

Shale Gas Wastes: Ohio Public Policy & Potential Impacts to Water Supplies

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**An Ohio Fracture Flow
Working Group Presentation**

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2013 Focusing on Shale Gas Wastes

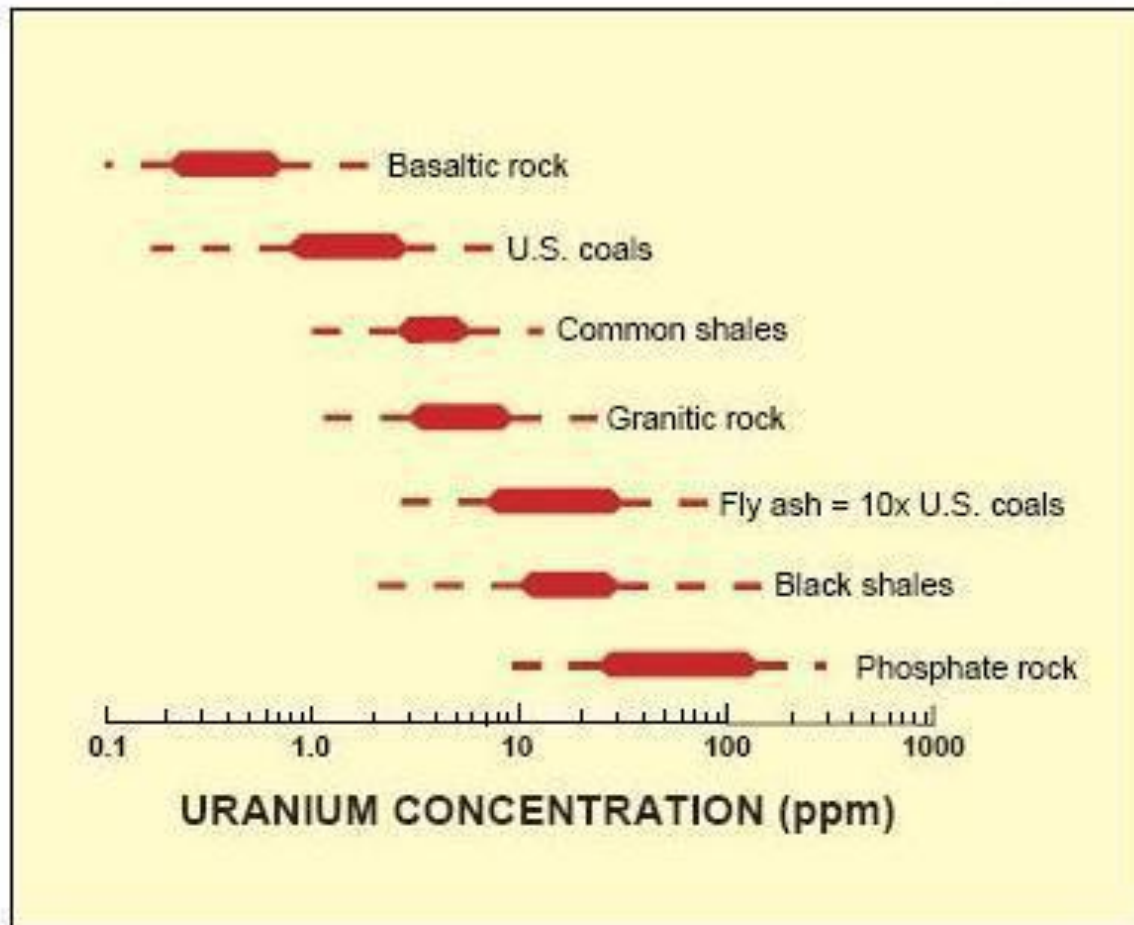
- **Ground Shale Rock:** hydrocarbons, heavy & radioactive metals, Ohio–NORM, US EPA-TENORM
- **Drilling Muds:** who knows what, **TENORM**
- **Fracking Fluids:** water, sand, who knows what, if recycled, are they **TENORM?**
- **Brine:** salts, hydrocarbons, heavy & radioactive metals, Ohio-NORM, US EPA-TENORM
- **Drilling Site Wastes & Accidental Releases:** who knows what is being released
- **Where are they coming from?**
- **Where are they going?**

Why the Current Concern?

- **Ohio has paid for State & Local governments by taxing** (tipping fees, etc.) **out of state waste streams** (solid, C&DD, industrial, medical, O&G, etc.) **for last 20+ years**
- **Shale Gas drilling has created a big, new waste stream not addressed by surrounding states** - seen as a new & easily captured revenue source by Ohio's Administration
- **Ohio DOES NOT have magic GEOLOGY**
 - that can swallow all wastes without repercussions

Why the Current Concern Cont?

- **Blacks shales are early sources of Uranium ore for the "Atomic Age"** (Chattanooga Shale, TN; USGS, 1961)
- **Black shales like coal are full of heavy and radioactive metals:** ^{232}Th to ^{228}Ra & ^{238}U to ^{226}Ra are most common series
- **^{228}Ra , ^{238}U & ^{226}Ra water soluble, also in brines**
- **US EPA limit on Uranium mill tailings, 5 pCi/g because of the Radium:** > LLRW Landfill, Utah or Washington State accept NORM
- **US EPA Drinking Water MCLs 5 pCi/l for Radium**



Typical range of uranium concentration in coal, fly ash, and a variety of common rocks.

Figure 1. Graph from Radioactive Elements in Coal and Fly Ash: Abundance, Forms, and Environmental Significance. U.S. Geological Survey Fact Sheet FS-163-97. October, 1997

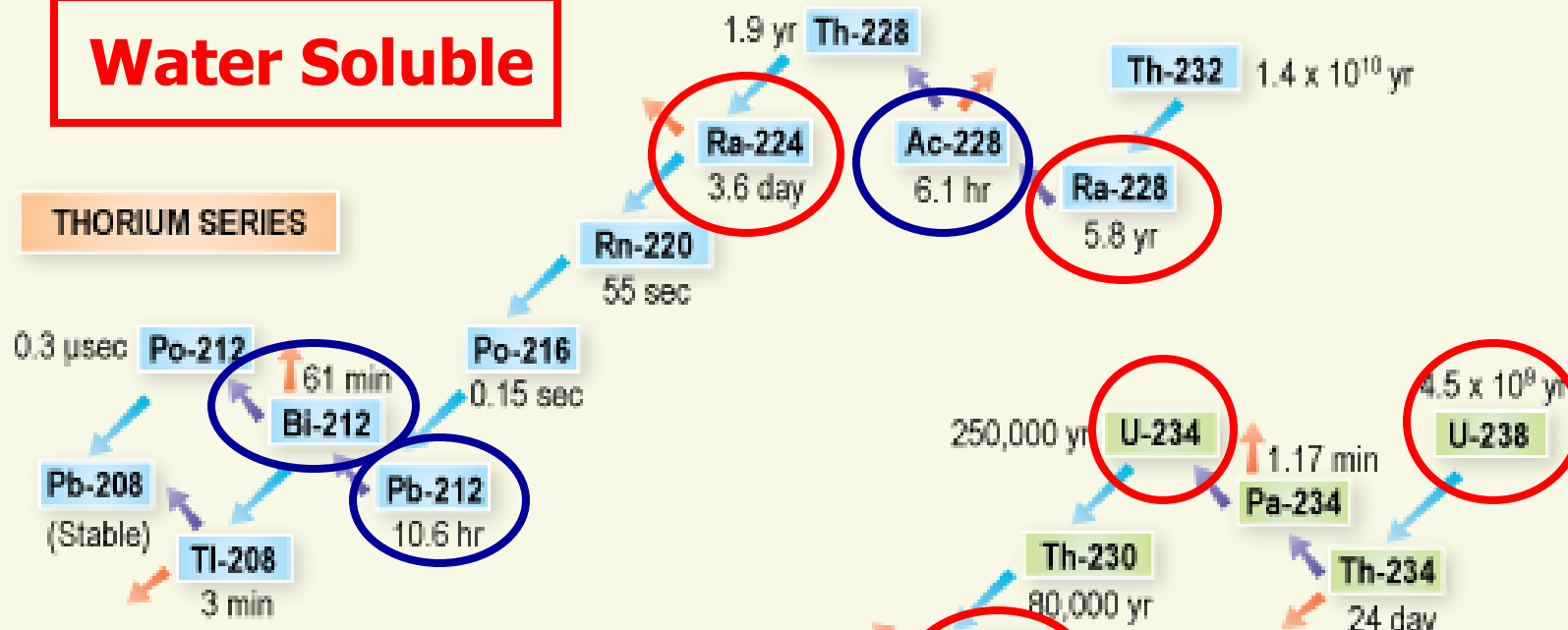
Why the Current Concern Cont?

- **Very limited chem data** (gamma) **for Utica shale, TENORM & brines:** 100's to 1,000's X 5 pCi/g or L
- **PA DEP Marcellus Shale U content:** 10-100 ppm
- **Uranium-238 content:** ~3.4 to 34 pCi/g
- **Radium-226 content:** ~ 3.4 to 34 pCi/g
- **Frac Water Ra-226:** 300 to 9,000 pCi/l
- **PA Marcellus brine chemistry up to 3,609 x MCLs for radioactivity:** 5 pCi/l US EPA
 - USGS reports median levels Ra >3x PA brines from conventional wells

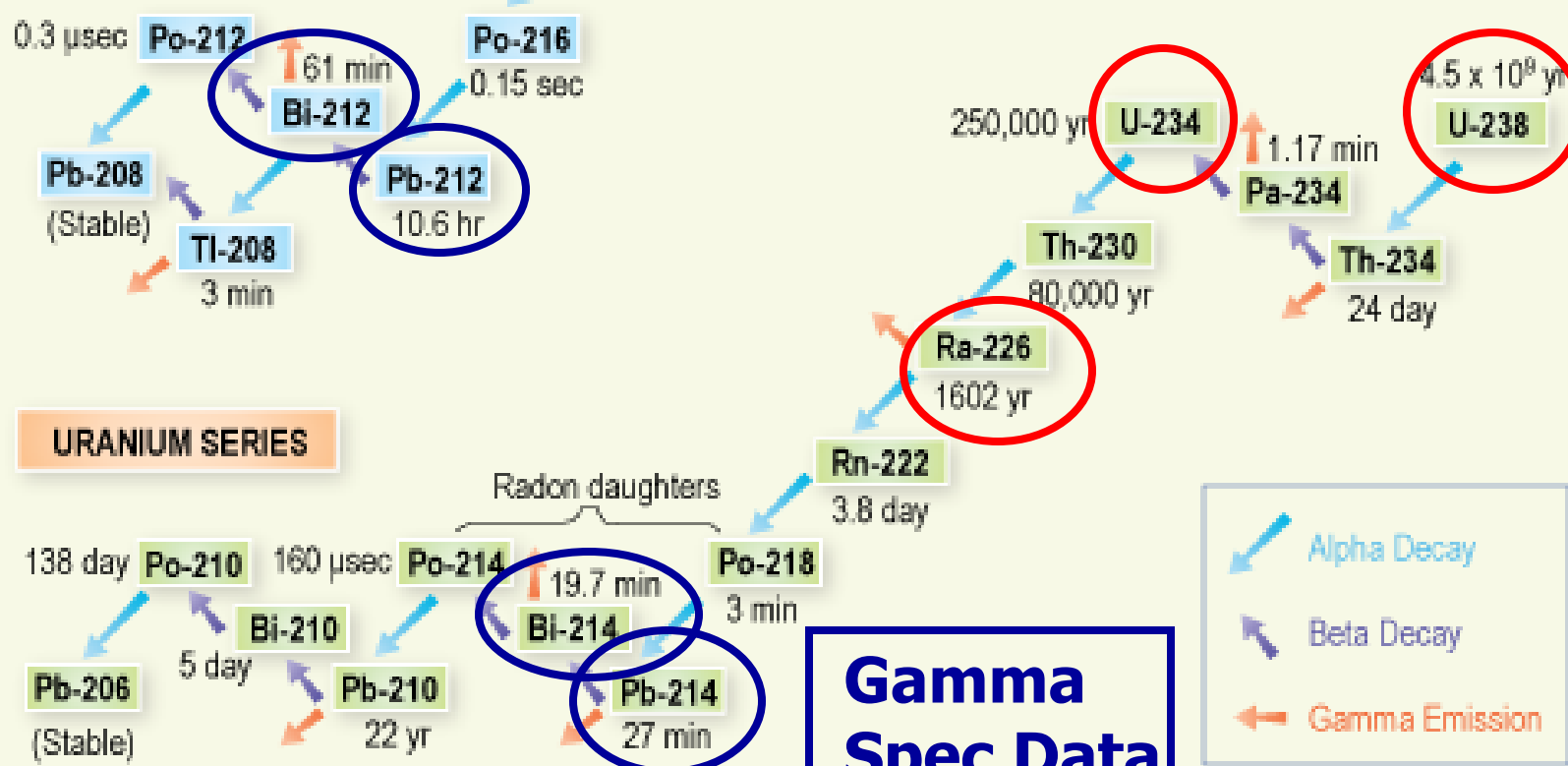
Radioactive Decay in Thorium and Uranium Series

Water Soluble

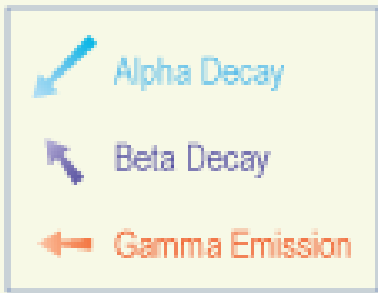
THORIUM SERIES



URANIUM SERIES



Gamma Spec Data



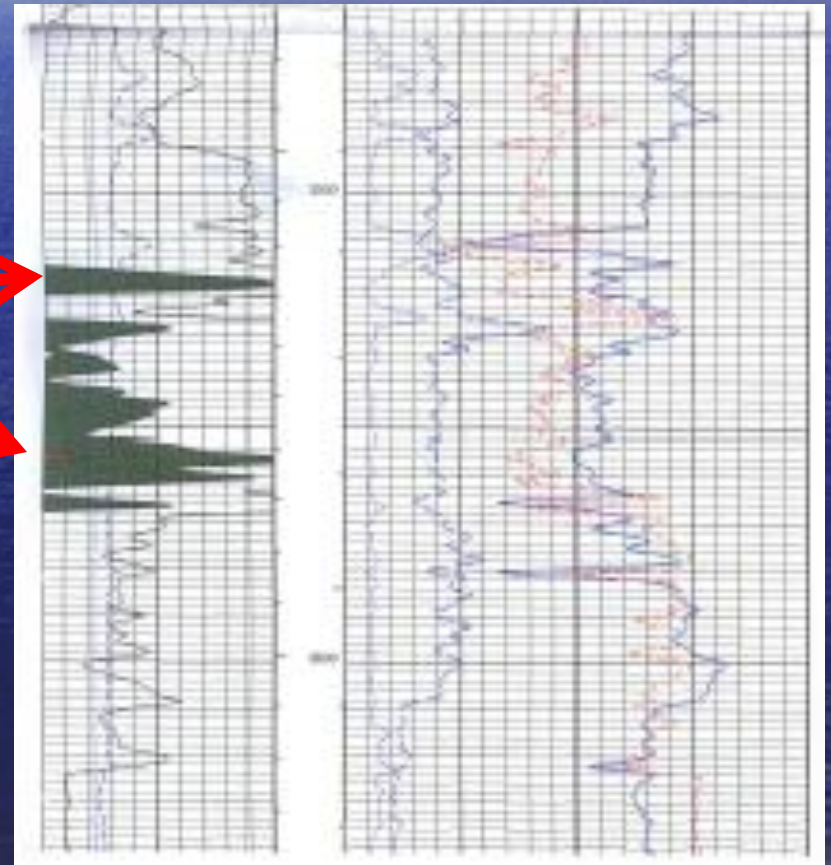
Why the Current Concern Cont?

- **NY brine up to 15,000 pCi/L**
 ^{226}Ra
- **Hard scale in used drilling pipes up to 6,000 pCi/g ^{226}Ra**
and up to 2,000 pCi/g ^{228}Ra
- **Ohio still contaminated from the Manhattan Project**
 - we know better now



Radioactivity = TOC = Gas

- Gamma Ray signature shows highest levels of radioactivity in the shale
- Horizontal laterals installed in hottest zones
- Shale cuttings are from hottest areas



5 pCi/l MCL: Why the Health Risk?

Periodic Table of the Elements

The periodic table is color-coded by groups: Alkali Metals (red), Alkaline Earth Metals (orange), Transition Metals (yellow), Other Metals (light green), Nonmetals (green), Noble Gases (blue), and Inner Transition Metals (dark green). A red arrow points to Calcium (Ca) in group IIA, period 4. A red circle highlights Radium (Ra) in group IIA, period 7. The table includes element symbols, atomic numbers, and names. The Lanthanide and Actinide series are shown at the bottom.

Legend:

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Other Metals
- Nonmetals
- Noble Gases
- Inner Transition Metals
- Gaseous State
- Liquid State
- Solid State
- Synthetically Prepared

Periodic Table Data:

IA	IIA	IIIB	IVB	VB	VIB	VII	VIII	IX	X	XI	XII	IIIA	IVA	VA	VIA	VIIA	VIIIA													
1 H 1.0079	2 He 4.0026											3 Li 6.941	4 Be 9.0122	5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179											
11 Na 22.990	12 Mg 24.305	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948					19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30													
55 Cs 132.91	56 Ba 137.33	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04															
87 Fr (223)	88 Ra (226)	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)															

Lanthanide Series: La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb

Actinide Series: Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No

*Name Not Officially Assigned

Because water-soluble Radium replaces Calcium in your bones if you drink it

Shale Gas Wastes: A Growth Industry for Ohio

- **Wastes coming into Ohio by road, rails & soon by river barge, port Washington Co. in place**
- **Over 52% 2012 injections in Class II wells came from out of state, mostly PA & WV**
- **Dedicated out-of-state Class II wells being installed in SE Ohio (new one Athens Co.)**
- **No Public Hearings being held for anyone**
- **With NY still to be decided & barge ports for Ohio River/Gulf wastes coming on line**
 - **may be up to 80% out of state wastes in a few years**

Shale Gas Wastes: A Growth Industry for Ohio cont.

- **Ground Shale Rock with drilling muds to Solid Waste and C&DD Landfills; no records of how much or where, just listed as “solid wastes”; used as daily cover, not buried**
- **All Fracking Fluids & Brines to be injected in Class II wells except when spread on roads (brines), “solidified” and put in landfills or other management processes yet to be determined**
- **ODNR Div. Oil & Gas Resources calls the shots; OEPA and ODH are second**

New ODNR OEPA ODH Regulation Chart

- **Waste Streams Generated During the Exploration and Production for Oil and Natural Gas**
- **Summary of Potential Regulatory Oversight, January 2013**
- [www.epa.state.oh.us/portals/34/document/NewsPDFs/Oil-Gas Waste Matrix Jan20132.pdf](http://www.epa.state.oh.us/portals/34/document/NewsPDFs/Oil-Gas%20Waste%20Matrix%20Jan20132.pdf)
- **Check it out**

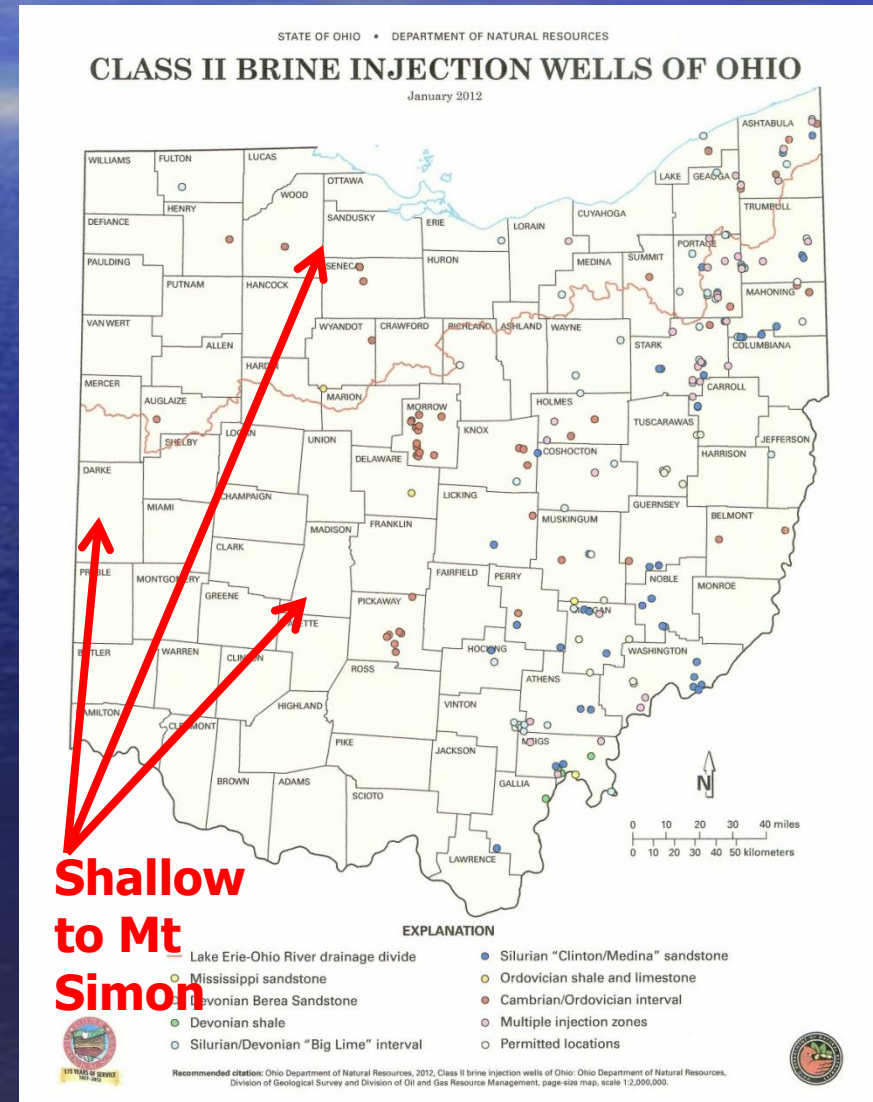
Class II Injection Wells

- Class II Injection Wells Revisions

(above Pre-Cambrian basement rock now)

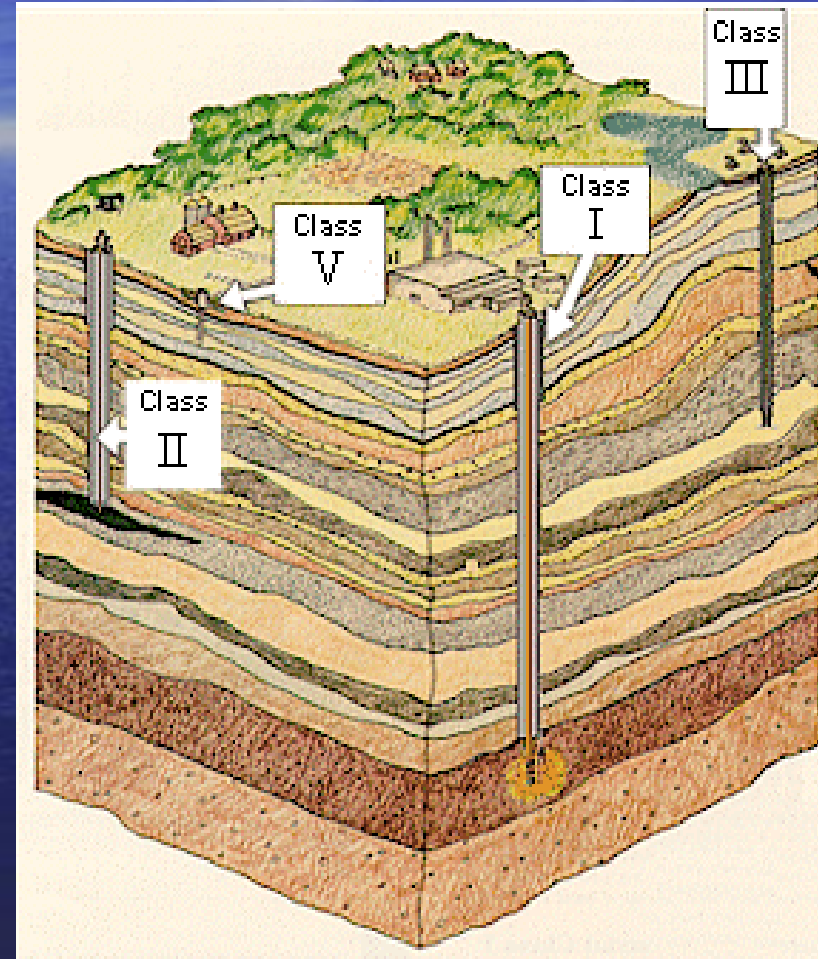
Seismic rules added by emergency in 2012 to lift moratorium, 30+ waiting applications being processed & approved

- Check new web site often
www.oilandgas.ohiodnr.gov



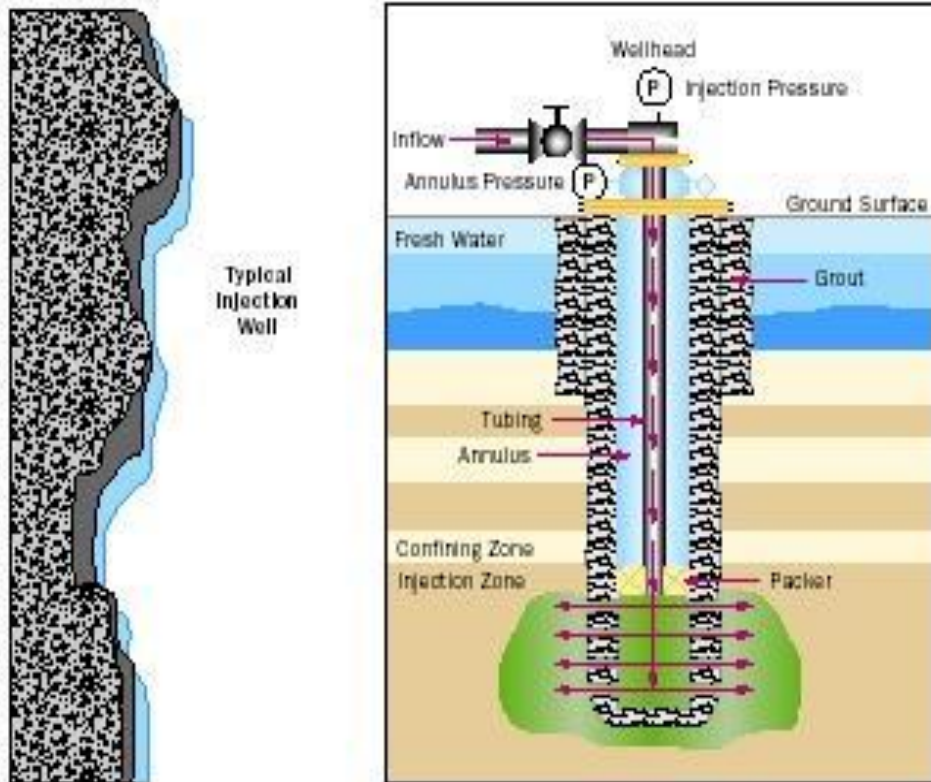
What are Class II Injection Wells?

- Class I – Hazardous Waste
- Class II – Oil & Gas Fluids
- Class III – Solution Mining of Minerals
- Class IV – **now banned**
- Class V – Stormwater, etc.
- Class IV – CO₂ Sequestration



Why Do We Have Them in the First Place?

DIAGRAM OF INJECTION WELL



SOURCE: Adapted from the National Energy Technology Laboratory.

- Originally used to rehabilitate old O&G fields
- Converted production wells in field to be rehabbed
- Brine & other fluids injected back into field to force out remaining product
 - Called "Flooding"

How Do They Fail?

- **Limited Site Visits by Operators**
 - can be operated 24-7-365
- **Surface & Near Surface Spills**
 - from valves, lines & tanks
- **Compromised Spill Protection Systems**
- **Structural Failure Over Time**
 - Casings and Cement
- **Earthquakes, increases w/ increase in pressure**
 - (National Resources Council rept., www.nap.edu/catalog.php?record_id=13355)



Do We Even Need Them?

- **Important for SS & LS O&G well field rehabilitation**
 - but not for shale gas production
- **All other uses**
 - long term, probably not
- **Planning now for the short term & intermediate futures**

Landfilling the Wastes

Legal disposal for
shale rock cuttings,
drilling muds and
associated wastes
Currently HB 59
requires
downblending if Ra
levels above MCLs
for TENORM only

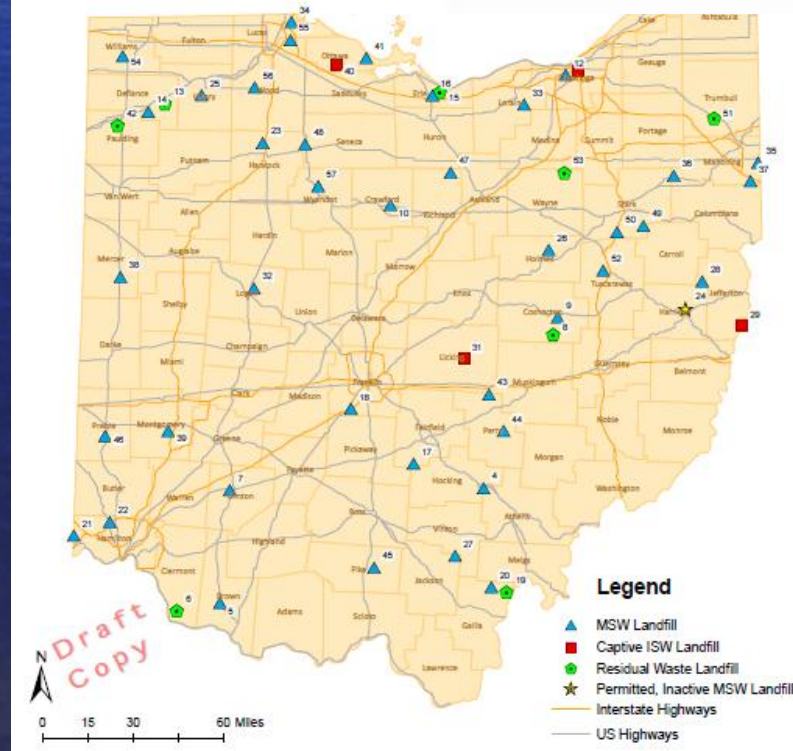
Press releases do not
indicate that chemical
binding of radioactive
materials to dilution
materials must occur

Ohio's debris landfills

The Ohio Environmental Protection Agency found high levels of pollutants in the water in 30 debris landfills.



Ohio Solid Waste Landfills: License



But are they LLRW Landfills?

- No solid waste and C&DD waste landfills in Ohio meet our siting & design criteria for LLRW disposal
- OSU Extension Research “Low-Level Radioactive Waste Fact Sheet Series” (RER-00) explains why



Cement vaults above ground, wastes drummed, overpacked and sealed

Ohionline.osu.edu/rer-fact/

Other Solutions for Brine Disposal Sure to Reach the Water



Dump it down a storm drain!

**Ben Lupo, president D&L
Energy/Hardrock Excavation
admits to at least 250,000
gallons of brine & oil-based
muds dumped into the
Mahoning River, 2012-2013**

**Use for deicing on
winter roads
still legal in parts of Ohio**



No one told Beaver Falls, PA

Recycling of Fracking Fluids

- **Chesapeake in Carroll County, Ohio**
- **Range Resources in PA**
- **Consol/Epiphany/PMC Biotech solar powered recycling pilot plant started in July 2012 in PA**
- **Number of others as well**

Why? Because they need the water for the next well & savings on reclaimed chemicals

Potential Problems from Recycling

- **Recycled fracking fluids need to be filtered**
 - to remove sand, rock cuttings, etc. before being reused
- **Filtered materials go to landfills**
- **Reusing the fluid increases the levels of Radium each time through, not removed**
- **Eventually TDS etc. so high that fluid must be disposed of in Class II wells anyway**
- **Ohio not collecting information on Recyclers**
 - who/where they are, how they collect fluids, how dispose of wastes

Repurposing of O&G Brine

- Almost everything in O&G brine has an industrial application & a current market
- Already “mine” salts in Ohio for industrial applications
- DOE/GE working on process to remove Radium-228 and 226 from brine
- Technology already exists to break O&G brine down, working on economics
- Why dispose of resources we need & would have to make/extract in other ways for other costs?
- Ohio could still extract “tax” for out-of-state brine if reprocessed here, real jobs for Ohio

Contacts for this presentation & Ohio Journal of Science Papers

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Ohio Journal of Science Web Link at OSU,
<https://kb.osu.edu/dspace/handle/1811/686>

Ohio EPA Division of Drinking and Ground
Waters Source Water Assessment and
Protection Program,
www.epa.ohio.gov/ddagw/swap_ssa.aspx



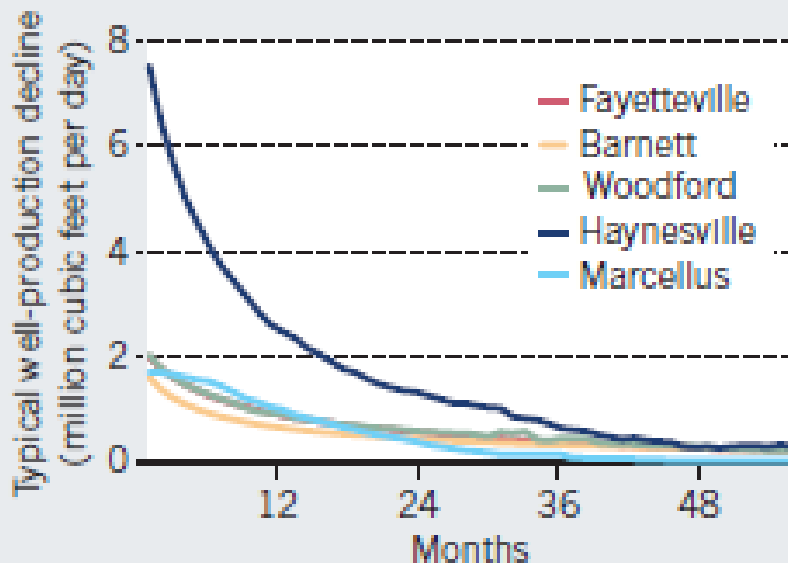
Keeping Ohio's Water Clean
Ohio Fracture Flow Working
Group

Even Without Disposal Issues, Does it Make Current Economic Sense to Drill?

- **Drilling Costs**
>\$42 Billion/yr
to maintain
production
- **Dry Gas Sales**
~\$33 Billion/yr
- **Some additional**
value from wet
gases

TOP FIVE SHALE PLAYS

Five US fields produce 80% of shale gas. The output of a typical well drops 80–95% in its first three years (top). Average well output across a field peaks and then falls as prime spots are used up (middle). Total field production falls 30–50% per year without new drilling (bottom).



JD Hughes, 2013, Nature vol. 494

How long to Protect from human interaction if use Michigan's 50 pCi/g limit

- 50 pCi/g Radium-226 (1,609 yrs/1/2 life) to 5 pCi/g is 3+ half lives, ~5,000 yrs, beginning of Egypt's pyramids
- 50 pCi/g Uranium-238 (4.468 Billion yr/1/2 life, from almost the birth of the earth until now 1 1/2 life) to 5 pCi/g, so 3+ half-lives, back to the beginning of the Universe
- 50 pCi/g Thorium-232 (14.05 Billion yr/1/2 life, longer than the age of the Universe until now 1 1/2 life) to 5 pCi/g, ~45 Billion years, more than the diameter of the visible universe