Baseline Monitoring in the Delaware River Basin Before Natural Gas Development

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Delaware River Basin Commission

DRBC Ambient Monitoring Framework for Natural Gas Development

- Background
- DRBC Monitoring Activities
    1. HOBO Conductivity Loggers
    2. Reanalysis of archived samples
    3. Biological Monitoring
    4. Toxicity Testing
    5. Radiochemistry Monitoring
- Future
    1. Regional Monitoring
    2. USGS Gage upgrades (*applied*)
- Partnerships

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Background

- In May 2010 Commissioners postponed approval of shale gas development, called for new regulations.
- ***Narrow window of opportunity*** to establish pre-drilling conditions.
- Marcellus shale underlies basin's Special Protection Waters area, requiring No Measurable Change to existing water quality.
- Aqueous wastes from hydraulic fracturing dramatically different than WWTP effluent or non-point runoff.

Drilling Activity from 2007- Nov 2011

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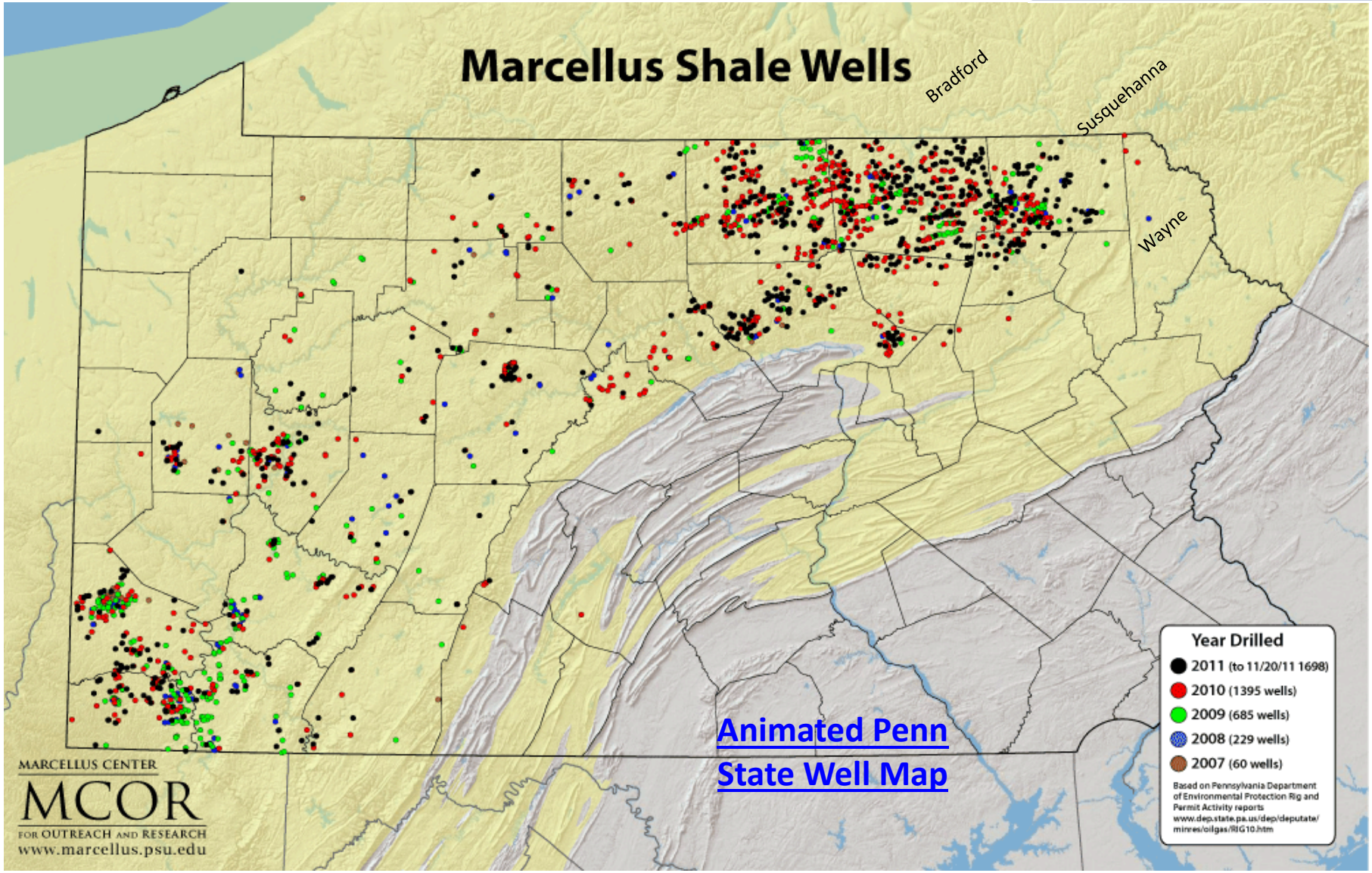
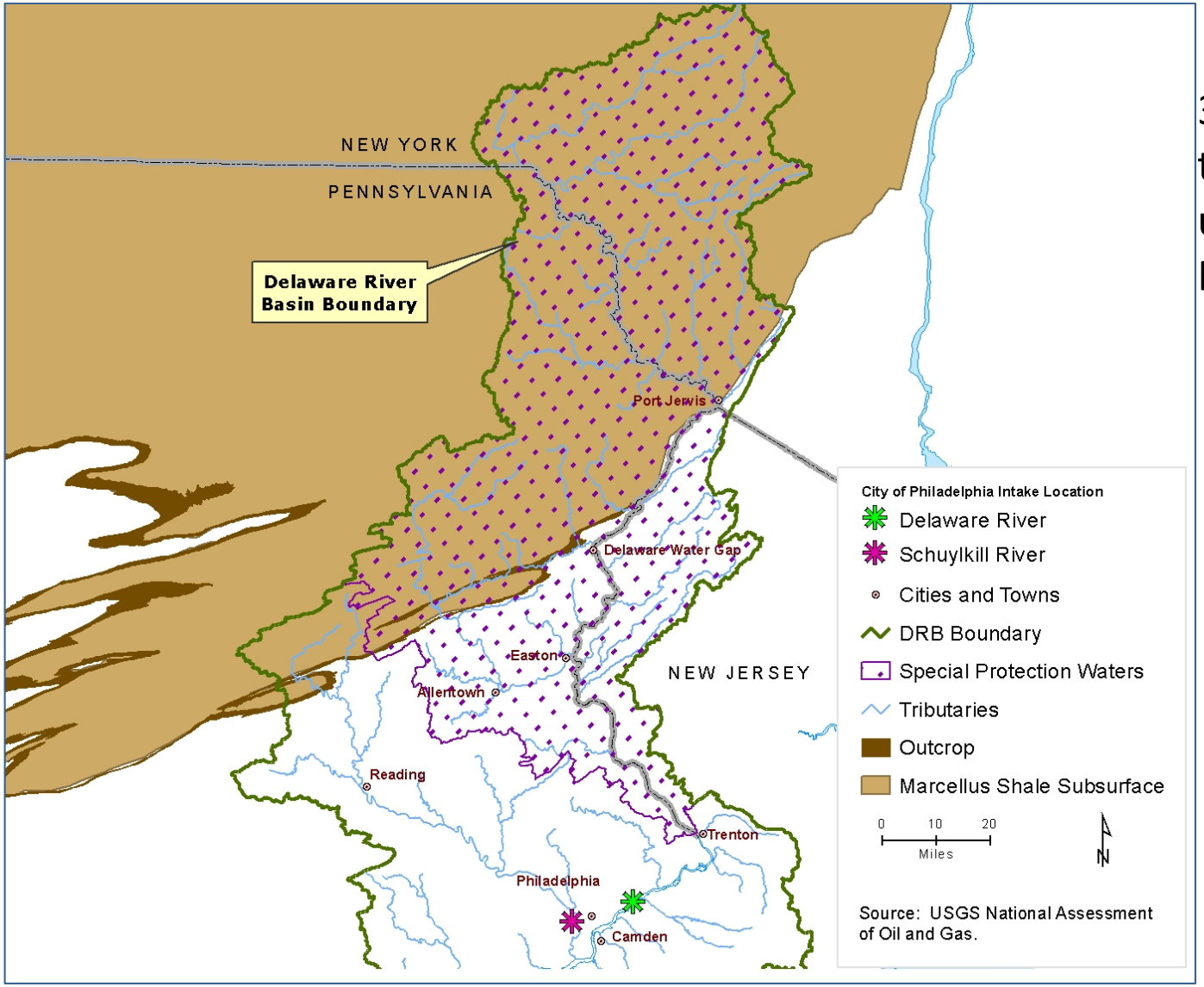


Marcellus Shale and Special Protection Waters



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

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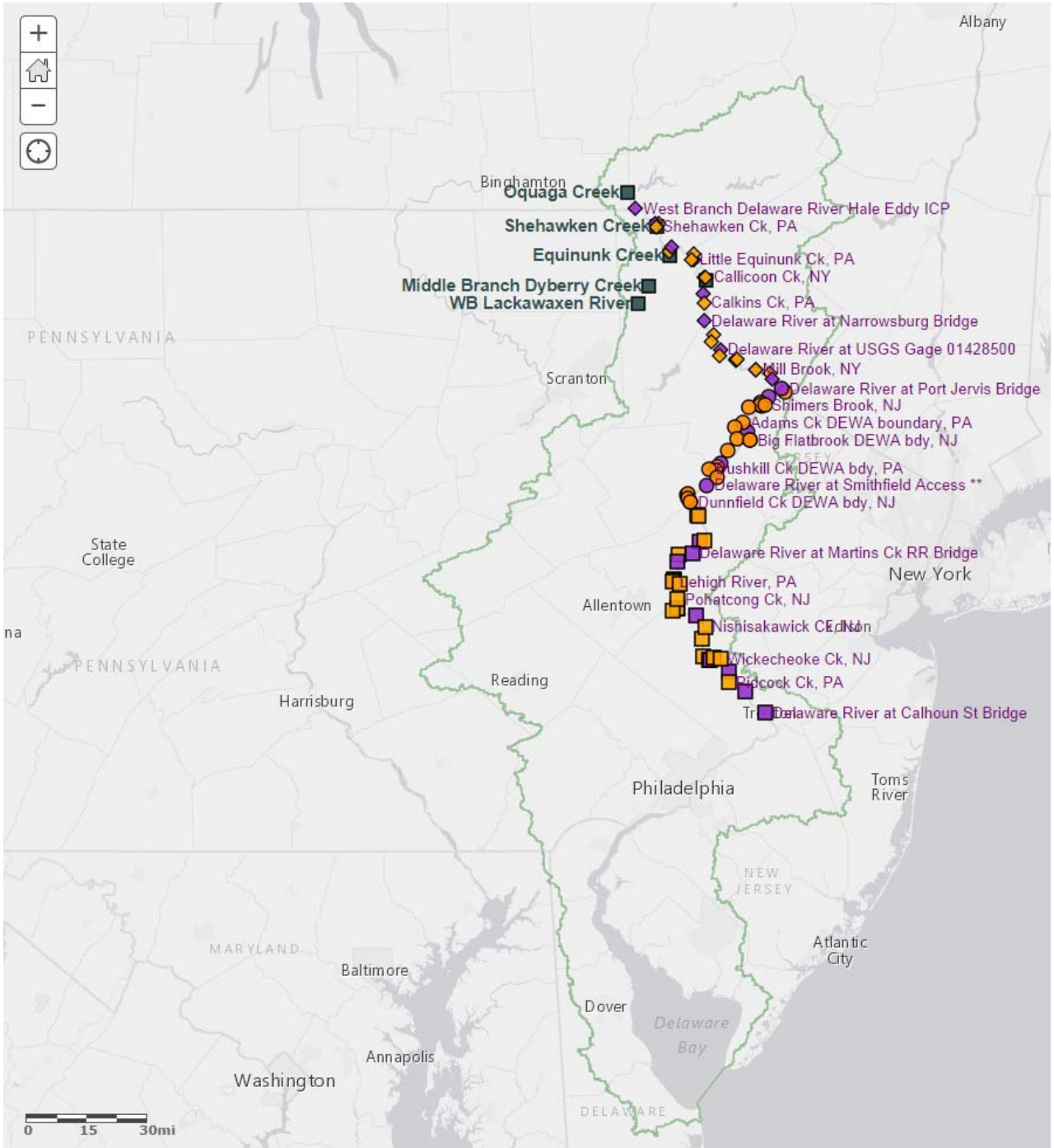

Locations of:

- HOBO Specific Conductance Loggers; and
- Archived Samples.

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HOBO-U24
Conductivity / Temperature Logger

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HOBO-U24 Deployment

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"Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas"
prepared for Marcellus Shale Coalition, December 2009

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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

Aqueous Waste TDS Percentiles (log scale)

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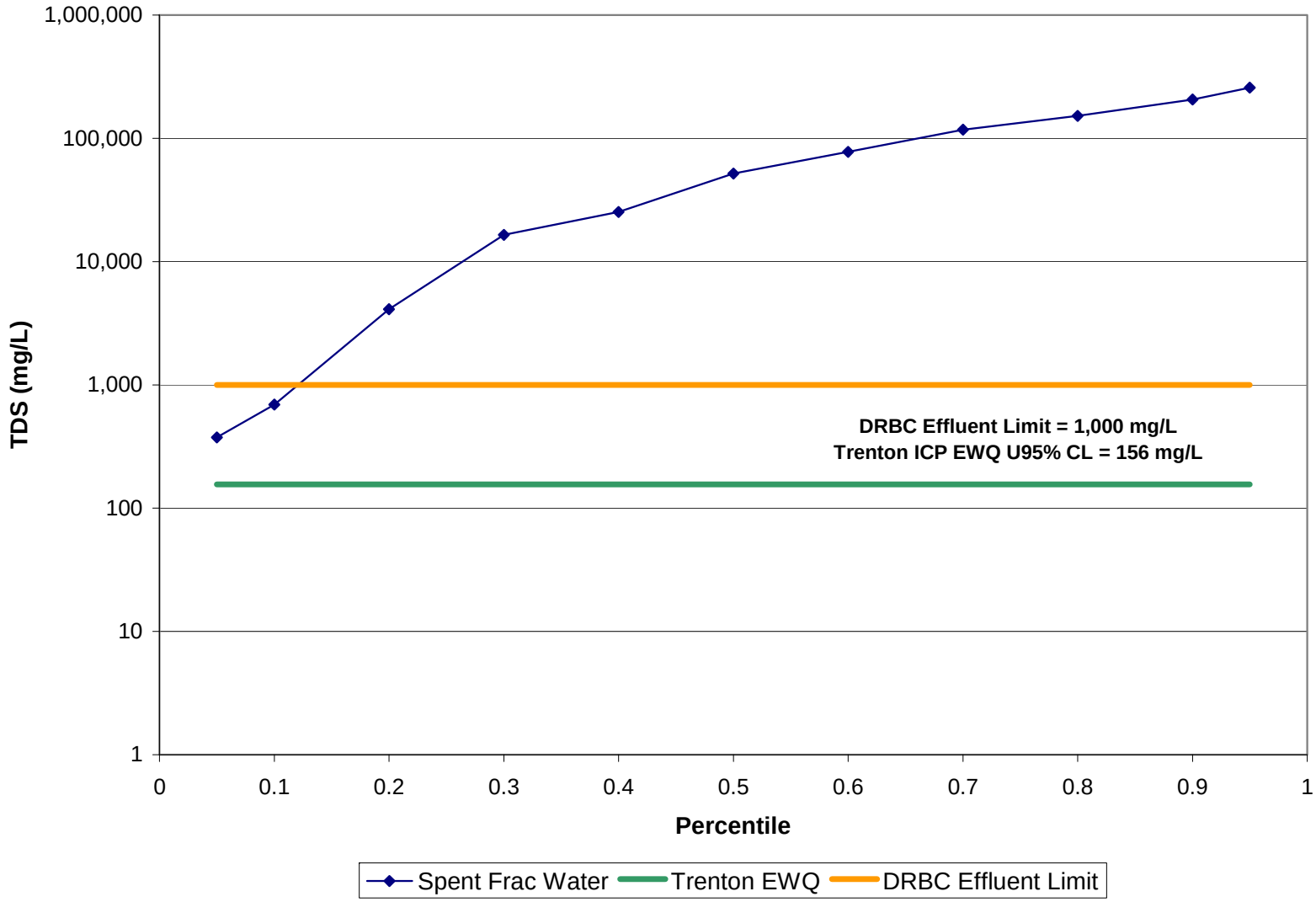

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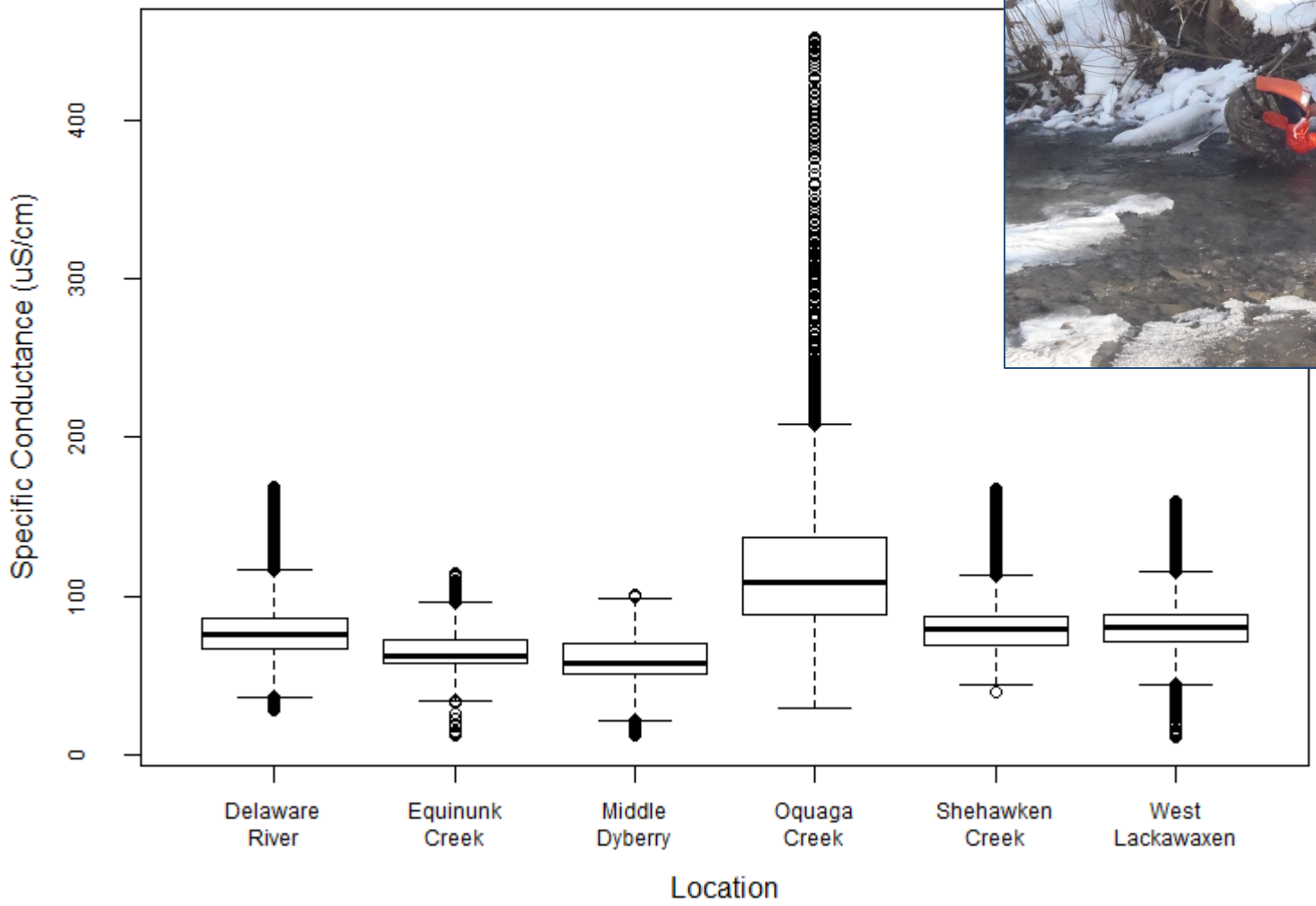
Specific Conductance Baseline

488,000 observations as of October 14, 2014



Reanalysis of Archived Samples

funded by Haas Foundation Grant and
National Park Service

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- Approx. 700 archived samples from Delaware River and tributary control points collected in 2009 and 2010.
- Upper, Middle, and Lower Delaware archived samples were analyzed for selected parameters identified in flowback samples.
- Two years of data to represent pre-drilling baseline chemical conditions.

Analytical Parameters

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

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Indicator Parameter	Method	Status
Na, Mg, Ca, K	Ion Chromatograph	New Analysis on previously archived sample
Barium, Strontium	ICP-OES	
Bromide	Flow Injection	
Sulfate	Flow Injection or turbidimetric	
Total Alkalinity	Titration	Original Analysis (before archiving)
Total Hardness	Titration	
TDS	Evaporation, gravimetric	
Chloride	Titration	Analyzed before *and* after archiving to confirm sample integrity

Results from 2009/2010 Archived SRMP Samples

Dissolved Barium mg/l

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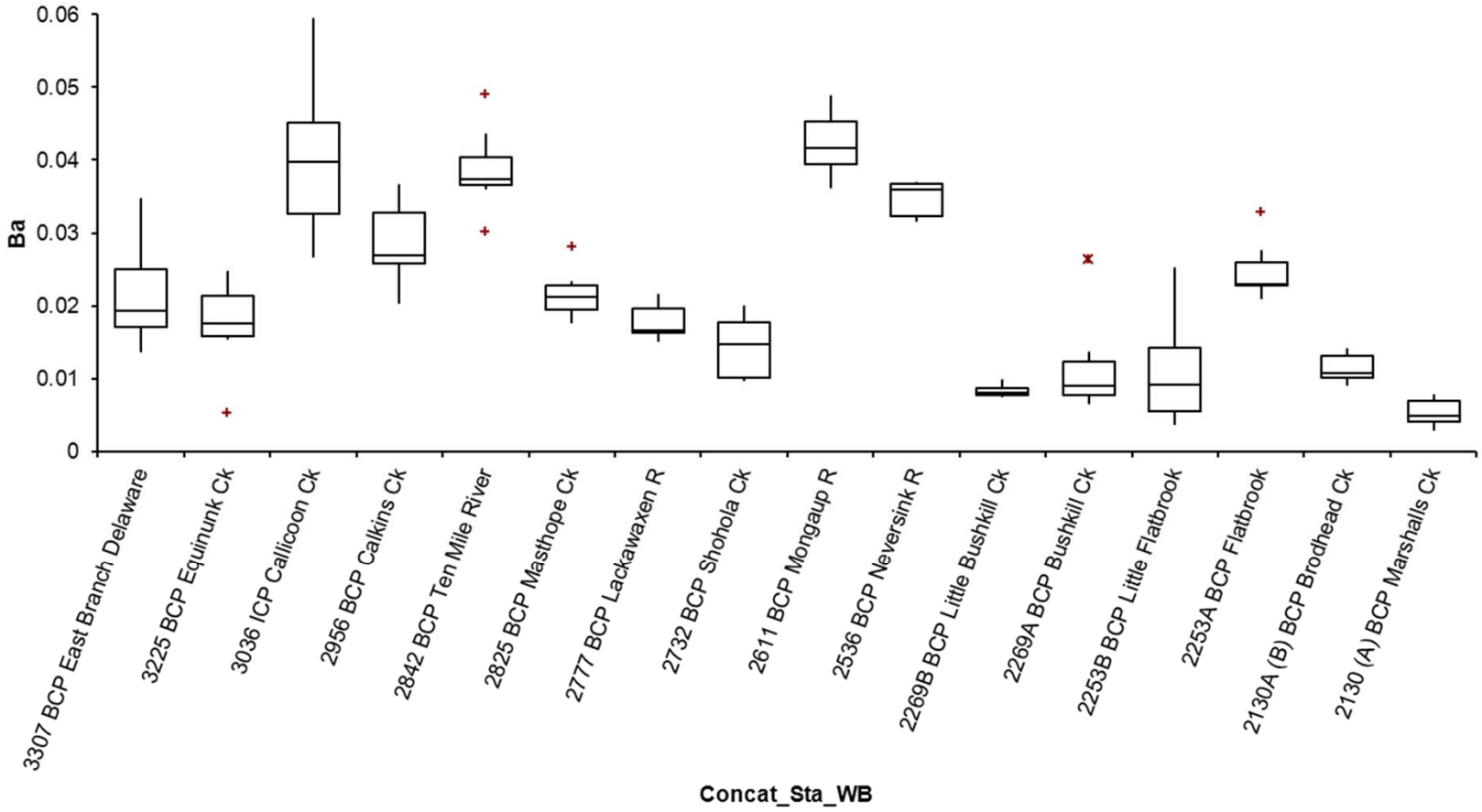
Compare these with typical aqueous waste concentration in 19 PA gas wells= 1482. mg/l



SRMP = DRBC/NPS Scenic Rivers Monitoring Program

Preliminary Results from 2009/2010 Archived Samples

Dissolved Strontium mg/l

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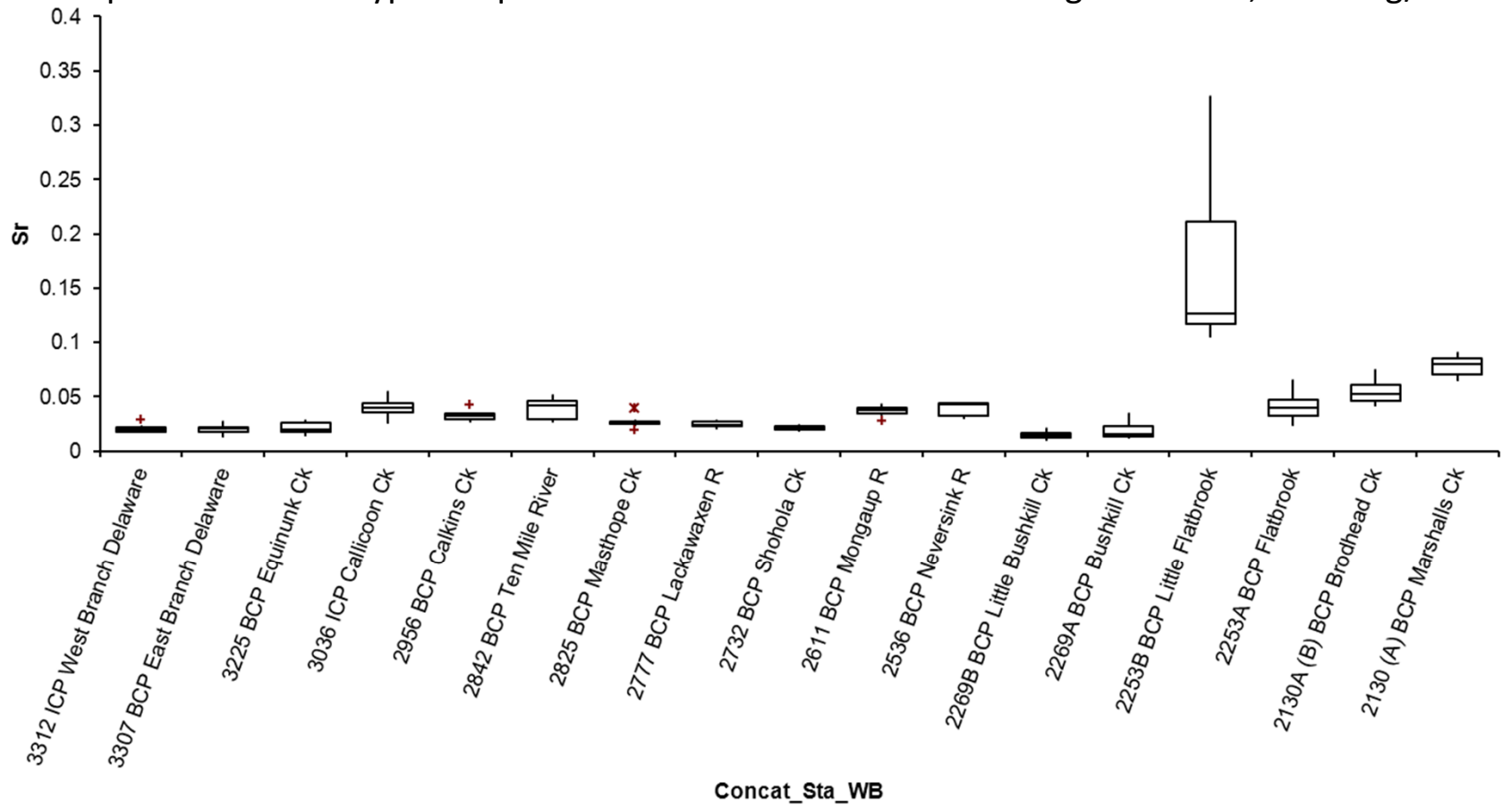
Compare these with typical aqueous waste concentration in 19 PA gas wells= 1,928.8 mg/l



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Ambient Biomonitoring – 2011

funded by Haas Foundation Grant

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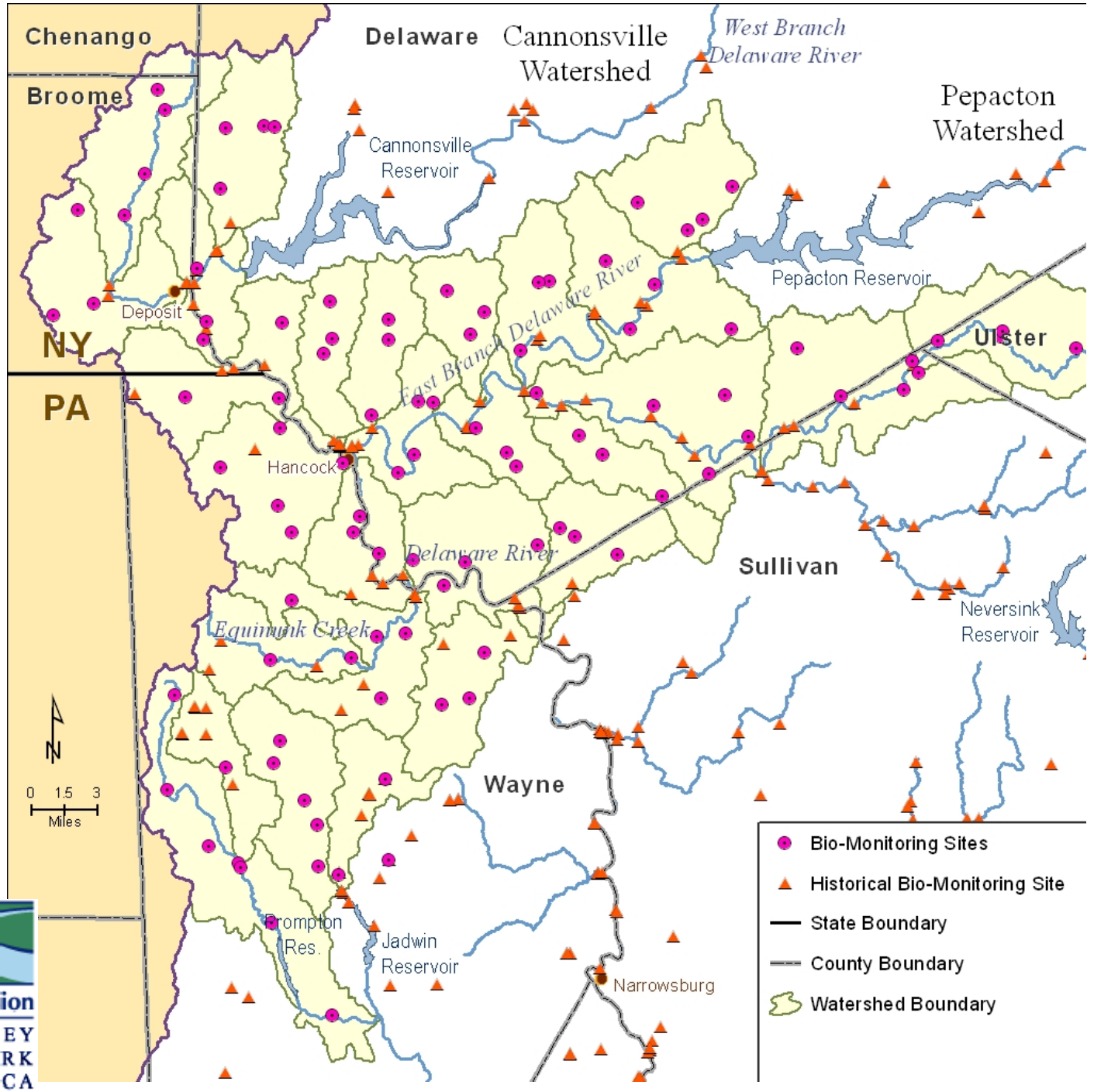
❑ Steps

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 2011: 35 sites sampled in PA using PADEP methods.
6. July/August 2011: 68 sites sampled in NY using NYSDEC methods.
7. Approximately 103 new samples; N= 5 to 7 for each of 28 targeted watersheds.

2011
Spring / Summer
Biomonitoring Sites

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



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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

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DRBC/Stroud Mayfly Toxicity Testing

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- 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)

DRBC/Stroud Mayfly Toxicity Testing - Chronic Results

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Parameter	Species	% Produced Water		Conductivity (µS/cm)	
	Dilution water:	Dyberry (soft)	WCC (harder)	Dyberry (soft)	WCC (harder)
LC50	*C. triangulifer*	0.37	0.42	1729	1889
	P. rivulare	0.37	0.41	1725	1868
	Ps. frondale	0.34	0.26	1588	1284
IC25	*C. triangulifer*	0.25	0.29	1245	1416
	P. rivulare	0.19	0.27	1009	1322
	Ps. frondale	0.14	0.14	819	830
	Fathead minnow (survival)	0.043	0.085	452	605
	Fathead minnow (growth)	0.042	0.083	452	605
	Ceriodaphnia dubia (survival)	1.17	0.813	2216	2408
	Ceriodaphnia dubia (reproduction)	0.495	0.545	2216	2408

Radiochemistry Monitoring

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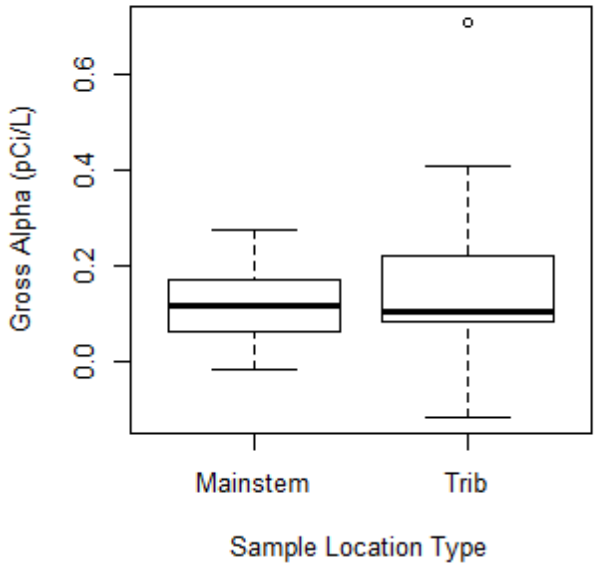
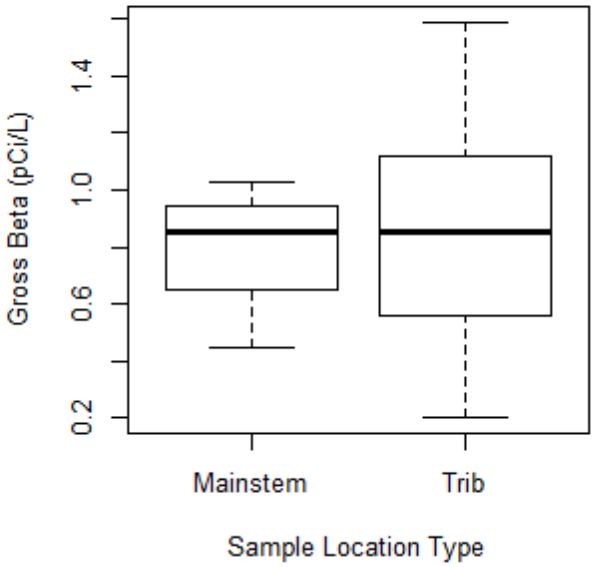
- 1-year quarterly monitoring
- 33 sites in Upper and Middle Delaware;
- Gross alpha & gross beta
- Radium -226 + Radium-228
- Whole water;
- Nitric acid preservation.

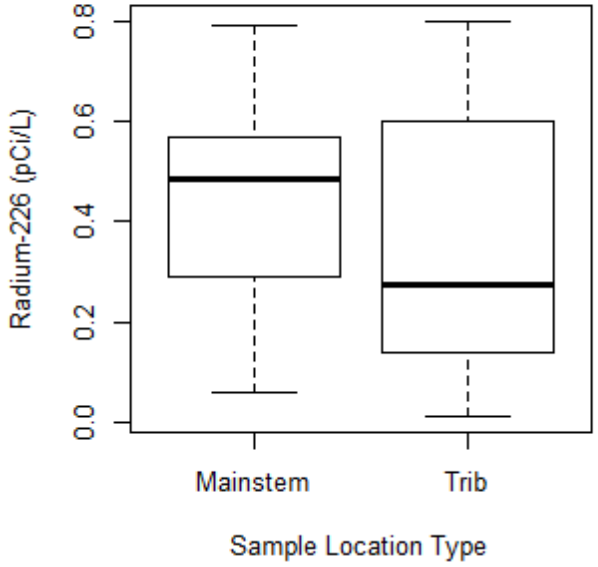
- Funded by William Penn Foundation;
- Started January 2014;
- Completion of quarterly in December 2014;
- Collect reserve samples in 2015.

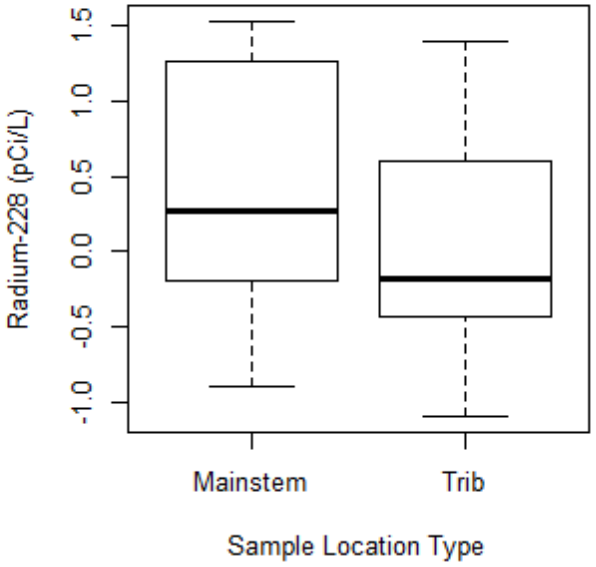




Initial Results

(1st quarter)





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Expected Next Steps

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- Some additional pre-gas expansion monitoring:
  - possibly including more HOBO sites, follow up biological monitoring, and continued analysis of gas-related parameters in existing monitoring programs;
- With commencement of gas development, implement monitoring requirements in final regulations;
  - Regional monitoring;
- Upgrade existing USGS gages to include specific conductance;
- Continued close coordination with partner organizations.

Partnerships

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- DRBC
- William Penn Foundation (funding)
- 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)
- NJ DOH; QC Laboratories Inc.; EcoAnalysts Inc. (lab support)

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Questions?

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