Session No. 81--Booth# 53
T12. Unconventional Natural Gas Plays in the Eastern U.S. and Canada with Emphasis on the Marcellus Shale and Potential Impacts of Hydraulic Fracturing (Posters)
Wednesday, 20 March 2013: 8:00 AM-12:00 PM
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IS THE WATER IN YOUR WELL UNIQUE?

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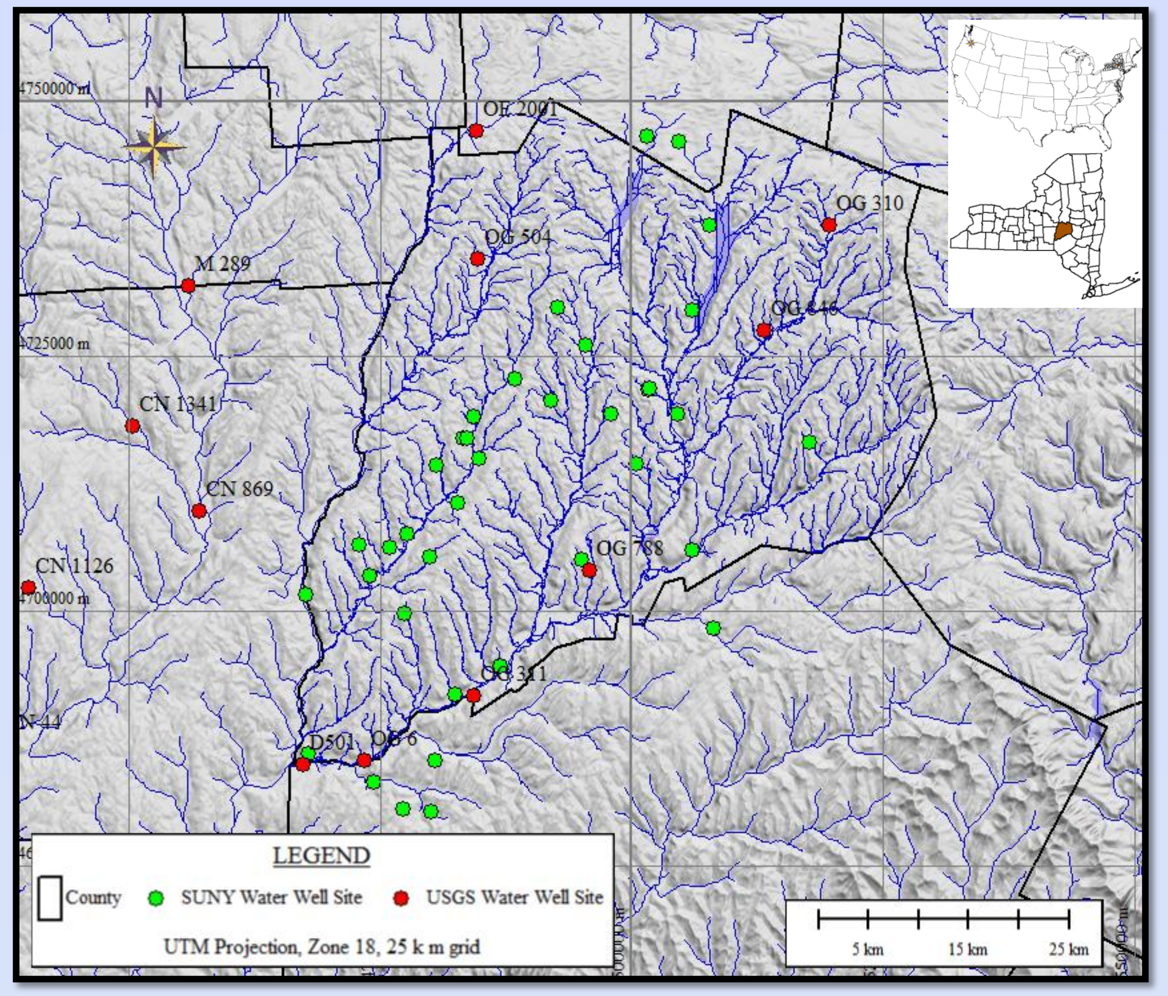
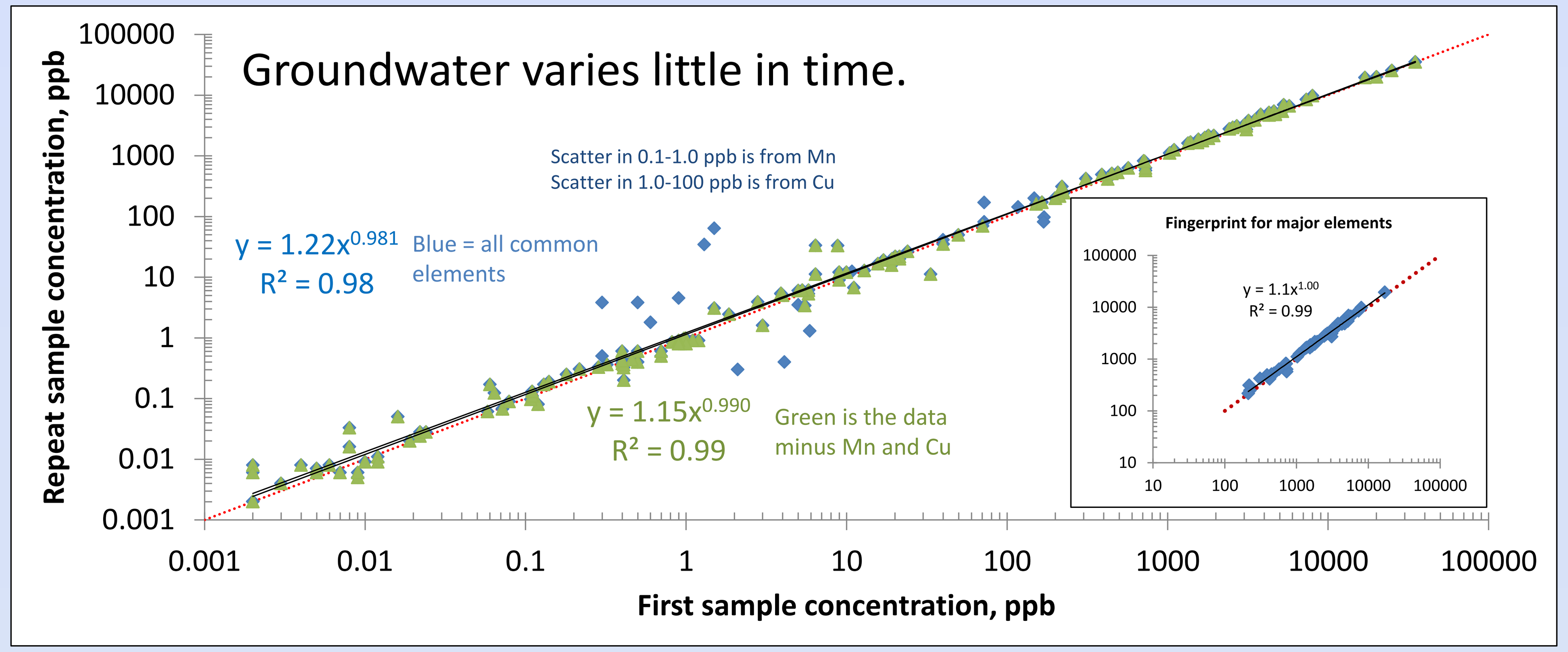
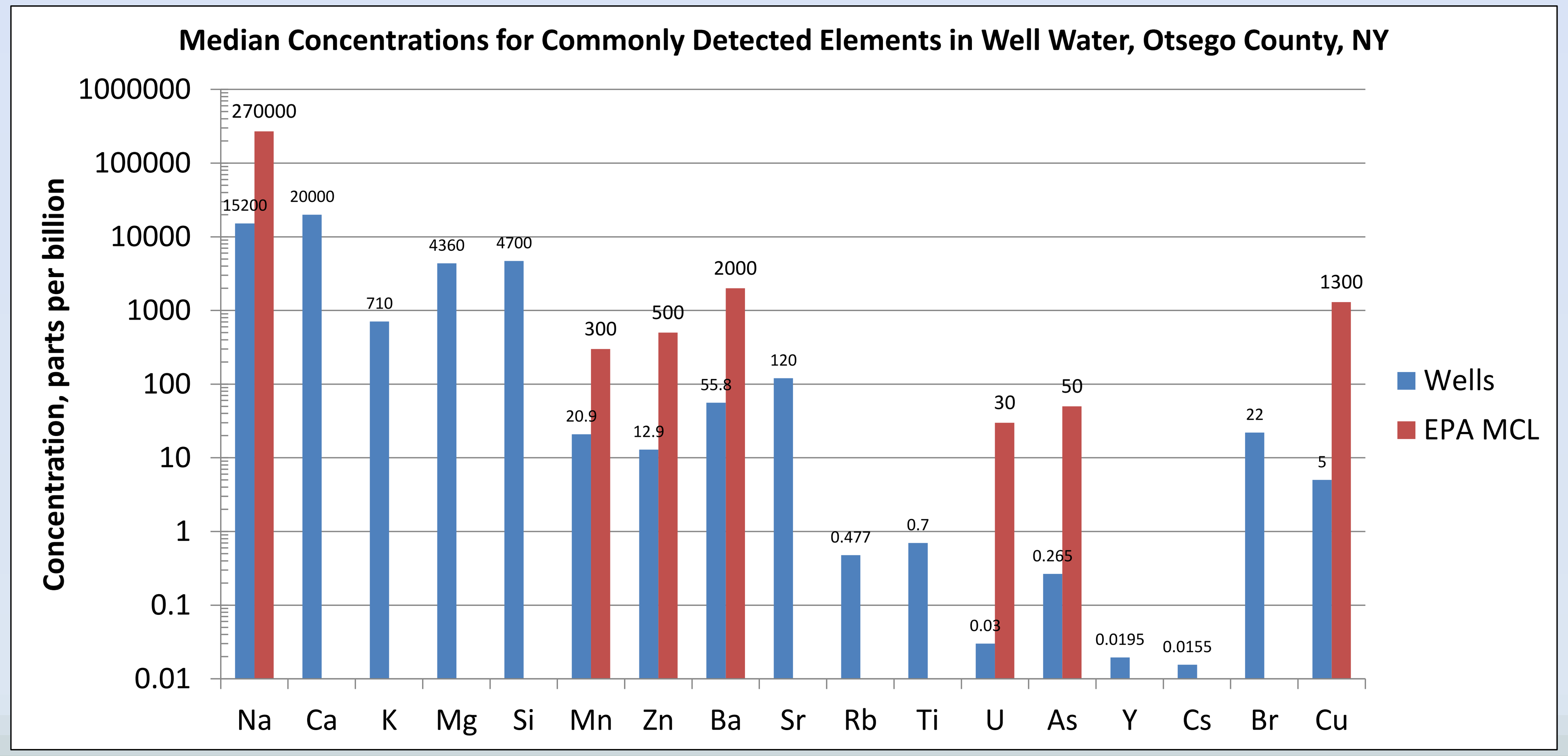


ABSTRACT: In advance of high volume hydraulic fracturing (HVHF) activities planned for central New York, we have initiated an inventory of groundwater elemental chemistry in local drinking water wells. We sampled **40 sites** and analyzed for anions and 66 metal ions. **7** of the wells were sampled more than once. Most of the wells penetrate unconsolidated sand and gravel and extend to Devonian age sedimentary strata. We find a significant range in elemental chemistry. We present a statistical summary of elemental concentrations, and we introduce a method for comparing wells against each other. The method is simple. The elemental concentrations in one well are plotted against another well, and a power law is fit to the data. The parameters (that is, the coefficient and the exponent) in the power law, along with a measure of the scatter, provide a powerful tool to characterize similarity and uniqueness. When the power law coefficient, correlation coefficient, and power law exponent approach unity, the samples approach identical concentrations. Similarity implies uniform dilution or concentration for all species being compared. When the exponent is approximately unity, the coefficient indicates which sample is more or less concentrated than the other. When the exponent is greater than unity, major elements are more enriched in one well. The correlation coefficient (R^2, in this case) measures the scatter around the power law relation. As the correlation coefficient approaches 0, a wide scatter exists, even if the exponent indicates similarity. We applied this method of comparing the elemental concentrations in two samples to each other to discover that individual wells look far more like themselves than any other well. One implication is that groundwater flow paths have characteristic chemical reactions with rocks along their path to the well, and reach a steady state concentration. Temporal variations amount to uniform changes in concentrations across all elements, such as might occur from mixing with very fresh water. Any mixing with non-identical water will yield either more scatter, or values for the power law parameters other than unity. We could detect 30 to 45 elements in most wells. Of the **47** samples we collected, 15 major, trace, and rare earth elements were detected in all wells, and provide a local fingerprint of groundwater.
Note: **Bold type** indicates changes from original abstract.

If you sample your well repeatedly, you should get about the same answer each time, that is, plotting one sample against another should fall on a line of unity. That is pretty much what we observe. See below.



We sampled 7 locations repeatedly. We plot each sample at a location against subsequent samples, for the elements detected in all samples. Scatter in the 1-10 ppb range is from Mn and Cu (blue diamonds), which might vary over time due to seasonal pH changes in the water, or insufficient flushing of the system prior to sampling. Note the tight correlation of the major elements. Red = unity.

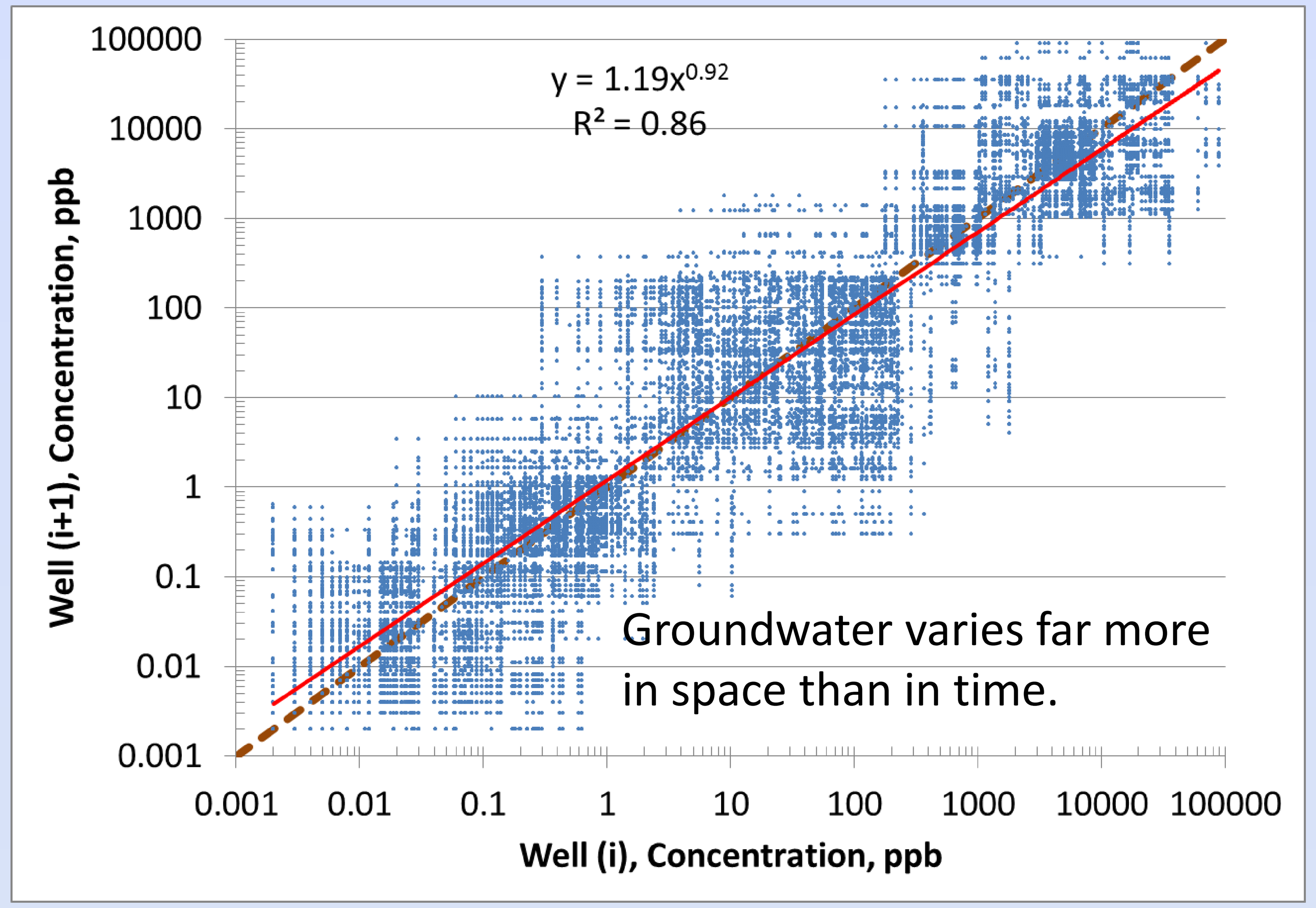


We analyzed for:

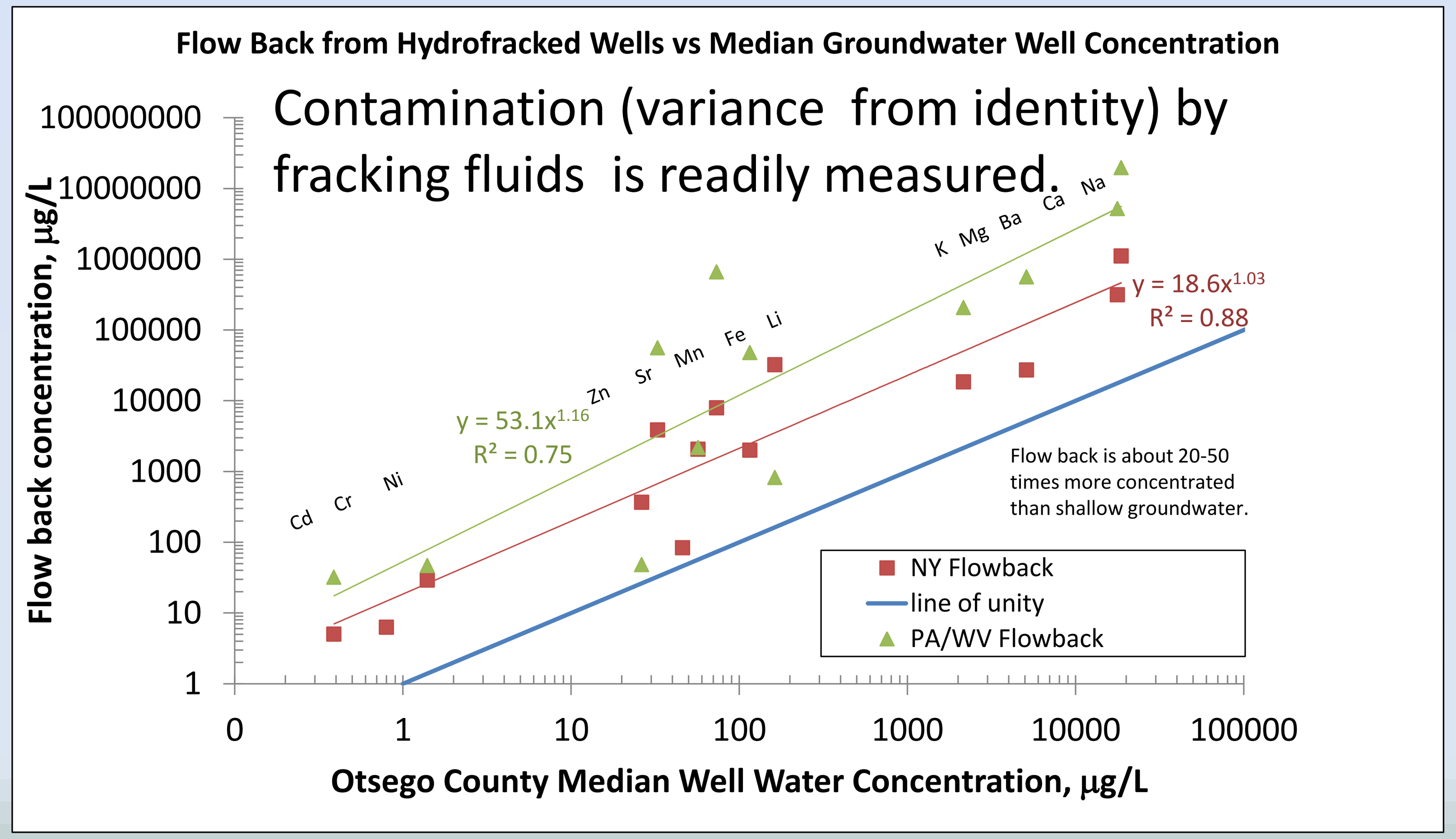
Analyte Symbol	Unit Symbol	Detection Limit	Upper Limit	Max	Min	Average	Std. dev.	Coeff. Var.	Median	# Samples > detection
Na	µg/L	5	35000	60900*	1100	18689	15618	0.84	15200	47
Ca	µg/L	700	20000	89800*	2100	17749	15460	0.87	20000	47
K	µg/L	30	20000	35500*	180	2157	5702	2.64	710	47
Mg	µg/L	1		18100	366	5114	3719	0.73	4360	47
Si	µg/L	200		8800	2700	4838	1446	0.30	4700	47
Mn	µg/L	0.1		371	0.3	57.06	79.90	1.40	20.9	47
Zn	µg/L	0.5		228	1.5	26.34	38.85	1.47	12.9	47
Ba	µg/L	0.1		217	1.6	73.57	65.29	0.89	55.8	47
Sr	µg/L	0.04	200	1390*	12.8	163.50	225.93	1.38	120	47
Rb	µg/L	0.005		1.95	0.113	0.64	0.38	0.59	0.477	47
Ti	µg/L	0.1		1.3	0.3	0.70	0.23	0.34	0.7	47
U	µg/L	0.001		0.634	0.002	0.13	0.16	1.27	0.03	47
As	µg/L	0.03		10.3	0.06	0.79	1.71	2.16	0.265	46
Y	µg/L	0.003		0.37	0.004	0.04	0.06	1.49	0.0195	46
Cs	µg/L	0.001		0.139	0.003	0.03	0.04	1.11	0.0155	46
Br	µg/L	3		1800	4	128	323	2.52	22	45
Cu	µg/L	0.2		200	0.3	46.17	65.95	1.43	5	45
Pb	µg/L	0.01		3.46	0.02	0.51	0.71	1.40	0.22	43
La	µg/L	0.001		0.04	0.002	0.01	0.01	1.08	0.004	39
Li	µg/L	1		400	2	32.82	65.98	2.01	15	38
Ce	µg/L	0.001		0.033	0.002	0.01	0.01	0.97	0.005	36
Nd	µg/L	0.001		0.317	0.002	0.04	0.06	1.61	0.014	34
Eu	µg/L	0.001		0.028	0.002	0.01	0.01	0.82	0.006	31
W	µg/L	0.02		20	0.06	3.76	4.06	1.08	2.59	29
Co	µg/L	0.005		0.084	0.011	0.03	0.02	0.55	0.028	29
I	µg/L	1		72	2	13.70	15.01	1.10	9	27
Gd	µg/L	0.001		0.119	0.002	0.02	0.02	1.33	0.009	27
Dy	µg/L	0.001		0.065	0.002	0.01	0.01	1.20	0.005	27
Ge	µg/L	0.01		4.19	0.02	0.41	0.83	2.03	0.17	25
Mo	µg/L	0.1		1.1	0.2	0.50	0.27	0.53	0.4	25
Fe	µg/L	10		420	20	116	116	1.00	80	23
Ni	µg/L	0.3		13.1	0.4	1.40	2.74	1.95	0.5	23
Cd	µg/L	0.01		6.63	0.02	0.39	1.37	3.52	0.05	23
Yb	µg/L	0.001		0.023	0.002	0.01	0.01	0.85	0.0035	22
Sm	µg/L	0.001		0.134	0.002	0.02	0.03	1.20	0.011	21
Er	µg/L	0.001		0.03	0.002	0.01	0.01	0.98	0.004	21
Al	µg/L	2		18	3	7.65	4.50	0.59	6	20
Se	µg/L	0.2		1.8	0.3	0.57	0.39	0.68	0.4	20
Sb	µg/L	0.01		0.05	0.02	0.03	0.01	0.34	0.03	19
Pr	µg/L	0.001		0.047	0.002	0.01	0.01	1.04	0.008	19
Zr	µg/L	0.01		10	0.02	0.94	3.01	3.20	0.02	10
Tb	µg/L	0.001		0.014	0.002	0.00	0.00	0.67	0.004	11
Ho	µg/L	0.001		0.012	0.003	0.00	0.00	0.68	0.003	10
Tl	µg/L	0.001		0.003	0.002	0.00	0.00	0.22	0.002	9
Ca*	µg/L	100		89800	22000	44700	28358	0.63	29250	6
Th	µg/L	0.001		0.003	0.002	0.00	0.00	0.22	0.0025	6
Sc	µg/L	1		2	2	2.00	0.00	0.00	2	5
Lu	µg/L	0.001		0.004	0.002	0.00	0.00	0.37	0.002	5
Re	µg/L	0.001		0.003	0.002	0.00	0.00	0.20	0.002	5
Na*	µg/L	100		60900	37700	45500	13337	0.29	37900	3
Sr*	µg/L	10		1390	630	897	428	0.48	670	3
Cr	µg/L	0.5		1	0.6	0.80	0.20	0.25	0.8	3
V	µg/L	0.1		0.3	0.2	0.25	0.07	0.28	0.25	2
Au	µg/L	0.002		0.2	0.2	0.20	0.00	0.00	0.2	2
Tm	µg/L	0.001		0.004	0.002	0.00	0.00	0.47	0.003	2
Hf	µg/L	0.001		0.003	0.002	0.00	0.00	0.28	0.0025	2
K*	µg/L	100		35500	35500	n/a	n/a	n/a	n/a	1
Ga	µg/L	0.01		0.02	0.02	n/a	n/a	n/a	n/a	1
Pd	µg/L	0.01		0.02	0.02	n/a	n/a	n/a	n/a	1
Ag	µg/L	0.2		0	0	n/a	n/a	n/a	n/a	0
Be	µg/L	0.1		0	0	n/a	n/a	n/a	n/a	0
Bi	µg/L	0.3		0	0	n/a	n/a	n/a	n/a	0
Hg	µg/L	0.2		0	0	n/a	n/a	n/a	n/a	0
In	µg/L	0.001		0	0	n/a	n/a	n/a	n/a	0
Nb	µg/L	0.005		0	0	n/a	n/a	n/a	n/a	0
Os	µg/L	0.002		0	0	n/a	n/a	n/a	n/a	0
Pt	µg/L	0.3		0	0	n/a	n/a	n/a	n/a	0
Ru	µg/L	0.01		0	0	n/a	n/a	n/a	n/a	0
Sn	µg/L	0.1		0	0	n/a	n/a	n/a	n/a	0
Ta	µg/L	0.001		0	0	n/a	n/a	n/a	n/a	0
Te	µg/L	0.1		0	0	n/a	n/a	n/a	n/a	0

Elements above analyzed by ICP-MS , except *, which were analyzed by ICP-OES. Analyses performed by Activation Labs, Inc. NELAP certified.

When we plot one well against another, a spectrum of possibilities exist, with a low likelihood of paired wells falling on a line of unity (brown dashes). See below.



We selected the 18 elements detected in most wells, and plotted each well against every other well. Clearly, water varies substantially across the region. The brown dashed line represents perfect coincidence of concentrations between wells. Some elements are over or at detection limits, and this generates more scatter and the linear patterns visible in the chart above.



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