DRBC Monitoring for Natural Gas Development

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Delaware River Basin Commission

Delaware River Basin Commission
DELAWARE • NEW JERSEY
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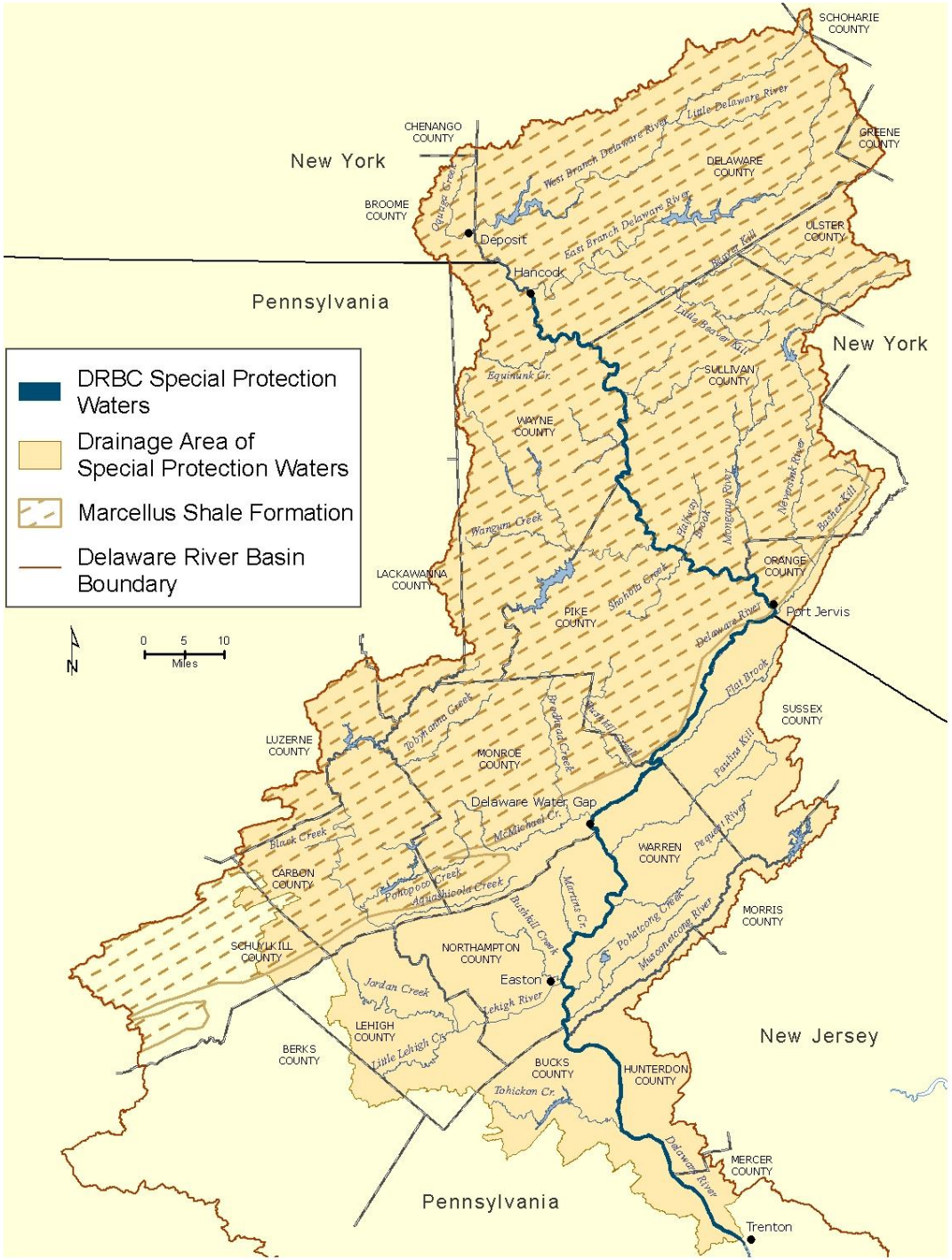
UNITED STATES OF AMERICA

DRBC Ambient Monitoring Framework for Natural Gas Development

- Background
- DRBC Monitoring Activities
  - Biological Monitoring
  - HOBO Loggers
  - Reanalysis of archived samples
  - Toxicity Testing
- Partnerships
- Monitoring Requirements Under Proposed DRBC Regulations (as of 3/12 – status undetermined)



Marcellus Shale and Special Protection Waters

36% (4,937 mi^2) of the Delaware Basin is underlain by the Marcellus Shale

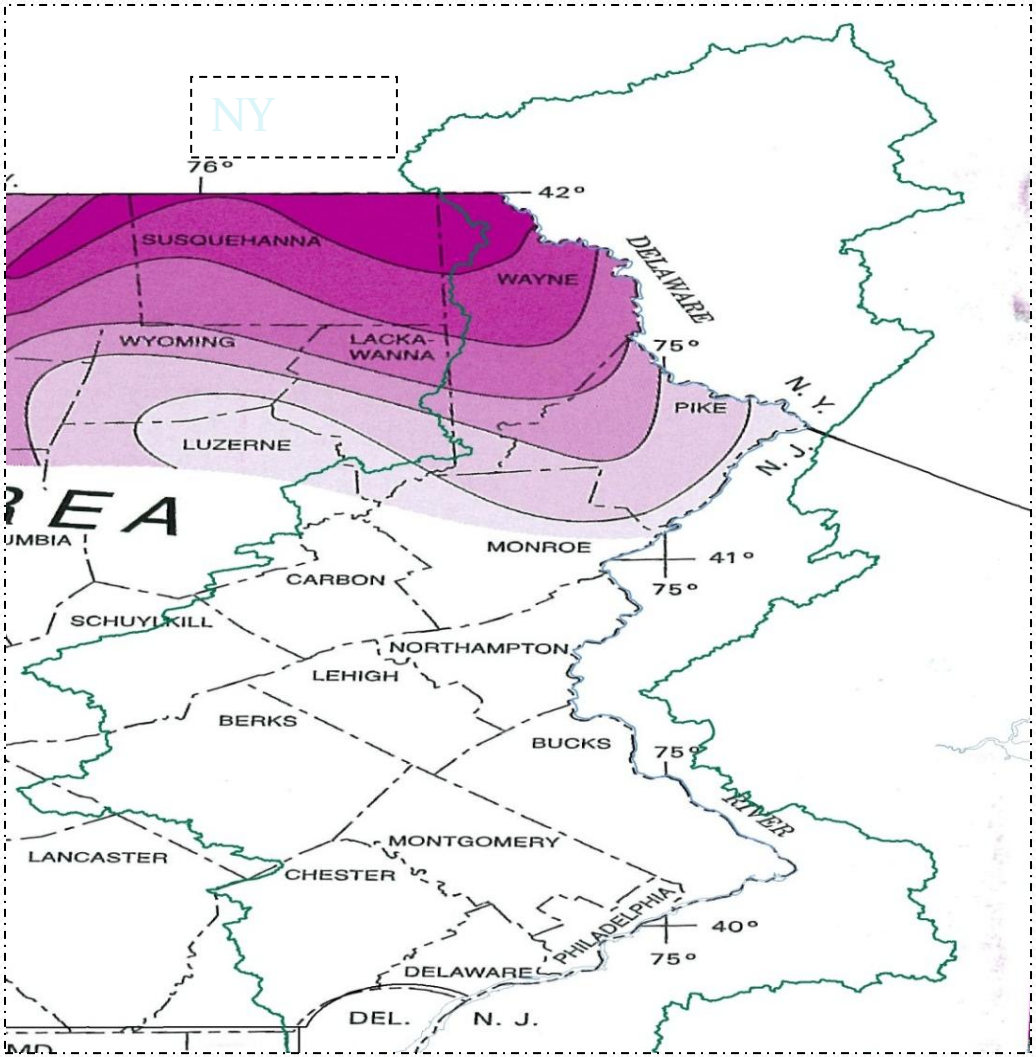
Areas with the Greatest Shale Gas Potential

Darker pink indicates greater percentage of organic shale and greater gas shale potential.

Organic carbon data from 19 samples in New York averaged 4.3%.

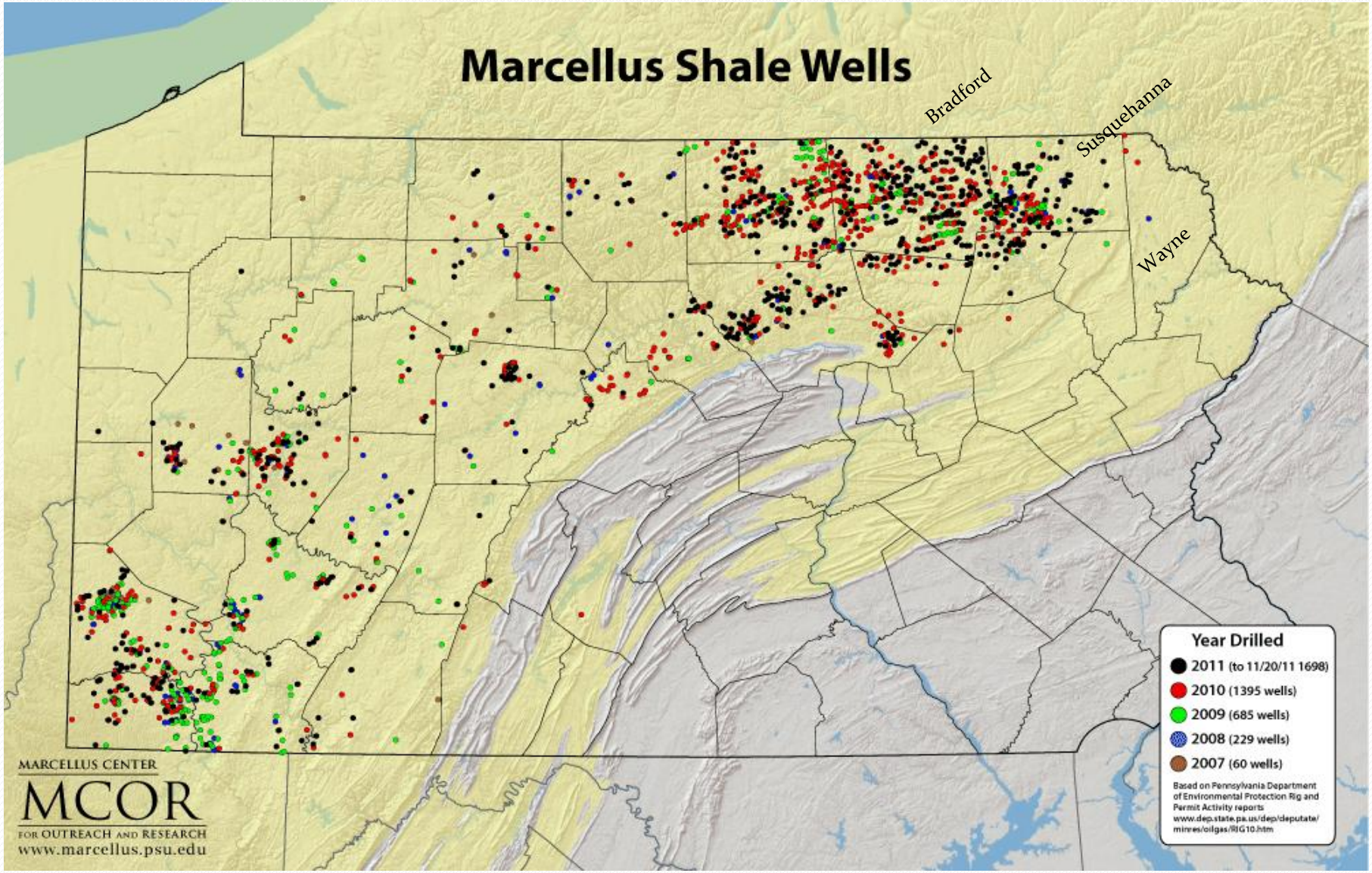
In east-central Pennsylvania, organic carbon ranged from 3 to 6% (Millic, 2006).

Source: Eastern Gas Shale Evaluation Project 1977-80mas modified by the Piotroski and Harper 1979.



From Pennsylvania Geology Vol 38 No.1 Spring 2008

Drilling Activity from 2007- Nov 2011



Background

- DRBC definitions of Existing Water Quality in Special Protection Waters may need to be updated to include parameters specific to NG development.
- DRBCs management goal of "no measurable change to EWQ" may be threatened.
- Flowback from hydraulic fracturing of wells is dramatically different than WWTP effluent or non-point runoff.
- As of early 2011 we asked - What actions would be most effective during the ***narrow window of opportunity*** prior to active drilling in the Basin to establish pre-drilling conditions?

Special Protection Waters

Sample page from DRBC water quality regulations, defining site-specific Existing Water Quality (EWQ). 24 Lower Delaware sites are now in SPW rules.

As of 2012, I am creating site-specific EWQ for 56 additional river and tributary sites from Hancock to Water Gap.

Even if there are no gas rules, we are still protected by SPW rules.

TABLE 2C. Definition of Existing Water Quality: Portland ICP

Delaware River at Portland-Columbia Pedestrian Bridge, Pennsylvania/New Jersey, River Mile 207.50

Parameter (Y)	Definition of Existing Water Quality			
	Median	Lower 95%CI	Upper 95%CI	Flow Relationships Site specific regression equation.
Ammonia NH3-N (mg/l) *	<0.05	<0.05	<0.05	
Chloride (mg/l)	12	11	13	Y = -0.00019515 Q + 13.325
Chlorophyll a (mg/m^3)	2.13	1.30	2.70	
Dissolved Oxygen (mg/l) mid-day*	8.70	8.38	9.06	
Dissolved Oxygen Saturation (%)	97%	95%	99%	
E. coli (colonies/100 ml)	16	8	25	Y = antilog (0.00007074 Q + 0.6659)
Enterococcus (colonies/100 ml)	20	12	60	
Fecal coliform (colonies/100 ml) *	20	12	36	Y = antilog (0.00006854 Q + 0.955)
Nitrate NO3-N (mg/l) *	0.68	0.48	0.74	
Orthophosphate (mg/l)	0.01	0.005	0.01	
pH	7.40	7.29	7.58	
Specific Conductance (umhos/cm)	97	88	104	Y = -0.00151181 Q + 106.6
Total Dissolved Solids (mg/l)	83	74	91	
Total Kjeldahl Nitrogen (mg/l)	0.29	0.19	0.40	
Total Nitrogen (mg/l) *	0.86	0.74	1.05	
Total Phosphorus (mg/l) *	0.04	0.03	0.05	
Total Suspended Solids (mg/l) *	3.0	2.0	4.0	Y = 0.00122363 Q - 2.8618
Turbidity (NTU)	1.6	1.1	2.8	Y = antilog (0.00005157 Q – 0.1356)
Alkalinity (mg/l)	20	16	22	Y = -0.00046984 Q + 23.547
Hardness (mg/l)	30	28	31	

EWQ values represent data collected twice per month from May through September 2000-2004. Total number of samples varied by parameter, however, due to design and sampling constraints.

* Wastewater treatment facility projects subject to the no measurable change requirement must demonstrate no measurable change to EWQ for this parameter. Implementation guidance should be consulted.

** EWQ value does not meet DRBC water quality criterion, state water quality criterion or both.

Ranking of Constituents in Flowback Water by Mean Water Concentration

Parameter Group	Results (mg/L)
Total Dissolved Solids mg/L 10 SM18 2540 C	81,627.02
Chloride mg/L 1 MCAWW 300.0A	49,472.68
Hardness, as CaCO3 mg/L 5 SM20 2340C	24,787.62
Sodium-DISS ug/L 5000 SW846 6010B	21,710.21
Sodium ug/L 5000 SW846 6010B	20,197.76
Calcium-DISS ug/L 5000 SW846 6010B	6,949.16
Chemical Oxygen Demand (COD) mg/L 10 MCAWW 410.4	6,686.42
Calcium ug/L 5000 SW846 6010B	6,518.05
Strontium-DISS ug/L 50 SW846 6010B	1,510.51
Strontium ug/L 50 SW846 6010B	1,433.30
Barium-DISS ug/L 200 SW846 6010B	1,156.48
Barium ug/L 200 SW846 6010B	1,149.11
Magnesium-DISS ug/L 5000 SW846 6010B	586.62
Biochemical Oxygen Demand mg/L 2 SM18 5210 B	553.74
Magnesium ug/L 5000 SW846 6010B	548.72
Bromide mg/L 1 MCAWW 300.0A	507.77
Potassium-DISS ug/L 5000 SW846 6010B	483.34
Potassium ug/L 5000 SW846 6010B	461.04
Total Suspended Solids mg/L 4 SM20 2540D	338.70
Dissolved Organic Carbon mg/L -- SM20 5310B	316.98
TOC mg/L 1 SM20 5310B	297.40
Acidity mg/L 5 SM20 2310B (4a)	250.66
Total Alkalinity mg/L 5 SM18 2320 B	131.50
Sulfate mg/L 1 MCAWW 300.0A	104.56

Summer 2011 Biomonitoring

Ambient Biomonitoring – 2011

funded by Haas Foundation Grant

- **Steps**
  1. Gathered existing baseline data (NYSDEC, PADEP, USGS, EPA).
  2. Targeted new sites in 28 HUC-12 watersheds PA/NY.
  3. Stations selected to complement the locations of other state and federal quantitative monitoring sites sampled since about 2000.
  4. Used state-specific monitoring protocols.
  5. April: 35 sites sampled in PA using PADEP methods.
  6. July/August: 68 sites sampled in NY using NYSDEC methods.
  7. Approximately 103 new samples; N= 5 to 7 for each of 28 targeted watersheds.

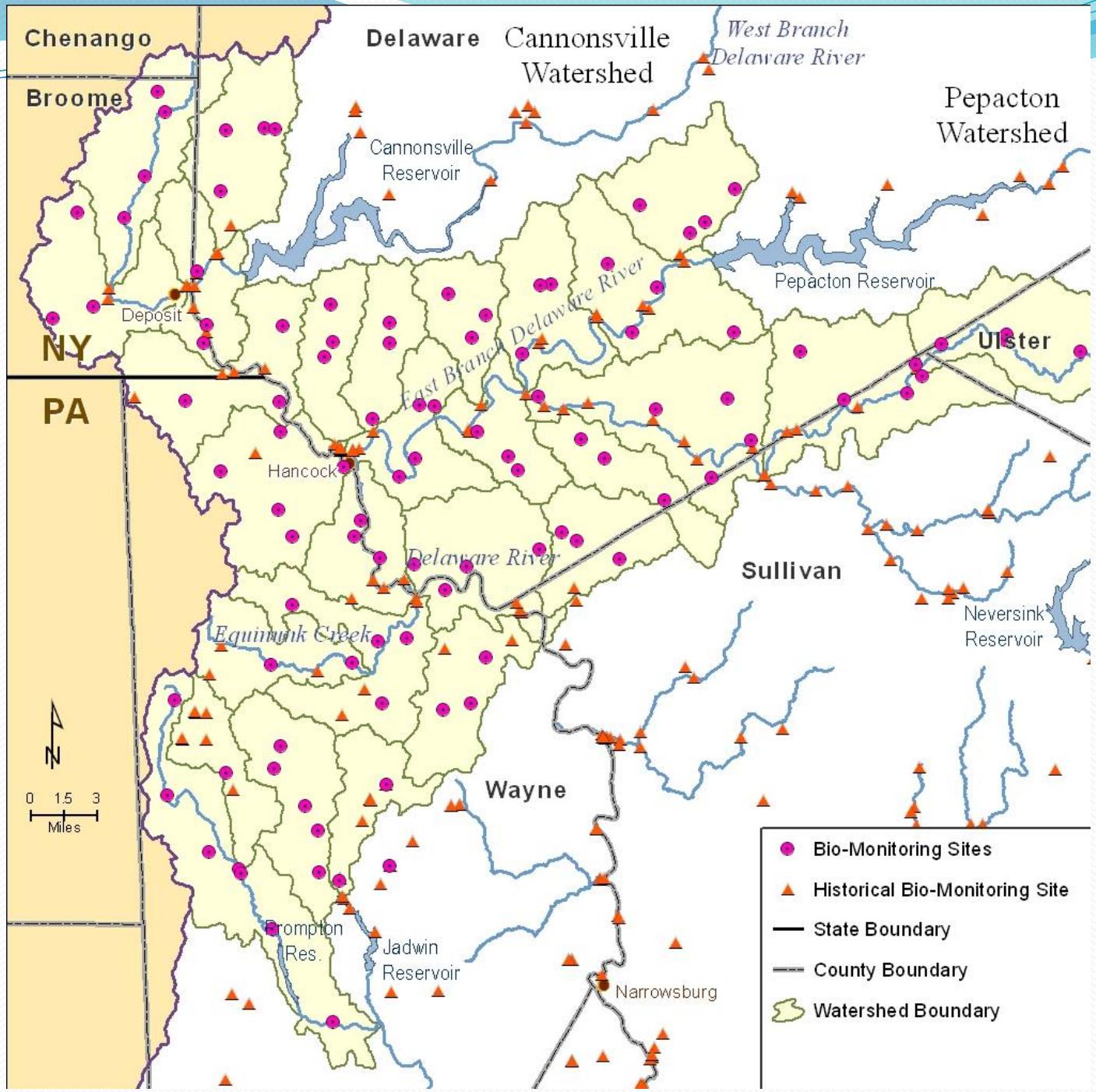
Ambient Biomonitoring - 2011

- **Steps (cont.)**
  8. Analysis: 200 count to genus/species depending on NY or PA regulatory needs; shooting for consistency with state programs / methods / index periods / data comparability. Selecting lab 4/12.
  9. Stations covered a range of stream types from small headwater streams to larger main stem streams and rivers within each HUC12.

- DRBC also plans an annual ambient monitoring survey (total of 150 sites with 75 sampled per year) to assess biological and habitat changes in the region.

2011
Spring / Summer
Biomonitoring
Sites

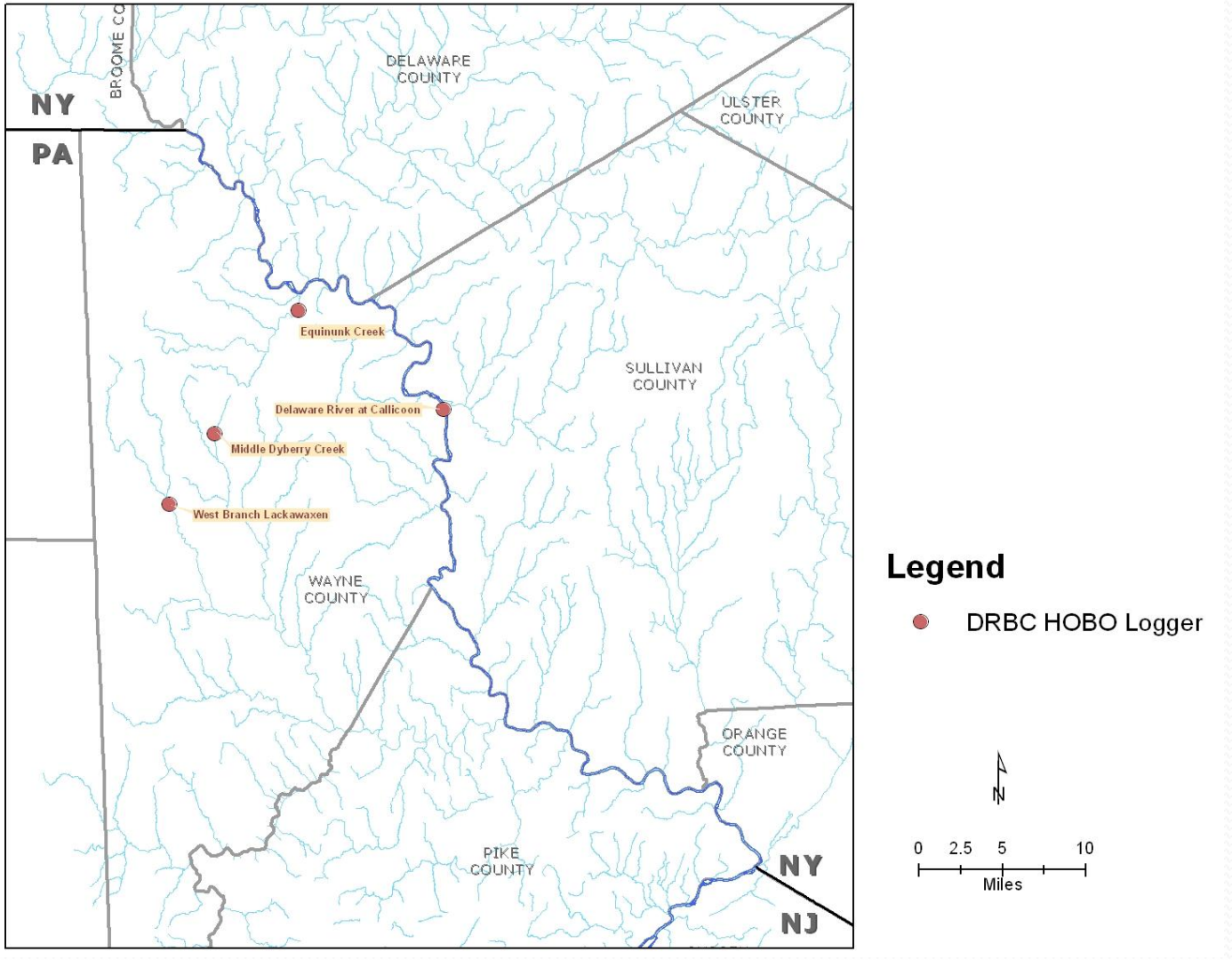
Wayne, Delaware, Broome, Sullivan, and Ulster County Sub-Watersheds



HOBO-U24
Conductivity / Temperature Logger

Deployment of HOBO SpecCond/Temp: 2010-2012

For establishing background specific conductivity including road salt runoff



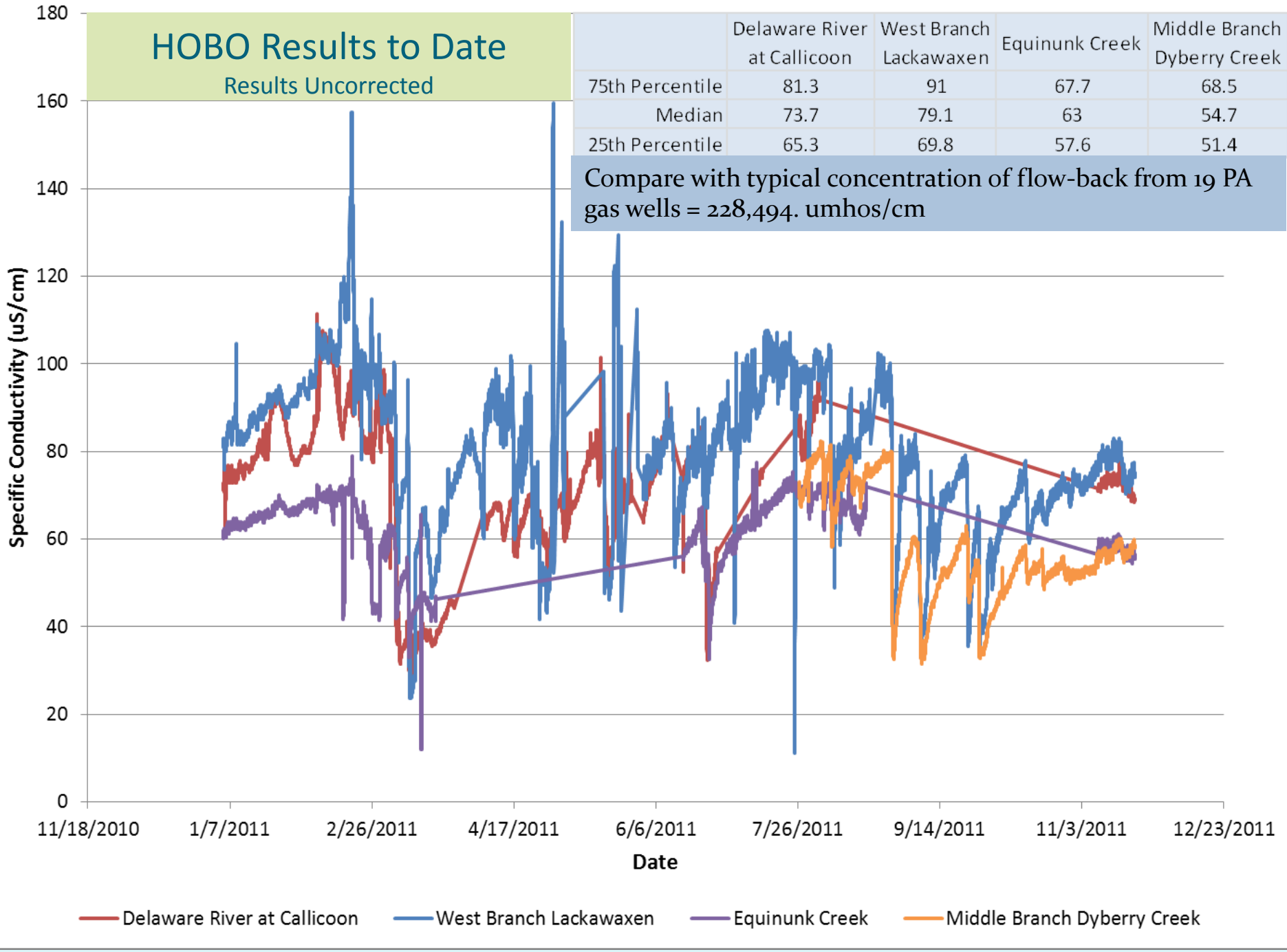
HOBO-U24 Deployment

HOBO Results to Date

Results Uncorrected

	Delaware River at Callicoon	West Branch Lackawaxen	Equinunk Creek	Middle Branch Dyberry Creek
75th Percentile	81.3	91	67.7	68.5
Median	73.7	79.1	63	54.7
25th Percentile	65.3	69.8	57.6	51.4

Compare with typical concentration of flow-back from 19 PA gas wells = 228,494. umhos/cm



Reanalysis of Archived Samples

funded by Haas Foundation Grant

- 717 samples from the Upper, Middle and Lower Delaware River collected in 2009 and 2010 at interstate and boundary control points were archived.
- 284 of the 717 samples were archived from the Upper Delaware River.
- Upper and Middle Delaware archived samples were analyzed for selected parameters identified in flowback samples.
- Approximately 500 samples taken by the Scenic Rivers Monitoring Program in 2011 were also analyzed for flowback parameters.
- Three years of data to represent pre-drilling baseline chemical conditions.

Analytical Parameters

Analyses conducted by Academy of Natural Sciences of Philadelphia and Smithsonian Institution

Parameters	**Method**
Filtration of Sample	Vacuum filtration
Na, Mg, Ca, K	Ion Chromatograph
Barium, Strontium	ICP-OES
Chloride	Titration
Bromide	Flow Injection
Sulfate	Flow Injection or tubidimetric
Total Alkalinity	Titration
Total Hardness	Titration
TDS	Evaporation, gravimetric

Archived Sample Analyses

Academy of Natural Sciences and Smithsonian Institution

Ion	FracWater (mg/L)	River Water (mg/L)	Column/ App Note	Range mg/L	MDL µg/L	Column/ App Note	Range mg/L	MDL µg/L
Anions			**Dionex AS18/154[4]**			**Dionex AS14/133[3]**		
Chloride	49,473	3-40	Hydroxide	0.2-200	2.5	Carbonate	0.2-200	2.9
Bromide	508	1-3	"	0.1-100	5.7	"	0.1-100	7.8
Sulfate	105	5-50	"	0.2-200	5.1	"	0.2-200	8.2
Cations			**Dionex CS16/141[2]**					
Sodium	21,700	3-50	MSA	0.1-1000	1.8			
Calcium	6,949	5-20	"	0.05-80	1.1			
Magnesium	587	2-15	"	0.05-80	1			
Potassium	483	5-10	"	0.05-80	3			
Strontium[1]	1,511	<0.2	EPA 200.7		1-30	ICP OES.MS		
Barium[1]	1,156	<0.1	EPA 200.7		1-30	ICP OES.MS		

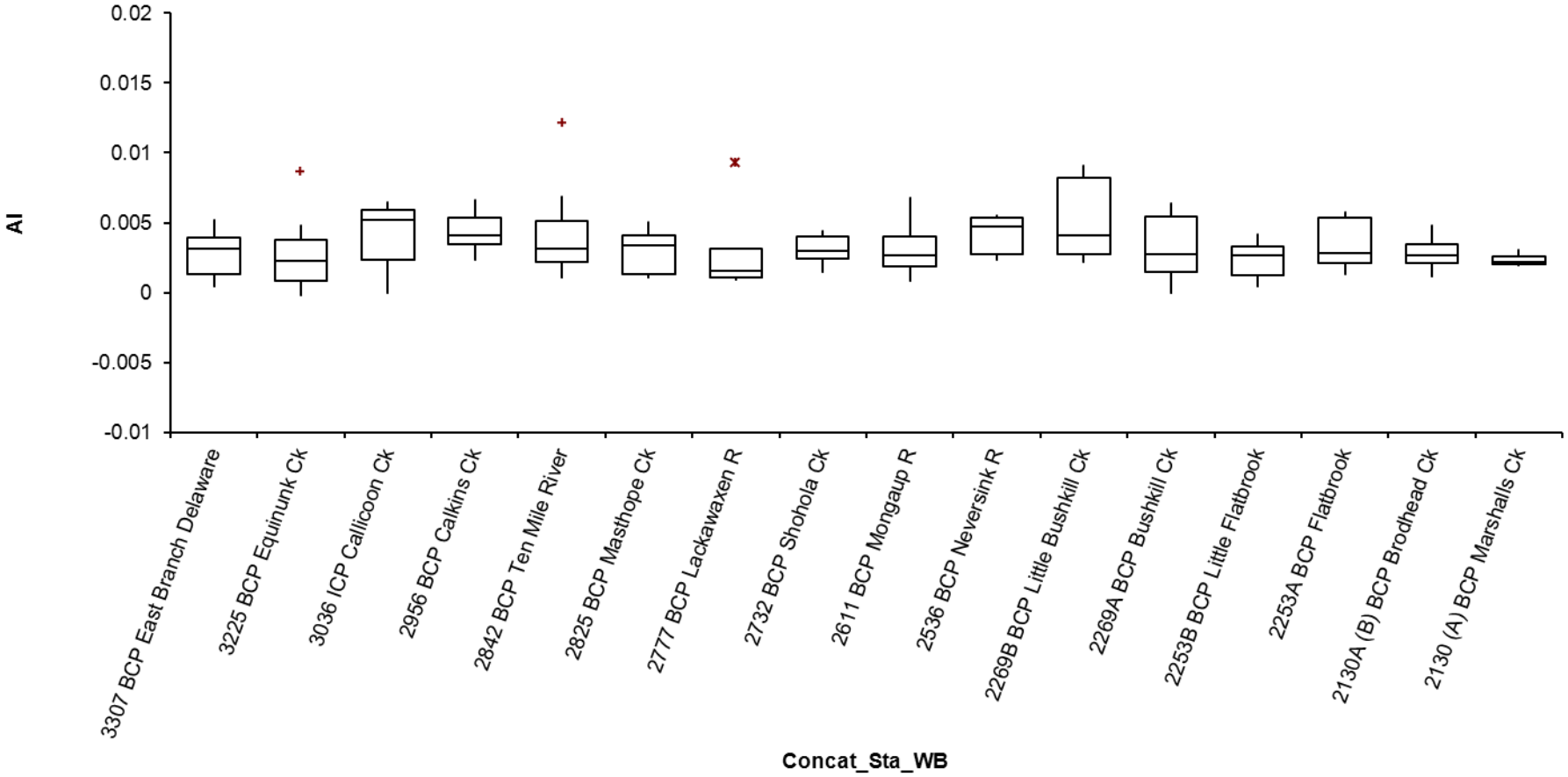
Total 2009-2010 Archived Samples

	BCP	**ICP**		*Subtotals*
Upper	149	135		*284*
Middle	95	94		*189*
Lower	145	99		*244*
Subtotals	*389*	*328*		
Total	**717**			

Preliminary Results from 2009-2010 Archived SRMP Samples

Dissolved Aluminum mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells = 0.596 mg/l

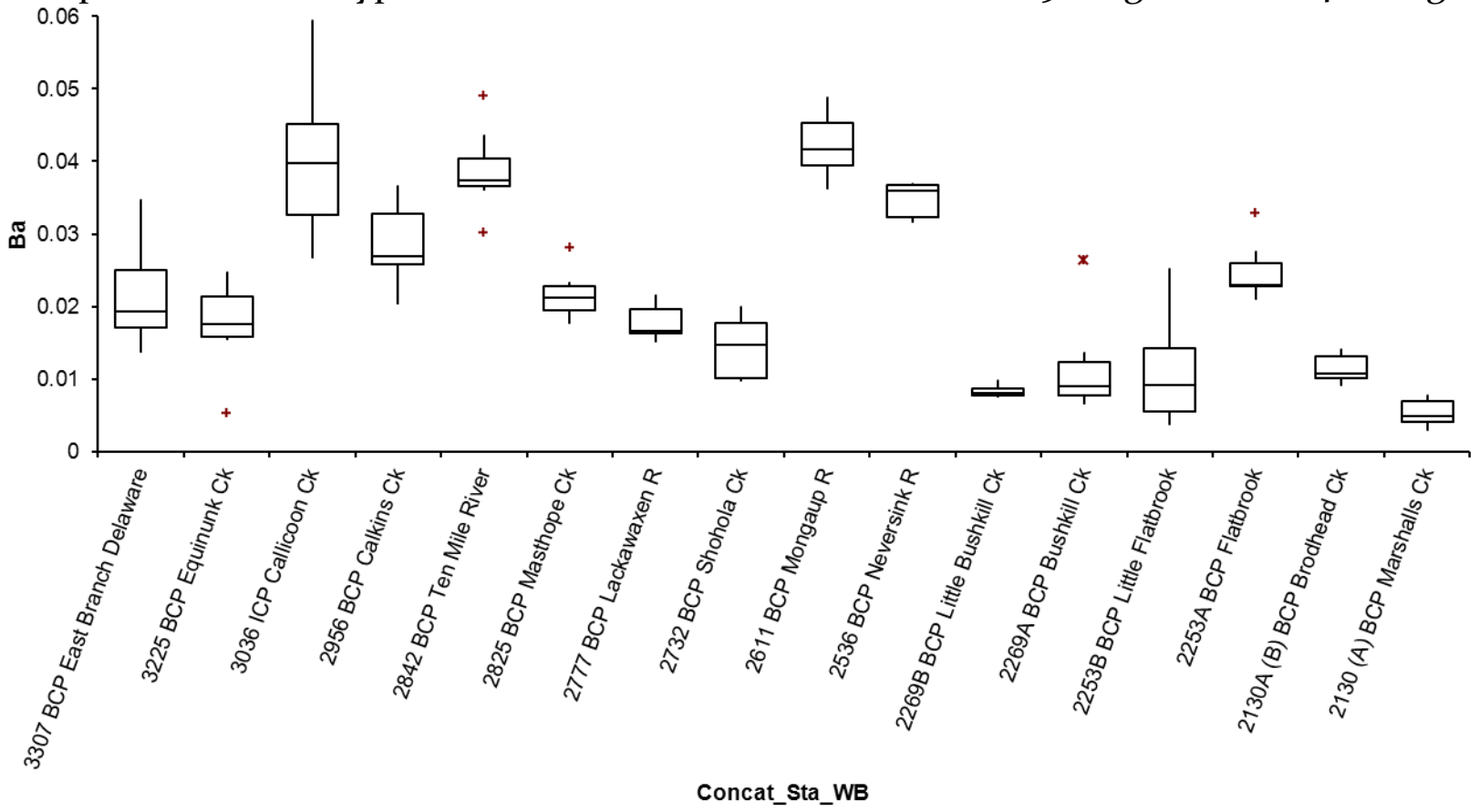


SRMP = DRBC/NPS Scenic Rivers Monitoring Program

Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Barium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 1482. mg/l

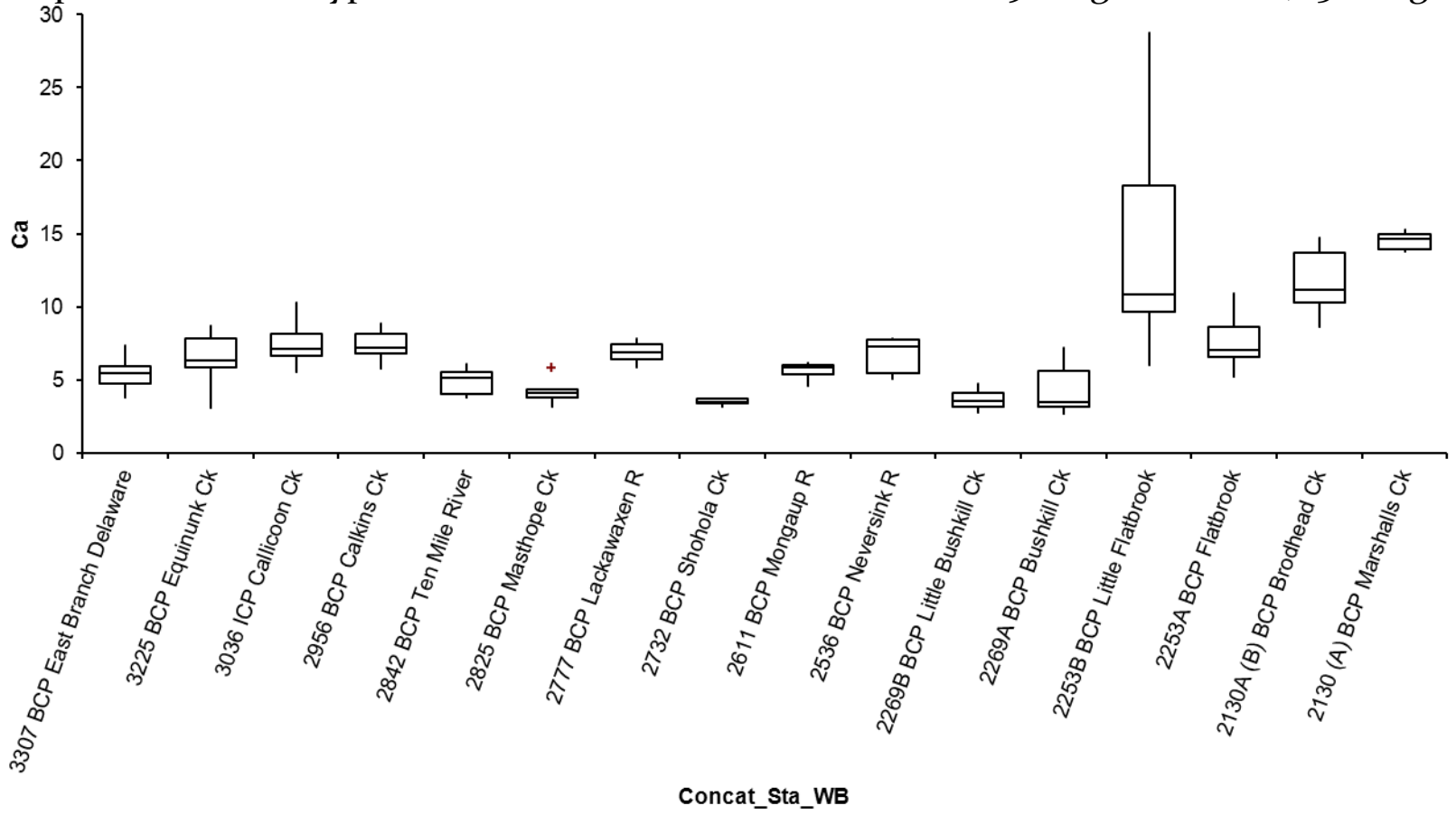


SRMP = DRBC/NPS Scenic Rivers Monitoring Program

Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Calcium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 8,850. mg/l



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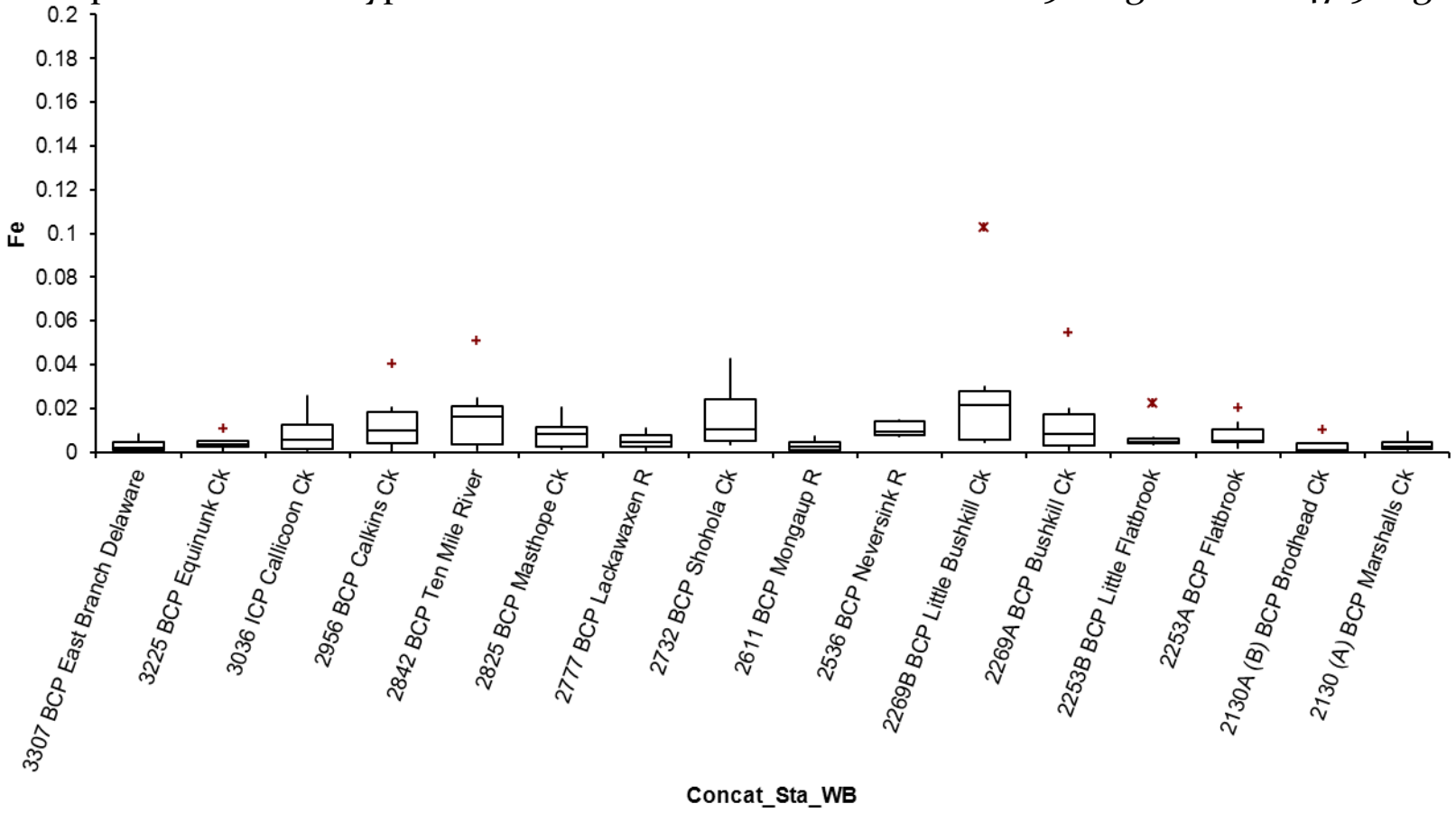
Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Iron mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 47.9 mg/l



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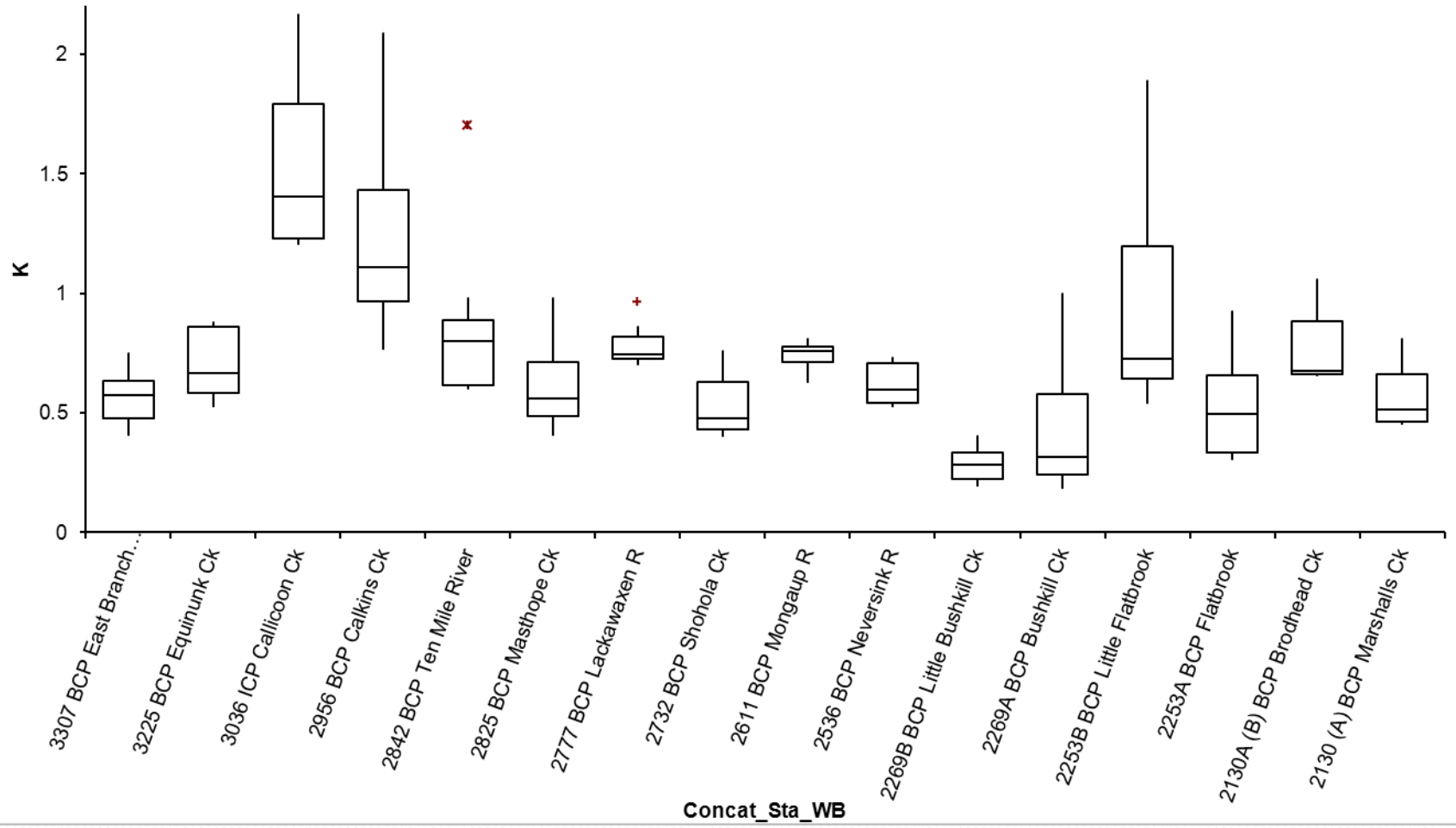
Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Potassium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 584.5 mg/l



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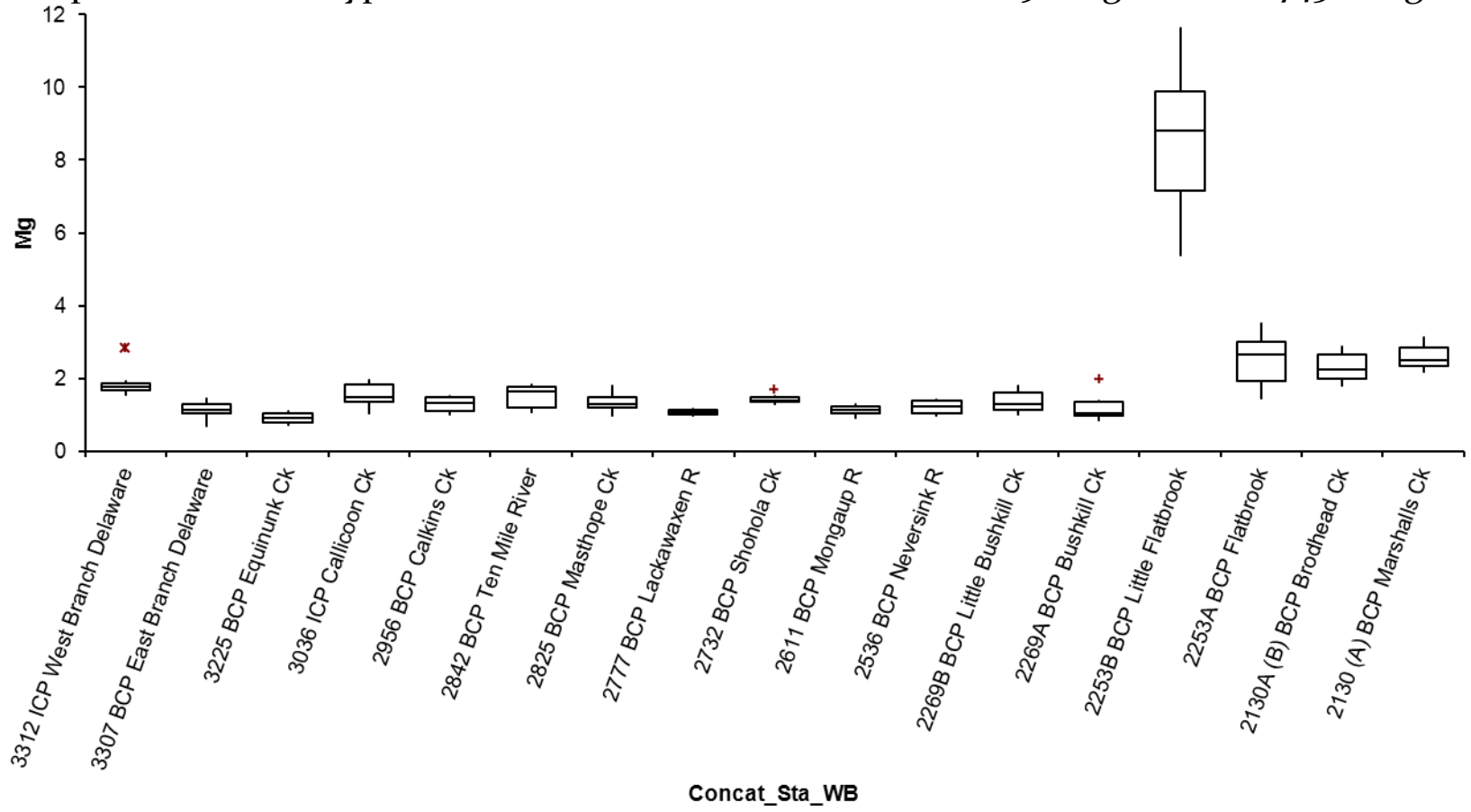
Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Magnesium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 745.8 mg/l

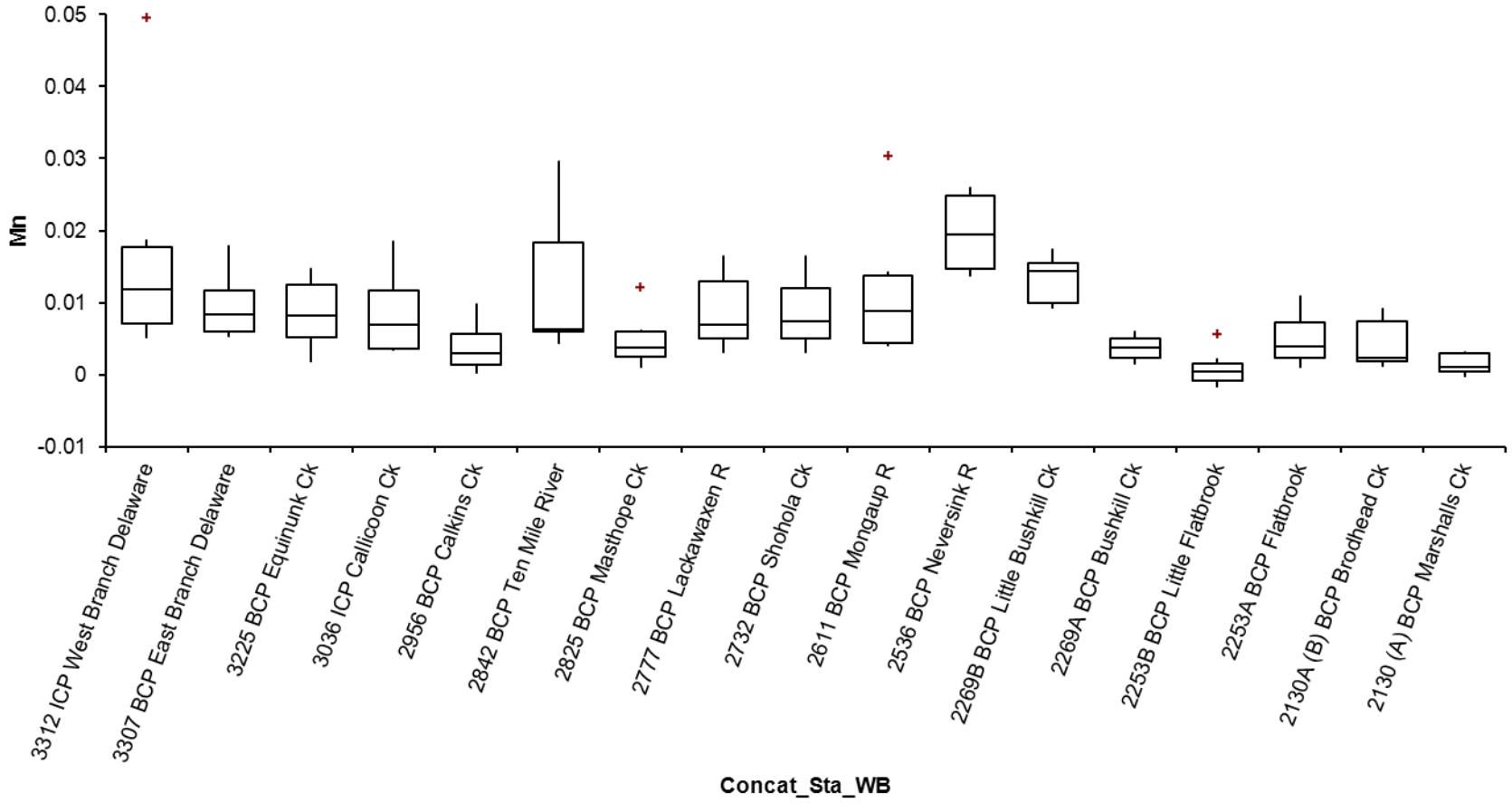


SRMP = DRBC/NPS Scenic Rivers Monitoring Program

Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Manganese mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 4.25 mg/l

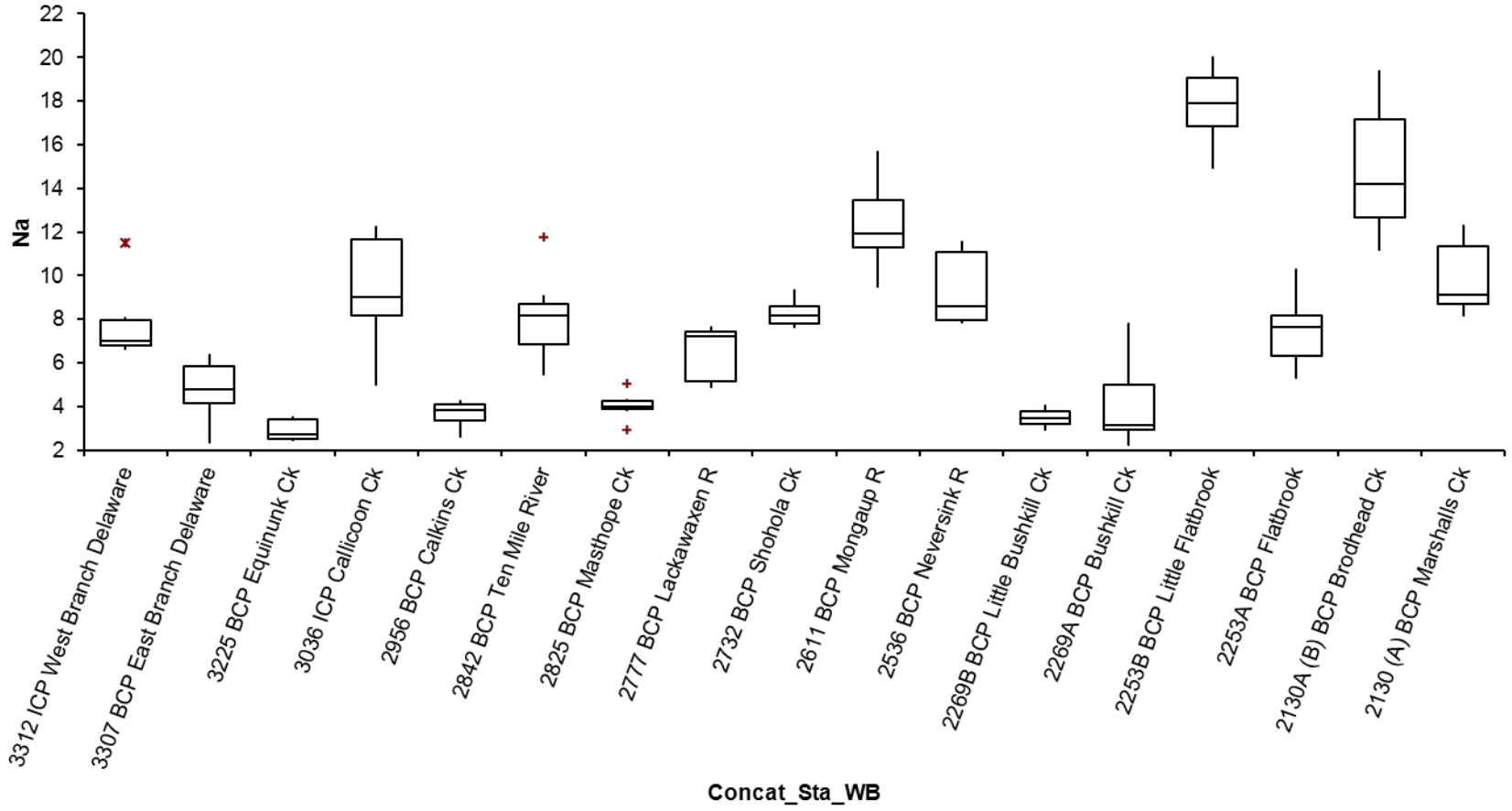


SRMP = DRBC/NPS Scenic Rivers Monitoring Program

Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Sodium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 27,674. mg/l



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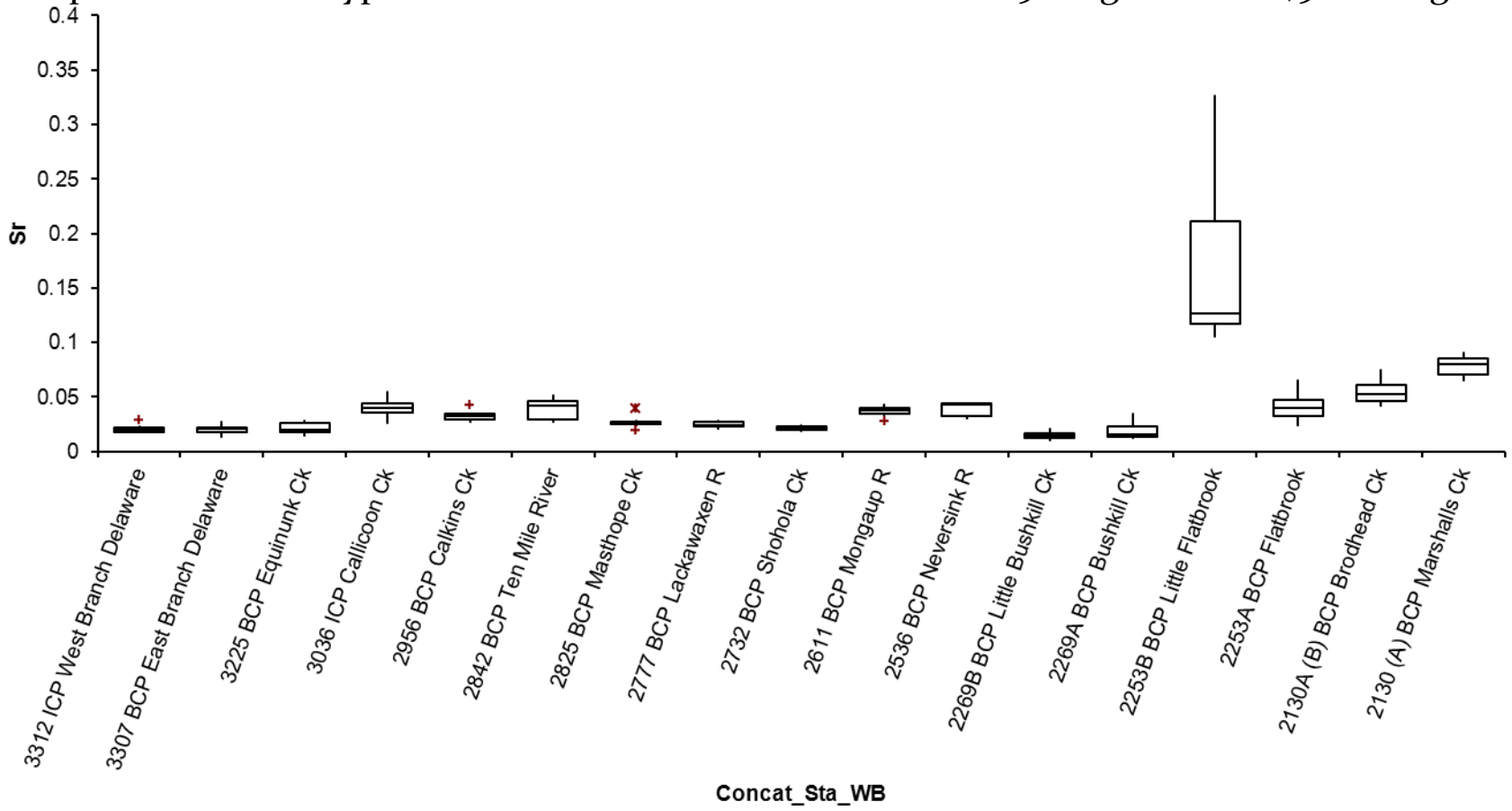
Preliminary Results from 2009/2010 Archived SRMP Samples

Dissolved Strontium mg/l

Compare these with typical flow-back water concentration in 19 PA gas wells= 1,928.8 mg/l



SRMP = DRBC/NPS Scenic Rivers Monitoring Program

DRBC/Stroud Mayfly Toxicity Testing

- The headwaters of the Delaware River Basin are typically soft (hardness - 21 mg/l) with low ionic strength (spec. Conductivity - 68). These water quality characteristics may influence the effects of pollutants.

- To evaluate the use of alternative toxicity test species and the impact of these waters on the response of traditional toxicity test species, the Commission is working with the Stroud Water Research Center

Centroptilum triangulifer
Photo from: www.discoverlife.org

DRBC/Stroud Mayfly Toxicity Testing

- Project tasks (2012) include:
  - Collecting pre-drilling alteration surface water samples in upper basin tributaries;
  - Collecting representative samples of natural gas drilling flowback/production water;
  - Sample analysis for physical-chemical parameters;
  - Toxicity testing using modified whole effluent toxicity test methods (*Pimephales promelas*, *Ceriodaphnia dubia*, and *Pseudokirchneriella subcapitata*)
  - Toxicity testing using alternative test procedures using native mayflies (*Centroptilum triangulifer*, and two additional mayfly species)

Partnerships

- DRBC
- U.S. Geological Survey
- National Park Service
- PADEP
- NYSDEC
- Stroud Water Research Center
- Dickinson University
- Delaware Riverkeeper Network
- Academy of Natural Sciences
- Smithsonian Institution
- U.S. EPA; Haas Foundation (funders)
- QC Laboratories Inc.; Axis Labs; EcoAnalysts Inc. (lab support)

Project Sponsor Proposed Monitoring Section 7.4(e)

- **Surface Water Monitoring** - including
  1) Pre-drilling site alteration/construction,
  2) Following each hydraulic fracturing, and
  3) Annually during production periods.

  Monitoring to be conducted by the Commission. Provision to allow project sponsor to conduct under plan approved by the Executive Director.
- At least one upstream and downstream surface water monitoring site (or reference/impact site).
- Continuous temperature and specific conductivity, water chemistry parameters and benthic macroinvertebrates.

Project Sponsor Proposed Monitoring Section 7.4(e)

- **Groundwater Monitoring** - survey and sampling of representative groundwater wells within 2000’ of well pad.
- Sampling frequency, parameters, analytical methods and detection limits will be specified by the Executive Director.
- **Sampling of flowback/production water** - required for each hydraulic fracturing event.
- Other requirements include reporting of the amount of fracturing fluids used and the mass of each chemical constituent of each additive.

Questions?

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Check out our redesigned website! http://www.drbc.net

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