



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION



Bureau of Radiation Protection

TENORM - PA Study & Regulatory Framework

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**NRC SLO Meeting
September 2017**

Disclaimer

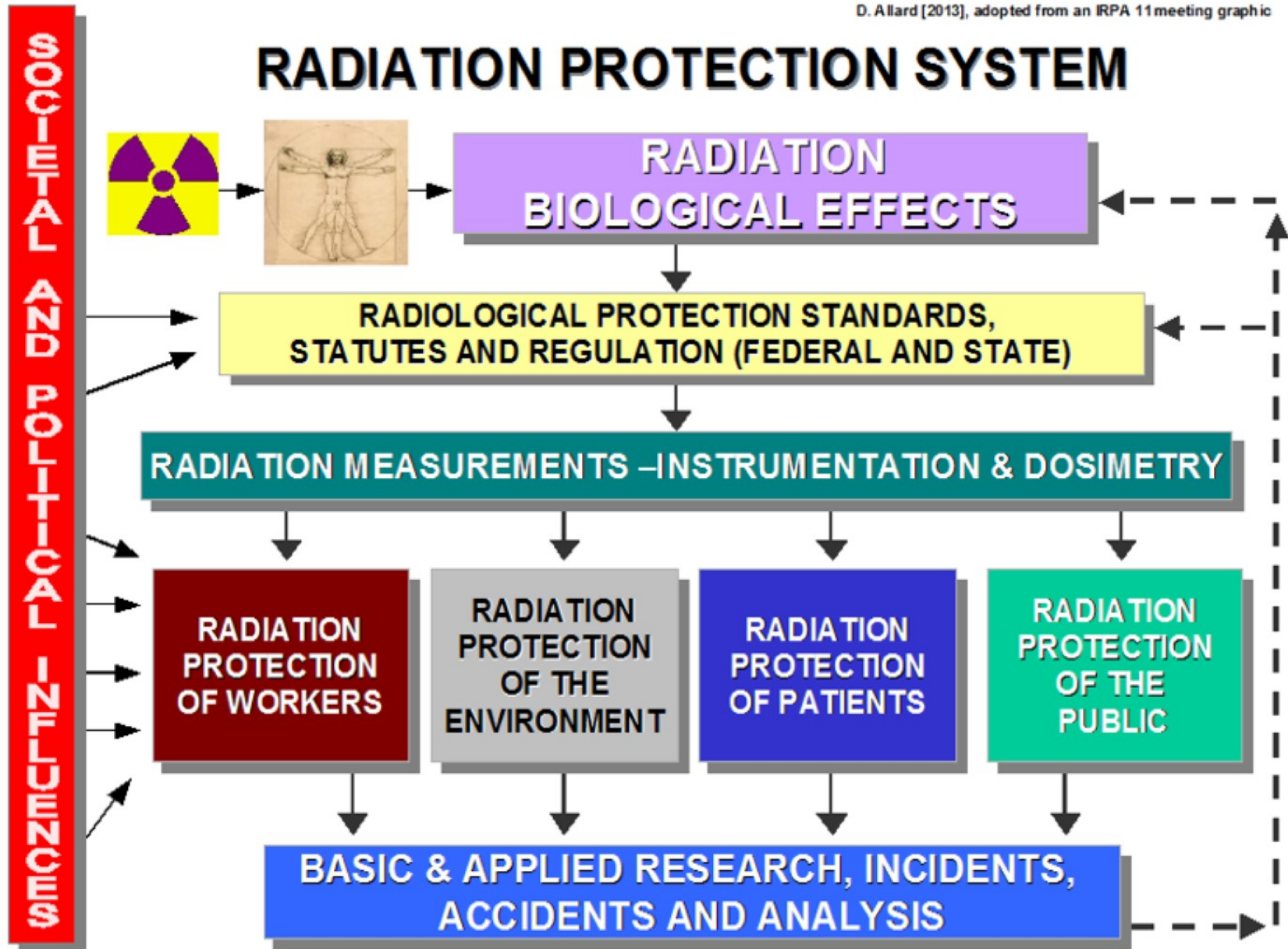
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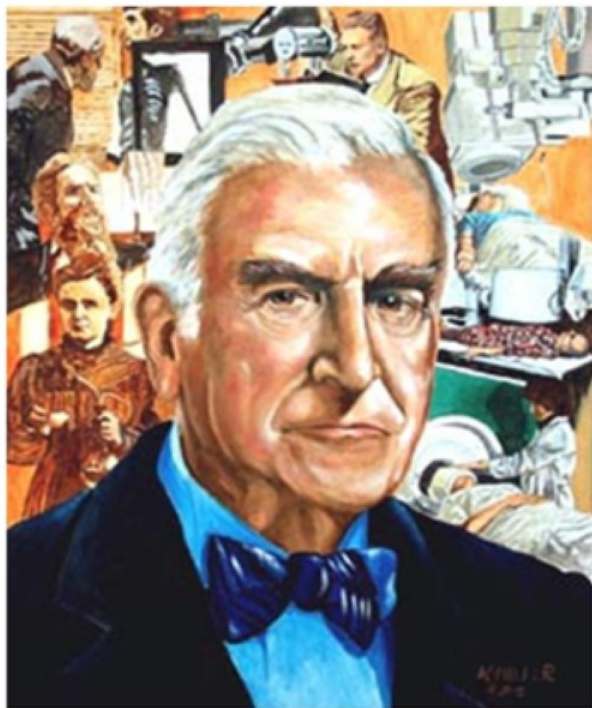
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RADIATION PROTECTION SYSTEM



➤ NCRP - Lauriston S. Taylor



Taylor painting by Ken Miller

“Radiation protection is not only a matter of science. It is a problem of philosophy, and morality, and the utmost wisdom.”

(L.S. Taylor, 1956)



TENORM & NORM Defined

Technologically Enhanced Naturally Occurring Radioactive Material

- *TENORM*, a naturally occurring radioactive material not subject to regulation under the laws of the Commonwealth or the Atomic Energy Act of 1954, whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities.
- *NORM - Naturally occurring radioactive material* - NORM is a nuclide, which is radioactive in its natural physical state - that is, not man-made - but does not include source or special nuclear material.

PA DEP Regulations, Title 25, Chapter 271

Generation of TENORM

- Oil & Gas Well Development and Production
- Mineral Sands Industry (e.g., zircons)
- Uranium and Other Mining Operations
- Water Treatment (residuals)
- Metal Refining and Recycle Industries
- Phosphate Production
- Geothermal Energy

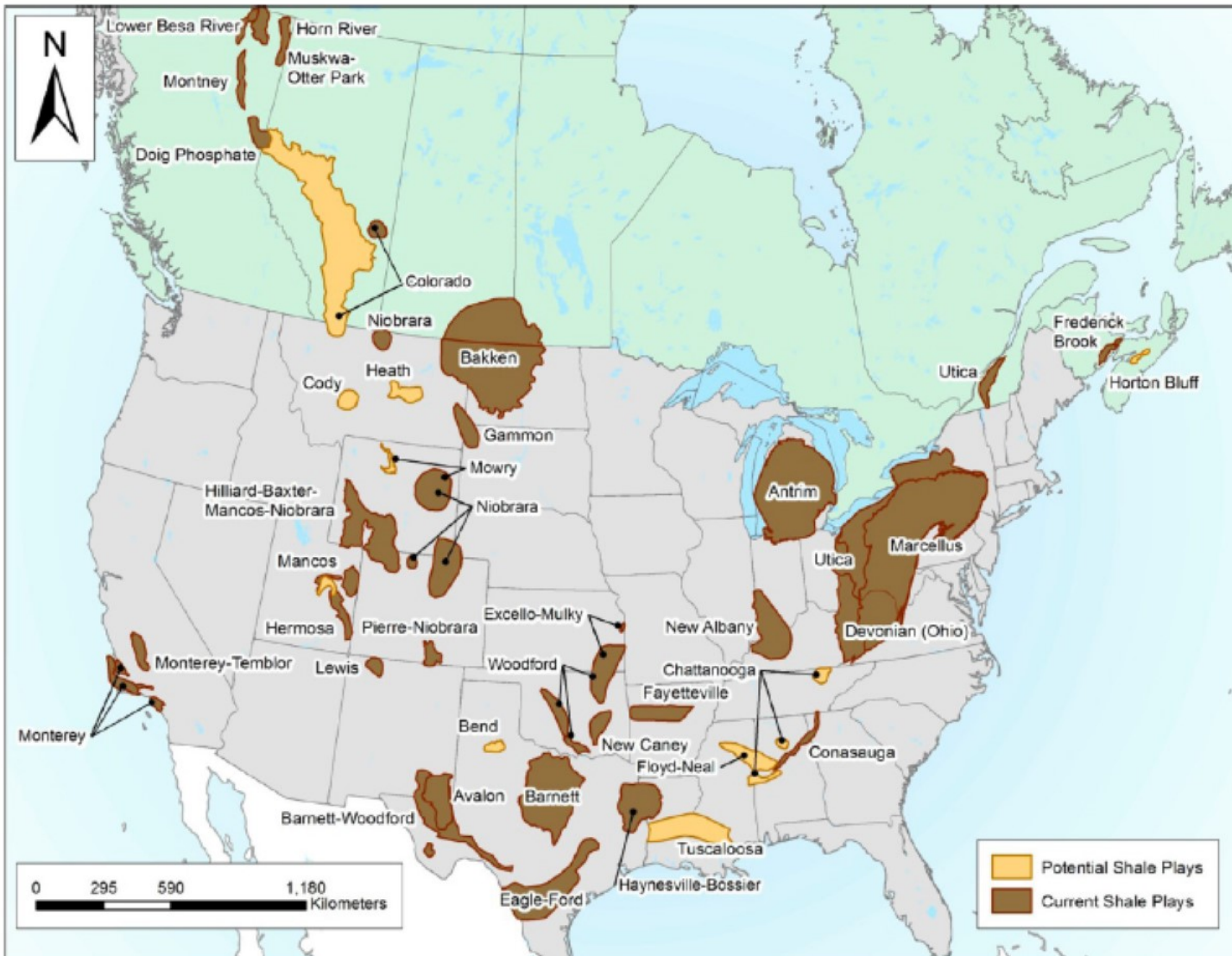


TENORM Regulatory Framework

- Environmental Protection Agency (EPA)
- Nuclear Regulatory Commission (NRC)
- Dept. of Energy (DOE)
- Dept. of Labor - Occupational Safety & Health Administration (OSHA)
- Dept. of Transportation (DOT)
- States (e.g., PA, ND, et al.)



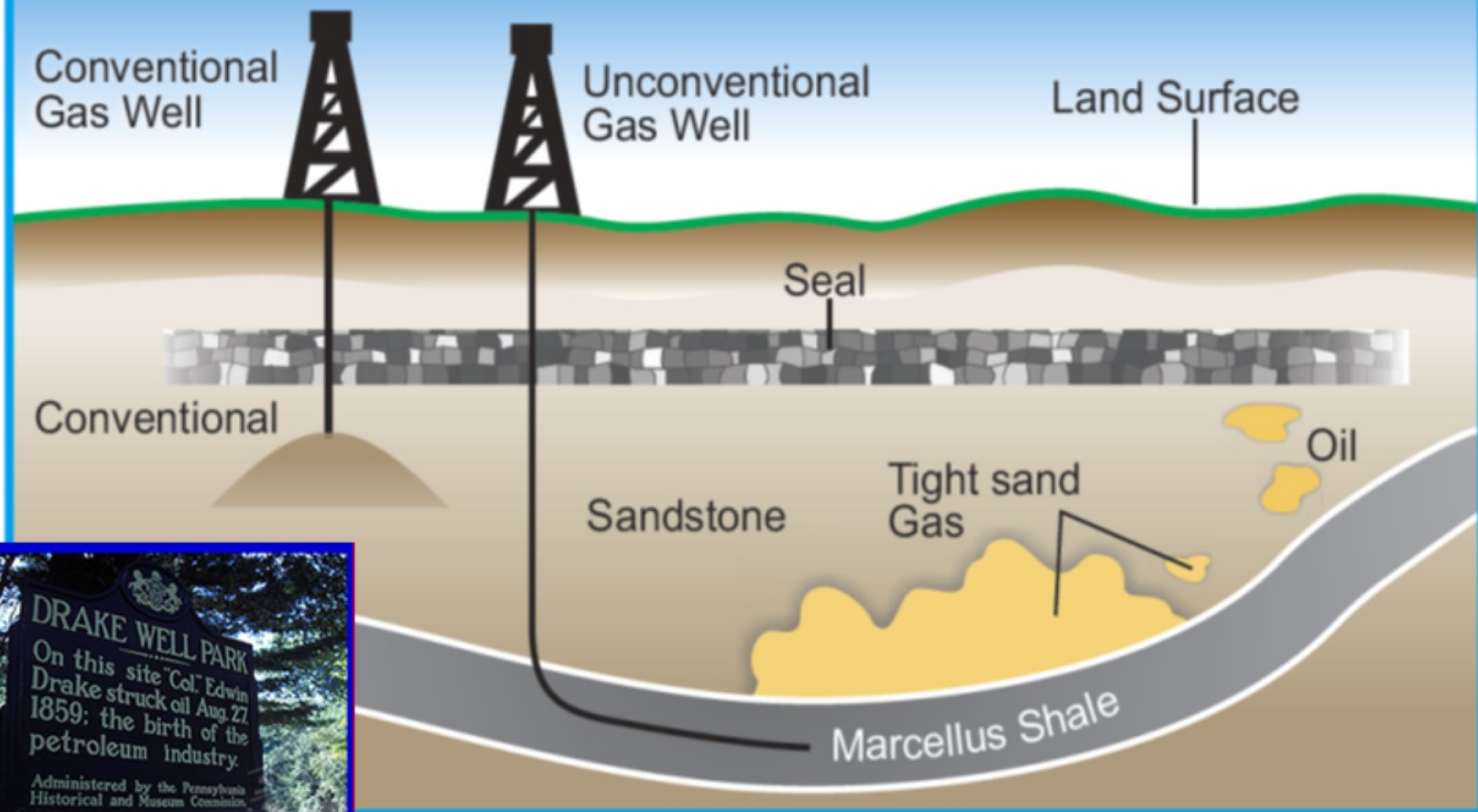
O&G Shale Plays



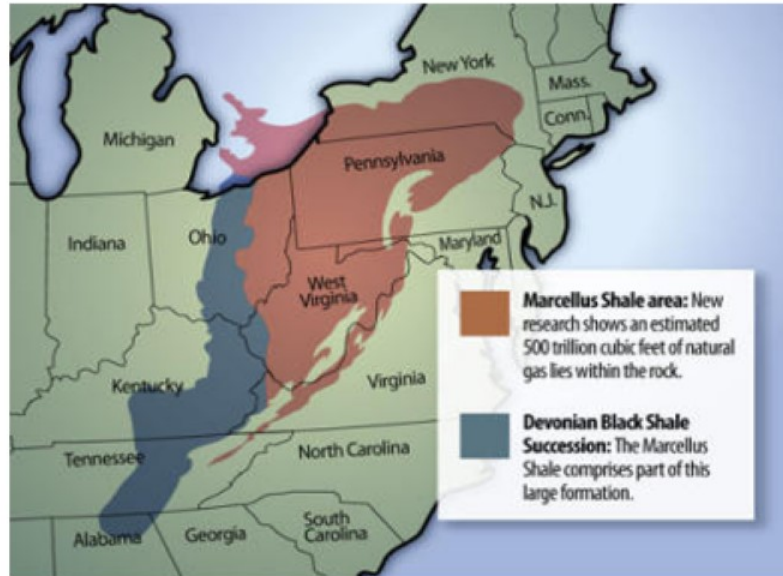
Map of unconventional shale plays in the U.S. and Canada, based on data from the U.S. Energy Information Administration.

O&G Well Types

Conventional and Unconventional Gas Wells

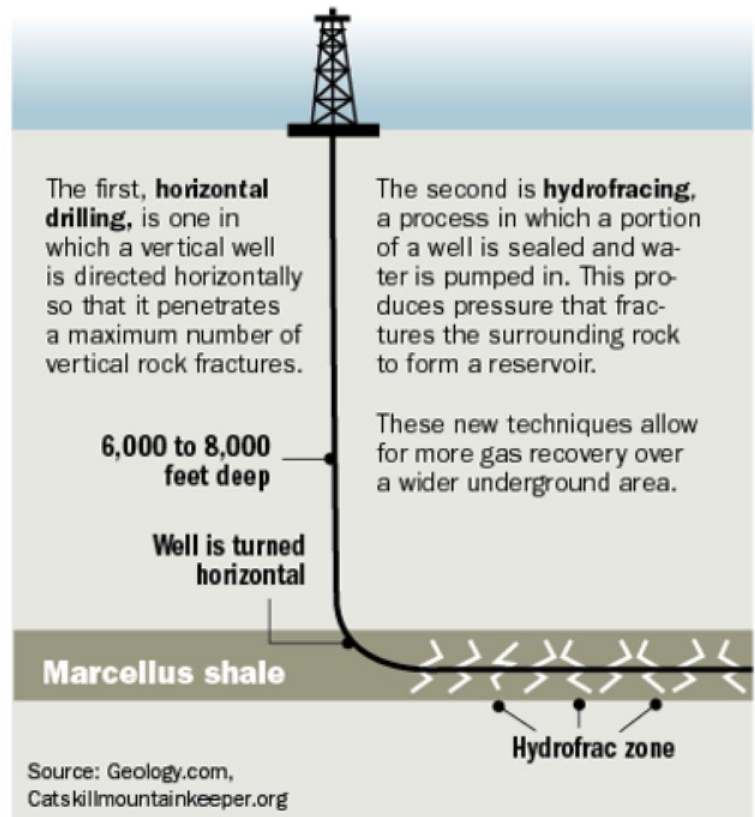


Marcellus Shale Drilling & Fracturing



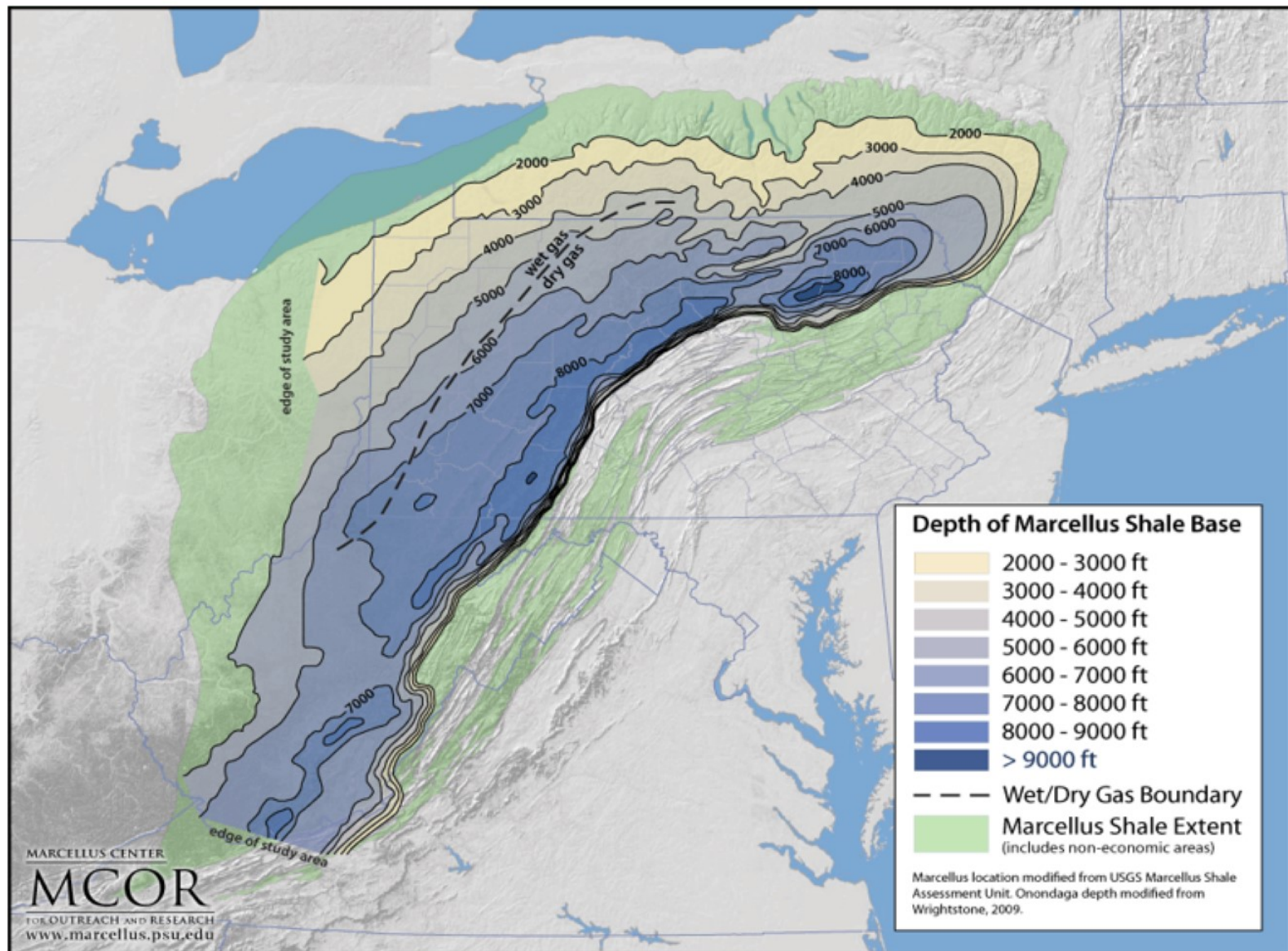
New techniques, better recovery

Two technologies relatively new to the Appalachian Basin are employed in wells drilled into the Marcellus formation.



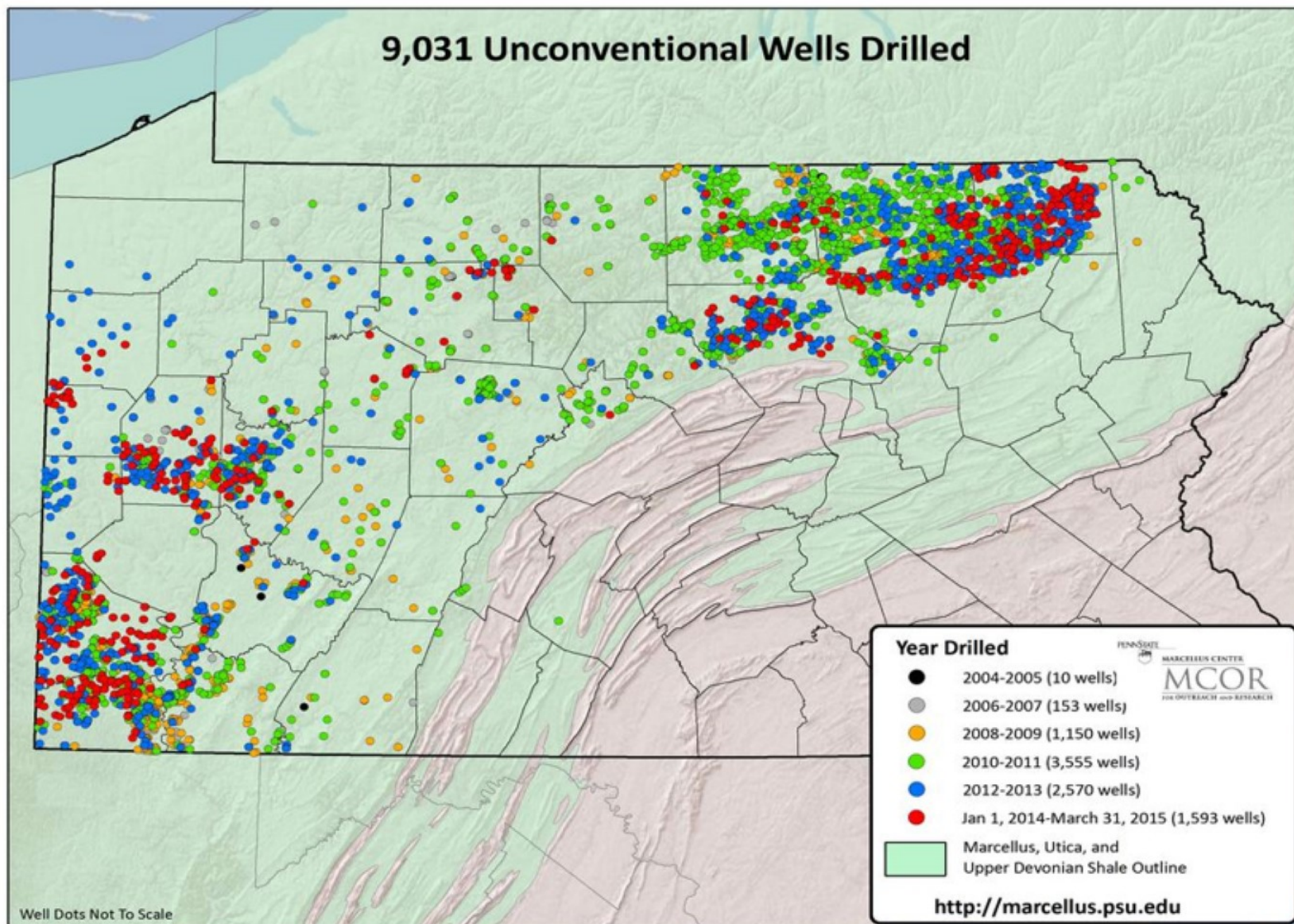
Post-Gazette

MS - Wet vs. Dry Gas



MS Gas Wells Thru 2015

9,031 Unconventional Wells Drilled



Marcellus Shale

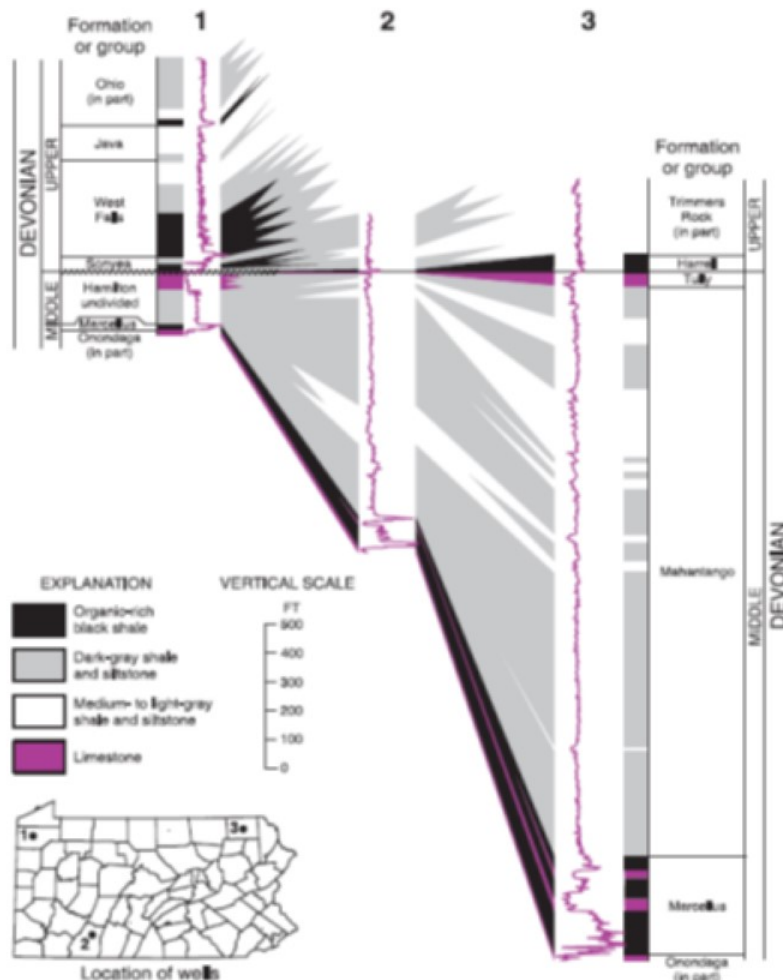


Figure 2. Correlation of Middle and Upper Devonian organic-rich shale facies and interbedded strata in three wells in Pennsylvania, based on gamma-ray log signatures (the jagged purple lines) and descriptions of well cuttings. Note that the black shales correspond in large part to higher-than-normal gamma-ray readings (radioactivity increases to the right in all log signatures).

URANIUM 238 (U238) RADIOACTIVE DECAY

type of radiation	nuclide	half-life
α	uranium-238	4.47 billion years
β	thorium-234	24.1 days
β	protactinium-234m	1.17 minutes
α	uranium-234	245000 years
α	thorium-230	8000 years
α	radium-226	1600 years
α	radon-222	3.823 days
α	polonium-218	3.05 minutes
β	lead-214	26.8 minutes
β	bismuth-214	19.7 minutes
β	polonium-214	0.000164 seconds
α	lead-210	22.3 years
β	bismuth-210	5.01 days
β	polonium-210	138.4 days
α	lead-206	stable

U-238 w Series Geochem

From: IAEA
TCS No. 40
May 2010

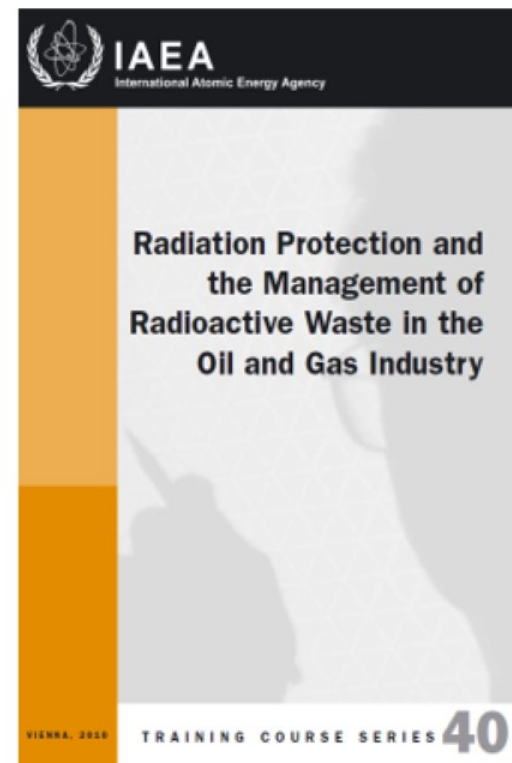
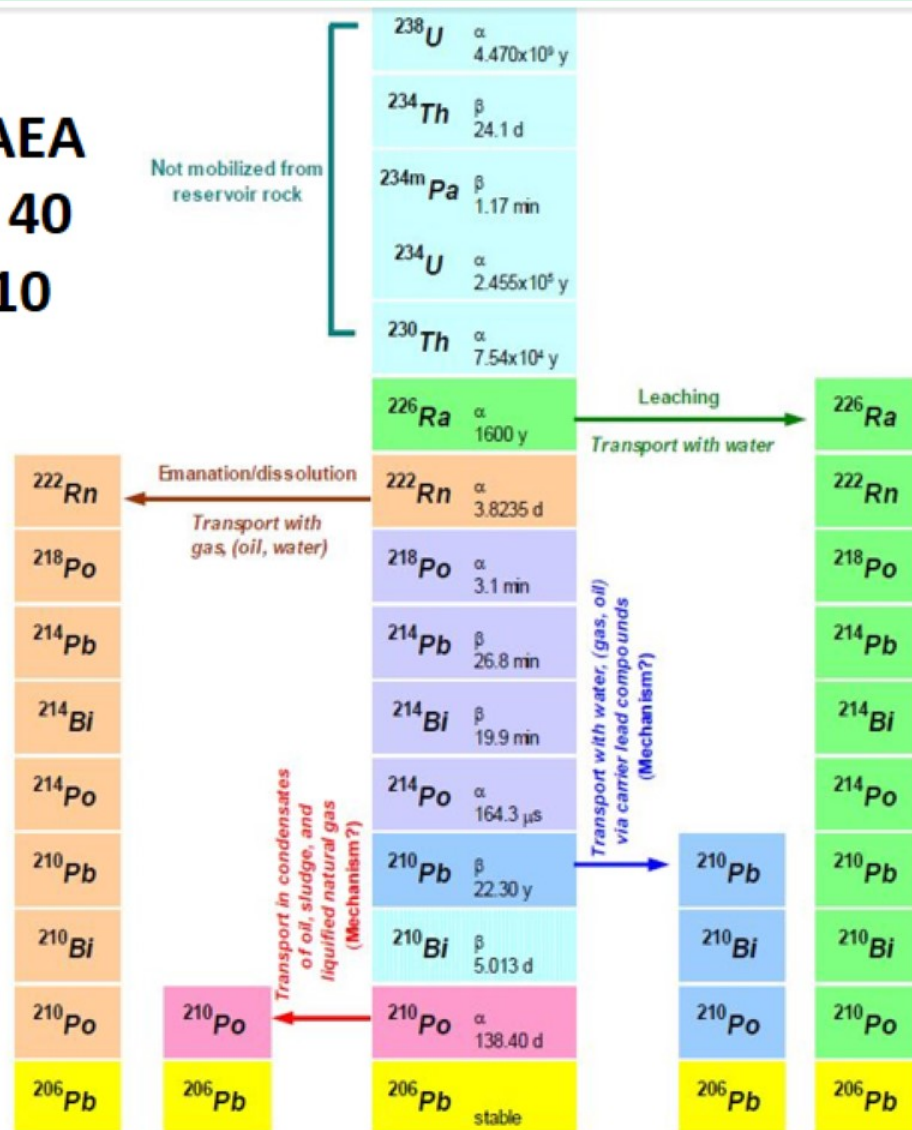


FIG. 41. Transport of ^{238}U progeny in oil and gas production

Study Background

Generation of TENORM waste had increased significantly. This was mainly due to the expansion in unconventional natural gas exploration and production in the Commonwealth.

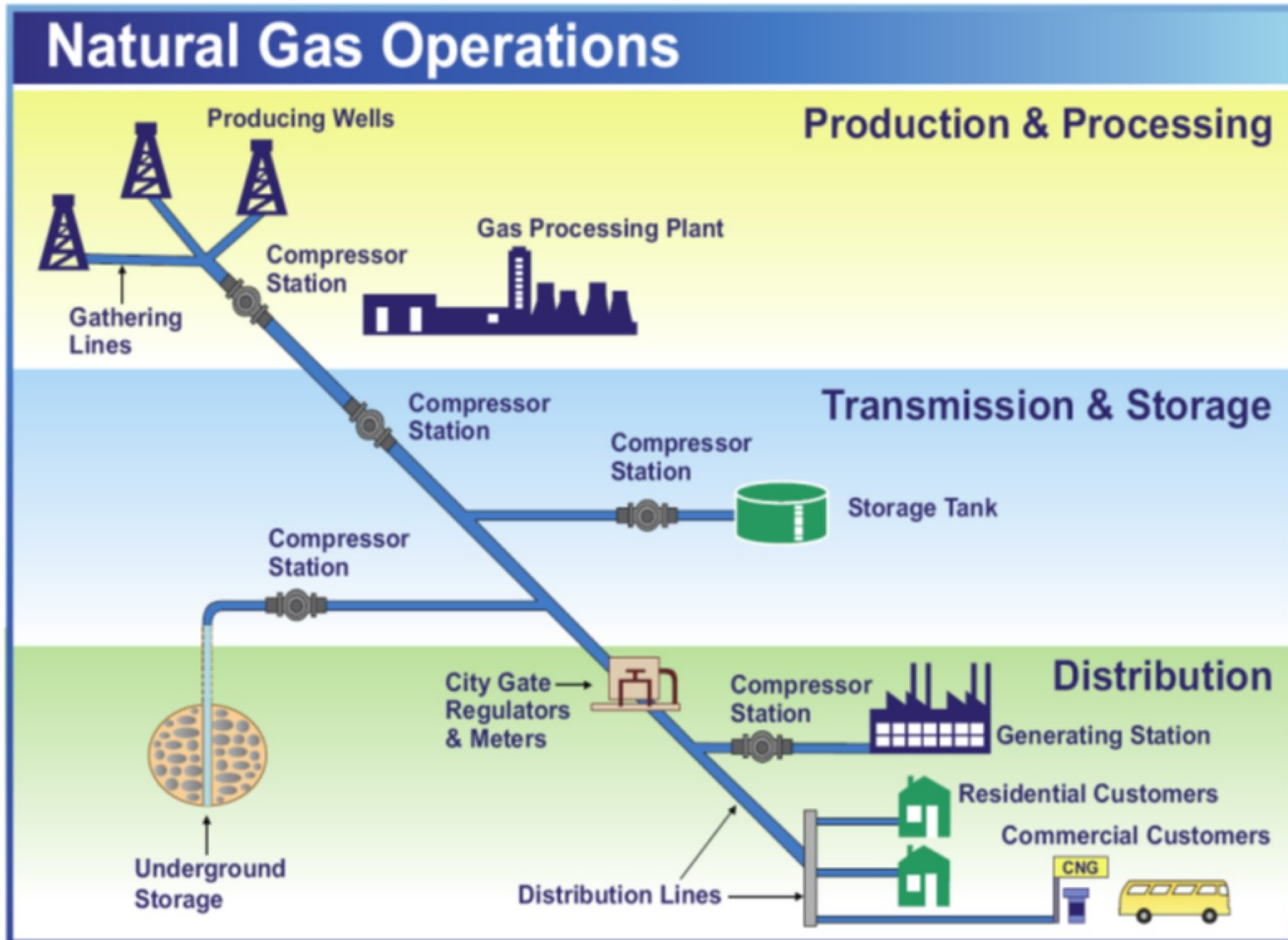
In 2013 DEP determined several issues with O&G TENORM needed to be addressed.

These issues include:

- Potential Worker Radiation Exposure
- Possible Public Radiation Exposure
- Unknown Environmental Contamination
- Waste Disposal



Natural Gas Production & Use



Site Categories for Sampling

- Well pads
- Waste water treatment plants (WWTPs)
- Waste sludge loads to landfills
- Landfills
- Underground natural gas storage sites
- Gas-fired electricity generating facilities
- Compressor stations
- Gas processing facility
- Beneficial use sites (e.g., roads)
- Decommissioned well casings

Field Work



MS Well pad

[Patriot News photo]

Field Work



Frac-water, proppant and
flowback sampling at a well pad

Field Work

Radon testing
at a gas storage
and electrical
generator
facilities



Field Work



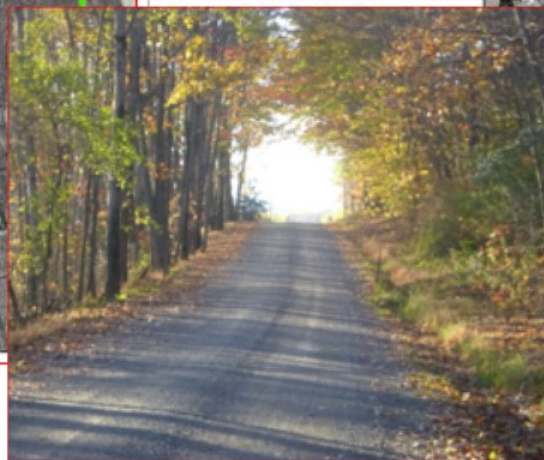
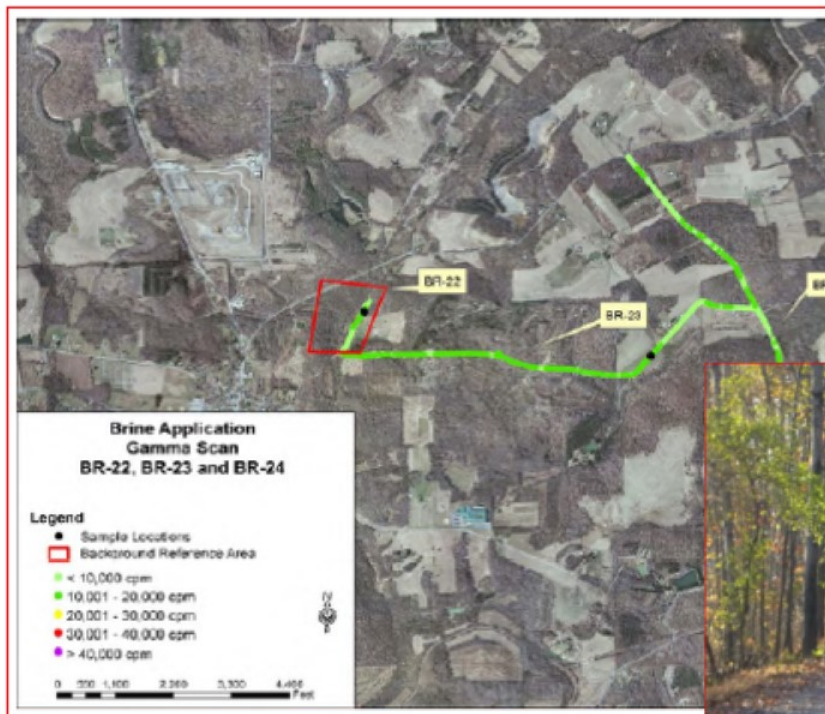
Pipe recycle

Field Work



Surveys at gas processing facility

Field Work



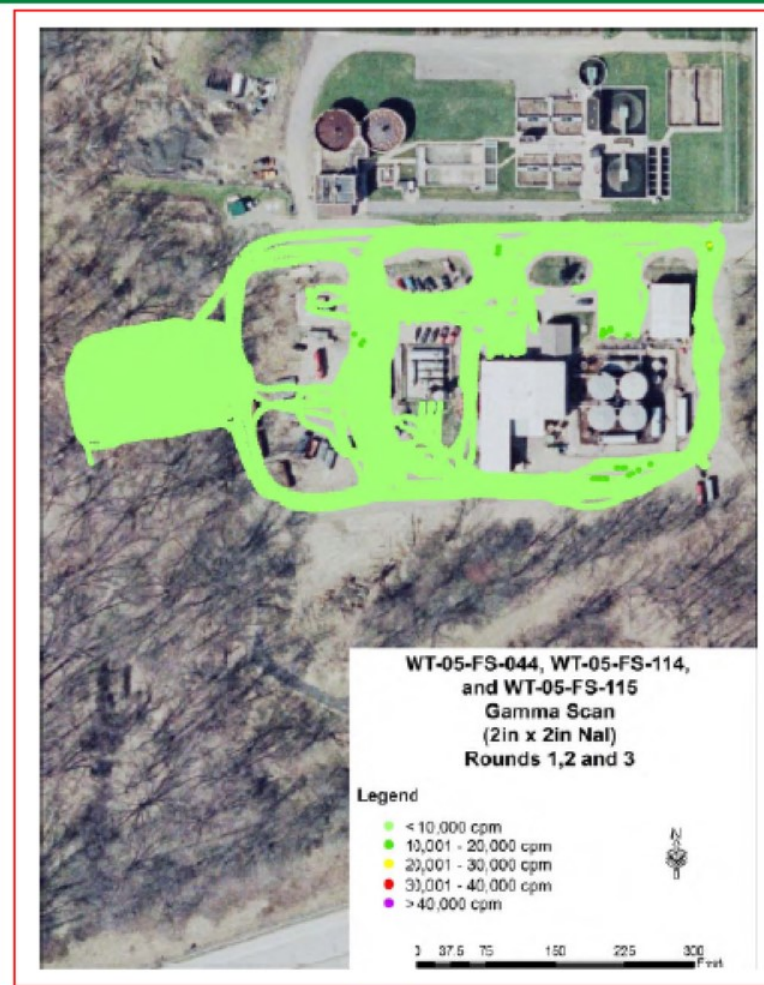
Beneficial Use of brine on roads

Field Work



Wastewater Treatment

Field Work

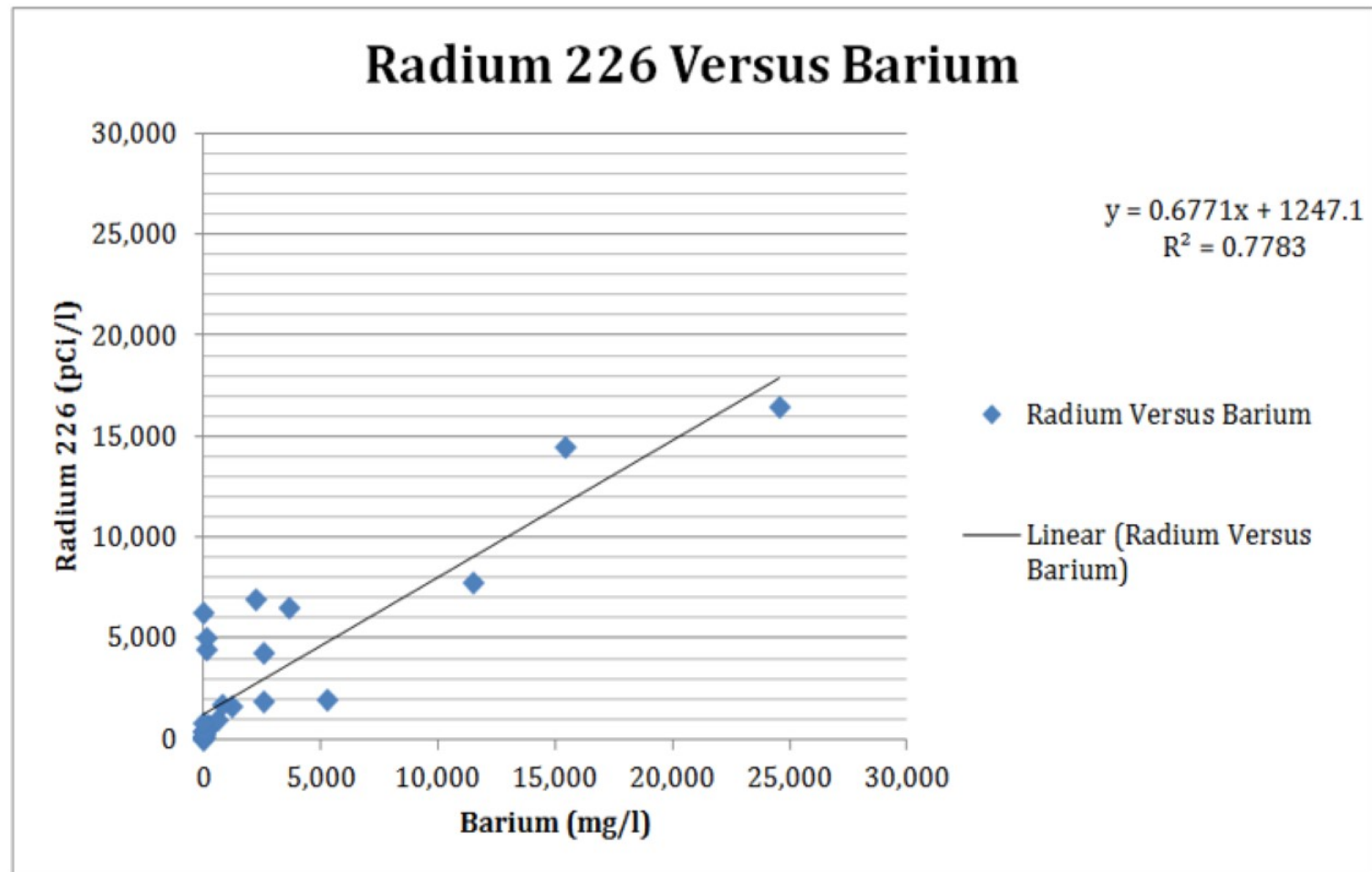


Wastewater Treatment Facilities

Study Results

Non-Rad Chem. Data on Flow-back H2O

Figure M-11. Ra-226 X-Y Scatter Plot versus Barium – Outlier Removed



DEP BRP Conclusions

- Study one of the most comprehensive to date
- Well sites and pads have low worker exposure
- O&G well frac and produced water high in Ra
- Potential for environmental impact with spills
- Unclear impact with the use of brines on roads
- Several wastewater treatment plants and environs require follow-up for clean-up
- ~25 % of TENORM sludge over DOT Class 7 limits
- Long-term Ra in LF leachate monitoring needed

DEP BRP Conclusions

- Sludge from wastewater treatment not in equilibrium between Ra-226 and Rn-222 decay products
- O&G industry data on samples taken during DEP study in-line with our data
- Landfill TENORM disposal protocols developed circa 2002 need to be re-examined
- Follow-up needed on 'pigging' and gas processing plants for potential worker Pb-/Po-210 exposure

TENORM Study Information

- Study and related documents are available at www.dep.pa.gov Keyword “TENORM”
- Overview of Study was provided to the appropriate DEP advisory committees and other stakeholders
- Overview of Study also being presented at various scientific meetings and conferences

TENORM RP Regulatory Framework

Regulate under RP or Solid Waste Laws?

Regulatory Scope?

- TENORM Definition
- Basic RP Standards
 - Occupational 5 rem/y
 - Public 100 mrem/y
 - Disposal 25 mrem/y
 - Clean-up 5 pCi/g
 - Surface dpm/cm²

How to Control?

- TENORM exemption
- Specific license
- General license
- Disposal or decon
- Other RP Permit
 - RP Action Plan
 - RP Management Plan

*Concerns: worker training, waste disposal...
and, accurate TENORM [Ra-226] measurements!*

Solid Waste Radiation Monitoring



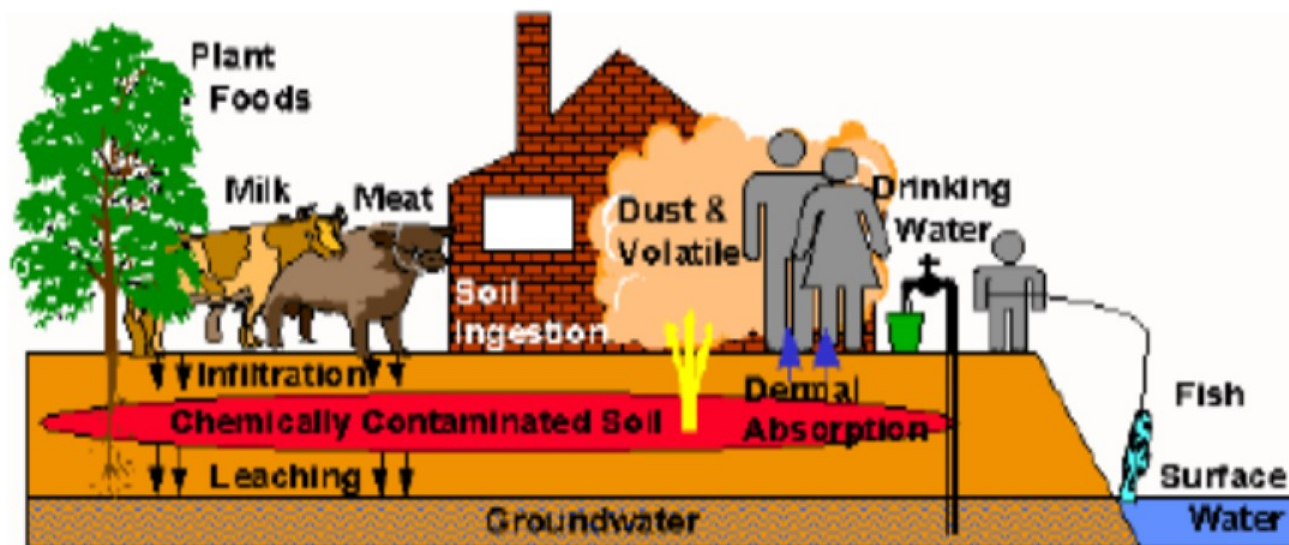
PA DEP Required SW Radiation Monitoring in 2001, and the facility to have an 'Action Plan.'



TENORM Waste Disposal

TENORM -

RESRAD code runs circa 2002 : “resident farmer” evaluation, public dose limit 25 mrem/yr, all pathways (i.e., radon, ground shine and drinking water), looking out 1000 years.



State Regs TENORM Disposal

For example, ND's New Regs – 50 pCi/g [Dec. 2014]



State	Disposal Limit (picocuries per gram)	Radionuclide	Type of Limit
California	1800	total picocuries/gram	landfill permit
Colorado	2000	total picocuries/gram	landfill permit
Idaho	1500	Ra-226 and Ra-228	landfill permit
Illinois	200	Ra-226	state rule for drinking water treatment sludge
Louisiana	30	Ra-226	state rule
Michigan	50	Ra-226 and Ra-228	state rule
Minnesota	30	Ra-226	state rule for drinking water treatment sludge
Mississippi	30	Ra-226 and Ra-228	state rule
Montana	30	Ra-226 and Ra-228	state policy
New Mexico	30	Ra-226 or Ra-228	state rule - landspreading
Texas	30	Ra-226 or Ra-228	state rule - landspreading
Utah	10000	Ra-226 and Ra-228	landfill permit
Washington	10000	Ra-226 and Ra-228	landfill permit
Wyoming	50	Ra-226 and Ra-228	state policy

Health Physics Society & TENORM

ANSI/HPS N13.53-2009

Approved: March 2009



Control and Release of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)

HPS Position Statement

Adopted January 1992



Health Physics Society
Specialists in Radiation Safety



HEALTH
PHYSICS
SOCIETY

COMPATIBILITY IN
RADIATION SAFETY REGULATIONS

POSITION STATEMENT OF THE
HEALTH PHYSICS SOCIETY*

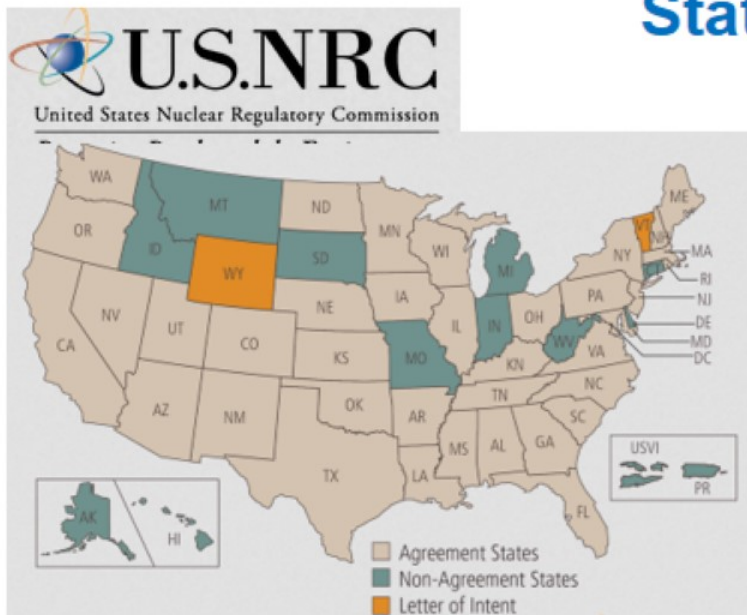
Adopted: January 1992
Revised: August 2000
Reaffirmed: July 2007

The Health Physics Society believes the current regulatory framework for establishing and enforcing regulatory radiation safety standards results in inconsistent, inefficient, and unnecessarily expensive public health protection policies regarding radiation safety. Therefore, the Society advocates the establishment of a regulatory framework with the following requirements:

1. A single, independent U.S. federal agency (herein called the Agency) shall have the responsibility and authority to establish all ionizing radiation safety standards for all controllable sources¹ of occupational and public exposures.

TENORM RP Regulatory Framework

States / OAS / CRCPD



<http://www.crcpd.org/>

June 2015

E-42 TASK FORCE REPORT

REVIEW OF TENORM IN THE OIL & GAS INDUSTRY

**E-45 WG - define TENORM
SR Part N - update**

SSRCR Volume I - April 2004

PART N

**REGULATION AND LICENSING OF
TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE
MATERIAL (TENORM)**

TENORM RP Regulatory Framework

“Current TENORM regs in the USA are fragmented !!”



John Boice

**But we're hopeful...
a new NCRP Scientific
Committee has been
stood-up to review
TENORM waste disposal.**

SC 5-2: Radiation Protection for NORM & TENORM from Oil & Gas Recovery



WE Kennedy,
Chair
Dade Moeller



D Allard
Pennsylvania Dept of
Environmental
Protection



M Barrie
Oak Ridge Associated
Universities



P Egidi
US Environmental
Protection Agency



G Forsee
Illinois Emergency
Management Agency



R Johnson
Dade Moeller



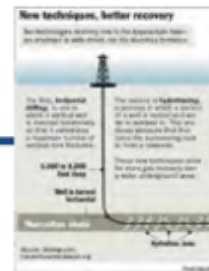
A Lombardo
PermaFix



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CRCPD



J Frazier
Staff Consultant





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Questions?



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