

Guidance Document

Title: NORM Waste Management

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SUBJECT

The management of Natural Occurring Radioactive Material (NORM).

OBJECTIVE

To explain measures implemented to provide adequate protection to human health and the environment during handling and temporary storage of NORM waste and of equipment that requires NORM decontamination.

BACKGROUND

NORM is material found where radioactive elements occur in the environment. NORM primarily consists of uranium and thorium as well as other elements that also release radium and radon gas once they begin to decay when exposed to the surface as a result of human activity. NORM may be referred to as Technically Enhanced Naturally Occurring Radioactive Materials (TENORM). The NORM radionuclides of usual concern associated with the petroleum industry include: Radium 226 and 228, and Lead 210. Examples of NORM waste associated with petroleum production are produced sands, wastewater and contaminated equipment.

The processing of raw materials by many resource-based industries may increase the concentration of radioactive substances in and around infrastructure, pipes (scale), drilling equipment and storage tanks. Special precautions are required during the handling, storage, transportation, decontamination and disposal. Improper controls of NORM can lead to the spread of NORM contamination, and result in contamination of land and groundwater, resulting in potential exposure to workers, the public and the environment.

DEFINITIONS

Activity: (becquerel or Bq) solely indicates the number of nuclear disintegrations per second but is also encountered as derived units such as activity per mass or volume (Bq/g[solid], Bq/L[liquid] and Bq/Nm³ [gas]).

Alpha (α): Positively charged particles consisting of two protons and two neutrons that are emitted by the nuclei of radioactive (unstable) elements as they decay. Alpha particles are relatively large and can be stopped by skin or a sheet of paper. An alpha particle is a helium nucleus. (*particules alpha*).

Beta (β): High-energy negatively charged electrons or positively charged positrons that are ejected by radioactive (unstable) elements as they decay. A beta particle is identical in mass and charge to an electron. Beta particles are relatively small and can be stopped by a sheet of aluminum or plastic a few millimetres thick. (*particules bêta*).

Effective dose: A measure of dose designed to reflect the amount of radiation detriment. The effective dose is obtained by multiplying the equivalent dose of each tissue or organ by an appropriate tissue weighting factor and summing the products. The unit of measurement is the sievert (Sv). (*dose efficace*).

Gamma (γ): Penetrating electromagnetic radiation emitted by an atomic nucleus during radioactive decay; a wave form of ionizing radiation. Also called gamma radiation. (*rayonnement gamma, rayons gamma*).

NORM Contaminated: means waste that exceeds the public exposure levels but do not exceed the levels at which they are classified as radioactive.

Radiation: Energy travelling through space in the form of waves or particles. Ionizing radiation (e.g. alpha particles, beta particles, gamma rays, X-rays and neutrons) has the ability to remove electrons from the matter it encounters.

Radioactive: Exhibiting radioactivity; emitting or relating to the emission of ionizing radiation or particles such as alpha and beta particles, neutrons or gamma rays. (*radioactif, radioactive*)

Radiation dose: A quantity of radiation that one is exposed to and a measure of the amount of energy absorbed by the body and is measured in units called the Sievert (Sv). Higher number of Sv equals higher dose equals higher risk of energy.

LEGISLATION

The legislative authority for the management of Waste Dangerous Goods/Hazardous Waste including NORM Waste is provided through the *Environmental Protection Act*, Parts VIII and XI (specifically sections 30, 31, 78 and 83). The following non-exhaustive list of legislation also applies to waste management facilities/ systems and sites:

Provincial Legislation

- *Environmental Protection Act* and Regulations
- *Occupational Health and Safety Act* and Regulations
- *Environmental Control Water and Sewage Regulations under the Water Resources Act*

- *Accredited Policy (PD;PP2001-01.2)*

Federal Legislation and Guidelines

- Health Canada – Canadian Guidelines for the Management of Naturally Occurring Radioactive Material (NORM)
- *Transportation and Works Act* and Regulations
- Canadian Nuclear Safety Commission

ENVIRONMENTAL ASSESSMENT AND APPROVAL PROCESS

Storage and decontamination facilities for NORM waste may require registration under the *Environment Assessment Regulations*. Industries planning to handle or store NORM waste shall contact the Environmental Assessment Division of Environment and Climate Change. Once released from the Environmental Assessment process, a request for a Certificate of Approval to construct and operate a NORM waste management facility is required pursuant to the *Environmental Protection Act*, Part XI. Prior to issuing an approval prerequisite information shall be submitted for review (refer to **Appendix A**).

DETECTION

Radioactive materials are unstable atoms that release radiation (in the form of alpha, beta and gamma) during decay process over time. The activity of NORM is measured by concentration (Becquerel - Bq/g or Bq/l). The larger the activity the more radiation produced by the source.

Radioactive contamination involves both internal and external exposures from contact with a radioactive material that may be encountered on surface or equipment. Prior to conducting any activity related to NORM, consultation with the Department of Service NL (Occupational Health and Safety) is required. **APPENDIX B** provides an overview on worker safety practices.

Generators/facility operators are responsible for conducting initial reviews of all NORM-contaminated sources prior to material arriving at approved Waste Dangerous Goods /Hazardous Waste storage facilities. NORM screening surveys are necessary to identify the potential exposure of workers to NORM; and for detecting radiation on equipment and surrounding environment. Surveys shall be conducted by personnel trained in radiation safety to determine if the suspect material is NORM. Radiation readings above typical background radiation levels may indicate the presence of NORM. The first step involved in the survey is to start with natural background reading at the worksite which is taken away from the source of radiation. This number should be subtracted from actual reading at NORM source to determine true value. (*Table 1, provides a summary of information to be included in a survey form*).

Table 1: Items to be included in NORM Survey Form

- Name of generator/client
- Date of survey completed
- Staff completing survey
- Type of equipment (location) being surveyed
- Type of instruments being used
- Natural background reading in $\mu\text{Sv/hr}$ & Counts Per Minute (CPM)
- Dose reading at source and 0.5 meters from source in (both in $\mu\text{Sv/hr}$)
- Surface contamination reading at source and 0.5 meters from source in (CPM)

NORM surveys are conducted with specialized instruments for: the detection of immediate dose (dose rate); and total/accumulated dose; and to measure contamination/presence of surface radioactivity (*Table 2 summarizes surveys, instruments and use*).

Table 2: Types of Surveys and Instruments

<i>Type of Survey</i>	<i>Use</i>	<i>Instrument</i>
Screening	Used to identify NORM exposures during initial screening and is used as a survey meter and for dose rates.	Geiger Counter (Operates in a variety of environments and is inexpensive Scintillation (more efficient for gamma radiation and detects low radiation)
Radiation	Used for worker assessment protection for dose rates based upon results from screening survey.	Geiger Counter (Operates variety of environments and is inexpensive Scintillation (more efficient for gamma radiation and detects low radiation)
Contamination	Used to check surface contamination of workers in air , and equipment and tools (interior and exterior)	Pancake Monitor to detect radioactivity measure alpha and beta surface contamination measured in counts per minute (CPM) activity over an area

Note: All equipment shall be calibrated in accordance with manufacturer's specifications and batteries shall also be checked regularly

NORM STORAGE

Below are storage requirements for the temporary storage of NORM contaminated waste at approved storage facilities.

- The storage of NORM waste shall be in a separate designated area with access limited to authorized personnel.
- All containers and equipment shall be labeled and sealed.
- NORM waste shall be stored in CSA approved containers.
- The NORM storage area shall be in a trailer and/or a designated area within a building segregated from non-contaminated items and any other types of WDG/HW.

- The storage area shall be contained within a secured fenced area and properly identified with the wording as shown below:

CAUTION Naturally Occurring Radioactive Material - Authorized Personnel Only

- A liner shall be required beneath the storage area where liquid NORM wastes are being stored.
- Materials with higher radioactivity should be placed near the centre of the storage area.
- Large equipment shall be protected from exposure to the elements.
- Larger NORM contaminated equipment that cannot be stored within the trailer/building shall be sealed in 6ml plastic or equivalent above ground on designated racks and/or pallets.
- For equipment with contamination limited to interior surfaces, open ends shall be capped or sealed.
- Reasonable measures shall be taken to prevent radioactive material from becoming airborne.
- Minimizing operations that may generate dust containing NORM (e.g., cutting, grinding or polishing). Keep material wet and undisturbed.
- NORM waste is permitted for storage for up to 6 months (for NORM waste < 70 BQ/g); 90 days for radioactive waste > 70 Bq/g) from receipt, at which time all materials must be shipped off site to an authorized facility for treatment/disposal.

DECONTAMINATION

Fixed NORM contamination on equipment poses only an external NORM hazard and if the dose is low enough it is usually shielded by the type of containment and may be transported by a licensed transporter to an authorized facility for NORM decontamination. Removal of NORM contamination however, poses both external & internal risks as the material can become airborne very readily. Decontamination controls are required. The removal of scale during decontamination requires radiochemical analysis. The results shall meet Health Canada's, UDRL'S (Unconditional Derived Released Limits (UDRL's)) as set out in **Appendix C – Table 5.1, Diffuse NORM** prior to disposal in a non-hazardous waste stream. NORM sources with surface contamination (internal/external) less than the limits in **Appendix C – Table 5.3, Discrete NORM** can be released without further investigation to service companies (equipment to be refurbished) and/or scrap recyclers.

Decontamination of NORM equipment using mechanical/abrasive methods need to be conducted in a controlled manner to prevent spread of NORM contamination. Considerations to be followed include:

- If a hazard has been identified atmospheric monitoring may be required to meet (**Appendix C Table 5.1 – Diffuse NORM limits for air**).
- Where possible, decontamination systems should be automated, as it is significantly safer than decontamination associated with hand-jetting activities.

- A designated area for decontamination shall be totally enclosed within a concrete room/self-contained unit –automated (or equivalent) and include a segregated area for decontaminated equipment and containers for contaminated material.
- All filters shall be considered NORM contaminated waste at completion of work.
- Wetting down of tools/equipment to minimize the release of airborne particles is an OHS requirement.
- Process water used in this operation shall be collected in a separate closed unit and filtered and reused. Waste liquid collected shall not be connected to any external drainage.
- Scale material shall be collected in containers and samples collected and analyzed to determine radioactivity and determination of correct disposal method.
- All equipment and surfaces shall be inspected and monitored before and after decontamination and information documented. All equipment must be free of detectable radioactive contamination.
- Once the work area has been verified free of loose NORM contamination regular activities can be resumed.

TRANSPORTATION AND DISPOSAL

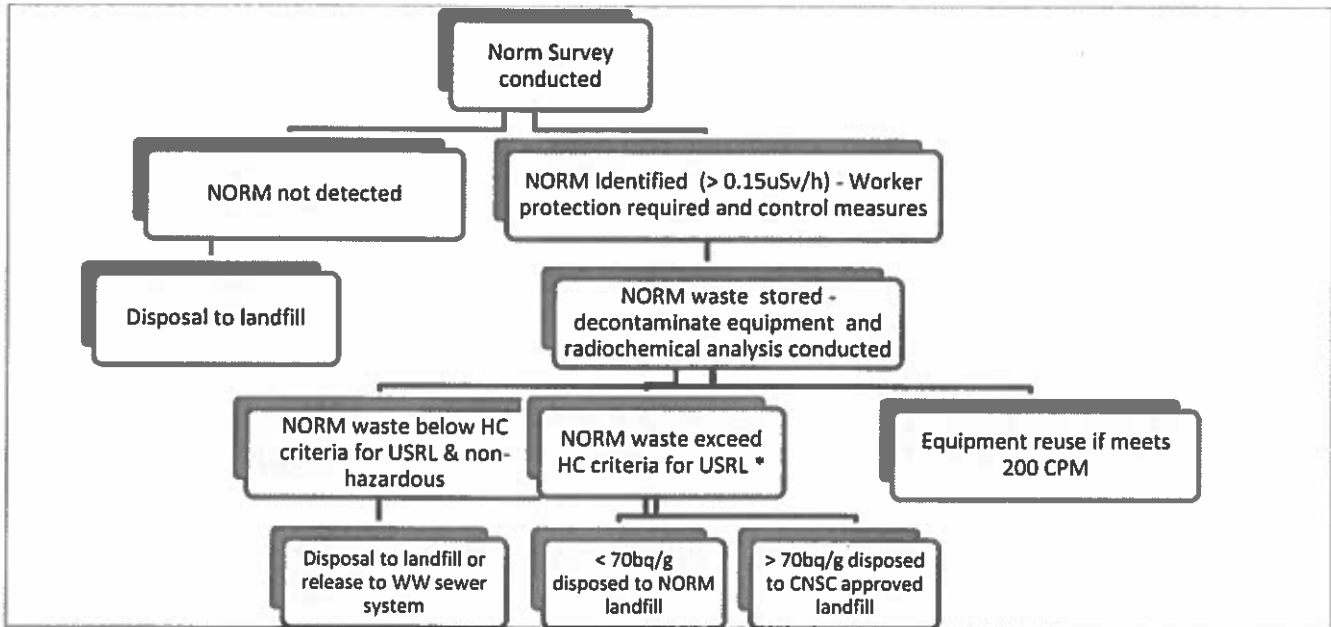
Facility operators shall ensure representative sampling and approved analytical methods are used for radiochemical analysis of NORM waste (wastewater, sludge and scale) prior to disposal. Confirmatory compliance sampling must be conducted on wastewater and or scale process prior to transport to an authorized facility for treatment/disposal. Representative samples shall be collected in approved containers and sent to an accredited lab for radiochemical analysis. Accurate quantification of NORM radionuclides requires specialized analytical techniques. Release limits published in Health Canada's, *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (Refer to Appendix C – Table 5.1)* provide recommendations based on the radiological properties of NORM. **Liquid waste will have to meet the limits set out in the *Environmental Control Water and Sewage Regulations, for Radium 226 and all other relevant parameters*.** In determining an acceptable material management option, other hazardous properties such as chemical toxicity shall also be considered.

Surface contaminated (internal and external) equipment intended for release to third parties not licensed to accept NORM contaminated materials must meet the unrestricted release criteria of 1.0 Bq/cm² averaged over 100 cm² (200 CPM) and be decontaminated prior to release.

All shipments with an activity less than 70 Bq/g are required to have a manifest shipped with the NORM contaminated items. The manifest must contain the descriptor “**Naturally Occurring Radioactive Material**” and are subject to *Federal Transportation Regulations*. Shipments with activity above 70

Bq/g are considered radioactive and fall under the federal jurisdiction of Canadian Nuclear Safety Commission (CNSC) packaging. **Figure 1 provides a summary of disposal methods.**

Figure 1: Flow chart related to NORM disposal



*Liquid waste will have to meet the limits set out in the *Environmental Control Water and Sewage Regulations*.

In Canada, there are three provincially licensed facilities available specifically for NORM disposal:

Unity salt cavern, Saskatchewan

Melville salt cavern, Saskatchewan

Silverberry Landfill, British Columbia

RECORD KEEPING

An annual report shall be submitted to the Department that summarizes assessments and analysis of scale and wastewater generated during processing. Where NORM waste is disposed of, records shall be maintained of the disposal activities.

An accurate inventory of materials must be maintained including originating location, date, activity or radiation dose levels and package contents including other hazardous properties to the materials being stored. Monthly inspections shall be performed to identify leaking or corroded containers, which must be immediately repacked or sealed

Table 3: NORM storage facility documents

- Container identification /pipe (ID # and type of container)
- Source of waste (originally generator and location)
- Surface rate of container equipment
- Type of waste (scale, sludge and / soil)
- Final destination and disposal site
- Date stored and date removed (to final disposal)
- Radionuclide present- radionuclide analysis (Ra228, Ra226. Pb210 etc)
- Details on maintenance and inspection of containers documented.
- Surface contamination level (Bq/cm²) if applicable

Additional Information can be obtained at:

1. Provincial Occupation Health and Safety: Nancy Hounsell (729-4450)
2. Radiological Characteristics Guidelines for Canadian Drinking water- Anar Baweha, Health Canada- 613-941-2355
3. *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Radiological Parameters* at www.healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-radiological-radiologique-eau/index-eng.php; Anar Baweha, Health Canada -613-941-2355
4. Provincial Government-Water Related, Water Resources Haseen Khan 729-2535.

REFERENCES

International Association of Oil & Gas Producers, *Managing Naturally Occurring Radioactive Material NORM in the oil and gas industry*, Report 412, March 2016: Available online at , <http://www.ogp.org.uk/pubs/412.pdf>

Canadian Nuclear Safety Commission, *Naturally Occurring Radioactive Material Factsheet*, November 2014. Available online: <http://www.nuclearsafety.gc.ca/eng/resources/fact-sheets/naturally-occurring-radioactive-material.cfm>

Health Canada, *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)*, 2013. Available online: <http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/norm-mrn/index-eng.php>

Stuart Hunt and Associates Ltd., *The Origin, Detection and Management of Naturally Occurring Radioactive Materials: A training course for workers encountering NORM in the workplace.* (For reference purposes contact company).

Stewart Hunt, *A brief discussion about NORM*: Available online: http://www.ipnas.ulg.ac.be/garnir/pdf/SECURITE_SOURCES/NormNuclear.pdf

Australian Government, August 2008 Australian Radiation Protection and Nuclear Safety Agency Safety Guide: *Management of Naturally Occurring Radioactive Material (NORM)*, Available online: <http://www.arpansa.gov.au/pubs/rps/rps15.pdf>



Government of Newfoundland and Labrador
Department of Environment & Climate Change

Pollution Prevention Division
(Waste Management Section)

Re: Information required prior to issuing a Certificate of Approval for the handling and Storage of NORM waste.

An official copy the Environmental Protection Act, SNL 2002 may be obtained from the Queen=s Printer. An unofficial version of this Act is available through the Government of Newfoundland and Labrador website (www.gov.nf.ca). Approval under the EPA does not release the proponent from any other permitting or regulatory requirements under other legislation.

The following information shall be submitted to this Department prior to the issuance of a Certificate of Approval;

General Information

- The application shall request a Certificate of Approval to operate a NORM Waste Management System (WMS) which may include: storage and or processing/decontamination.
- Legal name of the proponent(s), mailing address, civic address/site location and primary contact person for the purpose of the application shall be outlined.
- A notice of the proposed waste management system shall be posted in a local newspaper once per week for three consecutive weeks or notice shall be served by registered mail on the occupiers of property situated within one mile of the proposed site. Persons with objections to the proposed site may address their concerns in writing to the Deputy Minister, Department of Environment & Climate Change
- Documentation to verify property ownership or lease of the property shall be provided.
- A copy of approval from the local municipal authority to operate a WNS

Site Location/Description

- Description of the geographic area to be served by the proposed operation
- A location map and a site plan survey (legal) drawing (including description and distance to adjacent Building. Plans shall show all property boundaries, buildings, roads, utility corridors, contours, drainage channels, water bodies (include private/public water supplies) rights of way, easements, forested areas and adjacent land uses and separation distances. Plans shall be certified by a **Professional Engineer**.
- Provide an accurate description of the proposed site, access road, facilities and equipment, including GPS location coordinates. Attach an original base map (1:25,000 scale) and/or recent air photos
- Site compatibility with other land uses, and any environmental sensitivity of the area must be commented and addressed.
An environmental baseline study of the proposed site may be required prior to construction to establish initial hydro-geological/geological and drainage conditions. Upon review of your application, the Department will determine as to whether a baseline study will be required.
- The location of any proposed gas/oil storage tank system(s), hazardous material storage shall be outlined. Tanks will have to be approved and /or registered.

Operational Information

- Please provide details of a NORM waste management plan, Items to be included:
 - Identification of radiation and types of NORM contamination

- EHS requirements, worker training – **consult with OHS**
 - NORM legislation (Radiation dose (limits); Investigation thresholds radiation surveys, dose assessments – **consult with OHS**
 - Worker protection (external and internal exposure) – **consult with OHS**
 - NORM radiochemical analysis
 - NORM transport and disposal requirements
 - how will equipment be decontaminated
 - how will monitoring of site be conducted
- Define the design standards that will be met by the NORM storage containers (e.g. CSA standard). Include photos and/or design drawings for storage containment vessels. Will design drawings be approved /stamped by professional engineers within province?

Insurance/Assurance Related

- A surety bond, a deposit of money, or irrevocable letter of credit shall be provided in the amount \$20,000 (original signed – format available).
- In the policy directive PPD2000-03 (December 21, 2000), the Minister established fees for the processing of applications and preparation of approvals. To be determined
- Proof of Environmental Liability Impairment Insurance and Auto Insurance (coverage against liability arising from third party bodily injury or property) shall be filed with the department.

Contingency/Emergency Plan

- A Contingency/health safety plan which is specific to the proposed operation and to the location of operation (i.e. Newfoundland and Labrador) must be submitted to the Department. Company personnel shall be briefed on the contents of this plan and any associated emergency response procedures and equipment.
- A contingency plan is a set of predetermined procedures for the reporting, containment, removal and cleanup of a contaminant(s). The plan should reduce potential health hazards, damage to property and the environment and the cost of cleanup. The plan should include such items as:
- the role of the driver in response to an incident
 - notification and alerting procedures (internal and external procedures) including provincial contacts (telephone numbers)
 - responsibilities of the on site commander
 - spill control and clean up procedures
 - restoration of the spill site
 - information on the disposal of contaminants
 - resource inventory: equipment, manpower, consultants, treating agents, expertise, contacts, emergency information systems.
 - Information on staff training (health, safety and environmental response)
 - personal protective equipment for response personnel
 - prevention of explosion fire explosion and accidental releases be dealt with?

Decommissioning plan: A plan is to be submitted which has been developed in accordance with the CCME National Guidelines for Decommissioning of Industrial Sites

In addition to the preceding requests, a site inspection of the proposed location is to be conducted by the SNL. Upon confirmed site suitability and receipt of the completed application, the information will be reviewed by the Department of Environment and Climate Change and Service NL.

Preparation of an approval is contingent upon submission of requested information and documentation. Please note that additional information may be required throughout the approval process. Approval must be issued before construction work may commence.

Should you require clarification on comments and conditions contained in this correspondence or with any other questions which may arise, please contact me @ 709-729-1771 or joangann@gov.nl.ca

APPENDIX B: WORKER SAFETY PRACTICES

The practices below deal with **worker safety** and are not the mandate of Waste Management. **Consultation with the Department of Service NL - Occupational Health and Safety** is required for all workers involved with activities dealing with NORM storage and processing/decontamination.

Measures to be considered for the reduction of internal and external exposures:

- **Internal radiation exposure (absorption, ingestion and inhalation)**
 - personal protective equipment (PPE)- disposable or nonporous clothing and footwear.
 - use of respirators.
 - no eating/drinking/smoking.
 - segregating NORM contaminated waste from non-contaminated waste, proper storage and sealing of equipment.
- **External radiation exposure**
 - minimizing time around restricted areas where NORM waste is stored.
 - increasing the distance from the source you will decrease dose.
 - using shielding with layers of lead or brick will block the radiation. *Caution shall be taken when conducting readings of tubular because the walls act as shielding.*

Dose Assessment

Readings during radiation surveys of all equipment, valves and other waste containing NORM, shall be used to determine the potential exposure workers may receive during work activities. Health Canada, NORM guidelines have adopted an investigation threshold level of 0.3 mSv/per year (0.15uSv/hour). Any measurement above this level will result in project/job dose assessment. If this level is exceeded (above natural background) operators should ensure workers shall not exceed doses greater than 1 uSv/a (0.5 uSv/Hr).

Annual cumulative dose for workers shall be considered when determining the number of hours allowed at source. Results will determine the number of hours a worker can work at source and one meter from source. Employers are responsible for completing worker dose assessments (**Table C1 shows items to be included in a dose assessment**). Workers who have the potential to be exposed to NORM may be required to wear personal monitoring badges until monitoring demonstrates that NORM is consistently in the unrestricted classification under Health Canada.

Table C1: Dose Assessment Requirements

<ul style="list-style-type: none">➤ Employee and company name➤ Year To Date received dose uSv/per year➤ Expected to exceed investigated limit (0.3 uSv/hr)➤ Expected to exceed limit 1.0 uSv/per year	<ul style="list-style-type: none">➤ Dose Background reading - uSv/hr➤ Highest dose reading at source uSv/hr"➤ Number of hours to work at source➤ Cumulative dose for year/project
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NORM Storage

The principle of ALARA (As Low As Reasonably Achievable) applies to all occupational radiation exposure situations. The implementation of various safety measures/controls relating to distance, shielding and exposure time reduces your radiation exposure.

- NORM storage area must be managed and work practices established to ensure that annual exposure to incidentally exposed workers does not exceed 1.0 mSv/yr.
- Workers should receive appropriate training in the correct use of PPE (personal protective equipment) such as: wearing appropriate protective clothing, including gloves and coveralls.
- Proper hygiene shall be implemented in the NORM storage area: no eating, drinking or smoking.
- Workers are to ensure that any cuts or abrasions are thoroughly cleaned and covered and

should Workers working in dusty conditions shall be trained and wear approved and properly fitted respirators and report such items to their supervisor prior to start of work.

- There shall be a program in place to monitor hands, feet and clothing for contamination before leaving a designated NORM control area, to ensure that all workers are checked for any contamination with NORM before leaving the work area.
- Dose levels within the storage area must be recorded.
- All workers shall wear personal protective disposable coveralls (either PVC rain suit or Tychem). Discard all disposable coveralls, contaminated boots or gloves as NORM waste.
- An Emergency Response Plan is required and must meet the requirements set forth in the Occupational Health and Safety Regulations, including Sections 12(1)(e), 12(j), 38, and 39.

DECONTAMINATION OF NORM

- A safety meeting shall take place for workers reviewing hazards associated with this activity, and safety measures to be taken.
- Appropriate respirators must be worn during decontamination (refer to CSA Standard CSAZ94.4 and as amended)". Workers shall be properly fit tested and the employer shall have a respiratory protection program in place which is maintained.

RECORD KEEPING

Companies/Facility Operators are required to keep a record of the name and job category of each occupationally exposed worker in accordance to *Canadian Guidelines for the Management of Naturally Occurring Radioactive Materials (NORM)*.

APPENDIX C: HEALTH CANADA'S TABLES

(Source – Tables are copied from Health Canada's NORM Guidelines)

Table 5.1 - Unconditional Derived Release Limits- Diffuse NORM Sources

	Derived Release Limits		
	Aqueous (Bq/L)	Solids Bq/g	Air Bq/m ³
Uranium-238 Series (all progeny)	1	.300	0.003
Uranium-238 (U-238, Th-234, Pa-234m, U-234)	10	10	0.05
Thorium-230	5	10	0.01
Radium-226 (in equilibrium with its progeny)	5	.300	0.05
Lead-210 (in equilibrium with bismuth-210 and polonium-210)	1	.300	0.05
Thorium-232 Series (all progeny)	1	.300	0.002
Thorium-232	1	10	0.006
Radium-228 (in equilibrium with Ac-228)	5	.300	0.005
Thorium-228 (in equilibrium with all its progeny)	1	.300	0.003
Potassium-40	n/a	17c	n/a

Notes: Table 5.1 footnote

A Pathways Considered:

- **Aquatic**
 1. Value 10x Guideline for Canadian Drinking Water Quality.
- **Terrestrial**
 1. External groundshine from soil contaminated to infinite depth.
 2. Soil-veg-ingestion/soil ingestion.
 3. Inhalation of resuspended material.
- **Air**
 1. Inhalation at concentration resulting in 0.3 mSv.
 2. Exposure factor of 25% assumed.

Assumptions:

- All radionuclides and compartments in equilibrium.
- Typical values for uptake and transfer factors.
- No allowance for hold-up time.
- 25% "occupancy" factor for solid source (groundshine, soil ingestion, resuspension), 25% 'occupancy' factor for air, and 50% of vegetable intake grown on soil.
- No correction for shielding, surface roughness.

Where more than one long-lived radionuclide is present in a sample, the appropriate sum of the ratios of the activity of each long-lived radionuclide and its corresponding Release limit, must not exceed 1, for example:

The sum of the concentration of NORM isotope A divided by the derived release limit for isotope A plus the concentration of NORM isotope B divided by the derived release limit for isotope B and so on for each of the long-lived radionuclides present in the sample until the concentration of NORM isotope N divided by the derived release limit N must be equal to or less than 1

$$\frac{\text{Concentration NORM Isotope A}}{\text{Derived Release Limit A}} + \frac{\text{Concentration NORM Isotope B}}{\text{Derived Release Limit B}} + \dots + \frac{\text{Concentration NORM Isotope N}}{\text{Derived Release Limit N}} \leq 1$$

b) Aqueous Release limits ~10x Guidelines for Canadian Drinking Water Quality. Subsequent dilution of the release is assumed. Refer to the Provincial Drinking Water Standard where planned diffuse NORM releases must meet provincial drinking water standards. (See reference)

c) Natural abundance of Potassium 40 in potassium chloride.

d) No aqueous release limit is needed as potassium content of the body is under homeostatic control, and is not influenced by environmental levels.

Table 5.3 - Surface Contamination Unconditional Derived Release Limits - Discrete NORM Sources

Property	Limit
Dose Rate	0.5 µSv/h at 50 cm.
Surface Contamination	1 Bq/cm ² averaged over a 100 cm ² area

Notes:

1. A thin window radiation detector is recommended when monitoring beta/gamma sources of surface contamination.
2. Table 5.3 release limits are only applicable to fixed surface contamination. Loose surface contamination must be completely removed or all accessible surfaces stripped to ensure complete removal.
3. In most cases, decontamination efforts which meet beta surface contamination limits will concurrently provide for the control of mixed alpha / beta / gamma sources.

