Radiological Protection in North American NORM Industries

Presented To:

ICRP 2013

2nd International Symposium on the System of Radiological Protection

NORM Issues in the Real World - October 23, 2013

Presented By:

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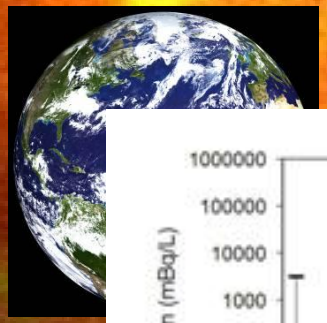
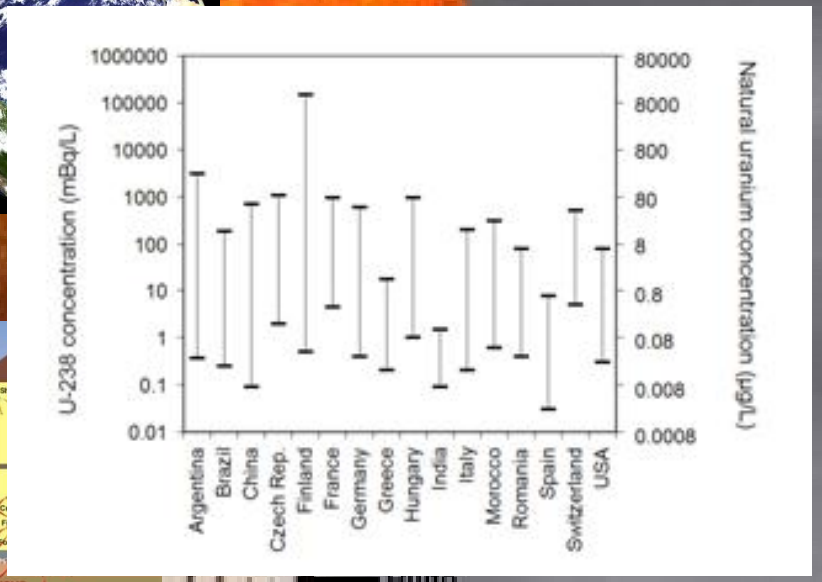
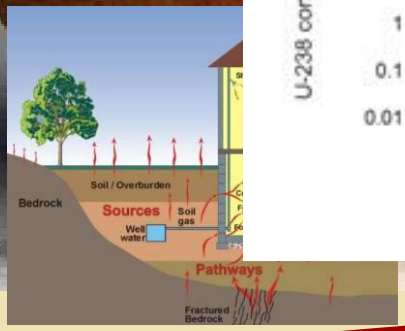
Everything is Radioactive

- **Cosmic rays**

- **Terrestrial sources**
  - Primordial radionuclides
    - Uranium-238 (4.5 billion years)
    - Potassium-40 (1.3 billion years)
    - Thorium-232 (14 billion years)
  - Exposures
    - External
    - Inhalation (radon)
    - Ingestion







Jupiter

Pluto

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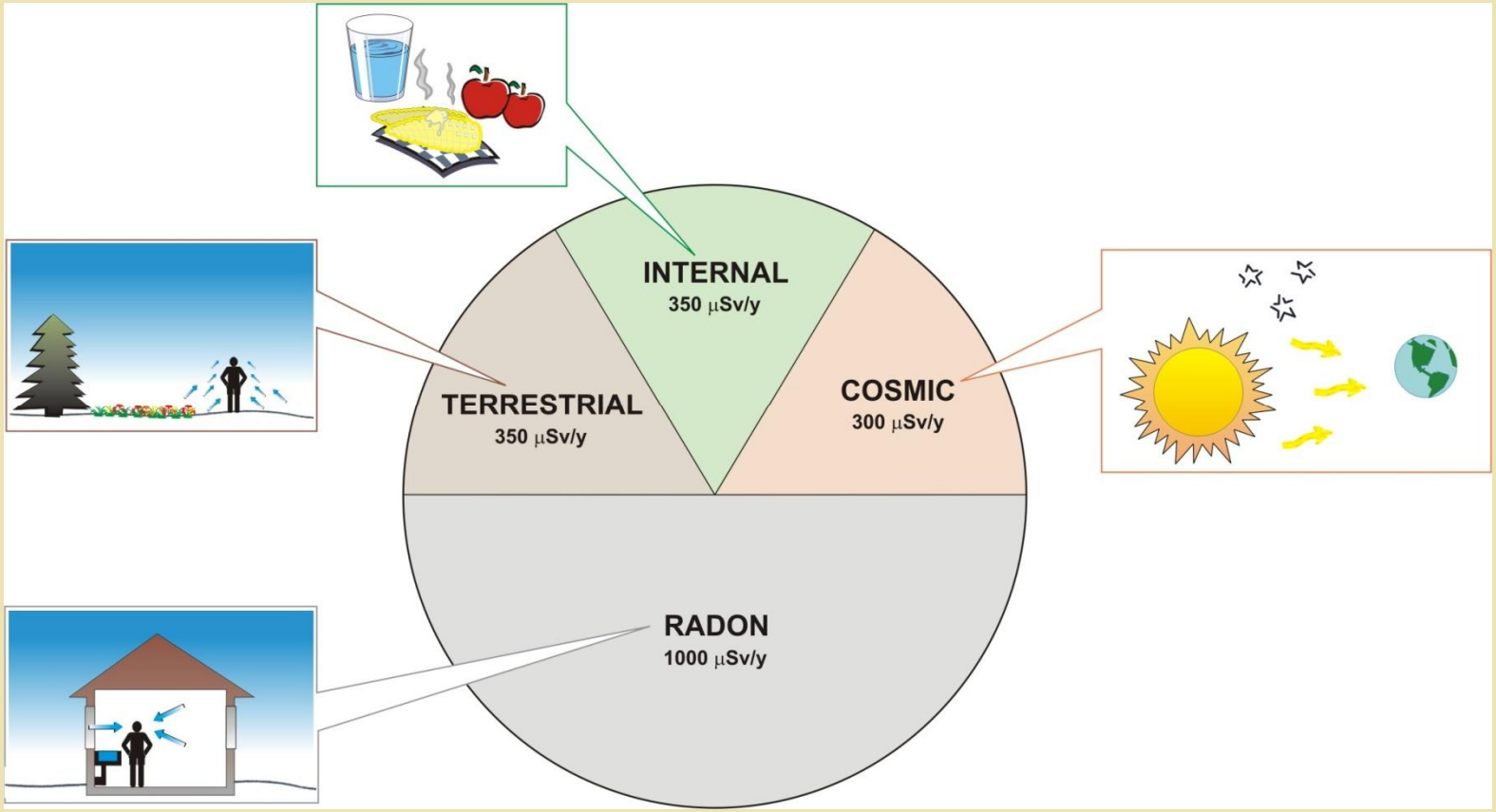
Radiation Dose from Natural Background

Approximate Natural Exposures in N. America



What is NORM?

- " **N**aturally **O**ccurring **R**adioactive **M**aterial, not subjected to regulations under the Atomic Energy Act, disturbed or altered from natural settings, or present in a technologically enhanced state due to human activities, which may result in a relative increase in radiation exposure and risk to public above background radiation level. " [HPS]

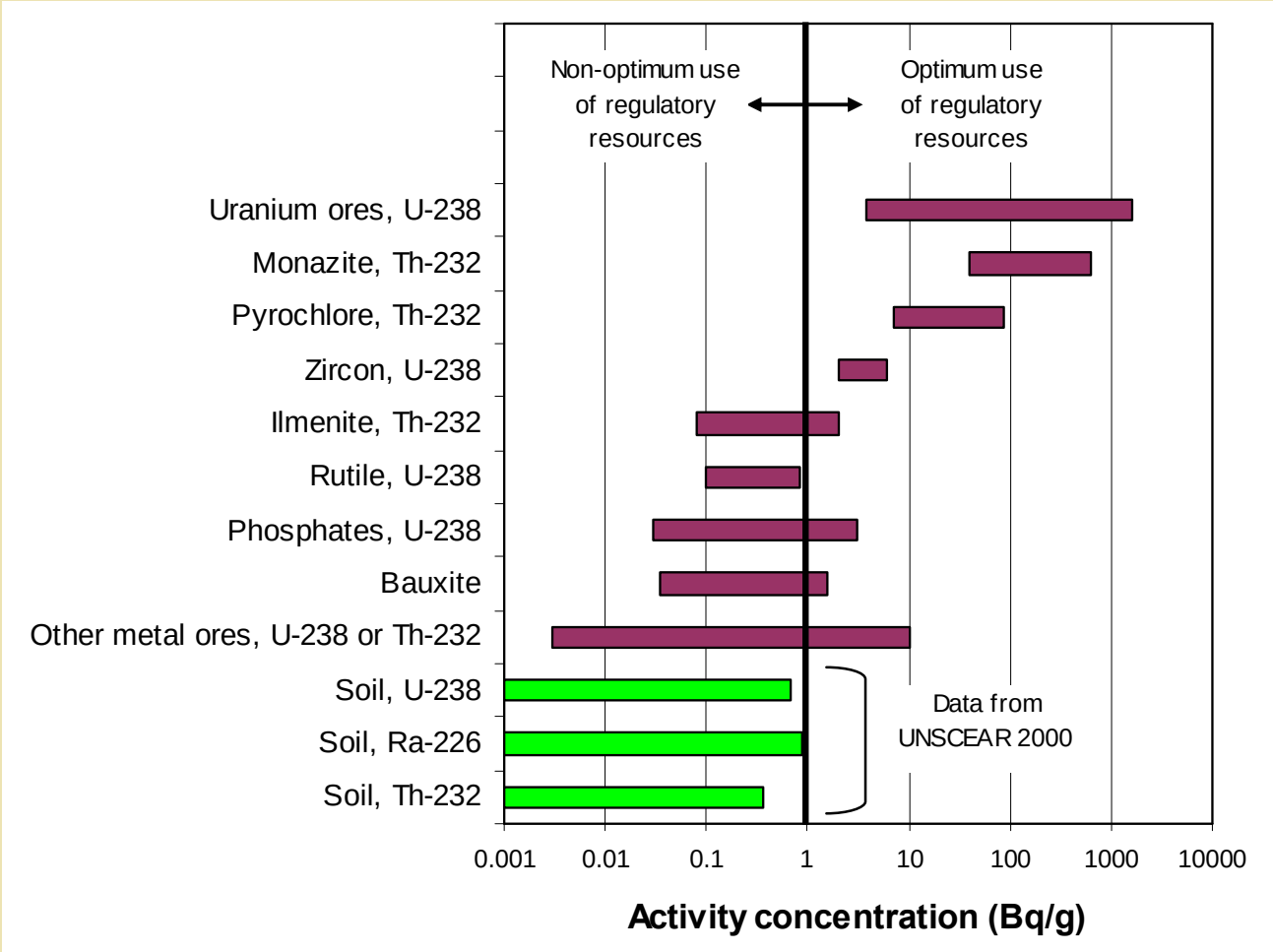
NORM Sources Identified by UNSCEAR 2008 Annex B

- Metal mining and smelting
- Phosphate industry
- Coal mining and power production from coal
- Oil and gas drilling
- Rare earth and titanium oxide industries
- Applications of radium and thorium (historic contaminated sites)
- Other –water treatment and other NORM wastes

Key Radionuclides

- **Uranium and thorium decay chain radionuclides, notably**
  - Radium (Ra-226) both as a source of external radiation in scales and sludges and as the source of radon (Rn-222)
  - Rn-222 transported as gas downstream of Ra-226 parent as the source of Pb-210 and Po-210

Concentration Ranges of Uranium and Thorium Series Radionuclides



After Wymer, 2008

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Uranium is NORM

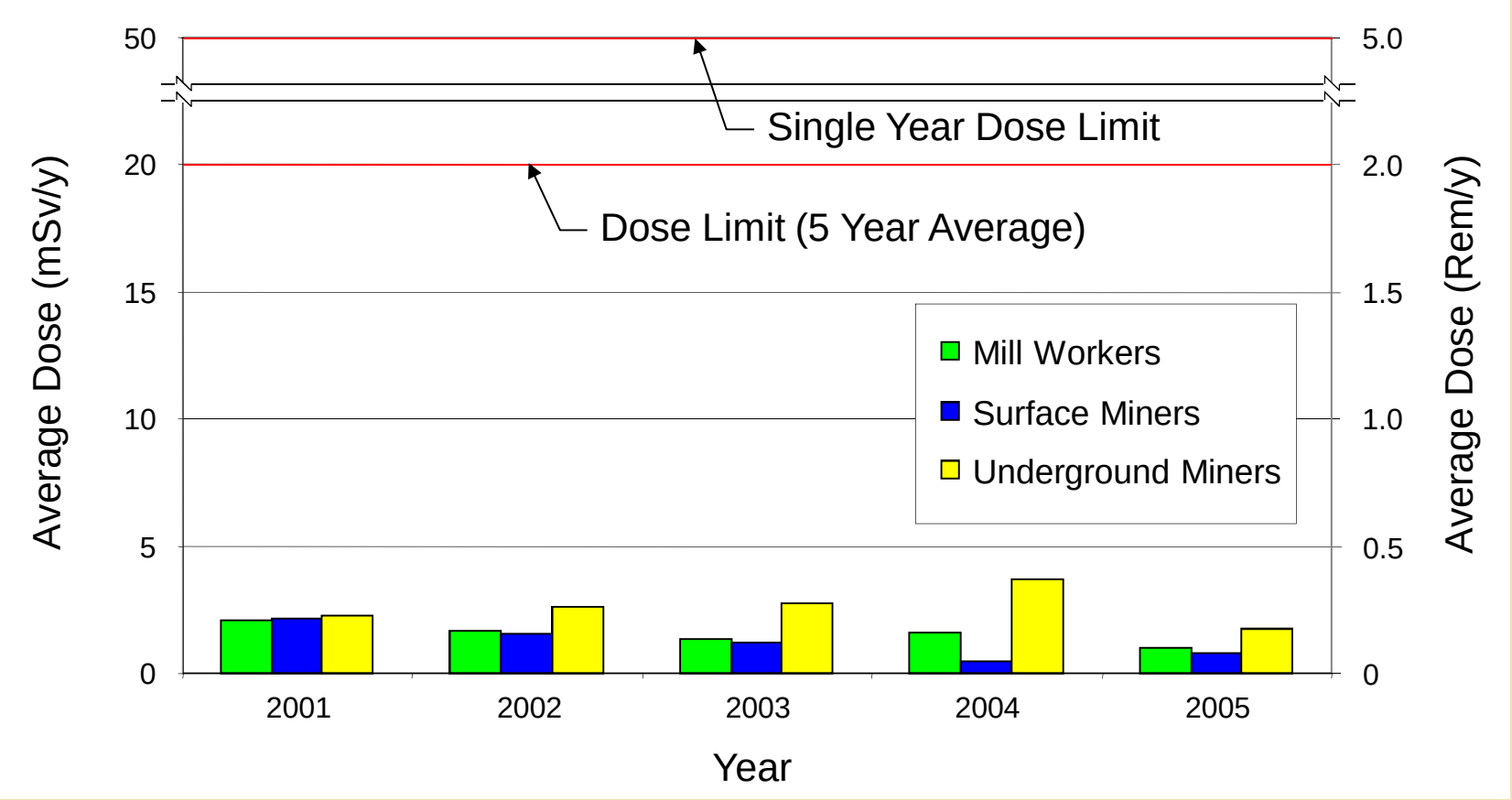
Uranium mining is a NORM activity

World Uranium Production*

Type of mining	U production (t), 2012
In-situ leaching	26, 263
Open cast	11,906
Underground	16,324
By Products	3,851
Total	**58, 344**

* After World Nuclear Association data

Average Annual Radiation Doses to Canadian Uranium Workers

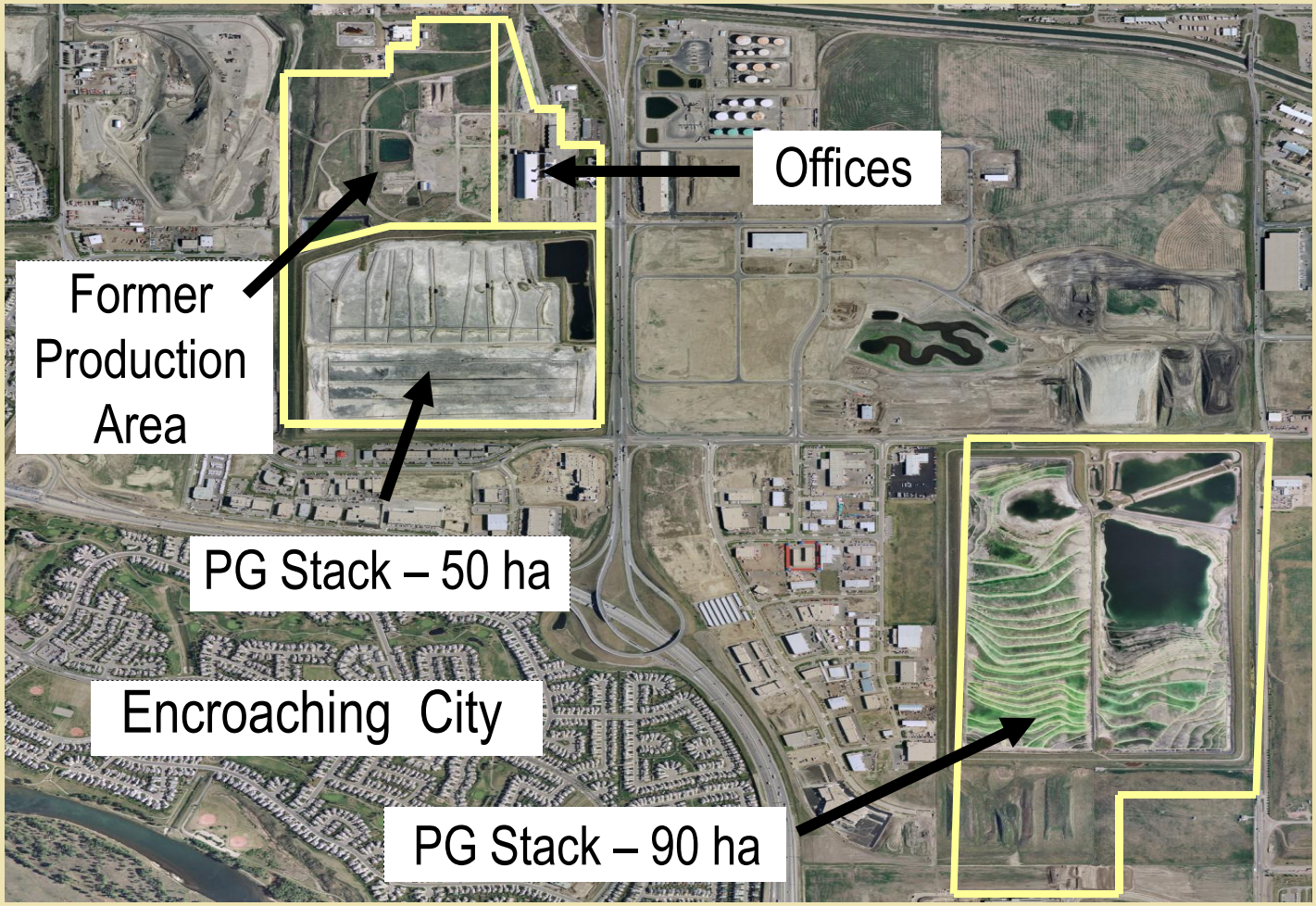


Source: Monitoring data from Health Canada National Dosimetry Services

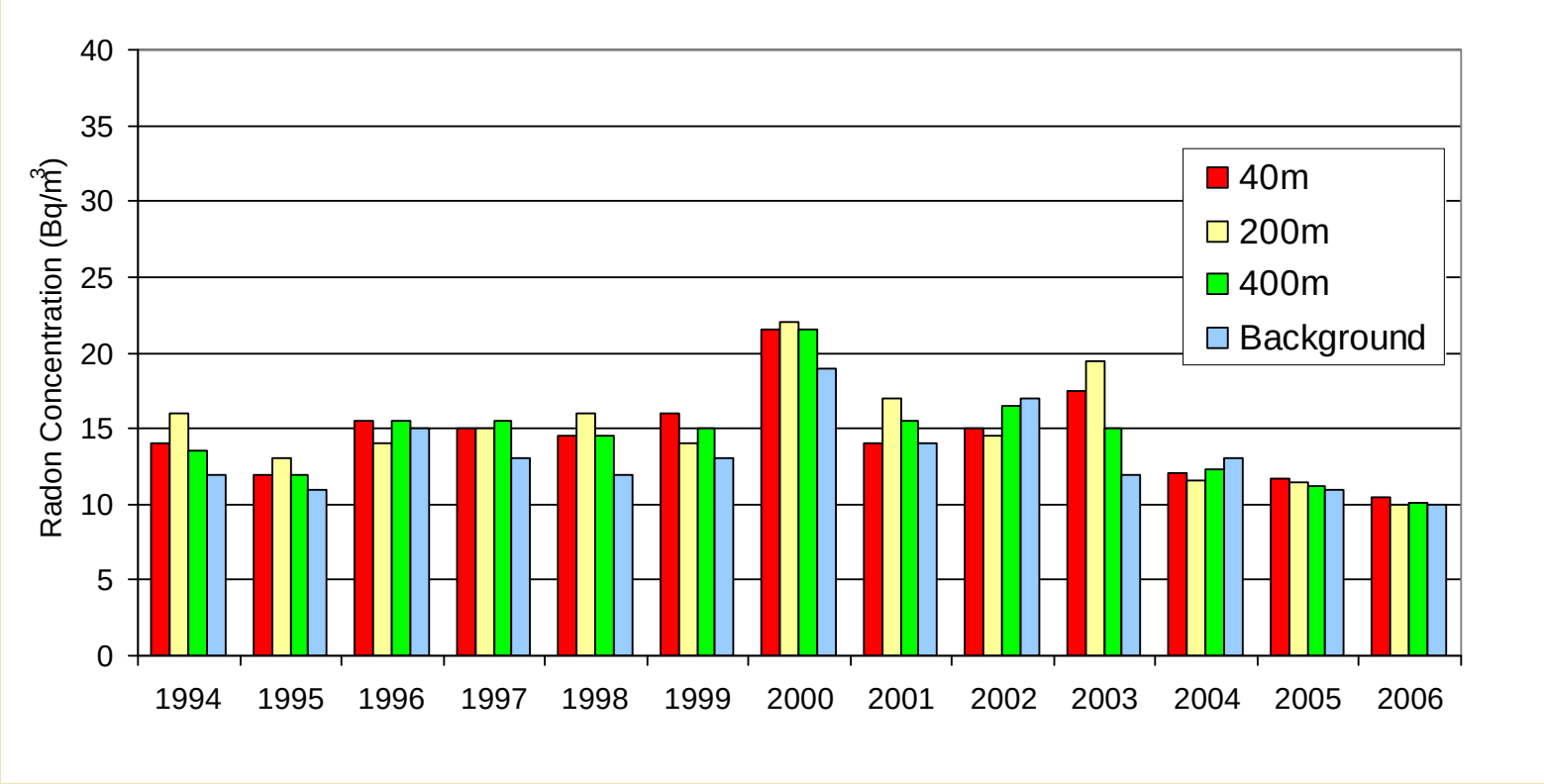
Phosphogypsum Stacks

- More than 10^9 tons of PG in North America
- Can be managed as waste or as useful by-product
- Current world-wide initiative ñStack Freeòto develop safe uses of PG

Location of Former Fertilizer Facility
(Non-Operating)



Annual Average Radon Concentration Around PG Stacks



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Radioactivity in REE Processing

- Th, U and daughters follow RE mineralization in mineral concentration
- Extraction process liberates RE; some Th, U and daughters
- REE concentrate needs to be low in radioactivity
- Extraction residues contain essentially all radioactivity
- Doses to workers and public are controlled through current RPP

Examples of Use of NORM By-Products

Examples of Potential PG Re-Use

- Composting
- Daily landfill cover
- Road base
- Agricultural
- etc.

Doses and risks to workers and public are low but subject to much debate.

Phosphate Slag

Amongst other uses, Slag can be used for road construction

Radionuclides from Coal Power Plants

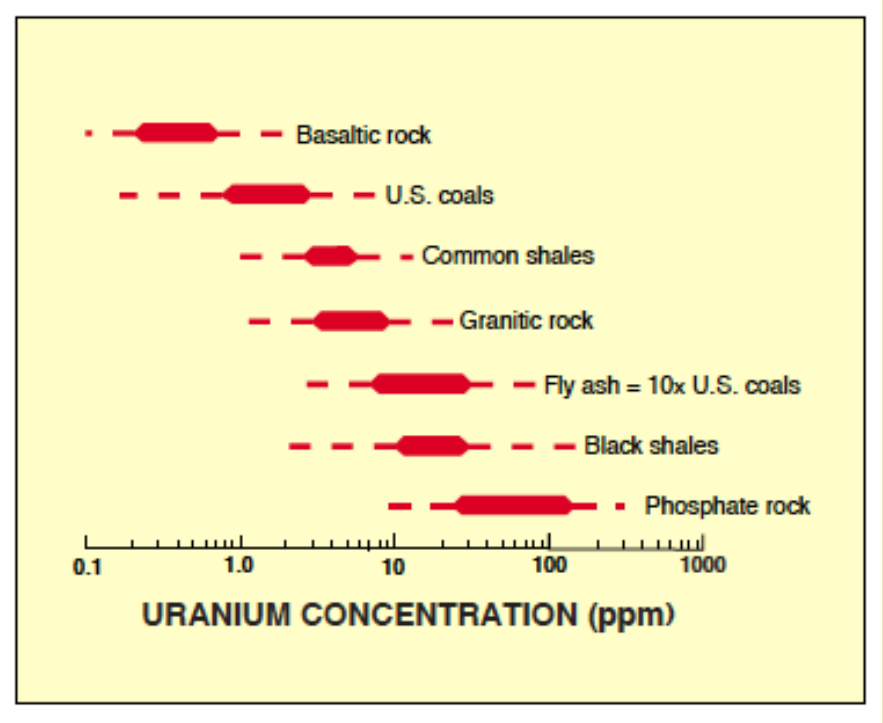
- **Naturally Occurring Radioactive Materials (NORM) are part of the mineral content and become concentrated in the ash**
- **When concentrated, the "NORM" becomes "TENORM" - Technologically Enhanced Naturally Occurring Radioactive Material**
  - gas phase as airborne effluents (primarily radon, some particulates)
  - solid combustion products (U, Th, Ra and progeny)
- **Average ash yield of coal burned ~10% by weight – quantity depends on mineral content of coal and boiler type (varies from 3-30%)**
- **Accordingly, the concentration of radionuclides in coal ash TENORM can be 10x greater than in the coal**

NORM in Coal Ash

- **10-30 ppm Uranium (7-20 pCi/g) similar to granite and phosphate rocks and black shales**

TENORM Activity in Coal Ash

Wastes	Radiation Level [pCi/g]		
	low	average	high
Bottom Ash	1.6	3.5-4.6	7.7
Fly Ash	2	5.8	9.7

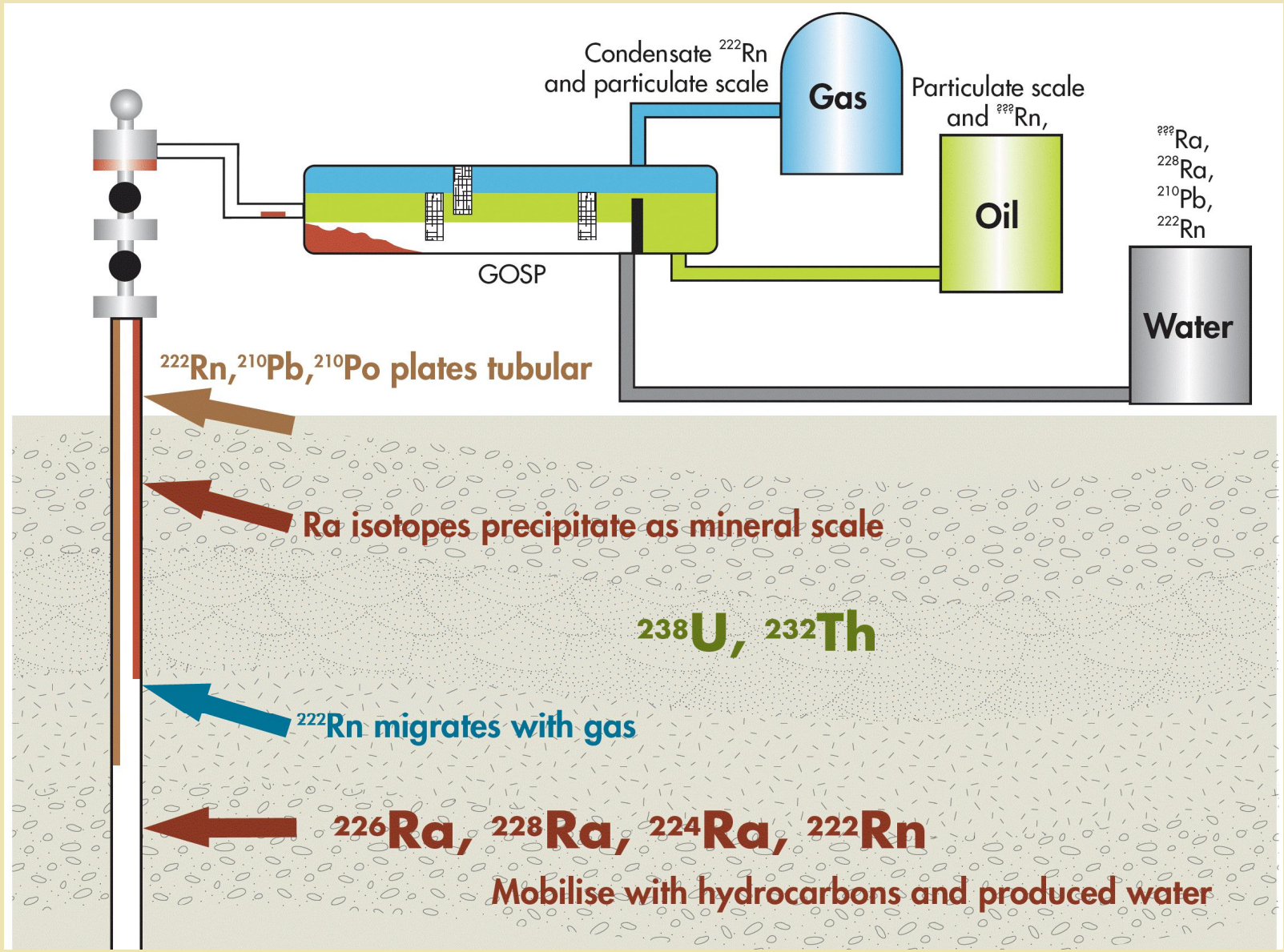


Potential Human Exposure Scenarios

- Atmospheric releases from stacks and ash piles (public inhalation, external exposures, ingestion of dusted food products)
- Workers at Coal plants fired power plants and landfill sites
- Workers who manufacture and use building materials containing ash
- Public inhabiting buildings constructed from materials containing ash

Oil and Gas

- Estimated 30% of the oil and gas wells are faced with TENORM issues.
- 20-100% of the facilities report presence of TENORM.
- 64% of Gas producing and 58% of oil producing equipment shows readings at or above background.



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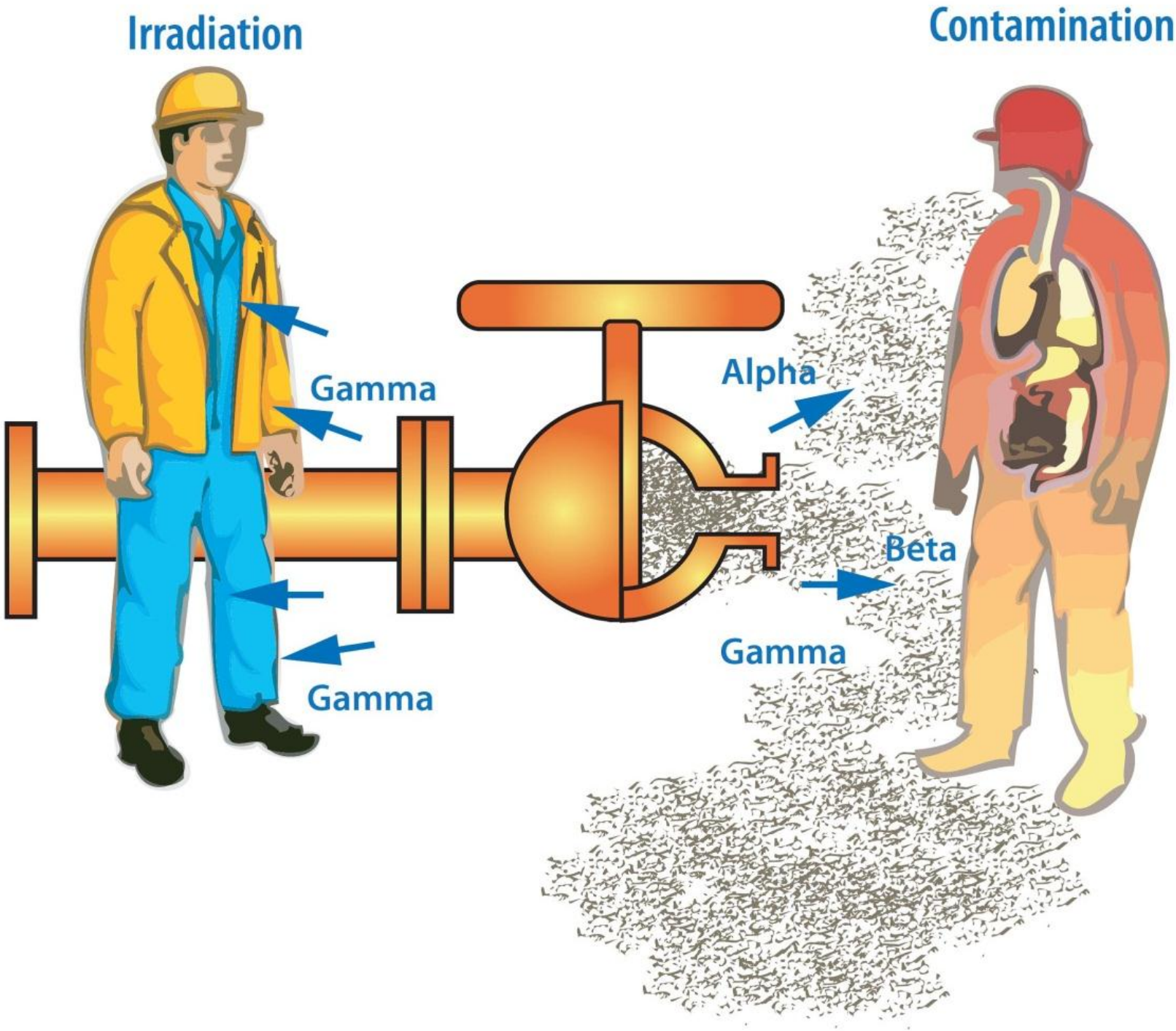
Plating and Implications

- Lead 210 will plate onto surfaces in natural gas, ethane, and propane lines
- Polonium 210, Bismuth 210 accumulate over time as Lead 210 decays
- All three radionuclides will be difficult to detect from the outside of equipment and pipes

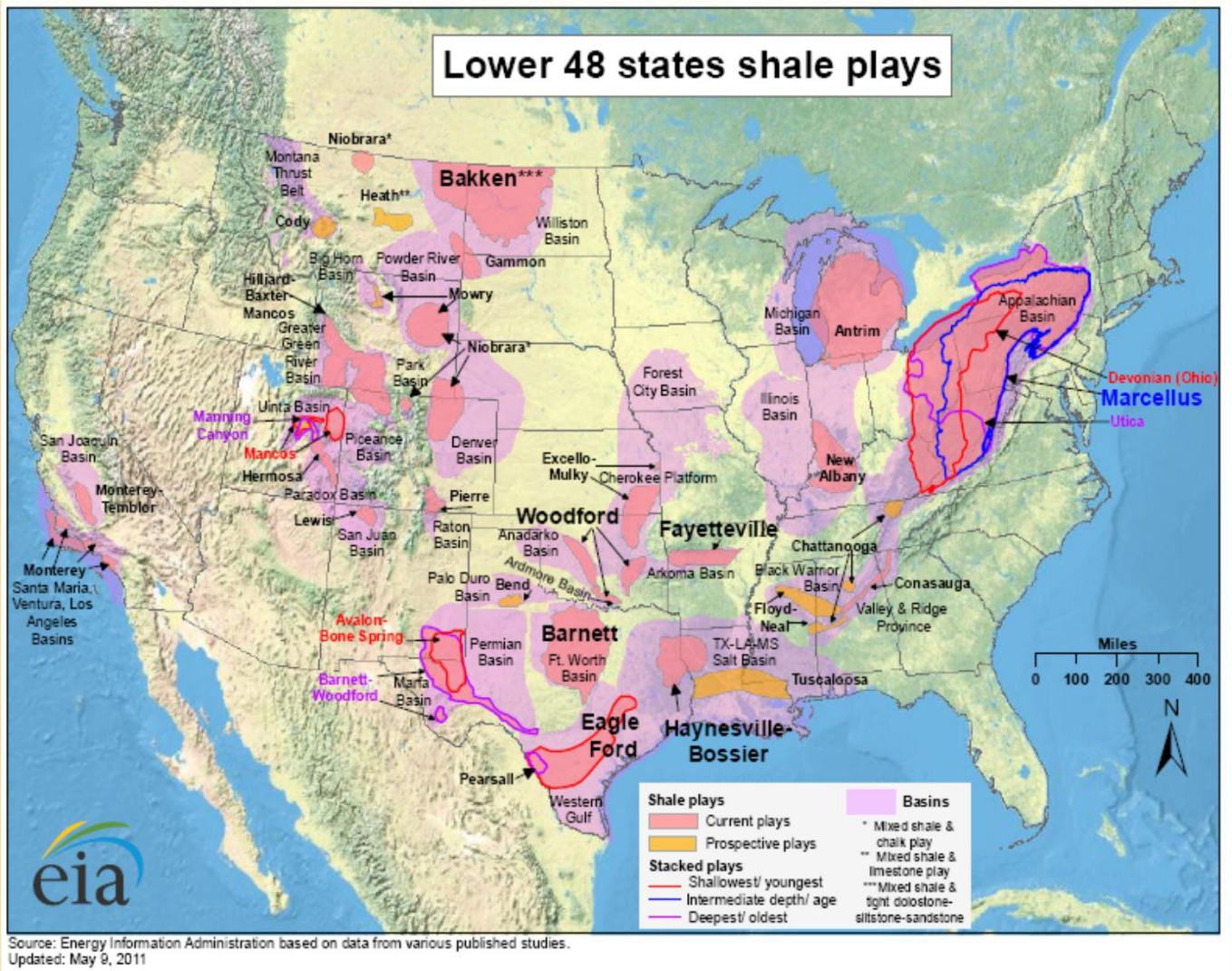
Plating and Implications


Irradiation
Contamination
Gamma
Gamma
Alpha
Beta
Gamma

USEPA,(1973) Radon Concentration in NG Distribution Line

	Radon-222 Concentration (pCi/L)	
Area	Average	Range
Chicago	14.4	2.3-31.3
New York City	1.5	0.5-3.8
Denver	50.5	1.2-119
West Coast	15	1-100
Colorado	25	6.5-43
Nevada	8	5.8-10.4
New Mexico	45	10-53
Houston	8	1.4-14.3
Overall	23	

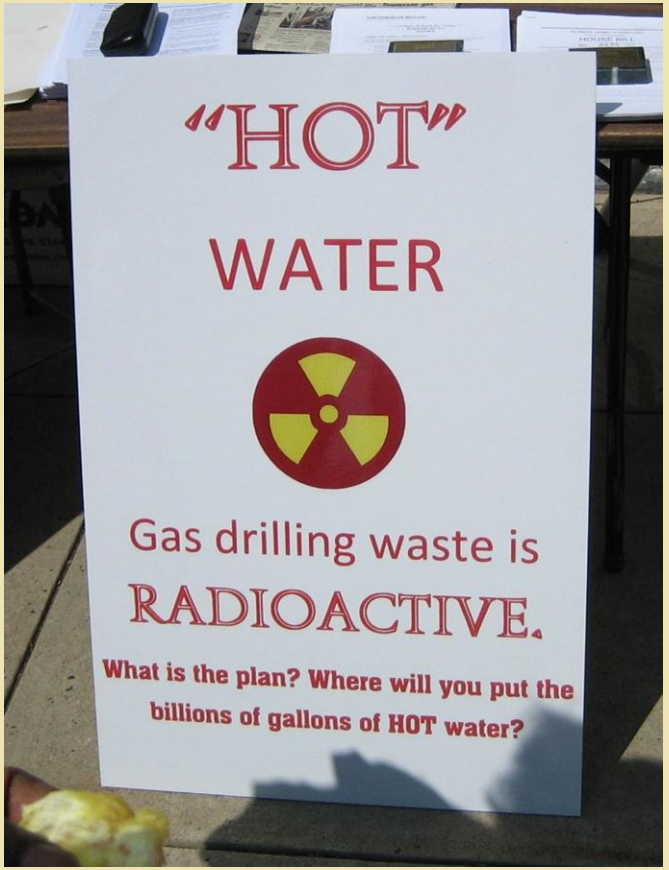
Shale Plays in Lower 48 States



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Environmental Concerns

Earth Day 2010



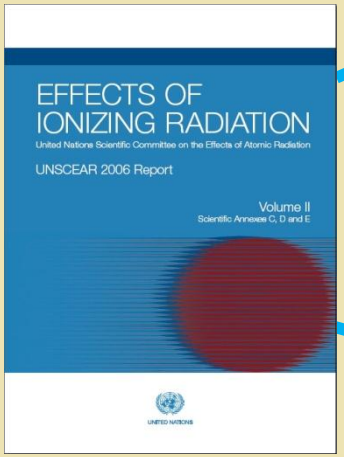
Marcellus Shale - Observations

- **Treated frac H20 sludge: 6 - 250 μR/h**
- **Treated frac H20 sludge: BG - 3,000 pCi/g**
- **Gas Well Environs, 45 PA Sites, CY08-09**
  - Background: 9.0 μR/h
  - Well Pads: 8.7 μR/h
  - Well Pits: 9.3 μR/h [some 15-20 μR/h]
- **Radon in Natural Gas: 37 pCi/L [1-79 pCi/L]**

FRACKING - EPA Study

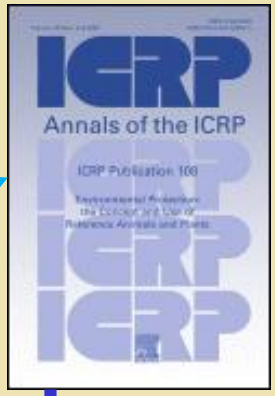
- EPA study of potential impacts of fracking on drinking water resources underway
- Study includes radionuclides (gross alpha and beta, uranium, radium, thorium)
- Study under SAB consultation
- Report of study results due late 2014

International Radiation Safety Regime



UNSCEAR
Scientific basis

issues
effects
risks



ICRP
Protection philosophy,
principles and units

recommendations

issues
levels
trends

ILO convention 115:
occupational
radiation protection

FAO/WHO
Codex Alimentarius Commission
(food contamination guides)

UN transport regulations for
radioactive material

IAEA, WHO, ILO, FAO etc.
-Safety standards
-Protection programmes

implemented by
Member States

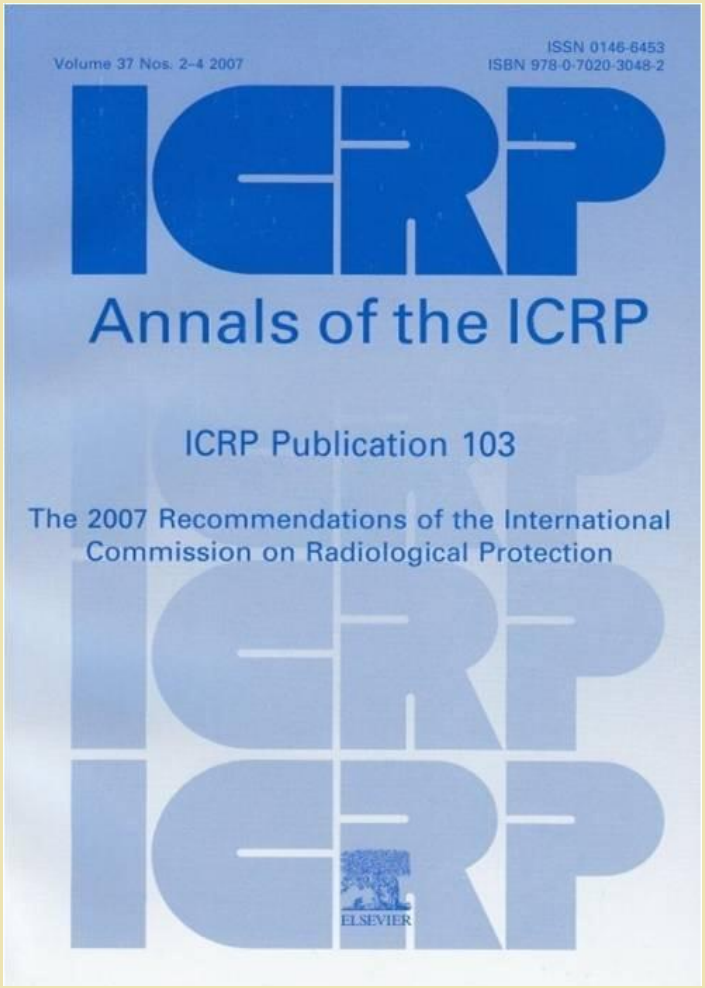
ICRP Document

Task Group 76
Application of the Commission's Recommendations to NORM (Naturally Occuring Radioactive Material)

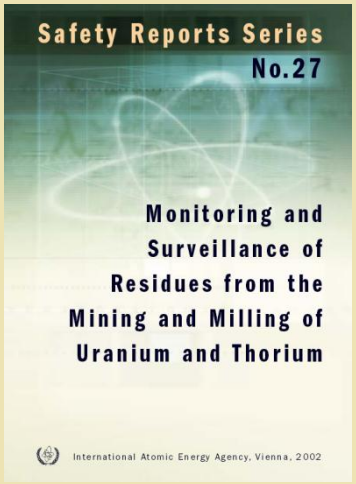
The Task Group is to develop a conceptual framework for the practical application of the new Commission's recommendations on radiation protection for Naturally Occurring Radioactive Material (NORM).

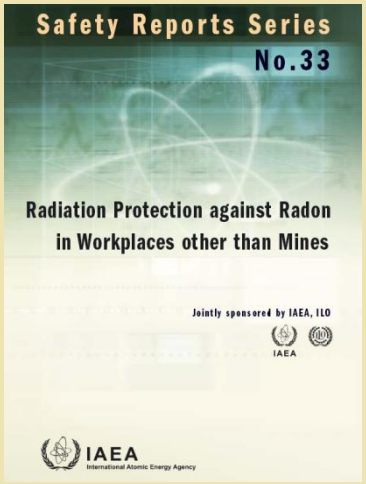
The new ICRP Recommendations, Pub 103, set out clearly that the system of protection applies to NORM either as an Existing or a Planned Exposure Situation. What is lacking is a decision aiding framework, based on the new recommendations that would allow radiation protection principles to have practical and consistent inputs for regulatory programs that are developed and implemented for the protection of workers, the public and the environment.

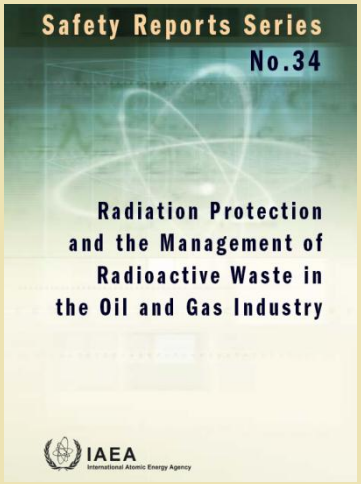
The work should in a first part present the generic framework covering broadly the entire range of activities associated with the processing, production or use of bulk materials with enhanced levels of naturally occurring radionuclides, including shipment and waste management, as well as the presence of such materials in consumer products, particularly in construction materials. In a second part the application of the framework should be illustrated to a few relevant activities that are currently a concern (oil, coal, rare earths, phosphate, to be selected by the TG.

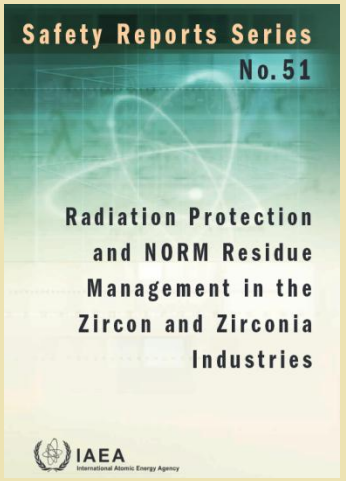


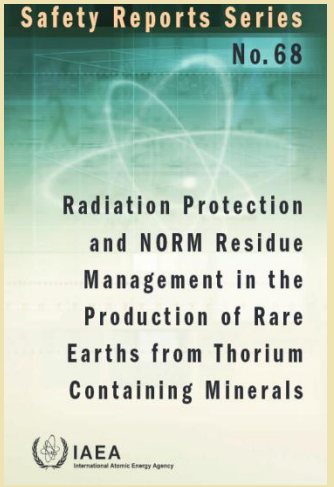
IAEA Safety Standards/Reports

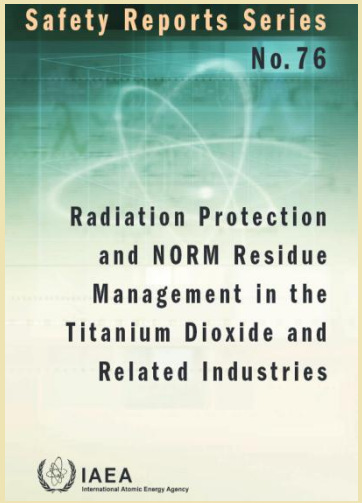


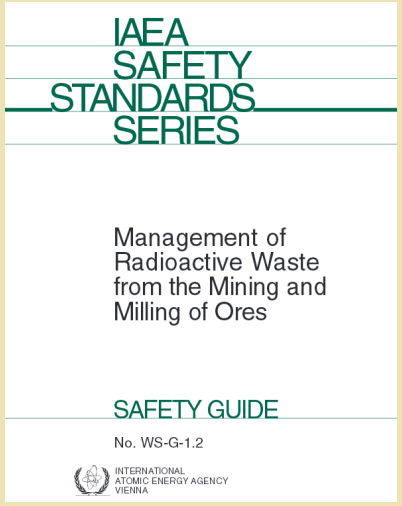


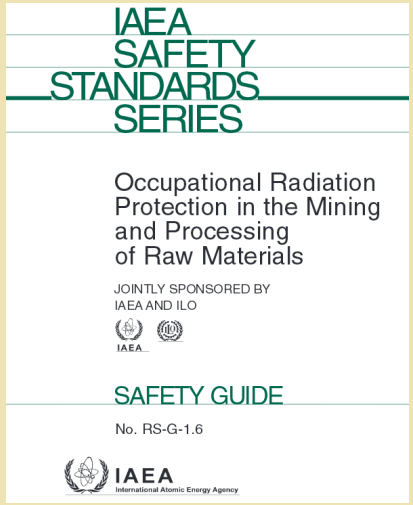


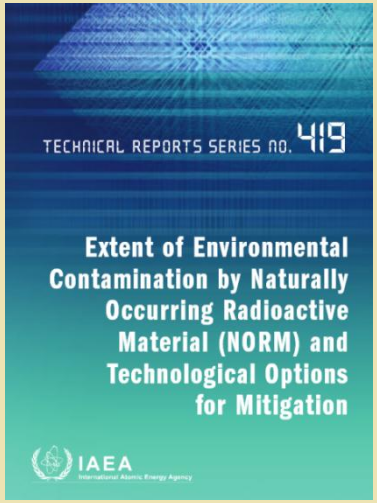












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Canadian Regulations Relevant to Uranium and NORM

- Canadian Nuclear Safety Commission (CNSC) has regulatory authority over nuclear fuel cycle and man-made radionuclides across Canada (e.g. medical radioisotopes)
- However, NORM specifically excluded from mandate of CNSC
- No federal regulations in Canada specific to NORM, except transport (generally follows IAEA) and import/export regulations
- Canadian Guidelines on the Management of NORM developed to fill regulatory gap

Canadian Regulatory Framework Relevant to Uranium Mining

- **The CNSC has dose limits (all pathways combined) for:**
  - Workers
    - 100 mSv cumulative over 5 years
    - Maximum of 50 mSv in any single year
    - ALARA
  - Members of the public
    - 1 mSv
- **Environmental Assessments**
  - Required for projects designated by the CNSC
  - May consult with other federal agencies
  - Very extensive

Current Regulatory Environment in US

- **States have taken the lead in NORM through the CRCPD Part N rules**
- **A number of state departments have NORM rules**
  - Texas
  - Colorado
  - Ohio
  - Louisiana
  - Arkansas
  - New Mexico
  - Many others

Risks from NORM Minerals

In the majority of situations, the NORM concentrations do not pose potential problems to the environment or human health

But

Processing of ores can lead to further enhancement of the radioactivity in the products, by-products, residues or wastes

Overall Conclusions

- Radioactivity in NORM production is an important issue for public and regulators
- Doses to workers and public are thought top be generally low but there is concentration of radionuclides at some steps in processing and care is needed
- Proven RPP practices are available to protect workers and the public
- Very important to communicate with local public