

Radiation Health Response Plan

2014

Emergency Management Branch,
Ministry of Health and Long Term Care

www.ontario.ca/radiationhealth



Important Notice:

If you are a health organization responding to a radiological/nuclear emergency and require immediate provincial assistance, please contact the Ministry of Health and Long-Term Care's Healthcare Provider Hotline at
1-866-212-2272

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Acknowledgements

Many individuals from local public health, hospitals, professional associations, emergency medical services, government, and the nuclear industry provided their time and expertise to help develop the Radiation Health Response Plan. The Ministry of Health and Long-Term Care acknowledges their hard work and dedication to protecting the health and safety of Ontarians. The Ministry would also like to acknowledge the support of their employers and colleagues in enabling them to participate in this process.

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Chapter 1 Introduction

1.1 The Requirement for a Radiation Health Response Plan

The [*Provincial Nuclear Emergency Response Plan, Master Plan 2009 \(PNERP\)*](#)¹ requires the Ministry of Health and Long-Term Care (MOHLTC) to develop and maintain a plan for the management of patients that have been exposed to radiation as a result of a radiological or nuclear incident of an accidental or deliberate nature. The *Radiation Health Response Plan (RHRP)* fulfills that requirement.

There are a variety of radiological or nuclear-related scenarios that could occur in Ontario; for example, Ontario has the highest number of nuclear power facilities in Canada, there are numerous industrial uses of radiation, and radiation sources are transported using provincial highways and railways on a daily basis. Moreover, international events over the past 30 years including the nuclear plant accident at Chernobyl in 1986, the contamination of thousands in Goiania Brazil in 1987, the public health concerns following the radiation poisoning of a former Soviet spy in Britain in 2007, and the meltdown of the Fukushima Daiichi Nuclear Plant in Japan following an earthquake and tsunami in 2011, demonstrate the need to ensure that Ontario's health system is prepared to respond and manage the health effects from a radiological/nuclear (RN) incident.

1.2 Purpose

The *RHRP* is designed to guide health sector planning at both the provincial and local levels across Ontario. It describes how Ontario's health system responds to an RN incident of deliberate or accidental nature, and the conditions under which precautionary and protective actions are implemented for the general public and health system.

The *RHRP* sets out a comprehensive provincewide approach to health planning and response, and provides information to guide local RN planning groups. It establishes the roles and responsibilities, the operational concepts, and the response principles for coordinating the provincial response of health organizations. The *RHRP* endeavours to strike a balance between providing enough direction to ensure a consistent provincial health response, while still allowing for local flexibility.

The *RHRP* primarily supports the *PNERP* and shall be activated within the context of that plan. However, the *RHRP* can be activated by the MOHLTC even if the *PNERP* has not been activated. For example, components of this plan could be used as a guideline for events that are not an imminent threat like an offshore nuclear incident which may or may not impact Ontario.

The process of developing and maintaining the *RHRP* is managed and coordinated by the Emergency Management Branch (EMB) of the MOHLTC. In the event of an RN incident, the health care system's response is managed from the Ministry Emergency Operations Centre (MEOC) following the overall decision-making structure defined under the *PNERP*. An RN incident will most likely overwhelm local resources and require provincial direction; the incident may also result in the activation of the *Federal Nuclear Emergency Plan (FNEP)*.

¹ Titles of acts, plans and supporting documents are formatted in *italics* in the text.

The *RHRP* is a “living document”. It is reviewed and revised at least once every five years, preferably following a full exercise of the plan, to reflect new response processes, current knowledge, best practices, and the evolving plans and mandates of federal and provincial organizations such as Health Canada and the Ontario Office of the Fire Marshal and Emergency Management. The review is conducted by a reference group that includes federal, provincial, and municipal representatives from emergency management; public health units; labour; the nuclear industry; and the health care delivery system.

This initial version of the *RHRP* contains information and resources to assist the MOHLTC’s stakeholders and partners in increasing their organization’s RN knowledge and understanding, and to support the development of their own RN plans. The information and resources can be found throughout the *RHRP* in the form of informative sections, text boxes, and footnotes that contain resources, references, and information from a number of leading RN sources outside of the government of Ontario, e.g., the U.S. Department of Health and Human Services’ [Radiation Emergency Medical Management \(REMM\)](#), [Radiation Emergency Assistance Centre/Training Site \(REAC/TS\)](#) in Oak Ridge, Tennessee, and the [International Atomic Energy Agency \(IAEA\)](#). These should be considered as possible references for creating RN plans only and should not be considered guidance from the government of Ontario. It is anticipated that future versions of the *RHRP* will evolve to become more response oriented with less additional information and resources.

1.3 Goal

The goal of the *RHRP* is to ensure the readiness of the Ontario health sector to respond to a radiological/nuclear incident of deliberate or accidental nature so that the risk of illness and death is minimized, and health workers are protected.

1.4 Scope

The *RHRP* involves the coordination of health organizations and their resources to deal with potentially exposed and/or contaminated persons following an RN incident of accidental or deliberate nature. Significant RN incidents will likely be beyond the capabilities of local health resources, and require strategic and tactical interventions at the provincial level. The plan covers incidents that occur inside the province as well as those that take place outside, but may have health impacts within Ontario. It is anticipated that all RN incidents, both large and small, will have health system implications and require engagement by the MOHLTC.

The *RHRP* covers coordination issues related to the entire health management process for the planning, response, and recovery phases. It addresses concerns for the victims directly affected by the incident as well as the management of public health and psychosocial impacts that may occur as an indirect consequence of the emergency.

The *RHRP* is a provincial health coordination plan and guidance document, not a complete list of procedures. Emergency procedures and checklists are the responsibility of the local level. The *RHRP* does not provide detailed plans and arrangements for local health organizations. Such organizations, which may be called upon to respond as part of the *RHRP*, should develop their own emergency plans and procedures that are supportive of the coordinating doctrine provided in the *RHRP*.

It is important to review this plan in its entirety in order to become familiar with its content and structure. The information contained in this plan can be adapted by users according to their own needs. The MOHLTC will plan regular awareness sessions with various stakeholders to promote this.

The *RHRP* is issued by the Emergency Management Branch of the MOHLTC, and the intended audiences are the health sector and emergency management professionals.

1.5 Nuclear and Radiological Emergencies

For the purposes of this plan, the *PNERP* definitions for a nuclear and radiological emergency are used.

A nuclear emergency occurs when there is an actual or potential hazard to public health, property, and/or the environment from ionizing radiation whose source is a major nuclear installation within or immediately adjacent to Ontario. Such a hazard is usually caused by an accident, malfunction, or loss of control involving radioactive material.

A radiological emergency would occur when there is an actual or potential hazard to public health, property, and/or the environment from ionizing radiation resulting from sources other than a major nuclear installation. Such a hazard is usually caused by an accident, malfunction, or loss of control involving radioactive material.

1.6 Next Steps for the MOHLTC in Radiological/Nuclear Planning

In addition to regularly exercising, reviewing and revising the *RHRP*, and strengthening internal processes, the MOHLTC will work with its partners to:

- Conduct awareness sessions promoting the *RHRP* and the assistance the MOHLTC can provide partners in conducting RN-related planning.
- Assess, and update as required, the equipment included in the CBRN (Chemical, Biological, Radiological, Nuclear) Emergency Preparedness Program.
- Provide opportunities for various types of health sector training on RN-related planning and response.
- Strengthen relationships with the health sector, and municipal, provincial, and federal partners, to ensure a collaborative and sophisticated response to an RN incident.

Acronyms and Abbreviations

AECL - Atomic Energy of Canada Limited
ALI - Annual Limits on Intake
ARS - Acute Radiation Syndrome
Bq - Becquerel
CANDU - The name of the Canadian developed nuclear power reactor system (from Canada Deuterium Uranium)
CBRNE - Chemical, Biological, Radiological, Nuclear, Explosive
CDC - Centers for Disease Control
CEMC - Community Emergency Management Coordinator
Ci - Curie
CJIRU - Canadian Joint Incident Response Unit - Canadian Forces
CMOH - Chief Medical Officer of Health - Ontario
CNSC - Canadian Nuclear Safety Commission
DFAIT - Department of Foreign Affairs and International Trade
DND - Department of National Defence
DRDC - Defence Research and Development Canada
DTPA - Diethylenetriamine Pentaacetic Acid
EC - Environment Canada
ED - Emergency Department
EDTA - Ethylenediamine Tetra-Acetic Acid
EHSB - Emergency Health Services Branch
EMAT - Emergency Medical Assistance Team
EMB - Emergency Management Branch
EMCPA - Emergency Management and Civil Protection Act
EMS - Emergency Medical Services
EOC - Emergency Operations Centre
EWC - Emergency Worker Centre
FERP - Federal Emergency Response Plan
FNEP - Federal Nuclear Emergency Plan
GOC - Government Operations Centre
GPMG - General Province-Wide Monitoring Group
Gy - Gray
HAZMAT - Hazardous Material

HC - Health Canada
HHR - Health Human Resources
HP - Health Portfolio (federal)
HPEOC - Health Portfolio Emergency Operations Centre
HVAC - Heating, Ventilation and Air Conditioning
IAEA - International Atomic Energy Agency
IC - Incident Commander
IHN - Important Health Notice
IMS - Incident Management System
ITB - Iodine Thyroid Blocking
kg - kilogram
KI - Potassium Iodide
LHIN - Local Health Integration Network
MCSCS - Ministry of Community Safety and Correctional Services
MCSS - Ministry of Community and Social Services
MDU - Monitoring and Decontamination Unit
MEMC - Ministry Emergency Management Coordinator
MEOC - Ministry Emergency Operations Centre
METER - Medical Emergency Treatment for Exposures to Radiation
MOH - Medical Officer of Health
MOL - Ministry of Labour
MOHLTC - Ministry of Health and Long-Term Care
mg - milligram
mGy - milliGray
mSv - milliSievert
NESS - National Emergency Stockpile System
NGO - Non-Governmental Organization
NRU - National Research Universal (part of Chalk River Laboratories)
OFMEM - Ontario Office of the Fire Marshal and Emergency Management
OPG - Ontario Power Generation
OPP - Ontario Provincial Police
OHSA - Occupational Health & Safety Administration
PAL - Protective Action Level

PEOC - Provincial Emergency Operations Centre
PHAC - Public Health Agency of Canada
PHO - Public Health Ontario
PHU - Public Health Unit
PLERT - Provincial Liquid Emission Response Team
PNERP - Provincial Nuclear Emergency Response Plan
PPE - Personal Protective Equipment
PSC - Public Safety Canada
RCMP - Royal Canadian Mounted Police
RDD - Radiation Dispersal Device
REACT/TS - Radiation Emergency Assistance Center / Training Site - Oak Ridge, Tennessee

RHRP - Radiation Health Response Plan
RN - Radiological / Nuclear
RTU - Radiation Trauma Unit - Toronto Western Hospital
SI - System Internationale
Sv - Sievert
UCRT - Urban Search and Rescue, Chemical, Biological, Radiological, Nuclear, Explosives Response Team (OPP)
UHN - University Health Network
WHO - World Health Organization

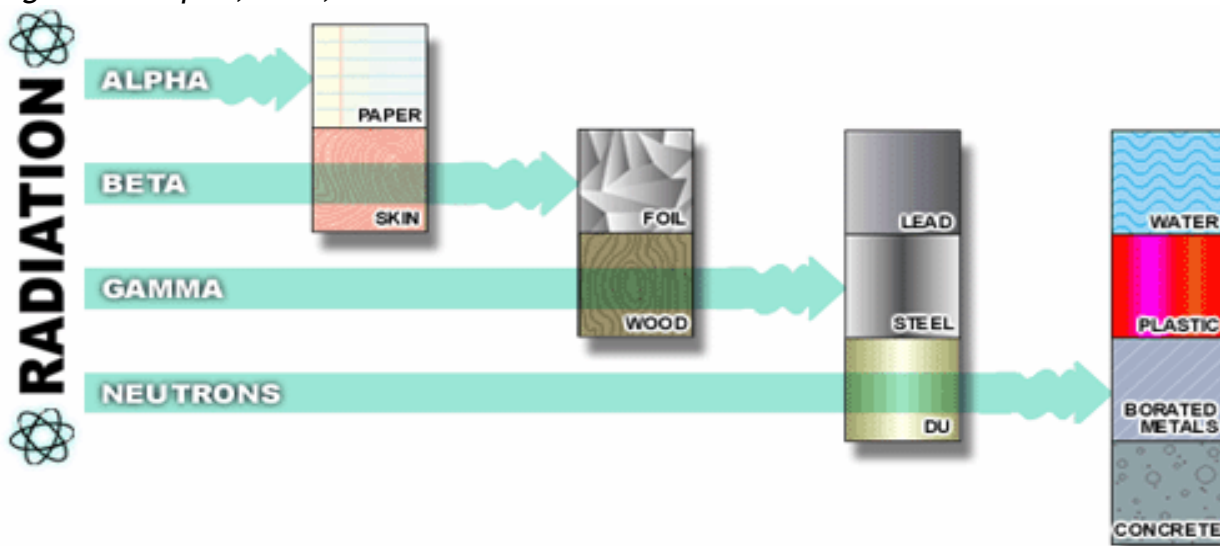
Chapter 2 Radiation Basics

2.1 Radiation

Radiation is energy in the form of high-speed particles or high-energy electromagnetic waves that can be found everywhere, for example: visible light, radio and television waves, microwaves, and cosmic rays. There are two basic types of radiation: ionizing and non-ionizing. Non-ionizing radiation does not have enough energy to ionize molecules, but it can still damage cells and tissue; it is generally low risk. Examples include heat, radio waves, microwaves, and ultraviolet light. Ionizing radiation presents a potentially higher risk to human health and takes the form of high-energy particles (alpha, beta) or electromagnetic waves (x-ray, gamma radiation). All nuclear radiation is ionizing. Ionization refers to the action of creating ions by ejecting an electron from an atom or molecule. The atom is a basic unit of matter that consists of a dense central nucleus surrounded by a cloud of negatively charged electrons.

The most common types of ionizing radiation are **alpha** (α), **beta** (β), and **gamma** (γ). Alpha particles (e.g., emitted from Americium-241) are large, heavy particles that only travel a few centimetres in air, and are easily shielded by a thin layer of paper. Alpha particles are solely an internal hazard if inhaled or ingested. Beta particles (e.g., emitted from Strontium-90) are smaller particles that move faster and can penetrate further than alpha particles, but can still be shielded relatively easily by aluminum foil or wood. Beta particles are mainly an internal hazard also, but may cause skin burns if applied externally. Gamma radiation (e.g., emitted from Cesium-137) can travel long distances in air, are highly penetrating, and require heavy shielding with steel, lead, or depleted uranium and can easily pass through the human body. Gamma radiation is both an internal and external hazard due to its penetrating power. **Neutrons** are a fourth type of ionizing radiation emitted in the process of nuclear fission. They can be shielded by water, plastic, borated metals, and concrete. Neutrons are highly penetrating and more damaging to tissue compared with x-rays.

Figure 2.1 Alpha, Beta, and Gamma Attenuation



Source: [Sandia National Laboratories](#).

2.2 Radioactive Decay

Radioactive material consists of unstable atoms that have too much energy in their nuclei. All radioactive substances decay over time. Some take fractions of seconds, while others may take many thousands of years. In theory, all radioactive substances stay slightly radioactive and are never completely inert. The time it takes for a radioactive substance to decay is measured according to its half-life, which is the time it takes for its radioactivity to decrease by half. For example, if the radioactivity of a substance decreased by half every two years, its half-life would be two years. It takes much longer for its radioactivity to decrease to very low levels, and after six years, it would have dropped to one-eighth of its original activity. At every step of its decay, the radioactive substance transforms into another substance as the composition (atomic number) of the nuclei in its atoms normally changes. The decay process continues until finally reaching an element that is stable.

2.3 Radiation Exposure

Exposure is the act or condition of being subjected to radiation externally. Another common term used is irradiation, which is the process by which an organism or object is exposed to radiation. People are exposed to small amounts of radiation every day, both from naturally occurring sources such as elements in the soil, cosmic radiation, man-made sources (artificial radioactivity), and medical sources (x-rays, radiation treatments). The amount of radiation from natural or man-made sources to which people are exposed is usually small.

Radiological incidents, such as industrial overexposures, lost or stolen sources, or malicious acts, could potentially expose people to small or large doses of radiation depending on the situation. Examples of sources of external exposure include: a sealed or intact radioactive source; an airborne cloud of radioactive material (cloud shine); radioactive material deposited on the ground (ground shine); and radioactive material deposited on skin and clothing.

The significance of radiation exposure to individuals depends on the duration, the nature of the source, the proximity to the source, and the availability and nature of shielding. It is possible for a person to be exposed to radiation, yet not be contaminated.

2.4 Contamination

Contamination is the deposition of radioactive material from an unsealed or breached source in water or air, or on the surfaces of: structures, areas, objects, clothing, or people. Contamination of humans can be external or internal. External contamination refers to materials containing radioactive isotopes deposited on the skin and/or clothes. Generally, this can be easily removed using soap and water. Internal contamination refers to radioactive material that is taken into the body through: inhalation from a cloud or re-suspended from contaminated surfaces, ingestion of contaminated food or water, injection, or absorption through skin or wounds. Internal contamination is more difficult to assess, and removal may require sophisticated treatment. Exposure takes place as long as radioactive atoms stay near, on, or in the body.

The effects of contamination are related to the amount of radiation to which an individual is exposed, the length of time of exposure, and the part(s) of the body affected. Human health impacts can range from very mild and self-limiting effects such as reddening of the

skin to severe burns, organ failure, and death; these effects can occur days to months after a serious incident. Other longer-term effects, like cancer, can also occur many years following exposure. For example, leukemia can take seven years to develop, while other cancers can take 20 to 30 years.

2.5 Radiation Measurement and Detection

Measurement

Absorbed Dose is a measure of the energy absorbed in tissue from radiation exposure received. **Dose rate** is a measure of the rate at which the exposure occurs over time. The dose rate indicates the level of hazard intensity, and is a critical quantity for first responders. Absorbed dose is purely a physical quantity expressed in units of Grays (Gy = 1 Joule per kilogram). When referring to the health impact of that deposited energy, absorbed dose is converted to **Equivalent Dose** to account for different types of radiation, and to **Effective Dose** to account for exposure of specific organs in the body. The equivalent and effective dose quantities are expressed in units of Sieverts (Sv). Grays and Sieverts fall under the *Système Internationale* (SI) (or International System) of units and measurements. In the US and in Québec, imperial units are used, respectively the Rad and the Rem; these units are 100 times smaller than the Gray or Sievert, respectively.

The level of radioactivity of a substance depends on the rate at which it emits radiation, or its activity. Activity of a substance refers to the strength of the source, but does not indicate if it is hazardous; it is expressed in units of Becquerel (Bq = 1 nuclear disintegration per second), which corresponds to the emission of one radioactive particle every second. In the US and Quebec, the imperial unit Curie is used instead, and it is a much larger quantity (37 billion Bq).

In most cases, as their work is typically far from the radiation source, it is anticipated that the external radiation hazard to health workers working as first receivers in hospitals would be low. This hazard would be measured in equivalent dose rate (mSv/hour). Consequently, there is more concern about minimizing the spread of contamination from patients, which is expressed in activity per surface area (usually Bq/cm²).

Table 2.1 Comparison of Radiation Terms

Comparison of Radiation Terms			
Term	Imperial unit	SI unit	Description
Activity	Curie (Ci)	Becquerel (Bq)	Amount of radiation emitted by a substance per second. Refers to the strength of the source. 1 Ci = 37 billion Bq
Absorbed dose	Rad	Gray (Gy)	Energy absorbed per unit of mass by a material or tissue. 1 Gy = 1 Joule/kilogram 1 Rad = 0.01 Gy
Equivalent and Effective dose	Rem	Sievert (Sv)	Equivalent dose is the product of the physical absorbed dose at a point in the tissue or organ, and the appropriate quality factor for the type of radiation giving rise to the dose. Effective dose is a quantity that further reflects the health risk associated with the dose to all organs, each receiving a possibly different dose. 1 Sv = 1 Joule/kilogram = 100 rads 1 Rem = 0.01 Sv

Table 2.2 Système Internationale (SI) Prefixes

Système Internationale (SI) Prefixes		
Prefix	Symbol	Value
nano	n	$10^{-9} \times 0.000\,000\,001$
micro	μ	$10^{-6} \times 0.000\,001$
milli	m	$10^{-3} \times 0.001$
kilo	k	$10^3 \times 1000$
Mega	M	$10^6 \times 1,000,000$
Giga	G	$10^9 \times 1,000,000,000$
Tera	T	$10^{12} \times 1,000,000,000,000$

Table 2.3 Examples of Radioactive Materials

RADIONUCLIDE	HALF-LIFE	ACTIVITY	USE
Cobalt-60	5 yrs	6.5 x 10 ⁸ MBq	Cancer therapy
Plutonium-239	24,000 yrs	1.2 x 10 ⁸ MBq	Nuclear weapon
Cesium-137	30 yrs	2.7 x 10 ⁷ MBq	Blood irradiator
Iridium-192	74 days	5.2 x 10 ⁶ MBq	Industrial radiography
Hydrogen-3	12 yrs	2.5 x 10 ⁵ MBq	Exit signs
Iodine-131	8 days	7400 MBq	Nuclear medicine therapy
Technetium-99m	6 hrs	750 MBq	Diagnostic imaging
Strontium-90	29 yrs	4 MBq	Eye therapy device
Americium-241	432 yrs	0.033 MBq	Smoke detectors
Radon-222	4 days	40 Bq/m ³	Environmental levels

Detection

Ionizing radiation requires specialized equipment for detection, and there are a number of methods and instruments available. The most basic method of detection involves collecting and measuring the electric charge liberated by ionizing radiation in a gas or solid state device. Examples of specialized equipment include: portal gamma monitors, hand-held alpha/beta monitors (e.g., Geiger-Mueller Counter), and electronic personal dosimeters.

Refer to [section 4.13](#) for more information on equipment provided in the Provincial CBRN (Chemical, Biological, Radiological, and Nuclear) Emergency Preparedness Program.

2.6 Dose Limits

The Canadian Nuclear Safety Commission (CNSC) has set effective dose limits for both the general public and emergency workers. These take account of the type of radiation and of partial body exposures corresponding to a whole body exposure of comparable health risk. These limits are reflected in the *Provincial Nuclear Emergency Response Plan (PNERP)*, and refer to regulated sources and practices; for all other circumstances, these dose limits provide a guide only.

Table 2.4 CNSC Effective Dose Limits²

	Non-Emergency	Emergency
Member of the Public (including emergency workers)	1 mSv / year (0.1 rem / year)	500 mSv ³ (50 rem)
Nuclear Energy Worker	50 mSv / year (5 rem / year)	500 mSv ⁴ (50 rem)
	100 mSv / 5 years 10 rem / 5 years	

Table 2.5 Examples of Radiation Doses

Example	Effective Dose
Flight from Vancouver to Toronto (5 hrs. at 39,000 feet)	0.025 mSv
Chest X-ray	0.1 mSv
Average Annual Dose Received by Canadians	2.6 mSv
Emergency Response Intervention level - <i>Sheltering</i>	5 mSv
Emergency Response Intervention level - <i>Evacuation</i>	50 mSv
Computed Tomography (CT) scan	10 mSv
Possible clinical symptoms from acute exposure	1000 mSv
Mild acute radiation syndrome	2000 mSv
Radiation therapy (localized to 1/10 of body & fractionated over time)	6000 mSv
Lethal Effective Dose for humans (LD50)	>4000 mSv

² Nuclear Safety & Control Act, Radiation Protection Regulations, CNSC, May 2000.

³ Maximum Dose allowed; no limit for a person who acts voluntarily to save or protect human life (such response actions should only be taken with an understanding of the potential acute effects of radiation to the exposed responder, and based on the determination that the benefits of the action clearly exceed the associated risks).

⁴ Ibid.

2.7 Reducing the Dose Amount

Radiation doses can be both external and internal. Reducing exposure to an external dose of radiation can be achieved by using principles of *time*, *distance*, and *shielding*.

Minimizing the **time** spent in a radiation field – the dose received in a constant radiation field with a fixed dose rate, is directly proportional to the time spent at that location. Reducing the time spent in a fixed dose rate field by half reduces the dose received by 50 per cent, i.e., linearly.

Increasing the **distance** from a radiation source – increasing the distance between a radioactive source and a survey instrument, causes a decrease in the measured dose rate. Doubling the distance from a fixed source reduces the dose received to 25 per cent of the original dose rate (inverse square law).

Providing a **shield** between the person and the radioactive source – the measured dose rate can be reduced or eliminated (exponential law).

Reducing internal radiation exposure can be achieved through the following actions:

- Wearing appropriate personal protective equipment
- Controlling the spread of loose contamination
- Decontaminating individuals and items in a timely manner
- Treating with appropriate pharmaceuticals in a timely manner e.g., potassium iodide, Prussian blue.

Protective actions to be taken by the public to reduce external and internal doses are described in [Chapter 5](#), along with more detailed information on triage and treatment of those exposed.

2.8 Health Impacts of Radiological Hazards

Possible health impacts of external and internal contamination from radiological hazards include:

a. Acute Radiation Syndrome (ARS) (deterministic)

Deterministic effects, or ARS, may result from a high dose received within a short period of time (for example several 1000 mSv received in a few hours). ARS is an acute illness that varies in onset from a few minutes to hours to days. The illness typically follows a pattern of prodromal signs/symptoms, a latent period, and a period of manifest illness, followed by improvement or deterioration. Each phase varies in length relative to the radiation dose received. Organ/tissue involvement is related to various radiation dose thresholds.⁵ Examples of symptoms include nausea, skin burns, or early death.

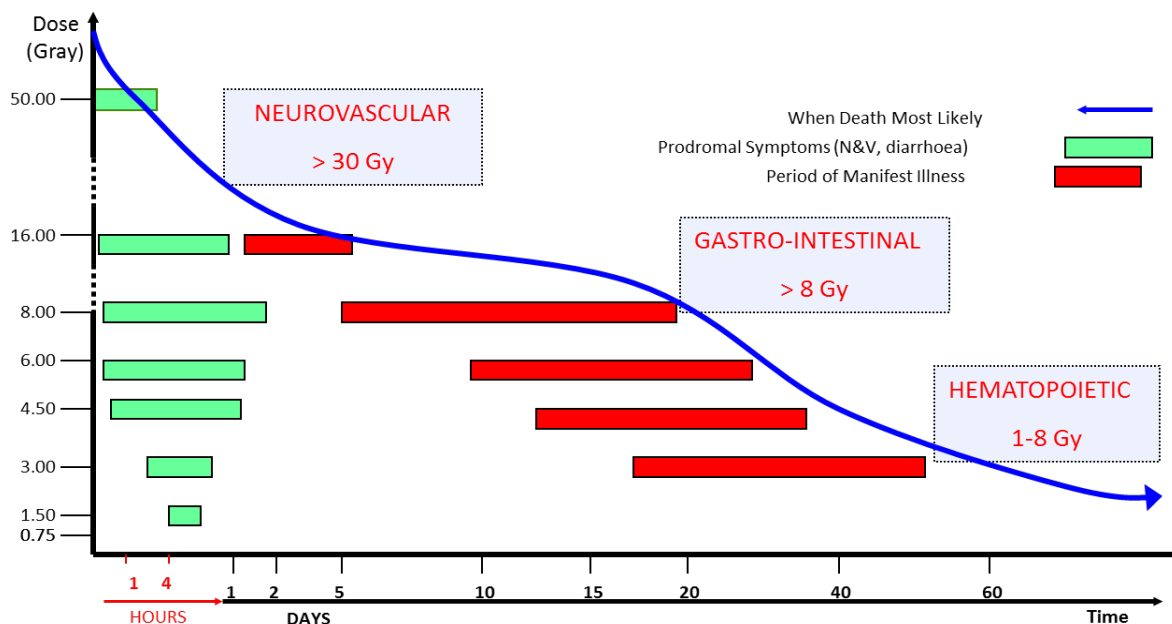
Onset of vomiting, lymphocyte and neutrophil kinetics, clinical history of signs and symptoms, and biochemical markers can be used for early dose reconstruction. Non-

⁵ Radiation Emergency Assistance Centre/Training Site, Medical Aspects of Radiation Incidents, U.S. Department of Energy.

radiation related medical and surgical urgencies require preferential attention before radiation and/or decontamination concerns rise to a level of priority.⁶

The graph below is intended to show the course of illness (on horizontal axis) in relation to the whole body effective dose (on vertical axis). The green denotes the onset of prodromal (pre-cursor) symptoms, the red represents the period of manifest illness, and the blue line represents death.

Figure 2.2 Clinical Course of Acute Radiation Syndrome (ARS)⁷



b. Delayed effects (stochastic)

Delayed or stochastic effects are possible and can include various forms of cancer, which can potentially develop several years after exposure to radiation (approximately 7-30 years). These effects are not seen during emergencies, but long after exposure. Longer-term effects caused by radiation are difficult to distinguish from the same illnesses caused by other factors, making it difficult to precisely establish a causal relationship between the occurrence of cancer in one individual and the dose received from a specific incident. There is no known threshold dose for cancer and hereditary effects.

Severity of longer-term effects does not increase with the dose received, but the probability of the effect occurring does relate to dose. Radiation is considered a weak carcinogen. In small doses (<100 mSv), its effects cannot be directly linked to any cancer or hereditary effects. The increased risk of developing a fatal form of cancer due to radiation exposure has been estimated at ~five per cent per Sv of Effective Dose, and considers a multitude of other factors and considerations.⁸

⁶ Ibid.

⁷ Burton, G. Radiation Exposure in Military Operations: Presentation for Basic Medical Officer's Training Course. Canadian Forces Medical Group, 2004.

⁸ Health Canada, Medical Emergency Treatment for Exposures to Radiation (METER), Radiation Basics and Health Effect (module 2)

c. *Psychological trauma and psychosocial effects*

Psychological trauma (to an individual) and *psychosocial effects* (to the population) stemming from an incident where radiation is involved are common (e.g., radiophobia). These two terms are often confused as they are related. In the *RHRP*, “psychological” refers to the impact on a specific individual’s mental state and the intervention for that particular individual.

“Psychosocial” refers to the impact of the accident on a section of the population.

Frequently, the psychological and psychosocial impacts can be the most destructive aspects of an incident. The ratio of psychological and psychosocial to medical casualties in disasters is 10-100 to 1. It includes both members of the public who are (or perceive to be) affected by the accident, and emergency responders who have to work in potentially hazardous areas and under considerable strain.

Chapter 3 Roles, Responsibilities, and Functions

3.1 Emergency Operations in Ontario

A radiological/nuclear (RN) incident in Ontario will have an impact throughout society and involve the broader emergency management system. The provincial emergency health response coordinates with the overall emergency response led by the Provincial Emergency Operations Centre (PEOC). The Ministry of Health and Long-Term Care (MOHLTC) is responsible for leading the health response and maintaining health services in Ontario. The MOHLTC's emergency response structure is provided in detail in the [Ministry Emergency Response Plan](#) (MERP).

3.2 Federal Government

The federal government is responsible for the development, control, and regulation of peaceful uses of nuclear energy; managing nuclear liability; and providing support and coordination to provinces responding to a nuclear emergency.

Areas of responsibility within federal jurisdiction during an emergency response include:

- Federal lands, programs, and services
- Emergencies affecting more than one province or territory
- Liaising with the international community and coordination of international support for an emergency in Canada
- Liaising with diplomatic missions in Canada
- Assisting Canadians abroad
- Coordinating the national response to a nuclear emergency occurring in a foreign country
- Critical incident response and coordination during a terrorist incident involving radioactive material

3.2.1 Public Safety Canada (PSC)

In the event of an RN incident requiring a coordinated Government of Canada response, unless otherwise specified, the Minister of Public Safety is responsible for overall federal coordination as described in the [Federal Emergency Response Plan \(FERP\)](#) on behalf of the Government of Canada.

The Minister of Public Safety is responsible for coordinating the Government of Canada's response to an emergency, and for promoting and coordinating emergency management plans for:

- Coordinating federal Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) surveillance at major public gatherings and events of national security interest.
- Coordinating the federal security response to a deliberate act or threat that may result in a radiological or nuclear emergency.

3.2.2 Health Canada

The [Federal Nuclear Emergency Plan \(FNEP\)](#), prepared by the Minister of Health, is an annex to the *FERP* that provides supplemental and specific multi-departmental and inter-jurisdictional arrangements necessary to address the health risks associated with a radiological or nuclear emergency.

The *FNEP* supports rapid mobilization of federal radiological assessment and other specialized capabilities to manage the potential health risks associated with a radiological or nuclear emergency. The plan defines specific roles and responsibilities of federal response organizations for nuclear emergency functions and linkages between federal and provincial/territorial emergency management organizations which can be initiated on a 24/7 basis.

Health Canada's Radiation Protection Bureau offers training for the Canadian medical community called Medical Emergency Treatment for Exposures to Radiation (METER). Requests for this training can be coordinated through Health Canada.

3.2.3 Public Health Agency of Canada (PHAC)

Within the federal Health Portfolio (HP), responsibilities for emergency management activities are shared by two organizations: Health Canada (HC) and the Public Health Agency of Canada (PHAC). The HP takes action to assist provinces to protect and mitigate the risks to the health of Canadians. The Health Portfolio Emergency Operations Centre (HPEOC) is the hub for these activities. The Ontario Regional office facilitates this interaction with the MOHLTC.

3.2.4 Canadian Nuclear Safety Commission (CNSC)

The Canadian Nuclear Safety Commission regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and implements Canada's international commitments on the peaceful use of nuclear energy.

3.2.5 Atomic Energy of Canada Limited (AECL)

AECL has a dedicated response team that can provide consequence management assistance to any nuclear incident. They have equipment and expertise in radiological monitoring and decontamination. They are available 24/7 and can be used as a supplement to initial response efforts.

3.3 Provincial Organizations

3.3.1 Office of the Fire Marshal and Emergency Management (OFMEM), and the Provincial Emergency Operations Centre (PEOC)

OFMEM is the lead organization for any RN incident in Ontario through the PEOC, and is responsible for the administration and implementation of the *PNERP*. OFMEM monitors, coordinates, and assists in the development of nuclear emergency response programs at provincial ministries, agencies, boards, commissions, nuclear facilities, and designated/host municipalities.

During an emergency, the provincial response to an RN emergency is coordinated through the PEOC. The PEOC is the central location from which the Ontario government's response is coordinated. The MOHLTC sends a liaison to the PEOC Planning and Operations Sections during an RN emergency.

The PEOC includes a scientific section with responsibilities for providing scientific direction, coordinating environmental radiation monitoring efforts, and utilizing analysis results to make decisions. The MOHLTC sends a representative to the scientific section during an RN emergency.

3.3.2 Ministry of Health and Long-Term Care (MOHLTC)

The MOHLTC is responsible for leading and coordinating the health response, and maintaining health services during an RN incident.⁹

Preparedness tasks performed by the MOHLTC to maintain the response capability in normal times include:

- Promoting awareness and understanding of the *Radiation Health Response Plan (RHRP)* to health stakeholders.
- Undertaking, assisting and overseeing the preparations necessary to ensure the effective implementation of the *RHRP*.
- Providing guidance and coordination to health stakeholders in developing emergency plans and arrangements for RN emergencies.
- Providing guidance and coordination to designated municipalities on stocking, distribution, and administration of potassium iodide (KI).
- Providing guidelines for handling of persons exposed to high levels of radiation.
- Participating in nuclear and radiological emergency training and exercises.
- Providing guidance regarding training for health workers and health care settings.
- Training of appropriate ministry staff on various elements of RN incidents.

Response tasks performed when there is an emergency include the following:

- Activating the *RHRP*.
- Operational coordination of health services in an emergency, under the general direction of the PEOC.
- Providing advice, either directly or through the PEOC, to local authorities regarding the need to implement precautionary and protective measures and appropriate related actions.
- Supporting health organizations providing medical care to potentially exposed and/or contaminated persons.
- Supporting public health and health services at reception and evacuee centres.
- During restoration operations, overseeing the required arrangements for follow-up medical monitoring, care, and rehabilitation for those with significant radiation exposure.

MOHLTC Scientific and Technical Advice

The ministry expects its emergency response activities to be evidence-based, incorporating the current body of scientific knowledge on the type of incident, and reflecting current best practices within the health system. The MOHLTC is responsible for making arrangements so that necessary scientific, technical and operational advice can be promptly provided during an emergency situation. Depending on the incident, this support can come from a number of locations such as the PEOC Scientific Section, Health Canada's Radiation Protection Bureau/Federal Technical Assessment Group (TAG), Public Health Ontario (PHO), experts from the health sector, and/or an external contracted agency. PHO has a number of resources that may be used during an emergency response as further described in the [Ministry Emergency Response Plan \(MERP\)](#).

⁹ Annex I, Appendix 7 of the *PNERP-Master Plan* designates the responsibilities of the MOHLTC and the CMOH for RN emergency planning and response, and for the purposes of implementing the *PNERP*.

The advice gathered supports the development of any guidance and/or directives to health workers.

Chief Medical Officer of Health for Ontario (CMOH)

The response roles of the Chief Medical Officer of Health in an RN emergency are as follows:

1. Act as Executive Lead for the MOHLTC's response to the emergency, as outlined in the [Ministry Emergency Response Plan \(MERP\)](#).
2. Provide advice to the PEOC and local authorities regarding associated health risks and the need to implement precautionary and protective measures for the general public and the health system to protect public health.
3. Decide, in collaboration with the PEOC and the local MOH, when KI should be administered.
4. Communicate to the public and responders, in collaboration with the PEOC, on the need and rationale for undertaking precautionary and protective actions and the administration of KI.

3.3.3 Ministry of Labour (MOL)

The primary role of the MOL in an RN emergency, as designated by the *PNERP*, is leading the Assurance Monitoring Group (AMG), which organizes sampling and monitoring of air, water, and foodstuffs (milk, drinking water, and vegetation), and directs its field monitoring teams with a view to confirming "safe" agri-food production areas. The MOHLTC is represented on the AMG along with the Ministry of the Environment (MOE), the Ministry of Agriculture, Food and Rural Affairs (OMAFRA), the Canadian Food Inspection Agency (CFIA), Health Canada, the OFMEM, and the MOL.

The MOL also leads the General Province-Wide Monitoring Group (GPMG) which is activated for incidents where it is suspected that radioactive contamination has been widely dispersed around the province. The GPMG monitors the collection, transport, analysis, and reporting of air, precipitation, and drinking water samples from predetermined locations across the province. The GPMG reports to the AMG. For more information, please see the MOL's [webpage](#).

3.3.4 Ministry of Community and Social Services (MCSS)

MCSS assists affected municipalities in the delivery of emergency social services, including emergency shelter, food and clothing, registration and inquiry services, and personal services when their capacity is exceeded and a provincial response is required. MCSS also liaises with non-governmental social service organizations, such as the Red Cross, on their role during an RN emergency. During a provincial response, the MOHLTC works closely with MCSS on the health-related aspects of evacuations, which can include psychosocial support, results of public health inspections at evacuee centres (food and water safety), and general access to health care services at evacuee centres.

3.3.5 Nuclear Facilities

In Canada, operators of nuclear generating stations, research reactors, or other nuclear facilities are responsible for on-site emergency planning, preparedness, and response. Off-site responsibilities include the provision and services of monitoring and decontamination units, advance procurement of KI, and preparedness with local hospitals for emergencies

involving their facilities. This responsibility does not extend to other emergencies. However, nuclear facilities are responsible for any off-site emergency involving the transport of spent nuclear fuel from their facilities.

3.4 Local Health System

3.4.1 Local Health Integration Networks (LHINs)

Ontario's 14 [Local Health Integration Networks \(LHINs\)](#) are responsible for ensuring the health services funded under their structure can continue to deliver health services during an emergency. LHINs engage LHIN-funded health organizations, also known as transfer payment agencies, to coordinate emergency response activities and tasks. These organizations include public and private hospitals, Community Care Access Centres (CCACs), community support service organizations, mental health and addiction agencies, community health centres (CHCs), and long-term care homes.

Depending on the scope of the emergency and health support needs, coordination across LHINs may be required. LHIN coordination tables can be used to support this process with status reports to the MEOC. Cross-LHIN action plans to prioritize response activities are developed with established mechanisms to coordinate actions across LHIN boundaries.

3.4.2 Emergency Medical Services (EMS)

During an RN emergency, the role for EMS may include the following:

- Setting up medical first aid and field triage facilities for injured persons.
- Assessing the status of victims to ensure priority is given to the management of life-threatening injuries.
- Assessing and treating life-threatening injuries immediately, and transporting such patients to hospital.
- If possible, initiating on-scene radiological assessment of patients with non-life-threatening injuries, triaging for appropriate medical or other actions, and gathering information for long-term follow-up.
- Coordinating with the emergency medical services liaison regarding medical services required on-scene to inform receiving hospitals.
- Assisting with the identification of contamination on victims and helping to minimize its spread.
- Possible supportive role in initial care at reception centres.

3.4.3 Hospitals

In the event of a radiological emergency, hospitals will take on an immediate role of being first receivers of the injured, contaminated, and other non-injured people showing up with concerns of radiation; activities include:

- Addressing serious life-threatening injuries first.
- Record keeping of all victims of an RN event.
- Assessing resources to estimate and contain radiation exposure.
 - For example, a radiation safety officer can provide expert advice and access to radiation-measuring instruments and shields available in Nuclear Medicine, Radiology, or Radiation Oncology services of the hospital.
- Psychological and psychosocial support and counselling.

For hospitals that are part of the Provincial CBRN (Chemical, Biological, Radiological, and Nuclear) Emergency Preparedness Program, activities include:

- Screening for acute exposure and triage of those externally contaminated from the non-contaminated (non-life-threatening scenarios).
- Monitoring for external and internal contamination.
- Conducting external decontamination.
- Reducing internal contamination and treating acute exposure symptoms.

Hospitals with a CBRN response team, activate to process contaminated casualties in a radiation emergency area, assessing the patient's medical status, and providing necessary treatment.

To support medical activities, hospitals need to couple the delivery of medical care with the appropriate level of contamination control to protect the patient, medical personnel, and hospital facility. This will require hospitals to develop policies and procedures for the deployment of triage stations/decontamination facilities to screen and decontaminate patients, and protect against contamination inside the emergency department. See [section 4.12](#) for more information on a hospital's role and expectations.

3.4.4 Cancer Centres

[Cancer Centres](#) are distributed throughout Ontario (14 centres). Each centre is staffed by a team of radiation specialists including medical staff, medical physicists, and radiation technologists. Each specialist has extensive training in the safe prescription and administration of very high doses of radiation to cancer patients, and is experienced in observing and managing radiation side effects. In addition, medical physicists have access to instrumentation for measuring dose levels from a wide range of x-ray and electron sources. In addition to expert personnel, cancer centres are equipped with radiation bunkers capable of containing high levels of radiation or contaminated individuals. Although Cancer Centres have not been closely involved in RN emergency preparedness planning, considering their expertise, they could play a major role in such an event.

3.4.5 Public Health Units

The role of a public health unit is to support the public health aspects of the emergency response at the local level, and assist with response activities as appropriate. This could include liaising with local Community Emergency Operations Centres, the acute care sector (hospitals/EMS), affected LHINs, and social service agencies.

Specifically, public health units may be requested to assist with the following emergency response activities:

- Risk communications and public awareness regarding precautionary and protective measures to be taken by local community as per direction of the PEOC and CMOH, i.e., evacuation, sheltering, thyroid blocking, food and water controls.
- Distribution of KI prophylaxis as per the advice of the CMOH.
- Health inspection of sanitation, food, and water at reception and evacuee centres.
- Assist with Monitoring and Decontamination Units (MDUs) for emergencies other than those involving nuclear facilities.

- Enforce any orders regarding the sale or distribution of foodstuffs, where those foodstuffs constitute a health hazard, once food and water ingestion controls have been put into place.
- Assess the public health impacts and risk communication in situations that may affect water and food safety.
- Assist the MOHLTC with assessment and surveillance regarding hazard and risk to public health for identification, tracking, and long-term medical follow-up from an epidemiological perspective.

3.5 Municipalities

A municipal response to a radiological emergency will be contingent upon the type of incident. All municipalities that experience a radiological event will implement their all-hazards emergency response plan, unless they have a specific radiological response plan. For emergencies at nuclear facilities, the *PNERP* identifies designated and host municipalities that have specific nuclear emergency response duties and plans.

3.5.1 Designated Primary Zone Municipalities

Designated municipalities are those located within a nuclear facility's primary zone.¹⁰ They implement the municipal emergency plan for nuclear emergencies and carry out the required emergency response under the guidance and support of the province. A municipal plan includes the following:

- Detailed arrangements and procedures for implementing precautionary or protective measures.
- Description of the public alerting system.
- Provision of emergency information.
- Arrangements to receive and accommodate evacuees, including liaison arrangements with other host municipalities, as appropriate.

3.5.2 Designated Host Municipalities

Designated host municipalities are those receiving evacuees following a nuclear facility accident. Host municipality plans include the following:

- Arrange for receiving and accommodating evacuees from designated municipalities.
- Coordination of reception plans and procedures with the nuclear facility's monitoring and decontamination arrangements.
- Detailed arrangements with various municipal departments, including social services, local LHIN, public health, fire, ambulance and volunteer agencies which would be involved in staffing and security arrangements for the reception and evacuee centres.

3.6 Other Specialized Resources

The following are some of the specialized resources that the MOHLTC may request for assistance or that may already be responding to the incident.

3.6.1 CBRNE Teams (Chemical, Biological, Radiological, Nuclear, and Explosive)

Ontario has three municipal CBRNE teams located in Toronto, Windsor, and Ottawa consisting of police, fire, and EMS. These teams have specialized training and may be deployed to respond to any incident believed to be radiological in nature. Many

¹⁰ Refer to section 4.15 for more information on zones in a nuclear emergency, and a list of designated and host municipalities.

municipalities without CBRNE teams have Hazardous Materials (HAZMAT) teams that respond to such incidents, albeit without the requisite RN expertise. These situations will likely require provincial and/or federal assistance by the Ontario Provincial Police's (OPP) Urban Search and Rescue, Chemical, Biological, Radiological, Nuclear, Explosives Response Team (UCRT); the Royal Canadian Mounted Police (RCMP) National CBRNE Response Team; and by Canadian Forces' Canadian Joint Incident Response Unit (CJIRU).

3.6.2 Provincial/Territorial Resources

Resources from unaffected provinces and territories could be accessed via operational mechanisms meant to support the Federal/Provincial/Territorial Memoranda of Understanding on Mutual Aid (2009), as a means of obtaining additional health-related surge capacity.

Emergency Medical Assistance Team (EMAT)

[EMAT](#) is a mobile medical field unit that can be deployed in a modular fashion within 24 hours to any location in Ontario. EMAT can provide acute and intermediate care beds, a staging and triage base for patients prior to transport to acute care hospitals, and staff for psychosocial support. EMAT can also provide patient isolation, medical support, and cold-zone decontamination in a CBRN (Chemical, Biological, Radiological, and Nuclear) incident. The team includes various types of health care workers sourced from all over Ontario.

3.6.3 Federal Resources

Following a request from the Province, the Federal Government could provide or coordinate access to a number of Federal resources (if available) during an emergency response, including: scientific expertise, radiation protection guidance, laboratory services, radiation monitoring, radioactive plume modeling, equipment, medical countermeasures, incident specific task/response teams, the National Chemical, Biological, Radiological, Nuclear, Explosives (CBRNE) Team, and international links to organizations like the International Atomic Energy Agency (IAEA). These resources could be coordinated by Health Canada under the FNEP.

Some examples of the federal government's resources that can be accessed during an emergency include:

(a) Incident Specific Task or Response Teams

Can provide:

- Background surveys, mapping, real-time surveillance and scientific reach back (detection and identification).
- Mobile/aerial RN surveillance systems (hand-held, backpack systems, car-borne, airborne).
- RN surveillance equipment at access control and screening points.
- Fixed-point surveillance systems.
- Mobile nuclear laboratories.

(b) National Emergency Stockpile System (NESS)

[NESS](#) is a stockpile of resources created to provide surge capacity for provinces and territories in response to public health emergencies. It is maintained by PHAC, and has a 24-hour response capability. Assets include:

- Pharmaceuticals, medical equipment and supplies, social service supplies, all-hazards supplies, and specific countermeasures.
- Examples of CBRN countermeasures include AtroPen (Atropine), Pralidoxime Chloride and DuoDote (atropine and pralidoxime chloride) auto-injectors, Botulism-Antitoxin (TypeABE), Prussian blue, Ca-ZN DTPA (Diethylenetriaminepentaacetate), and Potassium iodide.
- Many drugs within the NESS are held by pharmaceutical manufacturers in order to ensure that they are rotated, and that drugs are up-to-date drugs when required.

3.6.4 International Resources

Additional international resources can be obtained through Health Canada in accordance with the International Convention on Assistance in a Nuclear Accident or Radiological Emergency.

The United States Department of Health and Human Services has developed a website for [radiation event medical management \(REMM\)](#). There are many resources on the site that will assist in developing screening and decontamination protocols.

Chapter 4 Planning for a Radiation Emergency

Chapter four is divided into three parts related to Planning for a Radiation Emergency. The first part ([4.1 - 4.14](#)) provides details and guidance on a number of Radiological/Nuclear (RN)-related subjects that the health system should focus on in their own plans. All sectors of the health system should review these sections.

The second part of the chapter ([4.15 - 4.16](#)) provides important *Provincial Nuclear Emergency Plan (PNERP)* information that is relevant to the health system, including emergency planning zones, containment systems, and notification categories.

The third part of the chapter ([4.17 - 4.18](#)) covers 18 possible scenarios that may impact Ontario, and presents the main planning considerations for each.

Planning Priorities

For radiological/nuclear events, the following planning priorities are the areas of focus for the health system:

- a. Acute exposure. Plan for the treatment of a few acutely exposed patients. The terrorist threat of exposure of the public also ranks high on the risk scale. The MOHLTC is prepared to quickly mobilize the health care sector to identify and manage a large number of potentially acutely exposed patients.
- b. External contamination. Two risks dominate: a few contaminated patients, as a result of a small incident (e.g., transport), and a large number of low-level contaminated people (non-patients) as a result of an accident involving a nuclear facility.
- c. Internal contamination. Two risks dominate: a few people becoming significantly internally contaminated from several types of accidents, or a lot of people fearing being contaminated as the result of a terrorist act. In the latter case, reassurance monitoring may be required.
- d. Psychosocial. The dominant risks are those associated with nuclear facility accidents and terrorist events affecting a large number of members of the public. Plans should be based on the need to reassure, and potentially screen, a large number of otherwise healthy individuals (hundreds or thousands).

4.1 Training and Awareness of the Signs of Acute Radiation Exposure

The health system, especially emergency room and medical personnel, should be trained to be able to recognize the possible signs and symptoms of acute radiation exposure. This can be challenging as some of the signs and symptoms are non-specific and may resemble a gastrointestinal illness or skin disorder, depending on the type of exposure. The most common early signs of whole body overexposure are nausea and vomiting, which may begin a few minutes to hours post-exposure. If the exposure is more localized, early effects include erythema followed by edema, dry and wet desquamation, blistering, pain, necrosis, and gangrene or epilation. A more advanced diagnostic would reveal low lymphocyte counts and, in the case of exposure resulting from internal contamination, the contamination of bodily fluids. There is no risk for medical personnel in dealing with an uncontaminated overexposed patient. Refer to [section 5.10](#) and [Appendix J](#) for more information on assessing and managing Acute Radiation Exposure.

4.2 Planning for and Recognizing Potentially Contaminated Patients in Pre-Hospital and Hospital Sectors

Pre-Hospital

First responders should have appropriate training and equipment¹¹ to identify the presence of contamination on victims of radiological accidents. They should have plans and procedures for the extraction of potentially contaminated victims from a contaminated area, and for the transport to a designated hospital capable of stabilizing a contaminated patient. Their procedures should include a list of such hospitals and a requirement to communicate to them that the patient may be contaminated. They should also have training to transport the patient in a way that minimizes the risk to themselves and the spread of contamination. Refer to [section 5.9.2](#) for more information on transport to hospital.

Hospitals

Hospitals must have plans and procedures to promptly set up and staff a radiation emergency area. The plans can be based upon existing hospital disaster plans, but should also include radiation-specific information such as specialized roles, radiation-specific equipment, radiation protection, personal protective equipment (PPE), decontamination areas, and patient treatment areas. The procedures must take into account the priority for medical injuries while minimizing the spread of contamination. Consideration should be given to staff training so they are familiar with radiation monitoring equipment and decontamination best practices. Guidance on the setup of a radiation emergency area is in [Appendix H](#), and a procedure for contaminated patient care is provided in [Appendix I](#).

Hospitals should consider coordinating with internal staff that have radiological expertise such as radiation safety specialists and staff from nuclear medicine and radiation oncology departments to support external contamination monitoring activities. These departments would most likely have contamination and dose rate meters, as well as knowledge and experience using such equipment. This expertise may be leveraged to assist to identify contaminated individuals and triage them appropriately.

In cases involving a large number of potentially contaminated patients, the existing health care facilities may become quickly overwhelmed by patients and individuals that require screening for decontamination. Hospitals located in large urban centres, where the occurrence of a terrorist act with mass casualties is more plausible, should be prepared to set up monitoring and decontamination units outside the hospital (refer to [section 5.3](#) for information on Monitoring and Decontamination Units). Plans must include the provision of security (refer to [section 5.11](#)), access control and media management for those units. Refer to [section 5.10](#) for information on Hospital Response.

¹¹ Refer to section 4.3 Occupational Health & Safety for more information on appropriate equipment.

4.3 Occupational Health and Safety Planning for Radiological/Nuclear Incidents

The objective of occupational health and safety planning for RN incidents is to ensure health workers have access to appropriate training, contamination and exposure control practices, personal protective equipment, and other supports to reduce exposure to radiation and contamination in the workplace, when responding to an incident.

Where applicable, there are requirements under the Regulation for [Health Care and Residential Facilities \(HCRF\)](#) as part of the *Occupational Health and Safety Act*. These include requirements for the employer to develop written measures and procedures in consultations with the joint health and safety committee for the health and safety of workers. More specifically, there are requirements that these measures and procedures deal with safe working conditions, proper hygiene practices, and the use, wearing and care of personal protective equipment.

The degree of risk for responding health workers depends on factors such as the nature of the incident, the environment and circumstances in which they are required to perform response activities, and their specific role in dealing with the casualties.

At the Site of the Incident

Medical first responders, i.e., paramedics, are at higher risk as they generally perform activities at the site of the incident and may be expected to operate in an area where radiation is present, i.e., the radiological source and/or associated contamination. Those responders need to fully understand the application of the principles of time, distance, and shielding in the field and have access to PPE that provides the highest level of skin and respiratory protection. Refer to [section 5.9](#) Pre-Hospital Response for more information.

At Hospital

First receivers are health workers that provide medical care to victims of an RN incident at hospitals or other health care facilities that are remotely located from the incident, and not at the site of a hazardous materials release.¹² In general, the risk to first receivers is very low. The risk is further reduced by adopting routine practices and additional precautions. There is no risk for health workers in dealing with an uncontaminated patient who has been exposed to radiation.

Health workers providing care and/or services to individuals contaminated with a radiation source are potentially at risk for secondary contamination. Contamination can occur through the following pathways:

- Inhalation of airborne radioactive materials.
- Ingestion of radioactive materials taken directly into the mouth or cleared from the nasal passages, then swallowed.
- Radioactive materials deposited on skin.
- Injection of radioactive materials as a result of a puncture wound.

¹² OSHA Best Practices for Hospital-Based First Receivers of Victims, 2005.

Radioactive particles can stick to hard surfaces and clothing, which elevates the risk of people becoming contaminated indirectly by touching contaminated surfaces, e.g., clothing or other objects.

Health workers who may have to deal with potentially contaminated victims and patients, need to have the instruments, personal protection tools, and training to perform their work in the presence of radioactive contamination.¹³

Hospitals capable of receiving contaminated patients¹⁴ must develop plans and procedures for the setup of a radiation emergency area that include the following aspects:

- Screening for potentially contaminated patients, health workers, and visitors that would direct them to take appropriate steps to reduce risk, e.g., instruct those attempting to enter the health care facility to go to radiation monitoring areas.
- Procedures to safely and effectively dispose of contaminated clothing and waste water from decontamination facilities.
- Designating equipment to be used only in potentially contaminated areas.
- Deploying health workers to radiation emergency areas to reduce mixing and exposure.
- Identifying staff members to participate in radiation monitoring and decontamination activities.

More information on setting up a hospital radiation emergency area is available in [Appendix H](#).

Personal Protective Equipment (PPE)

Health care facilities and services that are not appropriately staffed or equipped to respond to an RN incident can still perform their essential functions. When radiation contamination has not been ruled out, the following personal protective equipment would provide adequate protection:

- N95 respirator or higher if required.
- Outer layer of protective clothing e.g., medical gown, water-resistant coveralls (Tyvek or equivalent) with name written on masking tape on the front and back.
- Two pairs of protective gloves. First pair of gloves (consider a different colour) with sleeves taped on the outside. Second pair of gloves not taped (change often).
- Eye protection.
- Shoe covers or booties, with pant legs taped on the outside.

The Canadian Standards Association (CSA) released a guideline in March 2011 entitled [Protection of first responders from chemical, biological, radiological and nuclear \(CBRN\) events](#). This standard is intended to provide guidance to responders in a CBRN event in order to reduce their personal risk while performing their professional responsibilities. It provides information to assist employers and managers in establishing a comprehensive CBRN personal protective equipment program, and specifies requirements for the selection,

¹³ The U.S. Department of Health & Human Services Radiation Emergency Medical Management (REMM) website has a suggested supply list for decontamination in emergency departments: <http://www.remm.nlm.gov/ersupplies.htm>

¹⁴ Hospitals that are part of the Provincial CBRN Emergency Preparedness Program should be able to take in contaminated patients (refer to section 4.13 for more information).

use and care of personal protective equipment. This standard is specifically targeted to fire, police, and medical first responders/receivers in the front line of the response. First receiver activities include those performed prior to admission or in an emergency department or similar facility, and likely include activities such as triage, decontamination, and initial and urgent treatment.

For more information on occupational health and safety for first receivers during CBRN incidents, see the U.S. Occupational Health & Safety Administration's (OSHA) [Best Practices for Hospital-Based First Receivers of Victims](#).

4.4 Planning for Mass Casualties

A mass casualty situation occurs when the demand for medical resources, due to the number and severity of victims, overwhelms the health system's capacity to respond. There is no fixed number of victims above which a situation can be called a mass casualty incident. As in any similar non-radiation situation, the health system needs to triage casualties to optimize the benefit for the most patients based on available resources. Many hospitals have already developed a mass casualty plan and/or Code Orange Plan. There should be specific planning added to these plans that cover RN incidents. It is strongly recommended that all hospitals designated to receive potentially contaminated patients develop a mass casualty plan.

There are a number of private industries, academic and research institutions, and professional associations that employ people with knowledge and experience in dealing with radiation, exposure, contamination control, and monitoring. The MOHTLC planning will include the development of inter-agency and private sector agreements that can be quickly activated to supplement response efforts. Cooperative agreements will be explored that provide for the prompt notification of these organizations with a request for specific levels of support. The MOHLTC maintains a list of specialized personnel and health care facilities that can be quickly mobilized to provide assistance to health care facilities involved in the management of a radiological emergency.

Dispatching medical assessment personnel to the scene of the incident and/or establishing outside-the-hospital triage can usually be managed through coordination between cooperating health care facilities in a given area, or through the local LHIN. However, the availability of trained monitoring personnel and survey equipment may be limited. As the scope of the incident widens, and the number of potentially affected victims expands, health care facilities can be overwhelmed quickly. This can hinder a facility's ability to process patients quickly, as well as reduce the number of staff available for monitoring. This may lead to the need for a Monitoring and Decontamination Unit (refer to [section 5.3](#) for more information).

In an emergency that generates mass casualties or evacuations, hospitals may experience surges of people seeking friends or relatives who may have been involved in the incident. Depending on the scale of the incident, hundreds of people may show up at emergency departments potentially disrupting the ability of medical staff to effectively provide medical services. Hospital emergency plans need to include details that link with local

municipality planning for registration and inquiry services¹⁵ and strategies to redirect hospital inquiries regarding family reunification appropriately.

4.5 Planning for the Evacuation of Health Care Facilities and Vulnerable Populations in the Primary Zone

Hospitals, nursing homes, long-term care facilities, and other health care facilities and organizations located in the Primary Zone of a nuclear facility must have plans in place for evacuation. Families of the residents should also be informed in advance of established arrangements.¹⁶ Similar planning should be done for any other vulnerable populations that cannot be moved easily without additional assistance. Planning may include identifying appropriate health care facilities in the pre-designated host community that can take in evacuees from health care facilities. Refer to [sections 5.2.3 - 5.2.7](#) for response-related information on evacuations.

4.6 Planning for the Provision of Health Care Services at Reception and Evacuee Centres

It is anticipated that most people will find their own accommodations following an RN incident, with planning assumptions expecting that 10 to 20 per cent of the total number of evacuees may require assistance with accommodations.¹⁷ Some evacuees may only require support until they can find their own accommodations. The MOHLTC will work with the local health sector to coordinate the provision of health services to reception and evacuee centres. With proper planning and preparation, the evacuations of large numbers of people can be conducted in a safe and orderly manner, with minimal risk and disruption.

The health system of the communities and surrounding regions hosting evacuees may be greatly impacted by the influx of evacuees. Demands on health human resources, critical care services, psychosocial support, and overall health services may strain local health system capacity. For this reason, host communities and surrounding regions require health surge capacity management plans with the ability to activate when required. Refer to [sections 5.2.3 - 5.2.7](#) for response-related information on evacuations.

4.7 Planning for Psychosocial Impacts

Psychosocial support is an approach to victims of emergencies to foster resilience of both communities and individuals. It aims to address public concerns and needs; ease the resumption of normalcy, and prevent the consequences of disruptive and traumatic situations. Health care and psychological care are important components of psychosocial support. During an RN emergency, the MOHLTC plays an active role in facilitating and coordinating both of these components. Please refer to [section 5.4](#) for more information on psychosocial response.

Psychosocial support can be a critical factor in a nuclear emergency response. The actual risk from radiation is low, but fear among the general public can lead to anxiety and panic. A large portion of the population may react disproportionately to the acknowledgement of

¹⁵ Refer to section 5.6 for more information on Registration and Inquiry Services.

¹⁶ Under the *Long-Term Care Homes Act, 2010*, each facility must have emergency plans for evacuation of the home, including a system in the home to account for the whereabouts of all residents in the event that it is necessary to evacuate and relocate residents and evacuate staff and others in case of an emergency.

¹⁷ *PNERP Master Plan*, Annex B, s. 4.3.2.

a radioactive release into the environment, even if evidence indicates no risk to the health of the public. It is anticipated that the number of people potentially psychologically impacted by the incident will likely far exceed the number of people physically affected. Managing psychosocial impacts from a health perspective includes three main functions listed below, along with how the MOHLTC responds to each:

- a. Providing timely and accurate information about the health risk associated with the event.
 - The MOHLTC develops material and tools for local health systems to communicate to the public at large and the victims of a nuclear or radiological emergency, in a manner that is clear and understandable. Refer to [section 5.8](#) for information on communications during a response.
- b. Providing means to reassure people who believe they may have been exposed or contaminated.
 - Depending on the situation, the MOHLTC can coordinate population monitoring throughout the province. Refer to [section 5.3](#) for more information on Monitoring and Decontamination Units.
- c. Coordinating with other agencies to ensure that the message to the public is consistent and accurate.
 - The MOHLTC coordinates with other agencies through the PEOC on all public communication actions by the health system. Refer to [section 5.8](#) for information on communications during a response.

Health workers must also ensure that these functions are included during treatment, and must be able to provide access to psychological support and counselling for patients. If the local health system is overwhelmed, the MOHLTC can provide assistance and coordination when requested. This capability is coordinated with PEOC.

4.8 Planning for Psychosocial Impacts on Health Workers

All health workers directly and indirectly involved in an RN incident may experience varying degrees of psychological distress as they work with distraught evacuees, and worry about secondary contamination and their family's safety. This distress may be experienced at any time during the incident, but also following in the form of post-traumatic stress disorder. The magnitude of distress can be greatly enhanced when the incident is the result of a deliberate act. Adequate psychosocial support is crucial and must be provided to all health workers.

Health organizations that may be involved in a radiological emergency must be prepared to arrange for the provision of support services to help health workers cope with the stress and anxiety associated with having worked with a radiological hazard. The MOHLTC is prepared to coordinate additional assistance to those organizations when it is not available on site. Since radiation incidents come with preconceived notions of the effects of radiation exposure and contamination, organizations should consider providing education on the effects of radiation. The Public Health Agency of Canada provides general information (not RN specific) on support for caregivers in [Responding to Stressful Events: Self-Care for Caregivers](#).

In certain circumstances, such as at reception and evacuee centres, additional monitoring may be required to assure safe radiation levels for health workers, municipal workers, volunteers, and other staff providing services. The PEOC and the MOHLTC arranges for this monitoring where required. Refer to [section 5.4](#) for information on psychosocial response.

4.9 Security Planning

Security is an essential element of any response to ensure the integrity of the treatment process. The presence of uniformed security at the scene, at triage locations, and at receiving hospitals is required to protect against unauthorized individuals interfering with health workers and compromising contamination controlled areas. Crowd control at the scene is usually a function of local law enforcement. However, it is important for hospitals to pre-plan with local authorities to supplement hospital security personnel with additional officers to assist with traffic and crowd control, both within and in adjacent areas, due to the increased attention focused on the hospital by the public and the media during a radiological emergency. Refer to [section 5.11](#) for security during a response.

4.10 Communications in the Planning Phase

4.10.1 With the Public

In the planning phase, the focus of public communications is raising awareness of the health risks that can occur during an RN incident and how to adequately prepare for such occurrences. The MOHLTC provides basic information for the public on health risks associated with an incident and the steps they can take to protect themselves and their families; available on the MOHLTC website. Refer to [section 5.8](#) for more information on communications during the response phase.

4.10.2 With Health Workers, Stakeholders and Internal Audiences

Hospitals, EMS, and public health units need to plan on coordinating communications with local agencies trained to respond at the site of an RN incident. During an RN event, effective coordination and sharing of information will be the key to ensuring health workers are appropriately protected and the overall health response is effective.

The MOHLTC conducts awareness sessions on the *Radiation Health Response Plan (RHRP)* with different stakeholder groups advising on their roles and responsibilities in an RN emergency and how they can plan for one. The MOHLTC also regularly updates stakeholders on new planning and response tactics, and emerging and potential hazards.

4.11 Long-Term Medical Monitoring

Following an RN emergency that impacts a large number of people, even if the doses received are low, there may be a requirement to assess the long-term health impacts. If required, the MOHLTC will coordinate a medical registry of victims (public and workers), medical follow-up of the population affected, and possibly an epidemiological study. The MOHLTC will determine at the time of the incident if such measures are required, and will be responsible for implementation. Refer to [section 5.7](#) for more information on the medical registry.

4.12 Hospital Expectations

The following hospitals are designated hospitals for a nuclear facility incident. They have Code Orange plans in place with their local nuclear generating station(s) as well as health physicist support from those stations to receive contaminated casualties in the event of an incident requiring medical services. There is no designated hospital in Ontario for Amherstburg that is associated with the Fermi 2 nuclear facility because it is in Michigan, USA and acute patients are not expected.

Table 4.1 Designated Hospitals for Nuclear Facilities

Toronto Western Hospital - Radiation Trauma Unit	Provincially designated as the Tertiary Care hospital for treatment of radiation casualties with acute radiation syndrome.
Rouge Valley - Ajax Hospital, Pickering Hospital, and Lakeridge Health - Bowmanville Hospital	Primary local hospitals designated to receive contaminated casualties from Pickering Nuclear Generating Station and Darlington Nuclear Generating Station.
Kincardine Hospital	Primary local hospital designated to receive contaminated casualties from Bruce Nuclear Generating Station.
Pembroke Regional Hospital	Primary local hospital designated to receive contaminated casualties from Chalk River Laboratories.
Amherstburg - No hospital	There is no designated hospital in Ontario for Amherstburg that is associated with the Fermi 2 nuclear facility because it is in Michigan, USA and acute patients are not expected.

4.12.1 Baseline Expectations for Ontario Hospitals

Hospitals that provide emergency/urgent care were equipped with a standardized package of CBRN supplies and equipment (predetermined according to level designation) as part of the Provincial CBRN Emergency Preparedness Program (refer to [section 4.13](#) for more information). It is expected that all hospitals that are part of the Provincial CBRN Emergency Preparedness Program have the capability to receive a contaminated person, and the capability to provide the following services:

- Access to medical care for contaminated victims.
- Use radiation detection equipment (portal and/or hand-held monitors¹⁸) to determine if external contamination is present, and triage/admit accordingly to the radiation emergency area or regular emergency department.
- Assess and treat medical problems including obtaining medical/incident history, determining contaminant (if possible), and taking considerations to minimize possible contamination intake.
- Survey patient for radiation and document contamination.

¹⁸ As part of the provincial CBRN Emergency Preparedness Program, radiation detection equipment was provided to hospitals. This includes: The MiniSentry gamma sensitive portal monitor, the MCB2 - Alpha/Beta/Gamma Contamination Monitor, and the Dosicard electronic dosimeter. Please refer to Appendix E for manufacturers' information.

- Collect samples for radiological analysis.
- Identify decontamination priorities (wounds, body orifices, intact skin), decontaminate and resurvey.
- Assess for signs of acute radiation syndrome and possible internal contamination.
- Refer to [section 5.10](#) for information on hospital response.

It is expected that receiving hospital(s) will require additional support in the medical management of a patient exposed to radiation, e.g., health physicists. Access to this support and expertise is coordinated through the MOHLTC's **Healthcare Provider Hotline at 1-866-212-2272**.

4.13 Provincial CBRN (Chemical, Biological, Radiological, and Nuclear) Emergency Preparedness Program

In 2005, the MOHLTC developed and implemented a comprehensive RN equipment strategy as a component of the Provincial CBRN Emergency Preparedness Program. The purpose of this program is to provide hospital emergency/urgent care sites with baseline capacity to respond to chemical, biological, radiological and nuclear (CBRN) emergencies to ensure the protection of patients and staff throughout the course of the emergency.

The objectives of the Provincial CBRN emergency preparedness program are to:

- Maintain a stockpile of equipment for use in the event of a CBRN incident affecting hospitals, public health units, and/or EMS services.
- Ensure equipment interoperability across the health system.
- Provide training on the role of each sector and on the use of the supplies and equipment.

The radiation/nuclear supplies and equipment purchased by the MOHTLC are the same for all hospitals, EMS, and public health units to ensure interoperability and common skill sets across the health system. Refer to [Appendix E](#) for CBRN equipment program manufacturers' information and a list of supplies and equipment.

For more information on the CBRN Emergency Preparedness Program, please contact the MOHLTC Emergency Management Branch (EMB) at 416-212-0822 or emergencymanagement.moh@ontario.ca.

4.14 Training and Exercises

All health organizations addressed in this plan should develop and implement training and drills programs covering all aspects related to their responsibilities under this plan. The MOHLTC, along with members of the health sector, will hold periodic exercises of the *RHRP*. A full or partial test of the *RHRP* will be held every three years; ideally this will be in conjunction with a full provincial or federal nuclear emergency exercise. Exercises can take various forms (tabletop, virtual, or field), and may be combined with other exercises. Initial training for hospitals and public health units were developed by the MOHLTC Emergency Management Branch as part of the Provincial CBRN Emergency Preparedness Program launched in 2005.

Health Canada's Radiation Protection Bureau also offers training for the Canadian medical community called Medical Emergency Treatment for Exposures to Radiation (METER). The training helps health workers acting as first receivers respond, work safely, and manage

casualties of RN events. Please contact the MOHLTC for more information on METER training in Ontario at emergencymanagement.moh@ontario.ca.

Additional information on resources for health workers related to the response to an RN incident is available on the [U.S. Department of Health and Human Services Radiation Emergency Medical Management website](#).

4.15 Emergency Planning Zones

4.15.1 Nuclear Emergencies

The map and chart below illustrate the designated municipalities identified by the *PNERP*. These are the municipalities in the vicinity of a nuclear facility, and have been designated under the *Emergency Management and Civil Protection Act* as requiring a nuclear emergency plan. *PNERP* also identifies the host municipalities assigned the responsibility for the reception and care of people evacuated from their homes during a nuclear emergency.

Figure 4.1 Nuclear Generating Facilities from *PNERP*, 2009



Table 4.2 Designated and Host Municipalities

Nuclear Facility	Designated Municipalities	Host Communities
Fermi 2, Michigan	Town of Amherstburg	City of Windsor, Town of Essex
Chalk River Laboratories	Town of Deep River and Laurentian Hills	Town of Deep River
Darlington Nuclear Generating Station	Regional Municipality of Durham	City of Toronto, City of Peterborough
Bruce Power	Municipality of Kincardine	Town of Saugeen Shores
Pickering Nuclear Generating Station	Regional Municipality of Durham and City of Toronto	City of Peterborough

According to the *PNERP*, the radii of the zones for the designated nuclear facilities in Ontario, as measured from the venting or release stacks, are:

Table 4.3 Planning Zones

Zones	Pickering, Darlington, & Bruce	Chalk River Laboratories	Fermi 2
Contiguous Zone	3 km	None	None
Primary Zone	10 km	9 km	23 km
Secondary Zone	50 km	50 km	80 km

According to the *PNERP*, the area around the boundary of a nuclear facility is divided into the following zones¹⁹:

Contiguous Zone: The zone immediately surrounding the nuclear installation. Priority evacuations, if necessary, are undertaken in this area because of its proximity to the source of the potential hazard.

Primary Zone: The zone around the nuclear installation within which detailed planning and preparedness are carried out for measures against exposure to a radioactive plume. (The Primary Zone includes the Contiguous Zone and also a Middle Ring and Outer Ring.)

Secondary Zone: A larger zone within which it is necessary to plan and prepare measures to prevent ingestion of radioactive material. (The Secondary Zone includes both the Primary and Contiguous Zones.)

4.15.2 Radiological Emergencies

According to the *PNERP*, for a radiological incident, there are no fixed zones since the event can occur anywhere. In the absence of fixed zones, a more operational concept is used, based on where actions are likely to be required. The two concepts used are “a controlled area” and “a protective action zone.”

¹⁹ Please refer to the *PNERP* for a more detailed description and diagram of zones for both radiological and nuclear incidents.

The **controlled area** is the zone under the direct control of the emergency responders at the scene. It is established on the basis of contamination and dose rate measurements. Access to this zone is restricted to emergency response personnel. The ‘Hot’ and ‘Warm’ zones are located in the controlled area.

The **protective action zone** is the zone, normally downwind, where public protective actions may be required based on the survey readings. This can vary from tens to hundreds of metres, depending on the event. The ‘Cold’ zone is located in the protective action zone.²⁰

4.16 Containment Systems and Planning Times at Nuclear Facilities²¹

Having an understanding of containment systems at Canadian nuclear facilities can aid in the planning for response activities. The timing of any release of radioactivity into the environment following an accident at a nuclear reactor depends both on the characteristics of the accident and the response of the containment system. Containment systems are specifically designed to prevent releases in the event of an accident, and it is only if the system fails to operate as designed or is bypassed, that the possibility of a significant early, i.e., within a few hours, release arises.

An early release can occur if the accident involves both a rapid release from the fuel, together with a failure of containment to isolate automatically or, if there is some other form of impairment, creating a pathway for the release of radioactivity to the environment.

Containment systems vary in design between different types of reactors and this also affects planning times. The containment design for Ontario’s Canada Deuterium Uranium (CANDU) reactors involves the use of a negative-pressure (vacuum building) concept, which can prevent an uncontrolled release even in the presence of impairment. Over time, the vacuum becomes depleted at a rate depending on the rate of air in leakage, requiring a controlled filtered discharge to the atmosphere, resulting in a sustained or intermittent emission. For planning purposes, the sequence of events and hold-up times to be used in the case of the CANDU reactors in Ontario are generally as follows:

- Typically, there will be a short interval after a loss-of-coolant accident (LOCA) before containment is isolated. During this interval, there may be an initial release of radioactivity (known as a “puff” release) of short duration. Any health impact of this initial release would be investigated and communicated along with appropriate protective actions.
- The interval between any initial puff and the start of a sustained emission could be as short as about one hour (impaired containment), but can be contained for a minimum of 2 days (Pickering), 2½ days (Bruce), or 7 days (Darlington).
- The duration of an emission (whether sustained or intermittent) could be several weeks. The largest release of radioactivity would most likely occur during the first few days.

In the case of the National Research Universal (NRU) reactor at Chalk River Laboratories, which has a relatively small reactor with only a limited containment capability,

²⁰ Refer to section 5.9 for more detailed information about zones for radiological emergencies, specifically Hot, Warm, and Cold Zones.

²¹ Adapted from *PNERP*, 2009.

radioactivity would be emitted to the atmosphere commencing at the time of the accident and would likely cease within one hour depending on the nature of the accident.

The containment system in the Fermi 2 reactor in Michigan, USA is a high-pressure, low-leakage design intended to prevent any release of radioactivity following an accident. A release would occur only if containment were impaired or bypassed, and in such cases would likely commence within a few hours of the onset of the accident. The duration of such a release would depend on the nature of the accident, but is unlikely to exceed 24 hours.

4.16.1 PNERP Notification Categories and Response Levels

Nuclear facilities notify the designated provincial and municipal contact points within 15 minutes. Within 15 minutes of receipt, the Provincial Emergency Operations Centre (PEOC) decides on the initial response level to be adopted, and notifies the designated municipality and the host municipality and confirms with the nuclear installation, if required.

Table 4.4 PEOC’s Notification Categories and Response Levels for Nuclear Facilities

Notification Categories	Provincial Response
Reportable Event	Routine Monitoring
Abnormal Incident	Enhanced Monitoring
Onsite Emergency	Partial Activation
General Emergency	Full Activation

PNERP, 2009.

4.17 Planning Scenarios

The planning scenarios contained in this document focus on radiological/nuclear (RN) incidents from a health perspective. A broad range of possible scenarios that may impact Ontario are covered. Due to the unpredictable nature of emergencies, actual RN incidents may be different from the types considered below. It is impossible to guarantee that all possibilities have been covered. The scenarios identified in the plan are intended to be illustrative and representative of the kinds of situations the health system may respond to. These scenarios provide a general understanding of the types of planning required for RN incidents.

The planning scenarios focus on the radiological impacts of the incidents and do not specifically address conventional trauma, which in many cases can be more consequential than the radiation exposure. In many cases, the radiological impacts are accompanied by conventional medical impacts, which normally take priority over the management of the radiological effects.

The scenarios are categorized as accidents or deliberate acts. Accidents are unpremeditated incidents, whereas deliberate acts involve the intentional release and/or placement of radioactive materials into the environment by terrorists, criminals, or persons with the intention of causing terror or harm to the public.

Table 4.5 identifies and describes each of the planning scenarios considered in this plan

#	Scenario title	Brief description
Accidents		
1	Power reactor accidental release	Accident affecting the nuclear fuel and leading to a release of radioactive fission products to the environment. The most serious events involve nuclear facilities in Ontario. Similar events at reactors outside the province will lead to similar, but less serious, impacts to Ontarians.
2	Research reactor accidental release	Same as above, but on a much smaller scale.
3	Radioactive spill	Contamination of an industrial facility resulting from the loss of integrity of liquid or gaseous radioactive sources.
4	Fire in a radiological facility	Fire affecting stored radioactive sources, leading to the contamination of the facility and possibly affecting the environment outside the facility.
5	Criticality accident	Unexpected and uncontrolled surge in the neutron flux of a nuclear pile or assembly, in a research or industrial facility, leading to significant exposure of the operators.
6	Industrial overexposure	Overexposure of industrial source users due to the loss of shielding of radioactive sources.
7	Lost or stolen source	Unknown location of radioactive sources resulting in the potential exposure of an unknown number of members of the public.
8	Medical overexposure	Errors in the administration of radioactive diagnostic or therapeutic treatments, leading to the overexposure of patients.
9	Transportation accident	Spill, contamination, or airborne release of radioactive material resulting from a transport vehicle accident with or without fire.
10	Satellite re-entry	Crash of a satellite containing nuclear material as a power source, resulting in contamination of a large surface area.
Deliberate acts		
11	Explosive radiological dispersal device or dirty bomb	Explosive device containing radioactive material resulting in both radiological and conventional injuries.
12	Deliberate exposure of people	Strong radioactive sources strategically placed to yield large exposures of a few persons or a large population.
13	Deliberate contamination of a site	Dispersion of radioactive contamination without an explosive device leading to a large area of contamination and subsequently exposing people to radiation.
14	Deliberate contamination of food or water supplies	Insertion of radioactive material in a suitable form at strategic points in the food or water distribution systems with the intention of contaminating a large population.
15	Sabotage attack upon a nuclear facility	Intentional damage to a nuclear facility with the intent of causing a release of radioactive material.
16	Nuclear weapon detonation	Detonation with a nuclear yield (as opposed to a fire or explosion affecting the plutonium contained in the weapon), resulting in hundreds to thousands of deaths and injuries.
17	Imminent terrorist threat	Information has been received or otherwise disclosed that terrorists, criminals, or other persons intend to commit a malevolent act involving the use of radioactive materials.
18	Poisoning of a person by contamination of food	Based on the Litvinenko incident; where a person contaminated the food of the victim with the intent to kill, thereby generating widespread contamination.

4.18 Planning Considerations for Each Scenario

This section presents the main planning considerations for each scenario. A detailed description of each scenario, expected impacts, and the response requirements for the health system is included in [Appendix K](#). In the following, “being prepared for” means having plans, procedures, tools, equipment, and training to carry out the required actions; [sections 4.1- 4.14](#) provide guidance and details to help health organizations in these areas.

1 & 2: Power and research reactor accidental release

For emergencies at a nuclear facility in Ontario, designated Emergency Medical Services (EMS) must have plans, procedures, tools, equipment, and training (“be prepared”) to respond to the facility in accordance with local arrangements with the licensee to assist on-site response personnel and evacuate potentially contaminated patients (refer to [section 4.2](#)). Designated health care facilities must be prepared to receive contaminated and potentially overexposed personnel from the station and to refer them, if required, to hospitals with the expertise to treat overexposed and internally contaminated patients (refer to [section 4.2](#)). Various sectors of the health system must be prepared to deal with the psychosocial aspects of the emergency (refer to [section 4.7](#)). If required, all health care facilities in the primary zone must be prepared to evacuate patients and personnel (refer to [section 4.5](#)).

3 & 4: Radioactive spill or fire in a nuclear or radiological facility

These types of accidents could occur at facilities that routinely use nuclear or radioactive material. Planning considerations only apply to health care services that are close to such facilities, and normally in accordance with previous arrangements with the licensee.

EMS personnel must have plans, procedures, tools, equipment, and training (“be prepared”) to respond to a potentially contaminated area, and to transport potentially contaminated patients to a hospital for further treatment. Hospitals must be prepared to receive contaminated and potentially overexposed personnel from the facility and to refer them, if required, to hospitals with the expertise to treat overexposed and internally contaminated patients (refer to [sections 4.1 & 4.2](#)).

5: Criticality accident

Criticality incidents could occur in a research reactor with flexible fuel configuration or a fuel enrichment facility.

6: Industrial overexposure

Very few people are likely to be involved, and the only risk is that of external exposure. Industrial overexposures can occur anywhere, as radioactive sources are used for numerous industrial practices. Therefore, all hospitals must have plans, procedures, tools, equipment, and training (“be prepared”) to manage the acute care of victims of an industrial overexposure, and to refer the patients to hospitals with expertise in the treatment of acute overexposure (refer to [section 4.1](#)).

7: Lost or stolen source

This scenario is not limited to a specific location. The impacts can be limited to a few persons or to a community, as in the case of Goiania, Brazil, in 1987. The most likely case for this scenario is the external overexposure of people who have found and handled the

source. The main planning considerations are the same as for the case of an accidental industrial overexposure (scenario 6). In the very unlikely event a source was in powder form and people were exposed, EMS, health care facilities, and local public health organizations need to be able to promptly and effectively implement a mass casualty plan (refer to [section 4.4](#) for information on planning for mass casualties).

8: Medical overexposure

Health care settings that administer medical procedures using radiation or radioactive substances must have plans, procedures, tools, equipment, and training (“be prepared”) to assess the overexposure, identify the affected patients, and deal with the psychological care that the victims and other patients following similar procedures require. They must also be prepared to deal with the psychosocial impacts on the victims’ families and the patient community at large (refer to [section 4.7 & 4.8](#)).

9: Transportation accident

The planning considerations for a transportation accident are the same as for the response to a radioactive spill (scenario 3). EMS personnel must have plans, procedures, tools, equipment, and training (“be prepared”) to respond to a potentially contaminated area and to carry potentially contaminated patients to a hospital for further treatment. Hospitals must be prepared to receive contaminated personnel from the scene. Refer to [section 4.2](#).

10: Satellite re-entry

Satellite re-entry could be a disastrous situation of very low probability. It is almost impossible to plan in detail for this event. Health care facilities must have plans, procedures, tools, equipment, and training (“be prepared”) to manage a large number of conventional casualties, and screen a number of people for possible contamination (refer to [section 4.2](#)). A mass casualty plan is required to manage this contingency (refer to [section 4.4](#)).

11: Explosive radiological dispersal device or dirty bomb

The planning considerations for a dirty bomb are essentially the same as for a transportation accident involving radioactive material with the following additions.

There is a high likelihood that the number of casualties and patients will overwhelm the local health response capabilities. Since a dirty bomb detonation is most likely to occur in a large city (e.g., Toronto or Ottawa), health care facilities in those regions need a prompt and effective mass casualty plan (refer to [section 4.4](#)). EMS needs to have plans, procedures, tools, equipment, and training (“be prepared”) to deal with a large number of contaminated patients (refer to [section 4.2](#)) and the Ministry of Health and Long-Term Care (MOHLTC) may need to coordinate the provision of monitoring and decontamination units to handle a large number of people (refer to [section 5.3](#)). Since acute radiation effects are not likely, the focus will be on contamination screening, decontamination, and the medical treatment of contaminated victims. Various health organizations in those regions need to manage the psychosocial impacts (refer to [section 4.7](#)).

12: Deliberate exposure of people

The health system needs to be able to detect multiple occurrences of overexposure, which can be the first indication that this type of event is taking place (refer to [section 4.1](#)). The

MOHLTC will coordinate the gathering and analysis of information regarding potentially overexposed victims throughout the health system. If required, the MOHLTC can assist in recommending specialized health care facilities that can take potentially acutely exposed patients. The health system must have plans, procedures, tools, equipment, and training (“be prepared”) to deal with the psychosocial impacts, taking into consideration that the number of exposed individuals can be large, and that their location may be geographically diverse (refer to [section 4.7](#)).

13: Deliberate contamination of a site

The planning considerations for this event are similar to scenario 12 with the exception that acute exposure is unlikely, and contamination is the main challenge. In this case, the MOHLTC coordinates the establishment of monitoring and decontamination units (MDUs) throughout the province, where potentially contaminated people may have travelled (refer to [section 5.3](#)). EMS may have to respond in the contaminated zone, but this is not likely, unless the event is concurrent with a conventional accident. Various parts of the health system must have plans, procedures, tools, equipment, and training (“be prepared”) to deal with the psychosocial impacts (refer to [section 4.7](#)).

14: Deliberate contamination of food or water supplies

This type of malevolent act is unlikely to lead to significant contamination or acute exposure. The main focus of a response would be managing the psychosocial aspects (refer to [section 4.7](#)). Public health must have plans, procedures, tools, equipment, and training (“be prepared”) to deal with this impact, including the provision of advice on food and water safety. The MOHLTC may be requested to set up MDUs to reassure people who may have been affected, that they are free of contamination; both external and internal (refer to [section 5.3](#)).

15: Sabotage attack upon a nuclear facility

The planning considerations for this type of act are identical to those discussed for scenarios 1 and 2.

16: Nuclear weapon detonation

This event requires planning for a very large number of conventional and contaminated casualties over a wide area. This event would overwhelm many of the local and regional health care facilities. This is a mass casualty situation, and the response would need to be coordinated by the MOHLTC in close cooperation with PEOC and federal organizations based on available resources (refer to [section 4.4](#)).

17: Imminent terrorist threat

There are no specific planning considerations for this type of situation. As described in scenario 12 (deliberate exposure of people), the health system needs to have plans, procedures, tools, equipment, and training (“be prepared”) to recognize multiple occurrences of early symptoms of overexposure (refer to [section 4.1](#)). In all other cases, the MOHLTC and the health system must be prepared to stand up resources and activate emergency plans to promptly respond to the event.

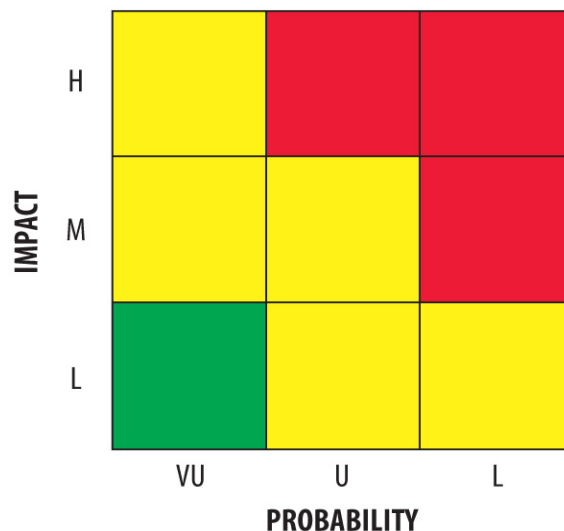
18: Poisoning of a person by contamination of food

As discussed above for scenarios 12, 13 and 14, this event requires hospitals to have plans, procedures, tools, equipment, and training (“be prepared”) to recognize the early symptoms of acute exposure (refer to [section 4.1](#)). The MOHLTC will be prepared to coordinate the screening and treatment of potentially contaminated patients, taking into consideration that the priority needs to be given to internal contamination. There could be a lot of people who have, or believe they have, come into contact with the contamination and, since those people may have travelled, the MOHLTC may be requested to coordinate the establishment of several MDUs throughout the province (refer to [section 5.3](#)). The health system must also be prepared to deal with the extensive psychosocial impacts of this event (refer to [section 4.7](#)).

4.18.1 Risk Assessment of Potential Radiological Impacts

Table 4.6 presents a risk assessment of the possible radiological impacts of the various scenarios (low-L, medium-M, high-H), from a medical and public health perspective.²² In this assessment:

- a. Each scenario is considered in terms of its most probable form of occurrence. For example, for power reactor accidental release, the planning basis reactor accidents are considered.
- b. For more severe forms of each scenario, for example a severe accident with core melt, contingency arrangements should be considered.
- c. External and internal contamination refers to levels that could require assessment and decontamination.
- d. N/A means that this impact is not considered credible.
- e. Colours refer to the risk matrix shown below.
- f. The definition of probability is highly subjective and is not based on a rigorous statistical analysis. *Very unlikely* (VU) means that the event will probably never be experienced. *Unlikely* (U) means that it could happen as similar events have happened in the past. *Likely* (L) means that the event will almost certainly happen.



²² Risk assessment was conducted in 2005 by International Safety Research Inc. and validated by a ministry reference group. It was subsequently revised in 2013 by ISR.

Table 4.6 Risk Assessment of Scenarios

#	Title	Overall probability	Acute exposure	External contamination	Internal contamination	Psychosocial	Explanation
1	Power reactor accidental release (off-site impacts)	Unlikely	Low	High	Low	High	Based on a planning basis accident. Such accidents have occurred in the past. Severe accidents could have greater impacts. The levels of external contamination would be low but may require decontamination.
2	Research reactor accidental release	Unlikely	Low	Low	Low	Med	Research reactors in Ontario have very low power. The main impacts would be limited to facility personnel. Off-site impacts would be very low.
3	Radioactive spill	Likely	N/A	Low	Low	Low	If properly managed, the impacts would be limited to tens of metres.
4	Fire in a radiological facility	Unlikely	Low	Low	Low	Med	Fire regulations in Ontario and requirements for the protection of radioactive material make this event unlikely to happen in the foreseeable future.
5	Criticality accident	Very unlikely	Low	Low	Low	Med	Criticality incidents could occur in a research reactor with flexible fuel configuration or a fuel enrichment facility.
6	Industrial overexposure	Likely	Low	N/A	N/A	Low	Mishandling of industrial sources is one of the most common causes of accidental radiation exposure.
7	Lost or stolen source	Likely	Low	Low	Low	Med	Several sources are lost each year in Canada. Most are small and not dangerous, and recovered within days. Most are sealed sources making the probability of contamination low.
8	Medical overexposure	Unlikely	Medium	N/A	N/A	Low	Several cases of medical overexposures have occurred in the past, some involving Canadian equipment, and most recently in Trinidad and Tobago (2010) with a Varian system from the USA. The victims are the patients, of which several could be overexposed before the situation is discovered. The psychosocial impact is mainly limited to the patients and their families.
9	Transportation accident	Unlikely	Low	Low	Low	Med	Transportation accidents involving radioactive material have happened. But those leading to contamination of the scene are rare.

#	Title	Overall probability	Acute exposure	External contamination	Internal contamination	Psychosocial	Explanation
10	Satellite re-entry	Very unlikely	Low	High	Low	High	Satellite re-entries are a rare occurrence. A re-entry impacting populated areas of Ontario is virtually impossible given the orbits and earth's vast surface area.
11	Explosive radiological dispersal device or dirty bomb	Very unlikely	Low	Med	Med	High	Based on the current threat assessment (2012). The overall probability may change if the Canadian threat assessment situation changes. This applies to all subsequent cases of terrorism.
12	Deliberate exposure of people	Very unlikely	High	N/A	N/A	High	See 11.
13	Deliberate contamination of a site	Very unlikely	N/A	Med	Med	Med	See 11. Due to dilution, acute exposure is not considered credible.
14	Deliberate contamination of food or water supplies	Very unlikely	N/A	Low	High	High	See 11. Level of contamination would likely be very low and would mainly represent a psychological concern. However, it may require monitoring of internal contamination levels in a large number of people for the main purpose of reassurance.
15	Sabotage attack upon a nuclear facility	Very unlikely	Low	High	Low	High	See 11. The impacts would not be fundamentally different than those of a conventional power plant accident. Only the probability changes.
16	Nuclear weapon detonation	Very unlikely	High	High	High	High	See 11.
17	Imminent terrorist threat	Unlikely	N/A	N/A	N/A	High	Although the execution of a terrorist act is considered very unlikely in the present risk assessment, the threat to commit one is considered possible.
18	Poisoning of a person by contamination of food	Unlikely	Low	Medium	Low	High	In addition to the Litvinenko case in the UK, there have been a number of cases where individuals have tried to use radioactive substances to cause harm to individuals.

Chapter 5 Responding to a Radiation Emergency

Chapter 5 is divided into four sections, all related to the response to a radiological/nuclear (RN) emergency:

- a. *Concept of Operations*, dealing with notification and structure of the Ministry of Health and Long-Term Care's (MOHLTC) response.
- b. *Community Response*, dealing with community activities related to the implementation of precautionary and protective actions.
- c. *Other Community Response Measures*, dealing with other community activities that do not fall under precautionary and protective actions.
- d. *Pre-Hospital and Hospital Response*, focusing only on the response in those two areas.

Concept of Operations

5.1 Notification

A description of the process by which information is shared with the MOHLTC:

When an incident occurs at a nuclear facility, the Provincial Emergency Operations Centre (PEOC), the Canadian Nuclear Safety Commission (CNSC), and/or Health Canada are normally the first government agencies to receive the initial report. For a nuclear emergency occurring in a foreign country, Health Canada and the CNSC are the official notification points of contact.

For radiological incidents, the notification trigger may be a 911 emergency call, or in some cases, e.g., a terrorist or a criminal act, the PEOC, the Royal Canadian Mounted Police (RCMP), or the CNSC may be the first authorities contacted.

It is also possible that the health system, having identified a pattern of acute radiation illnesses, would be the one notifying the MOHLTC that a situation may be in progress. Any suspected case of overexposure to radiation is to be immediately reported to the MOHLTC-Healthcare Provider Hotline. All reports are monitored, analyzed and followed up on. A large number of reports in one or several locations may be an indication that people are being exposed, intentionally or not, to radioactive sources. The MOHLTC determines if a case of overexposure is suspected. It takes only one suspected exposure case to activate the health response.

The MOHLTC is notified of a nuclear emergency by the PEOC or through the health system by Emergency Medical Services (EMS)/hospitals dealing with contaminated or overexposed patients. All notification reports must be made to the MOHLTC Emergency Management Branch (EMB) via the **Healthcare Provider Hotline at 1-866-212-2272**. The report is initially screened by the Healthcare Provider Hotline call taker who passes on the information to the EMB Director or a delegated manager (on-call 24-7), who triggers the *Radiation Health Response Plan (RHRP)* activation process.

Once the EMB Director/delegate has been informed of the incident, he/she contacts the call originator. If EMB was the first to be contacted directly by the primarily affected

health care facility, setting, hospital, or organization, the EMB Director/delegate then notifies the following partners:

- Executive Director, Public Health Division, MOHLTC
- The Chief Medical Officer of Health for Ontario/Associate Chief Medical Officer of Health
- PEOC: PEOC-Duty Officer
- Public Health Ontario (PHO)
- Health Canada: Federal Nuclear Emergency Plan (FNEP) - Duty Officer
- Health Portfolio Emergency Operations Centre (HPEOC): Public Health Agency of Canada (PHAC) and Health Canada Duty Officer
- Regional PHAC representative
- Local Health Sector (LHINs and PHUs)

If the *Provincial Nuclear Emergency Response Plan (PNERP)* is activated, and the PEOC requests the activation of the *RHRP*, the EMB Director/delegate activates the *RHRP*. If the *PNERP* is not activated, the EMB Director/delegate determines if activation of the *RHRP* is required. If the PEOC is activated, a liaison is sent there to represent the MOHLTC.

In the event the *RHRP* is activated, the EMB Director/delegate implements the Ministry Emergency Response Plan (*MERP*) and activates the Ministry's Emergency Operations Centre (MEOC). For details on the MOHLTC's response levels, please see the [MERP](#).

Annex D of the *PNERP* details specific notification and response levels for nuclear emergencies.

5.1.1 Health System Notification for Imminent Threat Situations

In a situation where there is a credible RN threat, but no consequences from radiation yet, it would be prudent to alert key health system partners within the threat area. This would allow them to be more vigilant in monitoring for signs of acute exposure, and to initiate preparedness measures to deal with acutely exposed patients should the threat become a reality.

The criteria for sharing the decision to issue such an alert to the broader health system will be made after the following points have been carefully considered:

- The nature of the threat, i.e., single or multiple threats; external exposure or dispersion of contamination.
- The issuance of an alert will result in the deployment of resources, which may later prove to be unnecessary.
- Releasing information on the threat to the broader health system increases the possibility that it will reach the public domain.
- Issuing an alert may cause unnecessary public alarm.

Health stakeholders and the PEOC will be informed of the measures to take should potentially exposed or contaminated casualties seek medical attention, as well as on which health care facilities have the expertise to deal with screening, contamination and exposure.

5.1.2 MOHLTC Emergency Management Response Structure

The MOHLTC uses the incident management system (IMS). IMS is a standardized and coordinated approach to managing incidents that provides functional interoperability at all levels of emergency management. It defines the basic command structure and roles and responsibilities required for the effective management and coordination at all response levels. The MOHLTC emergency response structure is provided in detail in the [Ministry Emergency Response Plan \(MERP\)](#).

The PEOC is responsible for decisions regarding the implementation of precautionary and protective actions. The MOHLTC will provide advice and guidance to PEOC on those decisions. The MOHLTC is responsible for deciding when to administer potassium iodide for iodine thyroid blocking (ITB). Guidance on precautionary and protective actions, protective action levels (PALs) and the way they are applied is provided in [Appendix C](#). Guidelines on the use of potassium iodide (KI) for ITB are provided in [Annex 1](#).

The MEOC coordinates with the PEOC and agencies involved in the on-site response, e.g., Ontario Office of the Fire Marshal, Ontario Provincial Police, Municipal CBRNE response teams (Chemical, Biological, Radiological, Nuclear, and Explosive). The MEOC ensures that information from the local health system is communicated to the PEOC, and that decisions from the PEOC are communicated back to the local health system. In addition, the MOHLTC liaises with the PEOC and other agencies involved in the on-site response, to ensure that information on the source and type of radiation is communicated to health care facilities²³ as soon as this information is known. The MEOC also coordinates with the local health system to ensure that the resources are optimally used, and to provide additional assistance when required.

²³ NOTE: Radiation events can happen very quickly and in some cases hospitals and clinics may already be inundated with contaminated patients from the scene before they are notified of the event.

Responding to a Radiation Emergency: Community Response

The health-related goals of a community response to an RN emergency are:

- To protect the health and safety of affected people, evacuees, health workers, first responders, and emergency response personnel.
- To provide guidance to the health system based on established emergency planning, provincial direction, and up-to-date information.

Information presented is intended for the following purposes:

- To provide community level information on response actions to assist local health emergency responders.
- To outline the expectations and proposed operational response of the health system to support community response activities.

The *Community Response* and *Other Community Response Measures* sections focus on providing information on precautionary and protective measures to deal with an RN emergency, as well as guidance on the methods for implementation. Although the focus on this section is response, this information should be considered from a planning perspective, e.g., when developing local plans and procedures.

5.2 Precautionary and Protective Measures

Protective measures of sheltering, evacuation, iodine thyroid blocking, and food and water controls form the basis of interventions that can be initiated en masse at the local level during an RN incident. This section provides a general outline of these protective measures and how the health system participates in their implementation and application.²⁴

There are three principles MOHLTC follows that form the general basis for intervention during an RN incident:²⁵

1. As a first priority, interventions are carried out to avoid serious immediate health effects.
2. Protective actions to minimize the occurrence of delayed health effects are to be initiated if they are likely to produce more good than harm in the affected population.
3. These actions are introduced and withdrawn at levels that produce a maximum net benefit to the population.

The *PNERP* prescribes Protective Action Levels (PALs) to provide technical guidance on the need for affected populations to take specific precautionary and protective measures for exposure and ingestion control. Refer to [Appendix C](#) for more information on PALs.

²⁴ Food and water controls will not be covered in-depth in the *RHRP* as it is the responsibility of the Ministry of Labour's Radiation Protection Monitoring Service. Please see the *Assurance/General Province-Wide Monitoring Group Plan* for more information.

²⁵ These principles are espoused by the IAEA, Health Canada, and generally agreed upon internationally. IAEA 1996; and Health Canada November 2003.

5.2.1 Decision to Adopt and Lift Precautionary and Protective Measures

The decision to adopt and lift precautionary and protective measures during a nuclear facility emergency would be made under the authority of the PEOC in consultation with other provincial ministries (including the MOHLTC and the CMOH) and the affected communities. The decision will be based on technical assessments, and operational, public safety and health considerations. Implementation of this direction is the responsibility of the local community through its community EOC. Emergency communications bulletins outlining precautionary and protective orders are issued by the PEOC in conjunction with the community EOC. In the event that an immediate decision is required that does not permit consultation with the community EOC, the PEOC decides on the required measures and then issues them directly to the public.

For a non-facility-based radiological incident where measures are needed immediately, initial protective action decisions are made by emergency first responders. The Assurance Monitoring Group (AMG) will be activated to collect samples for analysis by the Ministry of Labour's Radiation Protection Monitoring Service. Based on the results of the data, and operational and public safety considerations, precautionary and protective measures may be adjusted or lifted with direction disseminated through operational directives.²⁶ The Province will aim to discuss all precautionary and protective measures with the affected community prior to ordering them, even if a provincial emergency has been declared and the power rests solely with the Province.

5.2.2 Sheltering

This section provides general information on sheltering should health sector institutions have to adopt this measure. Information on sheltering for private homes is the responsibility of the PEOC. Sheltering orders are provided by the PEOC Emergency Bulletins²⁷ directing people to remain inside, close and seal all doors and windows, and shut off any external ventilation systems such as air conditioners and fans.

Sheltering is the protective measure of remaining inside solidly constructed, reasonably airtight buildings with doors and windows closed and ventilation systems turned off. The restriction of airflow into the building during the passage of a radioactive plume reduces inhalation exposure, while the solid construction of the walls reduces external exposure from radioactive material outside the building.²⁸

Sheltering provides protection against airborne and deposited radioactive substances. It is a quick protective measure to implement during the initial hours of the incident when monitoring and measurement results are not immediately available. During incidents where low-level radiation doses are projected (in the case of a small emission, or if variable wind conditions prevail during a large emission), sheltering helps reduce exposure as many radioactive materials rapidly decay and dissipate, and the walls of buildings assist to block much of the harmful radiation.

²⁶ Adapted from *PNERP - Implementing Plan for Other Radiological Emergencies*, 2011.

²⁷ Consult the *PNERP* for more information on PEOC Emergency Bulletins.

²⁸ National Radiological Protection Board, United Kingdom, 2001.

Generally, sheltering is most effective if a puff or a plume emission is of short duration, specifically less than 24 hours. The effectiveness of sheltering decreases with time for most structures, and it is difficult to keep people sheltered in place for a long time.²⁹

Emergency situations may call for sheltering initially, followed by evacuation measures (preferably during daylight hours). Examples of when this type of approach may be appropriate include:

- If an emission occurs suddenly with insufficient time to evacuate people before the plume arrives into the community.
- If it is safer to wait out transitory environmental conditions while taking additional time to safely organize an evacuation.
- If the emission requires continuous sheltering for more than 24 hours.

5.2.3 Evacuation

Evacuation is the controlled removal of people from an identified area to avoid or reduce exposure to a hazard. Generally, evacuation is the most effective method of avoiding exposure to radiation in an RN emergency with an emission release that has been contained and will be released in a few days.

The implementation of an evacuation could potentially involve some difficulty and risk, and can be quite disruptive and costly to the individual and community. Risks associated with evacuation include transportation accidents, anxiety, and separation, exacerbation of existing health issues, and possible exposure to severe weather conditions and/or competing disasters. The decision to evacuate will be carefully considered with these risks in mind and balanced against the risk to health from radiation. Evacuation orders are provided by the PEOC through Emergency Bulletins and numerous other channels.

Please see Figure 5.1 for a graphical illustration of where evacuees will likely be under various scenarios during an RN emergency.

Evacuation can be implemented in two ways:

General Evacuation:

A general evacuation would require all persons in the designated area to evacuate immediately. This situation could occur if the event is sudden; such as an unexpected emission from a nuclear facility.

Some groups that cannot be immediately moved without additional assistance may be exempted from a general evacuation. This exception also applies to any service institutions deemed critical at the time that would have to remain open in the evacuated area. Such groups would be automatically required to adopt sheltering in lieu of evacuation and, if appropriate, iodine thyroid blocking. The duration of sheltering would have to be considered in light of the fact that sheltering effectiveness decreases with time depending on the air exchange rate, the ability to function with internal air recirculation, and the time during which patients and personnel can remain inside. For these reasons, sheltering would be utilized for as short as possible until the threat dissipates or a safe evacuation can be conducted.

²⁹ IAEA 1996.

Note: Radiation levels are to be monitored as needed at organizations required to shelter in evacuated areas. In a nuclear facility emergency, this is managed by the facility. In a non-facility radiological emergency, the PEOC manages this activity. The MOHLTC coordinates with PEOC to ensure that this monitoring occurs.

Selective Evacuation:

This approach would involve specific population groups to be evacuated in anticipation of a general evacuation later, e.g., seriously ill patients in hospitals, bedridden residents of nursing homes, or residents/persons with disabilities.

Patients from hospitals, residents of nursing and long-term care facilities, and other facilities for people with various disabilities, may need to be evacuated directly to an appropriate facility outside the affected area. These evacuees may need to proceed via a Monitoring & Decontamination Unit (MDU)³⁰; albeit only if it is necessary and feasible from a health and safety perspective. This movement could be coordinated by the local Community Emergency Management Coordinator (CEMC) in partnership with the Local Health Integration Network (LHIN) that may be informed as to where the most appropriate facility would be. The MOHLTC MEOC provides support and coordination for such movement in cooperation with the affected municipality, where required. In the event of such a situation, affected health organizations need to inform the ministry, and provide information regarding the amount of people requiring evacuation assistance.

There may be people with mental health needs who are not linked with support organizations within the health system; if affected by the incident, these people may require additional care. Local health organizations should be prepared to receive individuals requiring additional needs. The MOHLTC can provide assistance and coordination as required.

5.2.4 Health System Impact of Evacuees on Affected and Host Communities

In the event of a general evacuation, the MOHLTC will engage with the affected and host health systems directly through the local LHIN, public health units, Community Emergency Operations Centres, and other health agencies as required. Through this engagement, the MOHLTC ensures health systems are able to respond adequately to the demand, and inquire whether they require additional support.

If needed, the MOHLTC can provide assistance and coordination to the affected region and/or host community's health system to support evacuation efforts. The MOHLTC assistance includes, but is not limited to: the provision of supplies and equipment, information and guidance (including occupational health and safety information), and medical surge support, e.g., deployment of the Emergency Medical Assistance Team (EMAT).

5.2.5 Reception and Evacuee Centres

Arrangements for the reception and care of evacuees are made by the affected and host municipality and covered in municipal emergency plans. Reception and care of evacuees may involve participation of public health, EMS, social services, and other health service

³⁰ Refer to section 5.3 for more information on MDUs.

providers as required. Responders may be health workers or volunteers with associated occupational health and safety obligations.

The general purpose of Reception and Evacuee Centres are as follows:

Reception Centres are set up to provide initial care, registration and inquiry services, and to facilitate the transition to an evacuee centre/emergency shelter. Registration and Inquiry services assist in reuniting families by collecting information and answering inquiries regarding the condition and whereabouts of missing persons. Reception Centres are organized and managed by municipalities. An MDU may be co-located at a Reception Centres.³¹

Note: In situations where evacuees do not need to physically attend a Reception Centre but still require Registration and Inquiry services, designated/affected municipalities are permitted to establish alternate arrangements, e.g., by phone, mail, or Internet.

Evacuee Centres (also known as emergency shelters) are facilities established to provide emergency social services (i.e., emergency shelter, food, clothing, registration and inquiry services, and personal services) to people who have been evacuated as a result of an RN emergency. The planning and operation of evacuee centres is led by municipalities. The Ministry of Community and Social Services (MCSS) can assist municipalities in the delivery of emergency social services when their capacity is exceeded and a provincial response is required. An Evacuee Centre may be co-located with a Reception Centre.

It is anticipated that most people will find their own accommodations, with planning assumptions expecting that 10-20 per cent of the total number of evacuees may require assistance with accommodations.³² Some evacuees may only require short-term support until they can find their own accommodations.

5.2.6 Health System Functions Provided at Reception and Evacuee Centres

The organizations responsible for providing specific functions at Reception and Evacuee Centres varies by community and depends on a number of factors, including: available resources, municipal emergency plans, and the configuration of health services in the community.

Health organizations that may be requested to assist with Reception and Evacuee Centre activities include public health units, Community Health Centres, Emergency Medical Services, Community Care Access Centres, and LHINs.

The functions and services provided to evacuees at these centres include:

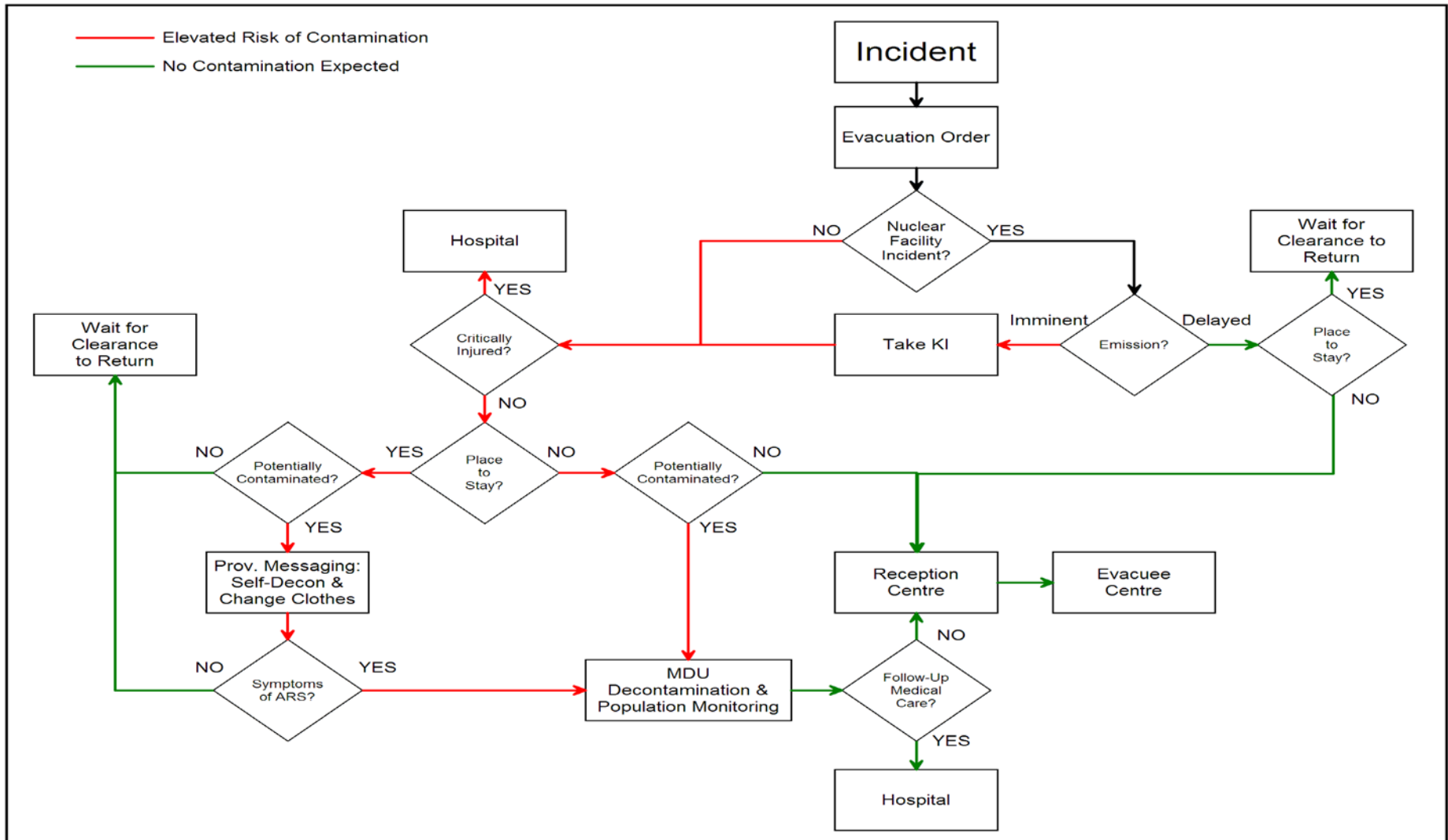
- Assistance with health-related issues.
- Medical aid, support and counselling, and referral to other services, as needed.
- Assistance with medication replacement, glasses, wheelchairs and other assistive devices.
- Assessment of sanitation, food, water, and other hazards.

³¹ Refer to section 5.3 for more information about MDUs.

³² PNERP 2009, p. 75.

Figure 5.1 Evacuee Flow Path Diagram

The diagram below is a graphical illustration of where evacuees will likely be under various scenarios during an RN emergency.³³



³³ Diagram designed by the MOHLTC Emergency Management Branch, 2012.

5.2.7 Relocation

Relocation is the displacement of a population from a contaminated area for a period of several weeks or longer. Relocation involves moving people and their belongings from their homes to evacuee centres, or to live in alternate accommodations. This could occur if the incident that caused the initial evacuation led to a moderate deposition of long-lived radionuclides causing the area to be deemed too hazardous for residents to return.³⁴ In such an event, the MOHLTC coordinates with the health sector to ensure health service continuity to the relocated population.

5.2.8 Iodine Thyroid Blocking

Iodine thyroid blocking is the method by which the thyroid gland's ability to absorb radioiodine is prevented or reduced through the ingestion of the stable iodine compound, potassium iodide (KI), before or shortly after exposure to radioiodine.

Iodine thyroid blocking is one of a number of protective measures available to deal with the effects of an emergency at a nuclear facility involving radioiodine. This measure will always be implemented in conjunction with either evacuation or sheltering for the public; with restrictions on entering affected areas; and for emergency workers entering affected areas.

NOTE: Iodine thyroid blocking using KI is only effective against radioiodine, which is only one of the many potential radionuclides that may be released in an accident at a nuclear facility or a nuclear blast. Iodine thyroid blocking is not effective against other radionuclides, and would not be advised for radiological incidents where radioactive iodine is not detected. Evacuation before emissions have started is the most effective protective measure in the event of a nuclear emergency because it protects the whole body from all radionuclides and all exposure pathways.

For more information on iodine thyroid blocking during a nuclear facility incident, please refer to the KI Guidelines in [Annex 1](#).

5.2.9 Food and Water Controls; Liquid Emission Response

Preventing potentially contaminated food and water from reaching the public is an essential protective measure following a radiological or nuclear emergency. The MOHLTC is a member of the Assurance Monitoring Group (AMG) led by the Ministry of Labour (MOL). The MOHLTC's role in the group is to provide guidance on the impact of radioactivity on human health. The information gathered by the AMG, through the MOL's Radiation Protection Monitoring Service, informs any actions that are needed to protect the public from contaminated foodstuffs or drinking water. In this situation, the MOHLTC can connect the AMG with local Medical Officers of Health who have powers to control the sale or distribution of foodstuffs, where those foodstuffs constitute a health hazard,³⁵ following an RN event. For more information on the AMG and the Radiation Protection Monitoring Service, please see the MOL's [webpage](#).

For situations involving a liquid discharge with abnormal levels of radioactivity from Ontario Power Generation (OPG) and Bruce Power into Lake Ontario and Lake Huron respectively,

³⁴ Health Canada, 2003.

³⁵ This power comes from section 13 of the *Health Protection and Promotion Act*.

the response is coordinated under the *Provincial Liquid Emission Response Procedure* and led by PEOC. In such an event, the Provincial Liquid Emission Response Team (PLERT) is formed to facilitate a coordinated response. The MOHLTC's role on the team is to report on the coordination of health activities, provide guidance on health issues, provide coordination between the CMOH and local health authorities, and indicate if any protective actions or health advisories/orders have been issued or recommended.

Responding to a Radiation Emergency: Other Community Response Measures

5.3 Monitoring and Decontamination Units (MDUs)

In the event that people are contaminated during an RN incident, assessment and decontamination will likely take place at one of the following four locations³⁶:

1. At the **site of the incident** by a specialized first response team, e.g., CBRNE Team, Hazardous Materials (HAZMAT) team.
2. At a **hospital** via any of three scenarios:
 - a. If a casualty is transported to hospital by first responders, and decontamination on the scene is not feasible or appropriate; or,
 - b. A casualty has left the scene and made their way to hospital on their own without being assessed by first responders; or,
 - c. If the incident does not involve a nuclear facility, is small scale, and the number of potentially contaminated casualties is appropriate for the local hospital to accommodate, hospitals may be requested to become a primary monitoring and decontamination site.
3. At **home** where self-decontamination³⁷ can be carried out according to instructions provided through public messaging, e.g., remove and bag clothes, shower, and receive follow-up monitoring elsewhere³⁸.
4. At a **Monitoring and Decontamination Unit (MDU)**. See below.

A monitoring and decontamination unit (MDU) is an important resource that may need to be mobilized in response to an RN incident. The main purpose of an MDU is to conduct the initial stages of population monitoring to identify those who may be contaminated and require additional follow-up.

Population monitoring is appropriate for all persons connected with the incident, especially:

- Persons who had any radiation-related health effects or symptoms identified at the time of the incident.
- Persons who may not have had radiation-related health effects or symptoms at the time, but were near the scene.
- Persons who participated in incident/emergency response, e.g., health workers, EMS personnel, hospital personnel, security personnel, etc.³⁹

MDUs are crucial to the response during the first few hours and days after a radiological incident. People affected need to be monitored with special equipment designed to detect radiation. The information gathered from the monitoring equipment helps determine if people are contaminated, either internally or externally, with radioactive materials from the incident.

³⁶ Refer to section 5.10 for more information on decontamination.

³⁷ For an example, please see Radiation Emergency Medical Management's (REMM) [instructions for performing self-decontamination](#).

³⁸ The MOHLTC will provide information to health workers on assessment and care of patients who may have been exposed to radiation.

³⁹ REMM, 2011.

The MDU provides monitoring for contamination and external decontamination services for affected people. Those suspected of internal contamination will be referred to hospital for follow-up care. It is important to note that in-depth medical screening for internal exposure is typically not a routine service offered in an MDU. However, the MOHLTC will work collaboratively with local hospitals/health partners to support this type of care if internal contamination is suspected.

The setup of an MDU is predicated upon incident type and magnitude, as well as the situational assessment of local needs. Large-scale incidents have the potential to impact a significant number of people, and health care facilities can be quickly inundated by those wanting to be monitored. This additional demand for care can have a significant impact on a hospital's ability to deliver routine services. In order to protect the capacity of local hospitals in an RN incident, MDUs that provide population monitoring will be made available if necessary.

5.3.1 Situational Requirements for MDU Setup

The setup of an MDU for monitoring affected people for external contamination may be required when:

- a. The population potentially exposed to the incident exceeds the capacity of local first responders and hospitals; and/or
- b. There are public concerns about exposure through population monitoring.

Responsible Parties

For incidents that involve an Ontario nuclear facility, the facility is responsible for establishing MDUs at sites predetermined by the designated municipality. If additional locations are required or deemed to be more efficient at the time of the incident, the Province will consult with the nuclear facility, the designated municipalities, and the proposed support municipalities to implement the new setup.

For all other radiological emergencies, the MOHLTC is responsible for establishing MDUs, and works with the affected municipality and health sector.

5.3.2 MDU Concept of Operations During a Nuclear Facility Incident

Organizations Responsible for MDUs⁴⁰:

- Designated municipalities (in their capacity as host municipalities) are responsible for arranging the necessary space and facilities for the accommodation of an MDU, and communicating the location through their respective EOCs to the PEOC. The PEOC informs the MOHLTC's MEOC. The MDU can be co-located at the reception centre or another suitable location.
- The nuclear facility is responsible for setting up and staffing MDUs and providing MDU functions at Emergency Worker Centres in the event of a nuclear emergency.

Determining the Need to Report to an MDU⁴¹:

- If the incident or condition has implications for public safety and may require the evacuation of affected areas, an MDU is setup and fully staffed by the nuclear facility on the direction of the PEOC.

⁴⁰ Annex F Personal Monitoring, *PNERP*, 2009.

⁴¹ *Ibid.*

- If it is anticipated that the evacuees will clear the affected area before an emission occurs, they **will not** be directed to report to an MDU.
- If evacuees cannot clear the affected area before an emission occurs, they may be directed to proceed to an MDU. More specifically:
 - In the case of a delayed emission⁴² from a nuclear facility:
 - Evacuees from affected sectors in the Contiguous Zone and Middle Ring who do not clear the Primary Zone before the emission occurs may be directed to report to an MDU, if appropriate;⁴³
 - Evacuees from affected sectors in the Outer Ring who do not clear the Primary Zone will most likely be instructed to carry out basic self-decontamination after evacuating the area.
 - In the case of an imminent emission from a nuclear facility:
 - Evacuees from all affected sectors (Contiguous, Middle and Outer) who do not clear the Primary Zone before the emission occurs will most likely be directed to report to an MDU, if appropriate. Otherwise they will be instructed to carry out self-decontamination after evacuating the area.
- In the event that the demand for MDU services is at maximum capacity, instructions will be provided through provincial messaging on how to self-decontaminate and where population health monitoring services will be provided. These communications are coordinated with the MOHLTC.

MDU Equipment:

- Nuclear facilities pre-equip MDUs with radiation detection instruments and monitors, decontamination supplies, KI tablets, and other equipment and documents necessary to carry out the activities. Portable radios and phones are supplied for communications purposes.

MDU Functions:

- Radiation monitoring and external decontamination.
- If required, on-site medical staff coordinated by the MOHLTC can assess patients for possible internal contamination and, if suspected, patients are referred to hospital for follow-up care.
- Provide institutional radiological monitoring for facilities that are unable to fully evacuate (e.g., hospitals, health care facilities), and for reception/evacuee centres on an as-needed basis.
- Monitor and implement radiological safety measures to reduce potential cross-contamination at reception/evacuee centres.

Health System Support to MDUs:

- The MOHLTC will collaborate with health system stakeholders to provide medical support services to the MDU, if required to:
 - Assess for risk of internal contamination.
 - Refer affected people to hospital for further evaluation if internal contamination is suspected.
 - Coordinate referral for psychosocial support services.
 - Provide further population monitoring.

⁴² Refer to section 4.16 for more information on containment and delayed emissions.

⁴³ Refer to section 4.15 for more information on zones.

- Advise which health care facilities require monitoring for institutional radiological hazards.
- Track patient information to support long-term medical monitoring.
- The MOHLTC will work with hospitals, local public health units, and Health Canada to coordinate bioassay and dicentric assay testing if clinically appropriate to support medical management.⁴⁴

Emergency Worker Centres (EWCs)

- MDUs are set up at EWCs to monitor and control radiation exposure to emergency workers who may be required to enter the areas affected by radiation.
- EWCs are municipally run facilities established during nuclear emergencies and staffed by nuclear facility personnel.
- Nuclear facilities pre-equip these centres with procedures, documents and records, personal dosimetry, radiation monitoring instruments, decontamination supplies, and other administrative needs.
- Emergency workers are defined as persons who are required to remain in or enter areas potentially affected by radiation from an accident. Personnel include police, fire-fighters, emergency medical services, Canadian Forces, and other essential services.

5.3.3 MDU Concept of Operations During a Non-Facility Radiological Incident

Organizations Responsible for MDUs:

- In coordination with the MOHLTC, affected municipalities are responsible for arranging the necessary space and facilities for the accommodation of an MDU at a Reception Centre or other suitable location.
- The MOHLTC is responsible for arranging with the municipality for the setup and staffing of the MDUs in the event of a non-facility-based radiological incident.

Determining the Need for and Reporting to an MDU:

- The initial request for the setup of an MDU normally comes to the PEOC from the municipal EOC at the request of the on-site incident commander. The ultimate decision to set up an MDU is made by the PEOC on the advice of the MOHLTC based on whether the number of people potentially exposed would exceed the capacities of the on-site decontamination team and local hospitals. Additional consideration would need to be given to whether population monitoring is required.

MDU Planning Assumptions:

- It is anticipated that an MDU can be set up within 12-24 hours following an RN incident.
- Seriously injured or medically unstable victims are dispatched to a hospital for medical care. MDUs are not staffed nor equipped to provide medical treatment services.
- Medically stable victims may be decontaminated at the scene by first responders. If the local level is overwhelmed and a provincial response is required, or if a number of victims do not receive decontamination at the site, the MOHLTC will liaise with appropriate provincial and federal partners to organize decontamination support.
- Due to the unpredictable nature and variable geographic locations of non-facility radiological incidents, setting up an MDU may not always be an appropriate plan of action. As a result, the MOHLTC may need to engage local hospitals as sites for primary

⁴⁴ Please see section 5.10 for more information on medical management.

decontamination or ensure that public messaging is provided on how to self-decontaminate at home, including what to do with potentially contaminated clothes.

- The main focus of MDUs for a non-facility-based radiological incident is to provide population monitoring with some external decontamination ability. The MDU is not responsible for rapid response to an incident or mass decontamination; the local level needs to provide that initial response.
- MDUs are setup a safe distance away from the radiological incident, and if possible co-located with a reception centre or other suitable location.

MDU Equipment:

- Equipment and staffing will be arranged by the MOHLTC and could include resources from the Government of Canada through the *FNEP*, staff from the local Public Health Unit, and the MOHLTC Emergency Medical Assistance Team (EMAT) among others.
- MDUs require radiation detection instruments and monitors, communications equipment, and other equipment and documents necessary to carry out the activities.

MDU Functions:

- Population monitoring and external decontamination.
- If internal contamination is suspected, patients are referred to an appropriate hospital as determined by on-site medical staff.
- The MOHLTC collaborates with health system stakeholders to provide medical support to the MDU. Additional services may include:
 - Internal contamination assessment.
 - Referral to hospitals for further exposure and internal contamination evaluation.
 - Referral for psychosocial support services.
 - Additional population monitoring.
- Tracking of patient information for purposes of a registry and long-term follow-up.
- Provide institutional radiological monitoring for health care facilities that are unable to fully evacuate, e.g., hospitals, long-term care homes; and for reception/evacuee centres as needed.
- If the MDU is co-located with reception and evacuee centres, staff from the MDU will also monitor RN safety at reception and evacuee centres as needed. If the MDU is not co-located, the MOHLTC ensures that RN safety is monitored.

5.4 Psychosocial Response⁴⁵

5.4.1 Psychological Support at Evacuee Centres

The population monitoring provided at an MDU, and regular assessments of the safety of Evacuee Centres, will help allay people's fears of radioactive contamination. However, once evacuees have been registered in Reception Centres and transported to Evacuee Centres, there could be a lot of questions, fears, and anxieties related to the incident, and evacuees will likely require psychological support. Evacuees who have not registered with a Reception Centre may also need psychological support in their temporary communities. This support is normally provided by the host community. Should local capabilities be exceeded and a provincial response is required, the MOHLTC can coordinate with the MCSS to arrange for assistance from the broader mental health system.

⁴⁵ Refer to section 2.8 Health Impacts of Radiological Hazards for the definitions of psychosocial and psychological used in this plan.

The role of psychological support workers at Evacuee Centres is to assist individuals, families and caregivers who may be experiencing psychological stress as a result of the incident.

For a hospital taking in many victims from the incident, it makes sense to consider setting up a treatment area for those seeking psychological care that is outside the emergency department (ED). This will decompress the ED, making it easier for medical patients to access the ED and for health workers to provide medical care.⁴⁶

For more information on psychological support during an RN emergency, please see Section E of the International Atomic Energy Agency's (IAEA) [Generic Procedures for Medical Response During a Nuclear or Radiological Emergency](#).

5.4.2 Psychosocial Response for the Affected Population

The psychosocial response for the affected population needs to focus on clear messaging about the situation. Psychosocial management and provincial messaging are coordinated by the PEOC with advice from the MOHLTC. Public Health Units (led by local Medical Officers of Health) receive information and direction from the Chief Medical Officer of Health and the PEOC on precautionary and protective measures. They help communicate this to their constituencies, and can work with their local Community Emergency Operations Centres to provide a health lens to the situation.

Provincial messages, communications to the media, and information provided by Medical Officers of Health will contain clear information and direction on the situation. Important health information concerning the event is released to the public as quickly as possible to allow for early identification of those exposed or contaminated with radiation from the incident. A clear explanation of the health risks, and where to get care if there are health concerns, is provided to assist in reducing anxiety.

If required, the MOHLTC will coordinate with appropriate experts in Ontario's mental health system for the provision of support resources in the form of a hotline and/or information. Resources include the Centre for Addictions and Mental Health's (CAMH) fact sheet: [Coping with Traumatic Events: Global Disasters Create Difficult and Uncertain Times](#). The Public Health Agency of Canada (PHAC) provides information on [Responding to Stressful Events](#) that occur closer to home. The MOHLTC will also provide information on how to access support services in the affected community.

5.5 Fatality Management

The management of a large number of fatalities falls within the jurisdiction of the Office of the Chief Coroner within the Ministry of Community Safety and Correctional Services (MCSCS). The appropriate process is outlined in the *Provincial Multiple Fatality Plan*. During *PNERP* activation, this plan would be activated as well, and the Chief Coroner would attend the PEOC as a member of the Command Section.

⁴⁶ Medical Emergency Treatment for Exposures to Radiation, Radiation biology and medically managing its effects (Summary A).

Assessment by those trained in working with RN agents is required prior to any recovery or identification of human remains. The PEOC makes a decision on the best way to proceed based on this assessment. The *Multiple Fatality Plan* also includes the objectives of Family Information Services/Family Assistance Centres as they pertain to victim identification, notifying individuals of cause and manner of death for their deceased family member(s), and release and disposition of remains.

5.6 Registration and Inquiry Services and Hospitals

The affected and host municipalities setup a registration and inquiry services to manage the influx of, and requests from, family and friends of people involved in the incident. The service also facilitates the reunification of families. Hospitals can setup their own inquiry services in cases where there is a large influx of casualties. Hospitals will coordinate with the municipalities to manage inquiries that they receive. In situations where casualties have been brought to hospitals in multiple jurisdictions across Ontario, the MOHLTC assists with the coordination and consolidation of information from various sources, while protecting the privacy of the information.

5.7 Database and Medical Registry of Victims

In a mass casualty case, a database and registry of victims is kept in accordance with mass casualty plans. For a radiation event, the radiation exposure data relating to the victims will also need to be kept. The MOHLTC determines when a central database needs to be established.

The MOHLTC will maintain a registry of the victims of a radiological incident. This registry includes all persons (public and workers) for whom an assessment of external dose or internal contamination was deemed required. It is maintained even if there is only a single case of overexposure. This data is maintained throughout the life of the patient. Specialized health care facilities performing these analyses are responsible for providing the relevant information to the MOHLTC MEOC.

The registry of victims serves three purposes: First, it is part of the victim's medical history and may be needed later for medical purposes. Second, there are legal and compensation implications (including Worker's Compensation) for which this information may be needed. Third, in cases involving a very large number of exposed persons, this data may be needed for epidemiological purposes.

The creation of the database and registry will be in accordance with all applicable laws, including privacy laws.

If the patient moves outside of the province, arrangements must be made amongst the health care facilities to transfer the patient's medical history.

5.8 Communications with the Public

The MOHLTC coordinates provincial health communications in accordance with its Crisis Emergency and Risk Communications Response Guide. The Ministry's lead spokesperson is identified by the Emergency Information Officer at the time of the emergency (for more information, see the [Ministry Emergency Response Plan \[MERP\]](#)).

If the PEOC is activated, all public communications are coordinated with the PEOC. If the PEOC is not activated, the MOHLTC, through the MEOC, coordinates public communications and key health-related messages. At the local level, hospitals, EMS, and public health units designate spokespersons and coordinate with each other and the MOHLTC to ensure that their communications are consistent with the health communications strategy.

Health communications focus on providing up-to-date and accurate information about the health risks, health impacts, and what health protection means for the public, health workers, and the health sector.

To communicate with the public, the MOHLTC uses a number of different mechanisms including Telehealth, Service Ontario's Infoline, the MOHLTC's website, Important Health Notices (IHNs), fact sheets, the Chief Medical Officer of Health, and media briefings/press conferences. Mechanisms have been put in place to ensure that Infoline is capable of doubling its capacity within 48 hours to handle an increased number of calls.

5.8.1 Communications with Health Workers and Health Organizations

To communicate with health workers, the MOHLTC's MEOC establishes communications with all affected health care facilities and organizations through IHNs, guidance documents, and regular health stakeholder teleconferences, and responds to enquiries through a 24-hour Healthcare Provider Hotline at **1-866-212-2272**.

Responding to a Radiation Emergency: Pre-Hospital and Hospital Response

The goals of medical response to an RN emergency are:

- To safely evacuate and provide emergency treatment
- To treat radiation injuries and injuries resulting from an emergency situation
- To decontaminate and minimize radiation exposure
- To prevent spread and cross-contamination of emergency responders

Actions of all medical response participants need to be in line with, and contribute to, establishing the above goals of the emergency response.

5.9 Pre-Hospital Response

Unless they are first at the scene, the Emergency Medical Services (EMS) team reports to the Incident Commander (IC). If they are first at the scene, the senior EMS team member assumes that role until relieved by a designated IC. In such a case, the priority is to save lives while maintaining basic precautions to minimize the radiation risk to the EMS personnel and the spread of contamination outside the immediate area of the incident.

The affected municipality determines who the IC is. EMS works as part of the joint Chemical, Biological, Radiological, Nuclear, Explosives (CBRNE) Team. A joint CBRNE team normally consists of EMS, police and fire. If the event is suspected of being a criminal act, scene of crime procedures apply, and EMS acts under the direct supervision of the police to minimize scene disruption and preserve evidence.

When responding to a nuclear facility incident, EMS reports to the facility contact point and works in support of the on-site emergency organization, in accordance with established local plans and agreements in place.

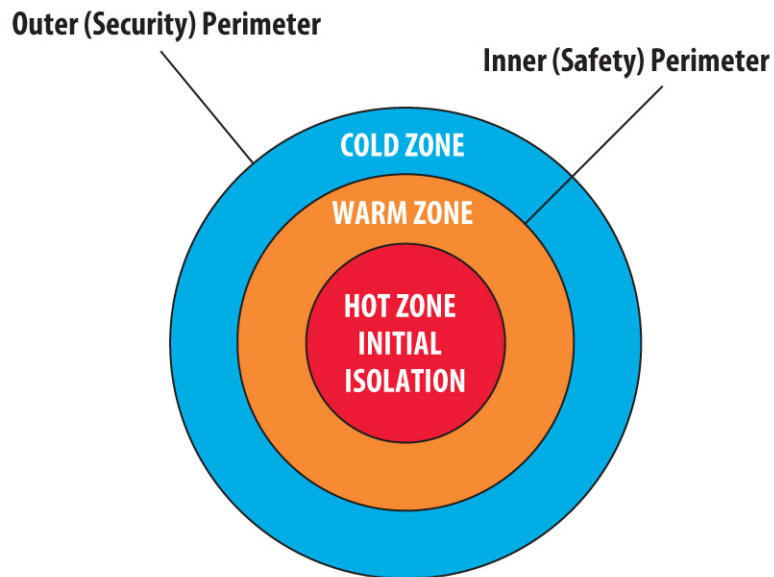
In a non-facility incident, the Joint CBRNE Team establishes the hot, warm, and cold zones. These zones are flexible and can be adjusted to respond to changes in weather patterns or changes at the source of the hazard.

The incident scene is normally divided into three zones⁴⁷: Hot Zone (inner perimeter); Warm Zone (inner perimeter); and Cold Zone (outer perimeter).

The principles to guide the medical response are to: Ensure safety of first responders and first receivers; and address life-threatening injuries first and contamination second.

⁴⁷ Refer to section 4.15 for more information on zones.

Figure 5.2 Hot, Warm, and Cold Zones



The **Hot Zone** is the area immediately surrounding the incident. The **Warm Zone** is a buffer area where contamination and/or exposure may be present and where urgent first aid, triage and decontamination are carried out. All medical responders working in the inner perimeter should be CBRNE trained and have appropriate personal protective equipment (PPE), including anti-contamination clothing, respiratory protection and personal alarm dosimeters (PADs) with the appropriate turn-back limits as directed by the Incident Commander. All non-CBRNE-trained medical responders should not enter the Hot and Warm Zones of the incident site.

The **Cold Zone** is a security-protected staging area for on-scene responders. The Incident Command Post is normally located in the Cold Zone. This is where routine medical triage and continuing medical treatment is provided. Based on clinical presentation, patients could be transferred to a staged EMS crew for continuing care and transported to the most appropriate hospital. Medical responders in the Cold Zone do not need to be CBRNE certified, and routine practices and additional precautions should provide adequate protection against contamination.

The treatment of life-threatening injuries and trauma is paramount. Efforts to medically stabilize a patient must always be performed before managing contamination problems or removing the patient from the contaminated area for hospital transport, unless the presence of conventional hazards requires the victim and the responders to be moved. If there are fatalities, they need to be moved to an area that is not accessible by the public or other victims. The deceased should be kept in this area until law enforcement officer(s) have acquired any available evidence, and living casualties have been transported to a health care facility. For information on Fatalities Management, refer to [section 5.5](#).

Potential radiological exposures should be mitigated through the use of personal dosimeters that provide real-time monitoring of the vicinity's radiation rate. Please refer to [section 4.12](#) for details on supplies and equipment for EMS provided under the Provincial Chemical, Biological, Radiation, Nuclear (CBRN) Preparedness Program.

In an incident where large numbers of victims are involved, EMS on-site functions could potentially expand based on the needs of the incident.

5.9.1 Activities of Emergency Medical Services

Upon arrival at the scene of an RN incident, local EMS must report to the onsite incident command post (located in the Cold Zone) to identify the appropriate locations to set up operations in the Cold Zone, i.e., triage, treatment, staging, transport, etc. If local EMS is the first responding agency to arrive on scene, although they may be the IC, they should not immediately enter the inner perimeter. It is recommended that they stage upwind and uphill and avoid contact with contaminated victims while considering the dangers of conventional hazards, e.g., fire, smoke, fumes, electrical hazards, chemical hazards, and explosives. As soon as possible, EMS should coordinate with qualified specialists for radiological monitoring and consider areas/zones established by first responders.

The response of EMS needs to be coordinated with overall joint first responder emergency efforts; specific activities are broken down into two main categories:

1. Hot and Warm Zone: CBRNE-trained EMS responders as part of a Joint CBRNE Team with fire and police may be required to participate as part of the following teams: Reconnaissance Team (Recce), Rapid Intervention Team (RIT), Extraction Team, Forward Triage and Treatment Team, Transfer Team, and Decontamination Team.
2. Cold Zone: non-CBRNE-trained EMS may be required to provide the following services: pre-entry and exit vital signs, establish staging area, triage, treatment, and transport of casualties.

5.9.2 Transport to Hospital

In the case of life-threatening injuries, transport to an appropriate trauma centre **must not be delayed** by the need to decontaminate the victim. Health care facilities must also be informed that transported victims may be contaminated.

If the casualty is medically stable and monitoring does not interfere with medical actions, time may be taken to perform a quick radiological survey to assess for contamination and decontaminate the casualty prior to transport. The results should be recorded on a body diagram. For an example of a body diagram, please see Clinical Resources and Tools in [Appendix D](#).

The U.S. Department of Health and Human Services' Radiation Emergency Medical Management (REMM) website has additional information on [Radiation Detection Devices](#) and [How to Perform a Survey for Radiation Contamination](#).

If possible, victims are to be transported by EMS personnel who have not entered the inner perimeter. Contaminated victims should be handled and transported using contamination control procedures (refer to [Appendix I](#)). EMS personnel must also use appropriate PPE if

patients are contaminated. If there is any doubt, assume all victims are contaminated until proven otherwise.

Trauma/medical care must always remain the top priority, and patients with life-threatening injuries should be transported to the appropriate health care facility as per established guidelines. As such, all hospitals need to be prepared to potentially receive and provide emergency medical care to a radiologically contaminated patient if required. In the event of the need to transport a significant number of casualties, the MOHLTC's MEOC will work in collaboration with CritiCall to coordinate arrangements for transport in order to optimize the distribution of potentially contaminated patients to hospitals.

A list of appropriate health care facilities that specialize in treating radiation is maintained by the MOHLTC's MEOC and can be accessed through the **Healthcare Provider Hotline at: 1-866-212-2272**. For additional guidance on the transport of victims to hospital, please refer to the International Atomic Energy Agency (IAEA) document, [*Generic Procedures for Medical Response During a Nuclear or Radiological Emergency, April 2005, procedure C3.*](#)

The receiving hospital's emergency department should be notified of patient transports as soon as possible, and the following information needs to be provided:

- Patient's medical condition
- The suspected presence of radioactive contamination and type of radioisotope (if known)
- Other hazardous material (HAZMAT) contamination
- Any other relevant information

On-Site Decontamination

There is minimal risk to a casualty if contamination is confined to the skin, i.e., not internalized. If contamination is external only, shoes and clothing should be removed. It stands to reason that clothing typically covers a large percentage of one's body, so properly removing the clothing will likely significantly decrease the amount of radioactive material.⁴⁸

Contaminated non-critically injured victims should be isolated and all contaminated clothing removed unless medically contraindicated. In cold environmental conditions, remove external contaminated clothing only just prior to transport. Use the following steps when removing clothing:

1. Cut the clothing from head to toe and down the sleeves.
2. Fold the cut parts of the material back over itself as it is cut.
3. Roll up the material.

Removing the clothing so it will be turned inside out reduces the possibility of spreading contamination.

⁴⁸ REAC/TS, *The Medical Aspects of Radiation Incidents*, 2010.

For additional details regarding the procedure of undressing contaminated victims, please refer to the International Atomic Energy Agency (IAEA) document, [Generic Procedures for Medical Response During a Nuclear or Radiological Emergency](#), April 2005.

Disposal of Contaminated Items

Contaminated waste, including clothing, should be contained in large plastic bags and removed from the area on a regular basis. This assists in preventing a source buildup of contaminated items which may increase background radiation and reduce the sensitivity of contamination meters. Temporary storage of radioactive material must be secured, and radioactive contamination that cannot be disposed of must be permanently stored at a licensed facility. For information on disposal, please contact the MOHLTC Healthcare Provider Hotline for assistance at 1-866-212-2272.

5.10 Hospital Response

The overall principle for hospital triage and treatment is to address life-threatening injuries first and contamination second. Patients are much more likely to succumb to the effects of their injury than as a result of their radiation exposure.

All individuals who arrive from the site by their own means should be considered potentially contaminated. Hospitals must triage and identify those who require decontamination. Routine practices and additional precautions are adopted by all hospital personnel handling potentially contaminated patients (refer to [section 4.3](#) on Occupational Health & Safety).

Three key factors to consider when triaging potentially exposed or contaminated patients are:

1. Medical stability
2. Degree of contamination
3. Dose received

Patients that are contaminated and in need of medical attention are transferred to a radiation emergency area setup to segregate contaminated patients from the rest of the hospital population, and to contain contamination spread. Guidance on the setup of a radiation emergency area is provided in [Appendix H](#). All personnel and patients leaving the radiation emergency area should be as free of contamination as possible. When decontamination efforts are no longer effective, and contamination has reduced to an appropriate level, patients can be transferred to the regular treatment area.

Process for Hospitals to Manage Patients Exposed to Radiation

Table 5.1: Process for Hospitals to Manage Patients Exposed to Radiation⁴⁹

Medical Stability	Step 1	Stabilize life-threatening injuries and ensure appropriate PPE and contamination control procedures	
	Contamination	Determine if externally contaminated	
Step 2		2a) If YES: Proceed to controlled area and remove clothing, assess and survey, provide medical treatment and collect samples for radiological analysis (proceed to 3).	2b) If NO: Admit to the regular emergency department to assess for possible radiation exposure or internal contamination (proceed to 4).
Step 3		Identify decontamination priority, collect samples, decontaminate, and resurvey	
	3a) Once contamination has been reduced to an appropriate level, admit to the regular emergency department (follow process outlined in 2b).		
Assessing Exposure	Step 4	Assess for signs of acute radiation syndrome (ARS)	
		4a) If YES: Repeat samples for radiological analysis (proceed to 5).	4b) If NO: Transfer or discharge, observe for symptoms within next 24 hours.
	Step 5	Assess for significant absolute lymphocyte decrease or other medical issues	
		5a) If YES: Proceed to Step 6.	5b) If NO: Discharge. Consider medical or radiological follow-up.
Step 6	Follow-up evaluations at health care facilities with expertise in the medical management of patients with radiation exposure. (Consult the MOHLTC for contact information of appropriate health care facilities.)		

For additional information, see Clinical Resources and Tools in [Appendix D](#) for the Radiation Casualty Assessment Tool and [the REACT/S Radiation Patient Treatment Algorithm](#).

⁴⁹ Flowchart developed by the MOHLTC - Emergency Management Branch, 2012.

Step 1: Medical Stability

Objectives

- Ensure safety of health workers, use appropriate personal protective equipment.
- Triage and provide care based on medical considerations; the treatment of radiological contamination is secondary.
- Have a process in place to manage medically unstable contaminated patients in the emergency department and take steps to prevent cross-contamination.

In the presence of life-threatening injuries, radiation exposure, is not usually the first medical priority due to the delay in health impacts, which can vary from hours to weeks. Triage should be conducted based on medical considerations, and care should be provided by the health care facility best suited to deal with the most pressing medical condition.

If a medically unstable patient is suspected of radiation exposure health care personnel should also assume radiological contamination, take necessary precautions, and move the patient immediately to the radiation emergency area.

Step 2: External Contamination Screening and Assessment

Objectives:

- Quickly identify patients who may be contaminated, and triage to a controlled area for further assessment.
- Perform a complete contamination assessment.
- Collect nasal swab samples and initial complete blood cell count (CBC) with differential as baseline measurements.
- Coordinate with internal staff resources that may have radiological expertise to support contamination monitoring activities.

Contamination screening should be done in triage stations or isolation areas before the patient enters the hospital. Contamination is assessed with a contamination meter scan of the whole body, concentrating on mouth, nose and wounds, through which the contamination can be internalized. If the contamination is from an alpha-emitting substance, standard contamination meters may not register the contamination unless a very careful scan is done and swipe samples are analyzed. Patients found to have external contamination should be admitted directly to a decontamination zone. Guidance on hospital contamination control procedures is provided in [Appendix I](#).

The treatment of contaminated patients is carried out in the radiation emergency area (refer to [Appendix H](#) for guidance on setup). Care must be taken to prevent the contamination of open wounds. With a stable patient, decontamination can proceed before transferring the patient to the regular care areas.

Further characterization of external contamination is helpful to assess the risk of the radiation injury to the skin and underlying tissues, to determine the potential for internal contamination, and to assist in making decisions about treatment and decontamination priorities. A step-by-step guide for a completed contamination assessment procedure is available in [Appendix I](#).

Identifying the radioactive emission type (α , β , or γ), assists in determining whether the intake is expected to be medically significant. Intake estimates should be verified by appropriate bioassay techniques (refer to [Appendix G](#)). The swabs should be placed in test tubes for future testing if required.

Step 3: Identify Decontamination Priority and Decontaminate

Objectives:

- Understand the goals of decontamination
- Determine decontamination priorities
- Perform decontamination procedure
- Manage residual radioactive contamination

External Decontamination

The goal of whole body external decontamination is to decrease external contamination to a level ideally no more than two times the background radiation level. This may require performing multiple decontamination cycles with a whole body radiation survey after each cycle.

The purpose of external decontamination is to:

- Decrease the risk of acute dermal injury
- Lower the risk of internal contamination
- Reduce the potential of cross-contamination of health workers and the environment

The decontamination process begins with the careful removal of all the patient/victim's clothing or having patients/victims undress themselves. Items are stored in an airtight container/bag. The removal of shoes and clothing can reduce external contamination by as much as 90 per cent.

Based on the results of the contamination assessment, and following the removal of clothing, decontamination should be conducted in the following order:

1. Radioactive shrapnel
2. Open wounds
3. Body entrance cavities (nose, mouth, ears)
4. Localized contaminated skin, starting with the area of highest contamination noted on the radiation body survey

Open wounds are a high priority, and health care providers should consider all open wounds to be contaminated until proven otherwise. It is important to decontaminate a contaminated wound as quickly as possible to reduce the patient's risk of incorporating the radionuclide as internal contamination.

In some cases, attempting to remove all contamination from the skin may not be feasible (contamination may be trapped in the outermost layer of skin) or desirable (vigorous decontamination may result in loss of normal intact skin barrier and pose an increased risk of internal contamination). In these circumstances, areas with residual radiation contamination should be covered with waterproof dressings/drapes in order to limit spread of contamination to other body sites, the immediate environment, and other people.

For additional resources and information on decontamination procedures, please consult the following:

- Reference: NCRP 161, Management of persons contaminated with radionuclides.
- U.S. Department of Health and Human Services' Radiation Emergency Medical Management (REMM) on [Decontamination Procedures](#) and a [suggested supply list](#) for decontamination of victims in the emergency department.
- Radiation Emergency Assistance Centre/Training Site (REAC/TS) on [Guidance for Radiation Accident Management](#).

Step 4: Assessing Acute Radiological Exposure

This step applies to both contaminated and non-contaminated (but potentially exposed) victims of a radiological accident.

Objectives:

- Assess for radiological exposure
- Collect tools to assist process
- Recognize key signs and symptoms of acute radiation exposure
- Understand the value of lymphocyte depletion kinetics to provide an estimate of radiation exposure dose

Determining the extent of acute radiological exposure is important and assists in informing medical treatment planning. This includes assessing the patient's incident history and treatment of presenting medical issues. Based on incident history, a baseline complete blood cell count (CBC) with differential test should be considered for all asymptomatic patients prior to discharge. Medical treatment planning should be done by a physician in consultation with health radiation specialists, e.g., health physicists.

Important factors to consider when assessing incident history include the timing of the incident, severity of symptoms, and onset of vomiting. Acute symptoms can range from mild to severe depending on dose exposure.

- Please refer to the following tools: History and Physical Form and the Severity Scoring Form in Clinical Resources and Tools in [Appendix D](#) developed specifically to capture significant details concerning radiation exposure and/or contamination.

Health workers should note the following as it relates to degree of radiation exposure:

- Key prodromal signs and symptoms of high-level radiation exposure; such as: nausea, vomiting, anorexia, fever, diarrhea, conjunctivitis, and skin erythema.
- Duration and onset of vomiting after exposure. Table 5.2 provides an estimation of the relationship between parameters.

Table 5.2: Onset of Vomiting after Radiation Exposure

Time (hours)	Duration (hours)	Dose Estimate (Gray)
Absent or >6	<24	0.5-2.0
2-5	12-24	2.0-3.5
1-2	24	3.5-5.5
Minutes	48	>5.5

NOTE: Patients with persistent symptoms of vomiting, skin erythema, and fever should undergo repeat testing of CBC with differential every 4-6 hours to assess for significant decreases in absolute lymphocyte counts.

An initial complete blood cell count (CBC) with differential test sample should be collected for radiological analysis and repeated every 6-12 hours. Lymphocyte depletion kinetics can be used to provide a preliminary estimate of radiation dose and guide initial clinical management of the patient in conjunction with other clinical and laboratory information.

- For additional background information on lymphocyte depletion kinetics, see the U.S. Department of Health and Human Services' Radiation Emergency Medical Management (REMM) [website](#).

Please see [Appendix J](#) for more information on managing acute radiation exposure.

Any hospital can collect bioassay and blood samples, but only specialized labs can do the bioassay test and chromosomal analysis. Hospitals that cannot perform the analysis can request information from the MOHLTC on where and how to send the samples. The MOHLTC coordinates with Health Canada to identify labs for analysis of bioassays. Guidance on the collection of blood for chromosomal analysis is provided in [Appendix G](#).

Patients with any indication of possible acute exposure must be immediately reported to the MOHLTC's **Healthcare Provider Hotline at 1-866-212-2272**. The MOHLTC can assist with arranging access to radiation specialists/health physicists to provide advice on medical treatment options.

Step 5: Assess for Whole-body Radiation Exposure and Other Medical Issues

Objectives:

- Serial CBCs with differential should be obtained if appropriate.
- Track absolute lymphocyte count over time and assess depletion rate.
- Understand the potential systemic health effects associated with radiation exposure dose.
- Understand and use of the Radiation Casualty Tool Severity Scoring Form.

If internal contamination is suspected, the complete blood cell count (CBC) with differential should be obtained or repeated (if initial baseline was done). To assess or rule out whole-body exposure, serial CBCs should be obtained, and the absolute lymphocyte count calculated and tracked over time. The lymphocyte depletion rate is directly related to radiation dose received.

An early drop in absolute lymphocyte count is an indicator of possible acute exposure. Lymphocyte depletion kinetics can be used to estimate severity of injury. For additional

details please refer to Radiation Casualty Tool Severity Scoring Form for Hematologic Symptoms in Clinical Resources and Tools [Appendix D](#).

In addition, consideration should be given to other possible medical complications, including gastrointestinal syndrome and pulmonary damage (occurs at radiation doses >8Gy) and neurovascular syndrome (occurs at radiation doses >30 Gy).

Table 5.3: Summary of Possible Medical Complications at Different Radiation Doses

Syndrome	Effective Radiation Dose	Potential Systemic Effects	Potential Result Without Intervention
Hematopoietic	>1 Sv	<ul style="list-style-type: none"> ▪ Targets hematopoietic stem cells, including white blood cells, platelets, red blood cells ▪ Infection, poor healing ▪ Petechiae, bleeding ▪ Anemia 	<ul style="list-style-type: none"> ▪ 1-8 Sv fatal within 30-60 days (failed hematopoietic system)
Gastrointestinal	>8 Sv	<ul style="list-style-type: none"> ▪ Poor absorption ▪ Ileus - vomiting and GI distension resulting in: <ul style="list-style-type: none"> ▪ Fluid and electrolyte shifts ▪ Dehydration ▪ Acute renal failure ▪ Cardiovascular collapse ▪ GI bleeding ▪ Sepsis 	<ul style="list-style-type: none"> ▪ >8 Sv fatal within about 10 days. (GI mucosa breakdown)
Pulmonary	>8 Sv	<ul style="list-style-type: none"> ▪ Latent period to presentation of interstitial pneumonitis is 50 days ▪ Possible development of pulmonary fibrosis at 1 year 	
Neurovascular	>30 Sv	<ul style="list-style-type: none"> ▪ Vomiting and diarrhea within minutes ▪ Confusion and disorientation ▪ Severe hypotension ▪ Cerebral edema ▪ Convulsions/coma ▪ hyperpyrexia 	<ul style="list-style-type: none"> ▪ >30 Sv fatal within 24-48 hrs. (Cerebral edema)

For additional details, please refer to the Radiation Casualty Tool Severity Scoring Form for Gastrointestinal and Neurological symptoms in Clinical Resources and Tools see [Appendix D](#). The Severity Scoring Form can be useful in determining the overall response category and inform direction of medical management.

For additional information on managing internal contamination, see [Appendix J](#).

Step 6: Follow-up Evaluations for Radiation Exposure

Patients who are severely contaminated internally, and/or are suspected of having received a significant radiation dose, are referred to a radiation specialist to assist in identifying the isotopes, their chemical form, and the total body burden. Dose reconstruction efforts may be required to estimate the radiation dose received. This information can assist medical professionals in predicting possible health consequences to determine a treatment strategy.

Bioassays are procedures which estimate the amount of radioactive material deposited in the body, either by direct measurement or by detection of radioactivity in the excreta (feces and urine). Bioassay measurements are generally the most reliable data available for assessing internal exposures, and provide an accurate measurement of alpha, beta, or gamma contamination. In addition, bioassay data is applicable to all routes of entry and almost all radionuclides.

Bioassay Sampling

Alpha and beta emitters are the most hazardous internal contaminants detected through bioassay sampling. Accurate bioassays require carefully executed sampling over time (24-hour collection or multiple samples), and knowledge of the type of contaminant and the precise time of contamination.

Initial samples of urine should be used to establish baseline levels of radioactivity and should be obtained from a patient as soon as their medical condition allows. For instructions on the 24-hour urine and spot urine sample collection process, please refer to [Appendix F](#).

Chromosomal Analysis (Dicentric Assay)

The dicentric assay evaluates chromosomal damage in cells and provides dose response curves that are essential in predicting radiation exposure doses in accidentally irradiated individuals. This type of cytogenetic analysis is performed through blood samples and is used to more accurately determine the whole body dose as well as information on partial versus whole body exposure. Analysis of chromosomal aberrations is the present day standard for the biological assessment of radiation exposure.

To optimize the recovery of lymphocytes from the blood, it is very important that the blood be collected and shipped according to the established Health Canada protocol (refer to [Appendix G](#)).

The MOHLTC MEOC can arrange access to specialized health care facilities for bioassay and chromosome analysis. The MEOC can be contacted through the **Healthcare Provider Hotline at 1-866-212-2272**.

5.11 Security for EMS and Hospitals

Emergency Medical Services (EMS)

When responding to a deliberate act, particularly one that involves the use of explosives (as in the detonation of a “dirty bomb”), EMS need to be aware of the possible presence of secondary threats, such as a second device set to disrupt the work of emergency responders. They should also consider that perpetrators may still be present at the scene or be among the victims. In cases involving a large number of casualties (mass casualty situations), requiring the setup of triage and health care facilities at the site, arrangements should be made with the on-scene controller for protecting the victims from unwanted interference from observers and the media.

In all cases of deliberate acts, preserving evidence is a priority. Investigators present at the scene, and law-enforcement personnel, may be in charge of on-scene control. It is

therefore essential that health officials, especially those present at the scene, establish effective cooperation with law-enforcement and security teams.

Hospitals

Hospitals need to work with local law enforcement agencies to ensure the security of patients and crowd control at the hospitals, if required. Depending on the number of victims or perceived victims, there is a chance that there will not be sufficient law enforcement personnel to assist hospital security. In this situation, hospitals need to be prepared to work alone for some time.

5.12 Health System Cost Tracking

During an emergency situation, all health organizations track costs that are above and beyond their normal scope of practice. Details on reimbursement will be provided by the MOHLTC at an appropriate time, either during or following the emergency.

5.13 Deactivation, Recovery, and Follow-Up

In the aftermath of an RN emergency, recovery activities will be required. A transition to the recovery phase is adopted after initiating conditions of the emergency have stabilized and immediate actions to protect public health and safety have been completed. The MOHLTC plans and leads the recovery of the health sector.

The MOHLTC will not deactivate the MEOC while the PEOC is still activated without prior consultation with the PEOC.

Prior to deactivating the MEOC, the MOHLTC will:

- Determine the role of the health system in the provincial recovery plan.
- Determine which functions need to be sustained.
- Establish a plan for the maintenance of these functions.
- Inform all relevant organizations.
- If required, establish a team, program, and/or other mechanism to ensure the continuation of these special functions.

The PEOC coordinates the development of a short-term and longer-term recovery plan. The MOHLTC establishes health action plans to support the provincial recovery plan. Health priorities include at least the following actions, which are likely to be maintained long after the emergency is declared to be over:

- Continued provision of health care to victims of the emergency.
- Continued population monitoring for reassurance.
- Assessment and advice on health risk associated with food and water.
- Continued psychosocial care for the affected populations.
- Advanced psychological care for severely affected victims and emergency workers.
- Plan and implement “business continuity” measures for affected health care services.
- Communications on the immediate and longer-term health impacts of the accident.

Appendices

Appendix A: Glossary

absorbed dose: Energy absorbed per unit of mass by a material or tissue.

activation: Putting a response plan into effect and requiring all concerned to commence implementing its provisions.

activity: The amount of radiation emitted by a substance per second. Refers to the strength of the source, but does not indicate if it is hazardous.

Acute Radiation Syndrome (ARS): An acute illness that may result from a large exposure, received within a short period of time to ionizing radiation, usually external and affecting a large part of the body. The illness varies in onset from a few minutes to hours to days, typically following a pattern of prodromal signs/symptoms that are manifestations of the reactions of various body systems to exposure.

alerting: Informing the population by means of an appropriate signal, that a nuclear or radiological incident has occurred and proper precautions must be undertaken.

Ambulatory patient: Patients able to walk.

Annual Limits on Intake (ALI): The amount of radioactive material a worker ingests or inhales each year.

anemia: A decrease in the number of red blood cells or less than the normal quantity of hemoglobin in the blood.

assurance monitoring: Actions taken to confirm that radiation levels are safe and fall within background or regulatory limits.

atom: A basic unit of matter that consists of a dense central nucleus surrounded by a cloud of negatively charged electrons.

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 measuring activity. The amount of radioactive material that will undergo one disintegration per second.

bioassay: Procedures which estimate the amount of radioactive material deposited in the body, either by direct measurement or by detection of radioactivity in the excreta (feces and urine). Bioassay measurements are generally the most reliable data available for assessing internal exposures, and will provide an accurate measurement of alpha, beta, or gamma contamination in the body. Bioassay data is applicable to all routes of entry and almost all radionuclides.

biodosimetry: The use of physiological, chemical or biological markers of exposure of human tissues to ionizing radiation for the purpose of reconstructing doses to individuals or populations.

carcinogen: A cancer causing substance.

chelating agent: A chemical that has the ability to firmly bind to a metal ion (in the case of internal contamination), and remove it from the body via the excretory process.

Code Orange: The signal used in hospitals to notify key responders of the impending arrival of a contaminated casualty.

containment systems: A safety measure at most nuclear reactors that prevent releases of radiation into the external environment for a defined period of time in the event of an accident.

contamination: The unwanted presence of radioactive material in water or air, or on the surfaces of structures, areas, objects, or people.

Contiguous Zone: The zone immediately surrounding a nuclear installation. An increased level of emergency planning and preparedness is undertaken within this area because of its proximity to the potential hazard.

countermeasure: An intervention or protective action taken to counter a danger or a threat. Examples include evacuation and sheltering.

criticality: A fission process where the neutron production rate equals the neutron loss rate to absorption or leakage. A nuclear reactor is “critical” when it is operating.

Curie: The traditional measure of radioactivity based on the observed decay rate of 1 gram of radium.

cytogenetics: The branch of genetics devoted to the study of chromosomes.

debridement: The removal of foreign material or contaminated tissue from a lesion until healthy tissue is exposed.

decorporation: Removal of radioactive isotopes from the body using specific drugs called “decorporation agents” and/or other procedures.

Designated Municipality: A municipality in the vicinity of a nuclear facility designated under the *Emergency Management and Civil Protection Act* as one that shall have a nuclear emergency plan.

desquamation: The shedding of skin in scales or small sheets.

detector: A device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis.

deterministic effect: A radiation-induced health effect that is certain to occur in an individual exposed to a radiation dose greater than some threshold dose, with a severity that increases with increasing dose. Examples include radiation sickness and skin burns.

dicentric: In genetics, having two centromeres.

dirty bomb: A device designed to spread radioactive material by conventional explosives when the bomb explodes. A dirty bomb kills or injures people through the initial blast of the conventional explosive and spreads radioactive contamination over possibly a large area – hence the term “dirty.” Such bombs could be miniature devices or large truck bombs. A dirty bomb is much simpler to make than a true nuclear weapon.

dose: The product of the absorbed dose at a point in the tissue or organ and the appropriate quality factor for the type of radiation giving rise to the dose.

dose rate: The amount of radiation dose which an individual would receive in a unit of time.

dosimeter: An instrument for measuring and registering total accumulated exposure to ionizing radiation.

edema: Abnormally large amounts of fluid in tissue.

effective dose: A quantity that reflects the health risk associated with the dose to all organs.

electron: An electron is a negatively charged component of an atom. Electrons exist outside of and surrounding the atom nucleus. Each electron carries one unit of negative charge.

emergency: An abnormal situation which, to limit damage to persons, property or the environment, requires prompt action beyond normal procedures.

emergency workers: A person who assists in connection with an emergency that has been declared by the Lieutenant Governor in Council or the Premier, under 5.7.0.1 of the EMCPA or by the head of council of a municipality under Section 4 of the EMCPA. This may include persons who are required to remain in, or to enter, offsite areas affected or likely to be affected by radiation from an accident, and for whom special safety arrangements are required. Examples of emergency workers include police, firefighters, ambulance and personnel from the Canadian Armed Forces, and other essential services. They do not include nuclear energy workers (pursuant to the Nuclear Safety and Control Act) or assurance monitoring field staff.

Emergency Worker Centre (EWC): A facility set up to monitor and control radiation exposure to emergency workers.

emission: The release of radioactive material to the environment from a nuclear facility in the form of either an airborne or a liquid emission.

epilation: Loss of hair.

erythema: A name applied to redness of the skin produced by congestion of the capillaries, which may result from a variety of causes.

evacuation: The rapid and controlled removal of people from an identified area to avoid or reduce high-level, short-term exposure to a hazard.

exposure: The act or condition of being subject to radiation. Exposure can be either external exposure (irradiation by sources outside the body) or internal exposure (irradiation by sources inside the body).

exposure pathways: The routes by which radioactive material can reach or irradiate humans.

field monitoring: The assessment of the magnitude, type, and extent of radiation in the environment during an emergency by such means as field surveys and field sampling.

first receiver: Health workers in a hospital or other health care facility where victims arrive for treatment. First receivers provide medical care at locations remote from the incident and not at the site of a hazardous materials release. Since victims may arrive for treatment still contaminated with hazardous materials, first receivers must also protect themselves by putting on appropriate PPE before delivering medical care.

first responder: An individual responsible for protecting and preserving life, property, evidence, or the environment during the earliest stages of a mass casualty event or other emergency. First responders generally work at or near the incident site.

food control: Measures taken to prevent the consumption of foodstuffs that have been radioactively contaminated above acceptable levels as a result of a nuclear emergency, including the supply of uncontaminated foodstuffs.

gastric lavage: The process of cleaning out the contents of the stomach, also called stomach pumping or gastric irrigation.

Government Operations Centre (GOC): Public Safety Canada's all-hazard emergency centre that provides an integrated federal emergency response to an event. Located in the National Capital Region, and established to coordinate national support to the affected provinces and activities under federal jurisdiction.

Gray: The international system (SI) physical unit of absorbed radiation dose, expressed as absorbed energy per unit mass of tissue. The SI unit "Gray" has replaced the older "rad" designation. (1 Gy = 1 joule/kilogram = 100 rad).

half-life: The time it takes for the radioactivity in an isotope to decay by half.

health care facility: A set of physical infrastructure elements supporting the delivery of health care services. A health care facility does not include a client's/patient's home or physician offices where health care services may be provided.

Health Care Provider Hotline: 24/7 line for health workers to contact the Ministry of Health and Long-Term Care's Emergency Management Branch (1-866-212-2272). This Hotline can be used by health system partners to reach the ministry during the response to an emergency. It is also operational during non-emergencies to enable health system partners to inform the ministry of a hazard or risk that has the potential to become an emergency.

health care setting: Any location where health care services are provided, including settings where emergency care is provided, hospitals, complex continuing care, rehabilitation hospitals, long-term care homes, mental health facilities, outpatient clinics, community health centres and clinics, physician offices, dental offices, offices of allied health professionals, and home health care.

health care services: Direct client/patient/resident care, including diagnostic, treatment and care services.

health organization: An organization or agency that receives funding from the MOHLTC to provide health services.

health physics: A scientific field that focuses on protection of humans and the environment from radiation. Health physicists use physics, biology, chemistry, statistics, and electronic instrumentation to help protect individuals from any damaging effects of radiation.

health sector: Part of the economy dealing with health-related issues in society.

health services: Services delivered by the health system, including health promotion, disease prevention, diagnostic, treatment and care services.

health system: The people, institutions and resources, arranged together in accordance with established policies, to improve the health of the population they serve, while

responding to people's legitimate expectations and protecting them against the cost of ill-health through a variety of activities whose primary intent is to improve health.

health worker: A person who performs work or supplies services for monetary compensation in a health setting.

hematopoietic: Pertaining to or effecting the formation of blood cells.

Host Municipality: The municipality assigned responsibility in the *PNERP* for the reception and care of people evacuated from their homes in a nuclear emergency. Can also be the municipality selected to be a host for evacuees during a non-facility radiological incident.

hyperpyrexia: An extremely high fever.

ileus: A partial or complete non-mechanical blockage of the small and/or large intestine.

Incident Management System (IMS): A standardized and coordinated approach to managing incidents that provides functional interoperability at all levels of emergency management, which defines the basic command structure, roles and responsibilities required for the effective management and coordination at all response levels.

intervention: Any protective action or countermeasure aimed at reducing, or averting, human exposure to radiation during a nuclear or radiological emergency.

Iodine Thyroid Blocking (ITB): Administration of stable iodine to block the uptake of inhaled radioiodines into the thyroid gland.

ionizing radiation: Any radiation capable of displacing electrons from atoms, thereby producing ions.

irradiation: The process by which an object is exposed to radiation.

isotope: A nuclide of an element having the same number of protons but a different number of neutrons.

Joint Health and Safety Committee (JHSC): Committee composed of people who represent the workers and the employer, as described under the Occupational Health and Safety Act. Together, they are committed to improving health and safety conditions in the workplace. Committees identify potential health and safety problems and bring them to the employer's attention. As well, members must be kept informed of health and safety developments in the workplace.

leukocyte: Any colourless cell; white blood cell; the cells that fight infection.

long-term care: A broad range of personal care, support and health services provided to people who have limitations that prevents them from full participation in the activities of daily living. The people who use long-term care services are usually the elderly, people with disabilities and people who have a chronic or prolonged illness.

lymphocyte: A white blood cell whose function is to cleanse the blood of debris or particles.

medical countermeasures: Drugs used to treat people exposed to radiation to reduce the absorbed radiation dose and hence the risk of possible future biological effects. Examples of radiological medical countermeasures: Prussian blue, Potassium Iodide (KI), Ca-DTPA and Zn-DTPA (diethylenetriaminepentaacetate). They can reduce the body's uptake by blocking

organs with the non-radioactive element or they can increase the elimination of the radioactive element from the body.

Ministry Emergency Operations Centre (MEOC) MOHLTC: A dedicated space within the Emergency Management Branch where the MOHLTC coordinates its emergency response.

monitoring: Determining the amount of ionizing radiation or radioactive contamination present.

Monitoring and Decontamination Unit (MDU): An important resource that may need to be mobilized in response to an RN incident. The primary purpose of an MDU is to conduct the initial stages of population monitoring to identify those who may be contaminated and require additional follow-up.

N95 respirator: A personal protective device worn on the face, covering the nose and mouth to reduce the wearer's risk of inhaling airborne particles. A National Institute for Occupational Safety and Health-certified N95 respirator filters particles one micron in size, has 95% filter efficiency, and provides a tight facial seal with less than 10 per cent leak.

neutron: A small atomic particle possessing no electrical charge, typically found within an atom's nucleus.

neutropenia: An abnormally low number of neutrophils.

neutrophil: A granular white blood cell.

notification: Conveying to a person or an organization, by means of message, warning of the occurrence or imminence of a nuclear or radiological emergency. This warning usually includes some indication of the measures being taken, or to be taken, to respond to it.

nuclear emergency: Occurs when there is an actual or potential hazard to public health, property, and/or the environment from ionizing radiation whose source is a major nuclear installation within or immediately adjacent to Ontario. Such a hazard will usually be caused by an accident, malfunction, or loss of control involving radioactive material.

nuclear establishment: A facility that uses, produces, processes, stores or disposes of a nuclear substance, but does not include a nuclear installation. It includes, where applicable, any land, building, structures or equipment located at or forming part of the facility, and, depending on the context, the management and staff of the facility.

nuclear facility: A nuclear reactor, sub-critical nuclear reactor, research reactor, or plant for the separation, processing, reprocessing or fabrication of fissionable substances from irradiated fuel. It also includes all land, buildings and equipment that are connected or associated with these reactors or plants.

nuclear installation: A facility or a vehicle (operating in any media) containing a nuclear fission or fusion reactor (including critical and sub-critical assemblies). It includes, where applicable, any land, buildings, structures or equipment located at or forming part of the facility, and, depending on the context, the management and staff of the facility.

nuclear substance: As defined in the (Federal) *Nuclear Safety and Control Act*.

offsite: Offsite refers to the area outside the boundary (fence) of a nuclear facility.

onsite: Onsite refers to the area inside the boundary (fence) of a nuclear facility.

operational directives: Direction given by an emergency response organization to implement operational measures.

operational measures: Measures undertaken by the emergency response organization to deal with the emergency, including measures to enable or facilitate protective action for the public, e.g., public alerting, public direction, activation of plans, traffic control, emergency information, etc.

Personal Protective Equipment (PPE): Clothing and/or equipment worn by workers (including first responders and first receivers) to prevent or mitigate job-related illness or injury. Individual PPE elements can include respiratory and percutaneous protective equipment.

petechia: A red or purple spot on the body caused by a minor hemorrhage.

plume: A cloud of airborne radioactive material that is transported from a nuclear or radiological source in the direction of the prevailing wind. A plume results from a continuing release of radioactive gases or particles.

population monitoring: Radiological tests and/or scans that are conducted on a patient to notify them of whether or not they have been contaminated with, or exposed to, radiation. Also includes long-term monitoring for health effects from the incident.

potassium iodide (KI): Substance used to prevent or reduce the uptake of radioactive iodine (radioiodine) by the thyroid. Potassium iodide is also known as a thyroid blocking agent.

precautionary measures: Measures which will facilitate the application and effectiveness of protective actions, sometimes called precautionary actions.

Primary Zone: The zone around a nuclear installation within which planning and preparedness is carried out for measures against exposure to a radioactive plume. (The Primary Zone includes the Contiguous Zone.)

prodrome: A symptom indicating the onset of a disease.

Protective Action Levels (PALs): Projected dose levels which provide technical guidance on the need to take certain protective measures.

protective actions: Actions designed to protect against exposure to radiation during a nuclear emergency, sometimes called countermeasure or protective measures.

proton: A component of an atomic nucleus with a mass defined as 1 and a charge of +1.

Provincial Emergency Operations Centre (PEOC): The central location from which OFMEM coordinates the Ontario government's response.

Prussian blue: A medical countermeasure for heavy metal poisoning, e.g., cesium and thalium.

purgatives: Laxatives.

radiation: Energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. Ionizing radiation is a very high-energy form of electromagnetic radiation.

radiation sickness: See acute radiation syndrome.

radioactive decay: The spontaneous disintegration of the nucleus of an atom.

radioactive material: Material that contains unstable (radioactive) atoms that give off radiation as they decay.

radioactivity: The process of spontaneous transformation of the nucleus, generally with the emission of alpha or beta particles often accompanied by gamma rays. This process is referred to as decay or disintegration of an atom.

radioactive waste: Disposable, radioactive materials resulting from nuclear operations. Wastes are generally classified into two categories, high-level and low-level waste.

radioisotope (radioactive isotope): Isotopes of an element that have an unstable nucleus. Radioactive isotopes are commonly used in science, industry, and medicine. The nucleus eventually reaches a stable number of protons and neutrons through one or more radioactive decays. Approximately 3,700 natural and artificial radioisotopes have been identified.

radiological device (RDs): Could be lost or stolen radioactive sources which may be in locations resulting in radiation exposure and/or contamination of the public, contamination of a site and/or contamination of food and water supplies.

radiological dispersal device (RDDs): A device that causes the dissemination of radioactive material.

radiological emergency: Occurs when there is an actual or potential hazard to public health, property, and/or the environment from ionizing radiation resulting from sources other than a major nuclear installation. Such a hazard will usually be caused by an accident, malicious act, malfunction, or loss of control involving radioactive material.

radionuclide (or radioactive isotope or radioisotope): A naturally occurring or artificially created isotope of a chemical element having an unstable nucleus that decays, emitting alpha, beta and/or gamma rays until stability is reached.

response phase: The phase during which activities focus on saving human life, on treating the injured, contaminated and overexposed persons, and on preventing and minimizing further health effects and other forms of impacts. This phase may last from a few hours to several weeks after the commencement of the emergency, and would be followed by a recovery phase, as necessary.

Restricted Zone: The area within which exposure control measures are likely to be needed, based on the results of field monitoring. These measures would be applied within this Restricted Zone as per the Protective Action Levels.

sealed source: A radioactive source sealed in an impervious container that has sufficient mechanical strength to prevent contact with, and dispersion of, the radioactive material under the conditions of use and wear for which it was designed. Generally used for radiography or radiation therapy.

Secondary Zone: The zone around a nuclear installation within which it is necessary to plan and prepare measures against exposure from the ingestion of radioactive material. (The Secondary Zone includes both the Primary and Contiguous Zones.)

selective evacuation: The evacuation of a specified group of people, such as seriously ill patients in hospitals, bedridden residents of nursing homes, or disabled residents.

sepsis: Whole body inflammation triggered by infection.

sheltering: A protective measure of remaining inside solidly constructed, reasonably airtight buildings with doors and windows closed and ventilation systems turned off. The restriction of airflow into the building during the passage of a radioactive plume reduces inhalation exposure, and the solid construction of the walls reduces external exposure from radioactive material outside the building.

shielding: The material between a radiation source and a potentially exposed person that reduces exposure.

Sievert: Unit of measure for Equivalent or Effective Dose related to biological risk of exposure to radiation, taking account of amount and type of radiation, as well as organ exposures. One Sievert equals 100 rem.

SI units: The *Système Internationale* (or International System) of units and measurements. This system of units officially came into being in October 1960 and has been adopted by nearly all countries, although the amount of actual usage varies considerably.

source term: A generic term applied to the radioactive material released from a nuclear facility. It includes the quantity and type of material released, as well as the timing and rate of its release. It could apply to an emission that was currently occurring, or one which had ended, or one which could take place in the future.

special group: A group for which special constraints arise in the application of a protective measure, such as intensive care patients in hospitals and institutions, bedridden patients in nursing homes, handicapped persons and prison inmates.

stochastic effects: A radiation-induced health effect which generally occurs without a threshold of dose. Examples include cancer and leukemia. The probability of occurrence is proportional to the dose, but the severity of the effect is independent of dose.

support municipality: Pursuant to Section 7.0.2 (4) of the EMCPA, the LGIC may, by order, specify a municipality to act in a support capacity to provide assistance to designated municipality(ies).

trans-border nuclear emergency: A nuclear emergency involving a nuclear facility, or a nuclear accident or event outside the borders of Ontario that might affect people and property in the province.

triage: The use of simple procedures for rapidly sorting affected people into groups so as to expedite treatment and maximize the effective use of medical and monitoring supplies.

vascular: Pertaining to blood vessels.

venting: The release to the atmosphere of radioactive material from the containment of a nuclear facility through systems designed for this purpose.

vulnerable group: A group which, because it is more vulnerable to radiation, may require protective measures not considered necessary for the general population, such as pregnant women and, in some cases, children.

Appendix B: References & Links

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Appendix C: Protective Action Levels (PALs) - From *PNERP*

The PALs used in the *PNERP* (reproduced below) are expressed in terms of projected radiation doses (i.e., the potential dose people may be exposed to) for the initiation of exposure control measures of evacuation, sheltering, and iodine thyroid blocking.

PALs are expressed as lower-and upper-level thresholds:

- At or above the lower level, the protective measure **should be** applied unless valid reasons exist for deferring action.
- At or above the upper level, the protective measure **must be** implemented, unless implementation clearly entails greater risks for the people involved than those from the projected radiation dose.

In the event of a radiological emergency, the PEOC provides the MOHLTC information, advice, and direction on the implementation of PALs, and the MOHLTC informs health system partners as soon as possible to guide an appropriate response. The protective action levels (PALs) are provided below:

Protective Action Levels (PALs) Exposure Control Measures				
Protective Measure	Lower Level		Upper Level	
	Effective Dose	Thyroid Dose	Effective Dose	Thyroid Dose
Sheltering	1 mSv (0.1 rem)	10 mSv (1 rem)	10 mSv (1 rem)	100 mSv (10 rem)
Evacuation	10 mSv (1 rem)	100 mSv (10 rem)	100 mSv (10 rem)	1 Sv (100 rem)
Iodine Thyroid Blocking	-	100 mSv (10 rem) *see notice below	-	1 Sv (100 rem)
Ingestion Control Measures				
Banning Food/Water Consumption	Radionuclide Concentration Level			
	CS-134, CS-137, Ru-103, Ru-106, Sr-89	I-131	Sr-90	Am-214, Pu-238, Pu-239, Pu-240, Pu-242
Foods for general consumption	1 kBq (27 nCi) per kg		100 Bq (2.7 nCi) per kg	10 Bq (270 pCi) per kg
Milk, Infant foods, Drinking water	1 kBq (27 nCi) per kg	100 Bq (2.7 nCi) per kg		1 Bq (27 pCi) per kg

***NOTICE:** The International Atomic Energy Agency (IAEA) recommends that ITB should be implemented if the projected equivalent dose to the thyroid exceeds **50 millisieverts (mSv) in the first seven days.**⁵⁰ Therefore, the intervention threshold for administration of

⁵⁰ IAEA Safety Standards Series No. GSG-2, Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, 2011.

KI in Ontario has been updated by the MOHLTC to also be set at 50 mSv thyroid dose in the first seven days for all target populations.

For more information on iodine thyroid blocking during a nuclear facility incident, please refer to the KI Guidelines in [Annex 1](#).

Application

- a. The PALs for exposure control measures are expressed in terms of, and shall be related to, the highest projected dose likely to be received by the most exposed individual in the relevant critical group.
- b. PALs are expressed over the duration of significant releases.
- c. The PALs for ingestion control measures should be applied to food prepared for consumption. The PALs are to be applied to the sum of the activity levels for each radionuclide within a group. However, they are applied independently to each group. For example, if in a foodstuff, the radiocesium is 50 per cent of the permitted concentration while the quantity of rubidium (which is in the same group as cesium) is 60 per cent of the permitted concentration, the item should be banned. However, an item containing 50 per cent of the permitted concentration of radiocesium and 60 per cent of the permitted concentration of Sr-90 (which is in a different group) would be acceptable. (Note: I-131 is grouped with radiocesium, etc. in the case of foods for general consumption, but is grouped with Sr-90 for infant food and water.)

Notes

1. The effective dose PALs above were adopted by the Province in 1984 upon the recommendation of Provincial Working Group # 3 and are generally consistent with Health Canada Intervention levels as published in Canadian Guidelines for Intervention During a Nuclear Emergency (2003). The latest authoritative international guidance on the subject confirms their continuing validity. (Cf. International Basic Safety Standards for Protection Against Ionizing Radiation and for Safety of Radiation Sources, International Atomic Energy Agency. Safety Series No.115, 2004.)
2. The intervention levels recommended in the International Basic Safety Standards (IBSS) are in terms of avertable dose, whereas the Ontario PALs are in the form of projected dose. This difference is essentially academic since the PALs are used most often in decisions on protective measures taken prior to any radiation exposure, and hence are being compared to avertable dose. In most cases where radiation exposure is already occurring, it would neither be possible nor desirable to base protective action decisions on calculations involving PALs; instead, they would be based on pre-planned responses and conservative estimates.
3. It is necessary to express PALs in terms of projected dose in order to conform to the Plan principle that protective measures should avert (or at least reduce) risk resulting from radiation exposure. Thus, expressed as projected doses, PALs in essence represent levels of risk from potential exposure, which justify the initiation of various protective measures. The risk commences when radiation exposure begins, and not when the emergency management organization starts to use PALs to assess the need for protective measures. If this assessment occurs in some circumstances after radiation exposure has commenced, the use of PALs in the prescribed manner will fulfill the above principle adopted in this Plan.

Appendix D: Clinical Resources and Tools - Health Canada

Instructions on use of RADIATION CASUALTY ASSESSMENT TOOL

This information packet ('tool') is designed to help with the assessment and management of casualties of an incident involving radiation. Use one packet per casualty, labelling each page. It should become part of the permanent record for that casualty. You do not have to use those parts of the tool that do not apply to that casualty.

1. Triage Guide

STABILITY	Question 1: Is patient stable?
	<input type="checkbox"/> "NO" then
	<input type="checkbox"/> "YES" then go to Question 2

- filled out by triage MD or RN
- used to establish initial priority (i.e. immediate treatment vs. immediate decontamination vs delayed treatment and/or decontamination)
- designed to look and function like the SARS screening tool

2. History and Physical form

Name _____ Age _____ M/F
 Date _____ Time of Arrival _____
 Physician: _____ Time seen _____ h
 Mode of arrival: self EMS other

HISTORY AND PHYSICAL

Vitals: HR _____ BP _____ / _____ Temp _____ °C
RR _____ sats _____ % on RA/Lpm

- filled out by treating MD
- used to record findings on history and physical
- prompts physician to obtain specifics relevant to treatment and disposition decisions unique to radiation exposure and/or contamination

3. Body Mapping form for Skin Contamination and Injury

Name _____ Age _____ M/F
 Date _____ Time of Arrival _____
 Physician: _____ Time seen _____ h

BODY MAPPING

Injuries, burns, skin changes secondary to radiation exposure

Circle location of injuries

- filled out by treating MD or RN
- used to facilitate recording location of skin contamination
- contaminated areas are recorded (with initial count and description) as they are discovered by person performing survey. All contaminated areas must be decontaminated, with final counts recorded as well
- also used to record location of injuries

4. Standing Orders

ALLERGY ALERT

- No known drug allergy
 Known allergies: _____

DATE	TIME	
		<input type="checkbox"/> i.v.: <input type="checkbox"/> NS vs <input type="checkbox"/>

- filled out by treating MD
- prompts physician to order specific labs, specimens, and medications relevant to treatment of radiation exposure and/or contamination

5. Severity Scoring form

SEVERITY

Time of Exposure _____
 Time of Symptom Onset _____
 Time of Assessment _____

Used to inform decision on decontamination

1. NEUROLOGICAL (Circle most severe)

Acute Symptom ²	1 (mild)	2 (moderate)
----------------------------	----------	--------------

- reference material for treating MD
- allows physician to estimate severity of injury due to radiation exposure when the exposure dose has not been determined. This may help with disposition decision
- Also lists Decontaminating agents for internal contamination with various agents

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
Date _____ Time of Arrival _____ h
Triage by: _____ Time seen _____ h

Mode of arrival: self EMS ambulatory stretcher

TRIAGE

STABILITY	Question 1: Is patient <u>medically stable</u>?	
	<input type="checkbox"/> “NO” then →	<ol style="list-style-type: none"> 1. Cover with sheet, assume contaminated 2. Move immediately to Contaminated Treatment Area
	<input type="checkbox"/> “YES” then go to Question 2	

CONTAMINATION	Question 2: Does patient have measurable skin <u>contamination</u> during 2 minute survey with Geiger Counter in triage?	
	<input type="checkbox"/> “YES” then →	<ol style="list-style-type: none"> 1. Identify as contaminated 2. Record sites/activity of contamination (p 5) 3. Prioritise for decon, move patient to decon site, then integrate into cohorted stream of uncontaminated ED patients 4. Further assess for Exposure ASAP
	<input type="checkbox"/> “NO” then →	<ol style="list-style-type: none"> 1. Identify patient as uncontaminated (using local standard colour coding). 2. go to Question 3

EXPOSURE	Question 3: Does patient have history, signs and symptoms of possible <u>exposure</u> to radiation?	
	<input type="checkbox"/> “YES”	<input type="checkbox"/> New onset of nausea, vomiting, diarrhea or skin changes? <input type="checkbox"/> New onset of weakness, confusion, unexplained low BP?
		<input type="checkbox"/> “NO”

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
Date _____ Time of Arrival _____ h
Physician: _____ Time seen _____ h

HISTORY AND PHYSICAL Form

Vitals: HR _____ BP _____ / _____ Temp _____ °C
RR _____ sats _____ % on _____ RA/Lpm

Chief complaint: _____
HPI: _____

Review of Systems (selected)

Neuro: Confusion Fatigue
Changes in: speech vision dizzy headache

Vomiting: yes or no # of times: _____
(began at _____ h, = _____ h after exposure)

Motor/sensory deficits? _____
Cognitive deficits? _____

Blood: Active bleeding? _____
Bruising Petechiae

Derm: Redness or Rash (Time of onset: _____ h)
Swelling Blisters Ulcers
Desquamation Hair loss Onycholysis
Dysaesthesia/pruritis

GI: Nausea (severity: _____/10) Anorexia
Abdominal pain Blood /mucus in stool
Diarrhea (began at _____ h; # of times: _____)
if female: LMP _____ Pregnant: yes/no/?

Details of radiation contamination/exposure: _____

Isotope known: _____ unknown
Type of particle: α β γ X-rays neutrons
State: solid/powder liquid gas/steam

Contamination see diagram

External contamination: yes no unknown
Extent of contamination (see diagram):
localised (skin/hair) Wound Generalised

Internal contamination: yes no unknown

Decontamination
Location: in field at ED , done by _____

Exposure yes no unknown
Time of exposure: _____ h, Duration: _____ h _____ min
Whole body Parts of Body _____

Past Medical History Immunosuppression
Cancer (radiation chemo , when? _____)
Previous fluoroscopy/Nuc Med testing/occupational exposure? _____
Other: _____

Medications (include dose & freq if known): _____

Allergies to meds: NKDA/ _____

Social history: _____

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
Date _____ Time of Arrival _____ h
Physician: _____ Time seen _____ h

Physical exam: _____

BIODOSIMETRY using different methods of estimating severity of exposure; use tables p7-8 or REMM Tool to calculate estimated dose (in Grays)

1. **Time of onset of vomiting** (see table on page 8)
- Interval between exposure & onset vomiting: _____ h
- Estimated dose: _____ Gray

2. **Absolute Lymphocyte depletion rate** (use REMM)
- single ALC _____ x10³, _____ hrs post-exposure
- serial ALC's: 2nd _____ x10³, _____ hrs post-exposure
- Estimated dose: _____ Gray

3. **Response Category:** Select highest value from 4 individual categories below

Neurological:	1	2	3	4
Hematologic:	1	2	3	4
Cutaneous:	1	2	3	4
Gastrointestinal:	1	2	3	4

OVERALL RESPONSE CATEGORY:	1	2	3	4
ESTIMATED DOSE(Gy):	(1-2)	(3-4)	(5-7)	(8-10)

Consistent biodosimetry estimate using all 3 methods is suggestive of radiation exposure at the indicated dose
(source: REMM , other: _____)

- Resources** (all are available 24/7 throughout Canada):
 Health Canada: (613) 954-6651 (FNEP duty officer)
 Radiation Trauma Unit (UHN in Toronto): (416) 603-5800 ext 5098
 REAC/TS: (865) 576-3131, www.remm.nlm.gov

Labs & Investigations:

- Blood samples**
 CBC: WBC _____ x10³.
 Abs Lymphocytes _____ Abs Neutrophils _____
 Hgb _____ mg/dL, Plt _____ x10³
 Chem 7: Na _____ Cl _____ K _____ CO2 _____
 BUN _____ Creat _____ Glc _____
 Pregnancy test (all females): neg/pos
 Thyroid: TSH, T3, free T4
 Tubes for chromosomal analysis (cytogenetics) collected, room temperature (if exposure potentially > 0.5 Gray)

Specimens _____ (scan with Geiger Counter, then label & save)

- Nasal swabs** (labeled L&R): activity: yes/no
 Mouth Swab: activity yes/no
 Urine sample: activity yes/no
 Stool sample: activity yes/no
 Emesis sample: activity yes/no

ECG: _____

imaging studies: _____

Course in ED: _____

Reassessed: Time _____ h: _____

Diagnosis: 1) _____
2) _____ 3) _____

Decorporating agent considered: Yes No

Disposition: home , transfer (to: _____), admit
 Follow-up: RTED if: _____
 FP/ED in _____ days (pt aware
 outpt labs

Prescriptions _____

see RADIATION STANDING ORDERS

Signature: _____ time _____ h
 see continuation sheet

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
 Date _____ Time of Arrival _____ h
 Physician: _____ Time seen _____ h

BODY MAPPING Form

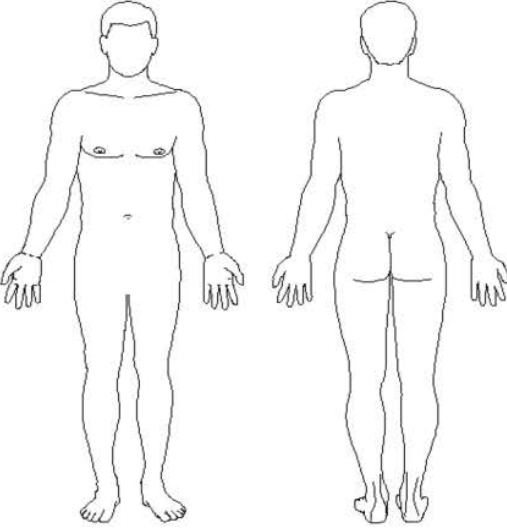
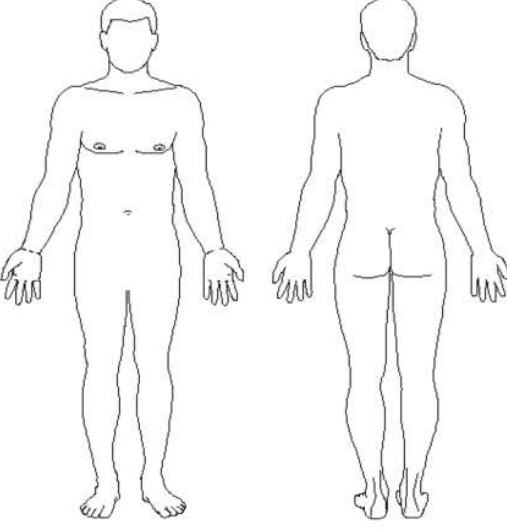
Injuries, burns, or skin changes					
		<i>Circle location of injuries, number consecutively. List details</i>			
		Site #	Details of Injury		
Contamination					
Initial survey done by _____ at _____ h Instrument: _____		Final survey done by _____ at _____ h Background counts per minute: _____			
		<i>Circle location of contamination, then number consecutively. List details below. Be sure to survey nose, mouth, hands & feet. Readings should be in 'counts per minute' (CPM)</i>			
		Site #	Description	Counts/min (initial)	Counts/min (final)

Image of form

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
 Date _____ Time of Arrival _____ h
 Physician: _____ Time seen _____ h

PHYSICIANS ORDERS

ALLERGY ALERT

- No known drug allergy
- Known allergies: _____

DATE	TIME	PHYSICIAN'S SIGNED ORDERS	Initial
		<input type="checkbox"/> i.v.: <input type="checkbox"/> NS vs <input type="checkbox"/> other _____, initial bolus _____ cc, then _____ cc/hr	
		<input type="checkbox"/> O ₂ @ _____ L/min by <input type="checkbox"/> NP <input type="checkbox"/> non-rebreather	
		Monitor: <input type="checkbox"/> cardiac <input type="checkbox"/> O ₂ sats	
		Labs: <input type="checkbox"/> CBC & manual diff q6hx4	
		<input type="checkbox"/> Lytes, BUN, creatinine, glucose	
		<input type="checkbox"/> Qualitative HCG (ICON)	
		<input type="checkbox"/> TSH, T3, free T4	
		<input type="checkbox"/> Tube for chromosomal analysis (<i>use green top tube</i>)	
		<input type="checkbox"/> other:	
		Specimens (note: label specimen, test with Geiger Counter, then save)	
		<input type="checkbox"/> Nasal swab (L&R)	
		<input type="checkbox"/> Skin wipe	
		<input type="checkbox"/> Urine sample	
		<input type="checkbox"/> Stool sample	
		<input type="checkbox"/> Vomit sample	
		<input type="checkbox"/> other:	
		Medications	
		<input type="checkbox"/> Pain:	
		<input type="checkbox"/> Nausea/vomiting:	
		<input type="checkbox"/> Anti-diarrheal agent:	
		<input type="checkbox"/> Home Meds (<i>itemize home meds including dose/route/schedule on separate page</i>)	
		<input type="checkbox"/> Decorporating agent ¹ : _____	
		other:	
		<input type="checkbox"/> see additional order sheet	
		Signed: _____ MD	

¹ See 'Severity Scoring Form', pages 7-8
 PAGE 6

RADIATION CASUALTY ASSESSMENT TOOL

PLACE ID
STICKER HERE

Name _____ Age _____ M/F
Date _____ Time of Arrival _____ h
Physician: _____ Time seen _____ h

SEVERITY SCORING Form

Time of Exposure _____
Time of Symptom Onset _____
Time of Assessment _____

Based on Waselenko JK *et al.* Ann Internal Med 2004;140(12):1037-1051,
also Fliedner TM *et al.* Oxford: British Institute of Radiology; 2001: 64pp
also refer to REMM website (www.remm.nhs.gov)

1. NEUROLOGICAL (Circle most appropriate description for each symptom)

Acute Symptom ²	1 (mild)	2 (moderate)	3 (severe)	4 (most severe)
Nausea	Mild	Moderate	Severe	Unbearable
Vomiting	~ 1 per day	~ 2-5 per day	~ 6-10 per day	> 10 per day
Anorexia	Mildly decreased appetite	Moderately decreased appetite	Severely decreased appetite	Unable to eat
Fatigue Syndrome	No functional impairment	Moderate functional impairment	Severe functional impairment	Unable to function
Fever	37.5-38 °C	38.1 - 40 °C	>40 °C for <24h	>40 °C for >24 h
Headache	Mild	Moderate	Severe	Unbearable
Hypotension	HR>100, BP>100/70	BP<100/70	BP <90/60 (transient)	BP <80/60 (persistent)
Neurological deficits	Minor deficit; no functional impairment	Moderate deficit; moderate functional impairment	Marked deficit; marked functional impairment	Severe deficit; loss of consciousness
Cognitive deficits	Mild cognitive impairment	Moderate cognitive impairment	Severe cognitive impairment	Profound cognitive impairment

2. HEMATOLOGIC (Circle most appropriate description for each symptom)

Acute Symptom ²	1 (mild)	2 (moderate)	3 (severe)	4 (most severe)
Abs Lymphocyte	≥1.5 x 10 ⁹ /l	1.0-1.5 x 10 ⁹ /l	0.5-1.0 x 10 ⁹ /l	<0.5 x 10 ⁹ /l
Abs Granulocyte	≥2.0 x 10 ⁹ /l	1.0-2.0 x 10 ⁹ /l	0.5 – 1.0 x 10 ⁹ /l	<0.5 x 10 ⁹ /l
Abs Platelet count	≥100 x 10 ⁹ /l	50-100 X 10 ⁹ /l	20-50 x 10 ⁹ /l	<20 x 10 ⁹ /l
Infection ³	Local; no antibiotics required	Local; topical or oral antibiotics	Systemic; oral antibiotics	Sepsis; i.v. antibiotics
Bleeding ³	Petechiae; easy bruising; normal Hgb	Mild blood loss; <10% decrease in Hgb	Gross blood loss; 10-20% decrease in Hgb	Spontaneous bleeding; >20% decrease in Hgb

² Acute symptoms are those that began after the radiation exposure, and not thought to be attributable to another acute cause

³ Only present subacutely

RADIATION CASUALTY ASSESSMENT TOOL

*PLACE ID
STICKER HERE*

Name _____ Age _____ M/F
Date _____ Time of Arrival _____ h
Physician: _____ Time seen _____ h

3. CUTANEOUS (Circle most appropriate description for each symptom)

Acute Symptom ²	1 (mild)	2 (moderate)	3 (severe)	4 (most severe)
Erythema	Minimal, transient	Moderate; isolated patches <10cm ² ; <10% of body surface area (BSA)	Marked; isolated patches or confluent; 10-40% BSA	Severe; isolated patches or confluent; erythroderma; >40% BSA
Sensation/ itching	Occasional pruritis	Slight; intermittent pain	Moderate; persistent pain	Severe; persistent pain
Swelling / Edema	Mild; asymptomatic	Moderate; symptomatic	Severe; symptomatic	Compartment syndrome
Blistering	Vesicles, with sterile fluid	Vesicles, with haemorrhage	Bullae, with sterile fluid	Bullae, with haemorrhage
Desquamation	Mild	Patchy, dry	Patchy, moist	Confluent, moist
Ulcer/ necrosis	Epidermal only	Dermal	Subcutaneous	Muscle / bone involvement
Hair loss³	Thinning, not striking	Patchy, visible	Extensive	Complete and most likely irreversible
Onycholysis³	Minimal	Moderate	Severe	Complete

4. GASTROINTESTINAL (Circle most appropriate description for each symptom)

Acute Symptom ²	1 (mild)	2 (moderate)	3 (severe)	4 (most severe)
Stool frequency	2 - 3 stools per day	4 - 6 stools per day	7 - 9 stools per day	>10 stools per day; intractable diarrhea
Mucosal loss with diarrhea	Rare	Intermittent, with moderate patches	Persistent, with larger patches	Continuous, with large patches
Bleeding with diarrhea	Occult	Intermittent	Persistent	Gross hemorrhage
Abdominal cramping & pain	Minimal	Tolerable	Intense	Excruciating

Decorporating agents (for use with internal contamination) ⁴		
Contaminant	Treatment	Dose and Administration
Cesium	Prussian Blue	1g tid po
Iodine	Potassium Iodide (KI)	age dependent dose; 130mg po for adults
Plutonium, Americium	DTPA	1g iv Ca-DTPA on day 1, followed on day 2 by 1 g iv Zn-DTPA daily - slow iv push or iv infusion over 30 min diluted in 100-250 ml 5% dextrose in water. Nebulized inhalation is an alternate route.
Uranium	Sodium bicarbonate	250mL (1-2 mEq/kg) NaHCO ₃ slow iv infusion
Tritium	Water	>6 L/day po
Radium, Strontium	Barium sulphate, Sodium alginate, or Ca-gluconate	-300g po single dose -5g po bid, then 1 g qid with water (Gaviscon) -2.5g iv infusion over 4 h diluted in 500ml of 5% dextrose in water; daily up to six days

Onset of vomiting after exposure		
Time (hours)	duration	Dose (Grays)
>6, or absent	<24 hours	0.5-2.0
2-6	12-24	2.0-3.5
1-2	24	3.5-5.5
Minutes	48	>5.5
Time interval prior to onset of vomiting for initial biodosimetry		

² Acute symptoms are those that began after the radiation exposure, and not thought to be attributable to another acute cause

³ Only present subacutely

⁴ For prescribing information and other decorporating agents, refer to REMM; for local availability refer to Disaster Plan

Appendix E: CBRN (Chemical, Biological, Radiological, Nuclear) Emergency Preparedness Program: Manufacturers' Information and List of Equipment and Supplies

- For Equipment Program Manufacturers' Information see the following:
 - [MiniSentry - Transportable Gamma Portal Monitor](#)
 - [Dosimeters](#)
 - [MCB2 - Alpha/Beta/Gamma Contamination Meter](#)

Supplies and equipment for hospitals

Hospitals have a level designation depending on the number of emergency victims to be managed:

- Level 1 - 100 victims
- Level 2 - 60 victims
- Level 3 - 25 victims
- Level 4 - 10 victims

Hospital designation levels are based on:

- Geographic distribution: at least one Level One or Level Two hospital in each LHIN
- Hospital capacity to manage emergency victims
- High-level hazard identification and risk assessment
- Each site of a hospital organization that has an emergency department or urgent care centre

Ontario's hospital sites that provide emergency/urgent care have received the following supplies and equipment:

- Decontamination equipment:
 - Tent (3-lane unfold decontamination system) plus related decontamination and spill control products
 - "Pop-up" tent model with snap-in shower system (curtains, internal shower catch basin, shower suspension kit with integrated plumbing system)
 - Flex non-ambulatory patient roller system
 - Water/air heaters
 - Basic spill control aids
- Personal protective equipment:
 - Level C apparel (chemical splash suits, cooling vests, boots)
 - Disposable coveralls
 - Hand protection (nitrile, butyl, and neoprene gloves)
 - Respiratory protection
- Radiation detection equipment:
 - Portal gamma monitor
 - Hand-held alpha/beta monitors
 - Electronic personal dosimeters

Supplies for emergency medical services (EMS)

EMS received kits containing the following:

- Personal protective equipment:

- Level C apparel (chemical splash suits, cooling vests, boots)
- Hand protection (nitrile, butyl, and neoprene gloves)
- Respiratory protection
- Radiation detection equipment:
 - Electronic personal dosimeters

Supplies for Public Health Units

Should a large-scale RN incident occur where potentially hundreds or thousands of people are contaminated; it is likely that public health units would be requested to assist in the setup and staffing of monitoring and decontamination units (MDUs), KI distribution, and with decommissioning the units after the accident. The MOHLTC has equipped public health units with the following:

- Personal protective equipment:
 - Disposable coveralls
 - Hand protection (nitrile, butyl, and neoprene gloves)
 - Safety glasses
 - Respiratory protection
- Crowd control supplies:
 - Barricade tape
 - Traffic cones
 - Two-way radio sets
- Radiation detection equipment:
 - Electronic personal dosimeter

Appendix F: Instructions for 24-Hour and Spot Urine Sample Collection

INSTRUCTIONS FOR 24-HOUR URINE COLLECTION

Materials Required

- Urine Collection Container 24-hr, 4 litres (VWR Scientific #87000-142 or equivalent).

Procedure for sample collection

The sampling shall be as directed below:

- a. When sample collection is to commence, empty bladder. **This urine is not to be collected.**
- b. Note the time.
- c. Collect all voidings in the subsequent 24-hour period, up to and including, that voided the next day at approximately the same time as the previous day.

It is essential that no radioactive contamination, other than that in the urine, is introduced into the collection container. Ensure that dust from clothing or surroundings does not enter the cubitainer.

Wash hands thoroughly before voiding urine.

Collect urine directly into the collection container.

Provide the following information.

Name _____
Agency _____
Telephone _____
Exposure Date _____
Start Sampling Date _____ Time _____
Stop Sampling Date _____ Time _____

INSTRUCTIONS FOR SPOT URINE SAMPLE COLLECTION

Procedure for sample collection

- i. It is essential that no radioactive contamination, other than that in the urine, is introduced into the collection container. Ensure, therefore, that dust from clothing or surroundings does not enter the container.
- ii. Wash hands thoroughly before voiding urine.
- iii. Collect urine directly into the plastic cup provided and transfer to shipping container.
- iv. **Provide the following information on container label.**
Name _____
Address _____
Telephone _____
Exposure Date _____
Sampling Date _____ Time _____
- v. Close container tightly, seal with tape and place in Ziploc Bag with absorbent sheet.

Appendix G: Procedures for Collecting Blood for Chromosomal Analysis (Health Canada)



Updated May 2014

Healthy Environments & Consumer Safety Branch
Consumer and Clinical Radiation Protection Bureau
Radiobiology Division

Procedures for the Collection, Packaging and Shipping of Blood

Chromosomal Analysis for Suspected Overexposure to Ionising Radiation

Analysis of chromosomal aberrations in human peripheral blood lymphocytes is the present day standard for the biological assessment of radiation exposure. It is also used when a person's physical dosimeter is absent or inoperative or when the reading of the physical dosimeter is missing or in dispute. To optimize the recovery of lymphocytes from the blood, it is very important that the blood be collected and shipped according to the protocol outlined below which follows Transportation of Dangerous Goods and IATA (International Air Transport Association) regulations. For best results, blood should be received within 24 h of sampling.

Instructions:


- Contact Dr. Ruth Wilkins at Health Canada prior to taking a blood sample. Health Canada will confirm the shipment and forward supplies (see supply list below) and shipping materials if required. Contact information and address are below.
- Fill out the Questionnaire/Consent Form provided for each donor. Please keep a copy for your records. The original is to be included with the sample in the shipment.
- Collect blood samples into *1 x 4 mL Lithium Heparin Vacutainer tube* (if not available, Sodium Heparin tubes are acceptable) and if possible, also collect a 1 x 4 mL EDTA Vacutainer tube. Gently rock the tubes for 1 minute to ensure proper mixing. Label the tubes unambiguously and include the *date and time of the blood draw*.
- Package and ship the sample by courier using overnight air express as soon as possible following blood collection. This ensures the blood samples can be received the morning following collection. Pack the blood samples carefully to prevent breakage of the tubes and maintain temperature during transit. The blood samples should be maintained between 18°C and 24°C (64°F-75°F). **Blood samples must not be cold.** Packing instructions are below.
- Contact Dr. Wilkins at Health Canada to confirm the shipment and provide us with the Waybill number. **THIS IS IMPORTANT FOR TRACKING THE SHIPMENT.**

For air transport, packaging and labelling must conform to the current International Air Transport Association (IATA) regulations. These regulations require that blood samples be packaged in accordance with *Packing Instructions 650 for Biological Substances, Category B*.

Packaging:

If you are preparing your own shipping container you will require the following items. Consult your shipping department or Health Canada if required.

Materials required:

- **Leak proof primary container** (4 mL Lithium Heparin Vacutainer tube)
- **Parafilm or tape**
- **Protective material** (e.g., bubble wrap, paper towel or other suitable material)
- **Sealable leak proof bag** (e.g., Ziploc freezer bag)
- **Absorbent material** sufficient to absorb the total volume of blood being shipped (e.g., paper towel or commercially available absorbent strips)
- **Secondary receptacle/Protective container** (e.g., Pressure vessel, commercially available Tyvex bag, bubble envelope)
- **Room temperature gel packs (10)** to maintain temperature (between 18°C and 24°C (64°F-75°F)) (e.g., available through Saf-T-Pak or cold packs that have been maintained at room temperature for a few days)
- **Large Styrofoam container**
- **Rigid outer packaging** (cardboard box)
- **Labels** – **1x** 6.25 cm x 6.25cm diamond shaped “UN3373” , **1x** “Biological Substances, Category B”, **2x** “DO NOT X-RAY”, **2x** “Time and Temperature Sensitive (18-24°C)”, **2x** PERISHABLE/RUSH, **1x** DO NOT FREEZE, **1x** DO NOT REFRIGERATE (these can be printed from your desktop computer but must comply with TDG regulations)

Documentation required:

- Questionnaire/Consent form (original copy)
- Itemised Packing list
- Waybill and Pro Forma Invoice

NOTE: Packaging should be completed by or supervised by personnel with a valid Transportation of Dangerous Goods certificate (Class 6.2 Infectious Substances)

- Secure the cap of the filled primary container (Vacutainer tube) with Parafilm or tape
- Wrap blood tubes in protective material to prevent breakage
- Place wrapped tubes into a leak proof bag or Specimen bag
- Place absorbent material in the leak proof bag with the sample tubes and seal the bag
- If available, include a temperature recorder and a physical dosimeter in the inner package next to the blood samples. (Those can be provided by Health Canada, see the supply list).
- Logtag must be started prior to packing blood samples (Press and hold the start button until only the green light flashes intermittently)
- Place the leak proof bag into a secondary receptacle, leak proof pressure vessel
- Surround the secondary container with **about 10 room temperature gel packs** in the Styrofoam container
- Place all in rigid outer packaging
- Place the original copy of the Questionnaire/Consent Form and an itemized packing list of the package contents between the secondary container and outer packaging of the shipping box

- Mark and Label the outer packaging as listed below

Marking and labelling on outer package for air transport:

- **name, address and telephone number of receiver and shipper**
- **name, address and telephone number of person responsible** if other than shipper
- **“Biological Substances, Category B”**
- diamond shaped **UN3373** label
- orientation **arrows** placed on opposite sides of the package
- Labels: **DO NOT X-RAY, TIME AND TEMPERATURE SENSITIVE (18-24°C / 64-75°F), DO NOT FREEZE, DO NOT REFRIGERATE** and **PERISHABLE RUSH**
- **“TC-125-1B”** if shipping container was purchased (e.g., STP 320 box) or **“125-1B”** if shipping container was put together with materials on hand

Waybill and Pro Forma Invoice information:

- Ensure ‘Health Canada’ is entered in the ‘Company Name’ box on the waybill
- For International shipments, in the ‘Incoterms desc’ box write ‘DDU’ (deliver duty unpaid). This indicates that Health Canada will be paying brokerage and/or customs charges and using the Health Canada Broker. **This is important to ensure quick customs clearance**
- Under "Description", *write ONLY the following:* **“UN3373 Biological Substances, Category B” (proper shipping name)** check the DG box for Da
- Place 3 paper copies of the Waybill, Pro Forma Invoice (available online i.e., FedEx.com) and Itemized Packing List, inside a clear shipping envelope (i.e., FedEx) and stick to the outside of the shipping box.
- Retain a copy of all the above documentation for your records

Shipping Address

Ship to:

Dr. Ruth Wilkins
 Health Canada
 Consumer and Clinical Radiation Protection Bureau
 775 Brookfield Road
 Ottawa, ON K1A 1C1
 CANADA
 Emergency phone: (613) 355-6028 (24/7)

Additional Contact information:

Dr. Ruth Wilkins (Radiobiology Division Manager)
 Emergency phone: (613) 355-6028 (24/7)
 Phone: (613) 941-7263
 Secure Fax: (613) 952-7584
 Email: Ruth.Wilkins@hc-sc.gc.ca

Sylvie Lachapelle, MLT (Senior Technician/Support)
 Phone: (613) 946-2607
 Cell: (819) 712-3835
 Fax: (613) 941-1734

Email: Sylvie.Lachapelle@hc-sc.gc.ca

Barbara Kutzner (Senior Technician/Support)

Phone: (613) 952-9069

Fax: (613) 941-1734

Email: Barbara.Kutzner@hc-sc.gc.ca

Shipper's address:

Itemized Packing List

Date: _____

To whom it may concern:

Included are _____ x _____ mL vials of human blood.

The samples are "UN3373 Biological Substances, Category B" and will be used for investigational purposes.

If there are any questions concerning these samples, please contact the following:

Person responsible: _____

Phone number: _____

Thank you.

(Signature)

Healthy Environments & Consumer Safety Branch
Consumer and Clinical Radiation Protection Bureau
Radiobiology Division

Supply List

Items that can be provided by Health Canada for blood collection, packaging and shipping

- Blood tubes: 4 mL Lithium Heparin Vacutainer
- Blood tubes: 4 mL EDTA Vacutainer
- Protective material: Bubble wrap tube mailers Saf-T-Pouch® to pack tubes separately
- Absorbent material for 100mL liquid volume
- Inner Leak Proof Polybag: Secura T Specimen Bag or STP-711
- Secondary receptacle: Biohazard Tyvek® Outer Envelope or Polypropylene Leak Proof Pressure Vessel
- Temperature recorder: Logtag
- Physical dosimeter: Optically Stimulated Luminescent (OSL) dosimeter
- Gel Packs specifically for room temperature: STP 315, STP317 or STT-521-1000
- Rigid outer packaging: Commercial box STP-320 box containing a large Styrofoam container
- Copies of Questionnaire/Consent Form

Exterior labels

- Do Not X-Ray*
- Time / Temperature Sensitive*
- Perishable Rush*
- Do Not Refrigerate / Do Not Freeze*
- UN3373*
- Biological Substances, Category B*

**Health Canada, Healthy Environments & Consumer Safety Branch
 Environmental and Radiation Health Sciences Directorate
 Consumer and Clinical Radiation Protection Bureau
 Radiobiology Division**

Questionnaire and consent form for the customer

**Exposure Information for Chromosome Aberration Analysis
 (TO BE FILLED OUT BY THE REQUESTOR)**

I, (Name), born (dd/mm/yy) consent to giving a blood sample for the purpose of estimating chromosome aberrations induced by exposure to ionizing radiation.

.....
 Signature

Blood sample taken by: Laboratory name:
 Laboratory Address:
 Telephone #: Fax: E-mail:
 Date and time blood sample taken : (dd/mm/yy) Specify anticoagulant:

Exposure Data : Radiation Worker or Non-Radiation Worker

1. Date and time of overexposure: (dd/mm/yy - time)
2. Place..... Company:.....
3. Brief description of overexposure:

4. Whole body exposure Partial body exposure Internal contamination
 Dose value: Part of body: Nuclide:.....
 Dose value: Dose value:.....
 How was this dose value obtained.....

5. Type of radiation:

x - ray	<input type="radio"/>	kV
γ	<input type="radio"/>	nuclide?
α	<input type="radio"/>	nuclide?
Neutrons	<input type="radio"/>	source?
Electrons	<input type="radio"/>	source?

Patient Physical symptoms: (refer to Radiation Assessment Tool if possible)

1. Time of onset of vomiting:

- Vomiting: yes no
 - number of times.....
 - (began at.....h, =.....h after exposure)
 - Interval between exposure and onset of vomiting:h
- Estimated dose: _____Gray

2. Absolute Lymphocyte depletion rate:

- Single ALC.....x 10³,h post exposure
- Serial ALC's 2nd.....x 10³,h post exposure
- Estimated dose:Gray

Patient Data:

1. Previous exposure through medical practice:

- Radiation therapy Date, Part of Body.....
- x - ray diagnoses Date, Part of Body.....
- Nuclear medicine Date, Part of Body.....

2. Illness within the last 4 weeks before taking the blood sample:

3. Intake of medication:

Name of medication: Dose:..... Duration:.....

4. Smoker: no: yes: number / day:

5. Other diseases: HIV: Hepatitis:

Results of chromosomal analyses to be sent to :

Name:

Address:

Telephone # :

To be completed by Health Canada

Sample coding: _____

Appendix H: Guidance for the Setup of a Hospital Radiation Emergency Area

Hospital emergency departments receiving casualties with radiological contamination need to set up a radiation emergency area to process contaminated casualties, assess patients' medical status, and provide necessary treatment. These areas are set up to segregate contaminated patients from the rest of the hospital population, and to contain contamination spread. It is beneficial to have a specific plan and designated area in a hospital in advance so that the chosen location can easily transition from day-to-day operations.

The plan can be based upon existing contamination or quarantine plans, but should include radiation specific information such as specialized roles, radiation-specific equipment, radiation protection, decontamination sites, and patient treatment areas. The setup of a radiation emergency area should include the following aspects:

- Engineering controls** that make the work environment or setting safer.
- Administrative and work practices** that reduce the risk of exposure.

Engineering Controls

Engineering controls are the first and most effective line of defence. They involve permanent changes in the health care setting that reduce exposure in contaminated areas. They address risks associated with “human error”, non-compliance with recommended practices, and/or use of personal protective equipment. Existing health care settings should review their capital plans to assess the impact of the physical environment on health and safety, and make improvements where possible, e.g., building in traffic flow, barriers, and positioning of chairs in waiting areas.

The following are examples of engineering controls to manage radiation exposure:

- Setting up separate areas for radiation monitoring and decontamination to limit cross contamination.
- Physical barriers that shield the worker from potential exposure.
- Conduct radiological monitoring and decontamination in areas that have easy-to-clean surfaces in combination with appropriate cleaning procedures (administrative and work practices).
- Ventilation systems and Heating, Ventilation and Air Conditioning (HVAC) Systems that are designed and maintained in accordance with [CSA Standards](#), and can be used to isolate and protect sections of the health care facility when required.

Administrative and Work Practices

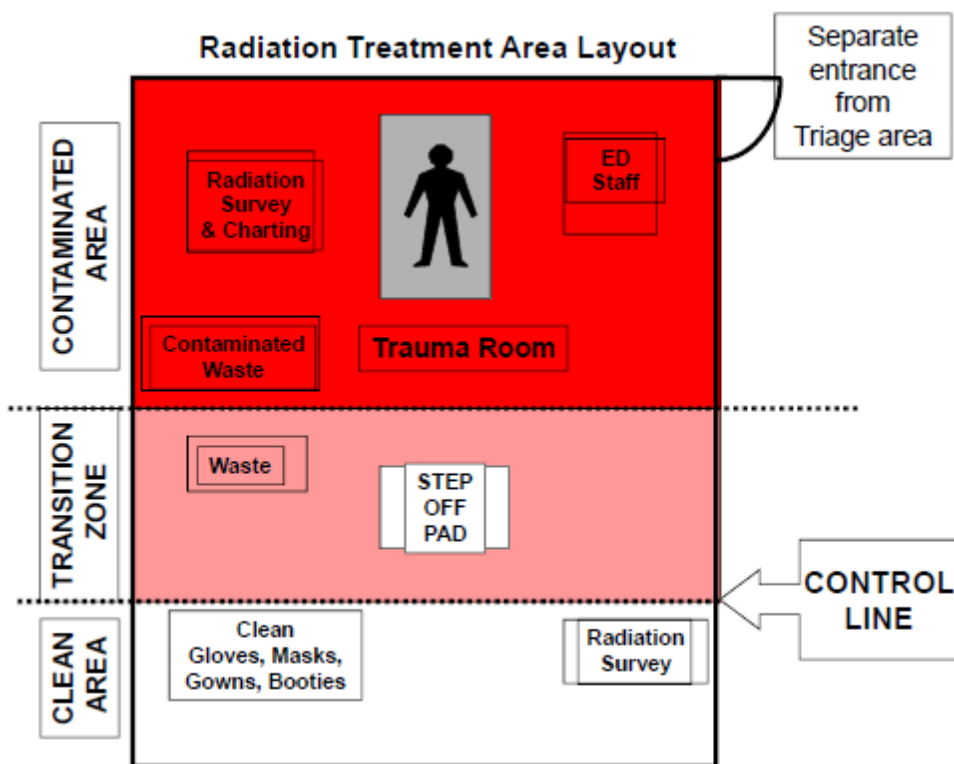
Administrative and work practices include ways of organizing and providing care and services at the organizational and individual level that reduces the risk of exposure to radiation when responding to an RN incident.

When developing work practices for specific tasks, employers should consult with health workers who have direct experience with those tasks and can provide valuable advice. Examples of changes in administrative and work practice include:

- Limiting the number of personnel, tools, instruments, and other objects permitted in radiation monitoring and decontamination areas.
- Limiting the time that workers are in a contaminated area.
- Establishing perimeters around radiation monitoring and decontamination areas.
- Minimizing the potential of contaminating equipment and tools used in radiation monitoring and decontamination areas by:
 - Placing small equipment inside sealed plastic bags.
 - Wrapping the hands of tools with tape and covering the wheels of equipment with plastic or duct tape.
- Covering contaminated surfaces and walkways with protective barriers, e.g., plastic sheeting, tape, etc.
- Avoiding transferring supplies and equipment from contaminated areas to non-contaminated areas.
- Conducting regular radiological monitoring of surfaces and staff in areas suspected of contamination.

At the organizational level, employers should assess patient/traffic flow patterns and implement procedures that direct potentially contaminated people to separate monitoring and decontamination sites, and limit access to those sites. These measures limit the spread of contamination to certain areas and help the health care facility maintain its regular operations, i.e., companies can continue to deliver supplies, and those who are not contaminated can enter the setting without risk of contamination.

Diagram of a Radiation Treatment Area Layout:



Source: Health Canada Medical Emergency Treatment for Exposures to Radiation (METER), Emergency Department Management (module 9).

Appendix I: Hospital Contamination Control Procedure

The following steps are recommended for a complete contamination assessment procedure:

1. Remove contaminated clothing and replace with clean clothing or wrap in sheet/blanket as needed.
2. Survey individual completely with a radiation survey meter for surface contamination on the body and record the levels (assume the contamination is “loose” and susceptible to being spread around until proven to be “fixed” to the skin).
3. Examine for contaminated shrapnel and other debris. (Caution: If dose-rate meter is available, a dose-rate should be taken.) Alternatively, an off-scale reading on a contamination meter may indicate the presence of radioactive shrapnel.
4. Identify the presence of contaminating radionuclides with a radiation survey meter that can distinguish between radiation type (i.e., Alpha, Beta, or Gamma), and provide a reading of activity level. Note: a radiation survey meter will not identify the specific isotope; a separate isotope identifier is needed for that purpose. Isotope identification is not an expectation of hospitals.
5. Survey hair, skin folds, and body orifices such as ears, mouth and nose for radionuclide contamination using a detector appropriate for the contamination of concern. This may also assist in assessment of level of concern regarding ingestion or inhalation.
6. Examine the individual for wounds and abrasions that could be routes for intradermal and internal radionuclide depositions.
7. Survey wounds and abrasions with a detector appropriate for the radiation of concern.
8. Take nasal swabs, and survey for evidence of inhalation.
9. Document external contamination; please see Clinical Resources and Tools in [Appendix D](#) for Body Mapping Form.

Please see the U.S. Department of Health and Human Services’ Radiation Emergency Medical Management (REMM) website for additional information on [Radiation detection devices](#) and [How to perform a survey for radiation contamination](#).

Early Rapid Assessment

Nasal swab samples can provide valuable information about inhaled radioactive material including:

- Identification of radioisotope and mode of isotope decay.
- A crude estimate of the amount of radioactivity deposited deep in the lung.
- The level of radioactivity measured from nasal swabs (in units of Bq) can then be used to estimate the dose of radiation received deep in the lung (in units of rad, cGy, rem, or Sv).

Nasal swab samples should be collected by swabbing the anterior of each nostril separately with a cotton swab. If intake is suspected, they should be taken as soon possible, preferably within the first hour. Delays in obtaining the nasal swabs affect intake estimation.

Each swab should be counted with a hand-held radiation detector and the results summed. Once the summed count rate is converted to activity, it is assumed to represent 10 per cent of the initial intake. This information can be used to compare to appropriate benchmark regulatory limits called Annual Limits on Intake (ALIs) for identified radionuclides.

Please see the U.S. Department of Health and Human Services' Radiation Emergency Medical Management (REMM) website for additional information on [Nasal swabs and estimate of internal contamination](#).

Appendix J: Specialized Radiation Health Care

In practice, critical initial treatment decisions are most likely based on incident history rather than dose estimates. As more detailed information is made available, treatment should be adjusted accordingly. This includes estimates of the radiation dose from the incident, information from air and surface sampling, and early reports of in-vivo measurements and bioassays.

Medical consultation to assess appropriateness of treatments with decorporation agents, chelating agents, and other methods to increase elimination will be done in conjunction with specialists who have expertise in treating patients exposed to radiation. The MOHLTC can facilitate access to a specialist upon request, and can be contacted through the **Healthcare Provider Hotline at 1-866-212-2272**.

Managing Acute Radiation Syndrome (ARS)

The management of ARS is focused mainly on support and recovery of the hematologic system. Early onset of anorexia, nausea, vomiting, and malaise are indications of higher doses. Two major aims of medical management are efforts to prevent the decreases in white blood cell count, i.e., neutropenia and sepsis.

As neutropenia worsens, the risk of infection increases. If the absolute neutrophil count drops below $100/\text{mm}^3$, the risk is greater. Neutropenic infections are common in ARS patients due to the weakened immune system; for this reason, antibiotic prophylaxis and antiviral and antifungal medications should be considered.

Cytokine therapy may be considered for patients expected to experience severe neutropenia. Maximum effectiveness is accomplished with administration early after exposure, preferably within 24-72 hours. Treatment should continue until absolute neutrophil count reaches an appropriate level or within normal range.

Radiation-induced vomiting should be diagnosed in the context of the history, as other causes of vomiting may be present. Radiation-induced vomiting tends to be more persistent compared to other causes such as pain or anxiety, and can be treated by granisetron (Kytril) or ondansetron (Zofran).

Managing Internal Contamination

Treatment for internal contamination requires knowledge of the potential risks involved, as treatment is closely linked with metabolic information. The urgency and importance of the treatment depends on the efficiency of the therapeutic method and the amount of the contaminant.

Basic principles of treatment include:

- Reducing absorption and internal deposition.
- Enhancing the excretion of absorbed contaminants.

Methods to reduce the dose received from internal contamination are accomplished by:

- Blocking the radioactive material from being incorporated into the organs of the body.

- Increasing elimination of the radioactive material from the body.
- Flushing the radioactive material from the body (lavage).

Precise treatment and decorporation methods are determined by health experts from specialized institutions based on a careful assessment of the risks and benefits of the method, and taking into consideration the condition and age of the patient.

Treatment of Specific Contaminants with Decorporating Agents

Please refer to the Radiation Emergency Medical Management (REMM) website for information on [managing internal contamination and isotopes of interest](#), including properties, treatment, and fact sheets.

Appendix K: Detailed Descriptions of the Planning Scenarios and Response Requirements

For RN events, the following planning priorities are the areas of focus for the health system. For each scenario, the type of response required to deal with each of these priorities is detailed:

- a. Acute exposure. Plan for the treatment of a few acutely exposed patients. The terrorist threat of exposure of the public also ranks high on the risk scale. The MOHLTC is prepared to quickly mobilize the health care sector to identify and manage a large number of potentially acutely exposed patients.
- b. External contamination. Two risks dominate: a few contaminated patients as a result of a small incident (e.g., transport), and a large number of low-level contaminated people (non-patients) as a result of an accident involving a nuclear facility.
- c. Internal contamination. Two risks dominate: a few people becoming significantly internally contaminated from several types of accidents or a lot of people fearing being contaminated as the result of a terrorist act. In the latter case, reassurance monitoring may be required.
- d. Psychosocial. The dominant risks are those associated with nuclear facility accidents and terrorist events affecting a large number of members of the public. Plans should be based on the need to reassure, and potentially screen, a large number of otherwise healthy individuals (hundreds or thousands).

Power reactor accidental release (scenario 1)

Description

The power reactors covered under the *RHRP* are the nuclear power stations at Bruce, Darlington, and Pickering and also the nearby Fermi 2 power station in Michigan, U.S.A. A possible scenario involves the failure of the nuclear process systems, leading to a loss of normal cooling of the nuclear reactor fuel. Provided that all designed safety systems are functional as intended, there will be no consequence and no exposure of the public. However, should the safety systems fail, releases of radioactive material to the environment are possible. The magnitude of the release depends on the extent of system failures and operator intervention.

For the majority of cases, the safety systems and consequent operator actions prevent fuel failure and limit the leakage out of the containment. In this case, there could still be a release into the environment, but it would be limited to the small inventory of fission products that are contained in the primary coolant that has been leaked from the fuel. In extreme cases, safety system failures may lead to fuel failure and melting of the fuel rods. Should that occur, more significant quantities of radioactive fission products may be released. If the containment system also fails, there could be very large releases of radioactive material to the environment.

Another scenario that can result in an accidental release from a power station is an accident involving either the wet or dry waste storage facility. The destruction of the waste storage facility could lead to the release of fission products as described above. If

this should occur, the consequences would be similar to the previously discussed example, but on a possibly smaller scale. This scenario is more likely to occur during a sabotage attack on the nuclear facility (scenario 15).

Consequences

Potential on-site consequences include internal and external contamination, as well as external exposure of workers. The number of people exposed would most likely be limited to a few emergency workers. Emergency worker protection guidelines are such that it is very unlikely (though not impossible) that anyone would be exposed to levels exceeding the acute effects thresholds. Severe contamination and exposure could result, for example, from firefighting efforts in a heavily contaminated area.

Potential off-site consequences depend of course on the extent of fuel damage and containment failure. It is very unlikely that any member of the public would be exposed to radiation levels or contamination that would trigger acute health effects. However, there could be internal and external contamination as well as exposure of the population below acute thresholds over a great distance. The *PNERP* assumes that the risk of contamination or exposure extends to the population living within the primary zone. There is a possibility, although the probability is extremely low, that this could extend well beyond the primary zone. Even though exposure levels would be much lower than the acute threshold, people who are found to be contaminated may need counselling, medical follow-up, and measures to minimize the internal contamination burden.

Even in the absence of evidence of contamination, people living in the affected area, as well as other concerned members of the public, may feel that their health has been affected by the radioactive release. Such psychosocial effects may prompt a large segment of the population to seek reassurance through the medical and public health institutions, including screening for contamination and exposure levels.

Depending on the season, agricultural products may become contaminated. The *Assurance Monitoring Group Plan* makes provision for the control of contaminated food products. However, food contaminated below the acceptable limit will be re-integrated on the market and made available for consumption. Although the risk from such low levels of contamination is negligible, perception and fear of health effects may play a significant role in the willingness of the population to consume these products, which may in turn have great impacts on the food supply and distribution system.

If the reactor is located near Ontario (within approximately 300 km), the main impact would be low-level contamination of the ground. This could require food control measures. It is very unlikely that any member of the public would be contaminated enough to require monitoring and decontamination, though many could fear that possibility. The impact on the health system would be minimal and mainly focused on reassurance. If the reactor is further than 300 km, there would be virtually no impact, other than psychosocial. If Ontario citizens were present in the accident area when it happened, they may be concerned enough to request radiation contamination screening upon their return to Ontario.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Screening and treatment of a limited number of emergency workers as well as counselling.	Acute exposure is possible. Internal contamination, whatever the level, requires medical attention. Counselling is also required.
Acute exposure of members of the public	Not required (except possibly for workers at the facility).	
External contamination of public	Screening and decontamination of a large population, followed by counselling.	Detailed plans should be developed for impacts within the primary zone. Contingency arrangements should be made beyond that zone.
Internal contamination of public	Not required.	Internal contamination is unlikely if external contamination is not detected.
Psychosocial effects	Screening for contamination should be made available to concerned public. Health information programs should be implemented.	The best way to deal with concerns of contamination is to demonstrate the absence of contamination.

Research reactor accidental release (scenario 2)

Description

Research reactors include facilities such as Chalk River's NRU reactor, McMaster, Royal Military College, etc. These reactors operate at much lower power than power reactors and, as a consequence, the potential for off-site impacts is much reduced. The nature of accidents is the same as for power reactors. Some research facilities do not possess pressure-retaining containment systems. Therefore, there is a possibility of off-site releases.

Consequences

Even in the worst-case scenario, there is no possibility of off-site acute impacts arising from this type of accident. However, all other potential consequences discussed above for power reactors are also possible. The difference will be the distance over which such impacts may occur. The distance affected is different for each case, and therefore an evaluation must be made for each facility. For example, in the case of NRU, the distance over which the risk of contamination is considered reasonable for planning is approximately 9 km. It is also possible that, in the worst-case scenario, the area affected could extend well beyond that distance. The risk of significant internal contamination for this scenario is very low off-site.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Screening and treatment of a limited number of emergency workers as well as counselling.	Acute exposure is possible but very unlikely. Internal contamination, whatever the level, requires medical attention. Counselling is also required.
Acute exposure of members of the public	Not required.	Not possible.
External contamination of public	Screening and decontamination of a large population, followed by counselling.	Detailed plans should be developed for impacts up to a few km, as specified in the technical planning basis for the facility. Contingency arrangements should be made beyond that radius.
Internal contamination of public	Not required.	Internal contamination is unlikely if external contamination is not detected.
Psychosocial effects	Screening for contamination should be made available to concerned public. Health information programs should be implemented.	The best way to deal with concerns of contamination is to demonstrate the absence of contamination.

Radioactive spill (scenario 3)

Description

This scenario involves the spill of radioactive material inside a nuclear or radiological facility (a facility using or storing radioactive material), resulting in the contamination of part or all of the facility. The spilled radioactive material may be in powder or liquid form. Resuspension or evaporation may lead to airborne contamination.

Consequences

The consequences depend greatly on the type of spill and the location. This excludes transportation accidents, which are described later. A spill could occur at a nuclear power station or a fuel processing facility, for example. The main impacts would be on the environment. However, there could be a significant concern over the contamination of the environment, water tables or fish. It is unlikely that urgent protective actions would be required, and the impact on the health system would therefore be limited. The focus would likely be on providing care to the facility personnel, longer-term measures, reassurance and possibly some screening, depending on the location of the spill.

Facility staff and first responders may become externally contaminated. Facility staff present at the time of the spill may be internally contaminated as well due to inhalation of the airborne contamination. Provided that proper procedures are followed, emergency responders are unlikely to become internally contaminated. External exposure levels for this type of accident are generally low, and acute exposure is unlikely.

The number of people that could be affected is relatively low and limited to the facility staff in the immediate vicinity of the spill.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Screening and decontamination as well as counselling.	Acute exposure and significant internal contamination are possible, but are not considered likely. External contamination is expected.
Acute exposure of members of the public	No planning required.	Not possible.
External contamination of public	No planning required.	Not possible.
Internal contamination of public	No planning required.	Not possible.
Psychosocial effects	Counselling for on-site staff.	Impact is limited to facility staff.

Fire in a nuclear or radiological facility (scenario 4)

Description

This scenario involves a fire in a facility that stores radioactive material. The fire may affect the integrity of the container and release the radioactive material. Once the radioactive material is released, the fire volatilizes the radioactive material causing it to be airborne. The fraction that is volatilized depends on the physical and chemical form of the material, and may range from 0.001% to 10%. The airborne contamination will initially be confined to the facility but, if the fire is extensive, may be released off-site. An example of this accident scenario occurred on March 31, 1994, when a fire at a nuclear research facility on Long Island, New York resulted in the nuclear contamination of three fire fighters, three reactor operators, and one technician. There were also measurable amounts of radioactive material released into the immediate environment.

Consequences

Provided that people are evacuated due to the fire, there should be no contamination or exposure of facility staff, except if a person becomes injured during the incident and is unable to leave the affected area. First responders may become externally contaminated but, provided that proper procedures are followed, are unlikely to become internally contaminated.

External exposure levels for this type of accident are generally low, and acute exposure is unlikely, except in the case of a person becoming injured and not being able to evacuate the affected area. For this exceptional case, there is also a likelihood of internal contamination through inhalation.

The number of people that could be affected is relatively low and limited to the facility staff in the immediate vicinity of the facility.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Screening and decontamination of a limited number of emergency workers and counselling.	Acute exposure and internal contamination are not considered likely.
Acute exposure of members of the public	No planning required.	Not possible.
External contamination of public	No planning required.	Contamination off-site is possible in the immediate vicinity of the site. Much less likely further away.
Internal contamination of public	No planning required.	
Psychosocial effects	Counselling for on-site staff; health information program for the public.	Even though the public will not be directly affected from the accident, the information program will deal with misconceptions about the impacts.

Criticality accident (scenario 5)

Description

This type of accident commonly occurs when there is a procedural error, such as when manually changing the configuration of a research reactor, resulting in an unwanted criticality of the reactor while the operator is next to it. Criticality accidents have occurred in processing facilities (22 accidents worldwide), and during criticality experiments or operations with research reactors (38 accidents worldwide).

An example of this type of accident occurred in Tokimura, Japan in 1999 at a fuel fabrication plant. Workers did not follow procedures when pouring clean liquid nuclear fuel in a batch process, which resulted in a mixture that became critical and started a self-sustaining chain reaction. Of the three workers involved, the one pouring the solution, received a dose of 6-10 Gy and died 210 days later, the one holding the funnel received 16-20 Gy and died 82 days later, and the third at a nearby desk received 1-4.5 Gy and was hospitalized for three months.

Criticality incidents could occur in a research reactor with flexible fuel configuration or a fuel enrichment facility.

Consequences

The main impact of a criticality accident is the overexposure of the operator(s) in the vicinity of the reactor or process at the time. Acute exposure is almost certain. The exposure is almost always instantaneous and with a sharp decrease in dose with distance. The probability of fatality is high within three meters from the accident location, but is unlikely if a person is located more than five meters away. Extremities near or touching the apparatus may be very highly exposed and may require amputation; even though the individual's whole body dose may be low enough for survival.

In general, criticality accidents result in heterogeneous dose distribution to the body and usually only affect a small number of persons. Exposure to the public is highly unlikely, but if there is exposure, the dose is often insignificant. There is little internal contamination associated with this accident type, and offsite release and contamination are not likely.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Decontamination and treatment of overexposure and counselling.	Acute exposure is almost certain for operators who were near the process.
Acute exposure of members of the public	No planning required.	Not possible.
External contamination of public	No planning required.	Very unlikely.
Internal contamination of public	No planning required.	Very unlikely.
Psychosocial effects	Counselling for on-site workers.	Impact is limited to facility staff.

Industrial overexposure (scenario 6)

Description

This type of accident generally occurs when proper industrial radiography procedures are not followed. For example, failure to use exposure control may lead to inadvertent overexposure to workers in the immediate work area, and touching the source for any reason often leads to serious injury to the hands. A good example is an accident that occurred on the June 21, 1990 at Sor-Van Radiation Limited, Soreq, Israel. This accident occurred at a commercial irradiator, in which packages are automatically moved through an area exposed to a Co-60 source. Several maintenance problems contributed to the accident, which began when packages became jammed in the irradiation area. An operator chose to reject the radiation warning indicator in favour of an indicator erroneously showing the cobalt source to be safe or in shielded mode. He overrode the safety features to enter the irradiation room and after a short period of time, felt burning in his eyes and a headache. He then immediately left the room and contacted his supervisor and then began vomiting shortly after. The worker received a whole body dose between 10 and 20 Gy and died 36 days later.

Consequences

Overexposure to a radioactive source can be minor or serious. In extreme cases, it will lead to acute effects. The number of people affected is limited to the operator or operators handling the source or equipment.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Decontamination and treatment of overexposure and counselling.	Acute external exposure is likely. Internal exposure is very unlikely.
Acute exposure of members of the public	No planning required.	Not possible.
External contamination of public	No planning required.	Not possible.
Internal contamination of public	No planning required.	Not possible.
Psychosocial effects	Counselling for on-site staff.	

Lost or stolen source (scenario 7)

Description

Although this is called “lost or stolen source”, the real hazard does not come from the loss itself, but from the inadvertent handling of the source by people who are not aware of the risk. There are several examples of such accidents in recent years.

In Thailand, a cobalt source was improperly discarded in a junk yard. It was found by junk hunters, who handled it for a few minutes before throwing it back in the junk pile. Four people suffered acute effects, but there was no contamination.

Another such accident occurred in 1987, in Goiania, Goias, Brazil. A radiotherapy unit from an abandoned clinic was removed and dismantled. The extracted radiological source (1,375 curies of Cs-137) was dismantled, then spread and handled by many people resulting in five fatalities, 20 radiation injuries, and massive amounts of contaminated areas that had to be cleaned up. A massive medical response had to be mounted.

There is a possibility that a missing source may also be lost or hidden within the facility.

Consequences

The consequences of lost sources can be benign to very severe, depending on the source and on the management of the event. In the worst cases, there will be dozens of overexposed persons, many above the acute threshold, internal contamination and external contamination of people and the environment over a wide area (equivalent to several city blocks).

More importantly, if it is known that a source is missing, the public will need to be notified. Depending on the nature and activity of the source, it may be required to warn the public about the possible symptoms of overexposure. This can generate widespread concern, as some symptoms of overexposure resemble those of a common flu. In the worst case, this can cause a large number of people to report to health care facilities. The health system must be ready to deal with the perception impacts of such an event.

The number of people that may need to be screened for exposure and contamination may be very large. In the case of Goiania, approximately 120,000 had to be monitored.

However, the number of physically affected people should be relatively small.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
On-site contaminated and overexposed people	Not applicable.	
Acute exposure of members of the public	Screening, treatment and counselling.	Acute exposure likely for person carrying the source. Plan for screening of a large population.
External contamination of public	Screening and decontamination.	Plan for screening of a large population.
Internal contamination of public	Screening and decontamination.	Plan for screening of a large population.
Psychosocial effects	Make available screening to concerned people. Health information program must be implemented.	Plan for screening of a large population.

Medical overexposure (scenario 8)

Description

These accidents occur when patients receive more radiation than prescribed by their attending physician. This may occur because of miscalculation of the activity of a therapy source, improper function of an X-ray device or accelerator, or when higher activities than intended are inadvertently administered during diagnosis and therapy. There also have been cases where the wrong patients are subjected to the wrong irradiation medical procedure.

In most cases, operators do not recognize that the accident has occurred until the patient returns to the clinic with radiation burns. A good example this type of incident, occurred at the East Texas Cancer Centre, Tyler, Texas, USA. A defect in the computer program controlling the Therac-25 radiation therapy accelerator resulted in overexposure to two patients. One male patient was overexposed on March 21, 1986, received an estimated localized dose of 165 to 250 Gy, and immediately experienced pain. He developed various radiation injuries over the next few weeks and died five months after the accident. The second accident, also male, received an overexposure dose to the face on April 11, 1986, which then produced immediate skin burns. The patient eventually went into a coma and died a month later of radiation injury to the brain. Eventually, a physicist identified the cause of the accidents.

Consequences

In most cases, the consequences are limited to a single patient. In some cases, several patients are affected before the error is found. These accidents almost always lead to acute exposure.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Acute exposure of patients	Treatment and counselling.	The dose received is normally easily established.
External contamination of public	No planning required.	Not possible.
Internal contamination of public	No planning required.	Not possible.
Psychosocial effects	Counselling for on-site staff.	Not required.

Transportation accident (scenario 9)

Description

This is a transport accident involving radioactive material. If the packages are not damaged, the radiological impact is minimal. However, if the packages are damaged by the impact or by a subsequent fire, the radiological consequences increase. Without a fire, the most likely impact is a spill limited to a few hundred meters from the scene. Within a fire, airborne contamination could result over a downwind radius of about 1 km, depending on the nature of the radioactive material.

Consequences

Transport staff and first responders may be overexposed, internally and externally contaminated, especially if they are unaware of the nature of the cargo, or unable to take appropriate protective actions. If standard HAZMAT procedures are followed, responders should not suffer any significant adverse health effects from radiation.

External exposure levels for this type of accident are generally low, and acute exposure is unlikely, except possibly for the transporters (drivers) if they are left unconscious near the source for an extended period of time.

Bystanders could be externally contaminated if there is a fire and/or if they try to assist the victims. However, the risk of significant internal contamination in members of the public is low.

The number of people that could be affected is relatively low and limited to the facility staff in the immediate vicinity of the spill.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Accident-site contaminated and overexposed people	Screening and treatment of transport operators if they are injured and remain near the source for extended period. Screening and decontamination of a limited number of emergency workers and members of the public who provided assistance. Counselling.	Acute exposure and significant internal contamination are not considered likely, except in the case of injured transport operators remaining at the scene.
Acute exposure of members of the public	No planning required.	Not possible unless they are involved in the accident.
External contamination of public	Screening and decontamination as well as counselling.	Those near the site of the accident may come into contact with the spill.
Internal contamination of public	No planning required.	Significant internal exposure of the general public is not likely, especially if proper emergency measures are adopted.
Psychosocial effects	Health information program for the public in the affected area.	Since the accident occurred away from a nuclear facility, providing information to the public will reduce the number of concerned individuals.

Satellite re-entry (scenario 10)

Description

Some satellites use radioactive material to provide on-board power. If a satellite re-enters the atmosphere, it burns and the crash can spread radioactive contamination over a wide surface area (several km). This happened in Canada with COSMOS 954 in 1978, where the debris from the crash covered an area of 124,000 km², with some readings as high as 5 Gy/h on contact.

Consequences

The main impact of this accident would be the crash itself, especially if the crash site is a populated area. Some radioactive fragments may also be quite radioactive and present a significant health hazard if they are handled by people who are unaware of the hazard. This could lead to exposure above the acute thresholds. In this case, the best strategy is to quickly secure the crash area and prevent access to the debris without radiation protection specialist supervision. Recovery could require the coordinated effort of a large number of military and response personnel.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Accident-site contaminated and overexposed people	Screening and decontamination of a potentially large number of recovery workers.	This should not be a medical problem provided that recovery work is performed under qualified supervision.
Acute exposure of members of the public	No planning required.	
External contamination of public	No planning required.	Although external contamination is indeed possible, this is a catastrophic event with a very low probability, which makes it difficult to plan for. In addition, if the crash is in a populated area, the radioactive contamination will be a secondary concern. Consequently, it is recommended that the response to this event will be improvised on the basis of available resources.
Internal contamination of public	No planning required.	
Psychosocial effects	Health information program for the public in the affected area.	Note that the crash itself will lead to much greater impacts than radiation.

Explosive radiological dispersal device (RDD) or dirty bomb (scenario 11)

Description

This type of malevolent act involves combining radioactive materials with conventional explosives to create a 'dirty bomb'. In this type of attack, the terrorists combine a traditional terrorist attack with the use of radioactive materials to enhance the real impact, fear and the perception that authorities are not in control. The explosion disperses radioactive contamination over a wide area (the blast radius), and downwind (contaminated plume).

Consequences

The main impact would be conventional: buildings collapse and trapped people, fire in the immediate vicinity of the explosion, dead or injured people from the effects of the blast and from fragmentation and disruption to power supply, gas supply, water supply and communication links within the immediate area of the blast.

Victims of the conventional blast will be contaminated. People downwind may also be contaminated. The distance at which contamination may be an issue depends on the device and the form of the radioactive material used. The IAEA uses a default distance of twice the blast distance as the initial estimate of downwind impact, with a minimum of 300 m.

First responders may become contaminated and exposed, especially if they are not aware of the hazard, and since conventional rescue operations will be carried out without delay. However, provided that standard protective posture for HAZMAT incidents is adopted, there should not be significant internal contamination, external exposure or health impacts from the external contamination.

Bystanders who are first at the scene, who help with the initial rescue operations, who may not be aware of the potential radiation hazard and may not have any protective gear may be contaminated, internally and externally, and exposed.

In all cases, it is unlikely that the doses received will exceed acute levels, unless the victims are trapped near high-activity sources emitting penetrating gamma radiation, such as Ir-192, Cs-137, and Co-60.

As for any malevolent acts, there will be a significant psychosocial impact for people in the affected area and beyond.

It is also important to note that the culprits may still be at the scene or part of the casualties.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Accident-site contaminated and overexposed people	Mass casualties response with possible contamination. Screening and decontamination of responders and members of the public (tens to hundreds). Counselling.	Acute exposure is not likely. Internal and external contaminations are likely.
Acute exposure of members of the public outside the scene	No planning required.	Not likely.
External contamination of public outside the scene	Screening and decontamination. Counselling.	
Internal contamination of public outside the scene	No planning required.	Significant internal exposure of the general public is not likely, especially if proper emergency measures are adopted.
Psychosocial effects	Health information program for the public in the affected area and beyond.	Public reassurance is crucial to regain a sense of security.

Deliberate exposure of people (scenario 12)

Description

This is a malevolent act that can be targeted at specific individuals or at society in general. The possibilities may include, for example:

- Concealing a strong unshielded radioactive source in the clothing, luggage, home, workplace or vehicle of target individuals; or

- Concealing a strong unshielded source in a place frequented by the public or on public transport.

The worst-case scenario is the indiscriminate exposure of a large population with the intent of causing crippling disruption of the economic, transport, health, and political infrastructure. Terrorists place several strong sources in public areas (shopping malls, subways, financial district, etc.), and do not inform the authorities for several days. The sources are undetected. Thousands to millions of people come in close vicinity to the sources and, within minutes, receive doses above the acute thresholds. A few days later, the terrorists inform the authorities, who confirm the presence of the sources.

Consequences

This is one of the most challenging events from a medical and public health perspective. A large number of people have been exposed to acute levels. An even larger number of people may have been in the vicinity of the sources. These people may be all over the country and the world by the time the event is discovered. Although they are not radioactive and present no hazard to others, they need to be located and screened. There could also be significant psychosocial impacts. People may fear that other sources may be “out there”. This could significantly disrupt normal economic and societal activities. The public would have to be warned (or would be informed by so-called experts) against the potential signs of radiation exposure. Since these symptoms resemble those of a common flu or cold, the health system may be overwhelmed by people reporting that they were in the affected areas and that they may suffer from radiation exposure.

The health system would have to deal with an extremely high number of potential victims, geographically dispersed. This would call for an unprecedented level of coordination on a provincial, national and international level.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Acute exposure of members of the public	Screening, treatment and counselling. Set up special facilities to handle the large number of potential victims outside the health care facilities. Coordinate with other jurisdictions. Mobilize the national system to get additional medical and radiological resources. Notify international organizations.	Plan for screening of a very large population across several jurisdictions. It is important to relieve the health care facilities from the burden of dealing with the large number of potential victims so that they can continue to perform their normal functions; alternate facilities may be required.
External contamination of public	No planning required.	The main concern with this type of event is the external exposure.
Internal contamination of public	No planning required.	The main concern with this type of event is the external exposure.
Psychosocial effects	Make available screening to concerned people. Health information program.	Public reassurance is crucial to regain a sense of security.

Deliberate contamination of a site (scenario 13)

Description

This type of terrorist act is similar to that of a dirty bomb in terms of radiological impacts, but without the explosion. The results sought by the terrorists would be mainly strategic, as this act does not achieve the same sensationalism as the use of an explosive dispersal device. In this type of malevolent act, the principal aim would likely be the long-term denial of a site such as a railway station, bus terminal, city's financial district or other key infrastructure facility. The culprits may use radioactive materials in such a way that it becomes impossible to recover the use of the site without demolition and removal of building debris. As the accident in Goiania (Brazil, 1987) demonstrated, a very small quantity of radioactive material can lead to significant radiological and environmental impacts.

Consequences

There will be widespread contamination at the site, which may contaminate (internally and/or externally) a large number of people who may have unexpectedly come in contact with it. However, due to dispersion, it is unlikely that people would receive acute exposure. If the event is discovered late, the movement of people, objects and vehicles may spread the contamination further.

Health planning considerations

The response to incidents of this nature is similar to the response to an explosive radiological dispersal device. The main difference is the way in which the response develops depending upon how the incident comes to light. Unless the terrorists or criminals announce their intentions or claim responsibility for the attack, the incident may remain clandestine for a lengthy period. Late disclosure of the incident would pose some very difficult challenges to the response team as the contamination might then be spread over an extensive area. Tracking the movement of people and vehicles away from the contaminated site would become increasingly difficult over time, making containment impossible.

In practice, the response very much depends on the discovery method. There are two possibilities for the discovery:

- a. Early discovery. If the aim is to deny the use of the area, it is likely that the culprits will inform the relevant authorities of their actions, knowing that the report of such actions will cause an immediate evacuation of the site.
- b. Delayed. It is also possible that there would be no information from the culprits until much later. In this case, the first indication of an attack may come from the medical assessment of victims.

The first case is very similar to the situation involving an explosive dispersal device without the conventional hazard.

The second case is very similar to the situation involving sources strategically located to deliberately irradiate people. The only additional challenge is the presence of contamination. This has two major impacts on the response. First, since the source is dispersed, unlike a sealed source, its strength decreases as it spreads. Second, the spread

of contamination means that investigators and radiological specialists are now searching for a diffused source; the number of people affected may be very large, and special precautions will need to be taken by all those handling potentially affected people. MDUs may have to be established for contamination screening.

Therefore, the requirements for health response are a combination of those required for scenarios 11 and 12, with the exception that acute effects are unlikely.

Deliberate contamination of food or water supplies (scenario 14)

Description

Radioactive contamination can be inserted at various points of the food and water distribution system. By contaminating the supply at the point of origin, terrorists can achieve widespread impacts. However, due to dilution, the magnitude of the impacts would be limited. By inserting the contamination downstream of the distribution system, terrorists can achieve greater impacts, but over a more limited or targeted area.

Consequences

It is almost impossible to contaminate a public water supply with a volume greater than 1000 m³ to a dose level that is immediately life threatening or that would warrant long-term medical follow-up. However, it would be possible to contaminate water supplies to levels above the action levels recommended for consumption. Contamination of food/products resulting in significant exposure to the large numbers of the public is very unlikely. However, there is a potential for significant exposure to a small number, such as those who consumed the contaminated products brought from the grocery store, especially if the contamination is inserted in the end product itself.

This type of malevolent act is unlikely to lead to significant internal contamination or acute exposure of a large number of people due to the enormous quantities of radioactive material that would be required to reach high levels of contamination in mass-produced or distributed supplies.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Acute exposure of members of the public	No planning required.	Highly unlikely, unless the contamination is injected in the final product, in which case the number of victims would be limited. See scenario 18 for this variant.
External contamination of public outside the scene	No planning required.	Highly unlikely.
Internal contamination of members of the public	Screening and counselling.	Significant internal exposure of the general public is not likely. However, re-establishing confidence of the public may require screening of representative groups.

Health System Priority:	Required response	Remarks
Psychosocial effects	Health information program for the public.	This response is similar to that for the non-radioactive contamination of food and water supplies. Walkerton would be a representative example.

Sabotage attack upon a nuclear facility (scenario 15)

This type of terrorist act can lead to the same radiological consequences as those described in scenario 1 for power reactor accidents or scenario 2 for research facilities. The only difference is the cause of the release. From a medical or public health perspective, the consequences and response requirements are the same.

Nuclear weapon detonation (scenario 16)

Description

The probability of an attack on the public by nuclear weapons is extremely low because it is believed that terrorists do not have the capability to develop and manufacture nuclear weapons. However, the future is unknown, and it is best for the health system response to be prepared for the worst.

Such a terrorist act would involve the use of what would most likely be a low-yield nuclear weapon (suitcase bomb). The device would be detonated as designed and would yield a high radioactive burst and considerable blast. There would be widespread destruction and contamination, well beyond the hazard distances achieved using a dirty bomb. It is important to note that this event is very different from the simple explosion, without nuclear yield, of a device containing radioactive material. For a nuclear detonation to occur, the device has to work perfectly as designed, which in itself is difficult to achieve.

Consequences

The detonation of a nuclear weapon will result in significant impact on any community, and the medical response at both the pre-hospital and hospital levels will be compromised. Hundreds to thousands of prompt fatalities are expected within the detonation zone, with an even greater number of persons with blast and burn injuries further away from the detonation zone. The size of the area will be related to the actual yield of the weapon. Fallout from these weapon detonations may lead to an even greater number of persons with significant levels of radiation exposure, and will have an even greater impact on the delivery of medical care. Therefore, small or large populations may experience varying degrees of trauma, acute radiation injury, contamination, and psychological consequences, and these must be taken into account when planning for radiation emergencies.

In the case of nuclear weapons attack, there will be hundreds to thousands of immediate deaths, and hundreds to hundreds of thousands of victims with burns, blast injuries and trauma, radiation exposure, contamination, and flash blindness. The detrimental consequences will be compounded by a nationwide psychological trauma.

Other consequences may include disruptions in communication systems and electric distribution networks, destruction or blockage of normal transportation routes, which will slow down rescue efforts. The severe fallout and the large amount of radioactive material deposited on the ground will also have an impact on the rescue response.

Health planning considerations

It is very difficult to plan for such an event. The local and provincial health infrastructures would be quickly overwhelmed. National and international assistance would be required. Initial medical response would focus on the very large number of conventional trauma. Follow-up response would have to focus on the rapid mobilization of provincial, national and international resources. It would call upon all the resources required for all of the other scenarios discussed before. Therefore, planning for health response for this scenario should focus on the organizational and logistics integration of all medical and public health resources available, and more specifically on:

- a. Alerting and mobilization of resources on a national level
- b. Establishment of an effective medical command and control structure
- c. Establishment of emergency health care facilities and coordination with existing health care facilities
- d. Mass casualty triage and dispatch
- e. Provision of international assistance

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Accident-site contaminated and overexposed people	Mass casualties response with possible contamination. Screening and decontamination of responders and members of the public (thousands). Counselling.	All types of conventional and radiological injuries are possible. There will also be a large number of fatalities.
Acute exposure of members of the public outside the scene	Screening, treatment and counselling. Set up MDUs to handle the large number of potential victims outside health care facilities. Coordinate with other jurisdictions. Mobilize the national system to get additional medical and radiological resources. Notify international organizations.	Plan for screening of a very large population across several jurisdictions. It is important to relieve the health care facilities from the burden of dealing with the large number of potential victims so that they can continue to perform their normal functions; alternate facilities may be required.
External contamination of public outside the scene	Screening and decontamination. Counselling.	Plan for screening of a very large population.
Internal contamination of public outside the scene	Screening and decontamination. Counselling.	Plan for screening of a very large population.
Psychosocial effects	Health information program for the public in the affected area and beyond.	Public reassurance is crucial to regain a sense of security.

Imminent terrorist threat (scenario 17)

Description

In some cases, terrorists may announce their intent to commit a malevolent act. The information provided to the authorities may or may not include the nature of the act. Should this be considered credible, provincial and national authorities are likely to raise the threat level and prepare for the worst by performing an imminent threat assessment, identifying immediate vulnerabilities, and taking measure to prevent the act or mitigate its possible impacts (e.g., access control, detection networks, preventive evacuations, etc.).

Consequences and health care planning considerations

Since there would be no impact until the act is committed, there is little that the health system can do to respond. However, in some cases, alerting and mobilizing the medical community may be part of the detection and mitigation measures.

In the case of an imminent threat to irradiate persons (scenario 12), the health system should be alerted to recognize the signs of possible radiation exposure. Reports of apparently disconnected events involving people who may have been exposed should be centralized, collated and assessed. This can serve as an early warning system of concealed illicit sources.

In all other cases, the broader health system should be prepared to mobilize its resources and stand by for an eventual attack.

Poisoning of a person by contamination of food (scenario 18)

Description

The best example of this scenario is the case of Litvinenko, who in 2006, was poisoned by food contaminated with radioactive polonium. Not only did Litvinenko become seriously ill, but the contamination spread through handling of the source by the culprit, and handling of the food by restaurant workers and members of the public. Very low levels of contamination were in many locations, including on passenger aircrafts. The fact that the radioactive substance used is an alpha emitter complicated the search for contamination; alpha detection requires special instruments and sampling.

Consequences

The consequences for the poisoned person(s) are severe and can lead to death. The health consequences for the rest of the public would be benign, but the fear of contamination could impose a significant burden on the health care community.

Health planning considerations

The type of response required to manage this type of event is described below.

Health System Priority:	Required response	Remarks
Acute exposure of the victim(s)	Screening and treatment.	
External contamination of public outside the scene	Set up screening units.	This will mainly be for reassurance.
Internal contamination of public outside the scene	No planning required.	
Psychosocial effects	Offer the public the possibility to be screened. Public information campaign will need to be implemented.	This will mainly be for reassurance.

Annex 1: Potassium Iodide (KI) Guidelines

See attached.

