



# 50 Good Reasons to Enjoy (and Protect!) Your Water

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Presented to the Butternut Valley Alliance  
Butternut Valley Grange, Gilbertsville, NY  
April 15, 2012

# Acknowledgements

- Funding Sources:
  - Otsego County Conservation Association
  - Research Foundation of State University of New York
  - Vibrant New York program run by Tim Hayes at The Center for Economic & Community Development (**CECD**) at SUNY Oneonta
- Members of the Butternut Valley Alliance and participants in the sampling program
- The loose affiliation of watershed managers who provided the impetus to form Catskill Headwaters Research Institute (USGS, SUNY, Otsego County Soil & Water District, NYS DOH, BFS, GASTEM-USA)
- Most of all: **The Water Sampling Team!!**
  - Leandra Baker, now at Barton & Loguidice
  - Fiona Lowry, soon to be at Public Health, U of MN Graduate School
  - Molly Reed, now at Plumley Engineering, P.C.

# Establishing a Baseline and a Fingerprint of Groundwater Chemistry Prior to High Volume Horizontal Gas Drilling in Otsego County, New York

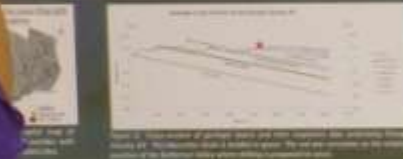
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## I. Introduction:

Horizontal gas drilling targets rock formations rich in natural gas. Well formations in the southern tier of New York, including the Marcellus and Utica Shales, are currently being examined for possible natural gas extraction (Figure 1). Our region of study, Otsego County, is underlain by the Hamilton Shale formation (Figure 2). A main concern surrounding extraction of natural gas is groundwater quality. In order to determine if drilling causes changes in groundwater chemistry, a preliminary study of baseline water chemistry in the region must be performed before drilling. The purpose of our study is to establish this groundwater chemistry baseline while determining the possibility of fingerprinting water that originates within the area targeted for natural gas.



## Methods:

Water samples were collected from residential wells or springs in Otsego County. On-site testing of pH, temperature and conductivity was performed before the water was bottled. After sampling, the water was tested for nitrate, phosphate, chloride and sulfur by a laboratory using a 2000 Portable Spectrophotometer. Trace elements (46 in total) within the water samples were analyzed using an Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). The concentration of the water was determined by plotting the 46 elements that were analyzed against a standard curve. Each well location was plotted against a regression line to determine the coefficient of determination (R<sup>2</sup>).

## III. Results:

### 1. Elemental Variability

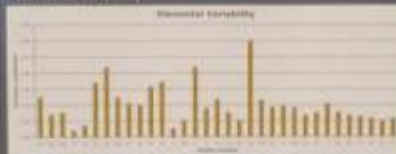


Figure 4: Elemental variability across different wells.

### 2. Calcium Concentrations



### 3. Mixing Models



Figure 5: Mixing models and scatter plot showing calcium concentrations.

### 4. Seasonal Variations



Figure 6: Seasonal variations in groundwater chemistry.

## IV. Discussion:

Fingerprinting of the water thus far has consisted of elemental variability, coefficient of variability (Figure 2) and seasonal variations (Figure 6). We found that the variability between major cations and rare earth elements. However, when we looked at elements such as Ca, Cu, Mn, and Zn, we found greater variability. When we looked at seasonal variations, we found that the variability between seasons is not significant. This variation could be due to differing rock formations moving through or moving off of ground and surface to the well. Our mixing model demonstrates that calcium which shows that the water is originating from the Hamilton Shale. Calcium was used as a reference element to generate baseline (Figure 4 & 7). The relationship between calcium, rare earth elements and other elements in the water is different. Such as elements. The consistency of our methods contribute to a model that can be utilized in fingerprinting water.

**Acknowledgments:** We would like to give a special thank you to the SUNY Oneonta, the research team with the research. The Otsego County Shale Gas Program is providing funding. Kelly Hall and Tom Hall. We thank Leslie Hasbargen for her comments, support and guidance.

Leandra Baker

# Why this sampling program?

- BASELINE data on groundwater is very sparse in our county; many of us drink from local private wells.
- We need to understand groundwater flow systems: water chemistry is a product of flow paths and water-rock reactions.
- The public needs this information: knowledge is power.

# Sampling Procedure

- **Goal:** Sample across region to get at natural variability
- **Goal:** Capture a representative sample of groundwater
- No chemical treatment
- Minimal time to react with indoor pipes
- Filtered for particulates
- Acid added to sample to keep the metals dissolved
- Bottled, labeled, and sent to Activation Laboratory in Canada to test for **cations**
- Aliquot tested in SUNY Oneonta Hydrology lab for **nutrients, anions, alkalinity** and some metals

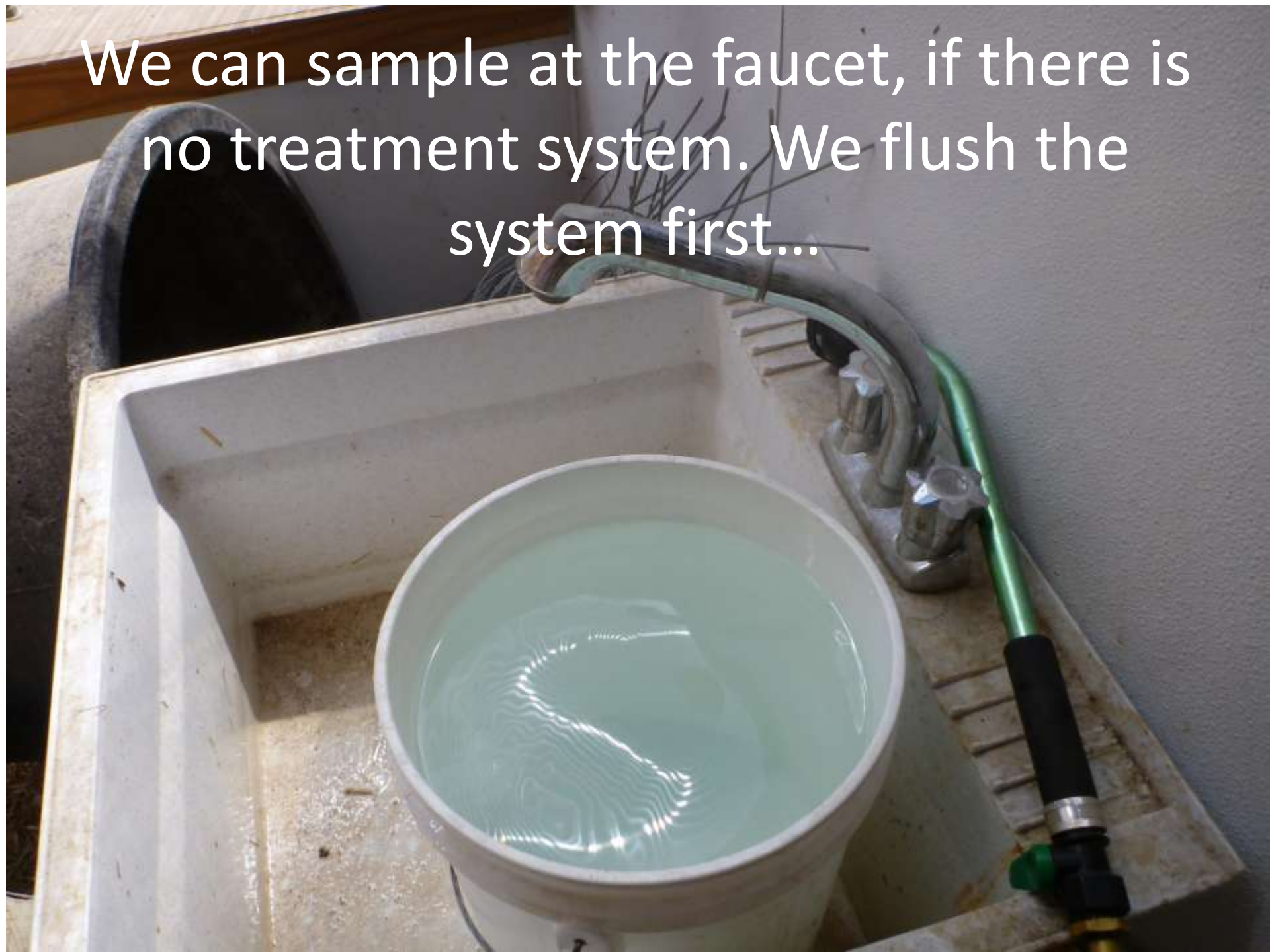
# What some well water can look like...



We filter the particulates, and test the dissolved content in the water.



We can sample at the faucet, if there is no treatment system. We flush the system first...

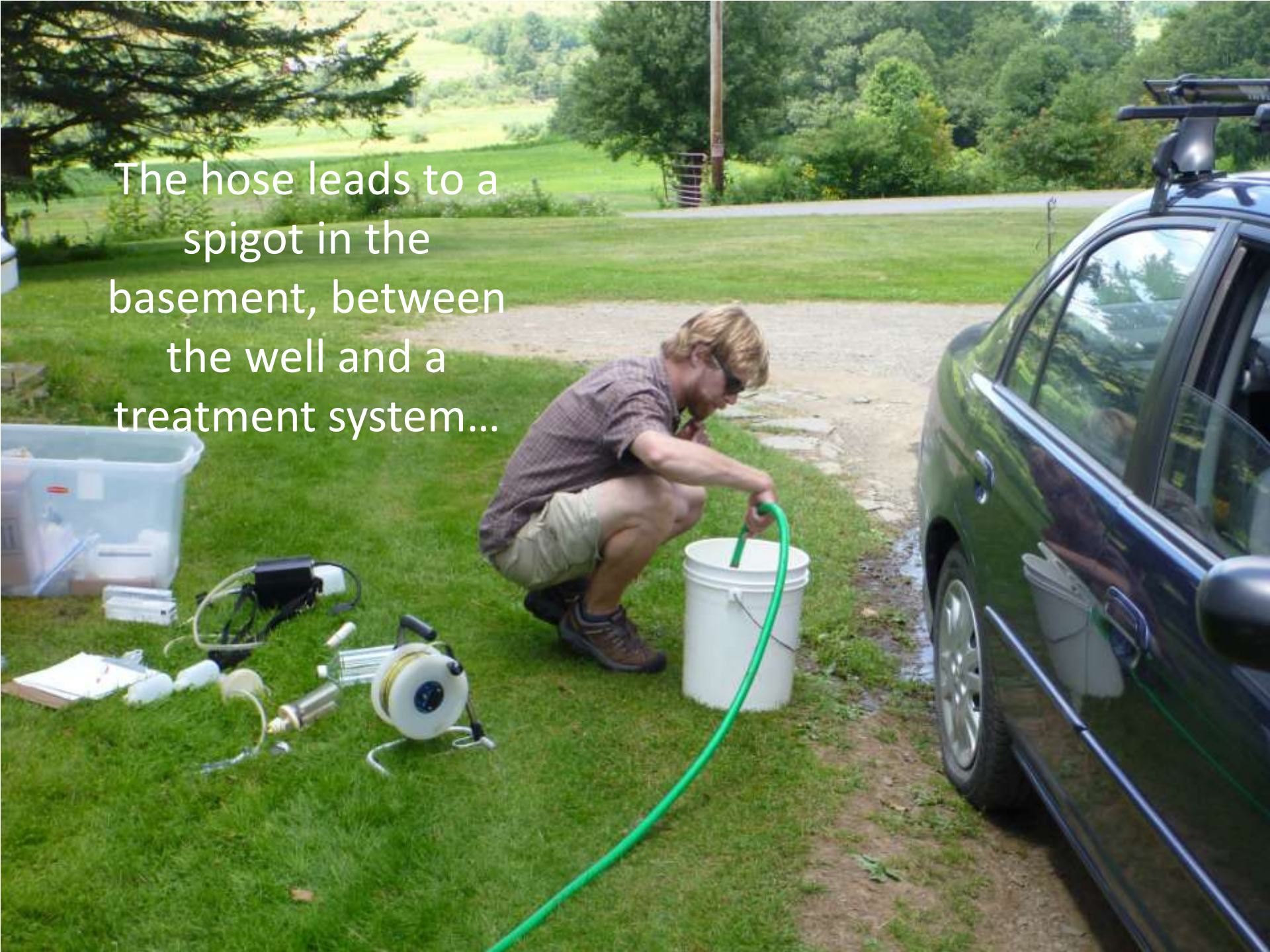



A chemical  
test in  
progress  
for Arsenic





The hose leads to a spigot in the basement, between the well and a treatment system...



A blue metal well cap is mounted on a rusty metal casing. The cap has a diamond-shaped logo with the word "HATZARD" inside. A white PVC pipe is visible next to the casing. The well is situated in a grassy field.

When unknown,  
we try to get  
well depths, and  
any other  
information  
about the  
substrate, casing  
openings, etc.



Testing for water depth in the well, and well depth



Pulling a  
pump



Barney and Sons Drilling

# Sampling a spring...



# Common basement plumbing system



# What did we sample for?

- 66 elements were tested for by ACT Labs with an ICP-MS device
  - Why? This was a VERY affordable way to get a lot of information! \$47.50 per sample, plus bottle and mailing costs.
  - More importantly, knowing these concentrations in the water provides IDENTITY, and it provides clues to groundwater flow paths, and water-rock reactions
- We also determined basic water quality measures: nutrients (nitrates and phosphates); chloride; sulfates; temperature, conductivity

# Elements we sampled for...

Na	Y	Dy	Zr	Ga
Ca	Cs	Ge	Tb	Pd
K	Br	Mo	Ho	Ag
Mg	Cu	Fe	Tl	Be
Si	Pb	Ni	Th	Bi
Mn	La	Cd	Sc	Hg
Zn	Li	Yb	Lu	In
Ba	Ce	Sm	Re	Nb
Sr	Nd	Er	Cr	Os
Rb	Eu	Al	V	Pt
Ti	W	Se	Au	Ru
U	Co	Sb	Tm	Sn
As	I	Pr	Hf	Ta
	Gd			Te

See <http://www.ptable.com/> for more info on elements

Most common elements are in first column; least common are in far right column. Of these typically 33 are detected in a well (some have more, some less.)



These were never  
detected in wells

Ag: Silver

Be: Beryllium

Bi: Bismuth

Hg: Mercury

In: Indium

Nb: Niobium

Os: Osmium

Pt: Platinum

Ru: Ruthenium

Sn: Tin

Ta: Tantalum

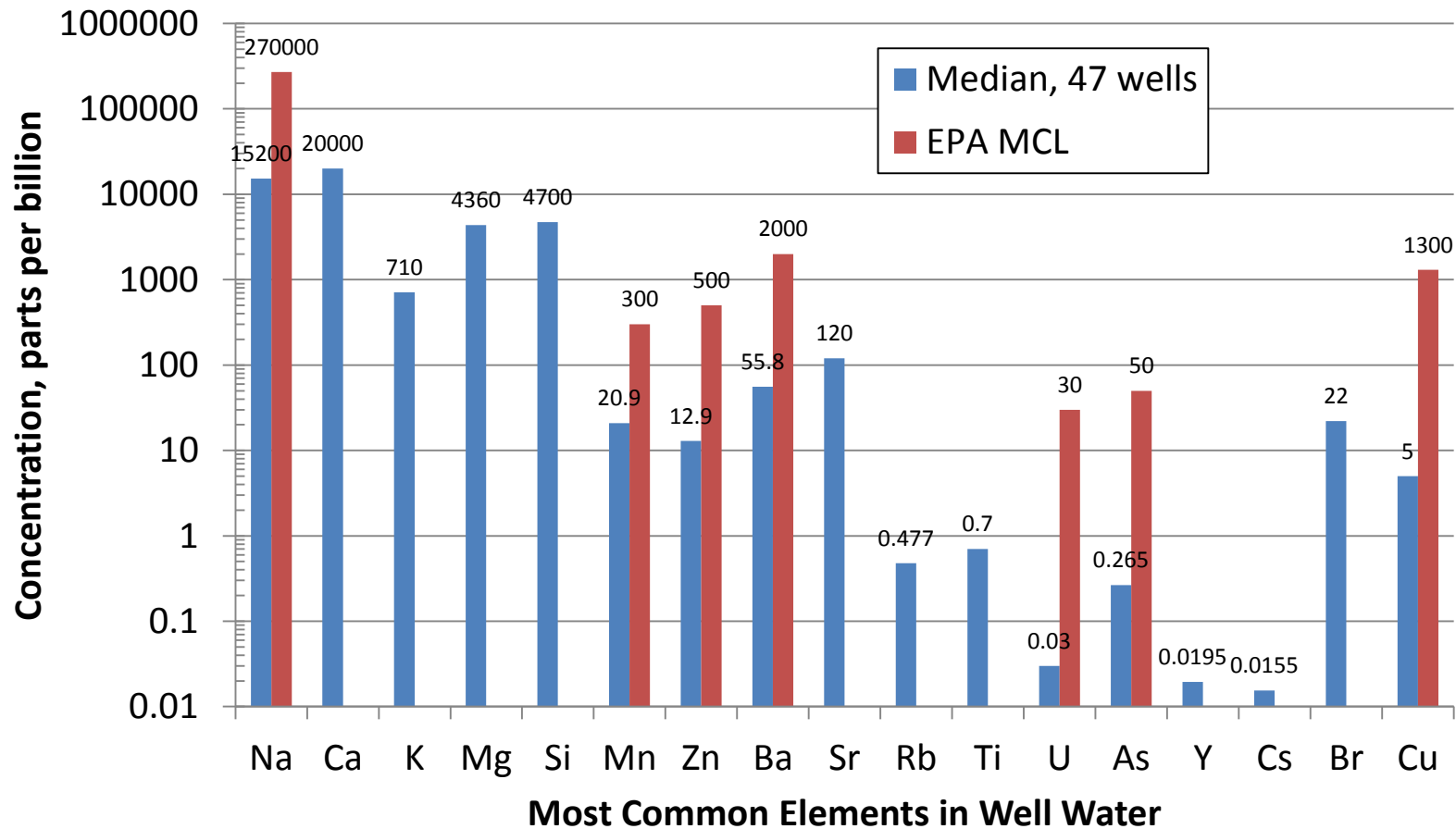
Te: Tellurium

# Well Water Concentration (Cations)

## Statistics...

Analyte Symbol	Coefficient of Variation (std dev / ave)	Standard Deviation (µg/L)	Min (µg/L)	Max (µg/L)	Median (µg/L)	Average (µg/L)	# Wells with analyte present
Na	0.84	15617	1100	60900	15200	18689	47
Ca	0.87	15459	2100	89800	20000	17748	47
K	2.64	5702	180	35500	710	2157	47
Mg	0.73	3719	366	18100	4360	5114	47
Si	0.30	1445	2700	8800	4700	4838	47
Mn	1.40	79.90	0.3	371	20.9	57.06	47
Zn	1.47	38.85	1.5	228	12.9	26.34	47
Ba	0.89	65.29	1.6	217	55.8	73.57	47
Sr	1.38	225.93	12.8	1390	120	163.50	47
Rb	0.59	0.38	0.113	1.95	0.477	0.64	47
Ti	0.34	0.23	0.3	1.3	0.7	0.70	47
U	1.27	0.16	0.002	0.634	0.03	0.13	47
As	2.16	1.71	0.06	10.3	0.265	0.79	46
Y	1.49	0.06	0.004	0.37	0.0195	0.04	46
Cs	1.11	0.04	0.003	0.139	0.0155	0.03	46
Br	2.52	322.95	4	1800	22	128.09	45
Cu	1.43	65.95	0.3	200	5	46.17	45
Pb	1.40	0.71	0.02	3.46	0.22	0.51	43

# Most commonly occurring elements (metals) in wells, and EPA MCL



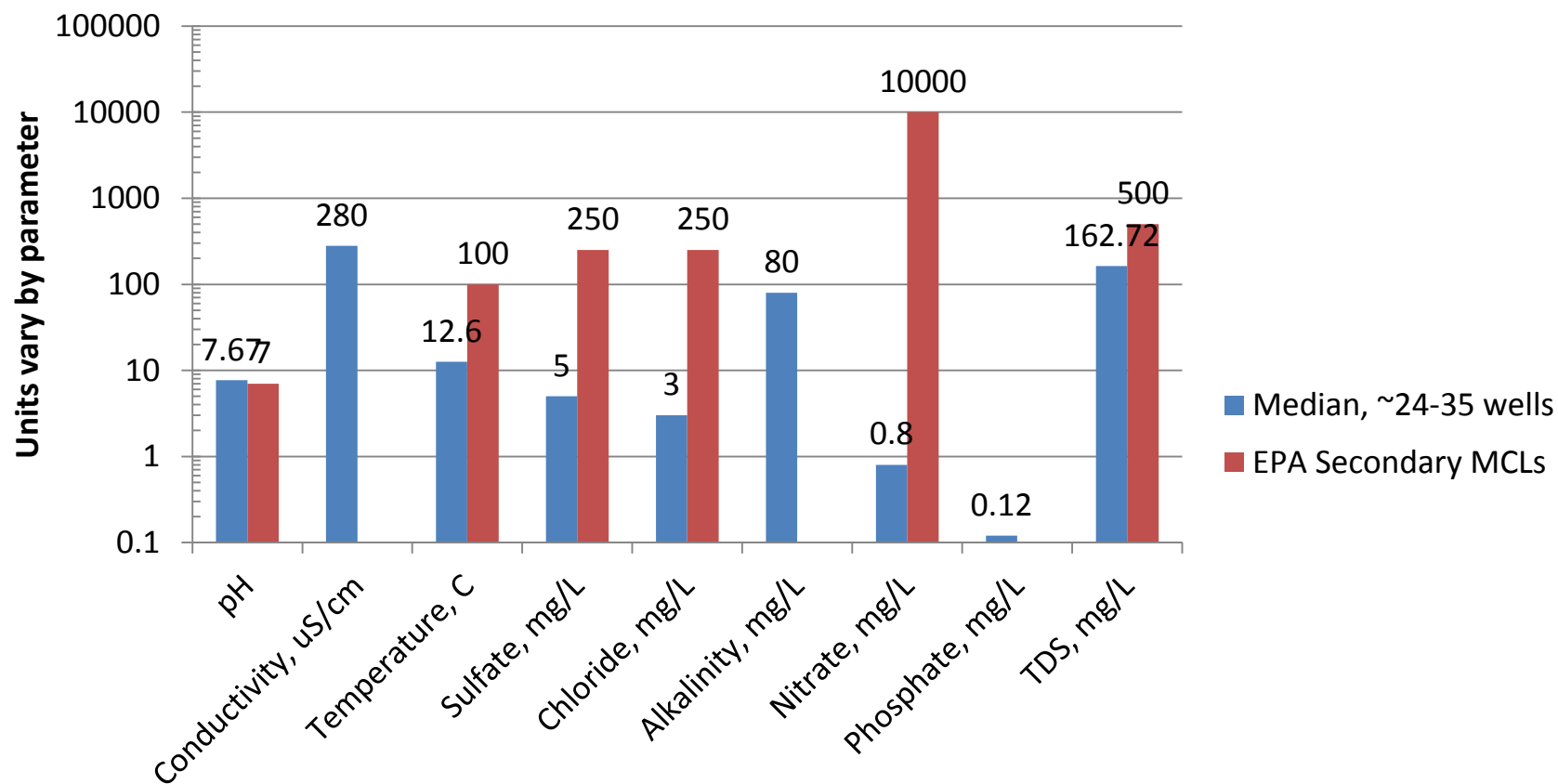
Wells which exceed EPA MCLs:

Cadmium: 1 well exceeds MCL

Iron: 3 wells exceed MCL

Manganese: 1 sample (spring) exceeds MCL

# Water Quality Indicators for 47 wells, with EPA Secondary MCLs



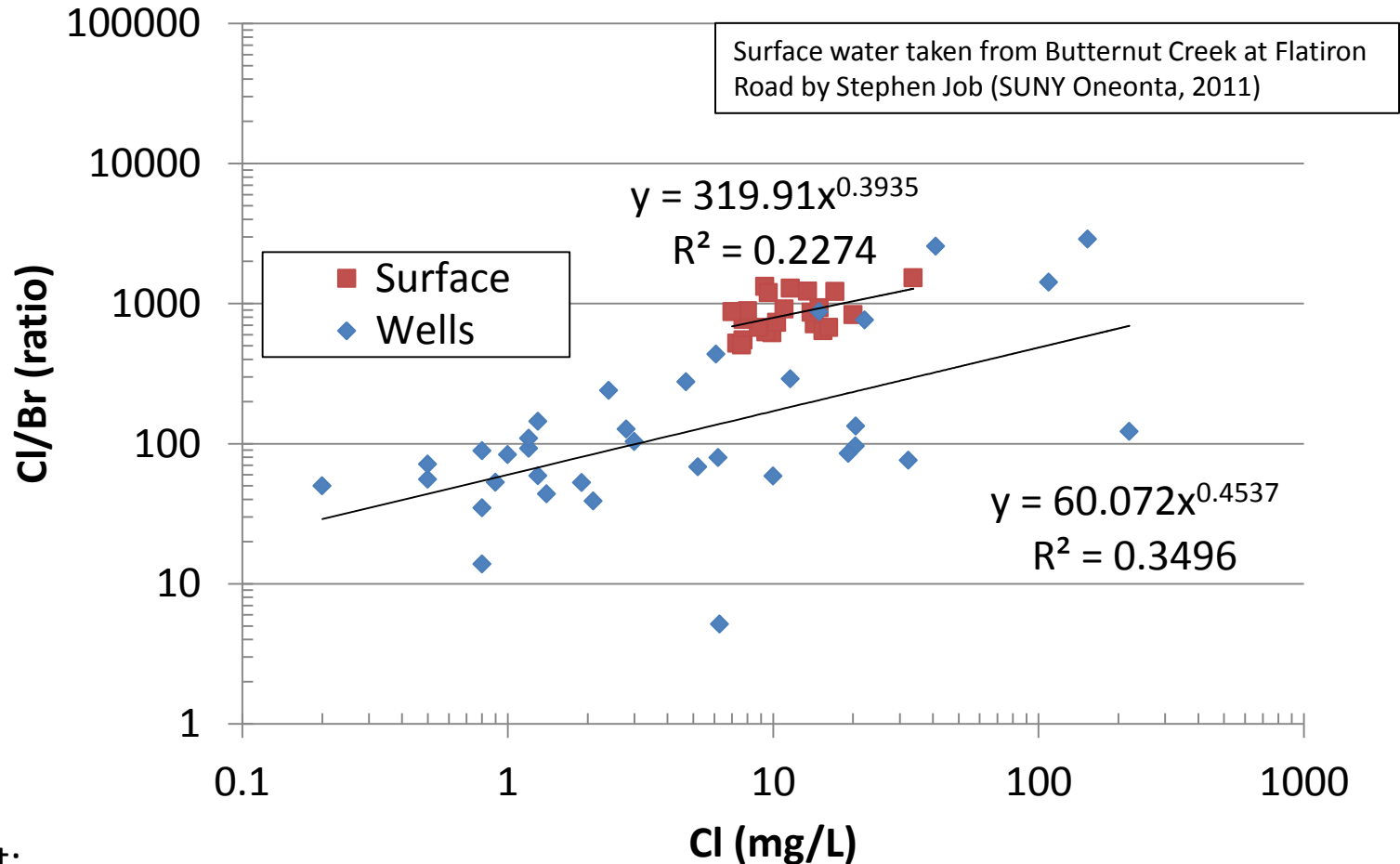
Water Quality Indicators and Guidelines, Median Concentrations

# Well Water Quality Indicators Statistics...

Analyte Symbol	Coefficient of Variation	Median	Standard Deviation	Average	Min	Max	# Samples
pH	0.09	7.67	0.68	7.6	6.36	9.3	35
Conductivity, $\mu\text{S/cm}$	0.70	280	218.20	310.0	50	970	35
Temperature, C	0.17	12.6	2.22	12.9	8.6	18.5	35
Sulfate, mg/L	1.47	5	9.48	6.5	0	50	31
Chloride, mg/L	2.54	2.8	28.14	11.1	0.2	152.9	31
Alkalinity, mg/L	1.34	80	207.38	154.8	0	1010.77	31
Nitrate, mg/L	1.39	0.8	1.93	1.4	0.2	7.9	25
Phosphate, mg/L	0.79	0.12	0.13	0.2	0.03	0.47	24
TDS, mg/L	0.36	162.72	71.15	200.3	155.9	282.4	3

Key Point: Chloride and Sulfate are highly variable; all exhibit moderate variability

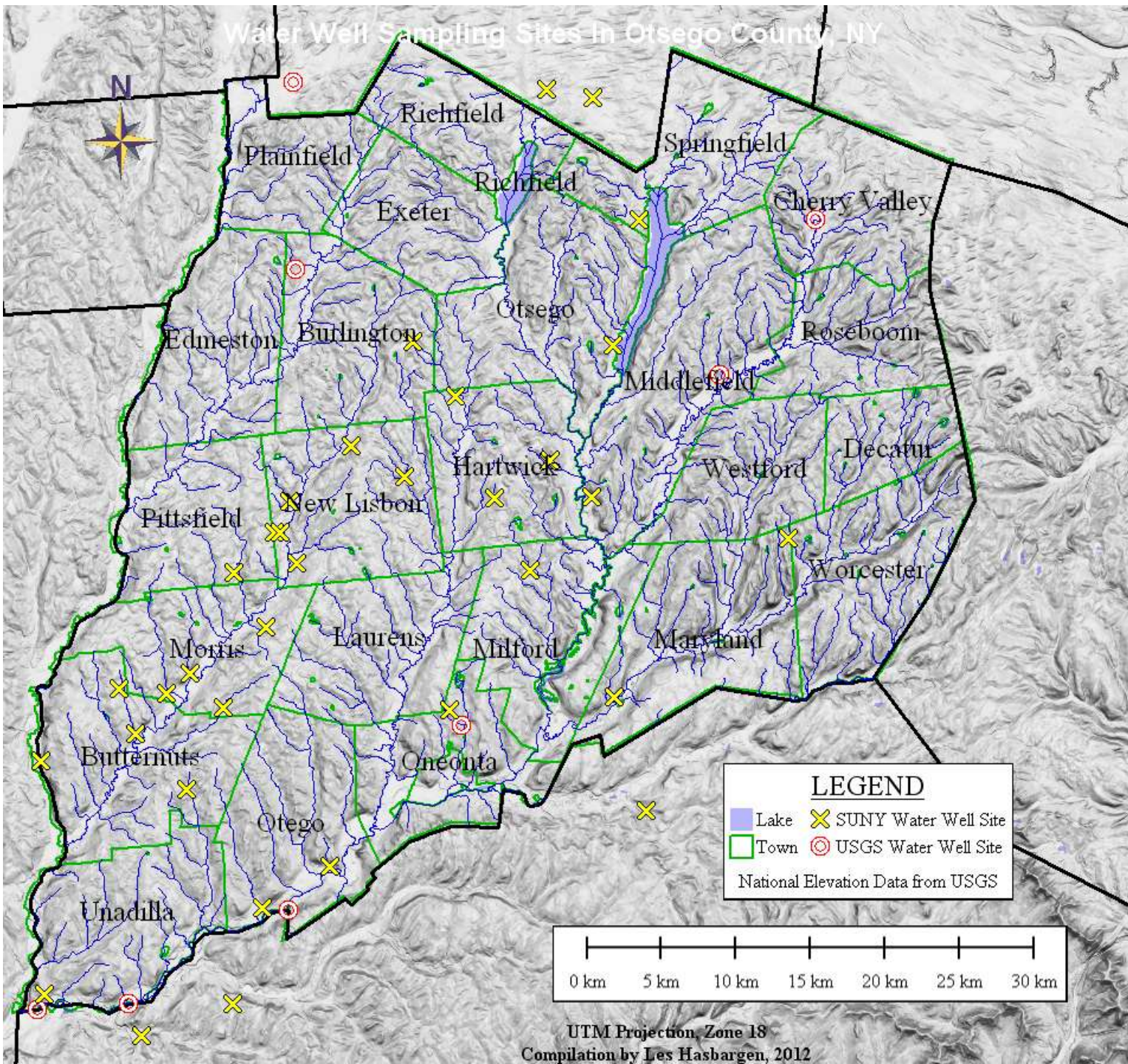
# Chloride-Bromide Ratio for Surface and Well Water



## Key Point:

Streams have higher ratios of Chloride to Bromide. While the ranges for stream and well water overlap, significant departures in stream values would be an indication of contamination.

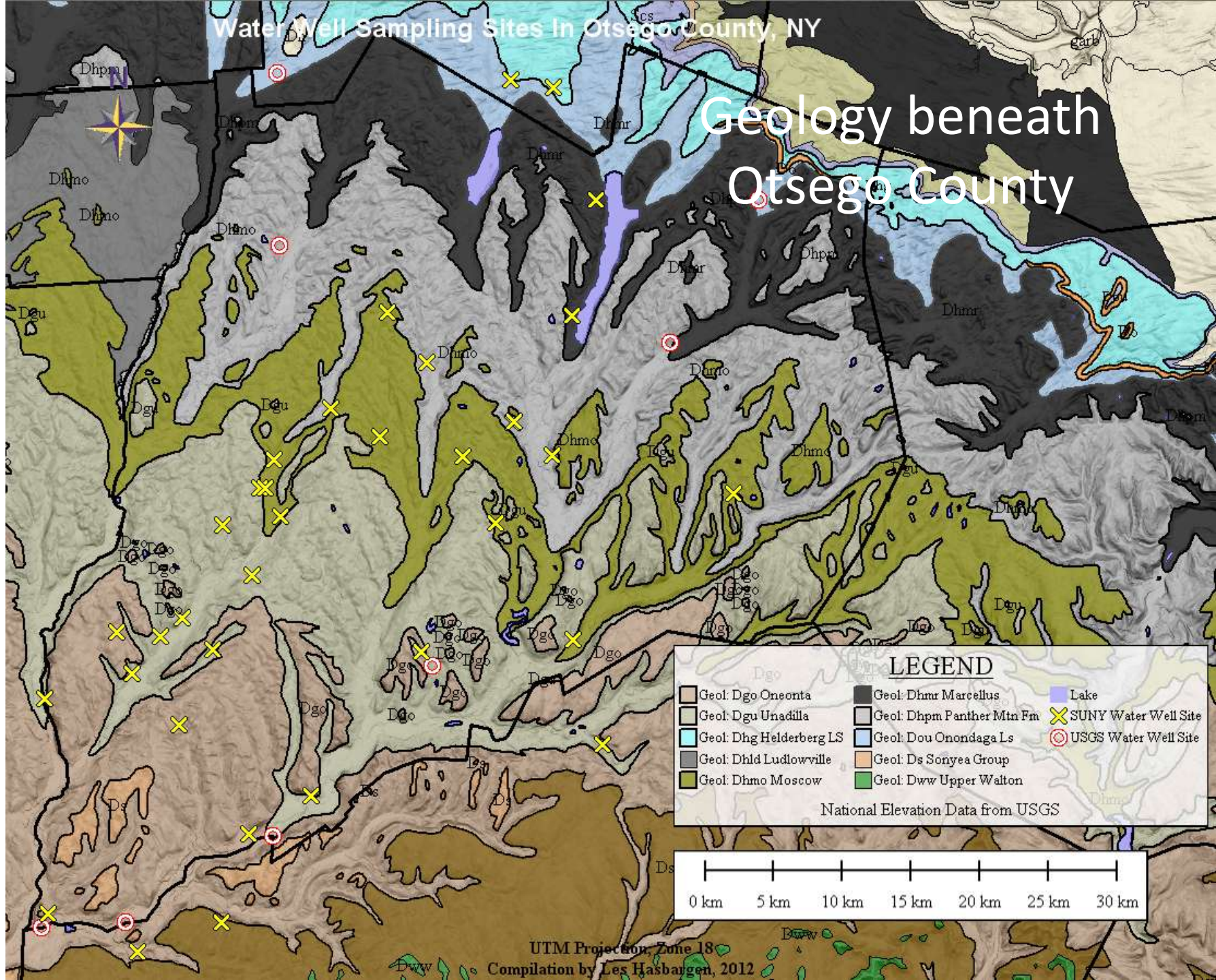
# Water Well Sampling Sites In Otsego County, NY



USGS and  
SUNY  
Oneonta  
well  
sample  
locations,  
2006  
through  
March  
2012

# Water Well Sampling Sites In Otsego County, NY

## Geology beneath Otsego County



**LEGEND**

Geol: Dgo Oneonta	Geol: Dhmr Marcellus	Lake
Geol: Dgu Unadilla	Geol: Dhpm Panther Mtn Fm	SUNY Water Well Site
Geol: Dhg Helderberg LS	Geol: Dou Onondaga Ls	USGS Water Well Site
Geol: Dhld Ludlowville	Geol: Ds Sonyea Group	
Geol: Dhmo Moscow	Geol: Dww Upper Walton	

National Elevation Data from USGS

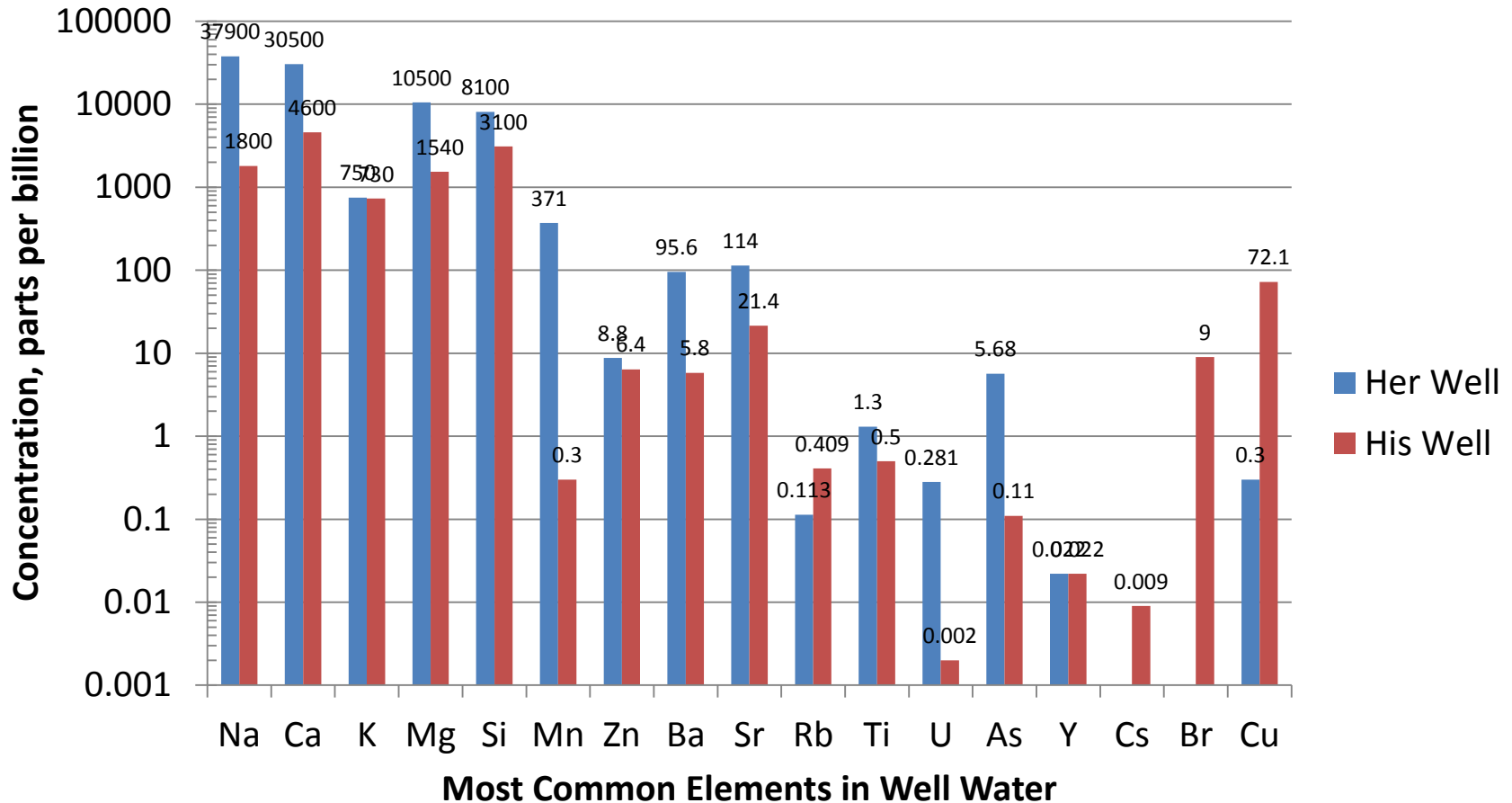




# Geology and Water Quality

- The previous map is “fresh off the presses”
- A systematic analysis of water and rock relationships has not been conducted yet
- We are hoping to get to this analysis this year, and provide a clearer picture of how these two key pieces of water chemistry are related

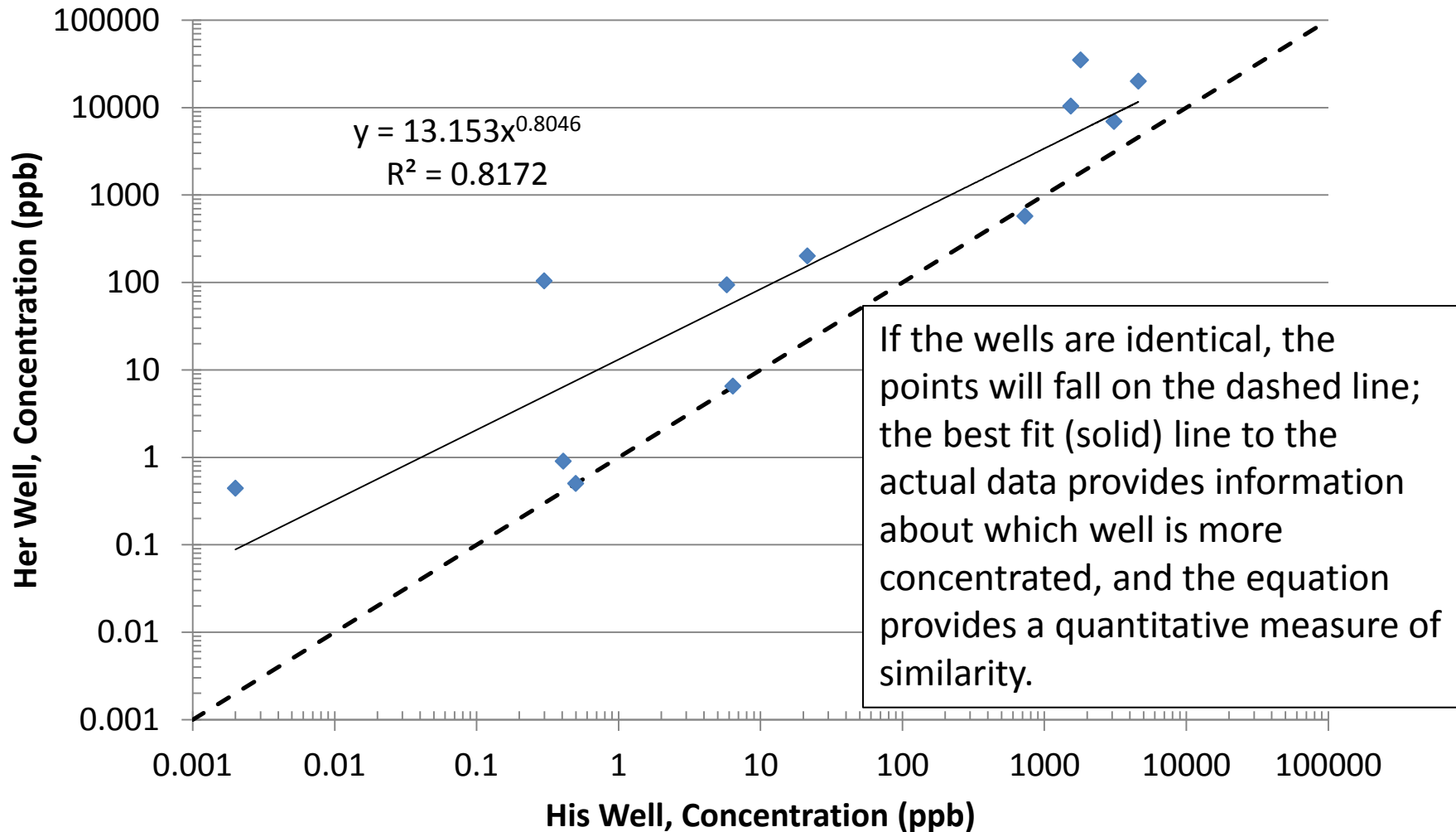
# A Comparison Between Wells: A Graphical View



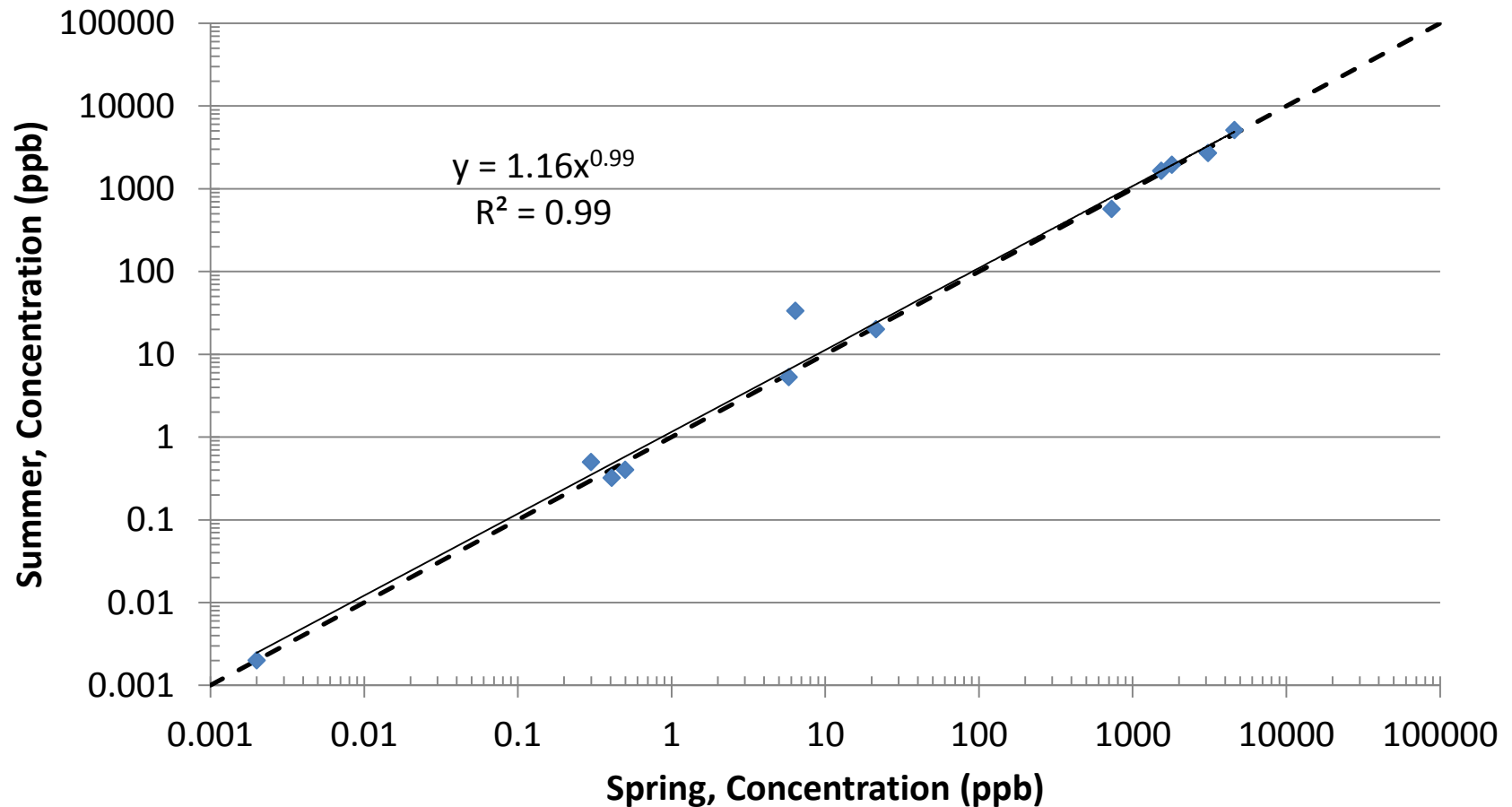
Note: Data are plotted on a logarithmic scale. In the example above, Her Well has much higher concentrations in Na, Ca, Mg, Mn, Ba, Sr, U, and As. His well has more Cs, Br, Cu.

# Comparison Between Wells

## A Quantitative View



# This well was sampled at two different times



Note that the data pretty much fall on the dashed line, with element showing a higher concentration in summer. The relation shows an individual well does vary, but the variability is far less than what we see between wells.

# A note on similarity using a “power law” equation

- A power law equation looks like:  $y = a x^b$
- In our case, if  $b = 1$ , then the coefficient “a” tells us how much more (or less) concentrated one well is compared to another. It’s a mixing model...
- When “b” is not equal to 1, then complicated mixing and water-rock reactions are in play
- $R^2$  describes how tightly the points fall on a best fit line. Values smaller than 1 mean the data are more distant from the line, which indicates complicated mixing and water-rock reactions are in play

# Interactive mapping of concentrations



- Catskill Headwaters Research Institute is creating a web site where you can map concentrations of the chemicals in groundwater for your area, and the site should be functioning by end of summer, 2012.
- We thank those well owners who participated!!!
- We offer a water sampling service, at cost, for those who would like us to test their water.
  - Contact Dr. Les Hasbargen for more information  
[Leslie.Hasbargen@oneonta.edu](mailto:Leslie.Hasbargen@oneonta.edu)  
607-436-2741

# We have a lot of work to do!!

- Are shallow wells fresher than deep wells?
- Does geology influence water quality in our area?
- Is there mixing from a deeper saline source?
- Gas migration: we know some wells in our area are gassy. How does this work?

# Surface Water Quality: A VERY important part of local hydrology

- Nutrients
- Ions
- Sediment
- Stream ecology
- Floods
- Erosion
- Management of loads for Chesapeake Bay, concerns over bridges and bank stability, etc.



# Bank stability and Channel History



Thanks for your attention!  
Questions!?

# For flyers/announcements

Title: 50 Good Reasons to Enjoy (and Protect!) Your Water

Authors: Les Hasbargen, Devin Castendyk, Fiona Lowry, Leandra Baker, and Molly Reed

Researchers at SUNY Oneonta have collected water quality information from numerous local wells for residences across Otsego and parts of Delaware counties in the past 2 years. Overall, chemical analyses show that residents drinking from local wells enjoy good water quality. The sampling program, funded by the Research Foundation and the Vibrant New York Program of SUNY, and Otsego County Conservation Association, seeks to provide a baseline for water well chemistry for residences without access to municipal water supplies. In addition, the differences in chemistry between wells suggests that fingerprinting of the water in a well is possible, and thus, changes to the well are detectable. Les Hasbargen will give a summary of their results on Sunday, April 15 at 1:30 p.m. at the Butternut Valley Grange in Gilbertsville, NY.