Citizen Science in Baseline Monitoring for Unconventional Hydrocarbon Development

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With thanks to the Shale Network team: S. Arjmand (Pitt), D. Yoxtheimer (Penn State), R. Vidic (Pitt), P. Grieve (Penn State), C. Wilderman (Dickinson College), J. Vastine (Dickinson), J. Pollak (CUAHSI), R. Hooper (CUAHSI), C. Simon (Pitt), J. Abad (Pitt), K. Brasier (Penn State), K. Jalbert (RPI), J. Williams (Penn State), M. Gonzalez (Penn State)
More than 7000 unconventional shale gas wells today in PA...only about 8 in 2008!
Properties where water supplies were contaminated and oil/gas activities were implicated through an investigation were binned into “cases” by the PA DEP. Cases include conventional and unconventional oil and gas activity and can implicate more than one gas well or more than one water supply. One case (Dimock PA) was associated with contamination at 18 water supplies.

About 45 spills (>400 gallons) reported to date based on PA DEP and media reports/crosschecks.

Based on positive determination letters, between 2005 and 2012, between 7 and 64 wells were implicated by PA DEP for contamination of groundwater.

Over this time period there were >8000 spudded wells, >4000 completed wells.
THE SHALE NETWORK

WWW.SHALENETWORK.ORG
ACCESSIBLE THROUGH HYDRODESKTOP (WWW.HYDRODESKTOP.ORG)

The ShaleNetwork is creating a central and accessible repository for geochemistry and hydrology data collected by watershed groups, government agencies, industry stakeholders, and universities working together to document natural variability and potential environmental impacts of shale gas extraction activities.
We are building the ShaleNetwork database as a HydroServer in the CUAHSI Hydrological Information System (NSF facility). CUAHSI’s tool, HydroDesktop, allows people to find the data.

Below: all locations for which Shale Network had uploaded data as of 12/2014. Data derives from peer-reviewed publications, universities, industry, government, volunteer groups.

As of December 2014:

Time Series: 137,579  
Sites: 25,429  
Variables: 125  
Total Values: 2,045,084

The database includes data for water quality in stream waters, spring waters, ground waters, injection, flowback, and production waters in the area of Devonian shale gas development in northeast.
Volunteer Groups contributing data to Shale Network database

- AlleghenyMons
- BeaverMons
- BradfordMons
- CCTU (Caldwell Creek TU)
- CrawfordMons
- FayetteMons
- French Creek Cons.
- GC Trout Unlimited
- God's Country Water Dogs
- Greene County Watershed Alliance
- GreeneMons
- Pa Senior Environmental Corps
- JeanneButler (ButlerMons)
- McKeanMons
- Mountain Ridge High School
- Murrysville Stream Monitoring Group
- PotterMons
- SusquehannaMons
- TeenShale Network - SCASD
- VenangoPASEC
- WarrenErieMons
- WestmorelandMons
- NY_Sentinels
- Allegany
- Broome Tioga
ALLARM: Alliance for Aquatic Resource Monitoring: Service Providers who Educate Volunteer Groups


Candie Wilderman, Julie Vastine, Dickinson College
ALLARM Background

• Founded in 1986 as a project of the Environmental Studies Department at Dickinson College, the Alliance for Aquatic Resource Monitoring provides technical support to communities to help them use science as a tool to investigate their stream health concerns.

• ALLARM employs 12-14 students during the school year who are actively involved in community collaboration, educational workshops, laboratory analysis, policy research, stream testing, and outreach.
Volunteer data: collected for Card Creek in Potter County by Cork Sauve of GC Trout Unlimited

Screen shot from HydroDesktop
What about data quality?

• We seek data from any group using established data protocols -- from industry sources, government sources, university sources, nonprofits, citizen scientists.
• Our basic philosophy is that even published peer-reviewed or gov’t data has problems associated with it, so as much as possible we want to put data online with appropriate metadata for researchers to assess...THE BEST WAY TO ASSURE DATA QUALITY IS TO PUT IT ONLINE FOR SCRUTINY
• The metadata includes as much information as possible about data quality.
• If problems are found in data we will note it and possibly remove the problematic data.
• Publications will be noted where they are available; likewise, use of ALLARM protocol will be noted for citizen groups (and some such protocol will be required).
We only include data from volunteer groups when they can demonstrate appropriate quality control.

Data from **NY Sentinels (red)** for NY state plotted with **USGS data (blue)**, accessed through HydroDesktop (www.hydrodesktop.org)
All locations with Shale Network data
May 2014 – just PA
All locations with Shale Network and EPA data May 2014 – just PA
Since 2010 when ALLARM began their program for volunteer group monitoring of shale gas related issues, 2 volunteer groups documented an anomaly: one shown here for Brannon Run, Venango County, 9/28/12

Found by Candie Wilderman, as part of ALLARM efforts
No unconventional shale gas wells; several conventional oil/gas wells.
Bob’s Creek: May 24 2010 spill of flowback. Data from USGS, SRBC, PA DEP available in Shale Network database

A leak in a liner allowed flowback water to run off a well pad site (leak discovered 5/24/2010 but was presumed to have started earlier) and PA DEP thought that some contaminant got into Bob’s creek, a Class A trout stream in Juniata Township, Blair County.
It is difficult to find evidence in public data of significant water quality impacts in PA due to shale gas activities. This could be because incidents have occurred at relatively low frequency and have been quickly diluted. However...

• We often lack specific information about location and timing of incidents
• A lot of WQ data are not released due to liability or confidentiality issues
• Sample and sensor data for analytes of interest are sparse spatially and temporally
• Even when sensors are deployed, they can malfunction or drift
• Pre-existing water quality impairments (e.g. acid mine drainage, road salt) make it difficult to discern shale gas impact
Conductivity was only measurable 2000 meters below the outlet. With 8000 unconventional shale gas wells, we would need almost 50,000 monitoring sites in PA alone!

Yue Han and Jorge Abad and Candie Wilderman have been working within Shale Network on algorithms to pick out streams that are not monitored by watershed groups but perhaps should be.
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Waste fluids from Susquehanna County sometimes have 30,000 µsiemens/cm specific conductance.
Bromide in surface water versus time for all 40 PA counties with Marcellus drilling

High concentrations since 2003 were generally in areas with permitted brine discharge or for Salt Springs. Line = Pre 2000 upper limit for USGS data. Detection limit = 10 – 200 ug/L. EPA is considering an MCL for Br = 6000 ug/L
Problems that need research

• Getting data from volunteers is understandably slow (we need a volunteer data portal)
• Keeping volunteers engaged and giving their time is understandably hard (we need ongoing engagement in design and interpretation of the science)
• Organizing, formatting, and uploading data takes time and entails human error (we need better tools for organizing and exploring data)
• We get results slowly and therefore give feedback to volunteers slowly (we need to learn to use data that are temporally and spatially sparse, and we need institutional supports that reward researcher-volunteer interactions)
Shale Network Annual Workshop

- We learn from our data contributors
- We show what we have learned from data
- We teach about using HydroDesktop to access the data
- We have been very successful in promoting conversations among volunteers, industry insiders, academics, government workers, and private consultants
- Enhanced interest by the public in PA is driving enhanced scrutiny and a higher rate of violations even in cases involving conventional oil and gas activity!

Sina Arjmand, graduate student with Jorge Abad at Univ of Pittsburgh, working with a PA Senior Environmental Corps Volunteer at Penn State Shale Network workshop

Brantley, 2015, in press
Observations about data sharing

• All entities have reasons not to share data
• Many entities want to build their own data models or cyberinfrastructure to house their own data
• The multiplicity of data models, data standards, and data cyberinfrastructures impedes the ability of researchers to glean knowledge from the data
• Building a cyberinfrastructure that is robust and efficient to use is difficult -- it takes resources over a sustained time (commercial products are pricey; nonprofit products can be simplistic or glitchey)
• Without access to publicly available data that can be easily inspected, the public loses faith in the process and the social license for an activity can be lost
Citizen Science and the Social License

• When science is delivered from “on high” to “lay people” sometimes the effort loses credibility (i.e., nuclear waste disposal issues, fracking issues)
• Involving citizens in the endeavor of science may be one way to build and maintain credibility
• In all science – including citizen science -- data quality and accessibility must be maintained so that scientists and nonscientists alike believe the data and the interpretation

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