

ALLARM Shale Gas Volunteer Monitoring Workshop



Dickinson

Workshop funded by Colcom Foundation and
Consortium for Scientific Assistance to Watersheds (C-SAW)

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ALLARM Background

Empower communities with scientific tools to monitor, protect, and restore PA streams.



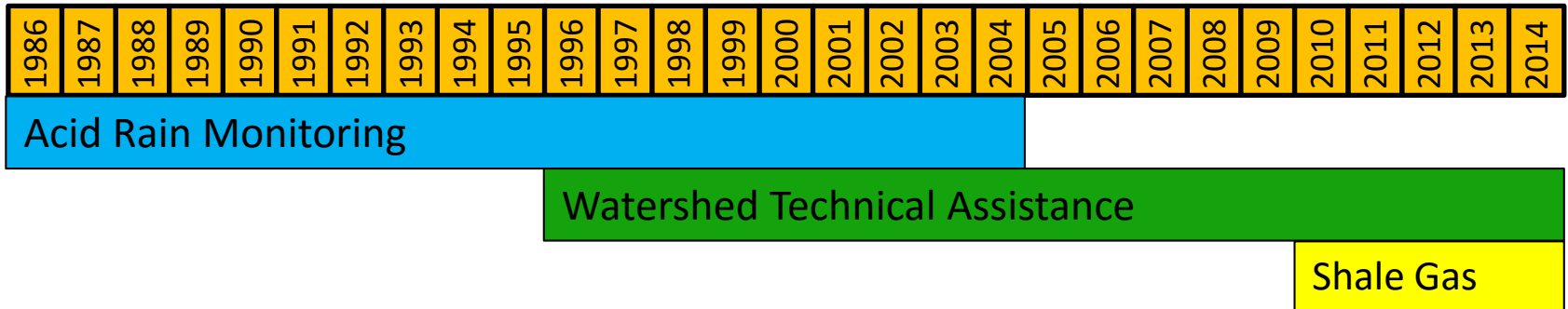
Educate. Engage. Empower.

Who we are

- Project of the environmental studies department (1986)
- 3 full time directors
- 1 science advisor/Dickinson faculty member
- 10 – 14 students



ALLARM History



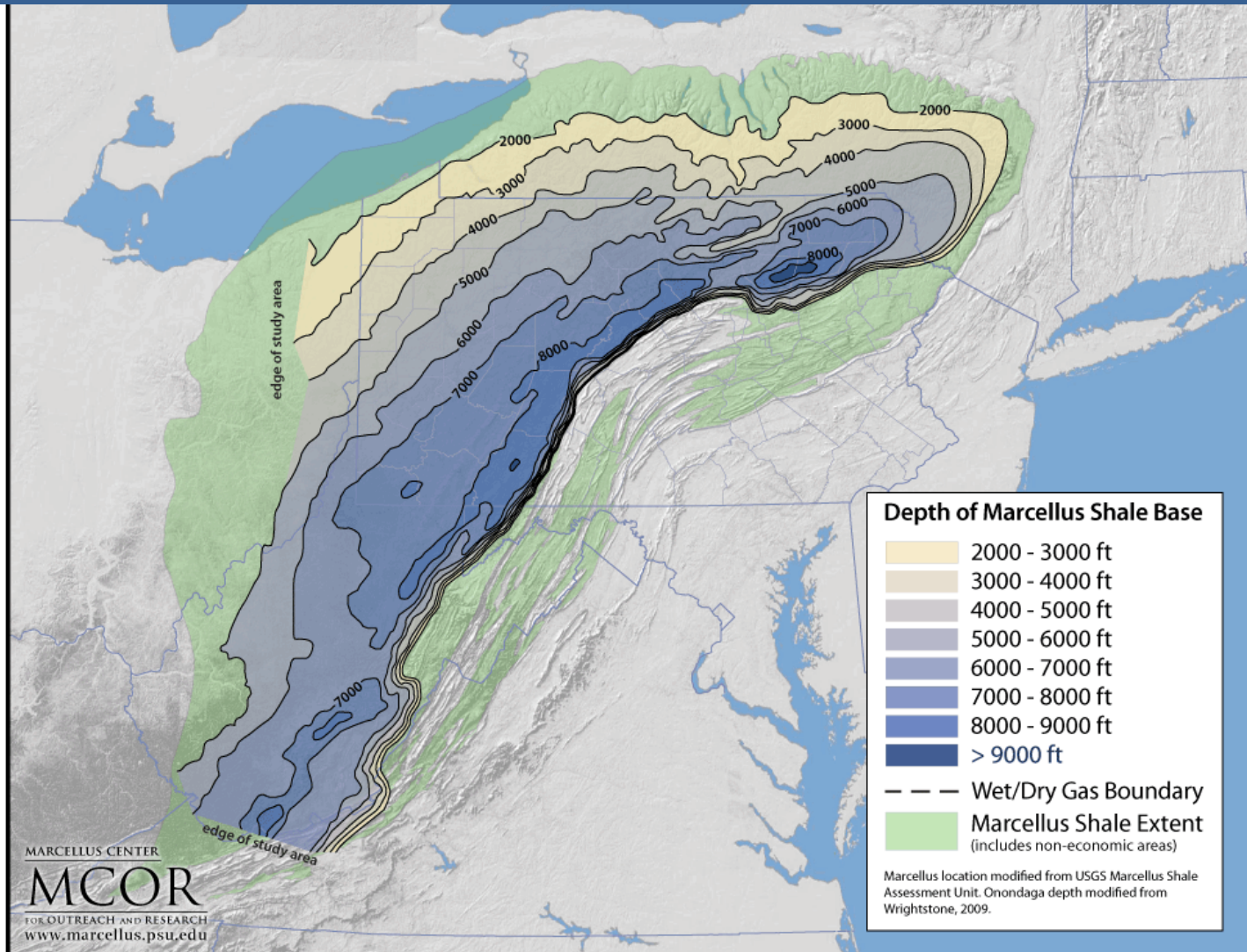
Monitoring Program	Region	Volunteers	Model
Acid Rain	Statewide	Individuals	Contributory
Watershed TA	Southcentral PA	Groups	Co-created
Shale Gas	Marcellus & Utica	Groups & Individuals	Collaborative

Science of Shale Gas

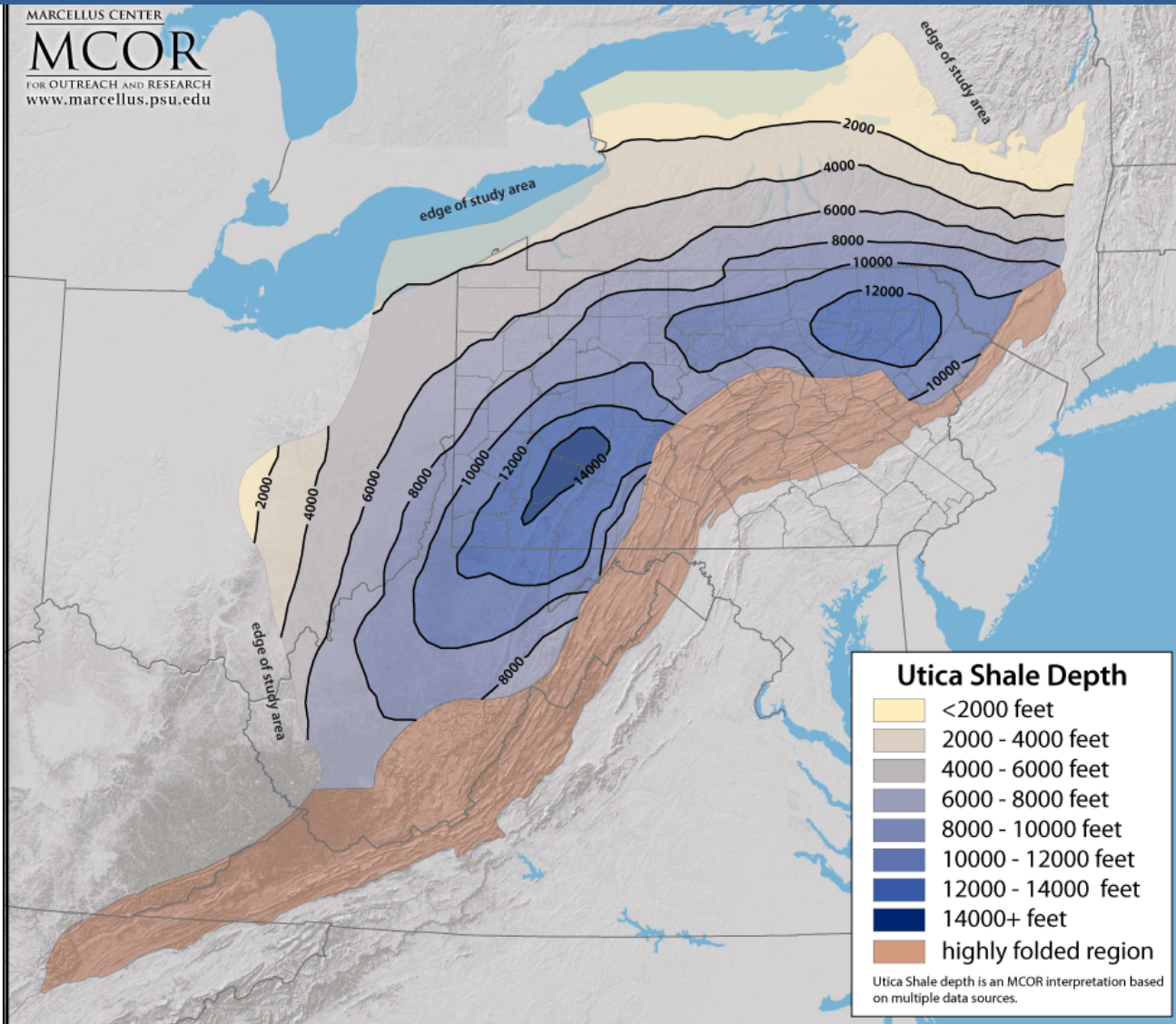


Source: Energy Information Administration based on data from various published studies
 Updated: May 28, 2009

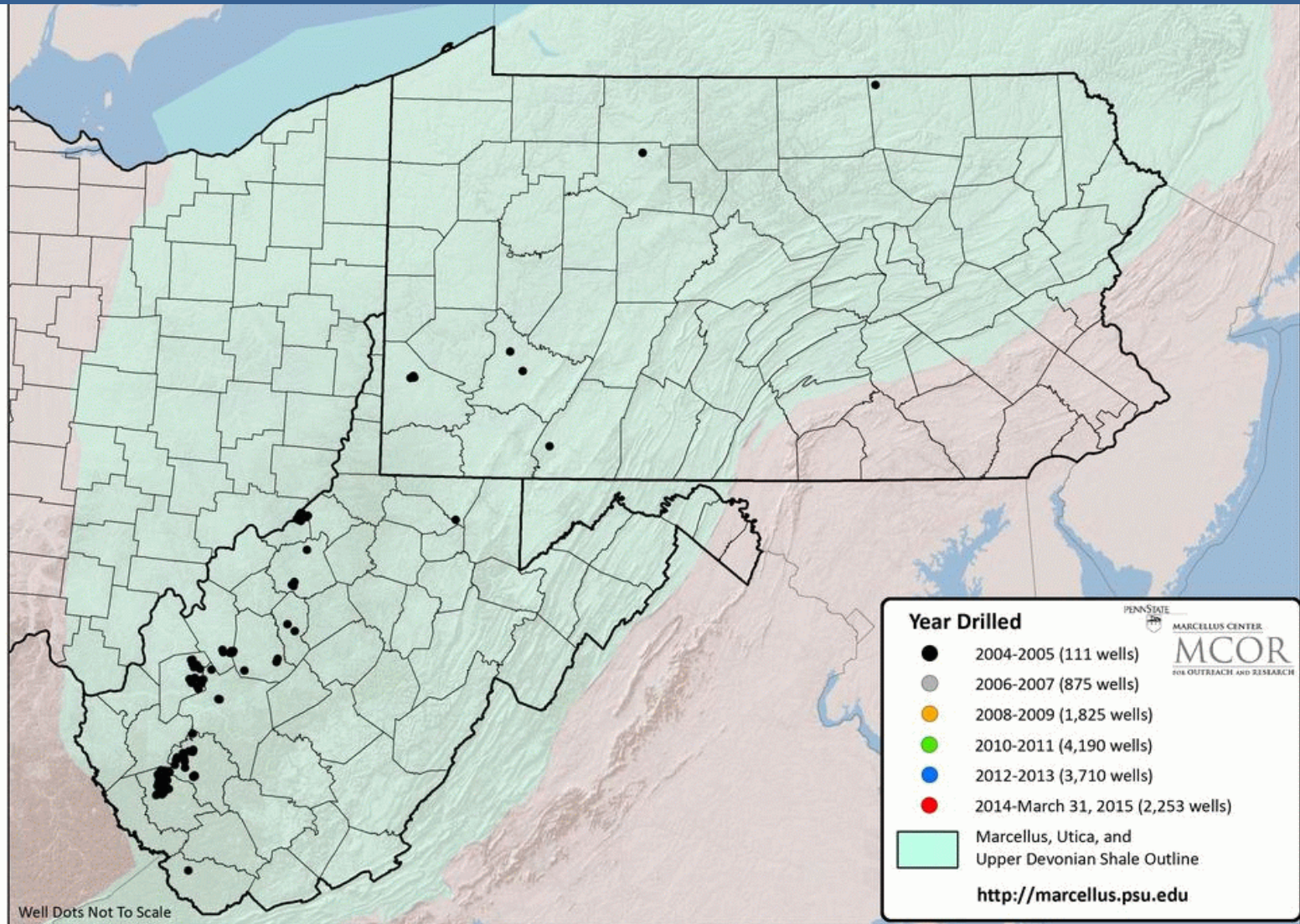
Depth of Marcellus Shale



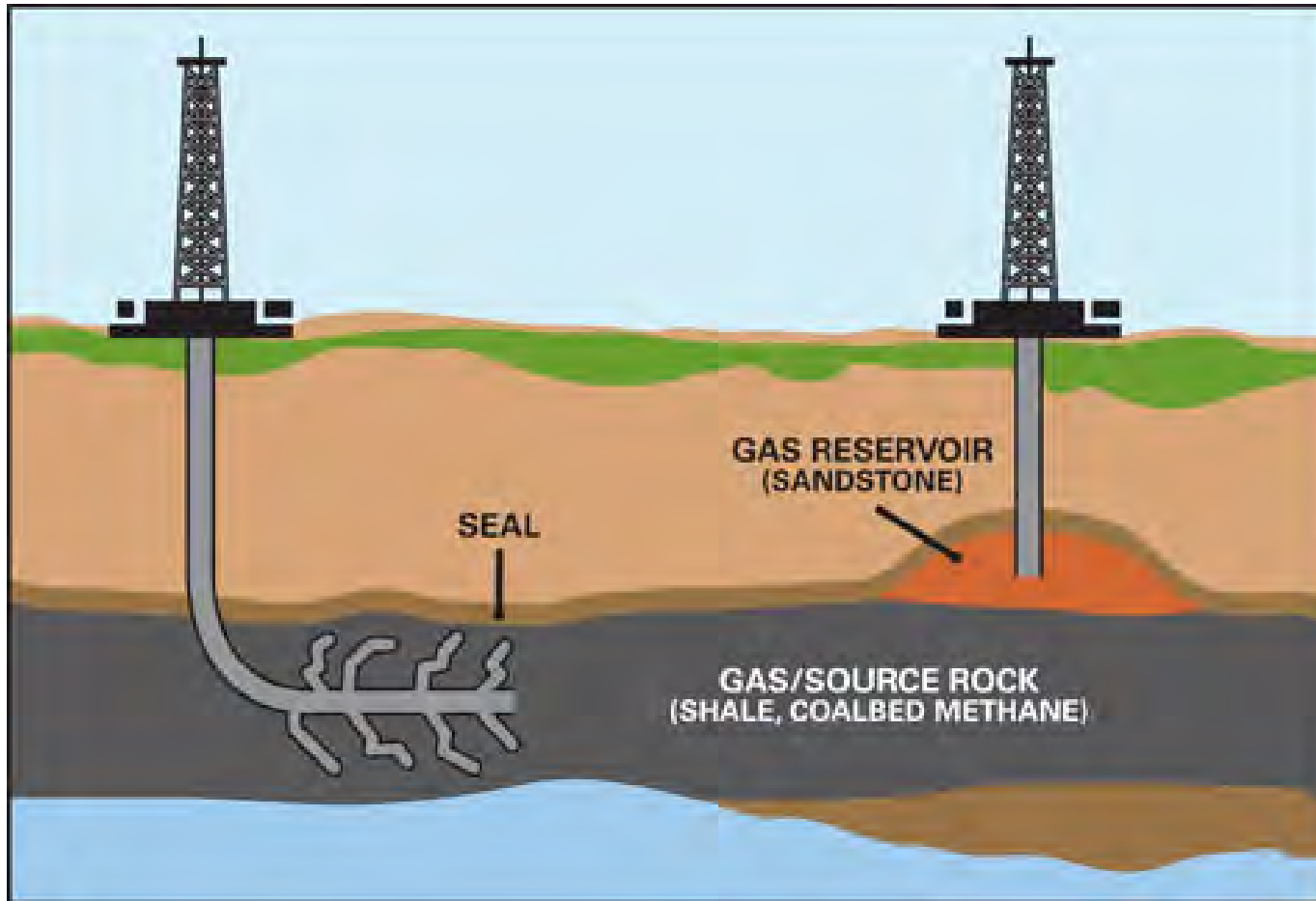
Depth to Utica Shale



Shale Gas Wells in Region



Unconventional vs. Conventional



Differences in Drilling

Traditional Hydrofracking

- In traditional hydrofracking, typically 20,000 to 80,000 gallons of fluid were used each time a well was hydrofractured.
- Traditional hydrofracking used 700 to 2,800 lbs. of chemical additives
- 1940s

High Volume Hydrofracking (HVHF)

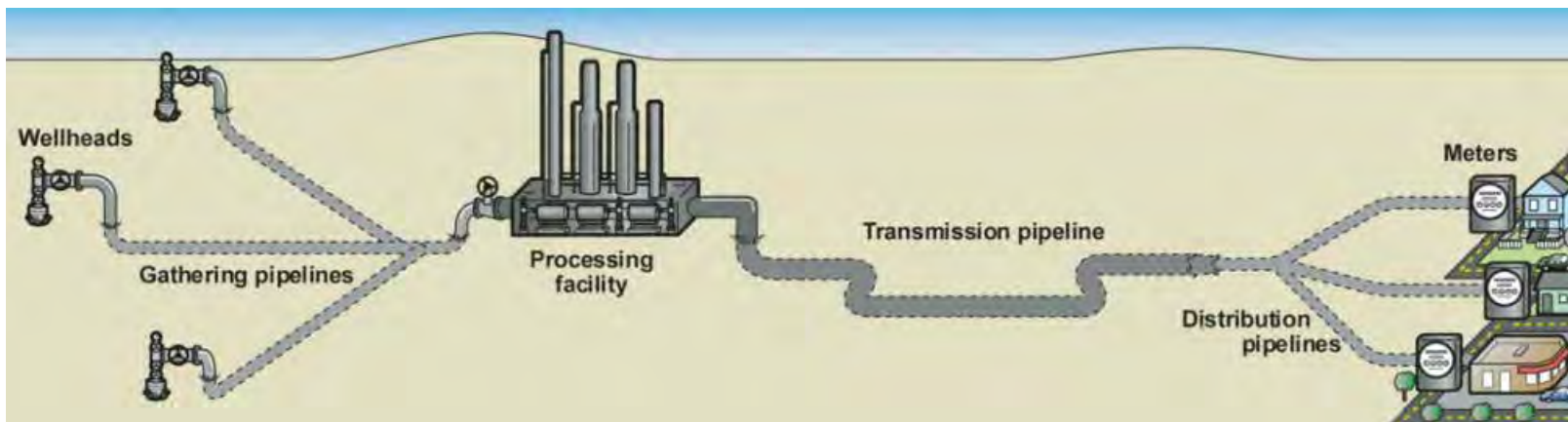
- HVHF uses between 2 and 10 million gallons of fluid (on average 5.6 million), the exact amount depends upon the length of the well bore and the number of fractures created along the lateral extent.
- HVHF uses between 205,000 and 935,000 lbs. of chemical additives, per well many of which are toxic to humans and wildlife.
- Late 1990s

3 Types of Pipelines

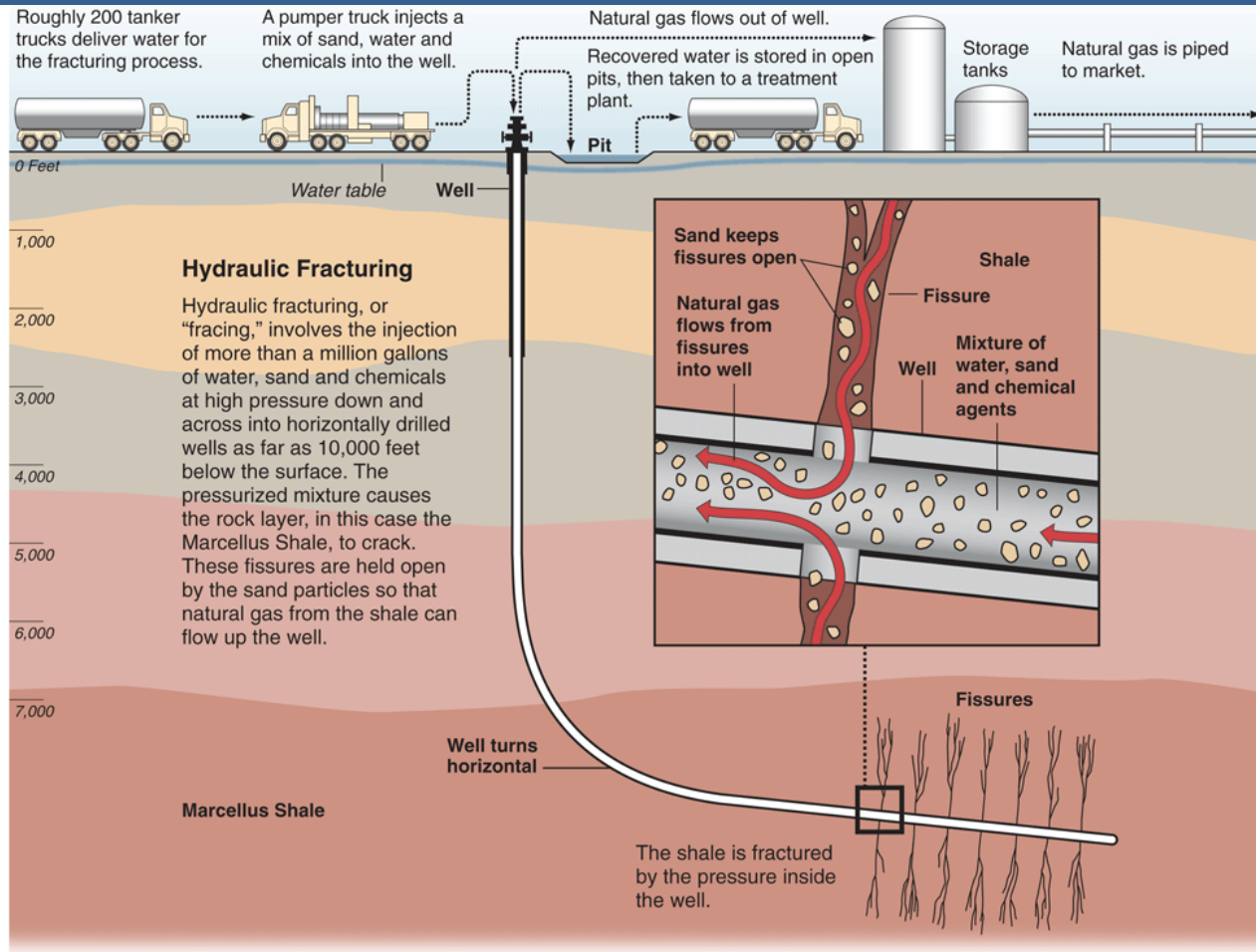
1. Gathering: Usually 6-24 inches in diameter. Carry gas at about 715 psi. These pipelines can travel long distances and there is no requirements to mark them or continually make sure they are cleared of vegetation etc. May clear rights-of-way of 30 to 150 feet wide.

2. Transmission: Large steel pipes (usually 24-48" in diameter), carry gas 200-1200psi. These federally regulated pipelines fall under eminent domain so don't need land owner permission. The land is periodically cleared of large vegetation. Permanent structures and trees may never be placed there. Right-of-way widths of up to 200 feet.

3. Distribution: Small pipes (2-24" in diameter) that can be made of steel, cast iron, plastic or copper. Pressure of gas is reduced to less than 200psi. Mercaptan is added to the gas to give it a rotten egg odor at the city gate prior to being sent through distribution lines.



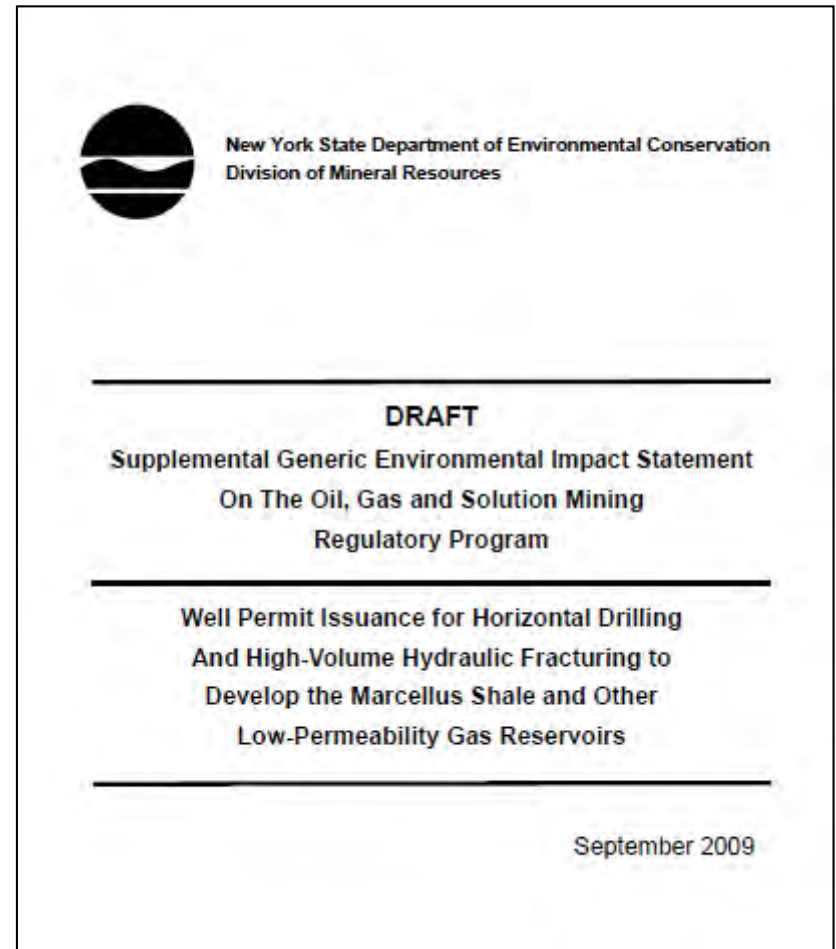
Hydraulic Fracturing (Fracking)



This protocol documents flowback pollution and visual observations in small streams.

Drilling Wastewater

- Frack water
 - Fluid that goes down the well
 - 160+ known hazardous materials
- Flowback water
 - Fluid that comes back out of the well
 - Steel and power companies can't use it because TDS levels are too high
 - Recycled
 - Inject water into ground or caverns/mines
 - Treat at authorized treatment facilities



Flowback water

Flowback water: water that returns to surface it consists of frack water plus chemicals released from underground rock formations.

- Quantity: 10-15% of frack water flows back
- Quality:
 - Brine (salty water) including high concentrations of chlorides, sulfates: very high TDS
 - Metals, e.g. barium iron, manganese, arsenic, strontium, lead, cadmium, chromium, aluminum
 - Naturally occurring radioactive materials such as uranium, radium, and radon
 - Bacteria
 - Methane
- Pathway to environment: spills, incomplete treatment, well casing leaks, migration through bedrock, illegal dumping



Volunteer Monitoring Protocol

Survey Type	Parameters	Methodology	Frequency
Chemical	<ul style="list-style-type: none"> • Conductivity and total dissolved solids • Barium and strontium 	<ul style="list-style-type: none"> • LaMotte PockeTester • Certified lab analysis 	<ul style="list-style-type: none"> • Weekly • Twice a year and to confirm contamination event
Water quantity	<ul style="list-style-type: none"> • Stage 	<ul style="list-style-type: none"> • Stream stage measurement 	<ul style="list-style-type: none"> • Weekly
Physical	<ul style="list-style-type: none"> • Gas Related Earth Disturbance • Spills and Discharges • Gas Migration or Leakage • Pipelines 	<ul style="list-style-type: none"> • Visual survey 	<ul style="list-style-type: none"> • Weekly



Why Volunteer Monitoring?

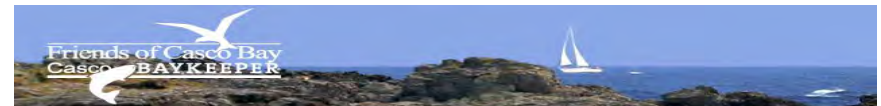


Volunteer Monitoring

- Citizens involved in data collection
- US: 1890 – 2016
- 48 states
- PA Streams: 1980s



NJ Watershed Watch Network



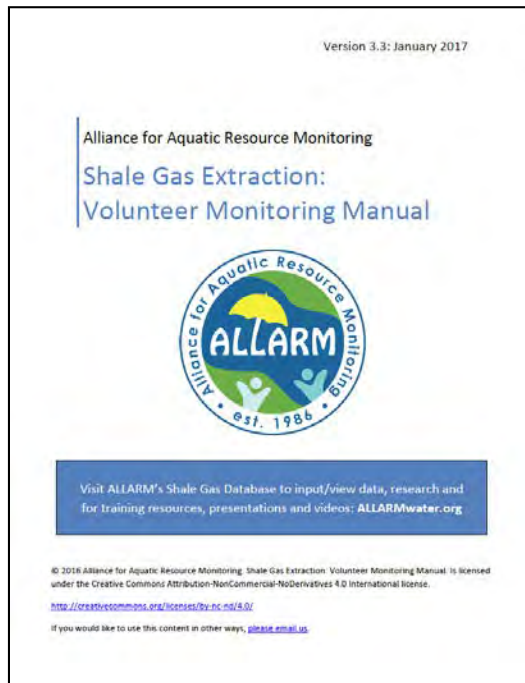
Citizen Stewards Water Quality Monitoring Program

TEXAS STREAM TEAM



Volunteer Monitoring

- Feasibility
- Affordability
- Scientifically robust



ALLARMwater.org

Red Flag Protocol: What Will You Monitor?

1. Flowback Monitoring:

Chemical Parameters

Indicator chemicals

Conductivity & TDS

Signature Chemicals

Barium

Strontium



Stage Monitoring

Relationship to
conductivity



2. Physical Impacts

Visual Observations:

- Land disturbances
- Spills and discharges
- Gas migration/leakages
- Pipelines



Conductivity and Total Dissolved Solids

- Conductivity measures the ability of water to pass an electrical current
- Total Dissolved Solids (TDS) measures the amount of ions dissolved in the water
(PA standard – 500 mg/L)



Voltage is applied between two probes to measure conductivity in microSiemens/centimeter ($\mu\text{S}/\text{cm}$)

TDS conversion
ratio factor

TDS value (mg/L)

Why Conductivity and TDS?

- Frack water mixes with natural brine, found in the shale
- Flowback water contains higher concentrations of salts and metals



Meter Trials



Dickinson students, faculty, and staff helped test conductivity/TDS meters to determine which meter is most accurate, precise, and easy to use.

Conductivity/Total Dissolved Solids Meter Testing

Thank you for participating in this meter testing session sponsored by the Alliance for Aquatic Resource Monitoring (ALLARM). Please answer the questions on page 1 about each water quality meter. Additional questions are found on page 2 – please provide as much feedback as possible!

Meter A: LaMotte Tracer Pocketster

Results	Solution A	Solution B	Solution C
Conductivity	_____	_____	_____
TDS	_____	_____	_____

Did the reading stabilize? YES NO

How difficult was it to calibrate the meter?

[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

How difficult was it to understand the directions?

[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

Meter B: Oakton Multi-Parameter PCSTestr 35

Results	Solution A	Solution B	Solution C
Conductivity	_____	_____	_____
TDS	_____	_____	_____

Did the reading stabilize? YES NO

How difficult was it to calibrate the meter?

[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

How difficult was it to understand the directions?

[1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]

1 2 3 4 5

Barium and Strontium

- Naturally-occurring metals found deep underground
- Indicate contamination from shale gas activities (signature chemicals)

Periodic Table of Elements

1	2											3	4	5	6	7	8	9	10														
1 H												3 B	4 C	5 N	6 O	7 F	8 Ne																
3 Li	4 Be											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar																
11 Na	12 Mg	III B	IV B	V B	VI B	VII B	VIII		IX	X	11 B	12 C	13 N	14 O	15 F	16 Ar																	
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr																
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe																
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	+AC	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Rf	105 Ha	106	107	108	109	110									

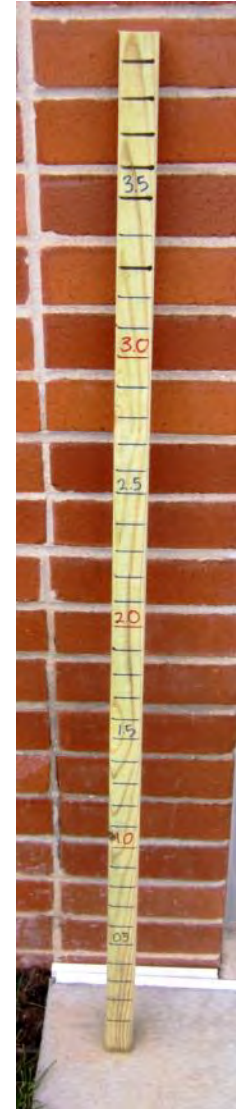
* Lanthanide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Legend - click to find out more...

H - gas	Li - solid	Br - liquid	Tc - synthetic
 Non-Metals	 Transition Metals	 Rare Earth Metals	 Halogens
 Alkali Metals	 Alkali Earth Metals	 Other Metals	 Inert Elements

https://www.msu.edu/~zeluffjo/periodic_table.gif

Stage Monitoring



Visual Observations

- Earth Disturbances
- Gas Migration/Leakages
- Spills and Discharges
- Pipelines



Marcellus Shale Well Sites in Dimock, PA; 2010

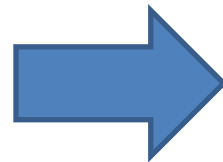
Monitoring Locations & Well Permits



Step 1:

Find where drilling permits have been issued, or identify priority streams or existing pollution issues:

- PADEP map/reports
- PADEP eNotice
- FracTracker



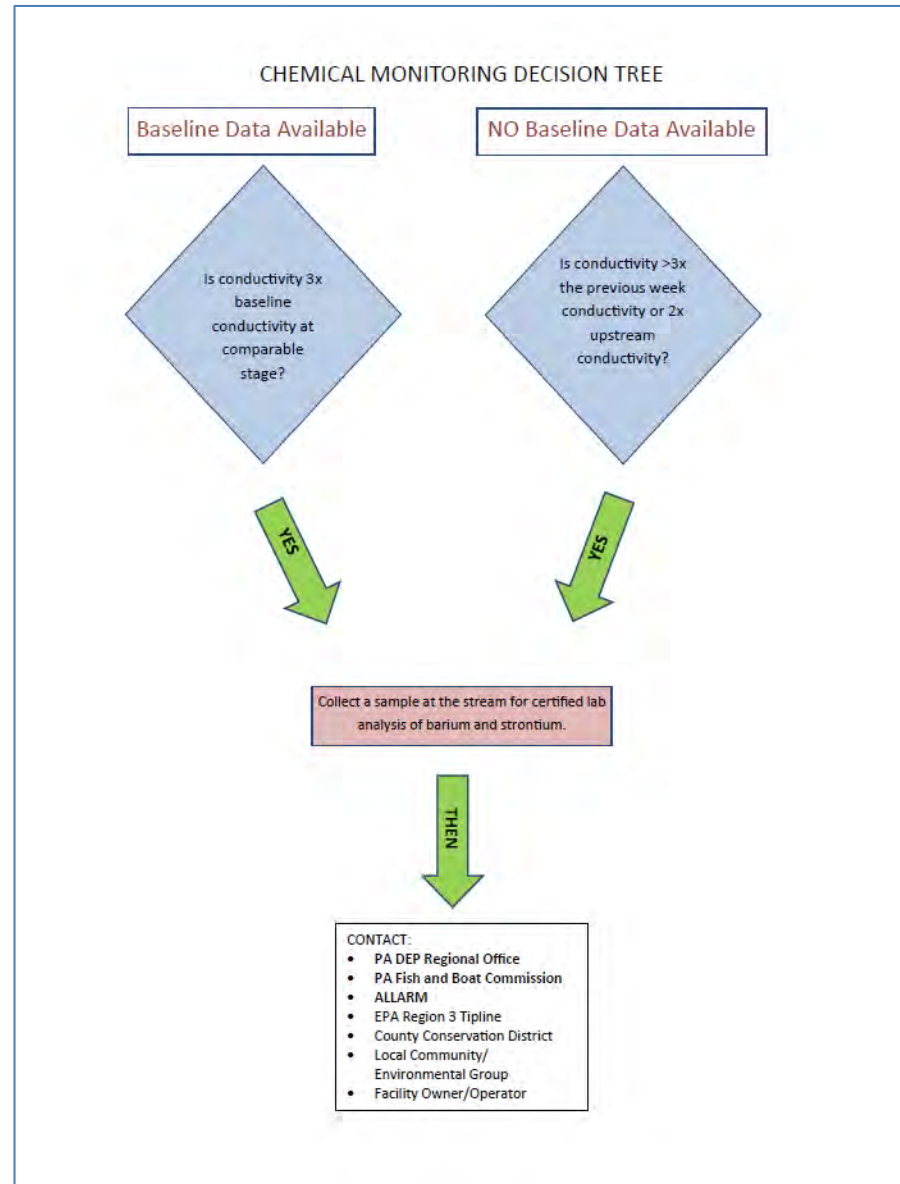
Step 2:

Find coordinates and choose monitoring site based on important features:

- Well locations
- Stream access
- Availability

Data Use: Decision Trees

Chemical Monitoring
*
Visual Observations
*
Pipelines



Report monitoring information when values exceed criteria in decision trees

Online Database and Toolkit

The screenshot displays the ALLARM website interface. At the top, there is a navigation menu with links for 'My Data', 'Local Data', 'Regional Data', 'Counties', 'Resources', 'About', and 'Contact'. A user profile section on the right shows 'Welcome Holden' and 'Logout My Profile'. The main content area is titled 'Regional Data (ALLARM)' and features a map of the Northeastern United States with several location pins. To the left of the map, there is a sidebar with 'Data' and 'Resources' sections. The 'Data' section lists: Name: ALLARM, 11 County(s), 73 Site(s), 1648 Observation(s), and 113 QA/QC reports. The 'Resources' section includes links for 'QA/QC Form', 'Field Data Sheet', 'Shale Gas Manual', 'Workshop Presentations', 'Meter Directions', and 'More Resources', along with an 'Add Observation' button. Below the map, there is a 'Sites' table with columns for Site ID, Last Observation, # Observations, Latitude/Longitude, and Options. The 'Observations' table below it has columns for Date, Site ID, Latitude/Longitude, Observer(s), and Options.

Regional Data (ALLARM)

Data

- Name: ALLARM
- 11 County(s)
- 73 Site(s)
- 1648 Observation(s)
- 113 QA/QC reports

Resources

- QA/QC Form [Add Observation](#)
- Field Data Sheet
- Shale Gas Manual
- Workshop Presentations
- Meter Directions
- More Resources

Sites

Site ID	Last Observation	# Observations	Latitude/Longitude	Options
WOLCRE 1.92	09/25/2015	4	41.920029, -76.550037	
UNTNORFORBIERUN 0.60	09/29/2012	20	40.719817, -80.492456	
PINFOR 0.09	09/04/2013	52	40.272567, -79.970032	
UNTSHERIV 1.78	09/26/2013	12	41.069167, -80.411667	
MCCRUN 1.06	12/12/2012	2	41.12012, -80.34102	
LITSEWCRE 7.84	10/19/2015	21	40.26861, -79.661694	
HAYRUN 3.54	03/25/2015	23	40.456722, -79.665433	
STERUN 2.71	09/29/2015	16	40.453647, -79.620658	

Observations

Date	Site ID	Latitude/Longitude	Observer(s)	Options
03/21/2016	UNTBURCRE 0.41	40.37272, -79.73981	CC	View Observation
12/21/2015	LITSUGCRE 6.01	41.60867, -79.79386		View Observation
12/10/2015	LITSEWCRE 2.30	40.57016, -80.18965	AC	View Observation
12/10/2015	LITSEWCRE 6.09	40.57604, -80.13816	AC	View Observation
12/10/2015	LITSEWCRE 4.54	40.57371, -80.158	AC	View Observation
12/10/2015	LITSEWCRE 0.73	40.558278, -80.200556	AC	View Observation

Building a Monitoring Constituency

- Movement - 2000 people trained since the start of 2010
- ALLARM, DRN, PACTU, PASA, MWA, Sierra Club, Waterdogs



Questions?

Alliance for Aquatic Resource Monitoring (ALLARM)

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ALLARMwater.org

Monitoring Locations & Well Permits



Identifying Monitoring Locations

We will be discussing:

- Tools for finding and tracking wells
- Considerations for monitoring sites
- Volunteer roles for the group



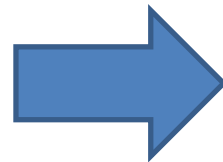
Determine Monitoring Locations



Step 1:

Find where drilling permits have been issued, or identify priority streams or existing pollution issues.

- PADEP map/reports
- PADEP eNotice
- FracTracker



Step 2:

Use reports and coordinates to choose monitoring site based on important features

- Well locations
- Stream access
- Availability

PA Oil and Gas Mapping

<http://www.depgis.state.pa.us/PaOilAndGasMapping>

Pros:

- Most current information
- Many options for searching (can search by well status, operator, permit number)

Cons:

- Somewhat clunky interface (but does have help page with definitions and guides)
- May have limited browser support

Tom Wolf, Governor Patrick McDonnell, Acting Secretary DEP Home

PA Oil and Gas Mapping

Current Tool: Identify

ESRI Streets Topo ESRI Imagery ESRI Street and Imagery PA MAP Imagery and ESRI Imagery

ESRI Streets ESRI Imagery

Tasks Legend Other Map Layers Resources

Oil & Gas Well Layers

Select at least one well designation from this list.

Unconventional Wells
 Conventional Wells

Select Both Clear Both

Well Type

Select at least one type from this list.

Gas Comb. Oil & Gas
 Oil Coalbed Methane
 Injection Dry Hole
 Test Multiple Wellbore
 Undetermined Waste Disposal
 Observation Storage Well

Select All Types Clear All Types

Well Status

Select at least one status from this list.

Active DEP Orphan
 Plugged DEP Plugged
 Abandoned DEP Abandoned
 ORND Regulatory Inactive
 PBNM

Select All Status Clear All Status

Well Selection Displayed on Map

Locate on Map

Identify Results: 5 results returned.

(1) Unconventional Oil and Gas Wells - BEAVER PAD 8 4H	
Operator	PENNERGY RESOURCES LLC
Operator No.	OGO-68305
Well Type	GAS
Storage Field Name	
Well Status	Active
Permit Date	11/5/2014
Spud Date	
Date Plugged	
Conservation Well	N

Close

90km
55mi

esri

FracTracker

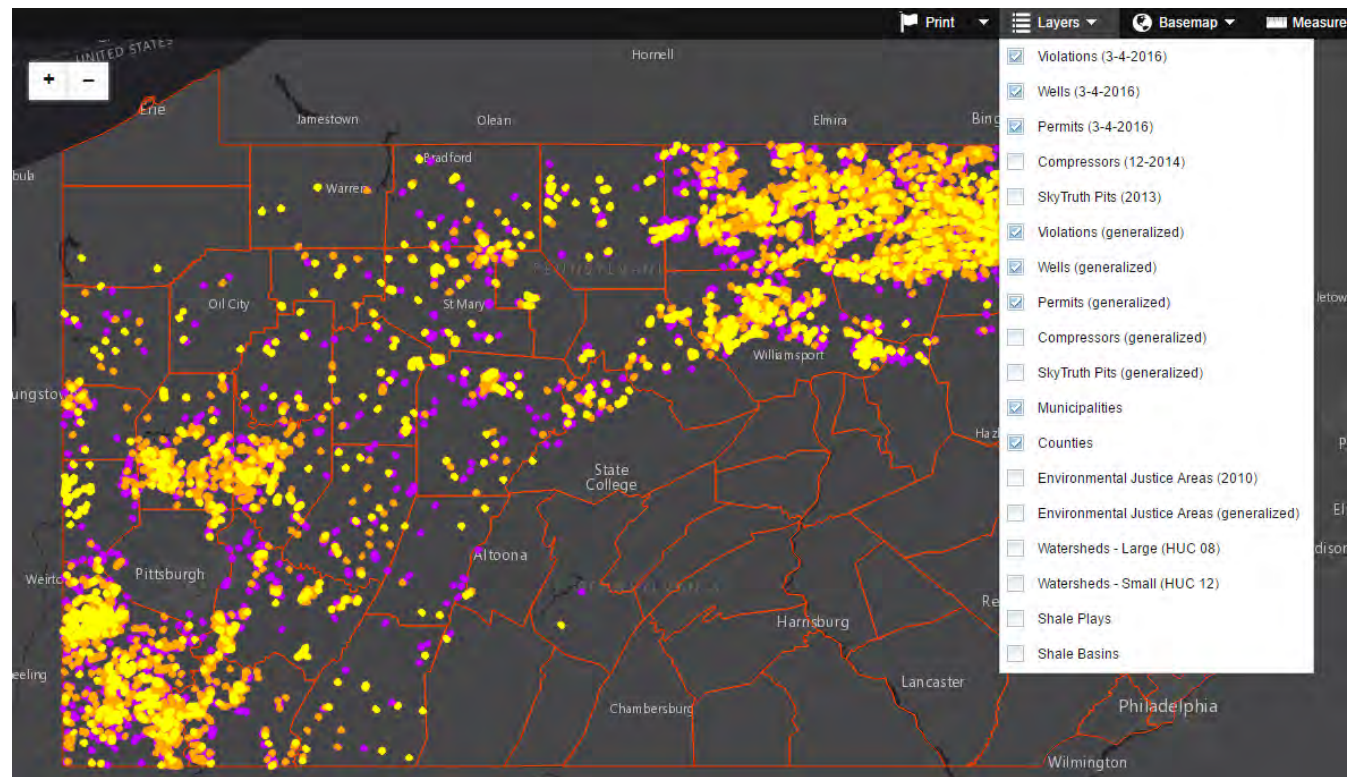
<https://www.fractracker.org/map/us/pennsylvania/pa-shale-viewer/>

Pros:

- Wider browser support
- Easier to use

Cons:

- Not always the most up-to-date information



DEP Reports

<http://www.depweb.state.pa.us>

The screenshot shows the homepage of the Pennsylvania Department of Environmental Protection (PA DEP). The background is a scenic image of a pond with lily pads and green reeds under a blue sky. At the top, a dark blue navigation bar contains the PA.GOV logo on the left and four menu items: CITIZENS, BUSINESSES, PUBLIC PARTICIPATION, and DATA AND TOOLS. Below the navigation bar is a search bar with the placeholder text "Enter Search Term Here" and a magnifying glass icon. In the lower-left corner, there is a dark grey box containing the PA DEP logo (a green leaf with a sunburst), the text "pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION", and the names "TOM WOLF, GOVERNOR | PATRICK MCDONNELL, ACTING SECRETARY". In the lower-right corner, there is a vertical list of links: "SITE MAP", "REGIONAL RESOURCES", and "REPORT AN INCIDENT". At the bottom of the page, there is a light grey bar with three social media icons: Facebook, Twitter, and YouTube.

DEP Reports

The image shows a screenshot of the Pennsylvania Department of Environmental Protection (PA.GOV) website. The top navigation bar includes the following links: CITIZENS, BUSINESSES, PUBLIC PARTICIPATION, and DATA AND TOOLS. The 'DATA AND TOOLS' menu is expanded, showing a list of options: GIS, **REPORTS** (circled in red), TOOLS, WEBINARS, DEP GREEN PORT, and ELIBRARY. A search bar with the placeholder text 'Enter Search Term Here' is visible. The main content area features the Pennsylvania Department of Environmental Protection logo, the text 'pennsylvania DEPARTMENT OF ENVIRONMENTAL PROTECTION', and the names 'TOM WOLF, GOVERNOR | PATRICK MCDONNELL, ACTING SECRETARY'. Below this, there are social media icons for Facebook, Twitter, and YouTube. The background of the website features a tablet displaying a bar chart and a pie chart, with other charts visible in the background.

DEP Reports

DEP > Data and Tools > Reports

REPORTS

In an effort to maximize transparency and improve efficiency, DEP provides easy access to dozens of online reports and key data about the many programs the agency administers.

RELATED INFORMATION

OIL AND GAS REPORTS

LAND RECYCLING REPORTS

RADIATION PROTECTION REPORTS

STORAGE TANK REPORTS

DEP Reports

[Oil and Gas Mapping](#)

INTERACTIVE REPORTS

[Interactive Reports Data Dictionary](#)

[Permits Issued Detail Report](#)

[Monthly – Permits Issued by County and Well Type Report](#)

[Year to Date – Permits Issued by County and Well Type Report](#)

[Oil and Gas Operator Well Inventory](#)

[Oil and Gas Compliance Report](#)

[SPUD Data Report](#)

[Wells Drilled By County](#)

[Wells Drilled By Operator](#)

[Oil and Gas Production Reports](#)

[Oil and Gas Well Production Status](#)

[Oil and Gas Electronic Notifications](#)

[DEP Orphan and Abandoned Wells](#)

[PUBLIC RESOURCES](#)

[OIL AND GAS FAQ](#)

[CONSERVATION LAW](#)

[CONTACTS AND DIRECTIONS](#)

[OIL AND GAS ELECTRONIC
SUBMISSION GUIDES](#)

[OIL AND GAS PRODUCTION
REPORTS](#)

[CONVENTIONAL OIL AND GAS
ADVISORY COMMITTEE](#)

[MARCELLUS SHALE ADVISORY](#)

[OIL AND GAS TECHNICAL ADVISORY
BOARD](#)

[ANNUAL REPORT](#)

[ABANDONED AND ORPHAN WELL
PROGRAM](#)

[LAWS, REGULATIONS AND
GUIDELINES](#)

DEP Reports


PERMIT ISSUED START DATE (MM/DD/YYYY) PERMIT ISSUED END DATE (MM/DD/YYYY) [View Report](#)

COUNTY MUNICIPALITY

REGION OPERATOR

UNCONVENTIONAL ONLY WELL TYPE

1 of 5 Find | Next

 **DEP OFFICE OF OIL AND GAS PERMITS ISSUED**
6/8/2016 10:22:54

County: 26 - Fayette; Municipality: All; Region: All; Operator: All; Unconventional Only: Yes; Well Type: GAS

125 Issued Permits from 1/1/2013 to 6/8/2016

REGION	COUNTY	MUNICIPALITY	PERMIT ISSUED DATE	OPERATOR	APPLICATION TYPE	AUTHORIZATION TYPE	API / PERMIT	UNCONVENTIONAL	CONFIGURATION	WELL TYPE	FARM NA
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24602	Yes	Horizontal Well	GAS	MARTIN UP NORTH 1H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24603	Yes	Horizontal Well	GAS	MARTIN UP NORTH 2H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24605	Yes	Horizontal Well	GAS	MARTIN UP NORTH 3H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	1/23/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24606	Yes	Horizontal Well	GAS	MARTIN UP NORTH 4H
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	8/22/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit Drill Deeper	051-24520	Yes	Horizontal Well	GAS	ROSA UNIT
EP DOGO SWDO Dstr Off	Fayette	Franklin Twp	8/22/2014	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit Drill Deeper	051-24524	Yes	Horizontal Well	GAS	ROSA UNIT
EP DOGO SWDO Dstr Off	Fayette	German Twp	1/20/2015	CHEVRON APPALACHIA LLC	NEW	Drill & Operate Well Permit	051-24617	Yes	Horizontal Well	GAS	ZALAC UNI
EP DOGO	Fayette	German Twp	3/19/2015	CHEVRON	NEW	Drill &	051-24622	Yes	Horizontal Well	GAS	ZALAC UNI

DEP Reports

Contains information about oil & gas wells:

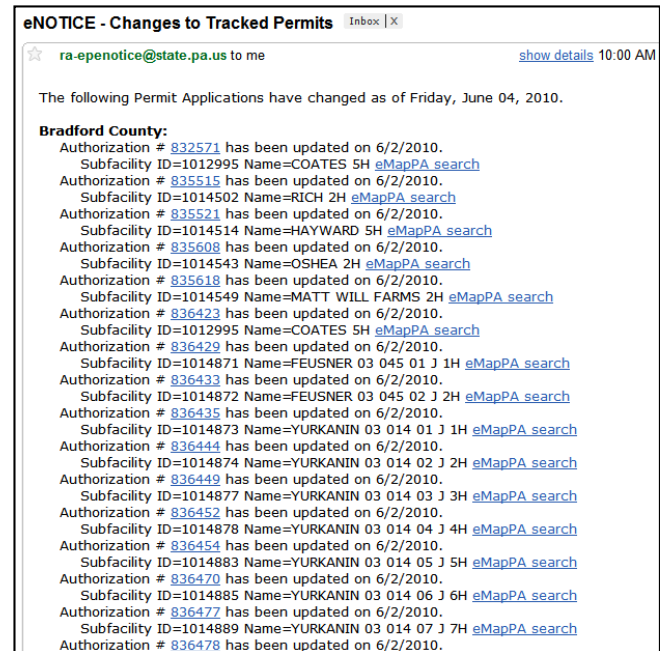
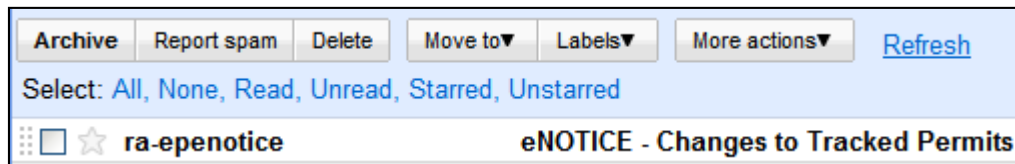
- Permits issued (by operator and county, updated weekly)
- Active well inventory (by county)
- Spud reports/date drilling begins (updated weekly)

DEP's Active Well Inventory: All of the active oil & gas wells in Washington County

COUNTY	MUNICIPALITY	PERMIT ISSUED DATE	OPERATOR	APPLICATION TYPE	WELL API	UNCONVENTINONAL	HORIZONTAL WELL	WELL TYPE	LATITUDE DECIMAL	LONGITUDE DECIMAL
Washington	Buffalo Twp	6/27/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24793-00-00	Yes	Yes	GAS	40.169305	-80.350775
Washington	Hanover Twp	6/13/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24787-00-00	Yes	Yes	GAS	40.421611	-80.511644
Washington	Hanover Twp	6/13/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24788-00-00	Yes	Yes	GAS	40.42163	-80.511538
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24692-00-00	Yes	Yes	GAS	40.226336	-80.445855
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24692-00-01	Yes	Yes	GAS	40.226336	-80.445855
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24693-00-00	Yes	Yes	GAS	40.226369	-80.445952
Washington	Independence Twp	6/26/2012	RANGE RESOURCES APPALACHIA LLC	NEW	125-24693-00-01	Yes	Yes	GAS	40.226369	-80.445952

eNOTICE

- DEP's Electronic Notification system
- Receive information and track changes to oil & gas permits
- <http://www.ahs2.dep.state.pa.us/eNOTICEWeb/>



Group Roles – Checking Permits

- It may be effective to designate one person to check for new permits in the area
 - Can be someone who is already checking permits, or someone interested in permitting information, and report information to the group



Safety Considerations



http://farm3.static.flickr.com/2405/1516087369_fb0226bc11.jpg

General advice

Develop language as a group that describes what you are doing...

“Monitoring stream health” vs. “Tracking down fracking polluters”



<http://www.alicia-logic.com/email/Close%20Encounter%20with%20a%20Pit%20bull.jpg>

Property Access

- Public land, such as State Game Lands or state forests, are open to the public
 - Access rights are not a concern
 - However, you are not allowed on active drilling sites due to safety concerns (industrial site)
- For private properties, always ask the landowner's permission



<http://unitednuclear.com/images/sign3.jpg>

Personal Safety

- Do *not* make contact with water or soil that could be contaminated unless you have protective clothing
 - Wading boots
 - Latex gloves
- Do not put yourself into a situation that may be dangerous.



Personal Safety

- When out in the field, bring a cell phone and *leave it on*
- Steer clear of confrontation. Leave the area if someone confronts or threatens you.



http://www.jaimesmcneal.com/Jaimes_McNeal/Blog/Entries/2009/12/21_Conflict,_it%E2%80%99s_not_just_for_breakfast_anymore!_files/shapeimage_2.png

Physical Parameters



Protocol developed alongside:

- Bradford County Conservation District
- Mountain Watershed Association
- PA Trout Unlimited
- Pine Creek Waterdogs
- EarthJustice



Visual Observations

- Document physical status of the stream
- Identify potential impacts/pollution events
- Report violations and/or suspicious activity



Recording Observations: Data Sheet



VOLUNTEER MONITORING FOR SHALE GAS IMPACTS Visual Observation Checklist

Be sure to enter all data at ALLARMwater.org

Site Information		Sample Information	
Monitor's Name		Assessment Date	
Site Location		Assessment Time	

Record latitude and longitude or Site ID/ location description

Earth Disturbances:

Stream:	Yes	No	Pipeline	Photo
Sediment enters stream, pond, or other water body				
Access Road:	Yes	No	Pipeline	Photo
Banks are not stabilized (no mulch, seeding, vegetation, etc.)				
Crosses stream and drainage from road empties into stream				
Not stabilized with clean substrate material (i.e. gravel)				
Drainage/mud/sediment from access road enters road ditch				
Drainage/mud/sediment from access road travels to main road				
Drill Pad, Storage Pond & Staging Area:	Yes	No	Pipeline	Photo
Earth disturbed at edge of water; no controls to stop/filter runoff				
Clean water enters the site from uphill with no diversion ditch				
Sediment BMP outlets empty into water body without filtering runoff				
Sediment BMP outlets are not stabilized (no mulch, seeding, vegetation, etc.)				

Take photograph (date and time stamp) and record on the data sheet

Spills and Discharges:

Stream:	Yes	No	Pipeline	Photo
Unusual odor				
Discolored water (i.e. oily film)				
Persistent foam/bubbles (where there isn't normal agitation)				
Dead fish/organisms				
Evidence of illegal dumping				

Gas Migration and Leakages:

Stream:	Yes	No	Pipeline	Photo
Gas bubbling to surface				
Unusual gas-like odor (mercaptan)				

Description of Observation(s):

Record thorough description of the observation

Recording Observations: Field Data Log

Record Site ID or latitude and longitude

Record multiple times or locations

Record visual observation description and outcomes

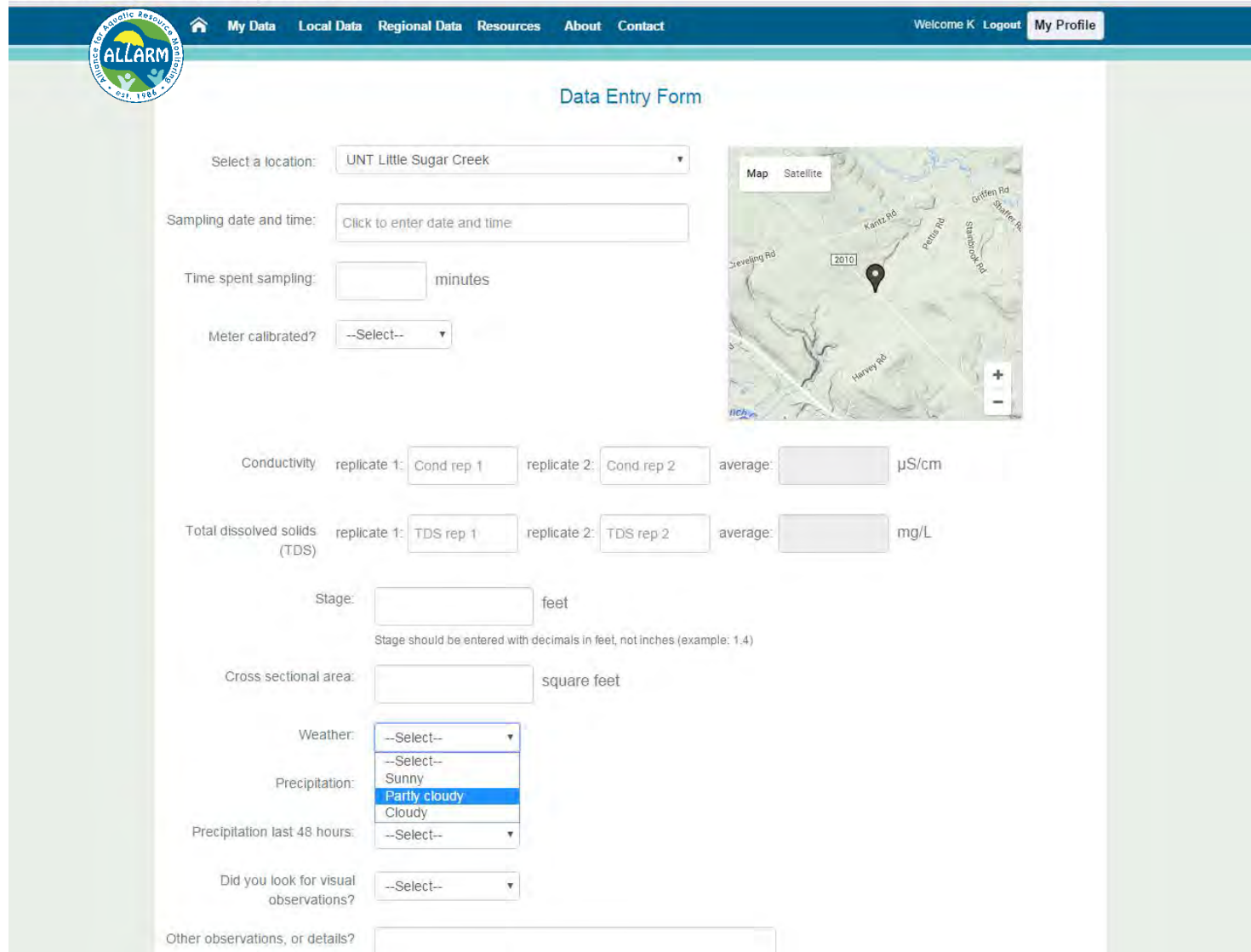
ALLARM Volunteer Monitor Field Log

Site ID or Stream Name: _____ Latitude (if no Site ID): _____
 Location Description: _____ Longitude (if no Site ID): _____ Monitor's Name: _____

Chemical and Stage Results										
Date (MM/DD/YY)	Time when you monitored	Conductivity (μS/cm) replicate 1	Conductivity (μS/cm) replicate 2	Average Conductivity	TDS (mg/L) replicate 1	TDS (mg/L) replicate 2	Average TDS	Stage (ft)	Calibrate (Yes/No)	Time spent monitoring (minutes)
A										
B										
C										
D										
E										
F										
Weather and Precipitation Observations			Visual Observations Results							
Weather (sunny, partly cloudy, or cloudy)	Precipitation (none, light rain, heavy rain, or snow)	Precipitation Last 48 Hours (none, light, or heavy)	Notable or reportable observations (refer to visual observation checklist)?	Violation Reported (Yes/No)	Violation Reported To:		Picture Taken? (Yes/No)	Pipeline Disturbance (Yes/No)		
A										
B										
C										
D										
E										
F										

Recording Observations: ALLARMwater.org

8/websites/allarm/DataEntryForm.php?LocationPicklist=1



ALLARM
Alluvial Resource Monitoring
est. 1986

Home My Data Local Data Regional Data Resources About Contact

Welcome K Logout My Profile

Data Entry Form

Select a location: UNT Little Sugar Creek

Sampling date and time: Click to enter date and time

Time spent sampling: minutes

Meter calibrated? --Select--

Conductivity replicate 1: Cond rep 1 replicate 2: Cond rep 2 average: $\mu\text{S/cm}$

Total dissolved solids (TDS) replicate 1: TDS rep 1 replicate 2: TDS rep 2 average: mg/L

Stage: feet
Stage should be entered with decimals in feet, not inches (example: 1.4)

Cross sectional area: square feet

Weather: --Select--
--Select--
Sunny
Partly cloudy
Cloudy

Precipitation: Partly cloudy

Precipitation last 48 hours: --Select--

Did you look for visual observations? --Select--

Other observations, or details?

Visual Observation Categories

- Earth Disturbances
- Spills and Discharges
- Gas Migration/Leakages
- Pipelines



<http://www.swarthmore.edu/x29615.xml>

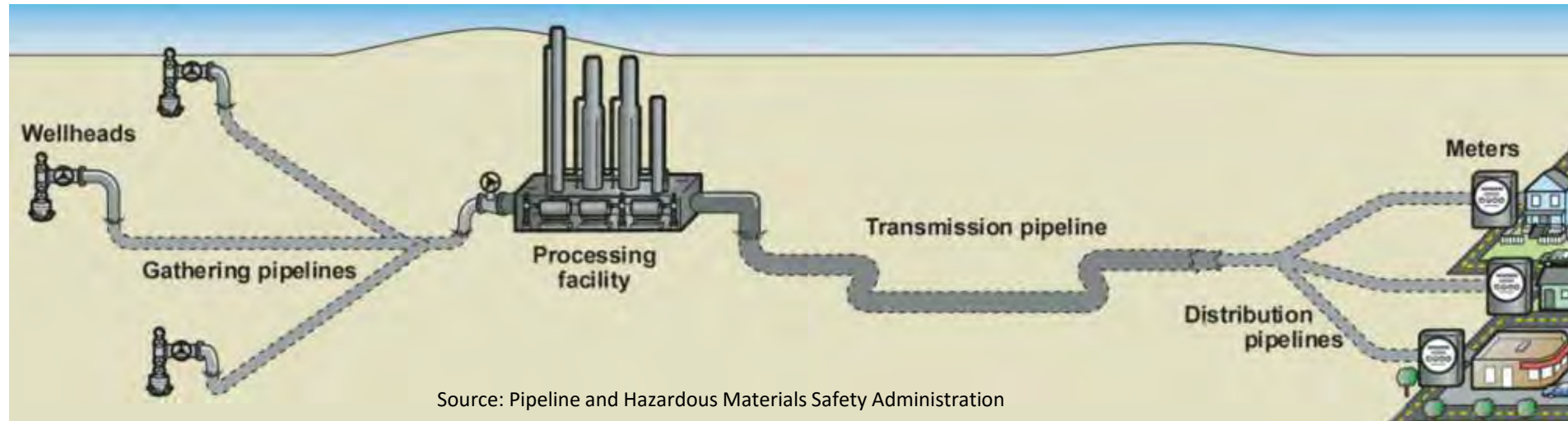
Marcellus Shale Well Sites in Dimock, PA; 2010

Pipelines

ALLARM

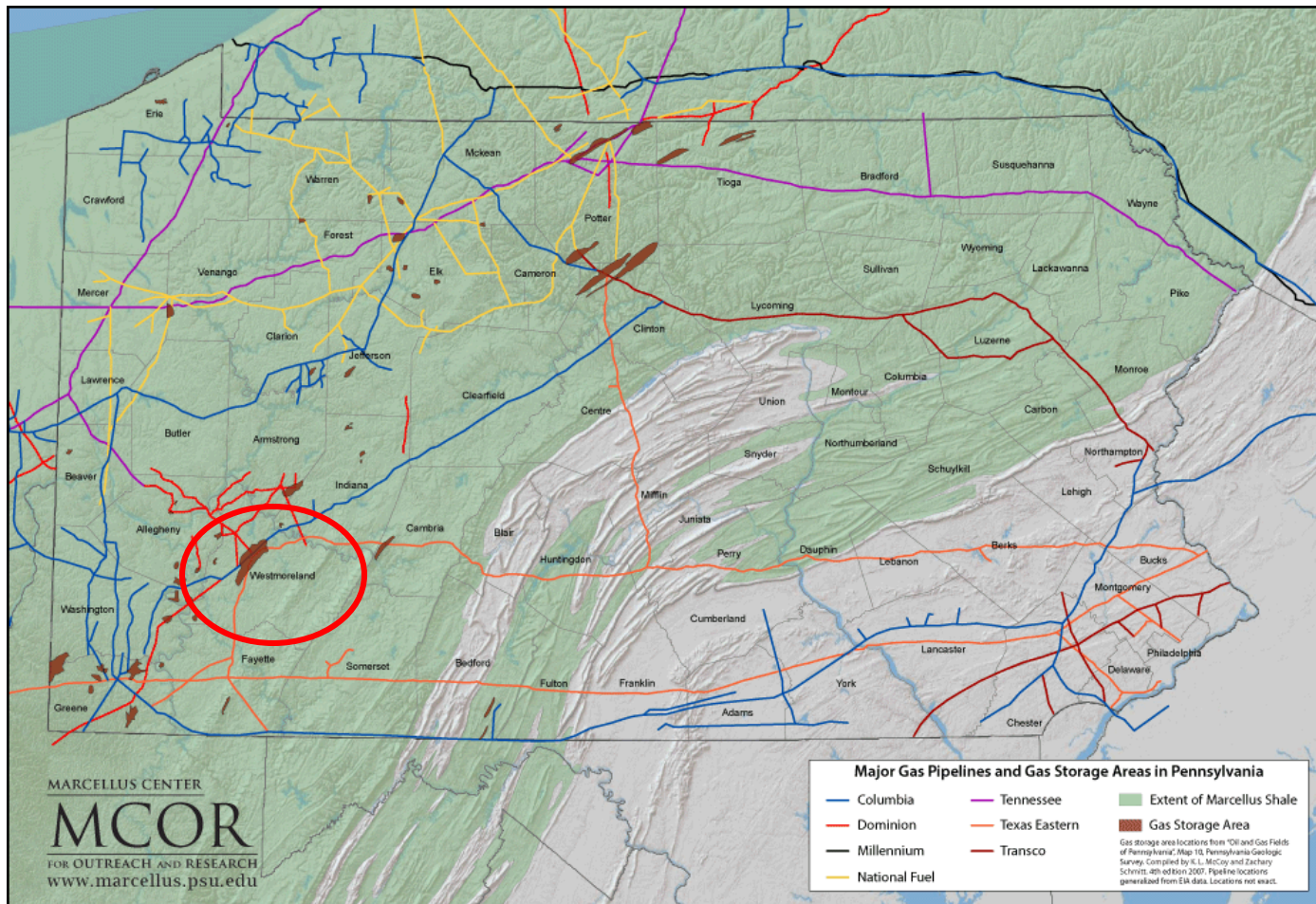


Types of Pipelines



- **Gathering Lines:** Small lines from wells.
- **Transmission Lines:** Larger lines that transport gas long distances, compressor stations every 40-60 mi to keep gas at a high enough pressure for travel.
- **Distribution Lines:** Small lines going into homes, businesses etc.

Major Pipelines



Environmental Concerns

- Erosion and sedimentation (largest concern, most common violation)
- Loss of riparian zones – vegetated buffer along the stream
- Stream geomorphology impacts (changes in stream shape)
- Habitat fragmentation
- Methane leakages

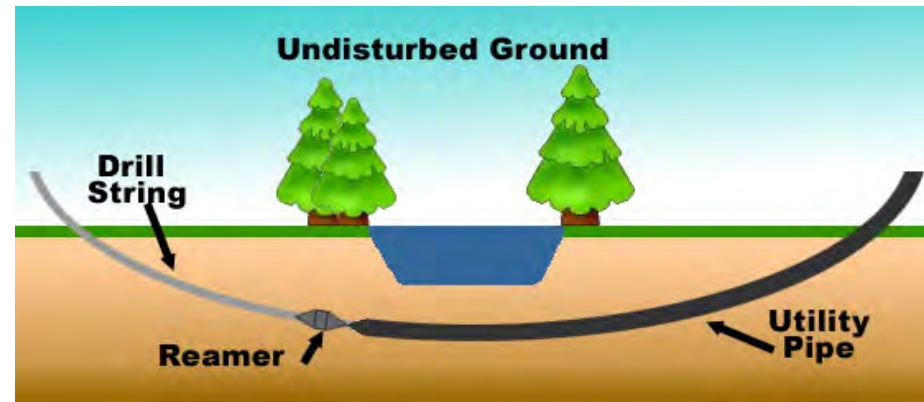


Stream Crossings

Through the stream

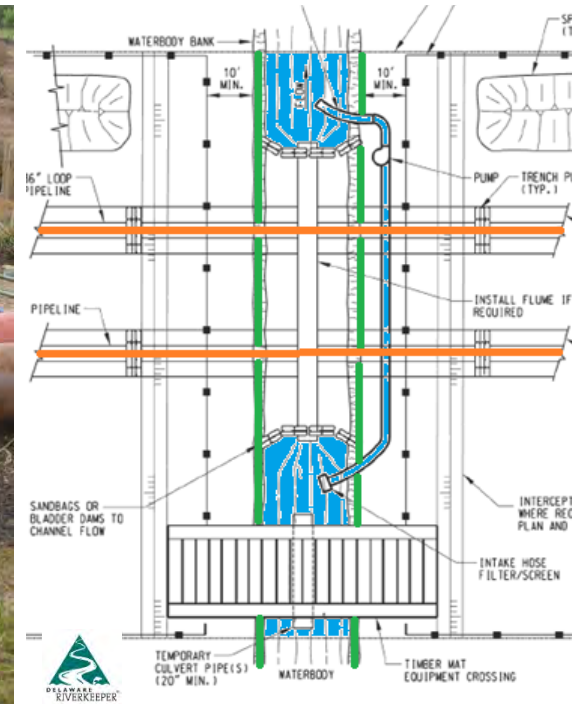


Under the stream



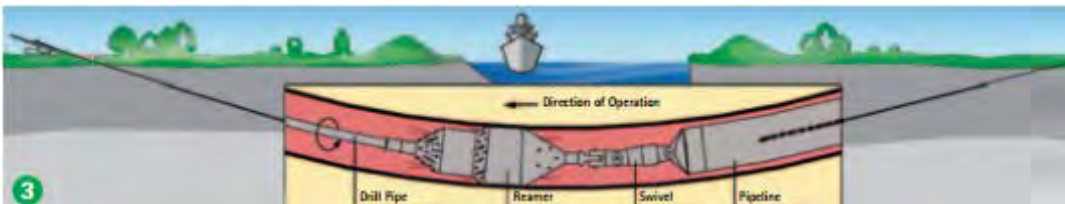
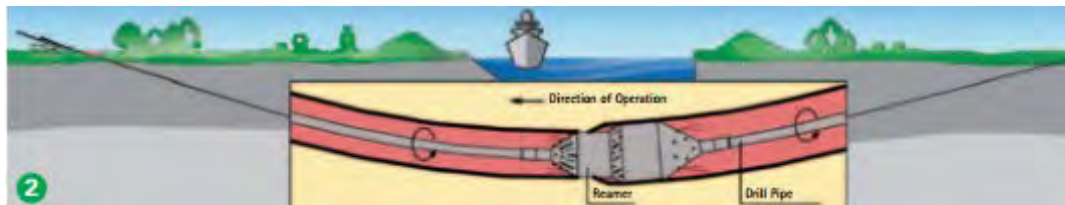
Through the Stream

- Open-cut
- Flumed or Partial Diversion
- Dam & Pump method



Under the Stream

Horizontal Directional Drilling



(Direct Industry, 2014)

(Nacap, 2014)



Earth Disturbances



<http://www.postcarbon.org/reports/shale-gas-well.jpg>

Earth Disturbances

- Sediment entering streams as a result of any earth disturbance



- Sediment on/from access roads, well pads.



What do you notice?



Access Roads



Photo courtesy of PA Council of Trout Unlimited



Photo courtesy of PA Council of Trout Unlimited

What do you notice with these access roads?

Main Roads



What's the issue here? Is this reportable?

Best Management Practices for E&S

Silt fence



Silt Sock



Diversion Ditch



Monitoring erosion and sedimentation best management practices (E&S BMPs): need to confirm that they are installed correctly and maintained properly.

Sediment from Earth Disturbances



Photo courtesy of PA Council of Trout Unlimited



Photo courtesy of PA Council of Trout Unlimited

Is there a problem with these best management practices?

E&S Best Management Practices

Is there anything wrong with this?



PA: Publicly available information



- E&S plans are on site & are available to the public.

Pipeline Erosion & Sedimentation

ALLARM



ALLARM



Tioga County, PA - Mudslides



Spills and Discharges



http://www.theintelligencer.net/photos/news/md/587542_1.jpg

Spills and Discharges

Unusual odor, color, foam
and/or bubbles



Dead fish and/or other
organisms



Spills and Discharges

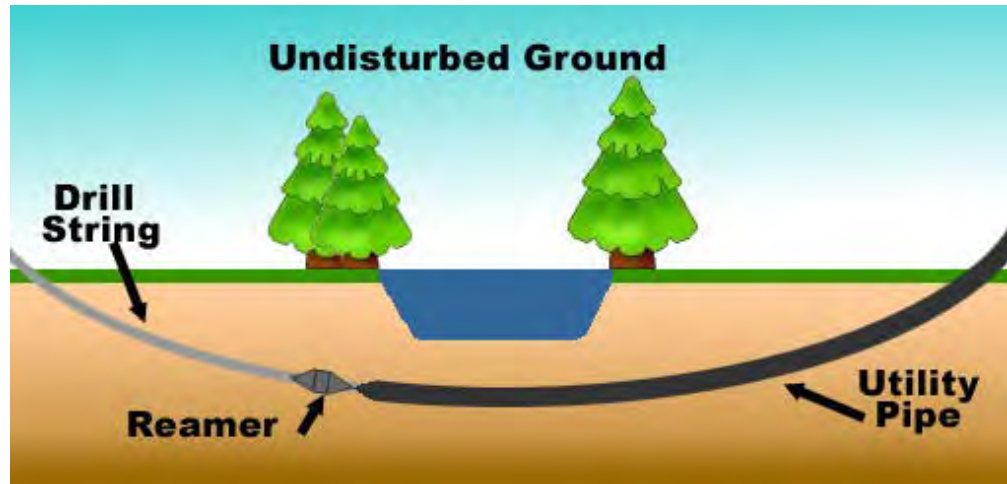


Drilling fluid spill at Cabot site
Dimock, PA
September 2009



Pipeline Spills and Discharges

Bentonite Blowouts



Illegal Dumping into Streams

- No pump running
- Bubbling at end of hose
- Unusual odors
- Discoloration of water near hose

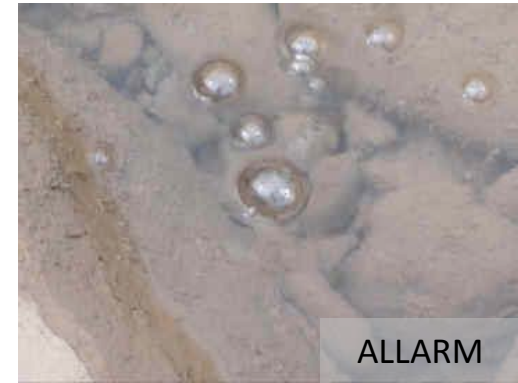


Illegal Dumping



Which is illegal dumping?

Gas Migration or Leakages



What do you see?



Data Management: Record Results

Site ID or Stream Name:		Latitude (if no Site ID):		ALLARM Volunteer Monitor Field Log						
Location Description:		Longitude (if no Site ID):		Monitor's Name:						
Chemical and Stage Results										
Date (MM/DD/YY)	Time (when you monitored)	Conductivity (µS/cm) replicate 1	Conductivity (µS/cm) replicate 2	Average Conductivity	TDS (mg/L) replicate 1	TDS (mg/L) replicate 2	Average TDS	Stage (ft)	Calibrate (Yes/No)	Time spent monitoring (minutes)
A										
B										
C										
D										
E										
F										
Weather and Precipitation Observations			Visual Observations Results							
Weather (sunny, partly cloudy, or cloudy)	Precipitation (none, light rain, heavy rain, or snow)	Precipitation Last 48 Hours (none, light, or heavy)	Notable or reportable observations (prefer to visual observation checklist)?	Violation Reported (Yes/No)	Violation Reported To:	Picture Taken? (Yes/No)	Pipeline Disturbance (Yes/No)			
A										
B										
C										
D										
E										
F										



My Data Local Data Regional Data Counties Resources About Contact Welcome Holden Logout My Profile

Volunteer monitors are collecting baseline stream data and testing for potential impacts from shale gas extraction

View Data Get Involved Contact Us

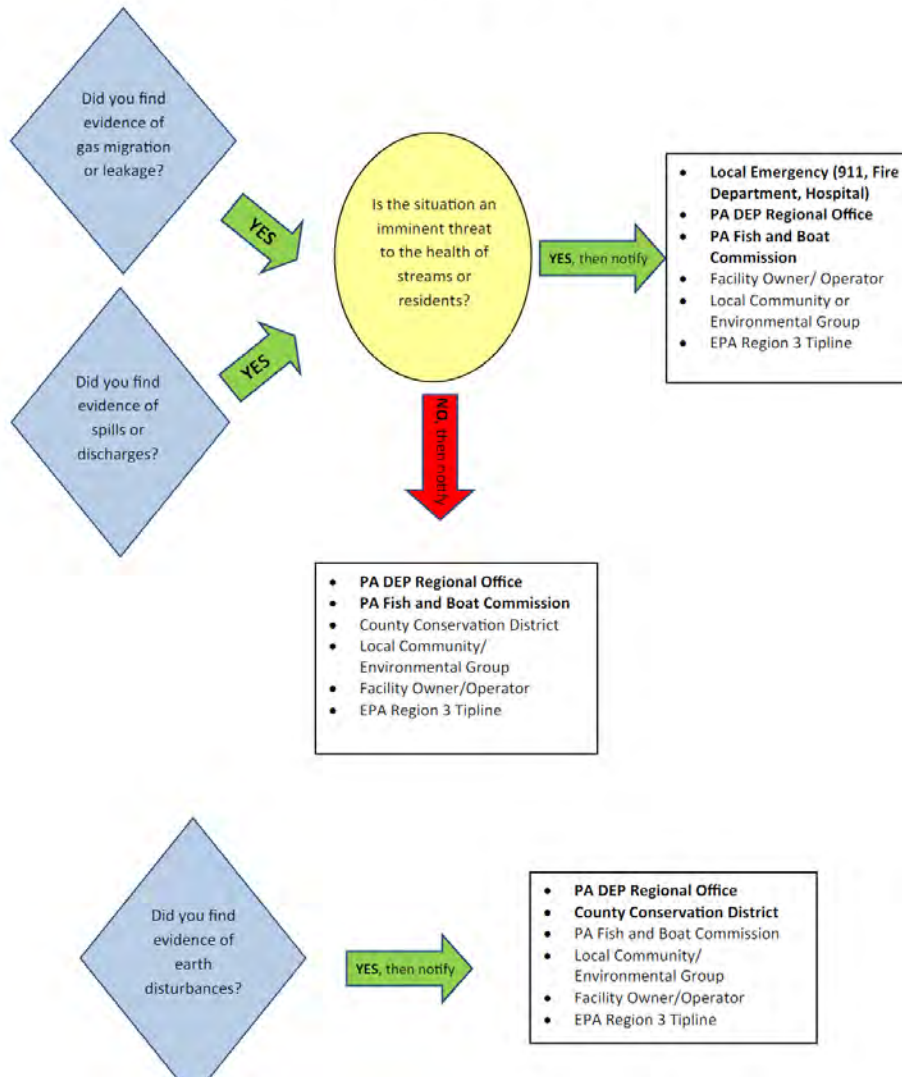


VOLUNTEER MONITORING FOR SHALE GAS IMPACTS Chemical and Stage Monitoring Data Sheet											
Be sure to enter all data at ALLARMwater.org											
1. Record your site and sample information in the boxes below:											
Site Information		Sample Information									
Stream Name		Monitor's Name									
Site Location		Collection Date									
Latitude Coordinate		Collection Time									
Longitude Coordinate		County Monitored									
2. Check the description that best matches your observation:											
Weather	Precipitation	Precipitation Last 48 Hours									
Sunny	Light rain		None								
Partly Cloudy	Heavy rain		Light								
Cloudy	Snow		Heavy								
3. Record your results in the boxes below:											
Parameters	Units	Replicate #1	Replicate #2	Average Result							
Conductivity	µS/cm										
Total Dissolved Solids	mg/L										
Stage	feet										
Inches to feet conversion:											
Inches	1	2	3	4	5	6	7	8	9	10	11
Feet	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92
4. Did you calibrate your meter the day you monitored?				Yes	No						
5. How much time did you spend monitoring? _____ hours											
Alliance for Aquatic Resource Monitoring (ALLARM) June 2016											

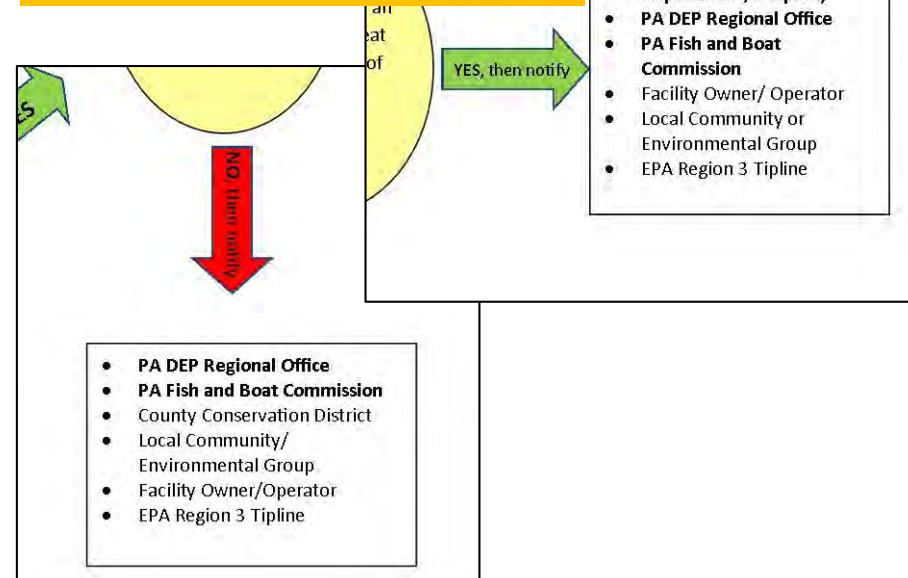
ALLARMwater.org

Reporting Observations

VISUAL OBSERVATIONS DECISION TREE

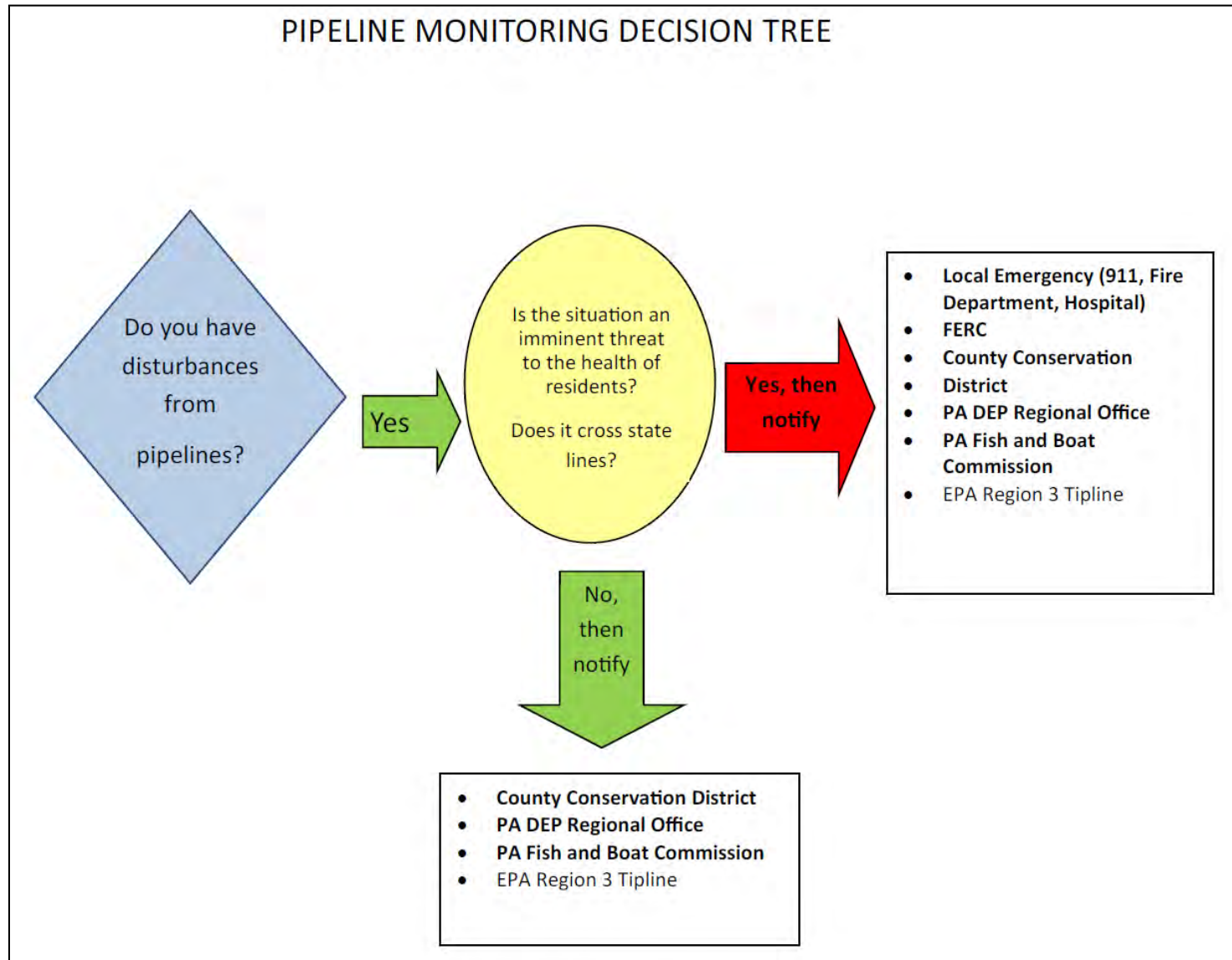


PA reporting decision tree:



It is important to communicate with your local agencies – “hey, we’re here and we’re monitoring.”

Pipeline Decision Tree



Chemical Parameters



Alliance for Aquatic Resource Monitoring

Objectives

- Learn about water quality parameters.
- Build basic skills for monitoring.
- Learn about quality assurance/quality control.



Indicators

Water Quality:

- Conductivity
- Total Dissolved Solids (TDS)

Water Quantity:

- Stage (water depth)



Meter Trials



Dickinson students, faculty, and staff helped test conductivity/TDS meters to determine which meter is most accurate, precise, and easy to use.

Conductivity/Total Dissolved Solids Meter Testing

Thank you for participating in this meter testing session sponsored by the Alliance for Aquatic Resource Monitoring (ALLARM). Please answer the questions on page 1 about each water quality meter. Additional questions are found on page 2 – please provide as much feedback as possible!

Meter A: LaMotte Tracer PockeTester

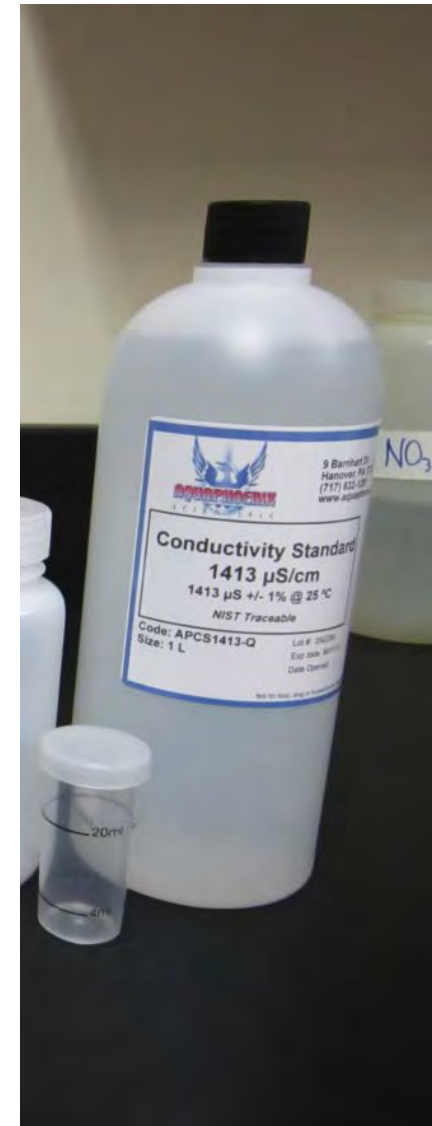
Results	Solution A	Solution B	Solution C		
Conductivity	_____	_____	_____		
TDS	_____	_____	_____		
Did the reading stabilize?	YES	NO			
How difficult was it to calibrate the meter? [1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]					
	1	2	3	4	5
How difficult was it to understand the directions? [1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]					
	1	2	3	4	5

Meter B: Oakton Multi-Parameter PCSTestr 35

Results	Solution A	Solution B	Solution C		
Conductivity	_____	_____	_____		
TDS	_____	_____	_____		
Did the reading stabilize?	YES	NO			
How difficult was it to calibrate the meter? [1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]					
	1	2	3	4	5
How difficult was it to understand the directions? [1 = very difficult; 2 = difficult; 3 = medium 4 = easy; 5 = very easy]					
	1	2	3	4	5

Calibration

- Calibrate every day you monitor
- Dispose of calibration fluid after use



Conductivity ($\mu\text{S}/\text{cm}$)

- Conductivity measures the ability of water to carry an electrical current/presence of ions:
 - Inorganic compounds = good conductors
 - Example: dissolved salts and heavy metals
 - Organic compounds = poor conductors
 - Example: pesticides
- Conductivity is measured with a meter. Voltage is applied between two electrodes in a probe immersed in water.



	<u>Ranges</u>
Distilled Water:	0.5 – 3 $\mu\text{S}/\text{cm}$
US Streams:	15 – 500 $\mu\text{S}/\text{cm}$
US Rivers:	50 – 1500 $\mu\text{S}/\text{cm}$
Industrial Waters:	up to 10,000 $\mu\text{S}/\text{cm}$

Total Dissolved Solids (mg/L)

- TDS measures the amount of ions in the water.
 - Example: dissolved salts, nutrients, heavy metals
- Meters first measure conductivity and calculate TDS using an equation.
- TDS can be measured directly using the gravimetric method (actual weight).



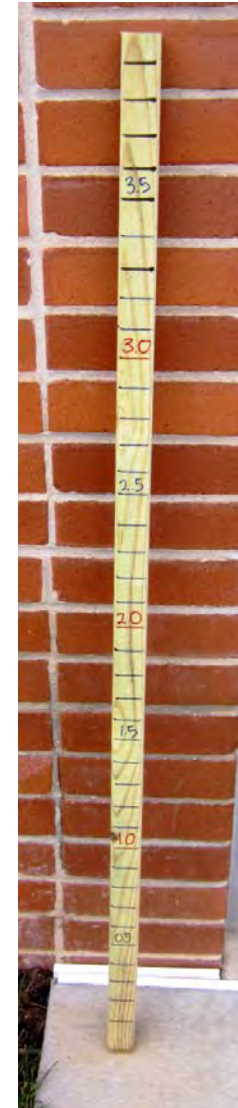
	<u>Ranges</u>
Fresh Water:	< 1,500 mg/L
Brackish Water:	1,500 – 5,000 mg/L
Saline Water:	> 5,000 mg/L

Why Conductivity and TDS?

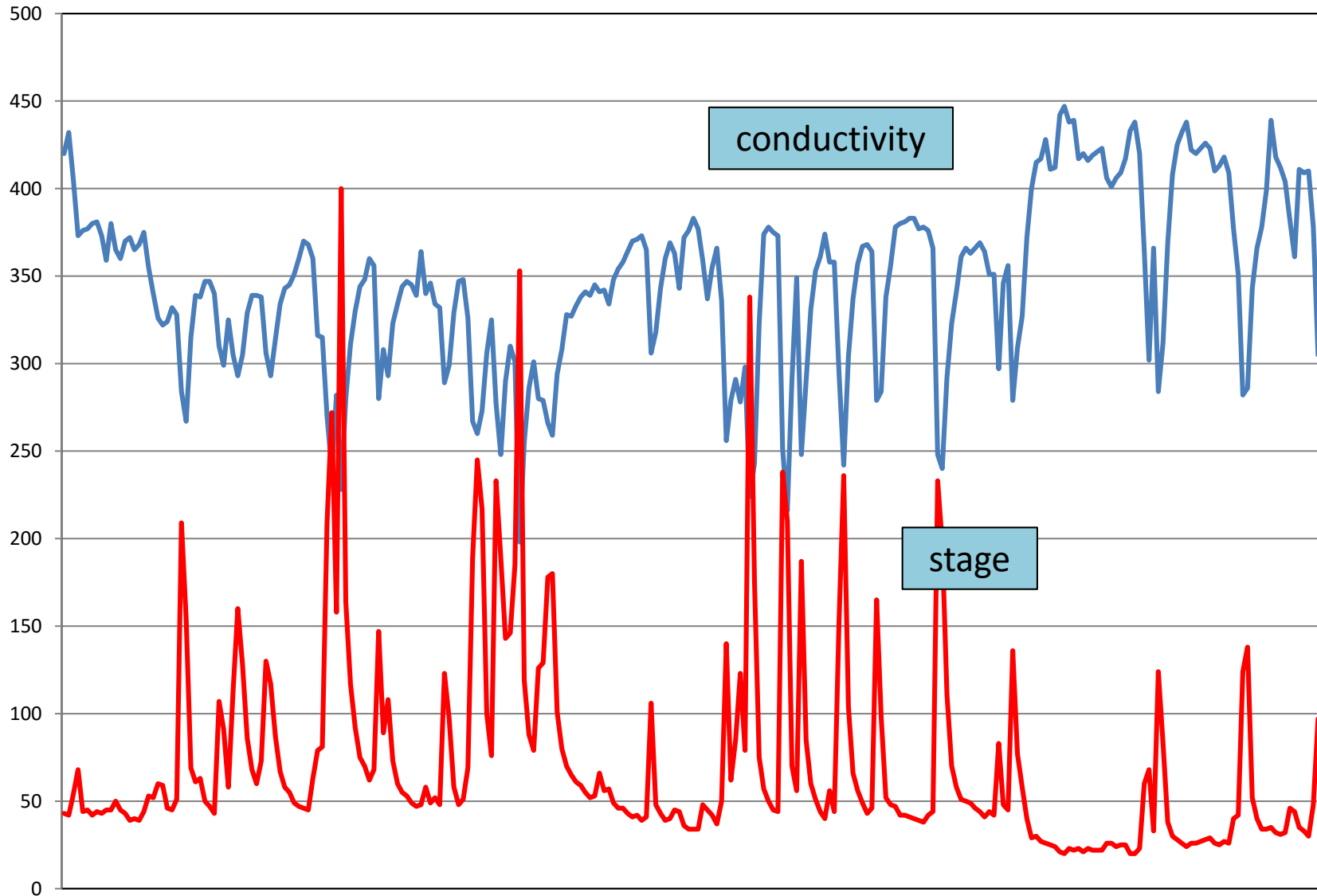
- Frack water mixes with natural brine, found in the shale
- Flowback water contains high concentrations of salts and metals



Stage Monitoring (ft)



Conductivity and Stage Relationship



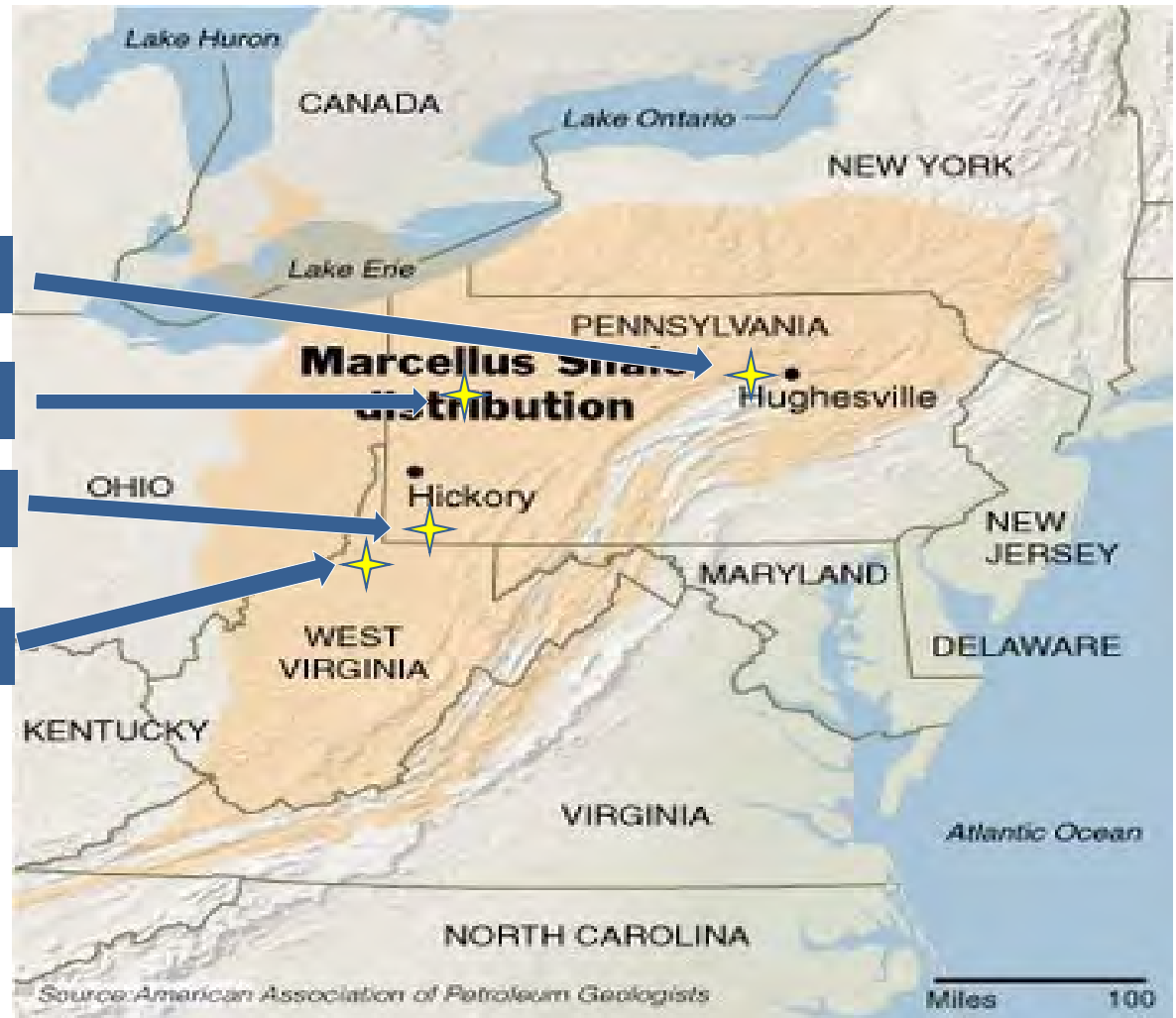
Flowback Water Concentrations

TDS: 70,000 mg/L

TDS: 211,000 mg/L

TDS: 132,000 mg/L

TDS: 217,000 mg/L



Source: Amy Bergdale, USEPA

Reportable Event

A conductivity level 3x or higher than a measurement at a comparable stage.

Date	Stage	Conductivity
2/6/2016	1.7	119.3
2/15/2016	1.7	132.3
3/7/2016	0.8	361
3/13/2016	1.7	670

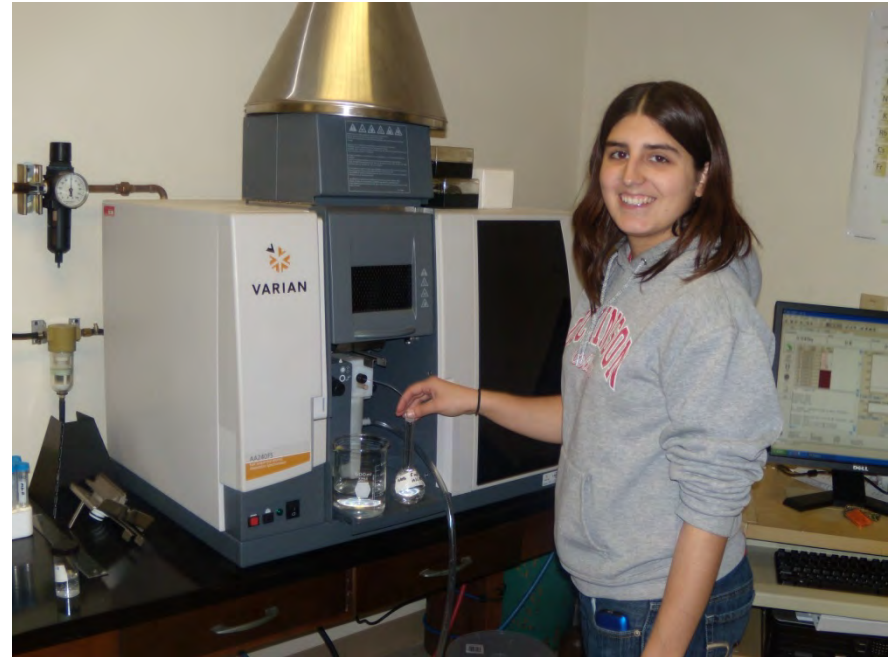
Reporting Events

Reportable Event Steps:

1. Re-calibrate meter and re-test your water.
2. Collect a sample for barium & strontium analysis (to send to a local, certified lab).
3. Contact your local group leaders.
4. Contact enforcement agencies.
5. Contact ALLARM.

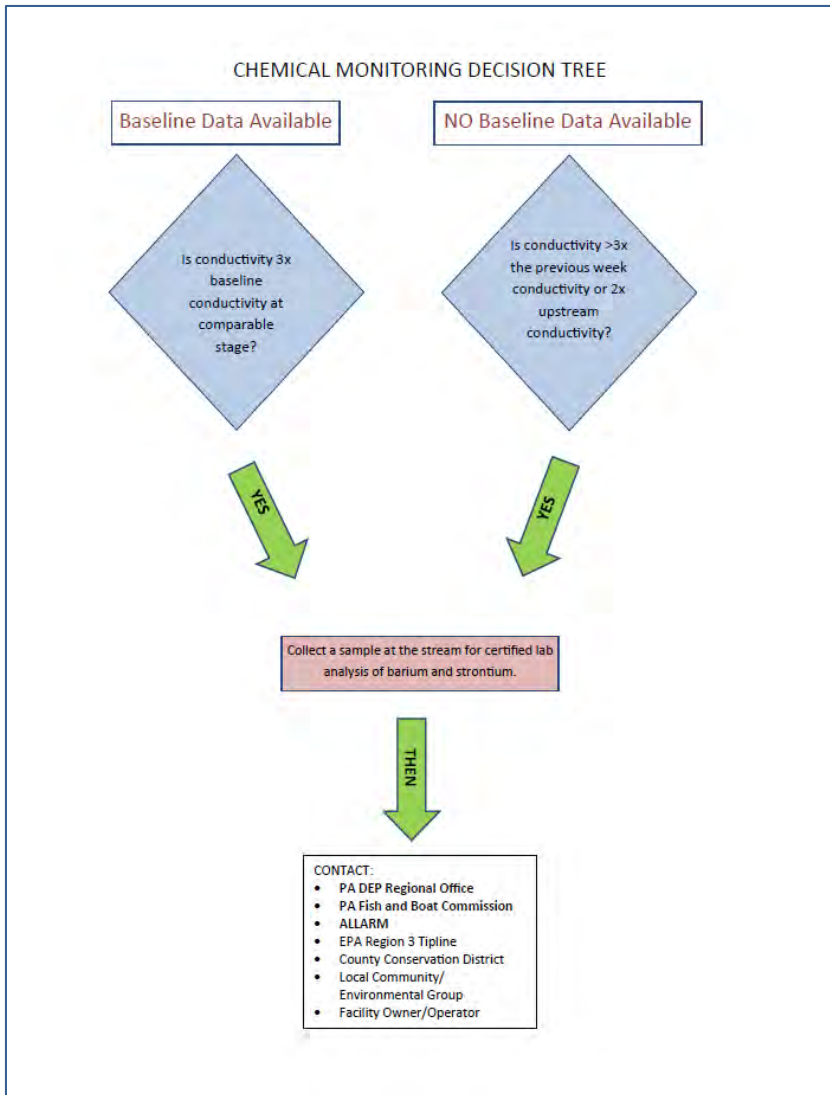
Barium & Strontium: Signature Chemicals

- If Conductivity/TDS levels increase, that ***could*** mean pollution from shale gas flowback water.
- Data are confirmed by analyzing samples for Ba & Sr



It is important to obtain baseline data for conductivity/TDS and barium/strontium. It is also important to understand how they relate under different flow conditions.

Reporting Events



CONTACT:

- PA DEP Regional Office
- PA Fish and Boat Commission
- ALLARM
- EPA Region 3 Tipline
- County Conservation District
- Local Community/
Environmental Group
- Facility Owner/Operator

Baseline Monitoring Steps

2. Conductivity & Total
Dissolved Solids
In-stream testing



1. Visual
Observation
Checklist

3. Stage
Monitoring

Stream Testing

- Test stream water with meter
 - Walk into middle of the creek
 - Or sample from a bridge using a bucket



Creekside vs. Home testing

Mandatory Creekside Testing

- Stage
- Visual observations

Can do at home in bad weather

- Calibration
- Conductivity/TDS

Meter does not stabilize quickly in freezing temperatures, turn the meter on when you arrive at the site or let the water warm to room temperature test at home or in the car.



Recording Results



VOLUNTEER MONITORING FOR SHALE GAS IMPACTS Chemical and Stage Monitoring Data Sheet

1. Record your site and sample information in the boxes below:

Site Information		Sample Information	
Stream Name		Monitor's Name	
Site Location		Collection Date	
Latitude Coordinate		Collection Time	
Longitude Coordinate		County Monitored	

2. Check the description that best matches your observation:

Weather	Precipitation	Precipitation Last 48 Hours
Sunny	Light rain	None
Partly Cloudy	Heavy rain	Light
Cloudy	Snow	Heavy

3. Record your results in the boxes below:

Parameter	Units	Replicate #1	Replicate #2	Average Result
Conductivity	µS/cm			
Total Dissolved Solids	mg/L			
Stage	feet			

Inches to feet conversion:

Inches	1	2	3	4	5	6	7	8	9	10	11
Feet	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92

4. Did you calibrate your meter the day you monitored? Yes No

5. How much time did you spend monitoring? _____ hours

Record site information

Record weather information

Record conductivity, TDS, and stage results

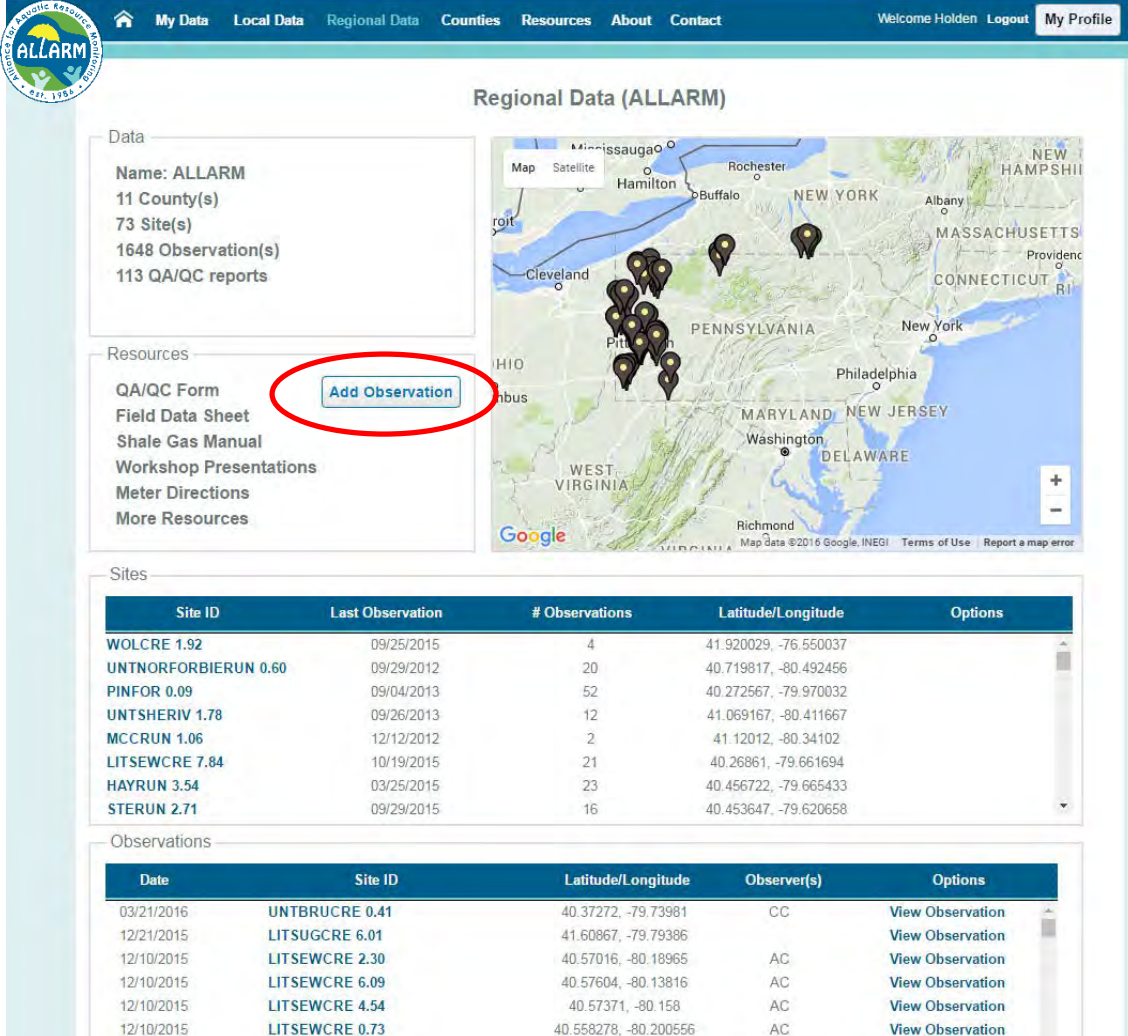
Record calibration and volunteer time.

Data Management & Quality Control

ALLARMwater.org

- 'My Data' profile page
- Submit data through site
- Can view data and create graphs
- Resources, research and forms all housed on site

allarm/RegionData.php?websiteID=12



The screenshot shows the ALLARM website interface. At the top, there is a navigation menu with links for 'My Data', 'Local Data', 'Regional Data', 'Counties', 'Resources', 'About', and 'Contact'. A user is logged in as 'Holden'. The main content area is titled 'Regional Data (ALLARM)'. On the left, there is a 'Data' section with the following information: Name: ALLARM, 11 County(s), 73 Site(s), 1648 Observation(s), and 113 QA/QC reports. Below this is a 'Resources' section with links to 'QA/QC Form', 'Field Data Sheet', 'Shale Gas Manual', 'Workshop Presentations', 'Meter Directions', and 'More Resources'. A red circle highlights the 'Add Observation' button in the Resources section. To the right of the Resources section is a map of the region showing several monitoring sites marked with pins. Below the map is a 'Sites' table with columns for Site ID, Last Observation, # Observations, Latitude/Longitude, and Options. Below the Sites table is an 'Observations' table with columns for Date, Site ID, Latitude/Longitude, Observer(s), and Options.

Regional Data (ALLARM)

Data

Name: ALLARM
11 County(s)
73 Site(s)
1648 Observation(s)
113 QA/QC reports

Resources

QA/QC Form
Field Data Sheet
Shale Gas Manual
Workshop Presentations
Meter Directions
More Resources

Sites

Site ID	Last Observation	# Observations	Latitude/Longitude	Options
WOLCRE 1.92	09/25/2015	4	41.920029, -76.550037	
UNTNORFORBIERUN 0.60	09/29/2012	20	40.719817, -80.492456	
PINFOR 0.09	09/04/2013	52	40.272567, -79.970032	
UNTSHERIV 1.78	09/26/2013	12	41.069167, -80.411667	
MCCRUN 1.06	12/12/2012	2	41.12012, -80.34102	
LITSEWCRE 7.84	10/19/2015	21	40.26861, -79.661694	
HAYRUN 3.54	03/25/2015	23	40.456722, -79.665433	
STERUN 2.71	09/29/2015	16	40.453647, -79.620658	

Observations

Date	Site ID	Latitude/Longitude	Observer(s)	Options
03/21/2016	UNTBURCRE 0.41	40.37272, -79.73981	CC	View Observation
12/21/2015	LITSUGCRE 6.01	41.60867, -79.79386		View Observation
12/10/2015	LITSEWCRE 2.30	40.57016, -80.18965	AC	View Observation
12/10/2015	LITSEWCRE 6.09	40.57604, -80.13816	AC	View Observation
12/10/2015	LITSEWCRE 4.54	40.57371, -80.158	AC	View Observation
12/10/2015	LITSEWCRE 0.73	40.558278, -80.200556	AC	View Observation

Data Management: ALLARMwater.org

8/websites/allarm/DataEntryForm.php?LocationPicklist=1

Data Entry Form

Select a location:

Sampling date and time:

Time spent sampling: minutes

Meter calibrated?

Conductivity replicate 1: replicate 2: average: $\mu\text{S}/\text{cm}$

Total dissolved solids (TDS) replicate 1: replicate 2: average: mg/L

Stage: feet
Stage should be entered with decimals in feet, not inches (example: 1.4)

Cross sectional area: square feet

Weather:

Precipitation:

Precipitation last 48 hours:

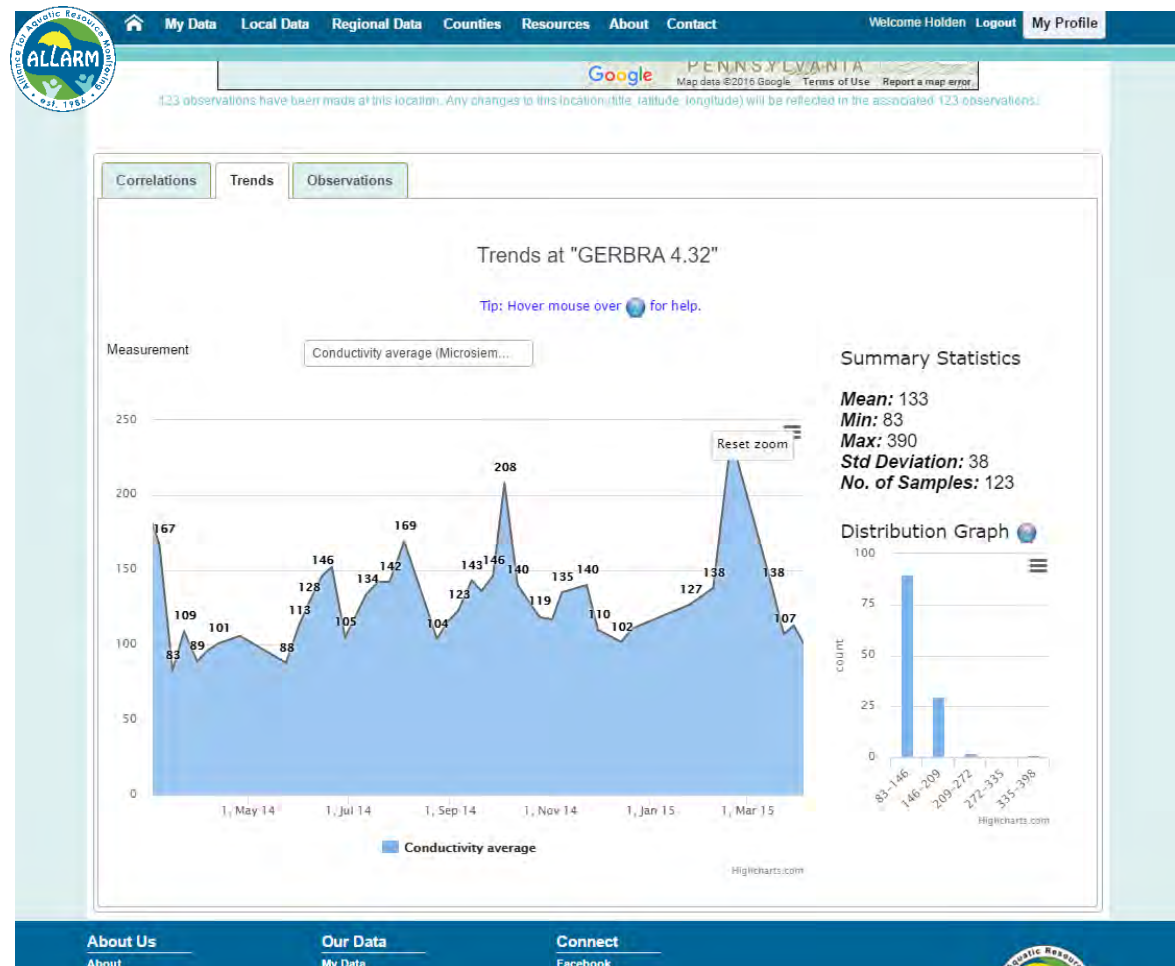
Did you look for visual observations?

Other observations, or details?

- Submit data through site
- Checks values and tests for reportable events

Data Management: ALLARMwater.org

- Can create data and create graphs
- Resources, research and forms all housed on site



Quality Control Program

- Ensures the credibility of the data collected.
- ALLARM will test the water using the same equipment as well as other methods.
- Compare monitor's results to ALLARM's results.

	Conductivity (LaMotte)	Conductivity (Accumet)	TDS (LaMotte)	TDS (Accumet)
Monitor	X		X	
ALLARM	X	X	X	X

Quality Assurance, Quality Control (QA/QC)

- Fill out QA/QC form
- Collect sample
- Send form and sample to ALLARM lab
- Do twice a year – high stage & low stage



Quality Control

Appendix E: Quality Assurance/Quality Control Form



SHALE GAS VOLUNTEER MONITORING PROGRAM Quality Assurance/Quality Control (QA/QC) Form



1. Fill out the label on your QA/QC bottle (shown to the right).
2. Enter the stream and face upstream. Fill your QA/QC bottle and pour the rinse water out downstream. Rinse your bottle and cap three times. Fill your QA/QC bottle completely with stream water and close it tightly with the cap.
3. Record your data in the chart below, as well as on ALLARMwater.org:

Parameter	Units	Replicate #1	Replicate #2	Average Result
Conductivity	µS/cm			
Total Dissolved Solids	mg/L			
Stage	feet			

4. Fill out the information in the boxes below:

Monitor Information		Sample Information	
Monitor's Name		Site ID or Stream Name	
Mailing Address		Latitude Coordinate	
		Longitude Coordinate	
Email Address		Collection Date	
County Monitored		Collection Time	
Affiliation (if applicable)		Equipment Used (i.e. LaMotte meter)	
		Bottle # (on label):	

5. Pack a small box with your QA/QC bottle and this QA/QC form. Secure the bottle so it cannot move around during shipment. Mail the box to ALLARM for QA/QC processing at:

ALLARM
Dickinson College
5 N Orange Street
Carlisle, PA 17013

- Send water sample to ALLARM within first month of monitoring for QA/QC and barium/strontium analysis.
- Be sure to log observations for QA/QC samples on ALLARMwater.org

In your kit

1. LaMotte Tracer PockeTester and calibration solution vial
2. 84 $\mu\text{S}/\text{cm}$ & 1413 $\mu\text{S}/\text{cm}$ standard calibration solution
3. Distilled water wash bottle
4. Stream testing bottle
5. 3 sample bottles
 - Two sample bottles for QA/QC
 - One bottle for pollution event Ba and Sr analysis
6. Gage Stick

