radioactive Spill Kit contents
3. NSW EPA Radiation Accident Report Template