

TENORM Waste Streams in the Oil and Gas and Water Treatment Sectors

“A better way to handle oilfield and radioactive waste”

Kurt Rhea
General Manager, U.S. Operations
Radiation Safety Officer

SECURE energy services

Serving the U.S and Canada

SECURE
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Secure Energy

- Headquarters in Calgary; U.S. Operations in CO and Bakken
- Midstream and Drilling support services operations in Canada
- Diversified on-site services in US and Canada
- Oilfield waste management
- Radioactive materials licensing in CO, ND, and NRC

What is TENORM?

- NORM - Naturally Occurring Radioactive Materials
- TENORM - Technologically-Enhanced
 - Radionuclide concentrations increased by or as a result of past or present human practices

Where is Radiation Found?

- Cosmic
- Terrestrial
- Radon
- Medical
- Industrial Sources
- Other Sources
(Food, Water, Consumer Products, etc.)

Other Industries Impacted

- Mining/Ore Processing
- Municipal Water Treatment
- Metal Recycling
- Forest Product Combustion
- Thermal Electric Production
- Water Filtration
- Fertilizer Production
- Ceramics



What comes to mind when one thinks about radiation?



Radiation



Why is TENORM an Issue?

- 1) Worker Safety
- 2) Environmental Protection
- 3) Liability
- 4) Regulatory Compliance
- 5) Public Safety and Perception

Regulatory Compliance & Liability

In 2001 Exxon Mobil successfully sued in the U.S. for contaminating land with NORM.

Result:

- \$1.06 Billion in punitive damages (reduced to \$225 million in 2006)
- \$56 million in cleanup costs
- Individual lawsuits brought about against the company from former workers and residents.

Exxon Mobil Ordered To Pay \$1.06 Billion For Polluting Land

By a WALL STREET JOURNAL Staff Reporter
NEW ORLEANS, La.—Exxon Mobil Corp. was ordered to pay \$1.06 billion to a former state judge and his siblings for contaminating 33 acres of land with radioactive material.

"The jury sent a clear message to Exxon in particular and the oil industry in general that these radioactive materials should and must be cleaned up immediately," said attorney Stuart Smith, who represents the landowners.

Representatives for the Irving, Texas, oil company couldn't be reached for comment, but the Associated Press reported Exxon Mobil plans to appeal.

The oil company didn't deny there was contamination on the land. In dispute during the five-week trial, held in Orleans Parish Civil District Court, was how widespread the damage was, how much it would cost to clean up, and when the oil company first knew there was a problem.

Former Jefferson Parish District Judge Joseph Grefer leased the land between the 1950s and 1992 to Intracoastal Tubular Services Inc., a company contracted to clean and refurbish Exxon's pipes.

The plaintiffs argued that the oil industry knew since the 1930s that its pipes were filled with residue containing signifi-

cant amounts of radium, a carcinogen, and Exxon said nothing in hopes of avoiding liability for cleanup costs.

Exxon Mobil claimed that less than 1% of the property was contaminated, that it could be cleaned up for less than \$48,000 and that the company didn't know about the contamination until the late 1980s. The company said it offered to clean up the property, but the plaintiffs refused.

The plaintiffs claimed the contamination was massive and that Exxon's offer to clean up the site, which came on the eve of the trial, was substandard.

The jury ruled the company should pay \$56 million for cleanup and \$1 billion in punitive damages for not disclosing the radium problem sooner.

May 25, 2001

NORM – A Lighting Rod for Industry



High Profile Cleanups

Cleanup underway in Noonan



12 HOURS AGO • BY LAUREN DONOVAN | BISMARCK TRIBUNE

NOONAN — A radiation team cleaning up an illegal oil field waste dump site in Noonan found an underground cache of the material and labels that are possible evidence of companies that contributed to the mess.

The cleanup was expected to take all day Wednesday, with a crew of six workers in oil-streaked suits and respirators pulling tons of low-level radioactive filter socks from an abandoned gas station in this tiny town near the Canadian

border.

The dump was discovered in late February and state and local officials started looking for the culprit and making plans to get the material safely disposed.

The property owner is a criminal fugitive in Wyoming and the state is using its own clean up funds instead of forcing the owner to deal with the situation.

Robert Krumberger, manager for Secure Energy Services, said his workers soon uncovered an underground sump area in the old garage, which also was full of the filter socks. He said he called for additional lined containers and estimated the building contained 60 cubic yards of filter sock waste, instead of the 40 originally estimated.

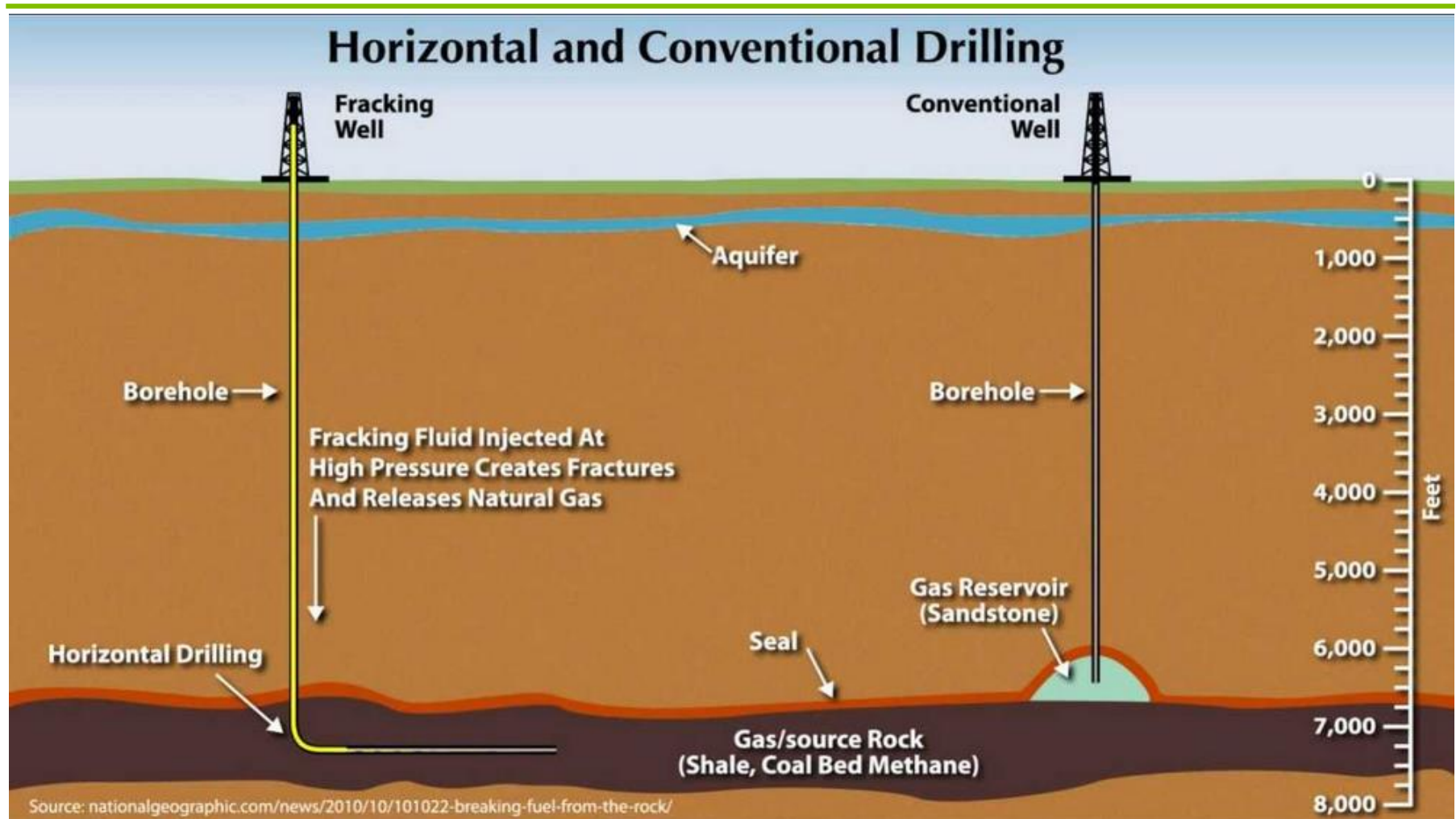


The Public, Regulators, and Employees

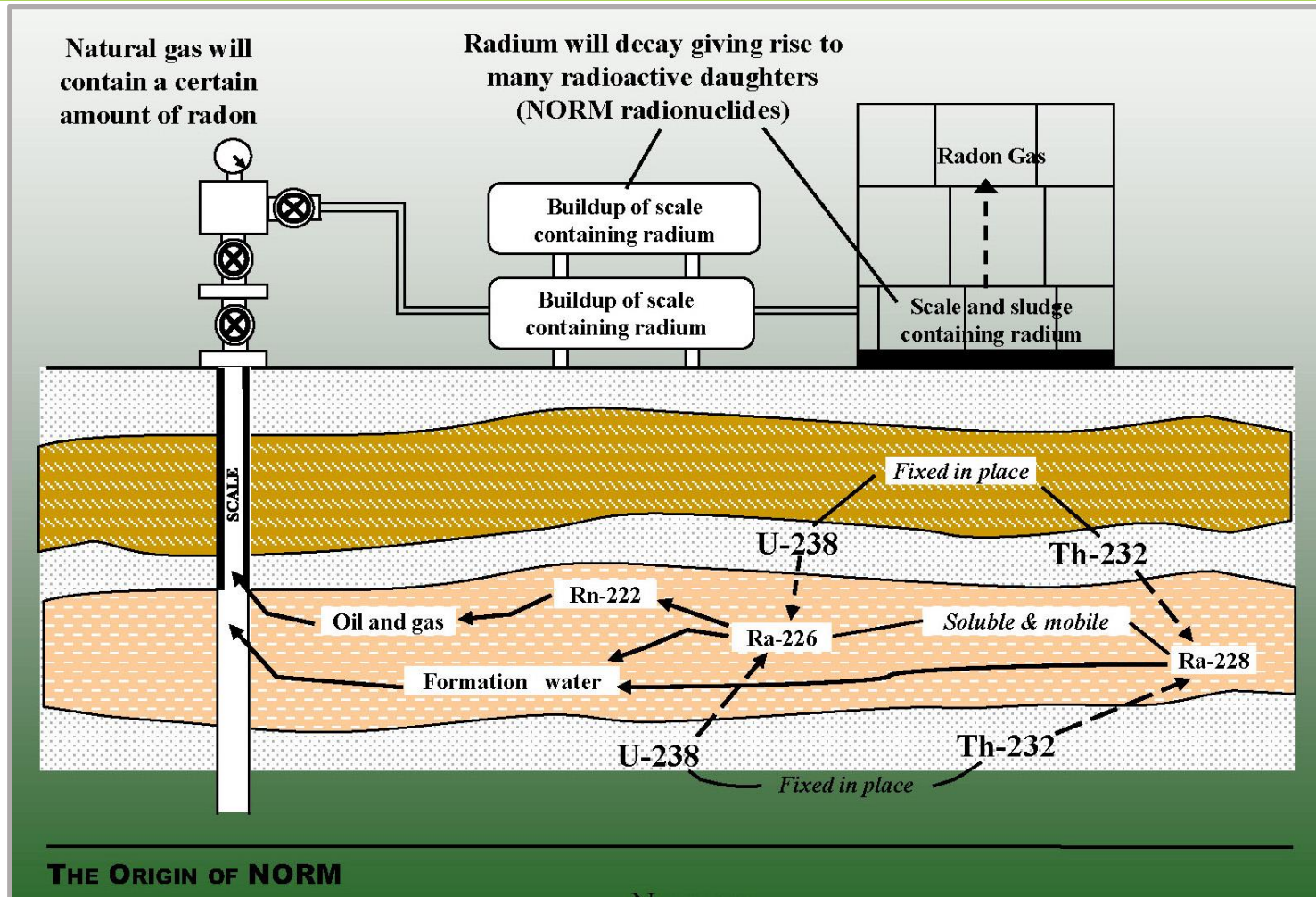
- States That Have Seen Very Public TENORM Issues
 - North Dakota
 - Colorado
 - West Virginia/Ohio/Pennsylvania/New York
 - Louisiana

- Challenges
 - Misinformed & Misconceptions
 - Employee Fears
 - Activists & Community Organizers – purposeful in misinforming
 - More Inflammatory than Pipelines, Spills, or Gas Emissions
 - Allowing Disposal or Raising Disposal Limits Is Difficult
 - Not In My Backyard
 - Makes Disposal Difficult

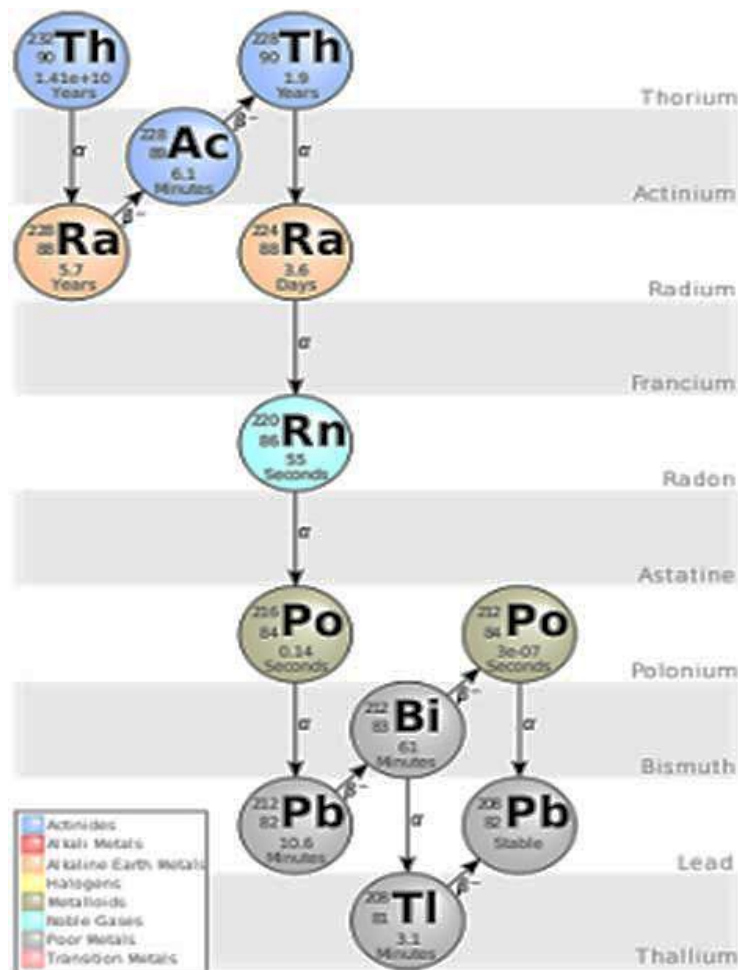
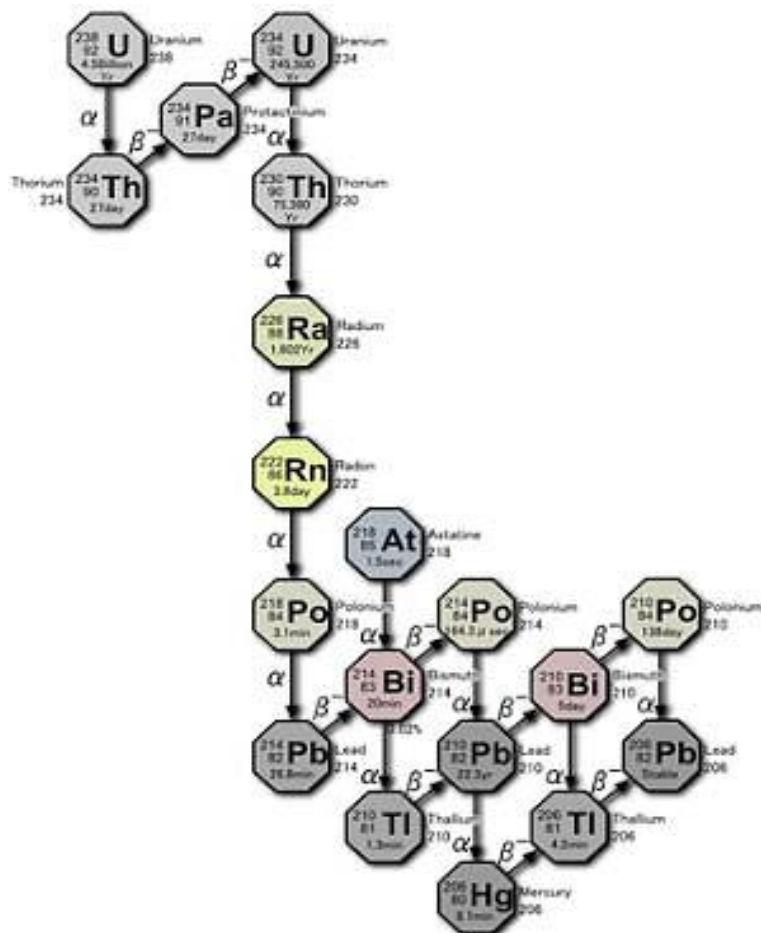
Impact of Shale Plays



Solubility = Mobilization



Decay Chains – So Much to Worry About



Clarifying Ponds and Tanks



Flowback & Produced Water

Radioactive Tails from Mega Ponds



Mega Pond Work



Filters and Screens



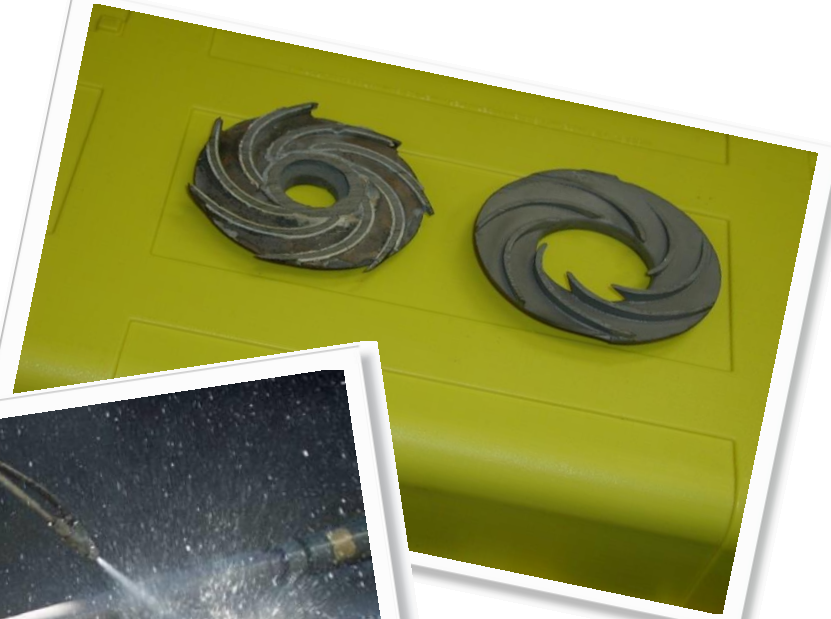
Taming the Wild West



Filter Socks: Radium-226, -228 and Lead-210



Bottom Hole Pumps & Sucker Rods



Scale from Produced Water: Radium-226 and-228



Stockpiles of Impacted Tubing



Dust, Filtration, and Suspended in Lubricants



Tanks, Tank Bottoms, and Pipe Scale



Tank Bottoms



Heater Treaters and Fire Tubes



Dealing with the Unexpected



Impacted Containment Floor & Debris



Floor View – NORM and Brine Impact



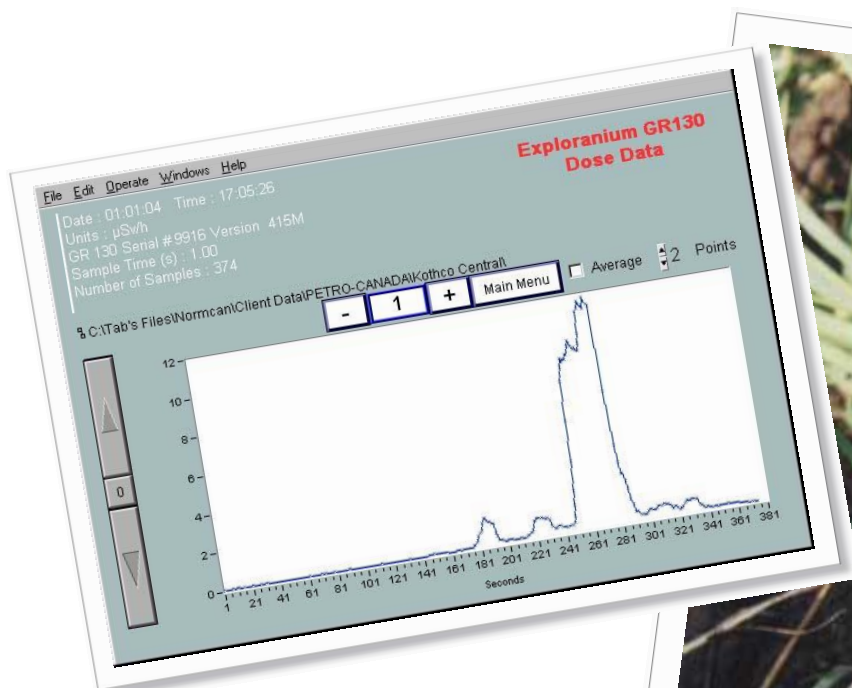
Systematic Extraction of Impacted Floor



Demolition & Impacted Debris Cleanup



TENORM in Soils and Drill Cuttings



Production Water Spill Fills Moat



Form Will Fool You



Levels Vary Dramatically

- Geology/Geography
- Processes & Equipment
- Time in Service

The Analytical Tells the Story



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Billings, MT 59101
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ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: 2016-833 [REDACTED] SWD Pipe Scale

Pace Project No.: [REDACTED]

Sample: [REDACTED] Pipe Lab ID: 10338579001 Collected: 02/08/16 14:00 Received: 02/15/16 11:33 Matrix: Solid
Scale

PWS: Site ID: Sample Type:

Results reported on a "dry-weight" basis

Comments: • Sample collection dates and times were not present on the sample containers.

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Lead-210	EPA 901.1	461.280 ± 760.140 (991.200) C:NA T:NA	pCi/g	02/25/16 22:26	14255-04-0	
Radium-226	EPA 901.1	22319.000 ± 3129.900 (922.400) C:NA T:NA	pCi/g	02/25/16 22:26	13982-63-3	
Radium-228	EPA 901.1	7672.700 ± 1020.400 (119.900) C:NA T:NA	pCi/g	02/25/16 22:26	15262-20-1	

Impacted Settling Pond



Pipeline Inspection Tools: Pb-210



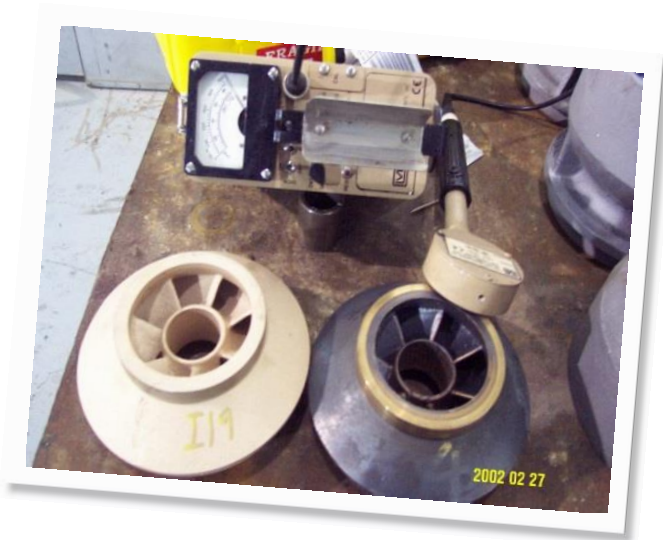
Radon-222 & Lead-210: Gas Systems

- Propane and ethane towers
- Reflux pumps/accumulators
- Propane loading pumps/filters/piping
- Desiccant driers
- Propane storage bullets



Radon-222 & Lead-210: Gas Systems

- Radon similar in physical properties to propane
- Pb-210 is typically dusty film coating on equipment or fine scale.
- Pb-210 is a beta emitter – no external TENORM survey



Treatment and Recovery Facilities



DAWSON CREEK



KOTCHO



RADIUM – The Gift That Keeps on Giving

- Two Isotopes: ^{226}Ra and ^{228}Ra (or Ra-226/Rad-228)
 - ^{228}Ra Half-Life is 5.7 years
 - Radon Half-Life less than 4 days
 - No magic wand – laws of physics apply
 - ^{226}Ra Half-Life is 1620 years
- Where Uranium exists, Radium will always be present
- Where Radium exists, Radon will always be present

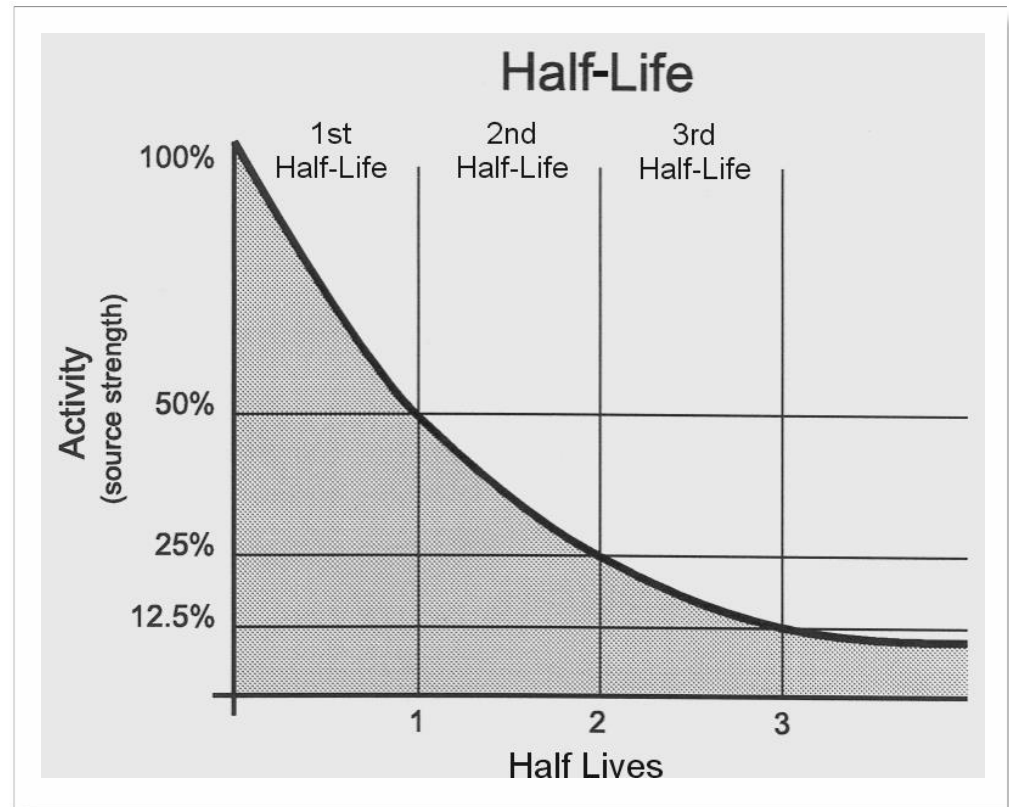
4 Be Beryllium 9.01218
12 Mg Magnesium 24.305
20 Ca Calcium 40.078
38 Sr Strontium 87.62
56 Ba Barium 137.327
88 Ra Radium 226.0254



Radiation & Radioactive Decay

Radioactive Half-Life

- Time ($T_{1/2}$) required for radioactivity of sample to decay to half of original concentration.
- $T_{1/2}$ of ^{226}Ra = 1620 yrs
- $T_{1/2}$ of ^{210}Pb = 22.3 yrs

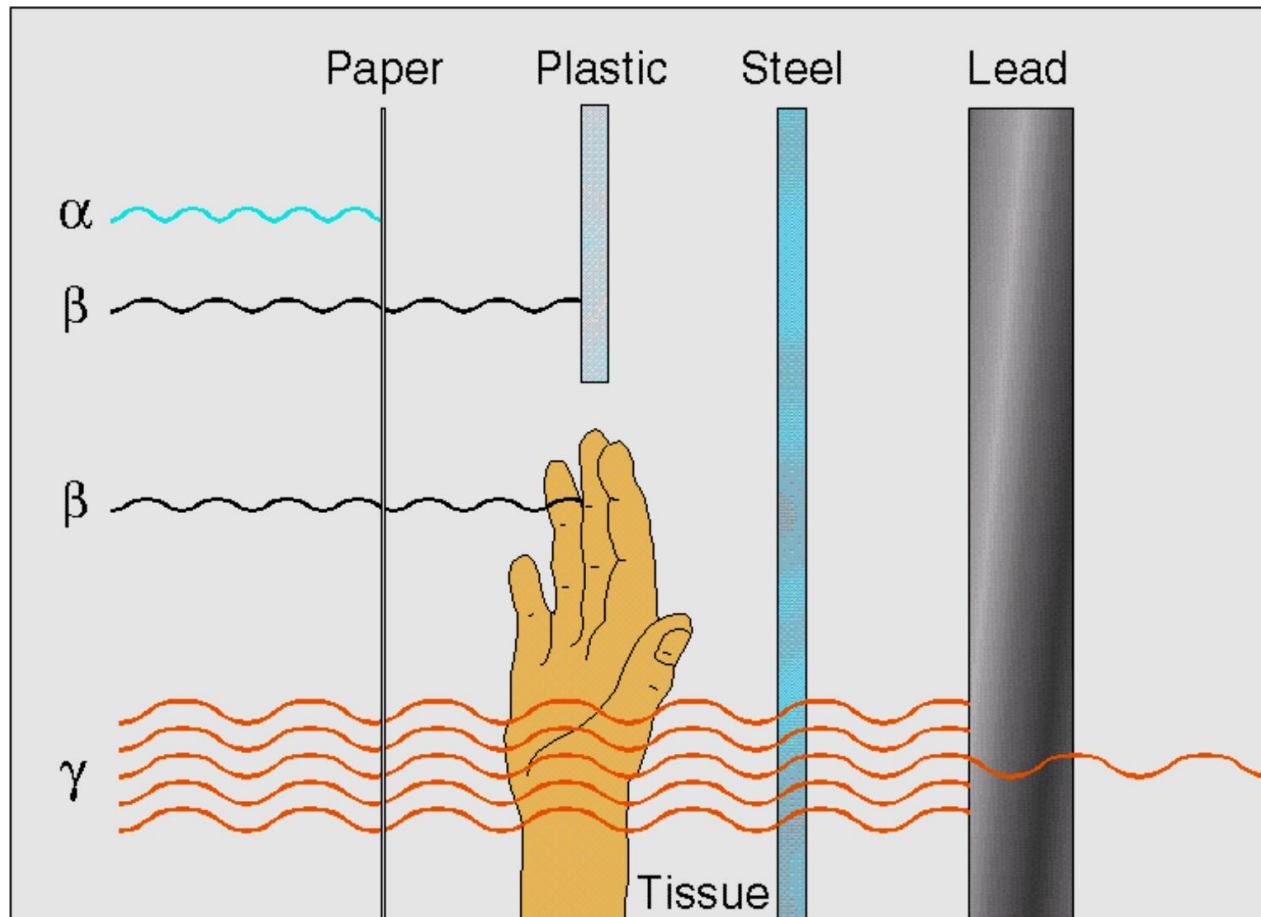


Radionuclide Health Concerns

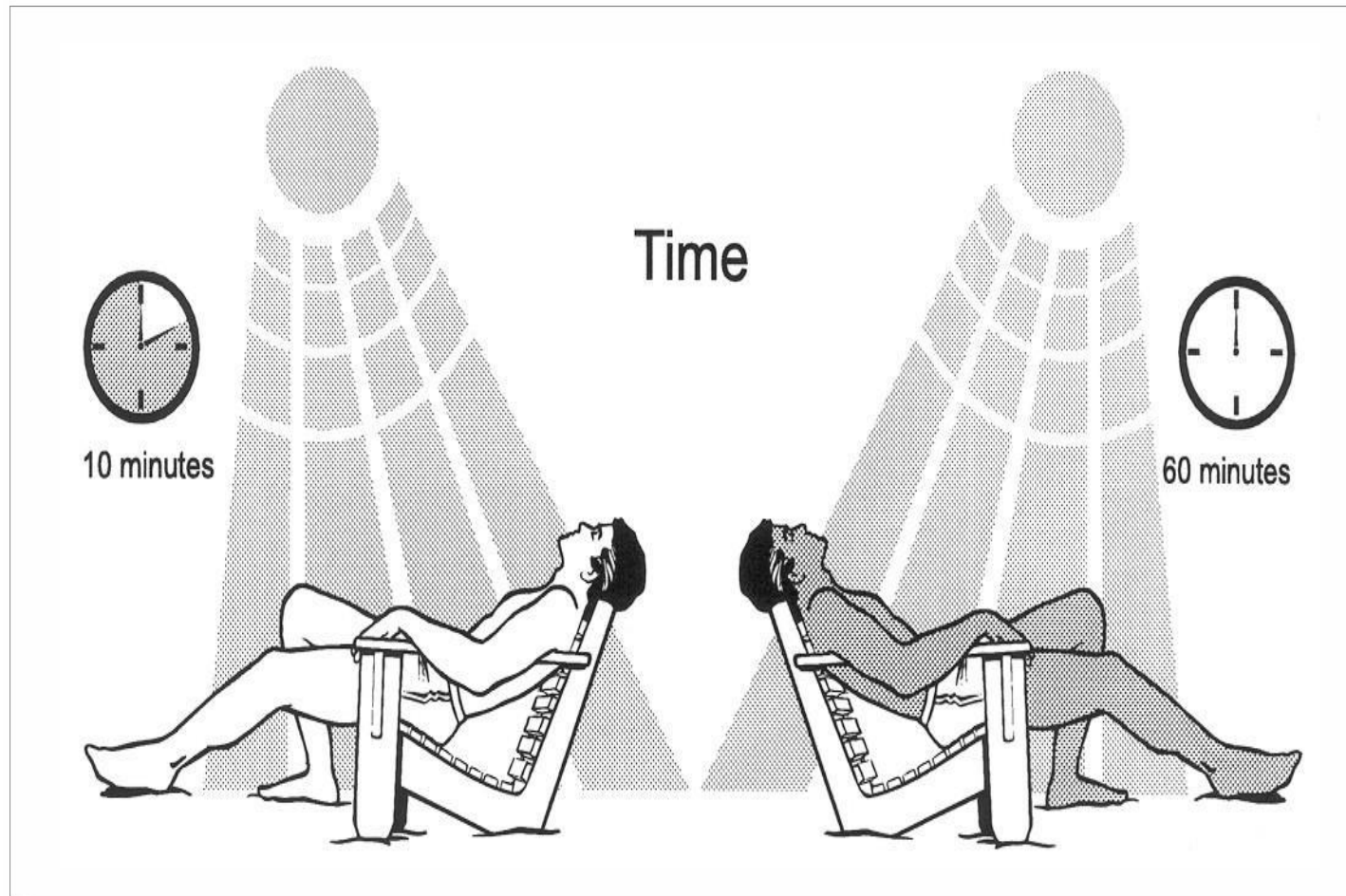
Avenues of exposure:

- Ingestion (Toxicity)
 - Drinking water and food preparation
- Inhalation (Alpha emitters)
 - Primarily limited to concerns with Radon, Thoron, Pb, Po
 - Polonium represents the greatest risk
- Gamma Radiation
 - Energy is emitted as radionuclides decay
 - Damages DNA; may cause cancer depending on levels

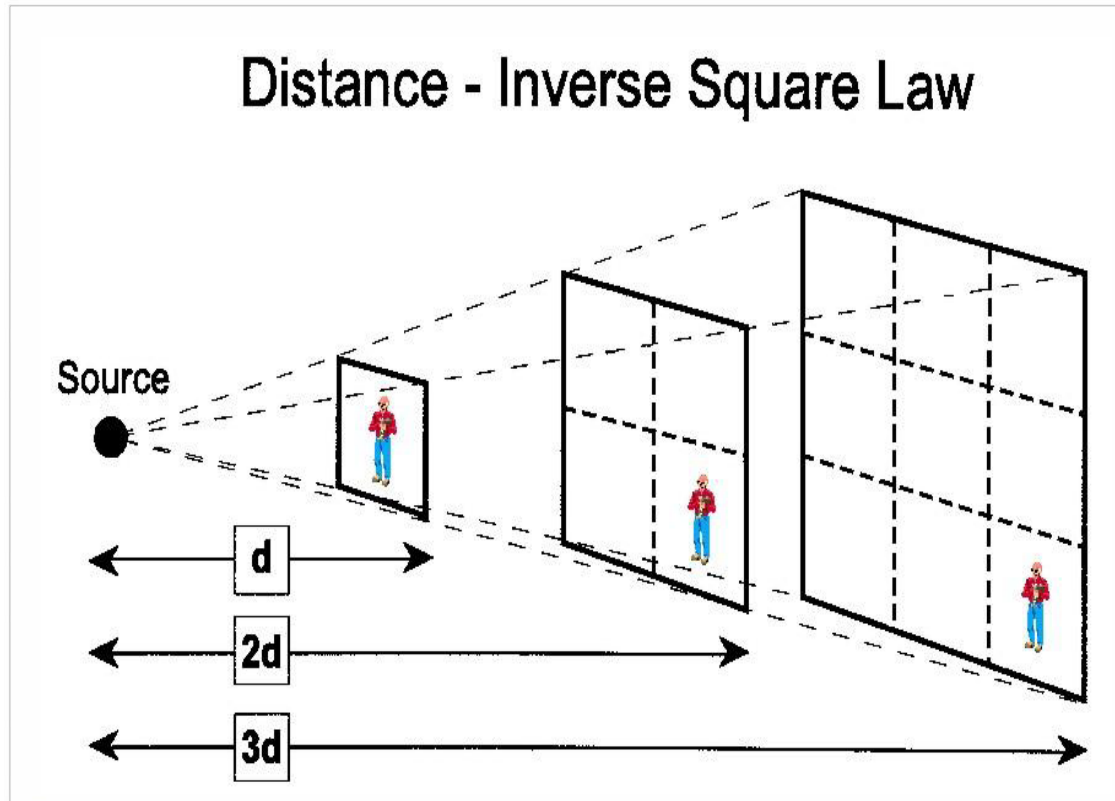
Radiation Emitted



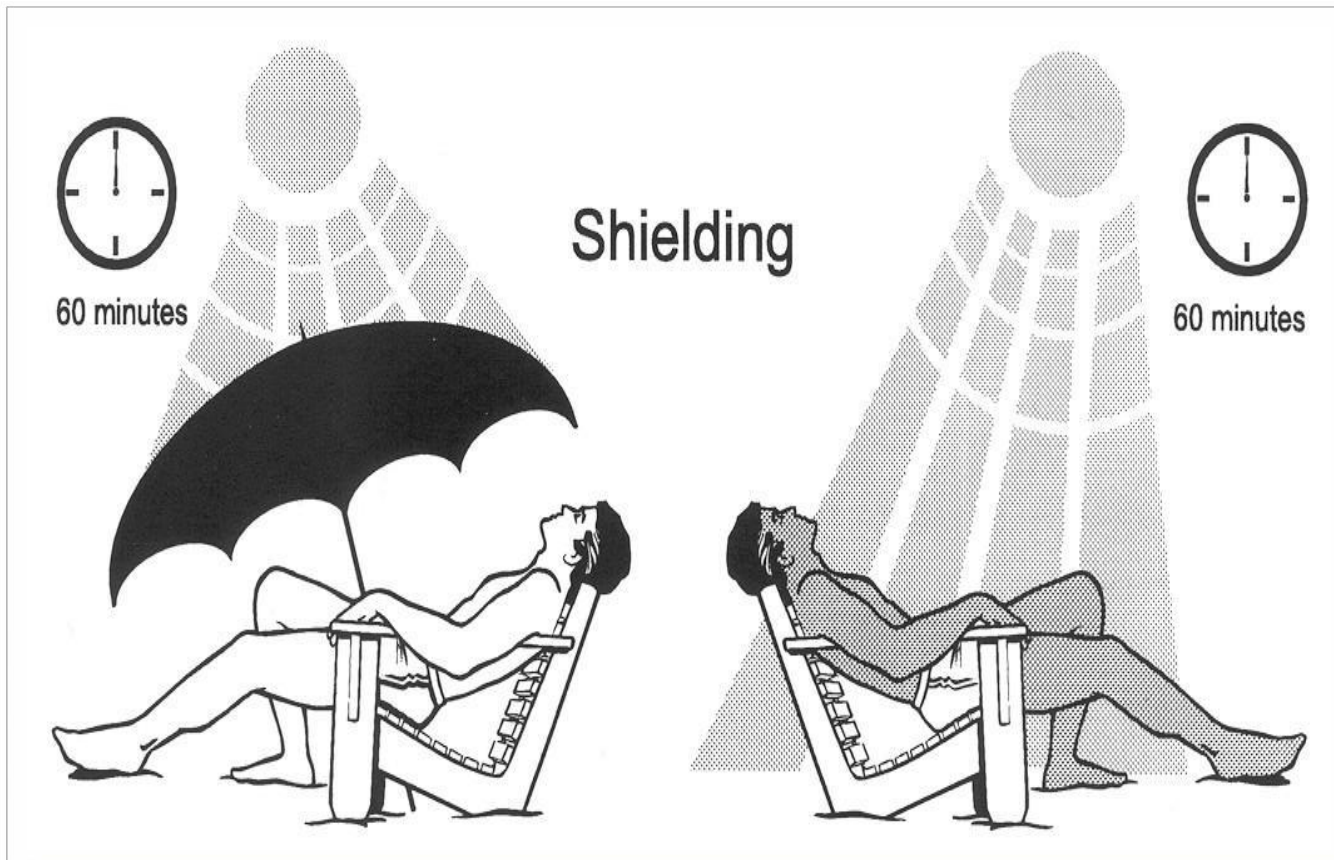
Worker Protection



Worker Protection



Worker Protection



Worker Protection

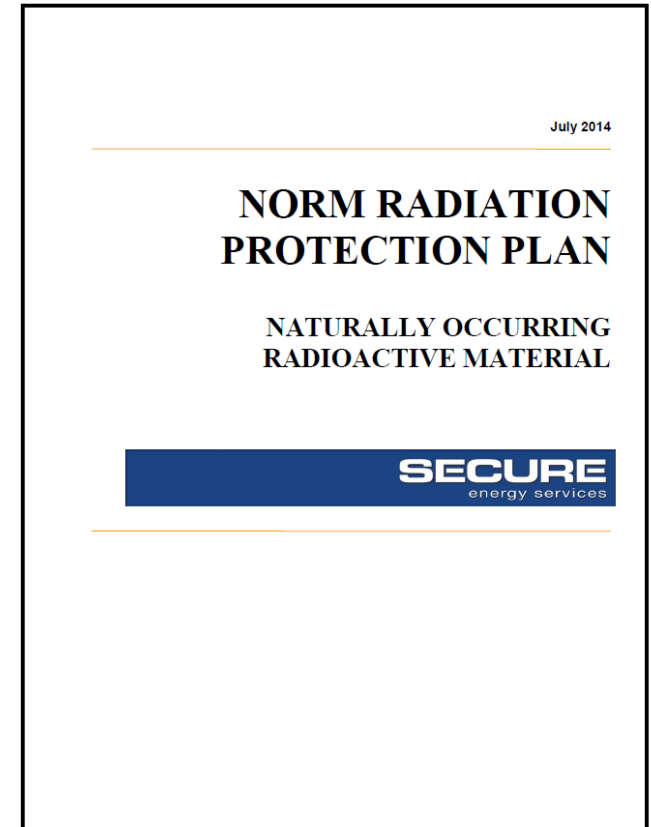
TENORM PPE

- ✓ HEPA P-100 respirators
- ✓ Safety goggles / glasses / face mask
- ✓ Latex rubber and / or neoprene gloves
- ✓ Rubber work boots
- ✓ Coveralls: Rubber, PVC slicker suits or impermeable disposable suits.
- ✓ Duct tape cuff openings



NORM Management Program

- A statement of purpose and responsibilities
- Risk identification, assessment and control
- ★ ■ Education and training
- Written work procedures
- Hygiene facilities and decontamination procedures
- ★ ■ Health monitoring – internal and external
- Waste Management
- Documentation



Sources of Radiation – U.S. Averages

NATURAL SOURCES – 310 millirem/year

- Cosmic (Space) 5%
- Terrestrial (Soil) 3%
- Radon and Thoron 37%
- Internal 5%

MANMADE SOURCES – 310 millirem/year

- Medical Procedures 36%
- Nuclear Medicine 12%
- Consumer Products 2%
- Industrial and Occupational .1%

Relative Exposure Levels

SOURCE OF EXPOSURE	urem	Per
Coal Burning Power Plant	165	yr
X-rays from TV set @ 1"	500	hr
Airplane ride @ 39,000 ft.	500	hr
Nuclear Power Plant at boundary	600	yr
Building Materials	3000	yr
Drinking Water	5000	yr
Chest x-ray	5-20k	exposure
Dental x-ray	10k	exposure
Cosmic Radiation (sea level)	26k	yr
Cosmic Radiation (in Denver)	50k	yr
Potassium in our bodies	39k	yr
3-Mile Island	80k	incident
Upper GI Series	245k	exposure
CT Scan	200k	exposure
Radon	200k	yr
Smoking (1 pk/day - Polonium)	280k	yr
Therapeutic thyroid exam	1 billion	exposure
Occupational worker skin limit	50 million	yr

Terms

- ALARA
- Survey
- Dose – Microrentgen (uR/hr) or Millisieverts (mSv)
- Energy level - pCi/g or Becquerel (Bq)
 - Measured in a lab
 - Units of (radio)activity, not mass

Colorado Regulation Progression

- Interim Policy and Guidance on TENORM (February 2017)
 - Established guidelines that are being used today
 - Drafted to address drinking water treatment residuals
 - Outdated
 - Waste acceptance as outlined does not correspond to available facilities
 - Exceptions allowed by CDPHE approval but very few granted in recent years
- May 12, 2017 Letter from CDPHE to Landfills
 - Notification of TENORM issue relative to oil & gas E & P Waste
 - Outlined potential path for resolution (to get landfills where they could take TENORM waste)
 - Called out the limitations and special permitting requirement by the Rocky Mountain Low Level Waste Board for waste coming into CO from out of state (or going outside of the compact region from CO)
- July 20, 2017 Rescission of May 12, 2017 Letter
 - Rescinded but still admonished landfill operators to properly characterize waste for TENORM

Colorado Regulation Progression

■ Why the Rescission?

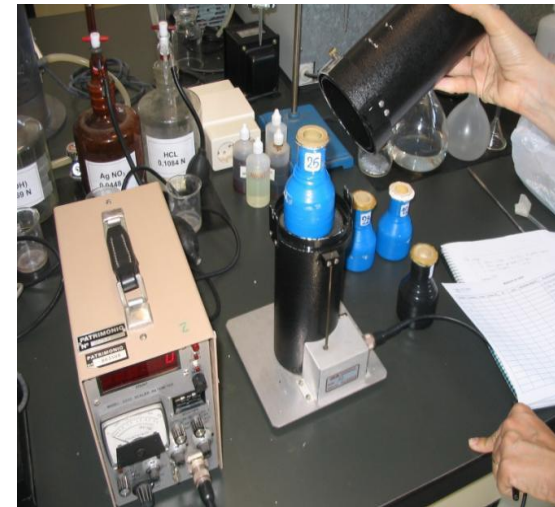
- Conflicting provisions between Solid Waste and the Radioactive Materials Unit
- Provision in radiation statutes that doesn't allow new requirements for disposal that go beyond the guidance published federally by the EPA

■ What's Next?

- Another letter will be sent to landfills modifying their waste acceptance criteria and outlining their testing requirements (likely this year)
- CDPHE will go to legislature to remove the rulemaking prohibition
- Stakeholder and rulemaking processes will follow
- Board of Health has to rule on any regulations involving radiation
- Rule/regulatory change implemented (likely 2-3 years out)

What Analytical Is Typically Required?

- Representative Sampling
- 21-Day In-growth Period
- Tests/parameters in CO
 - ✓ Gross alpha/beta
 - ✓ ^{Nat}Uranium
 - ✓ ^{Nat}Thorium
 - ✓ Radium-226
 - ✓ Radium-228
 - ✓ Lead-210



TENORM Waste Acceptance at CO Landfills

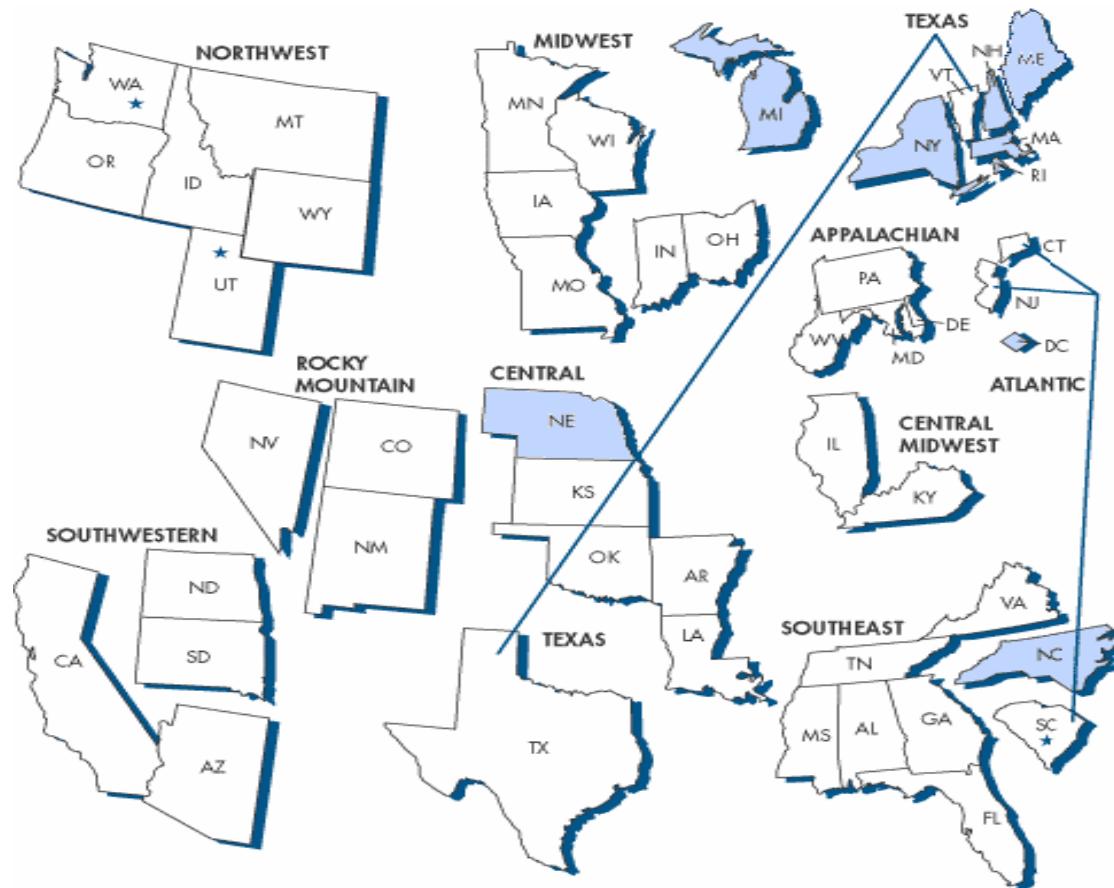
Operate under specific certificate of designation restrictions

- E & P Exemption isn't a free pass where radioactivity is concerned (6 CCR 1007-2) - *Analytical required*
- Thresholds for rejection:
 - ^{Nat}Thorium > 3 pCi/g *above background*
 - ^{Nat}Uranium > 30 pCi/g *above background*
 - Ra-226 plus -228 combined > 3 pCi/g *above background*
 - *Exceptions are available with CDPHE approval – a slow process*

Approved TENORM Landfills in the Region (Today)

- **Clean Harbors/Deer Trail** – 98 miles from Greeley
222 pCi/g combined Radium – slower profile process & pipe and debris are more difficult to gain acceptance
- **Buckhorn Energy/Lindsay, MT** – 581 miles from Greeley 50
pCi/g combined Radium or 100 μ R/hr debris
- **US Ecology/Idaho** – 775 miles from Greeley
1500 pCi/g combined Radium
- **Lotus LLC/Andrews, TX** – 701 miles from Greeley
Unlimited levels for E & P Exempt – can be expensive
- **Pawnee Landfill** (opening soon) – 56 miles from Greeley
50 pCi/g

Compacts



Other Regulatory Agencies

- NRC/state agencies regulate most uses of radioactivity (10 CFR 20 and others)
- DOT regulates transportation of radioactive materials (49 CFR 171-173)
- EPA regulates some environmental discharges or contamination but is silent specific to TENORM
- States regulate most NORM/TENORM and radiation-generating machinery
- FDA regulates medical devices that emit radiation

Other Regulations

- Dose to workers (10 CFR 20.1201)
- Training requirements (10 CFR 19.12)
- Badging requirements (10 CFR 20.1502)
- Records (10 CFR 20.2101)
- RSO qualifications (NUREG 1556)
- RAM transportation (49 CFR 171-173)
- Reports to regulators (10 CFR 20.2201)
- Posting and labeling areas (10 CFR 20.1902)
- Radioactive waste disposal (10 CFR 20.2001)

Questions?



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“A better way to handle oilfield waste”