# New sustainability perspectives on pollutant releases from Canada's nuclear sector

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Environment and Climate Change Canada (ECCC)
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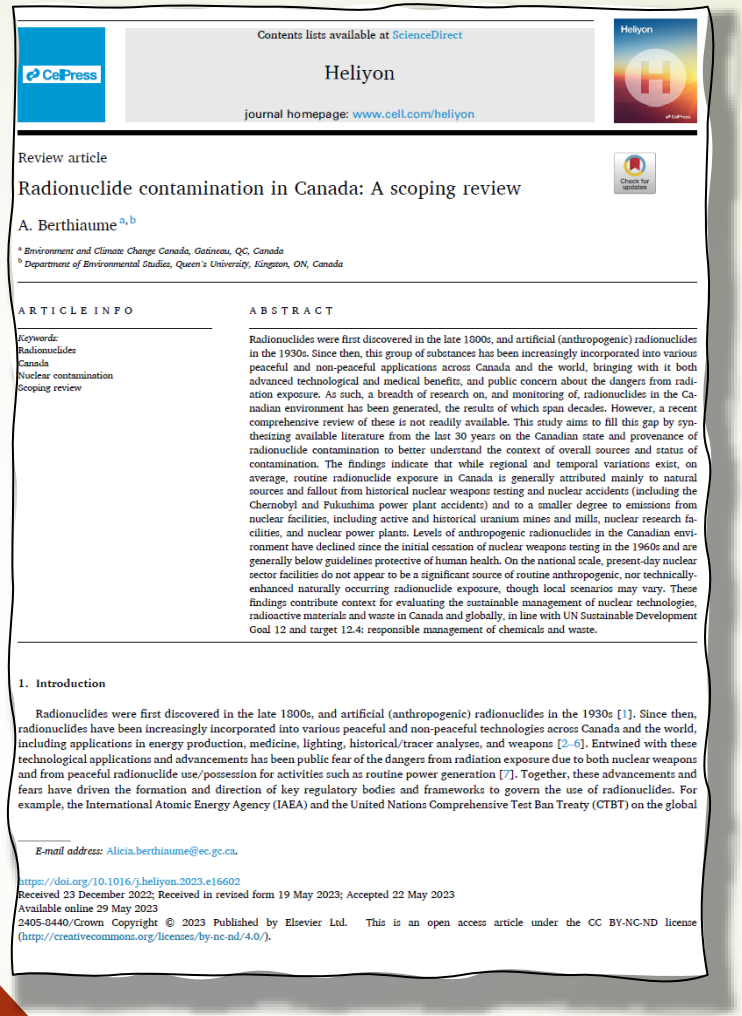

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Review article

## Radionuclide contamination in Canada: A scoping review

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ABSTRACT

Radionuclides were first discovered in the late 1800s, and artificial (anthropogenic) radionuclides in the 1930s. Since then, this group of substances has been increasingly incorporated into various peaceful and non-peaceful applications across Canada and the world, bringing with it both advanced technological and medical benefits, and public concern about the dangers from radiation exposure. As such, a breadth of research on, and monitoring of, radionuclides in the Canadian environment has been generated, the results of which span decades. However, a recent comprehensive review of these is not readily available. This study aims to fill this gap by synthesizing available literature from the last 30 years on the Canadian state and provenance of radionuclide contamination to better understand the context of overall sources and status of contamination. The findings indicate that while regional and temporal variations exist, on average, routine radionuclide exposure in Canada is generally attributed mainly to natural sources and fallout from historical nuclear weapons testing and nuclear accidents (including the Chernobyl and Fukushima power plant accidents) and to a smaller degree to emissions from nuclear facilities, including active and historical uranium mines and mills, nuclear research facilities, and nuclear power plants. Levels of anthropogenic radionuclides in the Canadian environment have declined since the initial cessation of nuclear weapons testing in the 1960s and are generally below guidelines protective of human health. On the national scale, present-day nuclear sector facilities do not appear to be a significant source of routine anthropogenic, nor technically-enhanced naturally occurring radionuclide exposure, though local scenarios may vary. These findings contribute context for evaluating the sustainable management of nuclear technologies, radioactive materials and waste in Canada and globally, in line with UN Sustainable Development Goal 12 and target 12.4: responsible management of chemicals and waste.

### 1. Introduction

Radionuclides were first discovered in the late 1800s, and artificial (anthropogenic) radionuclides in the 1930s [1]. Since then, radionuclides have been increasingly incorporated into various peaceful and non-peaceful technologies across Canada and the world, including applications in energy production, medicine, lighting, historical/tracer analyses, and weapons [2–6]. Entwined with these technological applications and advancements has been public fear of the dangers from radiation exposure due to both nuclear weapons and from peaceful radionuclide use/possession for activities such as routine power generation [7]. Together, these advancements and fears have driven the formation and direction of key regulatory bodies and frameworks to govern the use of radionuclides. For example, the International Atomic Energy Agency (IAEA) and the United Nations Comprehensive Test Ban Treaty (CTBT) on the global

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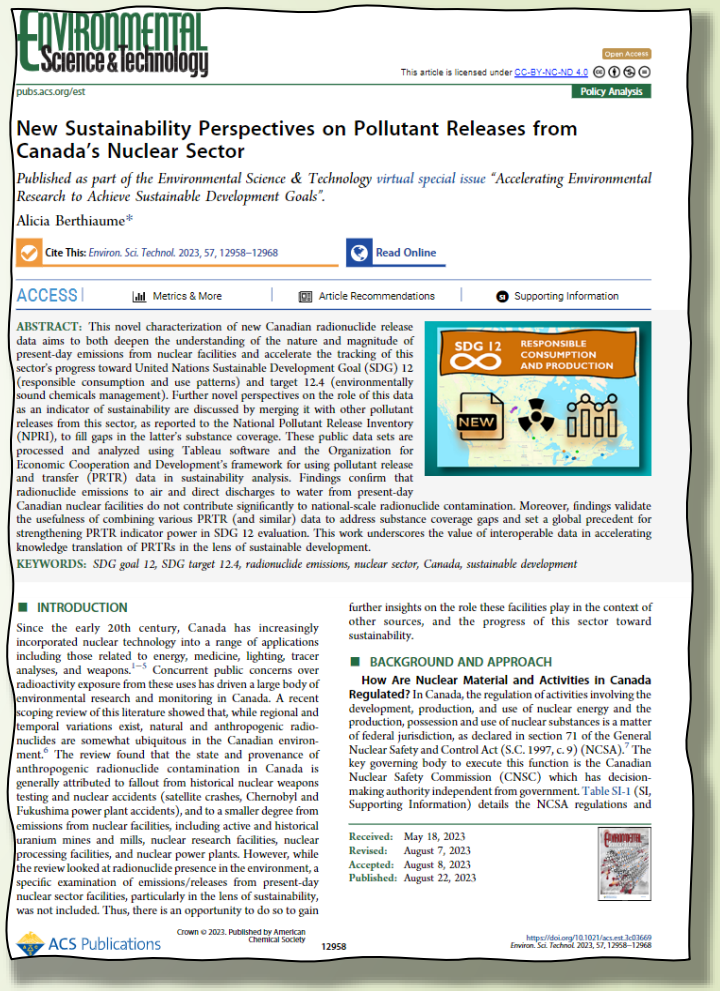

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Policy Analysis

## New Sustainability Perspectives on Pollutant Releases from Canada's Nuclear Sector

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Alicia Berthiaume*

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ABSTRACT: This novel characterization of new Canadian radionuclide release data aims to both deepen the understanding of the nature and magnitude of present-day emissions from nuclear facilities and accelerate the tracking of this sector's progress toward United Nations Sustainable Development Goal (SDG) 12 (responsible consumption and use patterns) and target 12.4 (environmentally sound chemicals management). Further novel perspectives on the role of this data as an indicator of sustainability are discussed by merging it with other pollutant releases from this sector, as reported to the National Pollutant Release Inventory (NPRI), to fill gaps in the latter's substance coverage. These public data sets are processed and analyzed using Tableau software and the Organization for Economic Cooperation and Development's framework for using pollutant release and transfer (PRTR) data in sustainability analysis. Findings confirm that radionuclide emissions to air and direct discharges to water from present-day Canadian nuclear facilities do not contribute significantly to national-scale radionuclide contamination. Moreover, findings validate the usefulness of combining various PRTR (and similar) data to address substance coverage gaps and set a global precedent for strengthening PRTR indicator power in SDG 12 evaluation. This work underscores the value of interoperable data in accelerating knowledge translation of PRTRs in the lens of sustainable development.

KEYWORDS: *SDG goal 12, SDG target 12.4, radionuclide emissions, nuclear sector, Canada, sustainable development*

### INTRODUCTION

Since the early 20th century, Canada has increasingly incorporated nuclear technology into a range of applications including those related to energy, medicine, lighting, tracer analyses, and weapons.[1−5] Concurrent public concerns over radioactivity exposure from these uses has driven a large body of environmental research and monitoring in Canada. A recent scoping review of this literature showed that, while regional and temporal variations exist, natural and anthropogenic radionuclides are somewhat ubiquitous in the Canadian environment.[6] The review found that the state and provenance of anthropogenic radionuclide contamination in Canada is generally attributed to fallout from historical nuclear weapons testing and nuclear accidents (satellite crashes, Chernobyl and Fukushima power plant accidents), and to a smaller degree from emissions from nuclear facilities, including active and historical uranium mines and mills, nuclear research facilities, nuclear processing facilities, and nuclear power plants. However, while the review looked at radionuclide presence in the environment, a specific examination of emissions/releases from present-day nuclear sector facilities, particularly in the lens of sustainability, was not included. Thus, there is an opportunity to do so to gain further insights on the role these facilities play in the context of other sources, and the progress of this sector toward sustainability.

### BACKGROUND AND APPROACH

**How Are Nuclear Material and Activities in Canada Regulated?** In Canada, the regulation of activities involving the development, production, and use of nuclear energy and the production, possession and use of nuclear substances is a matter of federal jurisdiction, as declared in section 71 of the General Nuclear Safety and Control Act (S.C. 1997, c. 9) (NCSA).[7] The key governing body to execute this function is the Canadian Nuclear Safety Commission (CNSC) which has decision-making authority independent from government. Table SI-1 (SI, Supporting Information) details the NCSA regulations and

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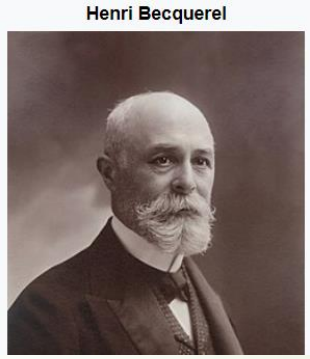
# Background

- Radionuclides (RNs) first discovered in late 1800s
- Natural sources (primordial, secondary, cosmic) (Naturally-Occurring Radioactive Material, NORMs)
- Technically-enhanced NORMs from human activities
- Anthropogenic sources
- Pro: nuclear tech advancements
- Con: Ionizing radiation is dangerous (various types and potencies)




*Source: Wikipedia*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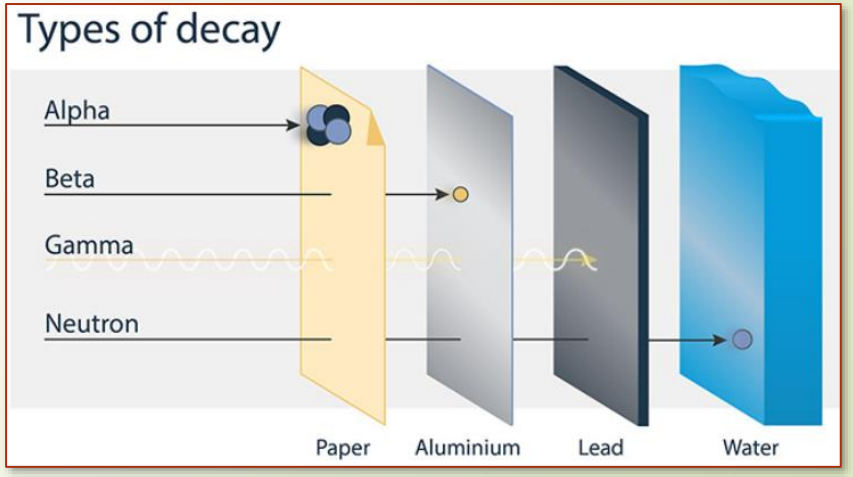
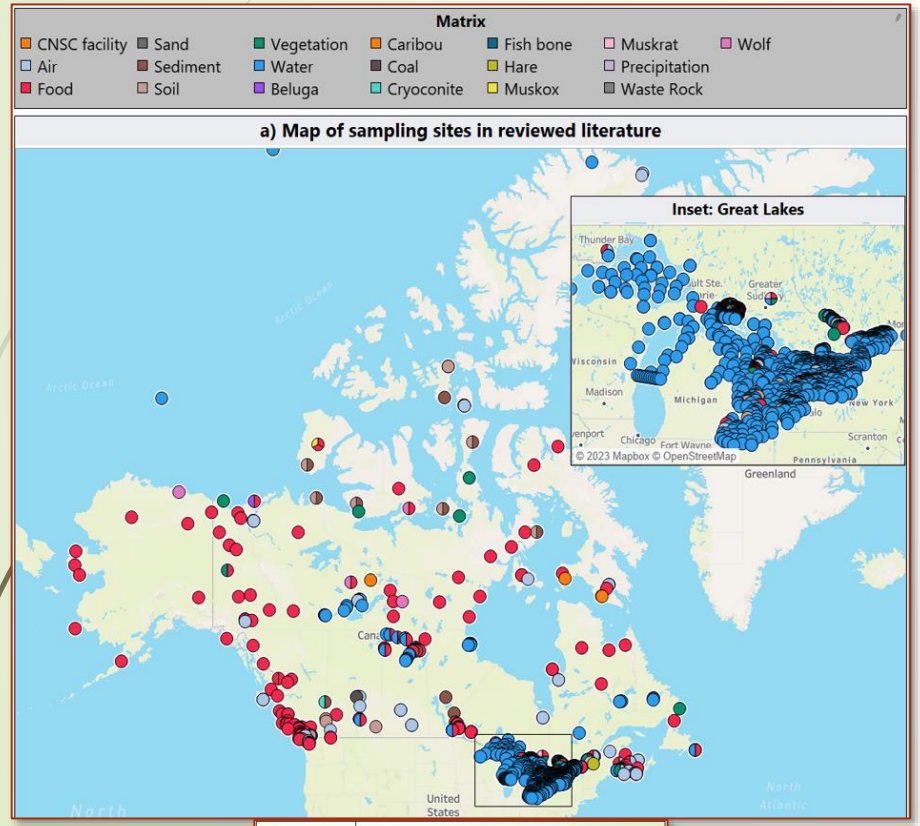
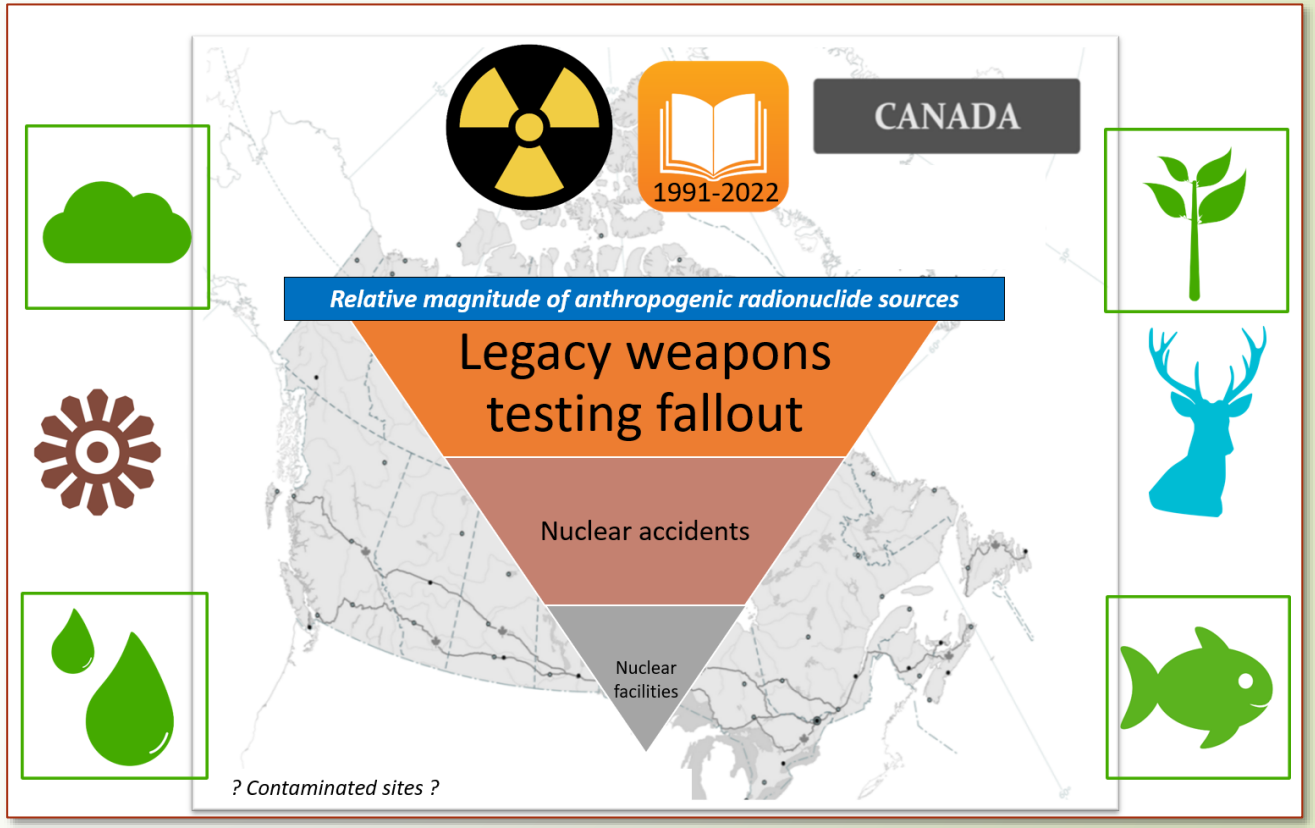



*Source: CNSC https://nuclearsafety.gc.ca/*

# State of RN contamination in Canada




| | |
|---|---|
| 80 | Years |
| 65+ | Radionuclides (RNs) |
| 1,300+ | Sampling sites |
| 75 + 16 | Research + Monitoring sources |
| 19 & 250 | Matrices & sub-matrices |
| 155,000 | Concentration measurements |
| 61 | Guidelines |



# Background (2)


CANADA

CONSOLIDATION

CODIFICATION

Nuclear Safety and Control Act

Loi sur la sûreté et la réglementation nucléaires

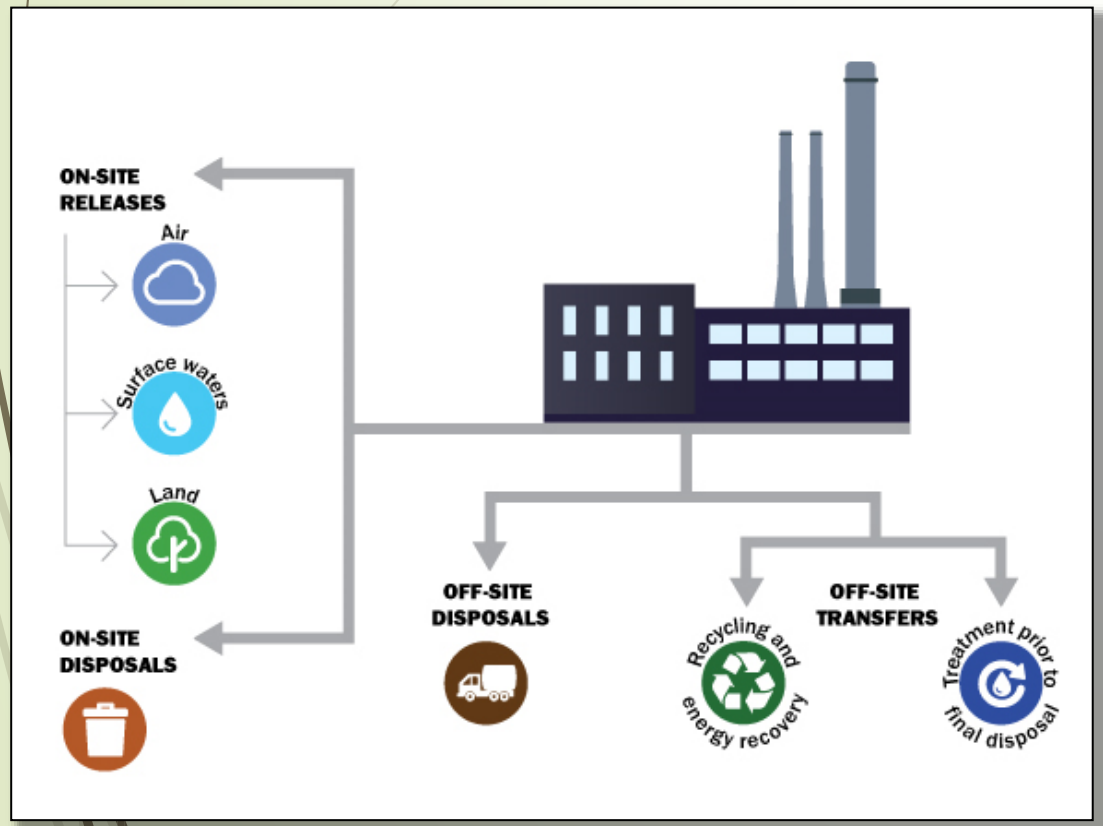
S.C. 1997, c. 9

L.C. 1997, ch. 9

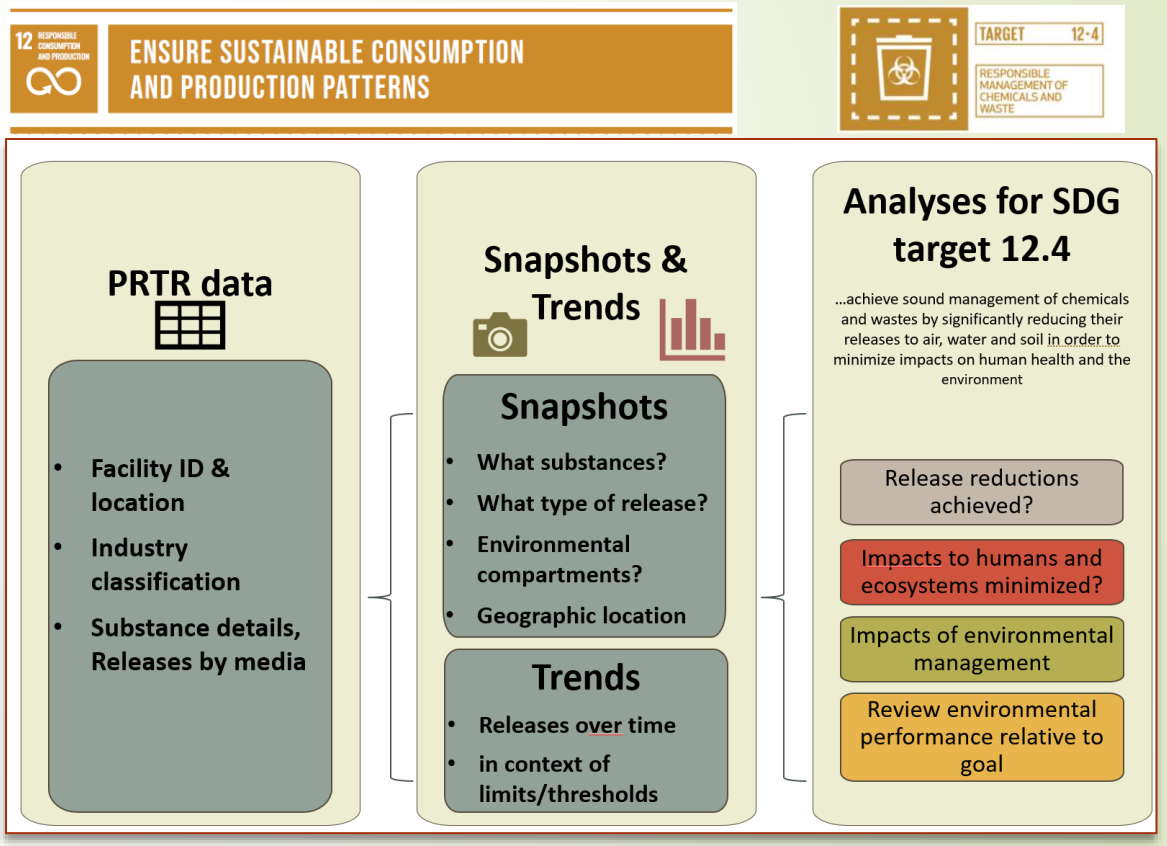
- In Canada, nuclear material is federal jurisdiction
- Canadian Nuclear Safety Commission (CNSC) is main authority
  - Collaborates with other departments, e.g., ECCC, Health Canada, Transport Canada, etc.
- Regulatory framework
  - *General Nuclear Safety and Control Act*
  - Many regulations and regulatory documents for nuclear facilities
    - Nuclear power plants, other reactors, nuclear fuel processing, medical facilities, research, uranium mines and mills, transportation, etc.
  - Environmental management includes **reporting releases**
- International regulation:
  - International Atomic Energy Association,
  - UN Comprehensive Test Ban Treaty (CTBT)

IAEA

# The Canadian National Pollutant Release Inventory (NPRI) & SDG 12



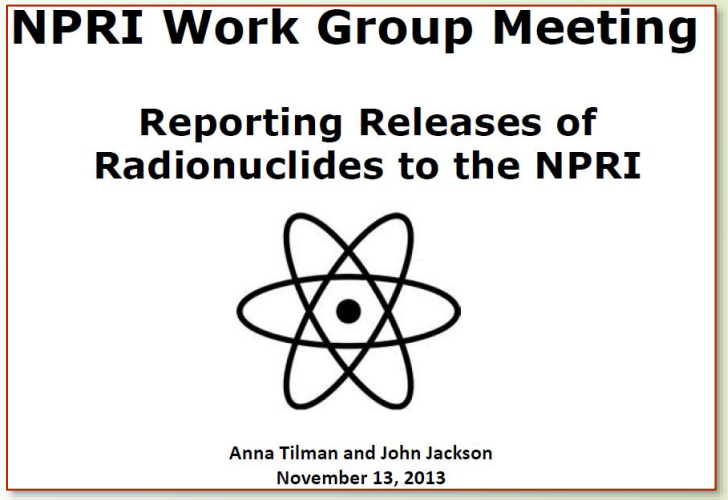

www.ec.gc.ca/inrp-npri/




Adapted from: https://one.oecd.org/document/ENV/JM/MONO%282017%297/en/pdf

# Current status of radionuclide release data

- Not currently on the NPRI
- Proposed to be, by ENGOs (2013)
- Declined, contingent on improved access to existing data
- Since 2018, CNSC has posted radionuclide data to GoC Open data, similar to NPRI
- https://open.canada.ca/data/en/dataset/6ed50cd9-0d8c-471b-a5f6-26088298870e
- ~950+ views & 500+ downloads in last 12 months
- Hyperlinks now live from NPRI to CNSC data
- This study: merged the 2 datasets

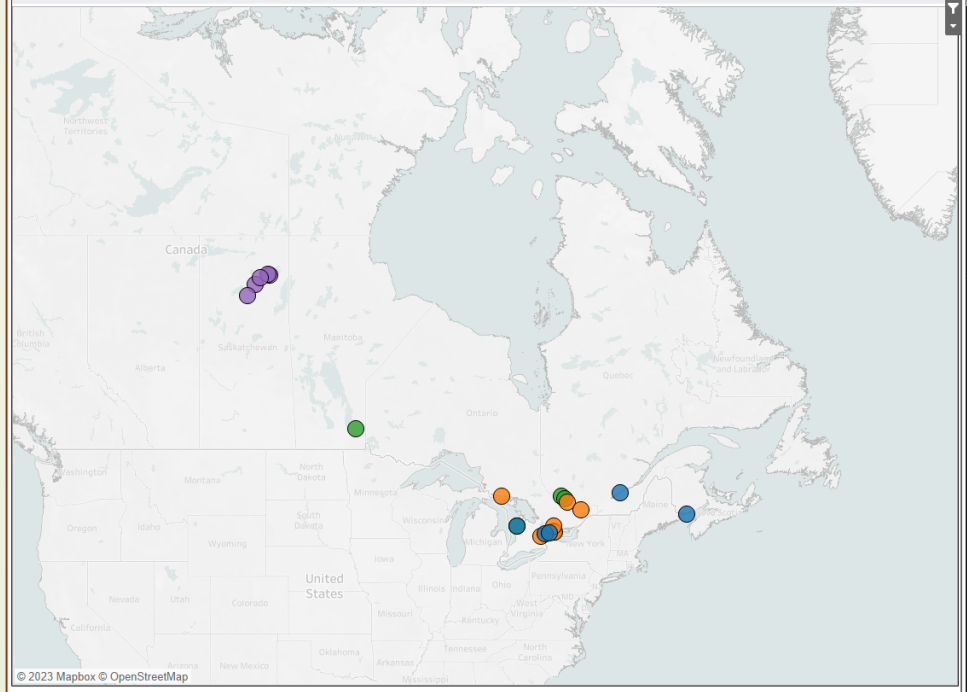



# Results

# Snapshot: Facilities, sectors, substances, env. compartments

| Reporting_Year | Facility_Name | Compartment | Substance Name | NAICS 6 code and title |
|---|---|---|---|---|
| (All) | (All) | (All) | (All) | (All) |

**a) Map of NPRI and CNSC facilities**




**Colour legend for map a) NAICS 6 code and title**

- 212291 - Uranium ore mining
- 221113 - Nuclear electric power generation
- 325189 - All other basic inorganic chemical mfg.
- 541990 - All other professional, scientific and tech'l services
- 562910 - Remediation services

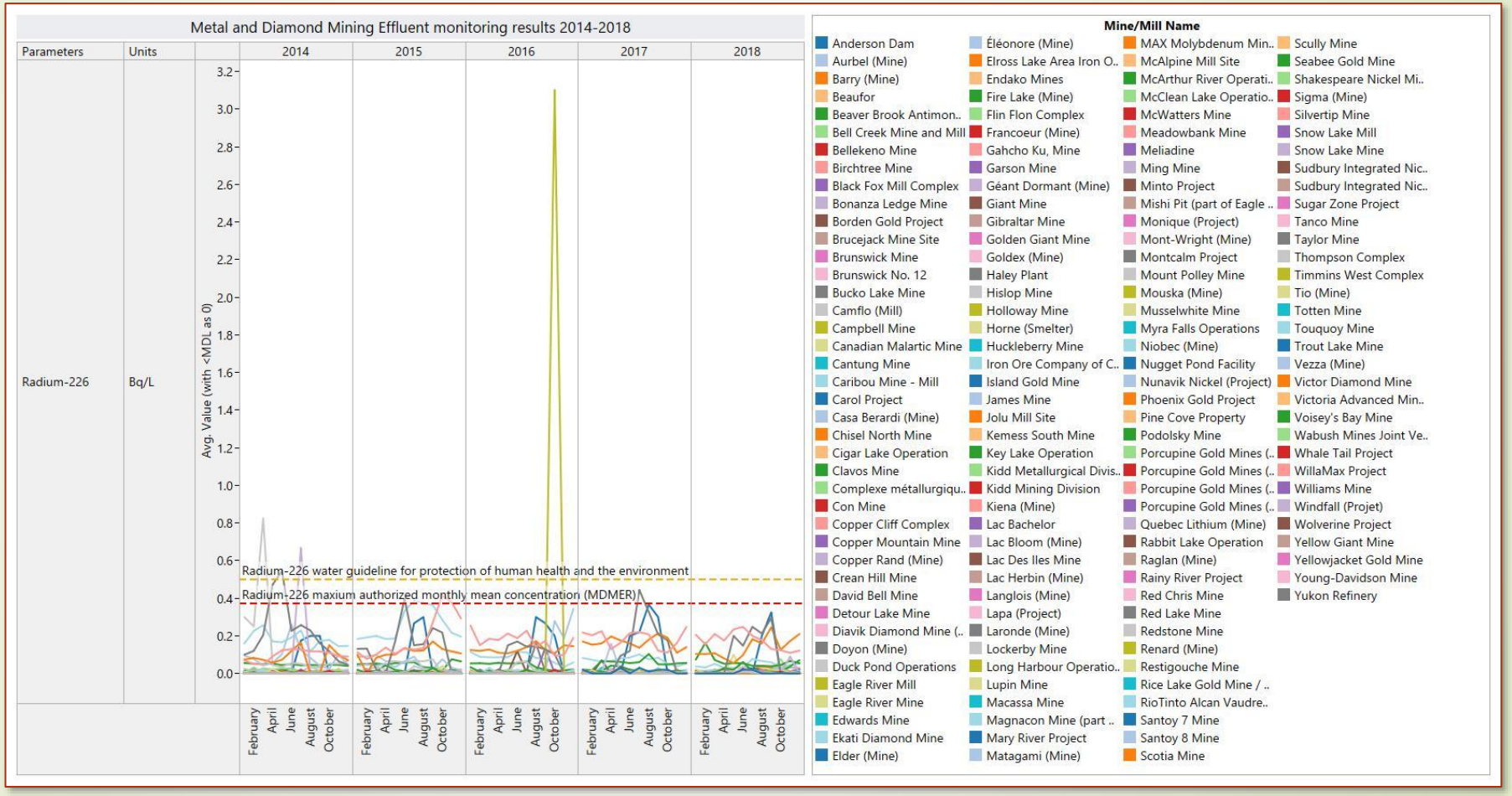
**b) Substances reported per industrial sector**

| | | CNL Nuclear Labs | | Nuclear power plants | Nuclear Processing facilities | Uranium mines and mills |
|---|---|---|---|---|---|---|
| | | 541990 - All other professional, scientific and tech'l services | 562910 - Remediation services | 221113 - Nuclear electric power generation | 325189 - All other basic inorganic chemical mfg. | 212291 - Uranium ore mining |
| Americium-241 | Bq | | | | | |
| Argon-41 | Bq | | | | | |
| Carbon-14 | Bq | | | | | |
| Cesium-137 | Bq | | | | | |
| Cobalt-60 | Bq | | | | | |
| Elemental Tritium (HT) | Bq | | | | | |
| Estimated public dose | mSv/a | | | | | |
| Iodine-125 | Bq | | | | | |
| Iodine-131 | Bq | | | | | |
| Lead-210 | Bq | | | | | |
| Particulate (gross beta/gamma) | Bq | | | | | |
| Particulate gross alpha | Bq | | | | | |
| Particulate gross beta | Bq | | | | | |
| Plutonium-238 | Bq | | | | | |
| Plutonium-239/240 | Bq | | | | | |
| Polonium-210 | Bq | | | | | |
| Radium-226 | Bq | | | | | |
| Strontium-90 | Bq | | | | | |
| Thorium-230 | Bq | | | | | |
| Total noble gases | Bq-MeV | | | | | |
| Tritium (HTO) | Bq | | | | | |
| Uranium (activity) | Bq | | | | | |
| Uranium (mass) | kg | | | | | |
| Xenon-133 | Bq | | | | | |
| Xenon-135 | Bq | | | | | |
| Xenon-135m | Bq | | | | | |

**Colour legend for table b) Compartment of release**

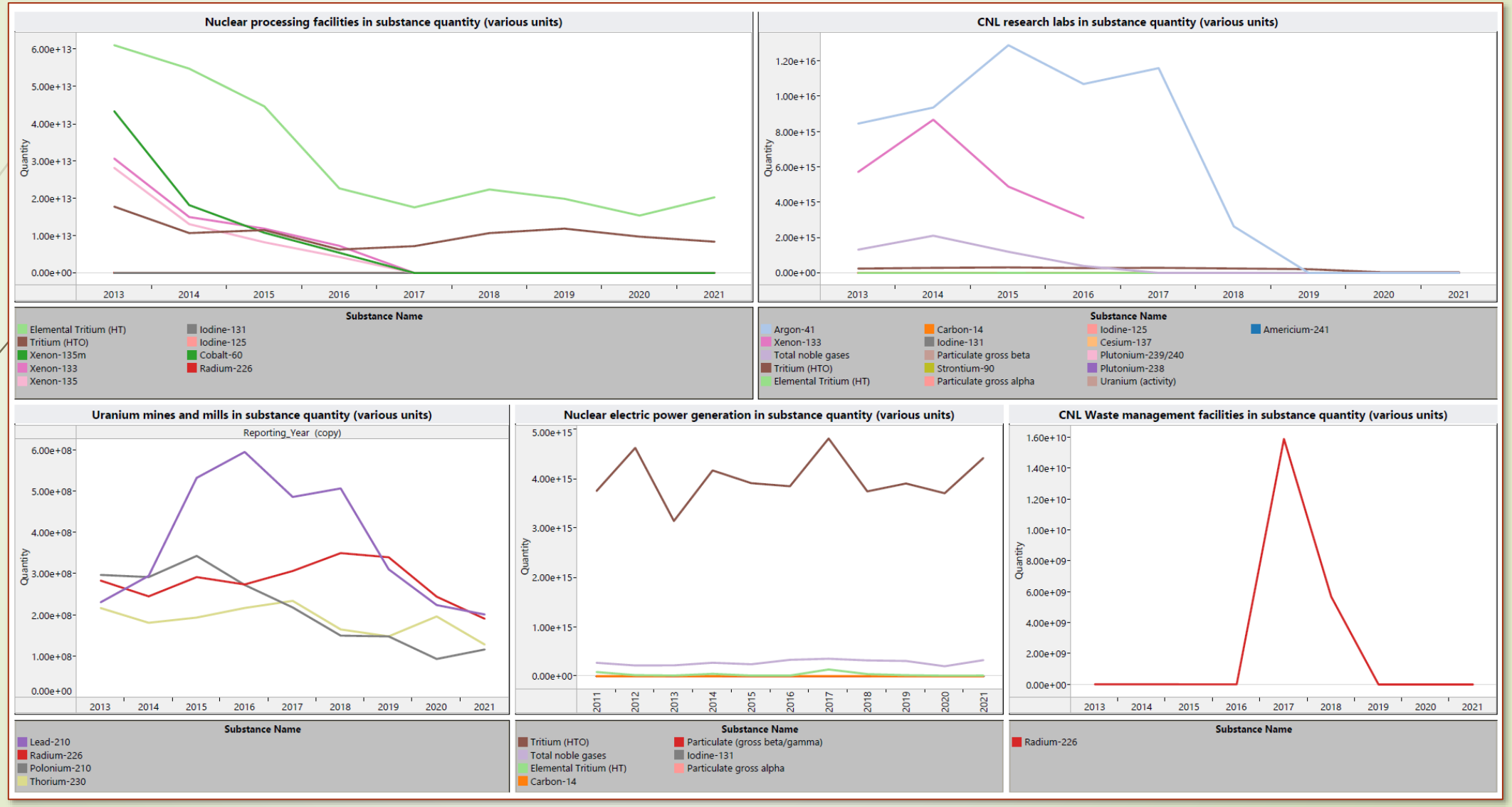
- Releases to Water Bodies
- Releases to Air
- All releases

# Metal and Diamond Mining effluent Regulations (MDMER) – Radium-226 reporting (2014-2018)

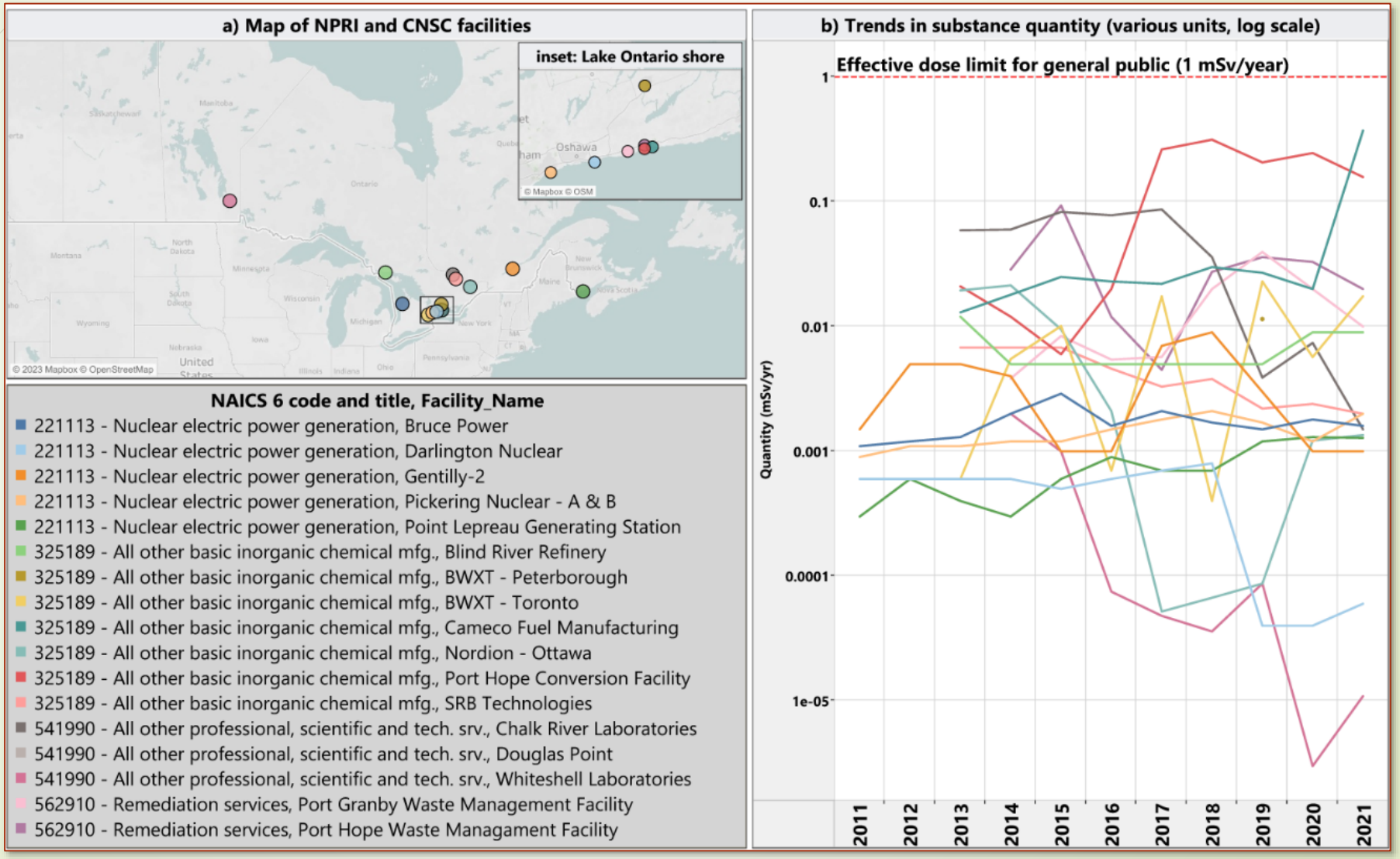



https://publications.gc.ca/site/eng/9.904555/publication.html

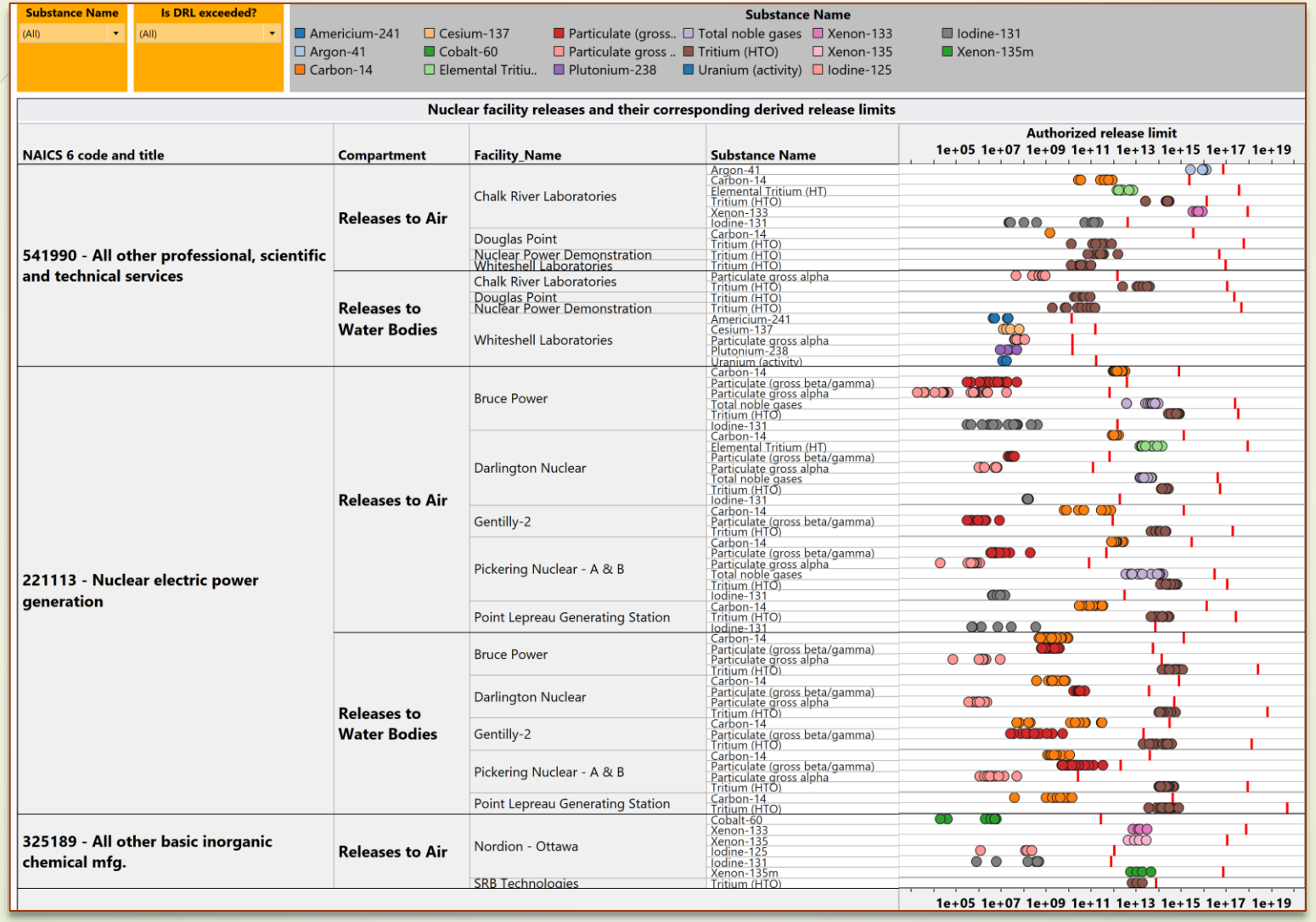
# Quantities & trends



# Insight into human impacts

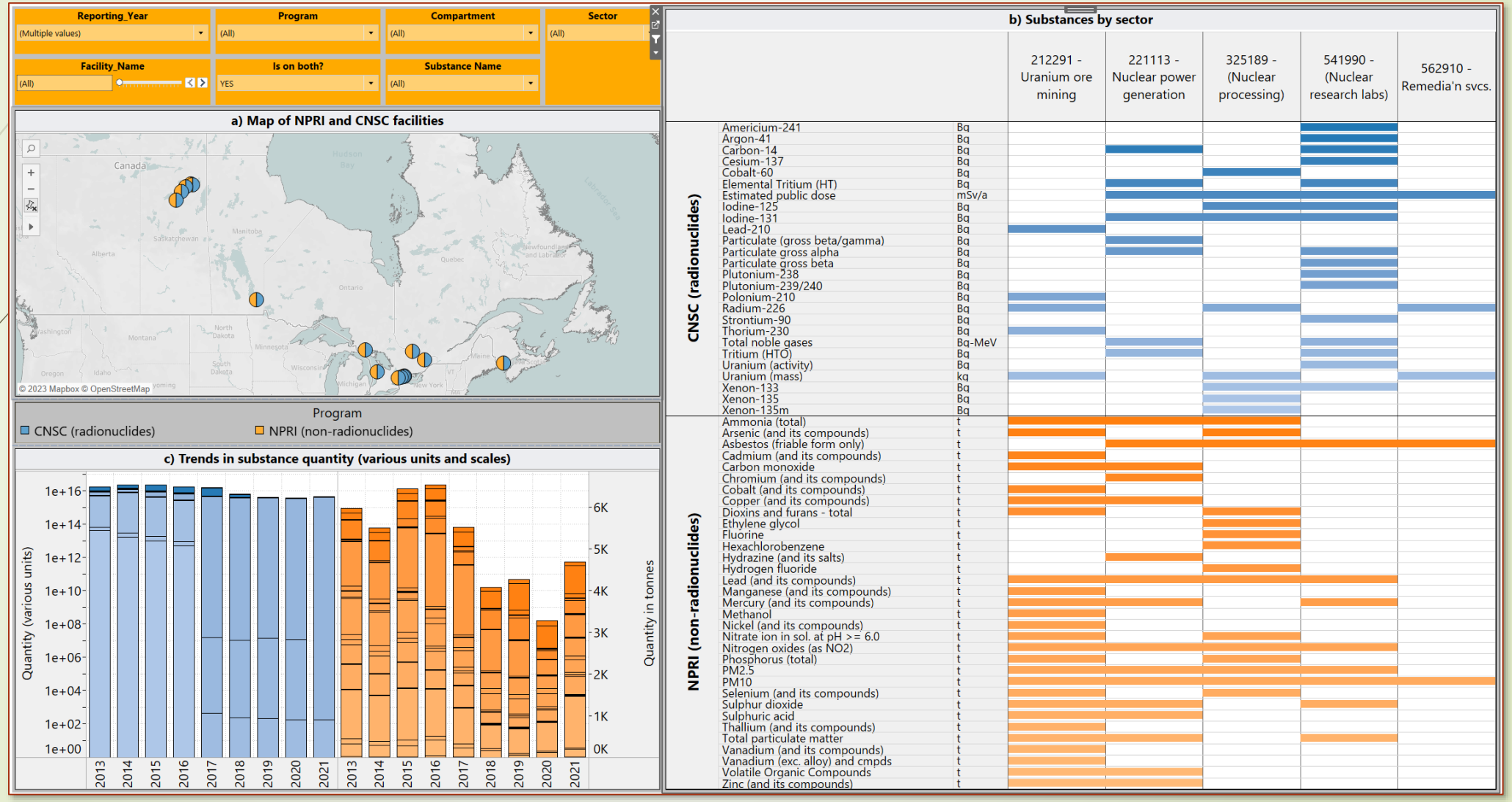


# Progress towards specific benchmarks




https://nuclearsafety.gc.ca/eng/resources/publications/reports/regulatory-oversight-reports/index.cfm

# Compatibility with the NPRI




https://public.tableau.com/views/Figure4_NPRIandCNSCdata-forTableaupublic/Figure5?:language=en-US&:display_count=n&:origin=viz_share_link

# Opportunities for improvement: Radionuclide release data


**More data**: Radionuclide spills/accidents, disposals and transfers data, Derived Release Limits (DRLs)

**Data details:** minor adjustments for better crosstalk between programs

**Sector coverage:** improve understanding of RN releases from:

- CNSC licensees currently not reporting (e.g., medical isotope therapeutics) and
- non-CNSC licensed facilities, (e.g., non-uranium mining).

# Conclusion

- **Combining existing RN release data in an NPRI-like format addresses this substance coverage gap**
  - More holistic view of nuclear sector facilities is possible
  - PRTR indicator power for this sector is improved
  - Template for application beyond Canada
- **Several opportunities for future work**: accidents, disposals/transfers, incorporation of release limits, and adjustments to increase sector coverage if/when warranted.