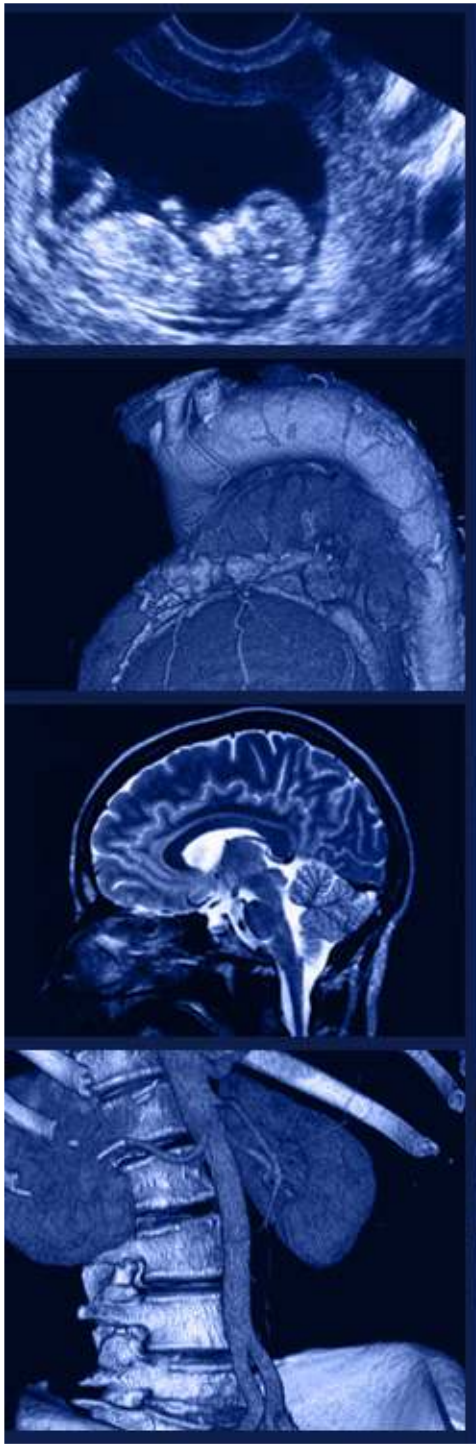

Canadian Nuclear Disaster Preparedness: Medical Perspective

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Causes of nuclear and radiation emergencies in Canada

- Accident at a nuclear power plant
  - The highest probability in Canada
- Detonation of a nuclear weapon or improvised nuclear device
- Placement of a hidden radiological exposure device
- Accident to a nuclear vessel in a Canadian port or re-entry of a satellite
- Radiation emergency in a medical facility
  - Radiation oncology (large activity sealed sources)
  - Nuclear medicine (diagnostic or therapeutic quantities)
  - Research (biomarkers),

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Power generating nuclear reactors in Canada

- More than 15% of Canadian electricity is generated by nuclear plants:
  - 18 active power reactors in Canada
  - 16 in Ontario on 3 sites
    - Bruce Power: 8 CANDU units, one of the largest facility in the world with a capacity of 6,268 MW
    - Darlington: 4 CANDU units
    - Pickering: 4 CANDU units 1 site in Quebec
  - 1 site in New Brunswick: 1 CANDU unit
  - 1 site in Quebec: Gentilly 2, shut down in 2012

Power generating nuclear reactors in Canada

- All Canadian nuclear plants use CANada Deuterium Uranium (CANDU) reactors built in Canada.
- CANDU is a pressurized heavy water reactor burning uranium fuel.

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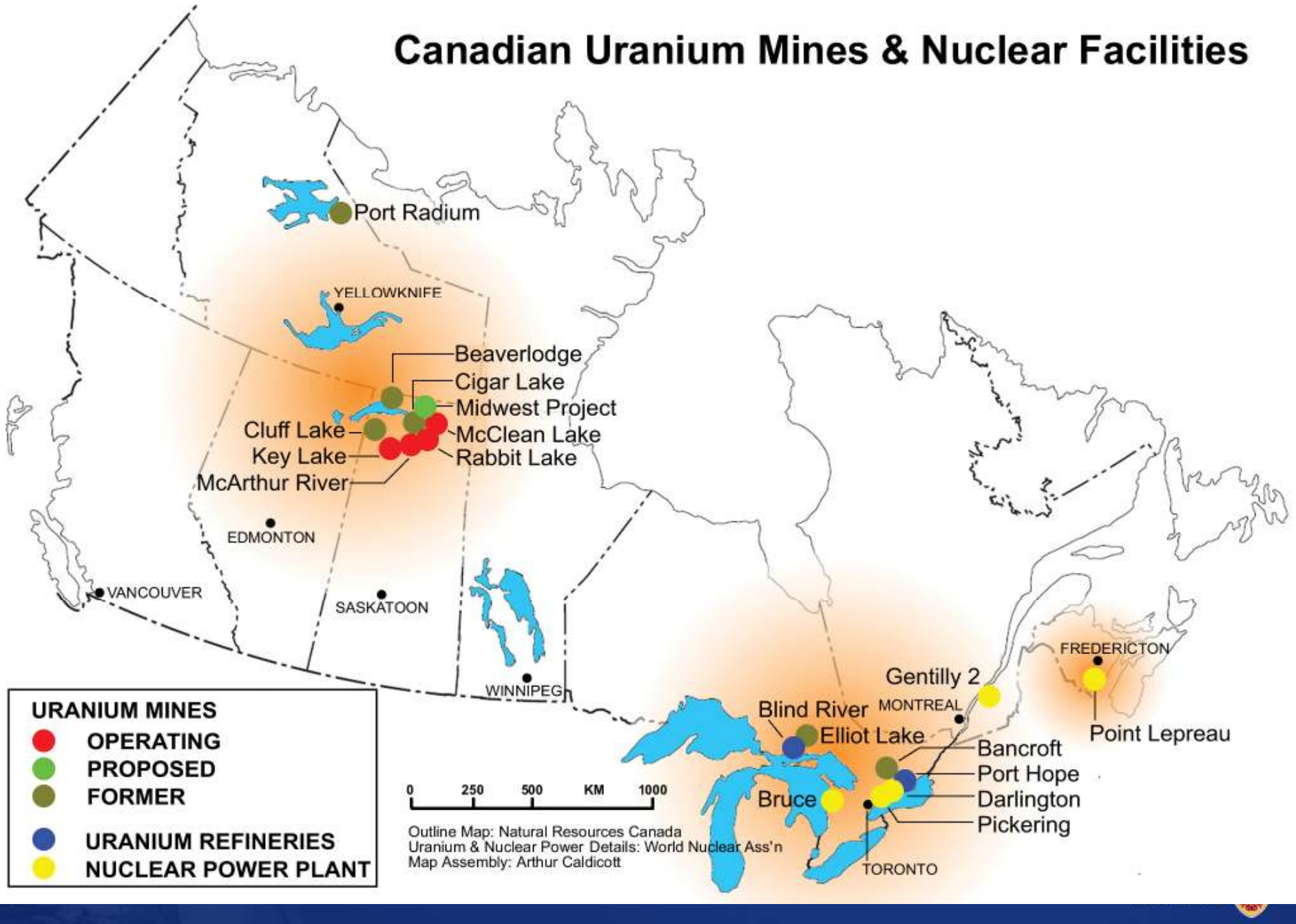
Canadian Uranium Mines & Nuclear Facilities



Research and medical nuclear reactors in Canada

- 3 major research reactors:
  - 2 at Chalk River
  - 1at McMaster University (McMaster Nuclear Reactor, 1959) functions at 3 MW
- Smaller 20 kW SLOWPOKE-2 reactors in other universities (Edmonton, Saskatoon, Kingston, Montreal)

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Research and medical nuclear reactors in Canada

- Medium flux MTR reactor, the most powerful research reactor at a Canadian University with a maximal power of 5 MW
- Fuel: uranium
- Light water de-ionized
- One of the largest supplier of Iodine-125
- Research and industrial applications

Research and medical nuclear reactors in Canada: Chalk River

- Atomic Energy of Canada Limited (AECL)'s **Chalk River** Laboratories represent the largest single complex within Canada's science and technology infrastructure and contains several nuclear facilities, including the National Research Universal (NRU) reactor and many other unique facilities and laboratories: innovation for industry, safety, security, health, environmental and clean energy technologies.

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Research and medical nuclear reactors in Canada: Chalk River

- **Molybdenum-99:** Used for medical diagnosis (imaging) of the brain, thyroid, parathyroid, heart, lungs, liver, kidney, spleen and bone marrow.
- **Iodine-131:** An isotope used mainly in therapy, imaging and diagnosis.
- **Iodine-125:** Used in prostate cancer treatment (brachytherapy), in-vitro diagnostic kits (radio immunoassays), bone densitometry devices, protein iodination.
- **Xenon-133:** A medical diagnosis tool, especially for scanning lungs.
- **High Specific Activity (SA) Cobalt-60:** Nickel-plated cobalt-59 pellets are irradiated in NRU for two to four years, becoming High SA Co-60. The High SA Co-60 produced in NRU is primarily used in cancer treatment applications.
- **Iridium-192:** Used as intense source of radiation for industrial imaging, including radiography and weld-inspection

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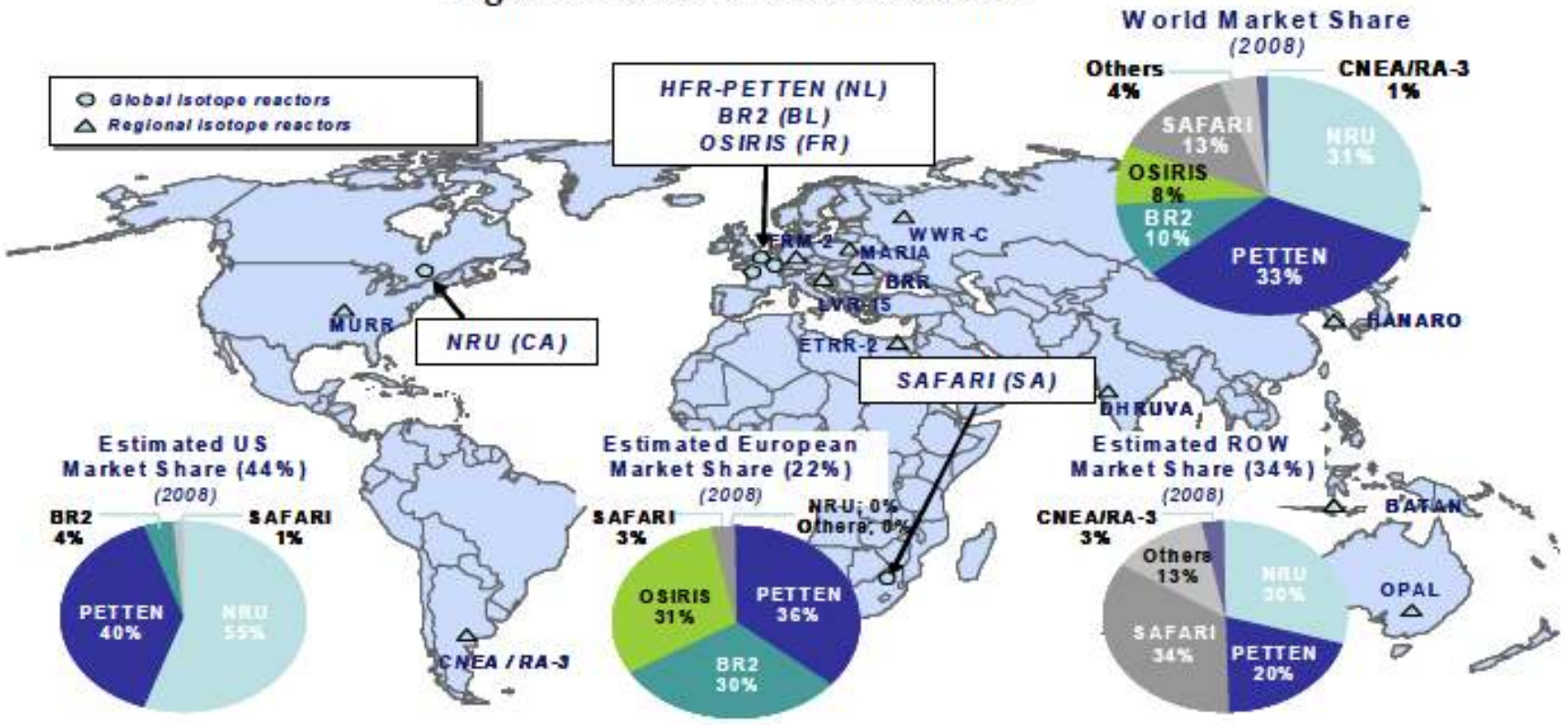
Production of Medical Isotopes in the World

Figure 1: 2008 Global Market Shares



Note: Market shares do not include the impact of the 2008 HFR-Petten shutdown

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Laws and Regulatory Agencies

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Canadian Nuclear Safety Commission

- Established in 2000 by the Nuclear Safety and Control Act (NSCA), the CNSC regulates the use of nuclear energy and materials to protect health, safety, security and the environment, to implement Canada's international commitments on the peaceful use of nuclear energy, and to disseminate objective scientific, technical and regulatory information to the public.
- The CNSC's regulatory framework consists of laws passed by Parliament that govern the regulation of Canada’s nuclear industry.
- The CNSC issues regulations, licenses and documents.

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Canadian Nuclear Safety Commission

- The CNSC has been responsible for implementing a number of improvements to the Canadian nuclear industry after the Fukushima accident.

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Lesson learned: post Fukushima improvements

What improvements did we make?

- The CNSC has assembled a 4-year action plan to ensure that Canada is prepared for the most extreme events.
- Operators had to review the Severe Accident Management Guidelines (SAMGs) in order to take into account multi-unit events like in Fukushima.
- Operators must ensure that emergency response facilities are equipped with additional portable backup power and telecommunication equipment.
- Operators must acquire portable equipment stored onsite and offsite to ensure reactors can be cooled and fuel pools replenished.
- Ontario in building a regional emergency management centre.

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Lesson learned: post Fukushima improvements

Can we monitor radiation levels?

- The CNSC has requested nuclear power plant operators to add additional radiation monitoring stations around their facilities to provide real-time data on radiation levels.
- In case of nuclear emergency, the federal government will deploy additional radiation monitoring equipment.
- Plant operators must enhance their existing modeling capabilities to predict the dispersion of radioactive releases.

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Lesson learned: post Fukushima improvements

Do we know if these improvements will help in case of emergency?

- Plant operators have conducted several emergency exercises involving severe accident scenarios previously considered unlikely.
- The exercises have allowed operators to validate their revised SAMGs and test newly acquired equipment.
- Large exercises have been conducted in Ontario and New Brunswick to test different levels of government response.
- Crisis website ready to be launched in case of major radiological accident.

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Lesson learned: post Fukushima improvements

Have regulations and standards changed?

- Nuclear power plant operators must submit to the CNSC offsite emergency plans.
- The CNSC is establishing standards for onsite and offsite nuclear emergency management and preparedness.

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Emergency Management Act (Federal)

- The Emergency Management Act (2007) recognizes the roles that all stakeholders must play in Canada's emergency management system. It sets out the leadership role and responsibilities of the Minister of Public Safety and Emergency Preparedness, including coordinating emergency management activities among government institutions and in cooperation with the provinces and other entities. Responsibilities of other federal ministers are also set out in the *Act*.

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Emergency Management and Civil Protection Act (EMCPA)

- The legal basis for emergency management in Ontario is the Emergency Management and Civil Protection Act (2009).
- Section 8 of the EMCPA stipulates that the Province shall formulate an emergency plan for nuclear facility emergencies.
- The aim of the plan is to protect the health, safety and welfare of the citizens of the region where the nuclear generating station is located, by establishing an effective system of emergency management to prepare for, respond to and recover from a nuclear emergency.
- Ontario has a Provincial Nuclear Emergency Response Plan (PNERP).

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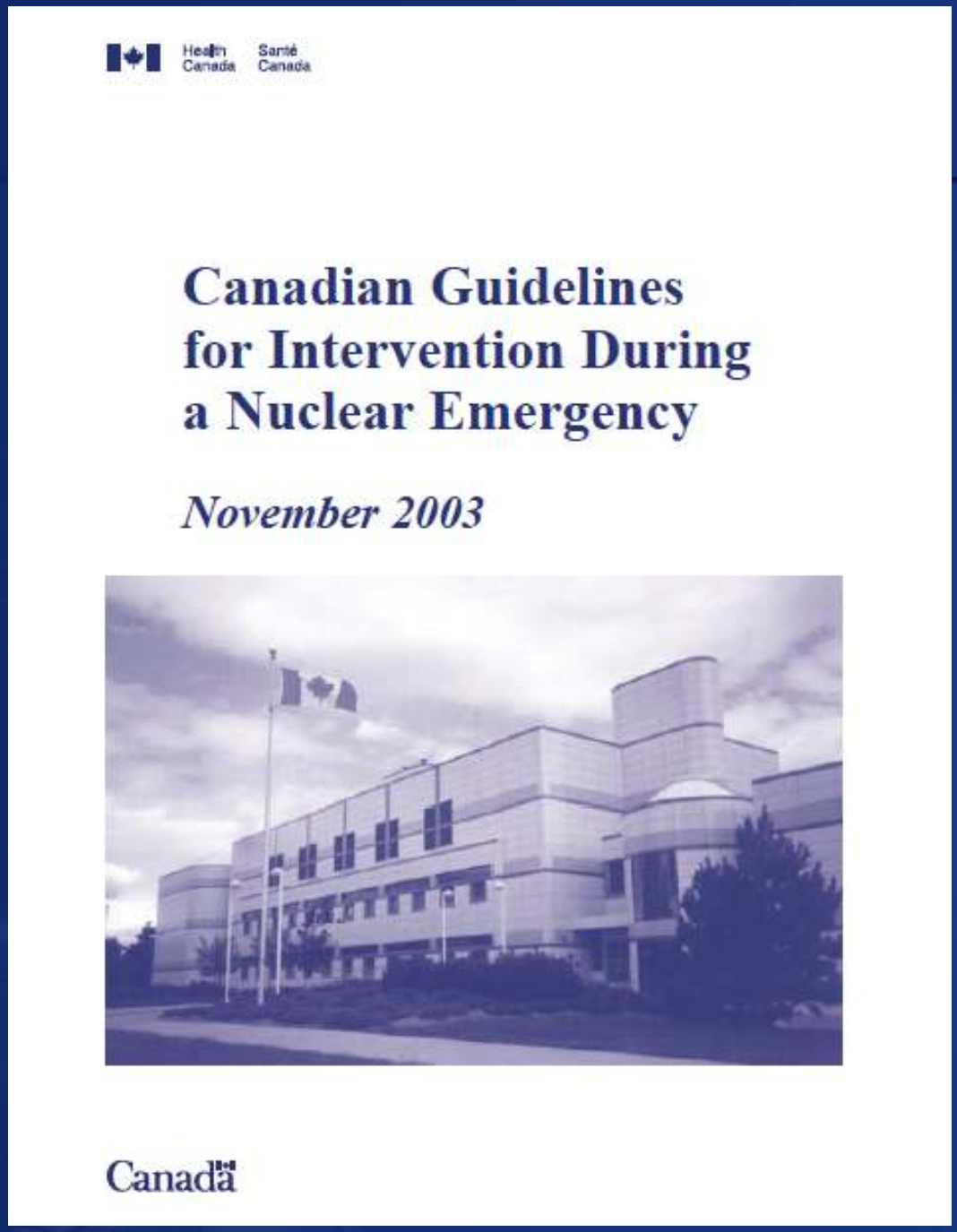
Health Canada



- This document sets out Health Canada's guidelines for intervention following a nuclear emergency in Canada or affecting Canadians.

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Health Canada

- The introduction of countermeasures to protect the public in an event of an emergency is based on a set of quantitative criteria known as Intervention Levels (ILs).

Health Canada Recommended Intervention Levels	
Countermeasure	Intervention Level (averted dose)
Sheltering	5 mSv in 1 day
Evacuation	50 mSv in 7 days
Relocation	50 mSv in 1 year (return when <50 mSv in a year and < 10 mSv in 1 month)
Stable Iodine Prophylaxis	100 mSv to thyroid
Food Controls[1]	1 mSv from each of 3 food groups

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Consumer and Clinical Radiation Protection Bureau

- The Consumer and Clinical Radiation Protection Bureau, a division of Health Canada, is responsible for the administration of the *Radiation Emitting Devices Act* which addresses radiation safety issues for ionizing and non-ionizing radiation emitting devices.
- The Consumer and Clinical Radiation Protection Bureau assesses, monitors and manages health and safety risks associated with ionizing and non-ionizing radiation.
- It administers and delivers METER, a training package to help hospitals and the medical community to prepare for radiation emergencies.

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Potassium Iodine (KI) Guidelines

- Intended only for communities within the Primary Zone of the major nuclear installations.
- Not intended for non-facility radiological incidents.
- KI only be used to protect against internal exposure to radioiodine through inhalation not ingestion.
- Ministry of Health (MOH) decides when to administer KI, in collaboration with the local Medical Officer of Health.
- No preventive distribution in Ontario.
- Nuclear facilities are responsible for providing KI
- Designated municipalities are responsible for facilitating the availability of KI.

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And what about medical preparedness in Canada ?

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Medical Preparedness in Canada

- All Canadian hospitals must have a preparedness plan in case of radiation emergency.
- Responsibilities must be assigned:
  - RSO (Radiation safety Officer)
  - Senior management
  - Support services
- Develop procedures
- Incident Management System in place
- Education and training
- Drills and exercises must be performed regularly.

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Incident Management System

- All Ontario hospitals are expected to adopt IMS
- Organizational structure to manage emergencies
- Command Centre: single focal point for
  - Information collection
  - Decision making
  - Direction of internal activities
  - Coordination with outside organizations
- Improves communication
- Defines roles
- Flexible and responsive

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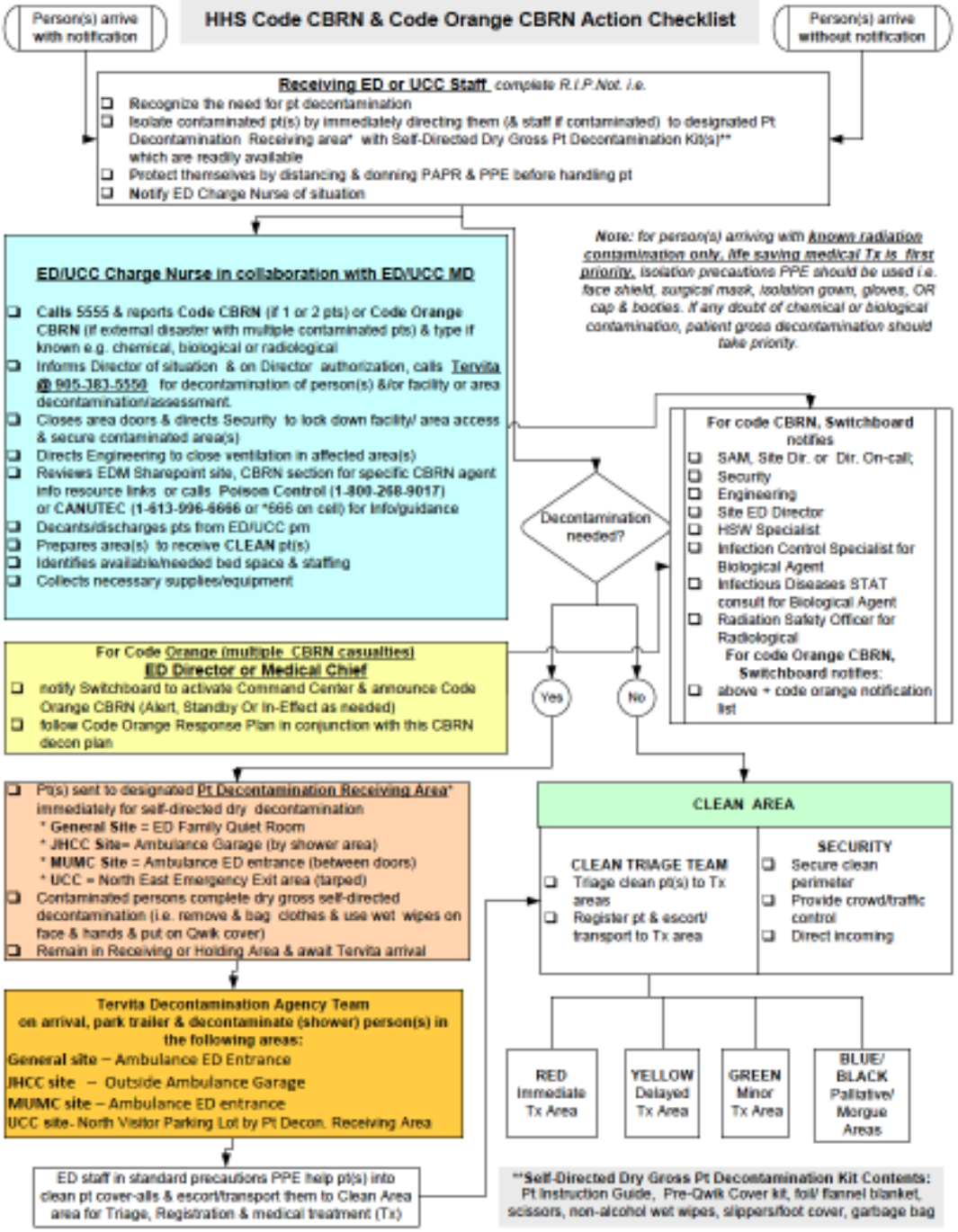

Code Orange CBRN Algorithm at Hamilton Health Sciences

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Hospital Treatment Algorithm

Medical Stability	Step 1	Stabilize life threatening injuries and ensure appropriate PPE and contamination control procedures	
Contamination	Step 2	Determine if externally contaminated	
		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 MOHLTC for contact information of appropriate health care facilities).	

PPE = Protective Personal Equipment

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CBRN Event Response Plan

- Follow 4 principles of ALARA to reduce the potential danger of radiation to personnel:
  - Time: minimize the amount of time anyone is exposed to a source
  - Distance: maximize the distance from the source
  - Shielding: establish adequate shielding and barriers, whenever possible
  - Removal: remove or contain the source of contamination.

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CBRN Event Response Plan

- Differentiate exposure from contamination:
  - Direct exposure does not render the body radioactive and an individual who has been exposed to ionizing radiation does not present a risk to others.
  - Contamination with radioactive materials remains in place until it is properly removed, but health care providers who practice the principle of ALARA and wear appropriate personal protective equipment can minimize the potential of exposure and contamination.

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Acute Radiation Syndrome (ARS)

Syndrome	Dose (Sv)	Symptoms
Hematopoietic	1 to 10	- Anorexia, fever, malaise - Blood cell count decrease - Infection and hemorrhage = primary cause of death
Gastrointestinal	10 to 20	- Severe diarrhea, fever, dehydration - Imbalance in electrolytes - Infection, dehydration = primary causes of death
Cardiovascular/CNS	> 20	- Extreme nervousness, confusion - Severe nausea, vomiting, watery diarrhea - Convulsions, coma

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Acute Radiation Syndrome (ARS)

Onset of vomiting post irradiation	Dose (Gy)
No vomiting	<1
2-3 (hours)	1-2
1-2 (hours)	2-4
<1 (hours)	4-6
10-30 (min)	6-8
<10 (min)	>8

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Teaching and training in CBRN

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Medical Emergency Treatment for Exposures to Radiation (METER)

Medical
Emergency
Treatment for
Exposures to
Radiation

- Health Canada has developed with partner organizations a training package to help hospitals and the medical community to prepare for radiation emergencies.
- This package is provided free of charge to medical communities interested in hosting a training session.

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Medical Emergency Treatment for Exposures to Radiation (METER)

- The METER course has been developed to train members of the medical community to be able to respond, work safely and manage casualties resulting from radiological events. The course material incorporates the best practices applied nationally and internationally.

- The course focuses on two key areas:
  - Essential knowledge about radiation and contamination, along with practical methods that can be implemented to ensure health and safety in the presence of radiation; and
  - Knowledge of the biological effects, signs, symptoms and treatment regimes that can be applied by members of the medical community to effectively manage casualties who have been exposed to radiation.

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Medical Emergency Treatment for Exposures to Radiation (METER)

The course demonstrates:

- How to screen for contaminated casualties using contamination meters
- The knowledge required to keep the team safe during treatment
- Simple and effective decontamination techniques, ranging from removing clothing to specific wound decontamination
- Practical ways to set up an emergency department that minimizes the spread of contamination, while remaining functional to treat casualties
- The signs and symptoms of casualties who were exposed to radiation requiring medical treatment, and how to quickly assess and prioritize these casualties through the application of tools like the Radiation Casualty Assessment Tool

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Medical Emergency Treatment for Exposures to Radiation (METER)

The course is intended to:

- First Receivers:
  - Emergency room physicians
  - Triage nurses
  - Emergency room nurses
  - Radiation safety officers
  - Nuclear medicine personnel
- Emergency management coordinators, planners and trainers
- First Responders:
  - Paramedics (Ambulance)
  - Fire (HAZMAT)
  - Police

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Medical Emergency Treatment for Exposures to Radiation (METER)

- Course topics include:
  - Ionizing radiation basic theory;
  - Radiation biology and potential health effects of exposure to radiation;
  - Types of radiological or nuclear events that may require a medical response;
  - Managing internal contamination and acute radiation syndrome;
  - Use of the Radiation Casualty Assessment Tool (RCAT);
  - Radiation protection instrumentation basics.

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But does it work in practice?

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CBRN preparedness training for emergency medical services providers

Researchers at McMaster University have assessed the CBRN preparedness training for hospitals and emergency medical services providers in Ontario and BC (Kollek, Welsford and Wanger).

- Though many Canadian emergency departments have disaster plans, those plans are often out of date, are infrequently reviewed and are rarely tested using live exercises (less than 7%).
- Only 30% of emergency departments have decontamination areas.
- 30% of emergency medical service providers have received no training, theoretical or practical, on how to work in a contaminated area;
- Less than 30% have been trained to provide medical care while wearing a personal protective equipment;
- 31% have received training on how to detect radiation.

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CBRN preparedness training for emergency medical services providers

- At the federal level, the Canadian Emergency Management College provided training on CBRN preparedness since 1954. The government shut it down in 2012.
- Canada also lacks formal guidelines and national standards in preparedness for radiation emergencies.
- METER is still offered by Health Canada on-demand.
- Many misconceptions about radiation and the health risks it poses.
- When untrained providers are called to respond to a contaminated scene, their lack of knowledge, training and practice threatens the safety of patients, EMS and hospital staff, and the health care system.

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Conclusion

- Preparedness, education and training are key to a successful response to a nuclear or radiological disaster.
- Many healthcare professionals and EMS providers have not been trained to identify and work in contaminated environments.
- Lack of knowledge, training and practice threatens the safety of patients and healthcare workers.
- **Education and training must be made mandatory by authorities and not left to random local initiatives.**

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