

Pennsylvania Private Well Water Quality- Our Case Studies

<http://www.water-research.net>



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<http://www.bfenvironmental.com>



<http://www.water-research.net>

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- The fee for the credits will be \$ 30.00(US)



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<http://www.bfenvironmental.com>

Water Research Center

<http://www.water-research.net>

Keystone Clean Water Team

<http://www.pacleanwater.org>



Prepared For

Sullivan County- 2014





Keystone Clean Water Team (Pacleanwater.org)



Private Well Owner and Community
Fact Based Education and Outreach Programs
Groundwater Quality
Private Wells
Energy Production, Use, and Conservation
Source Water Protection Issues
Renewable Energy



Septic Systems



Private Wells



Source Water Protection

Effort Start in 1989

- We conducted private well owner and watershed education programs on private wells
- Education Program on how Groundwater and Surfacewater are Connected !
- The role of non-point source pollution and the concept – We ALL Live Downstream.



Current Programs

- Free Assistance in Reviewing Baseline Data for Private Well Owners
- Free Website with Information on Water Quality Problems with Case Studies
- Educational Materials and Educational Presentations
- Cell Phone Recycling Program
- Training Program for Baseline Samplers
- Go to <http://www.water-research.net> or
- <http://www.carbonwaters.org>

Our Latest Educational Resource



Description of the following:

- a. Citizen Database
- b. Baseline Testing
- c. Drinking Water Standards
- d. Specific Water Quality Standards
- e. Treatment Options
- f. How to Shock Disinfect a Well
- g. How to Properly Construct a Well
- h. General Guidelines on Baseline Testing Parameters.

Only \$ 5.00

Other Resources at <http://www.pacleanwater.org>

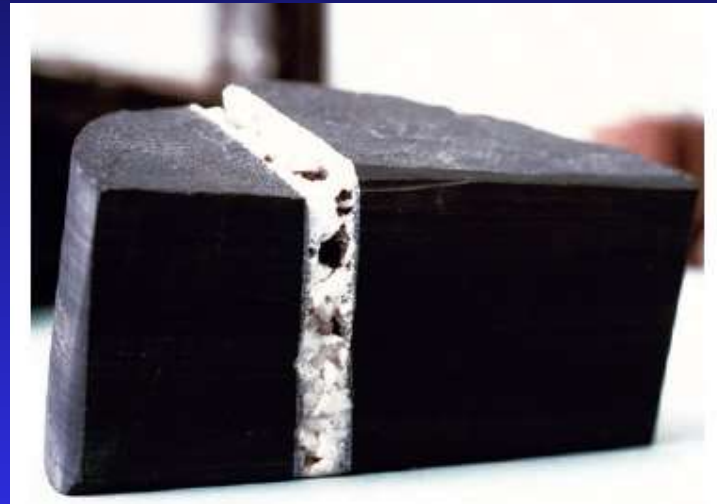
Today's Presentation

- Basic Geology
- Marcellus Shale (Formation and Process)
- Issues (Water Quality)
- Baseline Testing
- Water Treatment Approach

Our Drinking Water

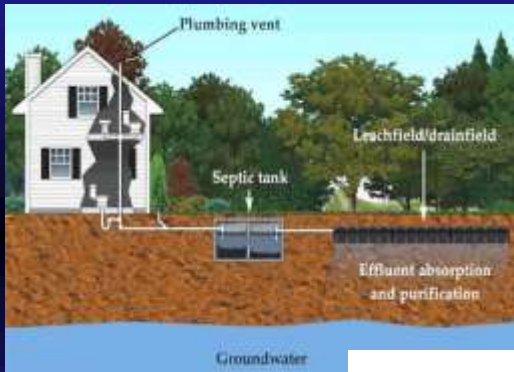


Marcellus Shale



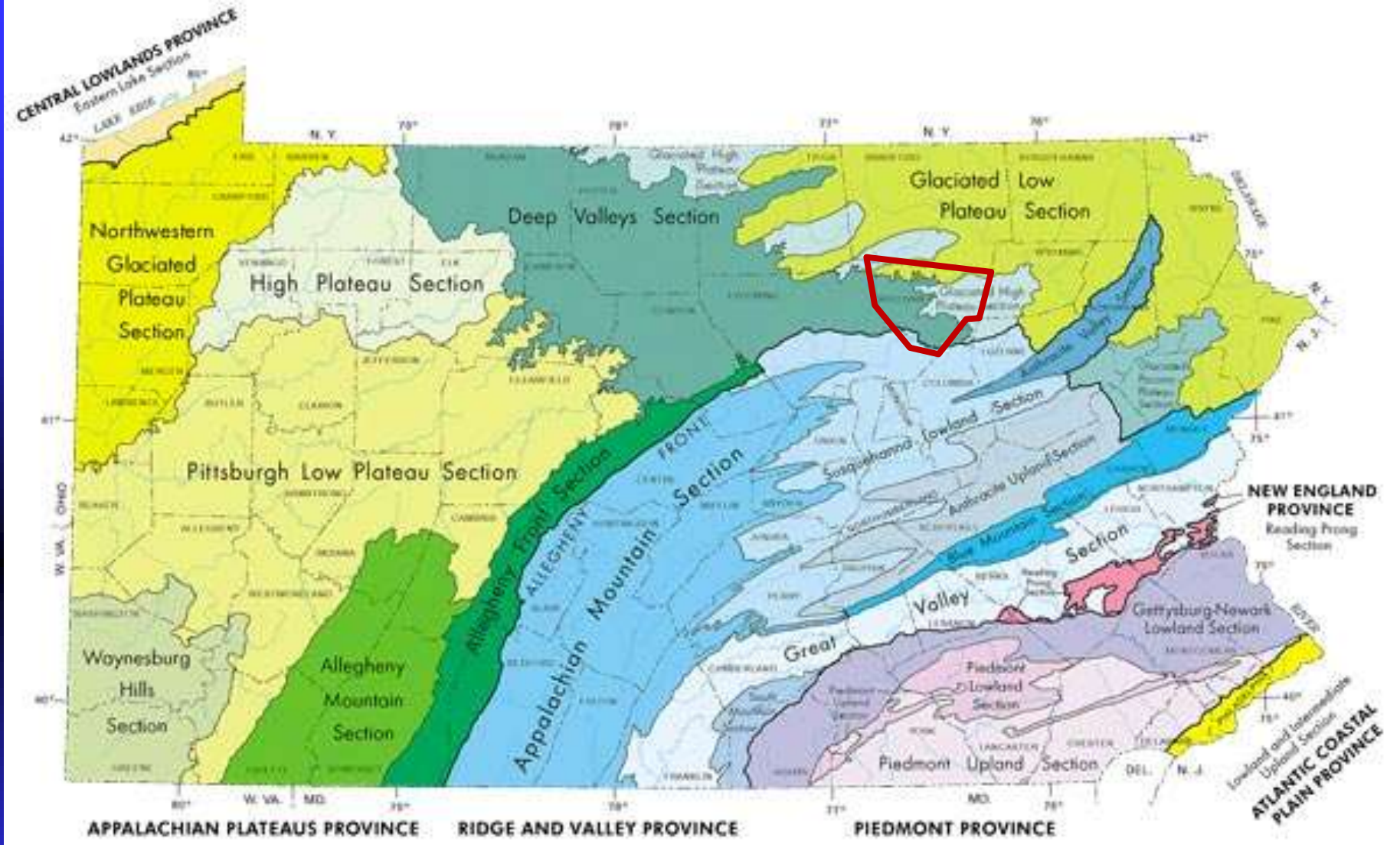
The Match Of the Century – Pick a Side and
Lets See Who Wins.

No – We don't want this situation - This
mindset is Causing the Problem?



**Not Just a Marcellus
Shale Issue and in some cases
other Private Wells are Part of the Problem**





Sullivan County was glaciated and it is located within Appalachian Plateau Province

Source: DCNR - <http://www.dcnr.state.pa.us/topogeo/map13/map13.aspx>

GLACIATION



Wisconsinan (17,000 to 22,000 yrs)

Late-Illinoian (132,000 – 198,000 yrs)

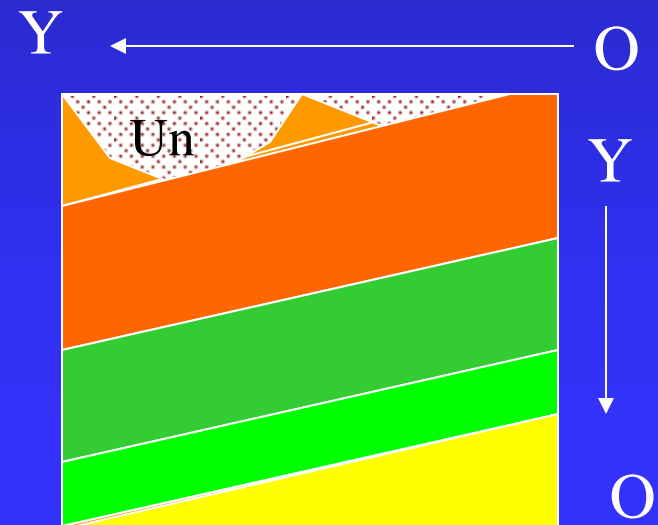
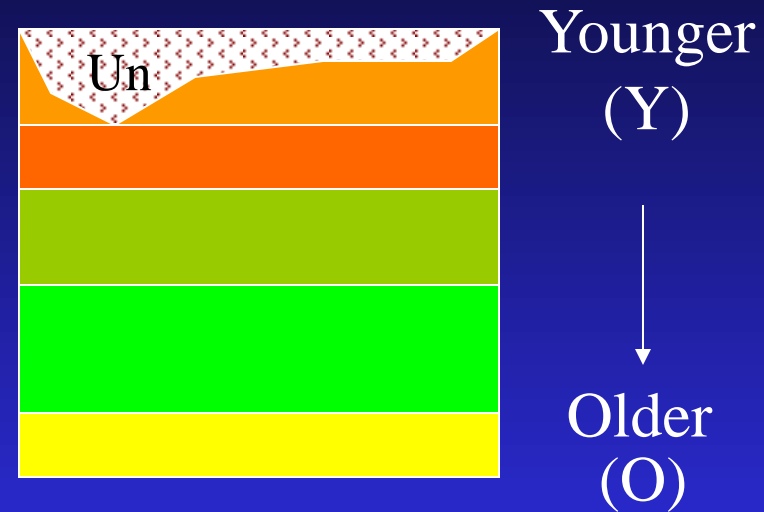
Pre-Illinoian (> 770,00 yrs)

Source: DCNR -
<http://www.dcnr.state.pa.us>

Appalachian Plateau Province

- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material

Unconsolidated Material (Un)



Appalachian Plateau Province

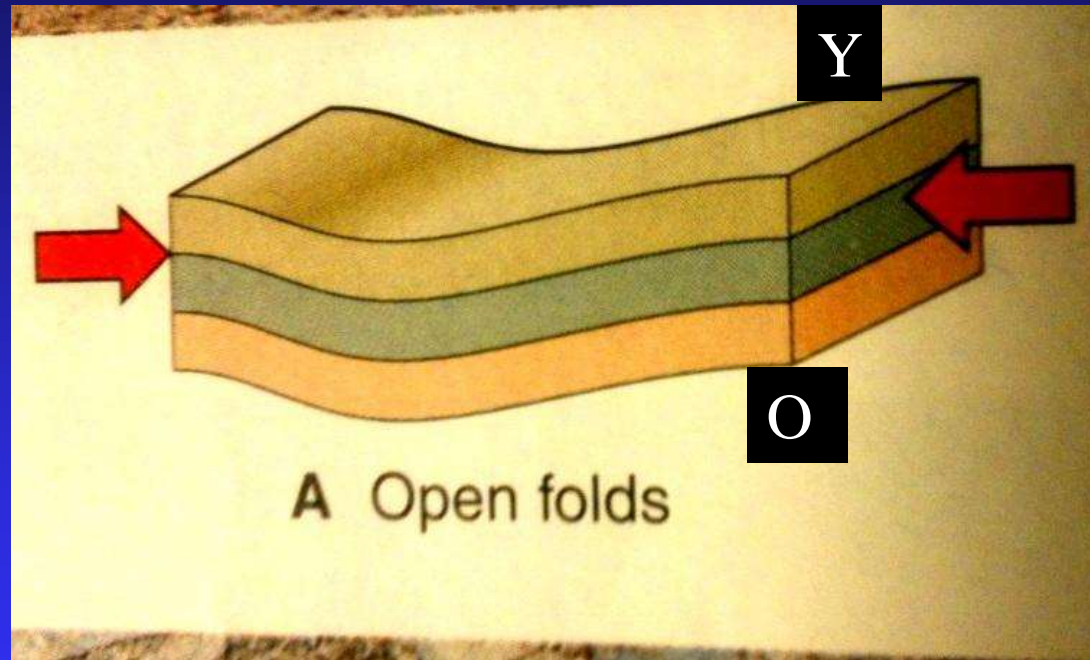


Y

O

Deep Valleys Section

- Bedrock has been folded into an open fold pattern.

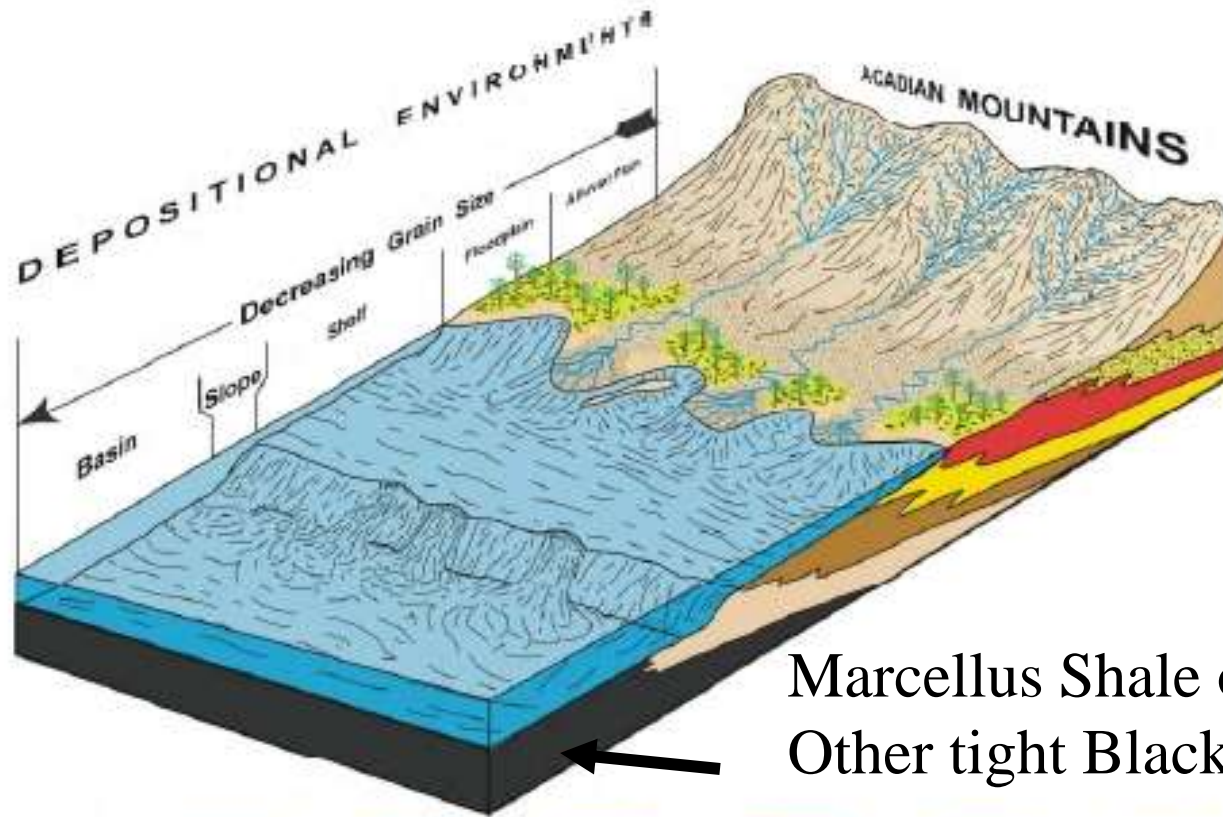


385 Million Years Ago



Source: <http://www2.nau.edu/rcb7/nam.html>

DEVONIAN DEPOSITIONAL ENVIRONMENTS



Marcellus Shale or
Other tight Black Shales

- | | | | | | | |
|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |
| Organic-rich
black shale | Submarine
ramp
turbidites | Shallow
outer shelf
sandstone,
siltstone,
and shale | Inner shelf,
delta-front,
and littoral
sandstone,
siltstone,
and shale | Continental,
fluvial-deltaic,
and marginal-
marine
clastics | Dominantly
fluvial
clastics | Undifferentiated
lithologies |

Modified from
Laughrey, 2009

Private Wells Not Regulated

■ Private Wells Are Not Regulated under Safe Drinking Water Act

◆ EPA – NO

95 % drilled wells

5 % hand-dug and other

◆ PADEP – NO

◆ County – Very Few Counties in PA

◆ Townships – some have basic ordinance on placement- some have comprehensive requirements



This is Drinking Water in PA?



50%

Other
50%

Corrosion



Iron / Manganese



Sediment / Gases



Bacteria

Citizen Database For Pennsylvania

Total Coliform (49%)
20% E Coli. Positive

Plasticizers (8%)

Lead (22 %)

bis(2 ethylhexylphthates)
What?
Plasticizers?

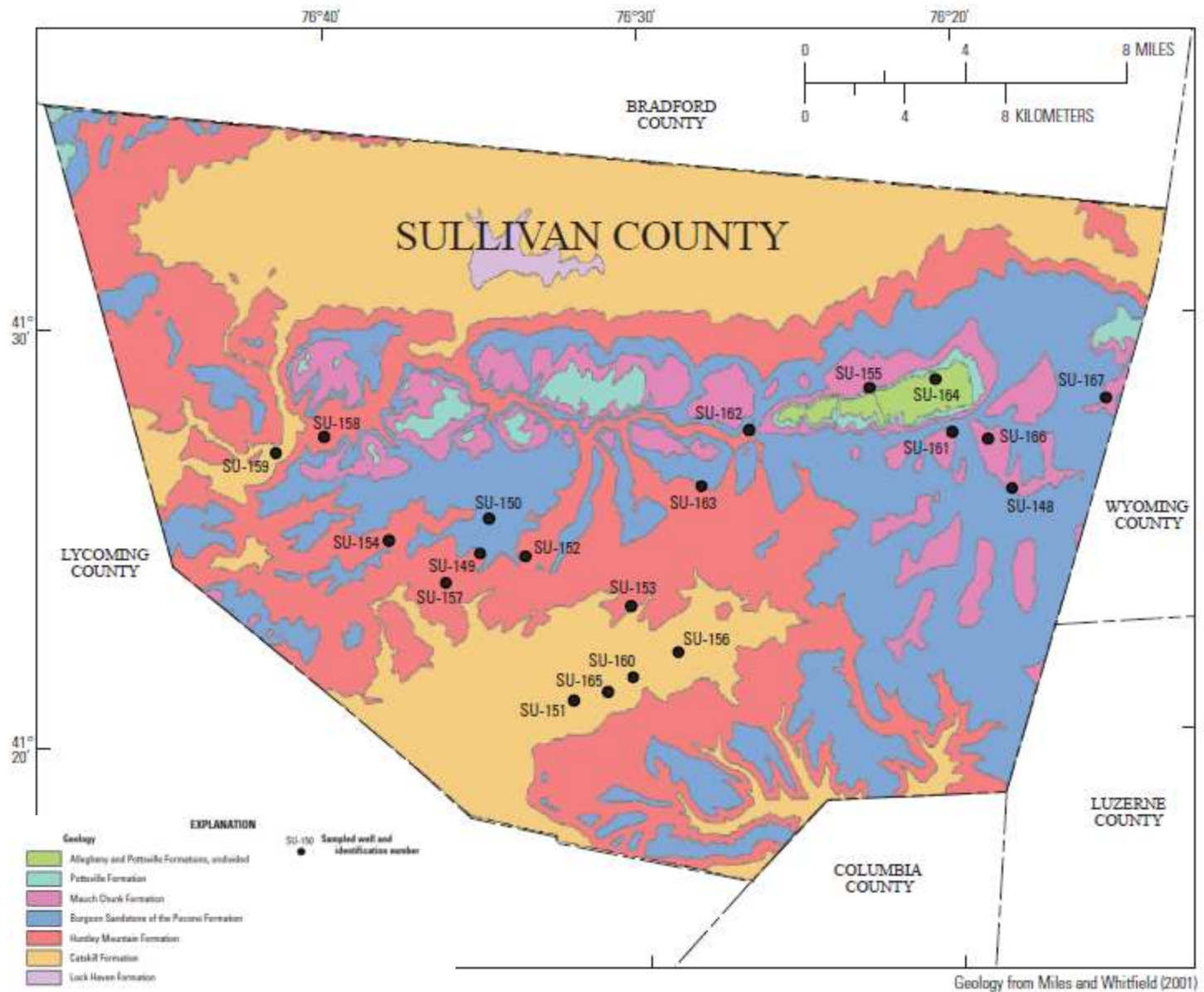
Arsenic (6%)

Well Influenced
by
Connate Water

Percent Exceeded



Up to 3% influenced by Saline Water – These same samples have methane approaching 7 mg/L or more.



Geology from Miles and Whitfield (2001)

Parameter	Percent Exceed Std.
Total Coliform	40
E. Coli	10
pH	45
Total Dissolved Solids	3
Nitrate + Nitrite N	< 1
Chloride	1
Sulfate	< 1
Arsenic	2
Barium	< 1
Iron	25
Manganese	30
Gross Alpha	5
Gross Beta	< 1
Uranium	< 1
Radon	5 to 10

Bacteria

Corrosive Water (Copper/ Lead)

Manganese (Black / Sulfur Odors)

Iron (Black, Red, Brown)

Gross Alpha / Radon

Arsenic

Note:

No real standard for “Radon”-
surrogates standard available for
gross alpha/beta.

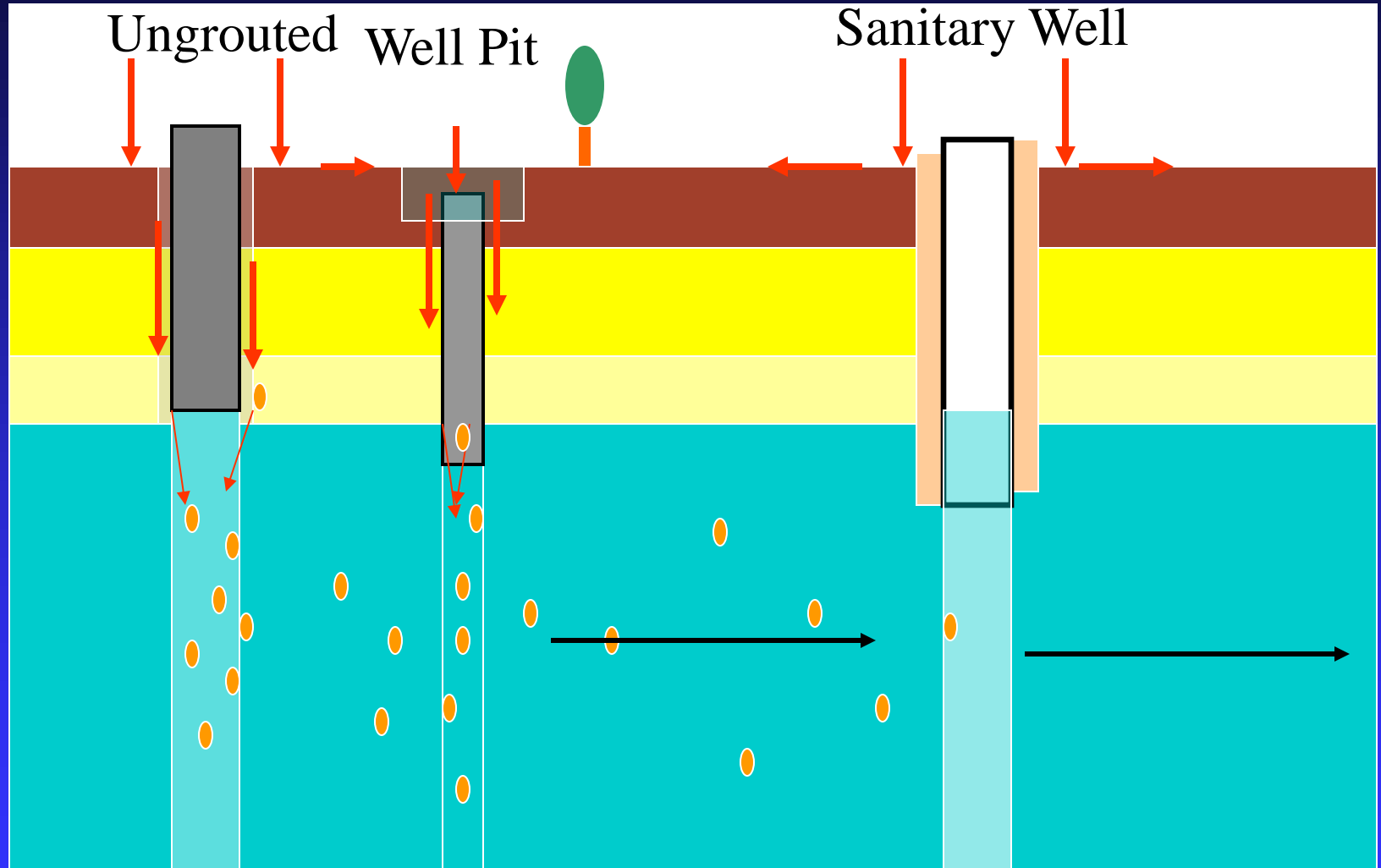
Most Contamination appears to be associated with Total Coliform Bacteria



- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

Therefore – In some cases - Our Private Wells are Facilitating Groundwater Contamination.

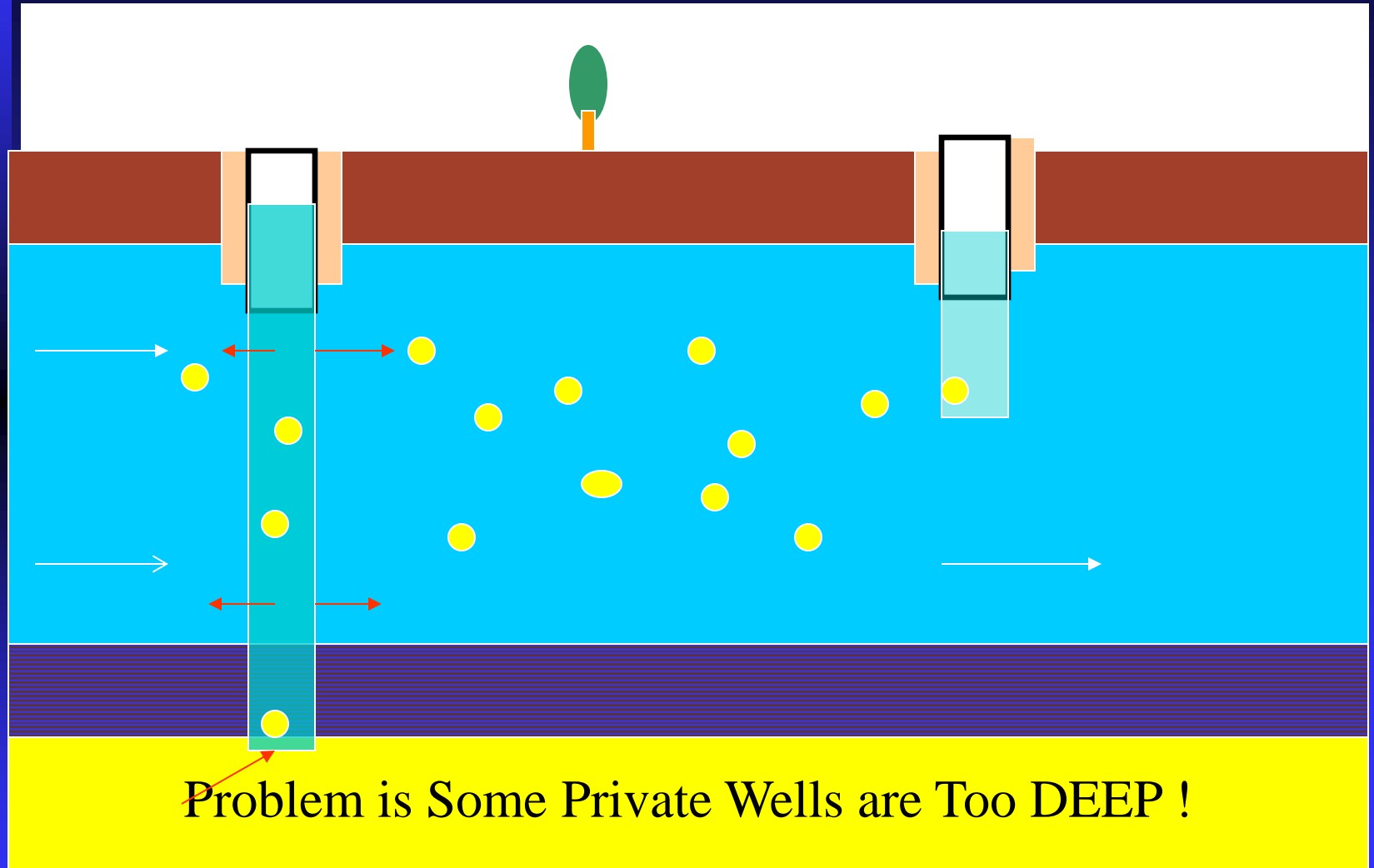
How Contaminants Can Get In to the Aquifer (Surface)



Some Private Well Photos



How Contaminants Can Move Up into a Shallow Aquifer

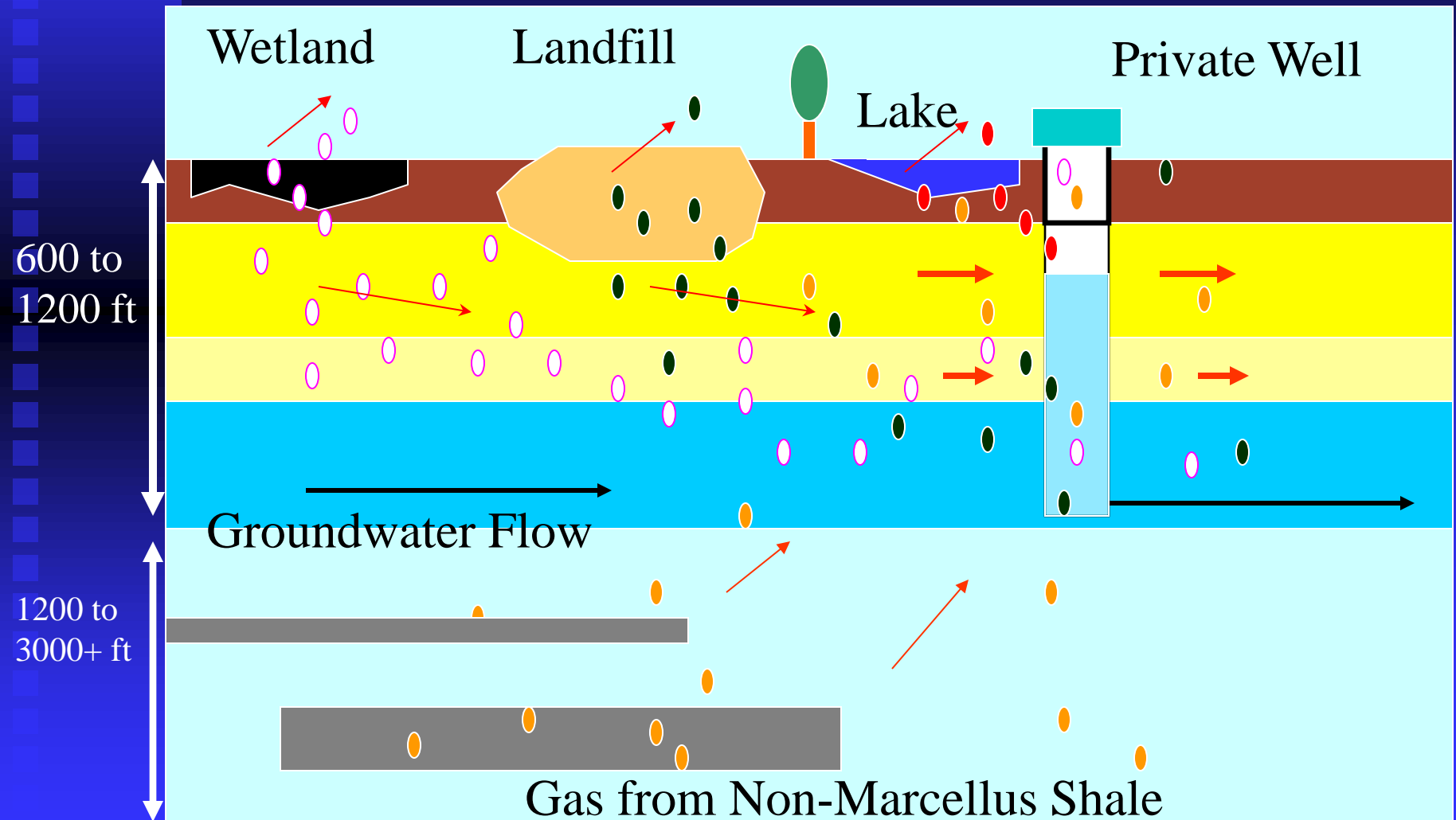


Problem is Some Private Wells are Too DEEP !

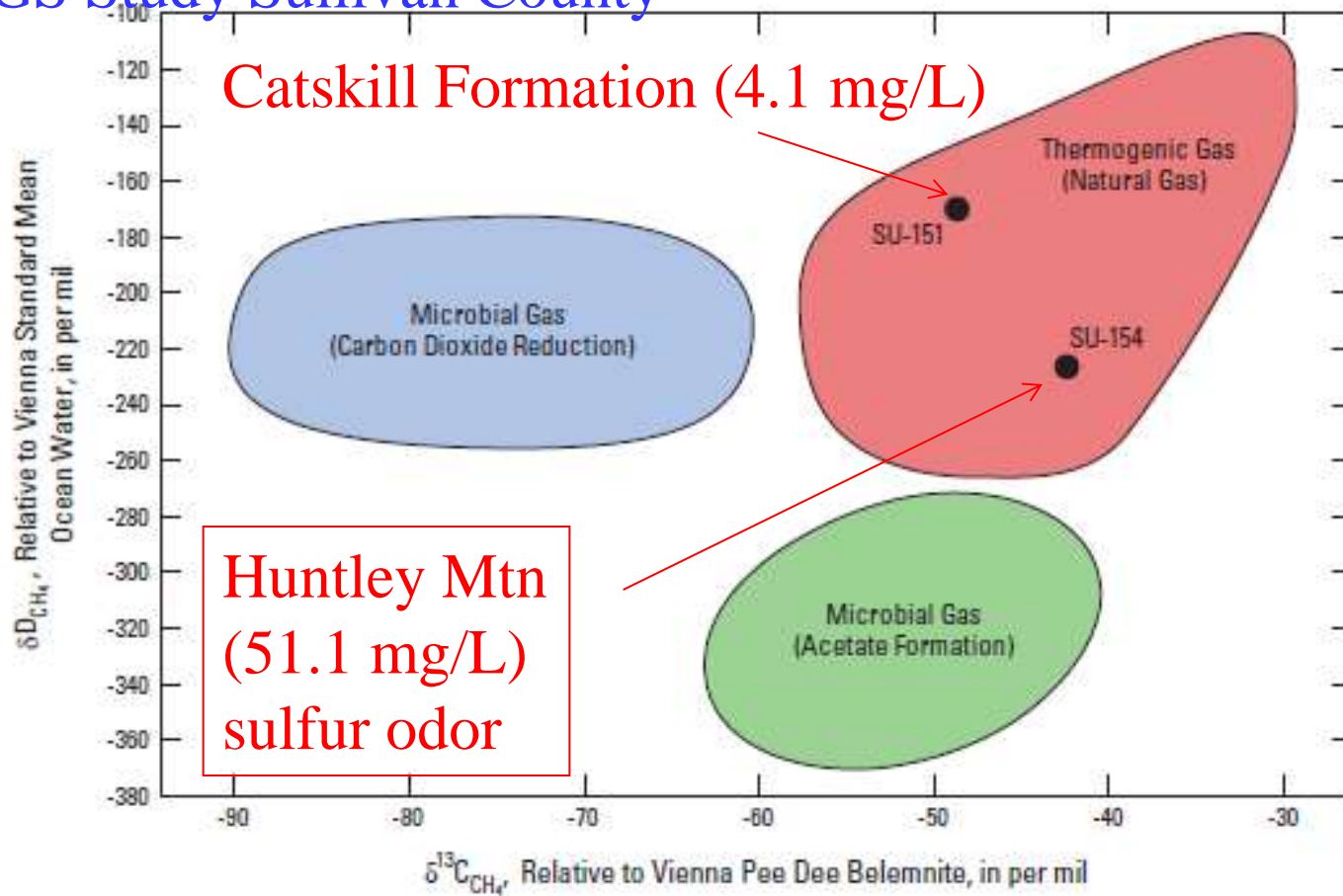
Methane in Water

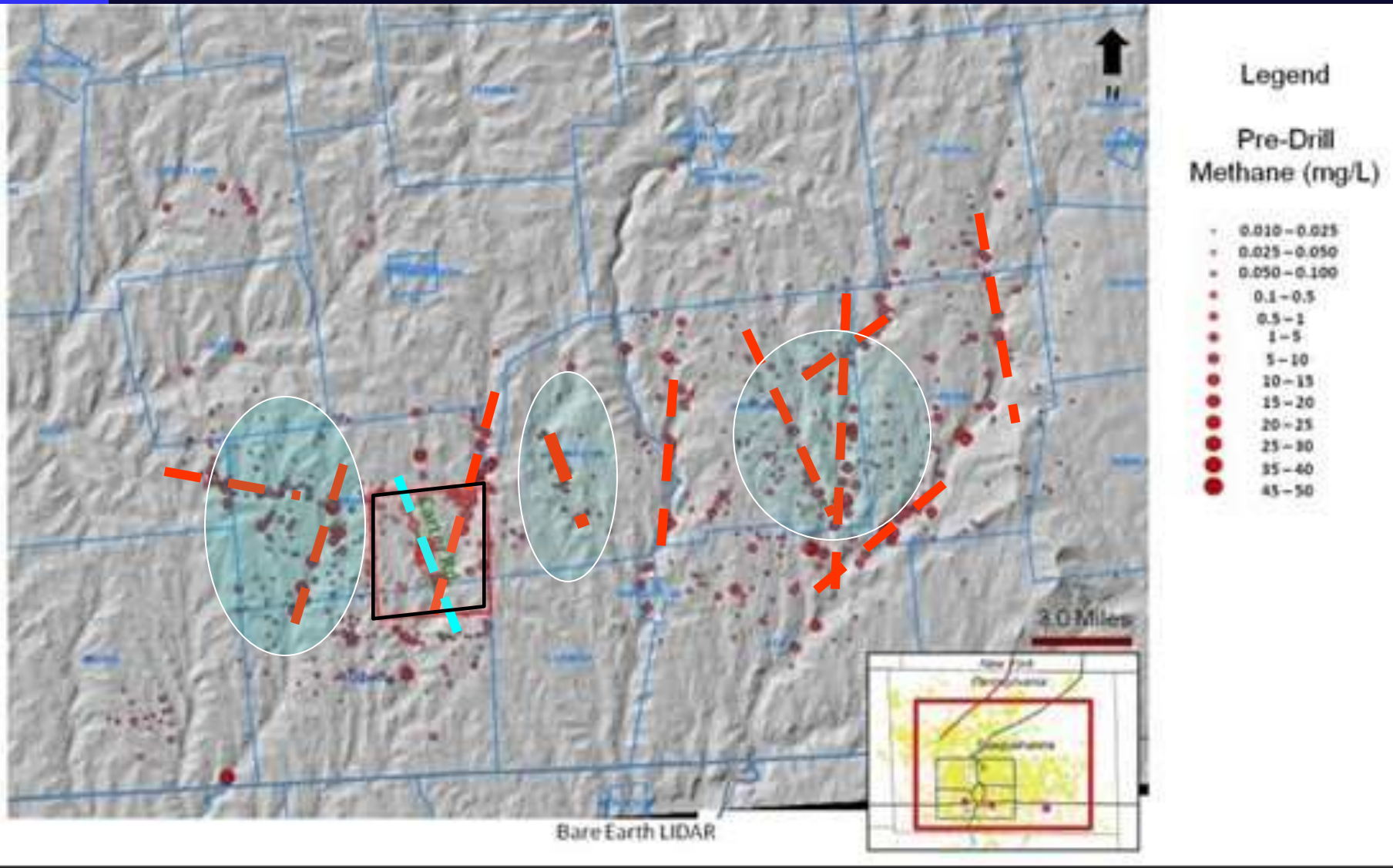
- Methane has been a hidden issue in NEPA.
- The gas is colorless, tasteless, and odorless and there are no known health effects.
- Potential concerns relate to flammability/ explosiveness of gas.
- Background – appears to range from non-detect to over 20+ mg/L (highly variable) in Pennsylvania

Methane Gas Migration- Not Related to Marcellus Shale



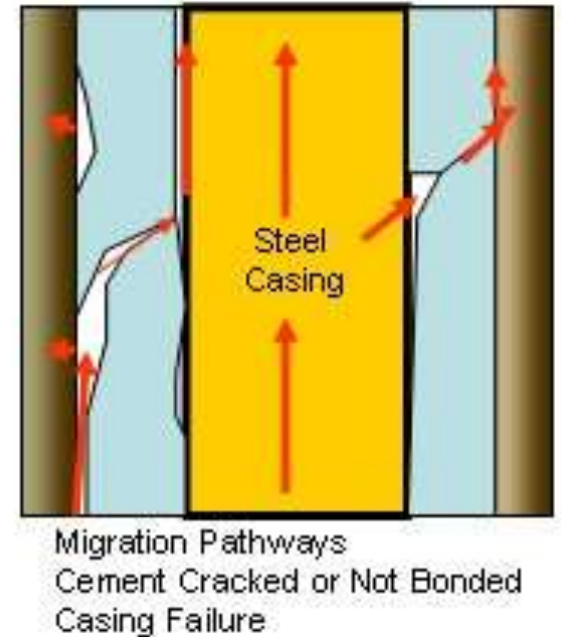
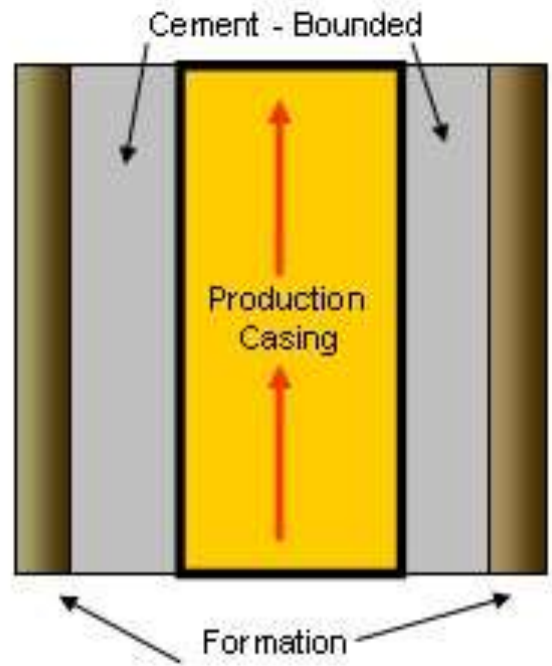
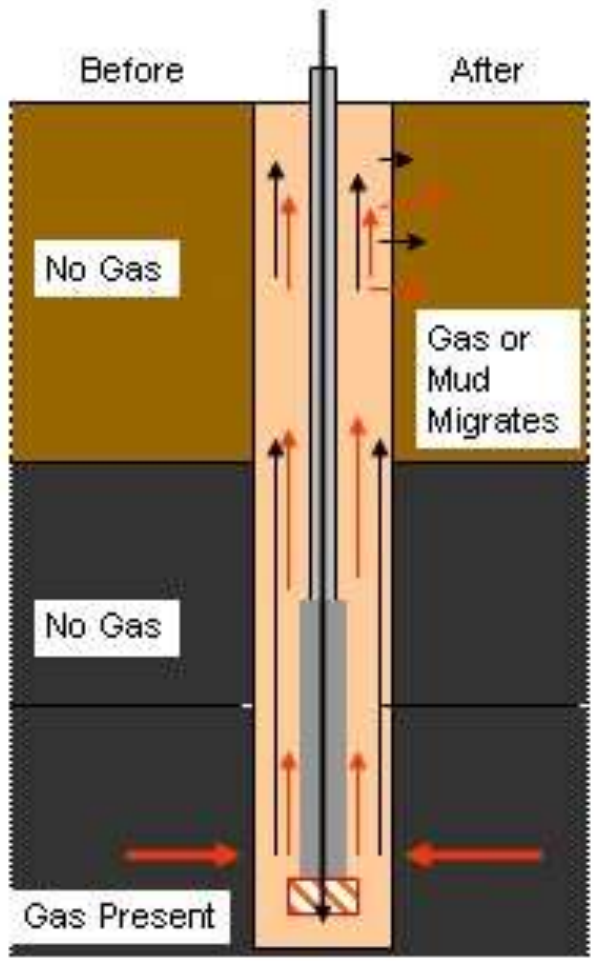
USGS Study Sullivan County





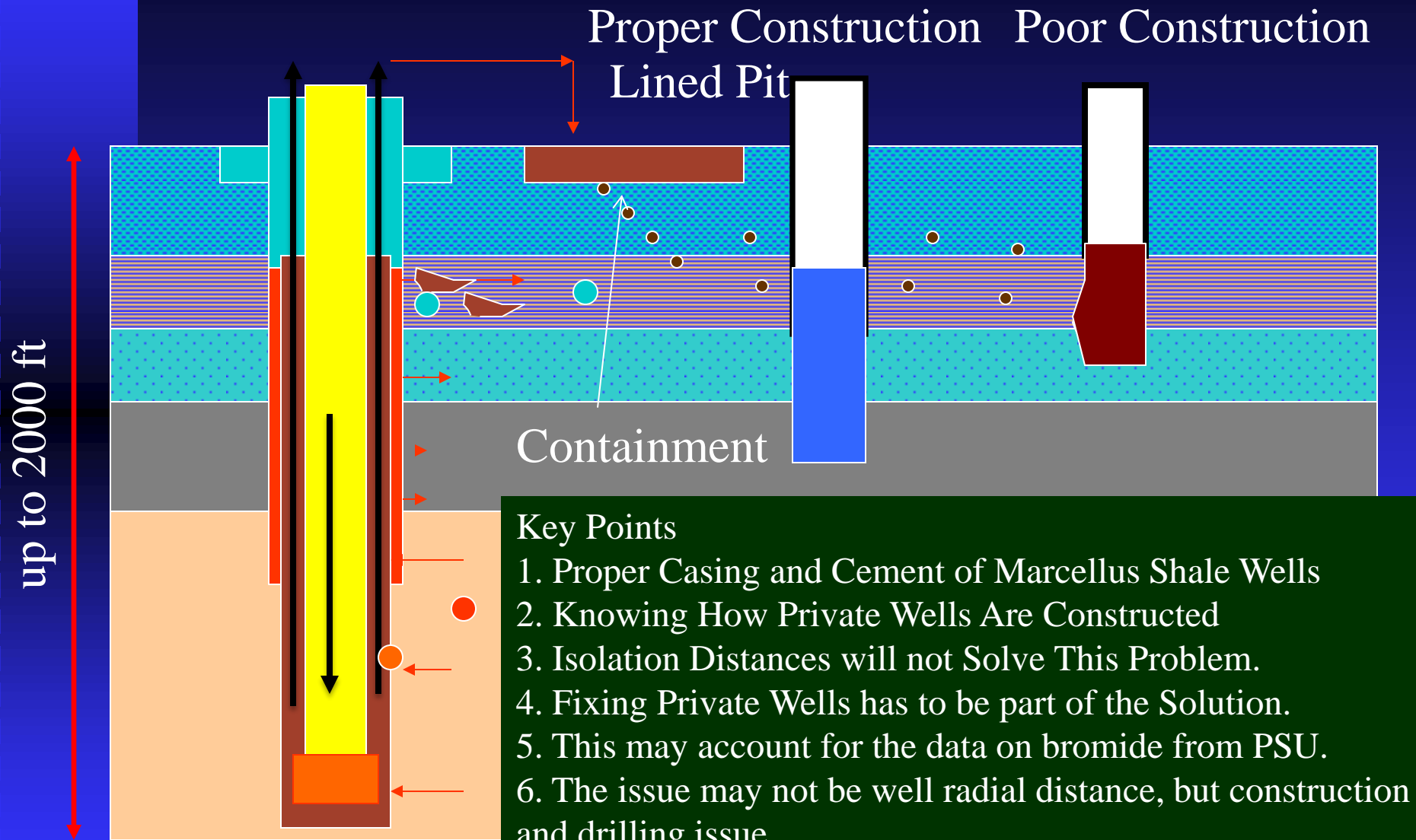
It looks like background methane levels may follow a linear/ curvilinear trend.

Problems with Gas Migration and Cement



<http://www.water-research.net/methanegas.htm>

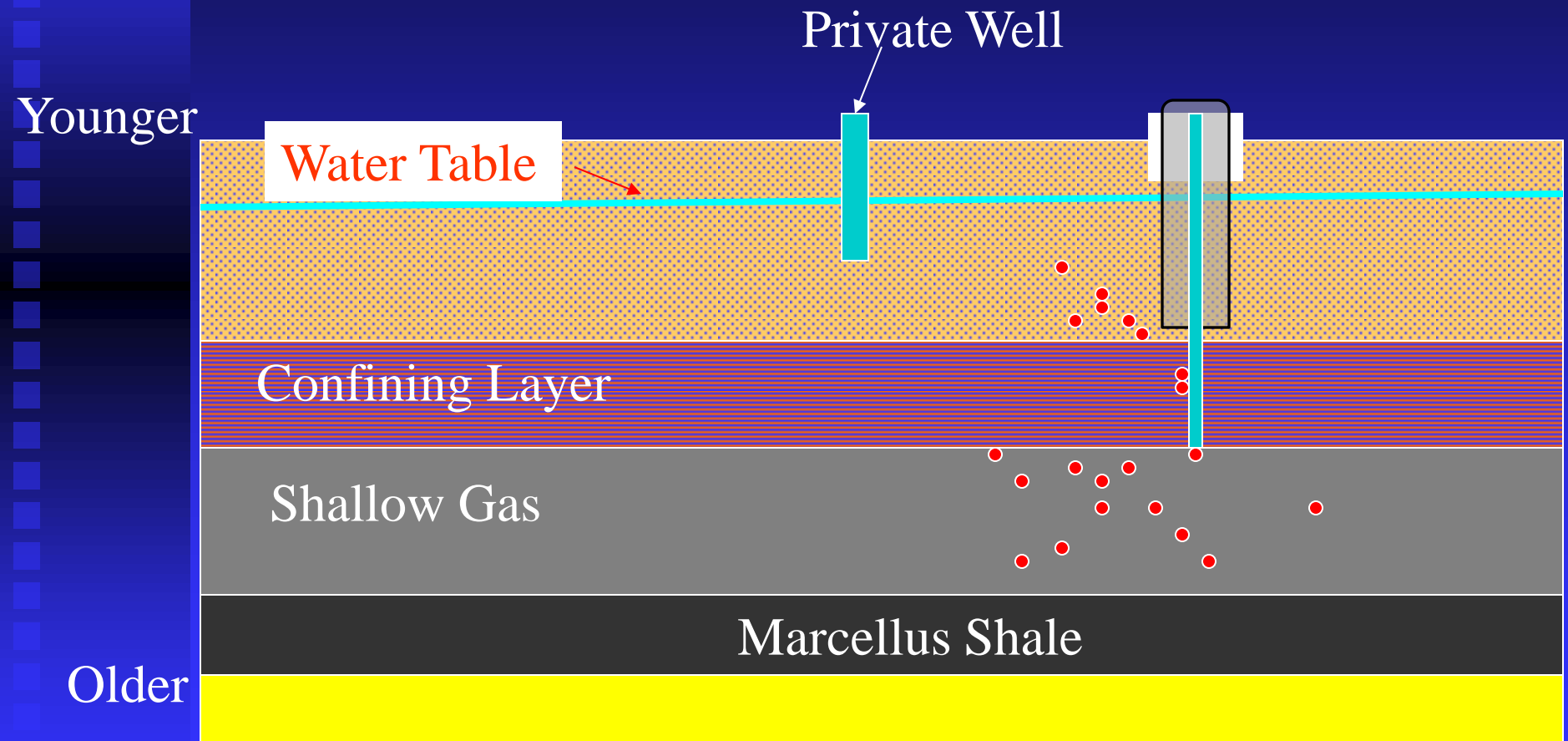
PSU Study -Migration and Disturbance During Drilling-losing circulation



Key Points

1. Proper Casing and Cement of Marcellus Shale Wells
2. Knowing How Private Wells Are Constructed
3. Isolation Distances will not Solve This Problem.
4. Fixing Private Wells has to be part of the Solution.
5. This may account for the data on bromide from PSU.
6. The issue may not be well radial distance, but construction and drilling issue.
7. Recommend closed loop drilling with water within freshwater aquifer (no muds) or water-based muds.

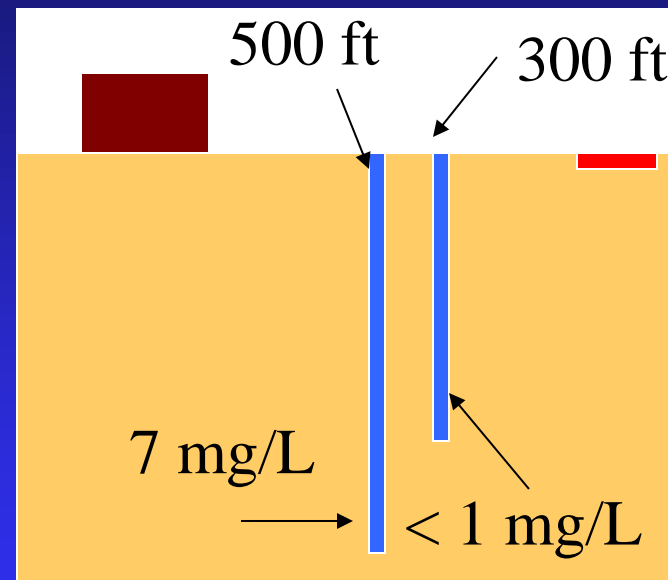
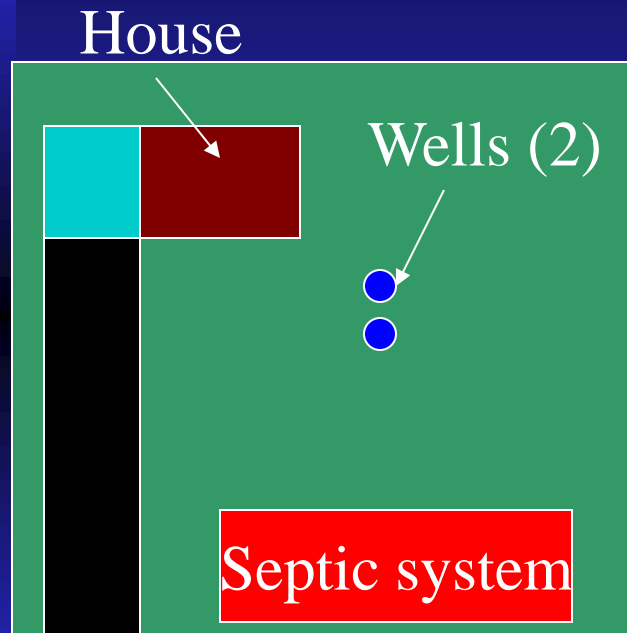
Migration Concepts- Non-Marcellus Shale - While Drilling- Proper Casement Placement



Migration



Methane Variability- Actual Examples- Well Depth Effect



How Can Methane Level be Above 28 mg/L ?



	<u>Methane Solubility</u>
Zero Head	28 mg/L
50 feet Head	69 mg/L
100 feet Head	110 mg/L
150 feet Head	151 mg/L
200 feet Head	192 mg/L

Therefore, Water Well methane levels can exceed 28 mg/L if water is not in equilibrium with the atmosphere.

Freshwater – Solubility as a function of pressure.

Changes in the Regulations

- Require Lined Sites with Containment and Real-Time Monitoring.
- Require Cement Bond Logging and Reporting.
- Require Cementing to Surface for all strings and production casing.
- Require Monitoring Private Wells Pre, During, and Post Development
- Increase baseline testing zone to cover the anticipated capture zone for the well pad.
- Volume of Water Not the Issue – But Hauling is an Issue – Promote Water Reuse and Use of Degraded Waters.
- More Cased Zones – Multiple Cement Casing
 - ◆ New Strings – Placed Based on Local Geology and Well Survey
 - ◆ Shallow Freshwater
 - ◆ Deeper Freshwater
 - ◆ Saline Zone Casing
 - ◆ PADEP should be consistent with EPA UIC Program

Water Treatment

disinfection

anion exchange

oxidation

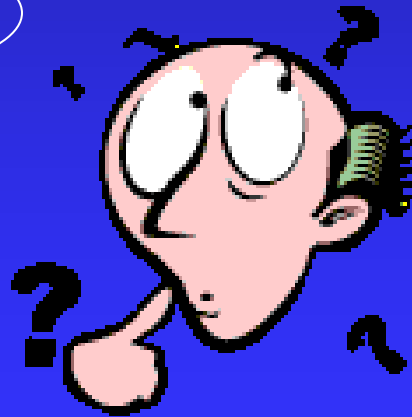
cation exchange

pH adjustment

filtration

adsorption

demineralization



Match the pollutant with the correct process!

Evaluate Well

Change Well Cap

Loose-fitting vs. Sanitary Sealed Well Caps

CAP



SEAL



Disinfection Shock Chlorination



<http://astore.amazon.com/waterwelldriller-20>

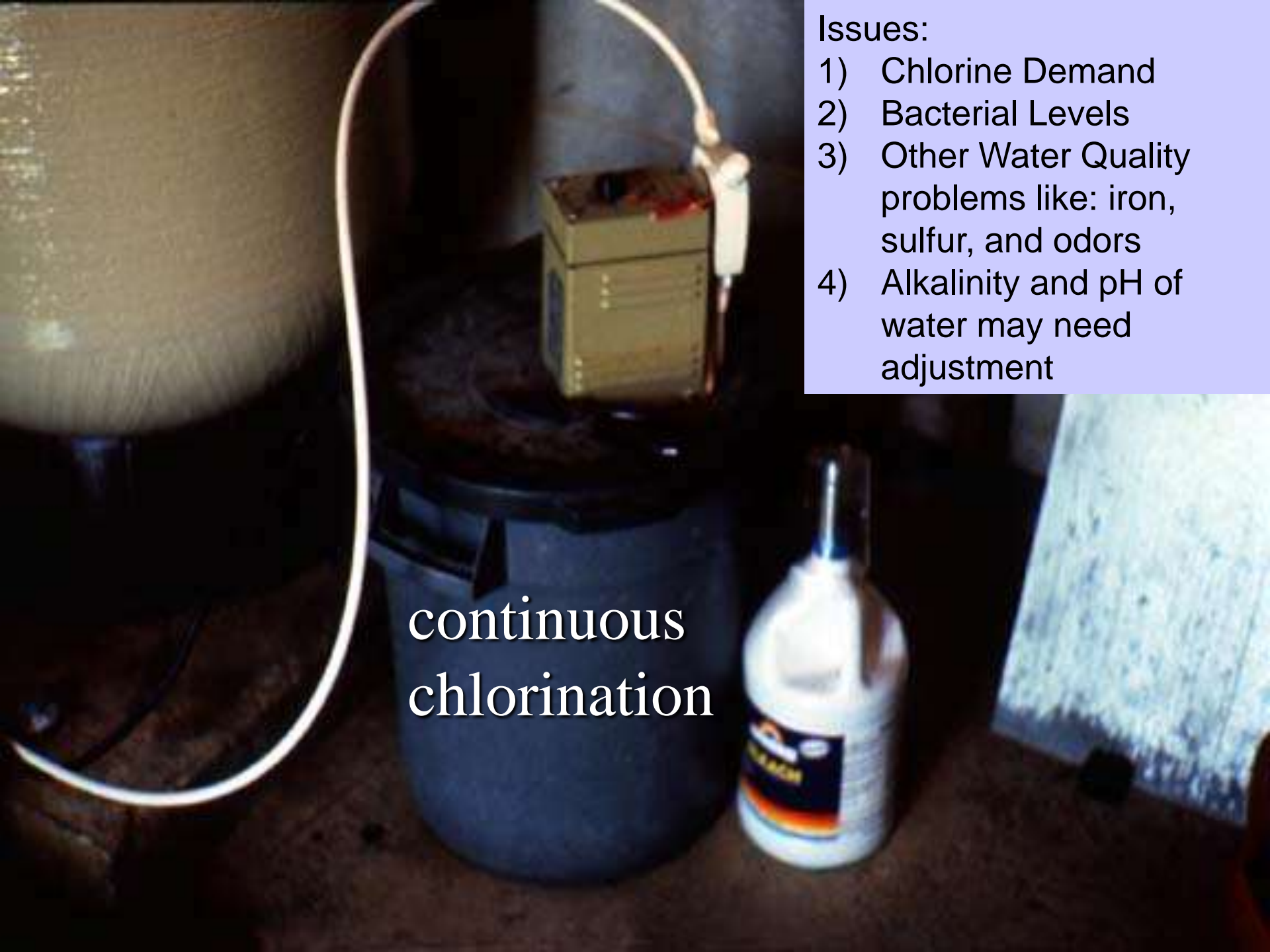
May work for small numbers of coliform bacteria. Should be conducted after all well repairs, flooding, or problems with elevated bacterial counts. After shock disinfection – retesting for total coliform, standard plate count, and nuisance bacteria may be need.

Iron / Nuisance Bacteria



- Periodic shock well disinfections
- Drop tablets chlorinators
- Chlorine feed system
- Ozone treatment
- UV treatment — may be possible
probably Class A Unit (turbidity, hardness, iron, manganese issues)





continuous
chlorination

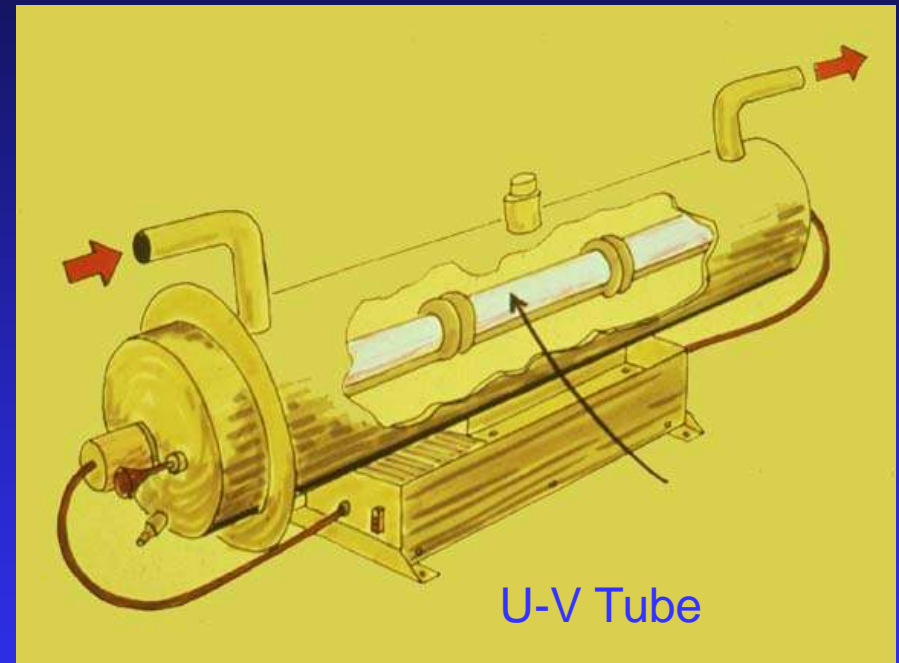
Issues:

- 1) Chlorine Demand
- 2) Bacterial Levels
- 3) Other Water Quality problems like: iron, sulfur, and odors
- 4) Alkalinity and pH of water may need adjustment

U-V Sterilizer

The Selection of UV
Unit system depends on the
following:

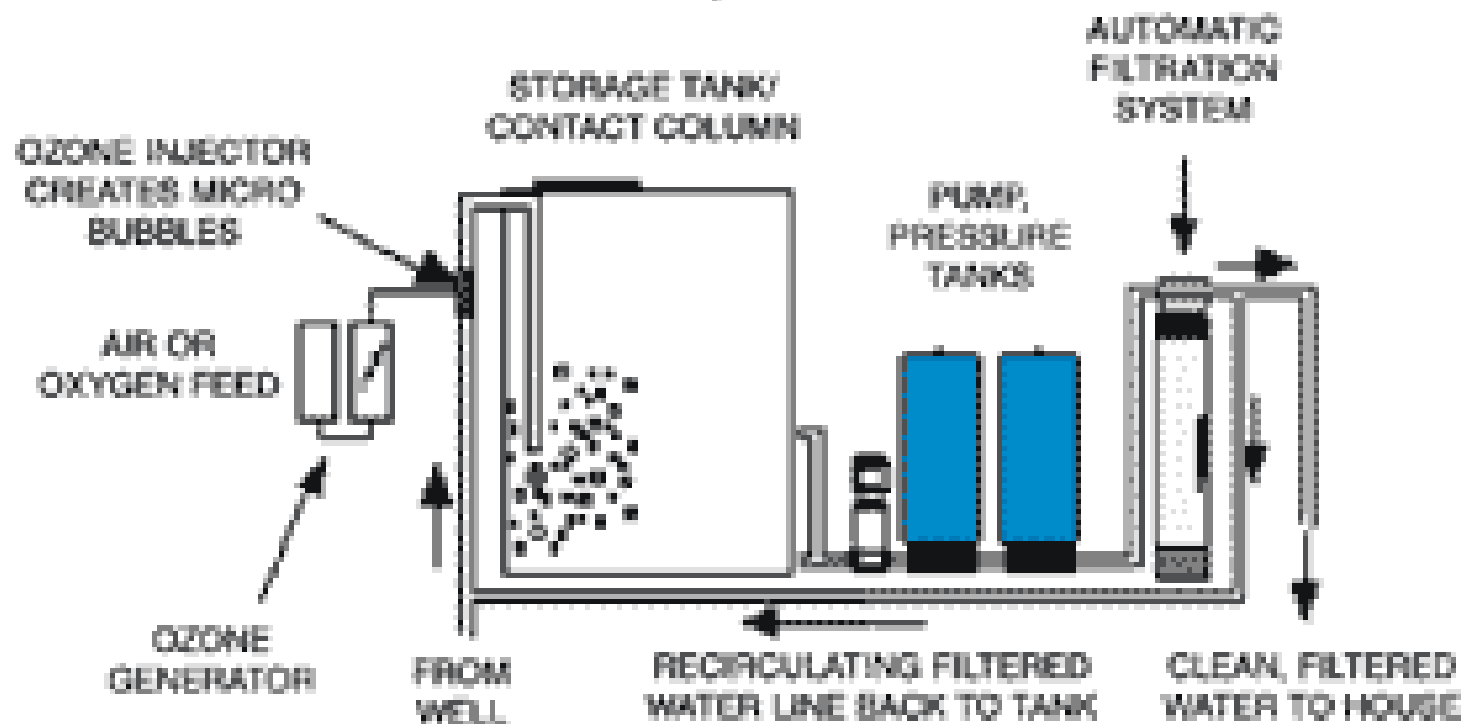
- a) General Water Quality
- b) Turbidity
- c) Hardness
- d) Iron and Manganese
- e) Bacterial Levels
- f) Source Water Type and Overall
Water Quality ?



[Http://www.nsf.org](http://www.nsf.org)

Ozone

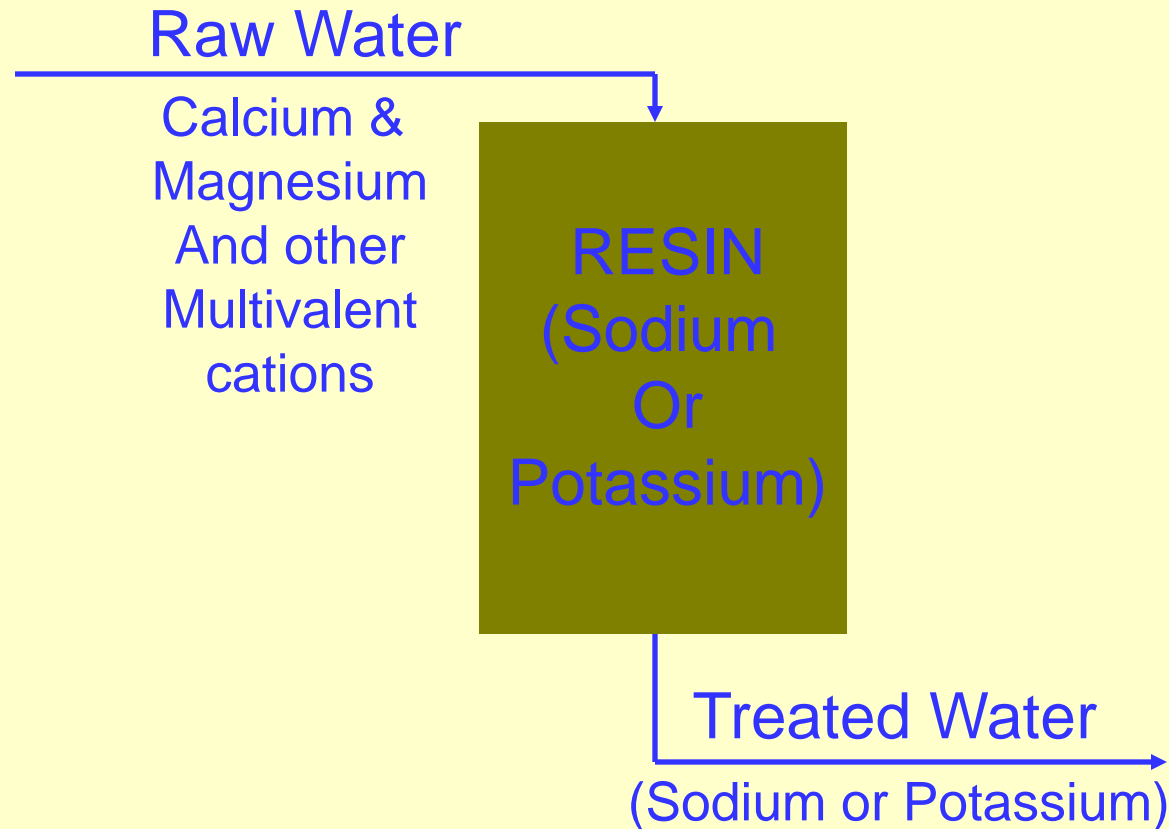
AUTOMATIC OZONE INJECTION, FILTRATION AND RECIRCULATION SYSTEM FOR IRON, MANGANESE



Water Softener

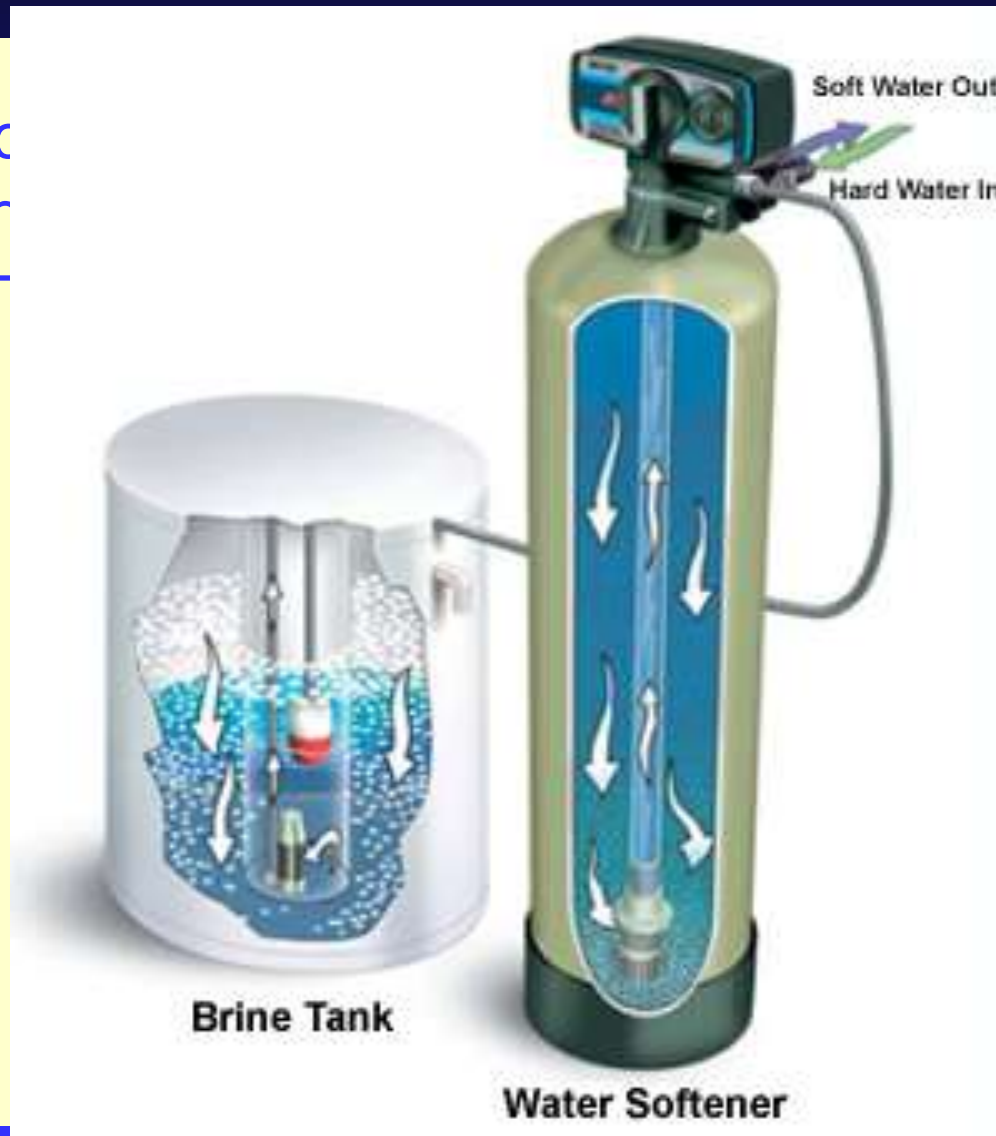
Do Not Remove All the Water Hardness !

Ion Exchange: Sodium for Calcium & Magnesium



Recharge with Brine

Calc
oth
←



n)

Carbon Filtration

■ Uses

- ◆ Remove man-made organic chemicals
- ◆ Remove miscellaneous tastes and odor from water – **assuming no bacterial problems**
- ◆ Remove radon gas from water

■ Maintenance

- ◆ Carbon must be replaced routinely

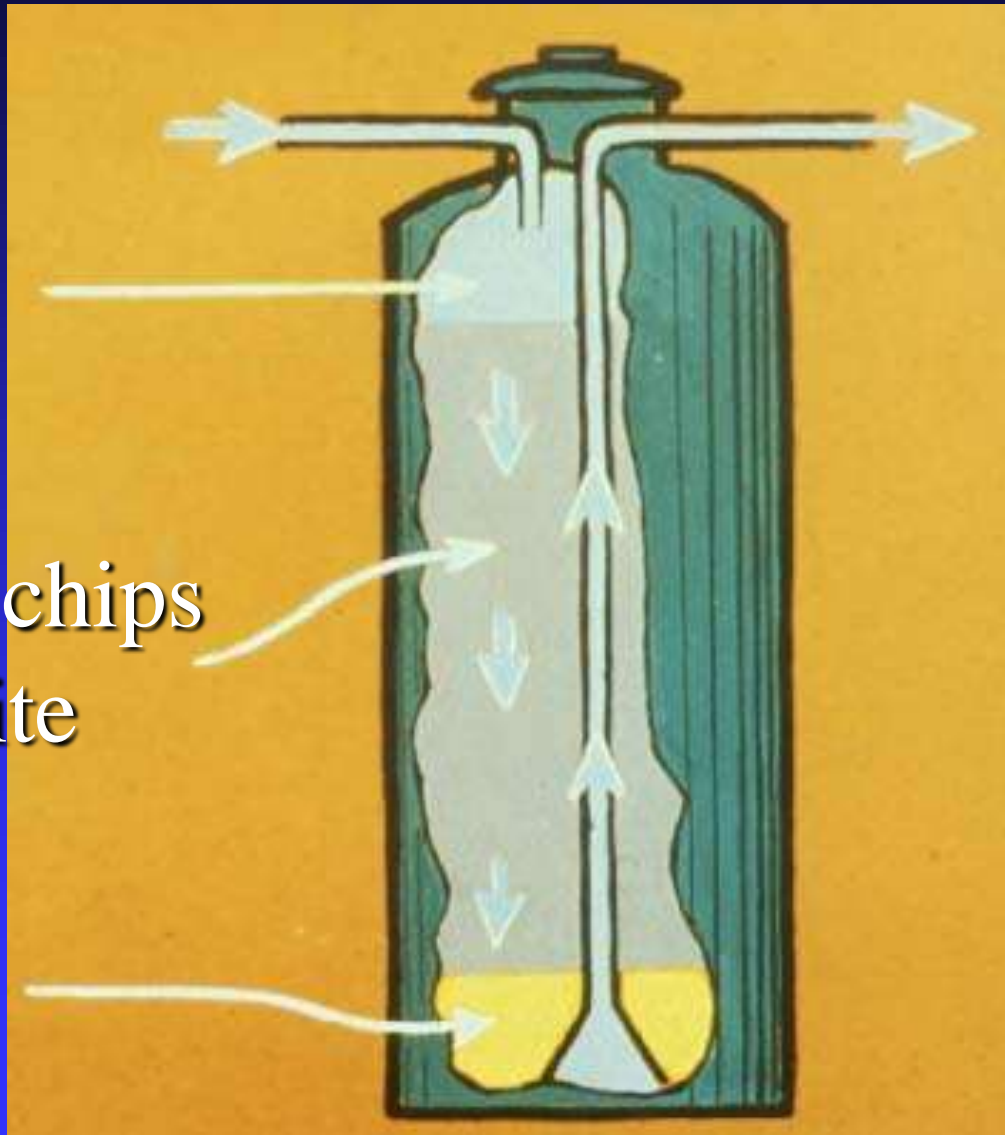


Acid (Corrosive Water) Control

Water

Limestone chips
or calcite

Gravel



Iron / Manganese Removal

- Form and concentration is important
 - ◆ Oxidized = visible, orange stain
 - ◆ Reduced = colorless or black
- Removal Methods
 - ◆ Water Softener
 - ◆ Chlorination / Filtration
 - ◆ Oxidizing Filter
 - ◆ Ozone



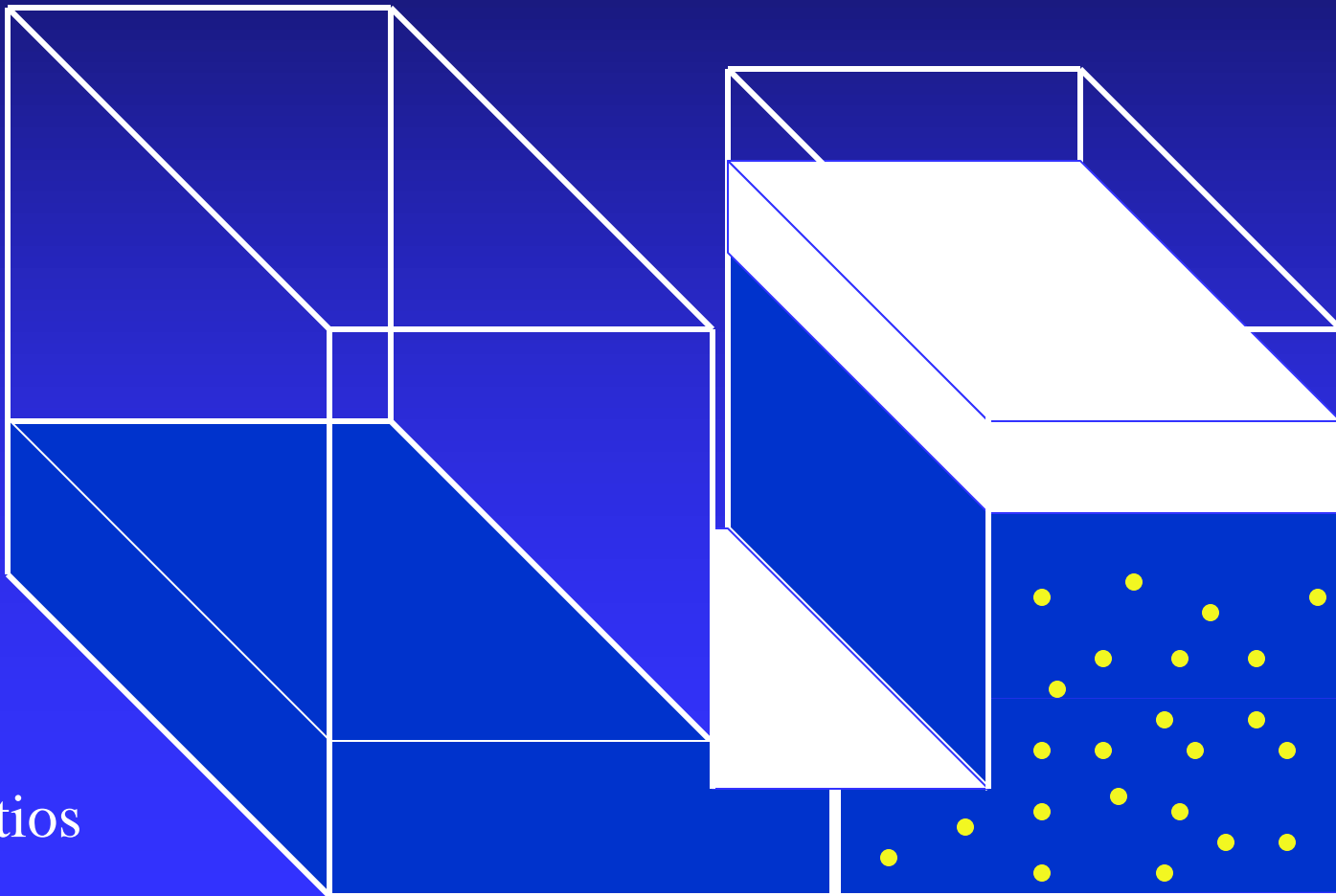
<http://water-research.net/iron.htm>

Hydrogen Sulfide

- Hot water only?
 - ◆ Adjust water heater to a temperature of 160C for 12 to 24 hours and then flush
 - ◆ remove or replace rod in heater (Warranty Issues)
- Carbon Filtration- **no bacterial problem**
- Chlorination/ Contact Tank / Filtration
- Aeration- **no bacterial problem**
- Oxidizing filter- manganese greensand

Reverse Osmosis

- force water through membrane
- removes many contaminants



Waste to
Water Ratios
2:1 to 5:1

Other



Go to <http://www.carbon-filtration.com>

Units are rated for Water that meets Drinking Water Standards
Not for Water with Levels above the Drinking Water Standard



Typically these are small carbon-block filters that will remove particles, reduce odors and taste problems, and have a limited exchange capacity for hardness and trace metals.

Check Out – <http://www.carbon-filtration.com>

Before You Buy Treatment Equipment Get the Facts- Not the Sales Pitch

- Have your water tested by a reputable accredited, approved, and/or certified lab
 - Don't rely on in-home water test results.
 - Don't rely on free water tests.
- Consult unbiased water quality experts and get multiple quotes for a system.
- Explore all alternatives
 - ◆ Well rehabilitation, New source, Local Pollution Control, Maintenance

Tips for Buying Treatment Equipment

- Seek reputable companies that have been around
- Ask for customer references
- Research company history
- Beware of hard sale techniques (scare tactics)
- Ask about maintenance requirements
- Get a detailed warranty
- Look for NSF and WQA certifications
- EPA certification means nothing
- Get everything in writing!
- If it sounds too good - it is!

Give Us (KCWT) a Call – We DO Not Sell or Install !

Sample No. BF0127

Test	Result	Maximum Contaminant Level (MCL)
Coliform bacteria	2 /100 mL	<1 /100 mL
Nitrate-N	1 mg/L	10 mg/L
pH	6.7	6.5 to 8.5**
Hardness	100 mg/L 6 gpg	No MCL (7-10 gpg is very hard)
Iron	0 mg/L	0.3 mg/L **

gpg = grains per gallon (1 gpg = 17.1 mg/L), ** = Recommended standard (RMCL)

Recommendation ?

Shock chlorination and retesting, possible continuous disinfection

Sample No. BF0242

Test	Result	Maximum Contaminant Level (MCL)
Coliform bacteria	150 /100 mL	<1 /100 mL
Nitrate-N	1 mg/L	10 mg/L
pH	6.7	6.5 to 8.5**
Hardness	100 mg/L 6 gpg	No MCL (7-10 gpg is very hard)
Iron	0 mg/L	0.3 mg/L **

gpg = grains per gallon (1 gpg = 17.1 mg/L), ** = Recommended standard (RMCL)

Recommendation ?

Shock Treatment and Retesting and Possibly Chlorination or UV light or Ozone

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And

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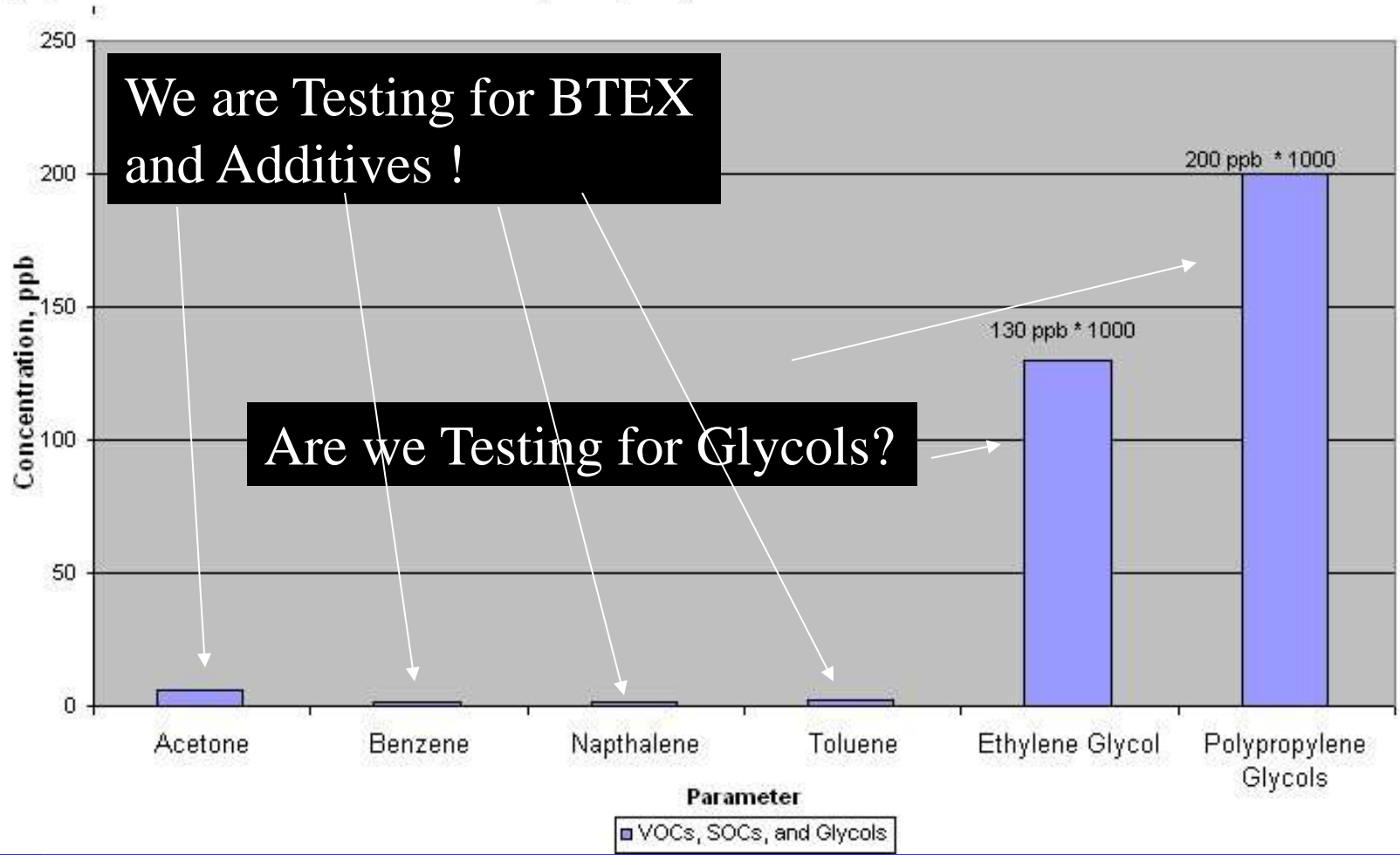
<http://www.water-research.net>

Support the Keystone Clean Water Team

<http://www.pacleanwater.org>



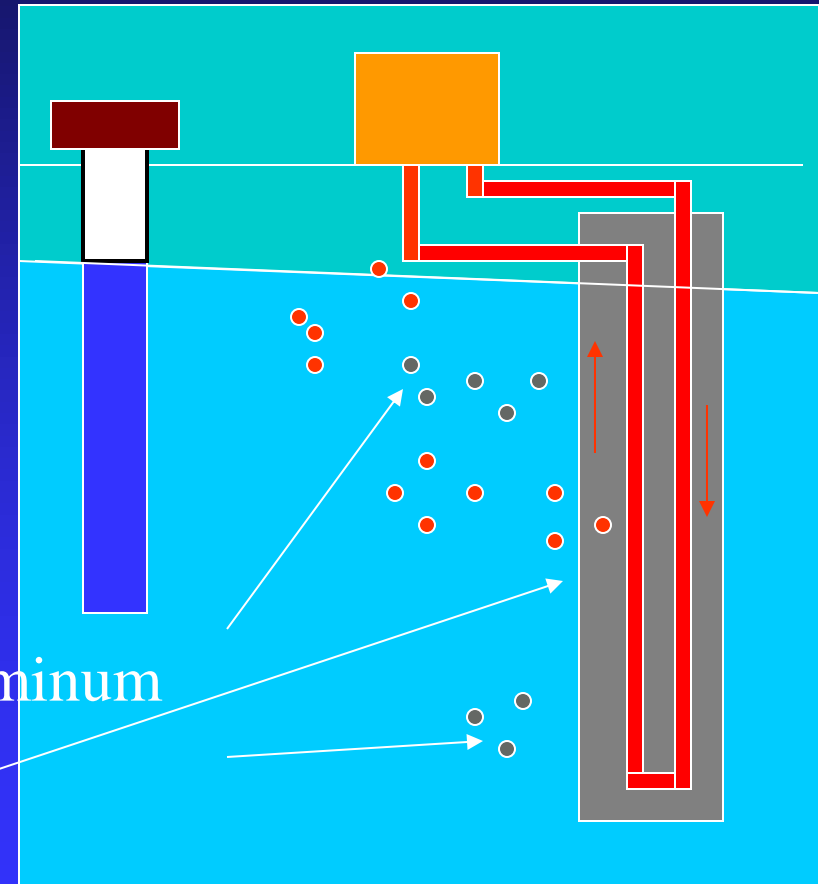
VOCs, SOCs, and Glycols in Flowback Water



Glycols- not a common problem – no real drinking water standard

- ground-water heating and cooling systems, deicing agents, and natural gas development
- EPA guidance is ≤ 7000 ppb or 7 mg/L (ethylene glycol)

Grout- Aluminum
Silicates

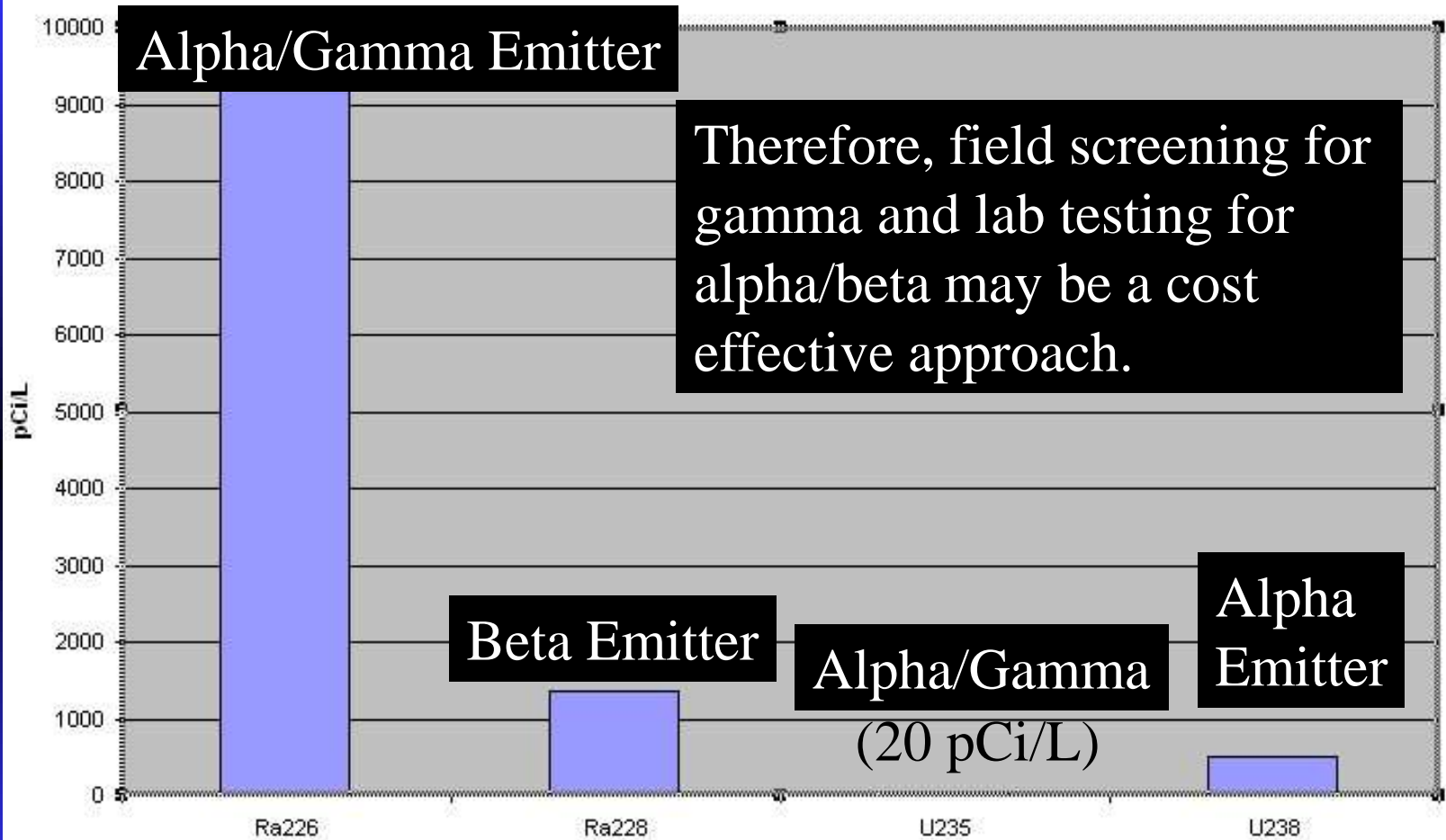


Private Well

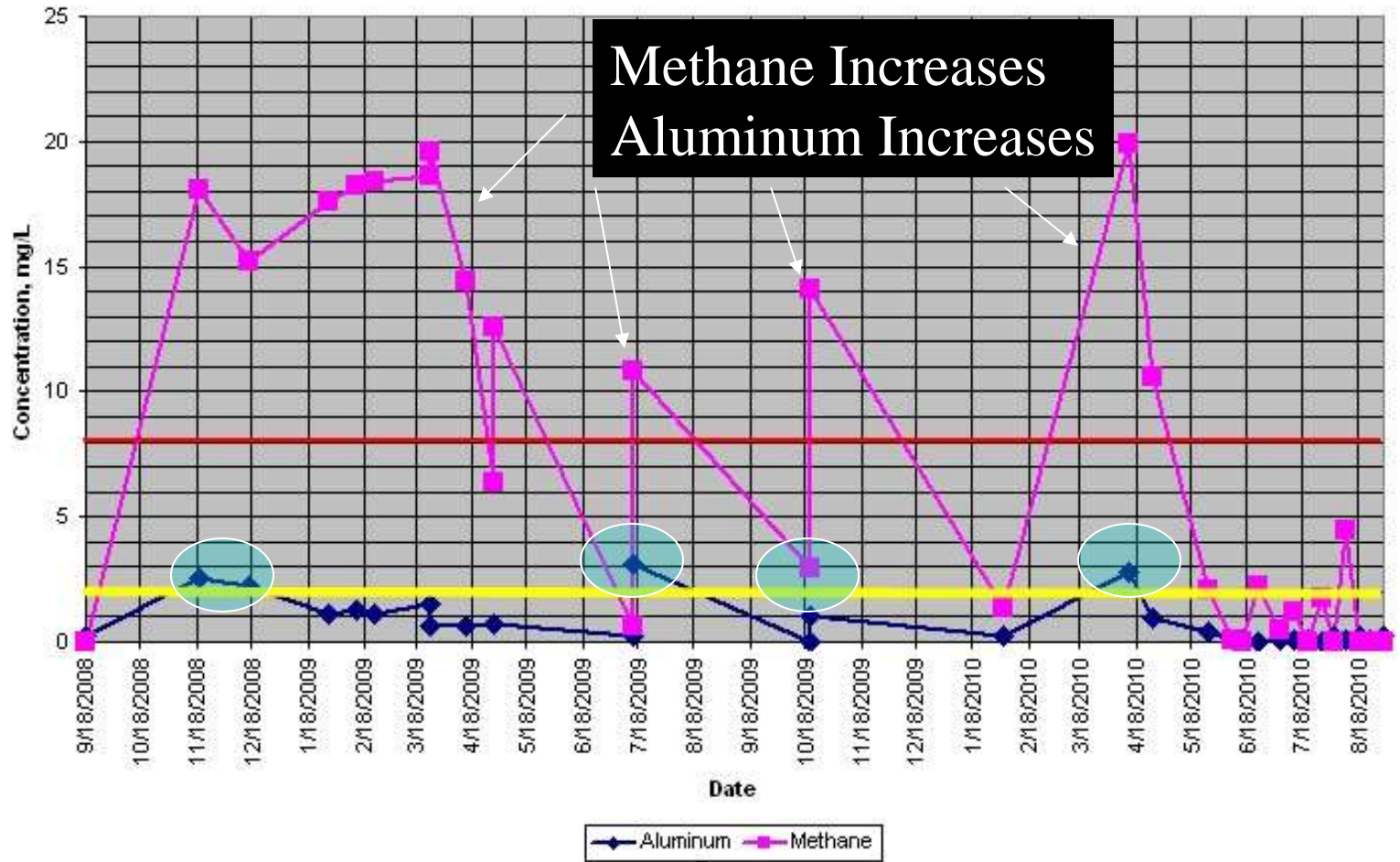
Ground Surface
Well

Recirculated Glycol in Plastic
Piping surrounded by Sand with Clay
No Construction Standards No Protective Casing

Radiological in Flowback Water



Water Quality Trend



Add Aluminum and Corrosion By-Products to
Baseline Testing