TENORM Disposal Options in North Dakota

LLW Symposia – Phoenix

March 15-19, 2015

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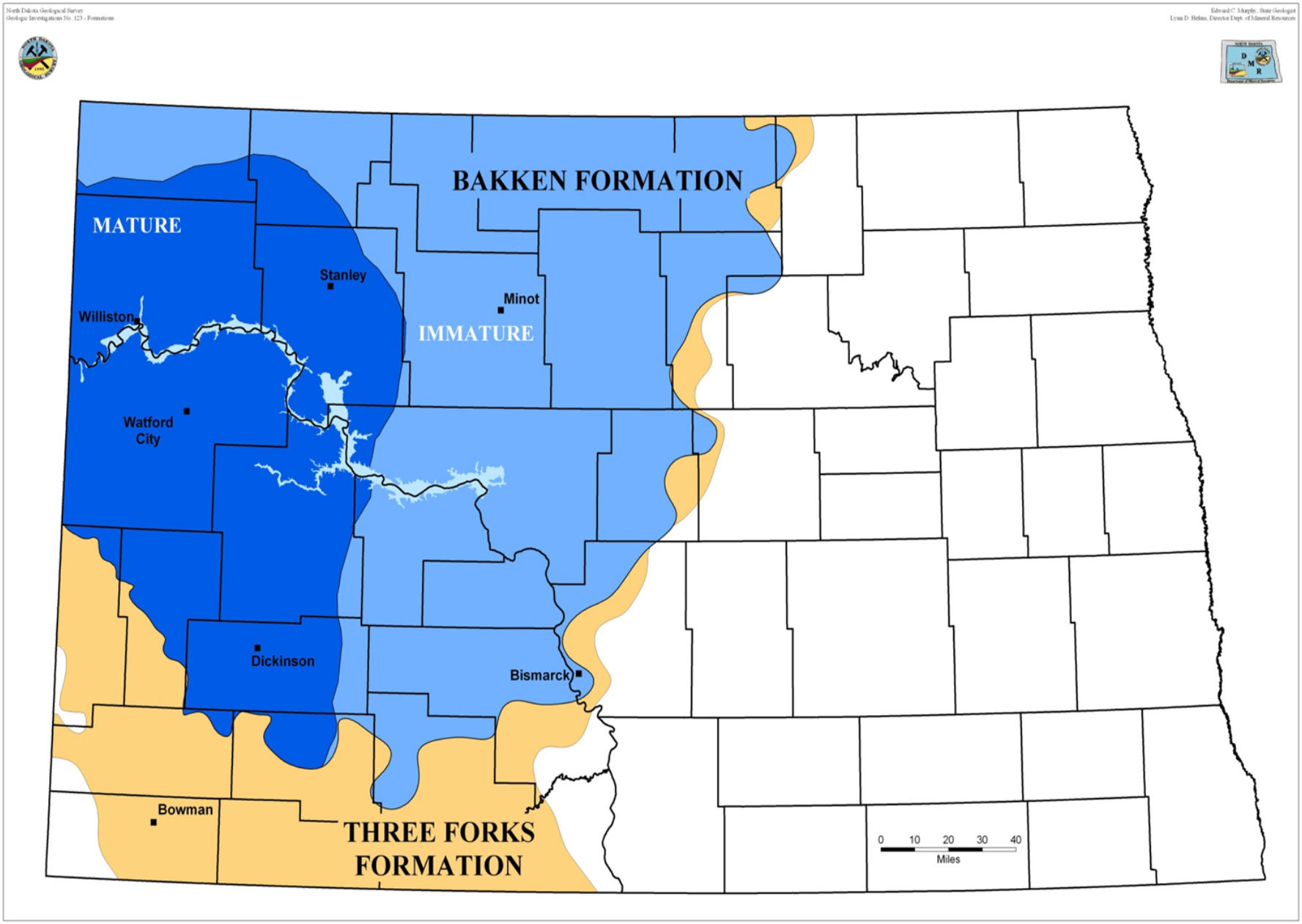
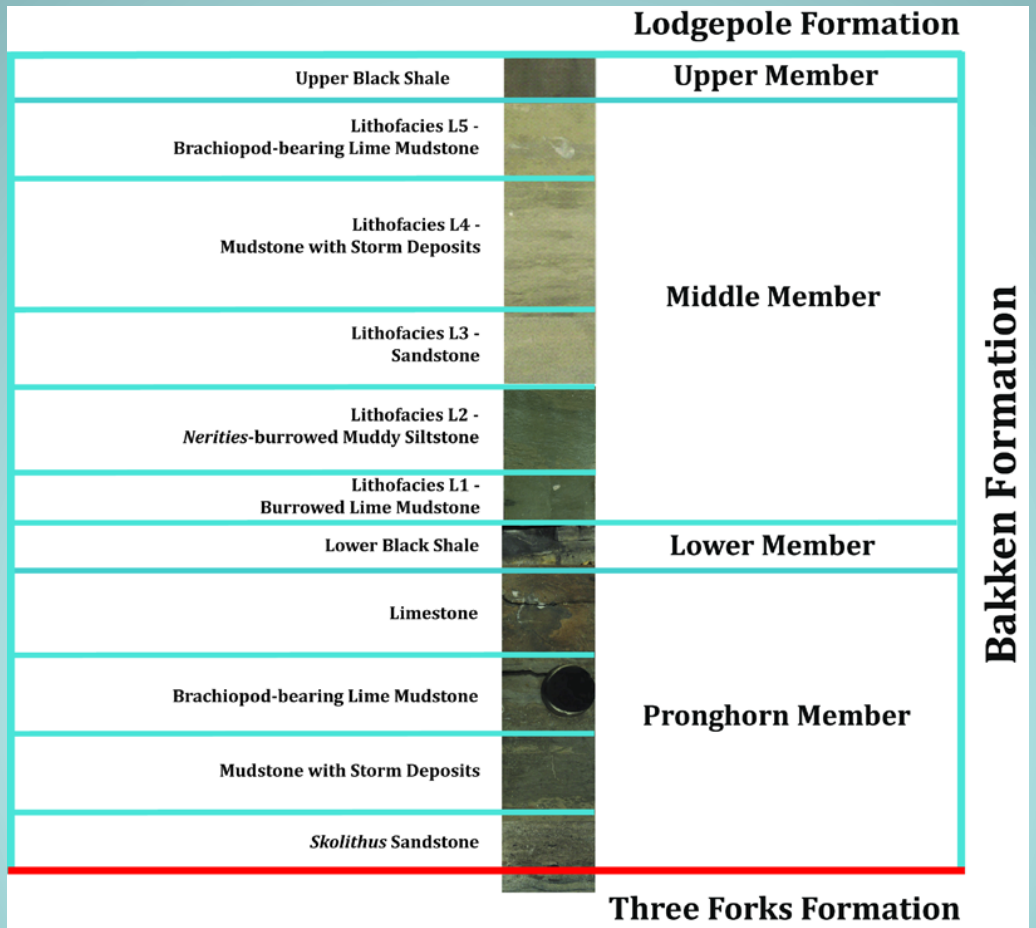

North Dakota Geological Survey
Geologic Investigations No. 123 - Formations
Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources
BAKKEN FORMATION
MATURE
IMMATURE
Stanley
Minot
Williston
Watford City
Dickinson
Bismarck
Bowman
THREE FORKS FORMATION
0 10 20 30 40
Miles

Lower Member 11,000 feet down Oil found at all levels on this diagram



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How much oil in North Dakota?

- 2013 Assessment
- Oil – 7.4 billion barrels (42 gallons/barrel)
- Natural gas – 6.7 trillion cubic feet
- Natural gas liquids – 0.53 billion barrels
- 193 drilling rigs operating capable of 20,000 ft. depth

AS of December, 2014

- 1,227,344 barrels/day produced
- 1,508,510 million cubic feet of natural gas/day
- 12,124 producing wells
- Estimated that there will be 50,000 – 70,000 producing wells when this is finished.
- Estimated to continue for more than 20 years
- February 2015 rig count 137 (lowest since July 2010)
- Drilling has begun about 125 miles to the southeast of current activity for natural gas with one well complete finding gas as expected
- 750 wells waiting on completion services (fracking)


Minneapolis - St

Hydraulic Fracturing

- **Already developed easy oil**
  - **Oil flows easily without fracking**
- **Unconventional Reserves**
  - **Reservoirs are tight**
  - **Uneconomic to produce w/o fracking**
  - **Must create a path for oil to flow**

Fracking Process

- Much of the flowback water is reused in the next well, but must be filtered before it can be used again. (**This is one of the problems facing North Dakota**)
- The produced water is taken to a **Permitted Salt Water Disposal Well** to be pumped down hole at 5,000+ feet.
- This water must be filtered so the disposal well does not get plugged up.
- These suspended materials contain Naturally Occurring Radioactive Materials (NORM).

Filter Socks!

June 1, 2014

- Leak Tight containers required
- Must have a Solid Waste Haulers permit
- Drivers must have HAZMAT endorsement
- Each company must supply a letter to the Department stating the name of the individual responsible for the radiation safety program
- Must submit quarterly load reports
- Must be registered with the ND Secretary of State
- Must have a Radioactive Material Haulers license

NORM

- Some of the radioisotopes found in the soils of North Dakota are:
  - Radium-226
  - Radium-228
  - Lead-210
  - Potassium-40

A Small Sample from North Dakota

Nearly 150 Illegal Oil Waste Dumps" – AP

"Filter Sock Mess Could Lead to Enforcement Action" – Bismarck Tribune

"Watford City Struggles with Radioactive Oil Waste" – Billings Gazette

"Strange Byproduct of Fracking Boom: Radioactive Socks" – Forbes

"Officials, Operator to Meet in Filter Socks Probe" – KX News

Trailers with stored socks

2-20 yard roll off containers

Background Measurements

- Early work done in 1984-1986 by USEPA-ORP out of Las Vegas and North Dakota Department of Health regarding background radiation levels
  - EPA 520-1-86-013
  - "Report on the Survey of Abandoned Uraniferous Lignite Mines in Southwestern North Dakota"
  - Work was done in western North Dakota as part of the UMTRA program
  - Background levels for Ra-226 found to be 4.2 pCi/gm during this work (1.4 – 9.7 pCi/gram)
  - Origination of 5 pCi limit for disposal in North Dakota

Currently in North Dakota

- Currently the solid waste disposal limit for TENORM in North Dakota is 5.0 pCi
- Landfills levy fines of $1,000.00 per filter sock if found in the load presented for disposal
- TENORM waste (filter socks, sludge, pipe scale, etc) is transported out of state
- Risk Assessment study currently underway with Argonne National Labs to possibly increase the disposal limits

Argonne National Laboratory

- **Radiological Dose and Risk Assessment of Landfill Disposal of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) in North Dakota**

Change in Disposal Limits?

- Argonne study is final, and the Department of Health has drafted rule changes to permit the disposal of TENORM (50.0 pCi/gram) in Special Waste landfills and large volume Industrial landfills for which a permit modification will be required for existing facilities.
- Any new landfill would need to submit a complete application as a Special Waste landfill.
- Oaks Landfill, just across the border in Montana, currently has a disposal limit of 30 pCi/gram.
  - Oaks is used frequently because of the close proximity to the oil fields.
- Clean Harbors or US Ecology are used as well for waste materials above the 30 pCi/gram limit of Oaks.

North Dakota Proposed Rules

- CRCPD Part N – modified to include Solid Waste Program
- North Dakota is licensing those companies that treat TENORM (must have trained RSO)
- Transfer stations require licensure
- TENORM transporters are required to be licensed
  - Solid waste permit required
  - Registration with the ND Secretary of State is required
  - Drivers must have HAZMAT endorsement
  - Quarterly load reports are required
    - Standard format used and filed electronically
  - Must have a qualified person responsible for their program

Quarterly Load Report

	A	B	C	D	E	F	G	H	I	J	K
2	COMPANY NAME:			License #		Year:	2015	Quarter:	1st Quarter Report		
4	Manifest #	Collection Date	Pickup Location	Disposal Date	Disposal Location	Weight (lbs)	Physical Form	Concentration (pCi/gm)	Cubic Yards	Gallons	
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											

Rule making process update

- Rules are in final draft form ready for the following process:
  - Public comment period (extended to March 2, 2015)
  - Public Hearing (3 held across the state)
  - Prepare response to Public Comments after March 2, 2015
  - Review by Attorney General (spring 2015)
  - Presented to the North Dakota Health Council (summer 2015)
  - Presented to Legislative Rules Committee (summer 2015)
  - Presented to Legislative Council for publishing (fall 2015)
  - Rules take effect after publishing (fall or winter 2015)

Assessment of TENORM Disposal in North Dakota Industrial Waste and Special Waste Landfills

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Environmental Science Division
Argonne National Laboratory

Public Meeting Presentation
Williston, Jan. 20 / Bismarck, Jan. 21 / Fargo, Jan. 22

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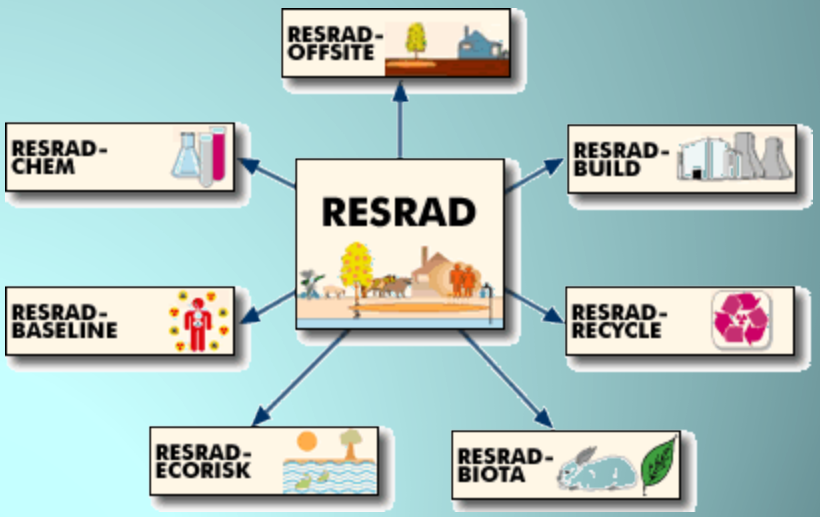
Argonne Has Developed Computer Codes to Assess Radiological Risk

- The RESRAD code was developed with funding from the U.S. Department of Energy and U.S. Nuclear Regulatory Commission.
- It is used to develop site-specific guidelines for managing residual radioactive materials:
  - Estimate radiation doses and cancer risks for future site users,
  - Evaluate the effectiveness of various disposal and remediation actions in terms of limiting future radiation exposures,
    - Evaluate uncertainty associated with key site and/or waste parameters, and
    - Establish appropriate cleanup criteria from a risk-based perspective.
- Argonne also has developed the TSD-DOSE code to evaluate risk from specific treatment, storage, and disposal (TSD) activities.



RESRAD = RESidual RADioactivity

Study Objective

- Support the North Dakota Department of Health's (NDDH) efforts to update Waste Management Rules regarding TENORM.
- Provide science-based radiological dose and risk assessment of the disposal of TENORM wastes in permitted Industrial Waste and Special Waste Landfills in North Dakota.
- Evaluate potential exposures to workers and the general public resulting from TENORM management and disposal, on the basis of available waste characterization data.
- Considered a number of activities:
  - Oilfield operations (worker exposures from well-site operations),
  - Mismanaged filter socks and proppants (accidental public exposures),
  - Transportation of TENORM to landfills (both drivers and general public exposures),
  - Landfill operations (both workers and general public exposures), and
  - Future use of the property following landfill closure (general public exposures).

TENORM Waste Streams from Oil and Gas Development in North Dakota

- Produced Water
  - Formation water that is produced along with hydrocarbons. Radionuclides that are mobilized in formation water are brought to the surface in this waste stream.
- Scale
  - Hard and relatively insoluble deposits that accumulate inside production and processing equipment and on solid debris (e.g., sand grains) that comes in contact with produced water (typically $BaSO_4$ or $SrSO_4$). Radionuclides can co-precipitate with the sulfate scales.
- Sludge and Filter Cake
  - Solid material including mud, sand, scale, and rust that settles or is filtered out of produced water. It is found in vessels used to store or manage produced water and in filter socks.
- Filter Socks
  - Disposable filters used for filtering produced water accumulate sludge and filter cake over time which may contain radionuclides
- Synthetic Proppants
  - Some imported synthetic proppants can contain low concentrations of radionuclides
- Contaminated Soils and Equipment

Several Different Pathway Analysis Codes Were Used to Support the Radiological Dose Assessments

- RESRAD
  - Future use of the property following landfill closure
- RESRAD Build
  - Oilfield operations
  - Mismanaged filter socks and proppants
- RADTRAN
  - Transportation of TENORM to landfills
- TSD-DOSE
  - Landfill operations
- RESRAD Offsite
  - Used to evaluate groundwater transportation of TENORM, including decay

Different Modeling Methodologies Were Used to Evaluate Various Scenarios

Well Site Operations and Accidental Public Exposures

- Dose rates based on average and maximum radionuclide concentrations as presented in available waste characterization data provided by NDDH

Landfill Operation and Future Use of Landfill Property

- Calculated the maximum concentration of radionuclides that could be disposed of in the landfill without resulting in doses greater than 100 mrem/yr for any receptor

Transportation-Related Exposures

- Dose rates based on the maximum concentrations calculated for the landfill disposal option

Hydrology

- Hydrologic modeling evaluated the possible movement of TENORM through the landfill into subsurface groundwater, and through the subsurface to a drinking water well.

Well Site Operations Sensitivity Analysis Results

Operations	Maximum Concentration		Average Concentration	
	With PPE (mrem/yr)	Without (mrem/yr)	With PPE (mrem/yr)	Without (mrem/yr)
Mixing hydraulic fracturing fluid	23	30	20	26
Pipe cleaning	127	650	14	390
Storage tank cleaning	70	73	3.8	7.4
Equipment cleaning at gas processing facility	0.012	670	0.0003	18
Sludge treatment	30	85.8	1.6	15.4

The use of PPE can effectively reduce potential exposures for many workers.

Based on maximum concentrations, doses for the equipment cleaning workers could be elevated even if PPE are used.

It may be necessary to limit exposure time to keep exposures to these workers below 100mrem/yr.

Accidental Public Exposure Scenarios

Scenario	Exposure Time Over One Year Period
Child playing with filter socks	24 hrs
Adult exposed to filter socks in a dumpster	40 hrs
Child playing in area where synthetic proppant has been dumped on the ground	100 hrs

These scenarios are not representative of all possible exposures related to improperly managed filter socks and proppants.

Accidental Public Exposure Assessment Results

Scenario	Maximum Concentration	Average Concentration
	Total Dose (mrem/yr)	Total Dose (mrem/yr)
Filter socks used a toy	0.21	0.051
Filter socks dumped in a dumpster	4.4	0.40
Illegal dumping of proppant on a field	1.4	1.2

For the scenarios modeled, the risks of short term exposure to improperly disposed of filter socks and synthetic proppant are low.

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Transportation Risk Assessment Scenarios and Results

Receptor	Base Case (1,000 Shipments/yr)	Maximum Case (2,000 Shipments/yr)
	Dose (mrem/yr)	Dose (mrem/yr)
Routine Conditions		
Driver[a]	20	20
Individual[b]	1.6×10^{-6}	3.2×10^{-6}
General population[c]	6.5×10^{-5}	1.3×10^{-4}
Accident Conditions		
General population[c]	3.6	7.2

[a] Based on 0.01 mrem/h, 2,000 h/yr.

[b] Estimated dose and risk are very conservative because an individual may not be present for all shipments.

[c] Doses to the collective general population are expressed in units of person-rem/yr.

Potential doses associated with transportation of TENORM wastes are very low both for drivers and members of the general public.

Calculation of Maximum Allowable Radium Concentration for TENORM Disposal in the Landfills

- Calculated for 100 mrem/yr public dose limit
- Used estimated allowable TENORM concentrations for individual radionuclides
- Used sum of fraction rule and conservative activity fractions in the waste stream

Recommendations Regarding Regulation of the Disposal of TENORM in Landfills

- To ensure that potential exposures to any landfill worker or member of the general public does not exceed 100 mrem/yr
- The average concentration of total radium should not exceed 50 pCi/g of total radium provided the following conditions were met:
  - No more than 25,000 tons of TENORM wastes were disposed of in a single landfill per year.
  - The average thorium activity concentration in the waste did not exceed 24 pCi/g.
  - TENORM wastes were covered by at least 2 m (6 ft) of clean cover material.

Two-Part Study

- Primary – evaluate whether landfills in North Dakota can safely accept any level of TENORM
- Secondary – evaluate possible TENORM exposure to workers and public even if landfill limit is not changed

Landfill Risk Evaluation

- Maximum TENORM concentration was back-calculated from a predetermined maximum exposure of 100 mrem/year
- Sample data is not necessary for these calculations

Worker and Public Risk Evaluation

- Several worker and public exposure scenarios were evaluated
- The study did not include any sample collection and analysis
- Available sample data was used to give a "ballpark" range of potential exposure

Data Limitations

- Not intended to be a comprehensive study of the full range and variation of TENORM in North Dakota
- Report acknowledges that sample data is limited
- Report states that the scenarios are not representative of all possible exposures
- All real-life situations will be different

Common TENORM Materials

- Filter socks
- Pipe and boiler scale
- Tank sludge and filter cake
- Lead-210 deposits in natural gas equipment

- Drill cuttings are <u>not</u> TENORM
  - Soil and rock dug out of a vertical hole
  - Drill cuttings are NORM
  - All samples collected are in the range of natural soil in western North Dakota

North Dakota Proposed Rules Highlights

- General License
  - To perform routine maintenance and/or decontamination on equipment and facilities controlled by the general licensee.
  - Notification to the Department of Health required within 60 days of becoming subject to the general license.

Highlights continued:

- Specific License
  - Application is required (fee required)
  - Financial Assurance is required
  - Operating and Emergency procedures manual is required
  - Criminal history background under ND Century Code is required
  - RSO required
  - Applies to all treatment facilities
  - Employee training program is required
  - Registration with ND Secretary of State is required

Proposed Rules
Radiation Control Program
NDAC Chapter 33-10-23

- Conference of Radiation Control Program Directors (CRCPD) has developed suggested state regulations that address TENORM
- CRCPD Part N is the model used in developing the TENORM rules for North Dakota
- Rules establish radiation protection standards for TENORM

- Licensure required for transporters of TENORM
- Licensure required for Treatment and Disposal facilities
- Establish standards for Radiation Protection
- Establish record keeping requirements
- Describes financial assurance requirements
- Establishes Radiation Safety Officer requirements
- Outlines worker training requirements

Proposed Rules Solid Waste Program NDAC Chapter 33-20-11

- Landfill TENORM disposal requirements
  - Maximum 50 pCi/g total Ra-226 + Ra-228
  - Maximum 25,000 tons per year
  - Covered by 1 foot of non-TENORM waste or daily cover material each day
  - Must be 10 feet below surface of final cover
  - If final cover slope >15%, then final cover must be at least 5 feet thick

- Leachate and groundwater monitoring are required
- Quarterly reporting to the NDDoH
- Worker training and safety program required
- Record of notice attached to property deed will indicate volume of TENORM disposed.

QUESTIONS?

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