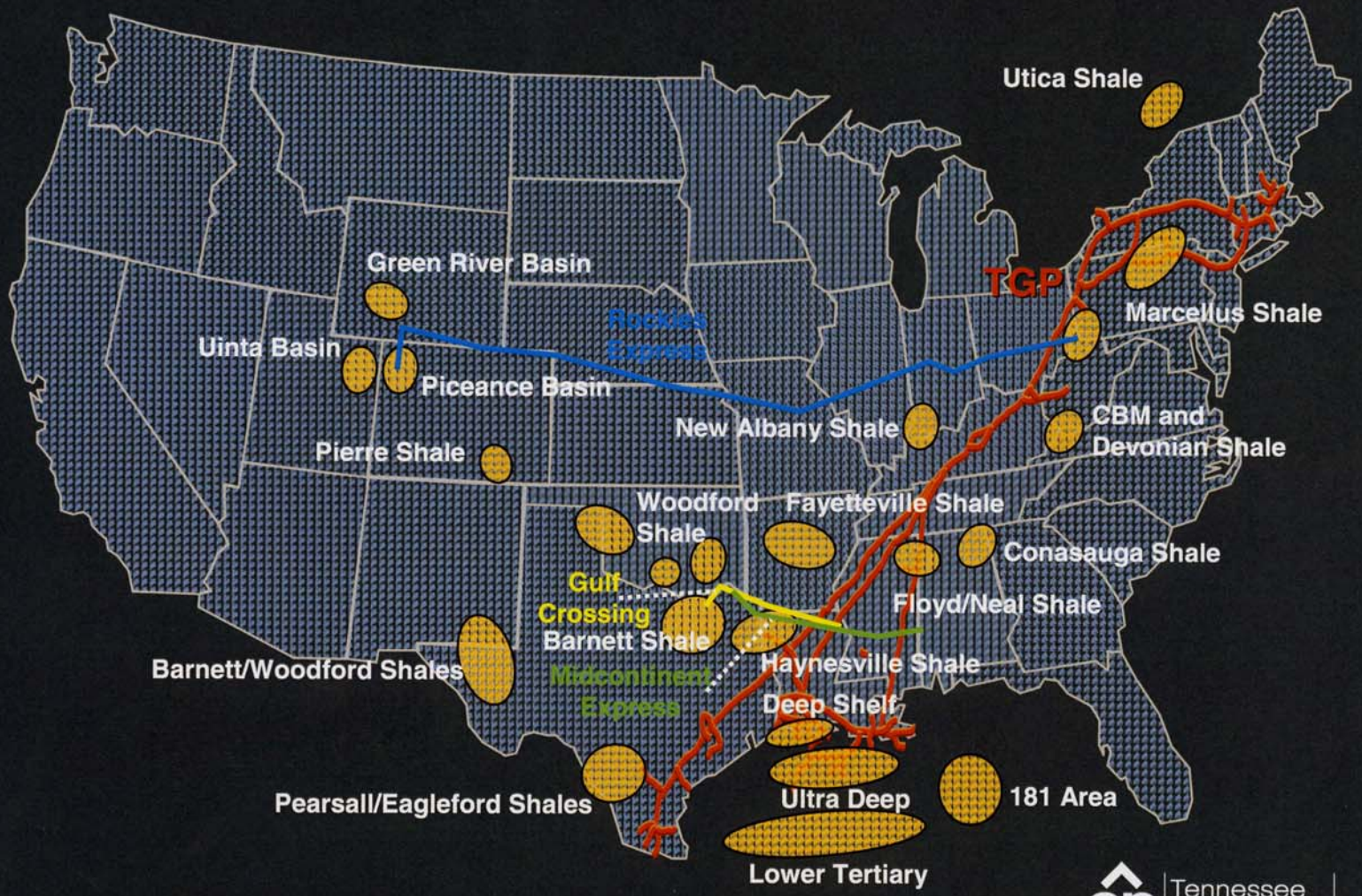

Bradford County
Conservation District
03/19/2010 3:17 pm

New York State Department of Environmental Conservation
Division of Mineral Resources

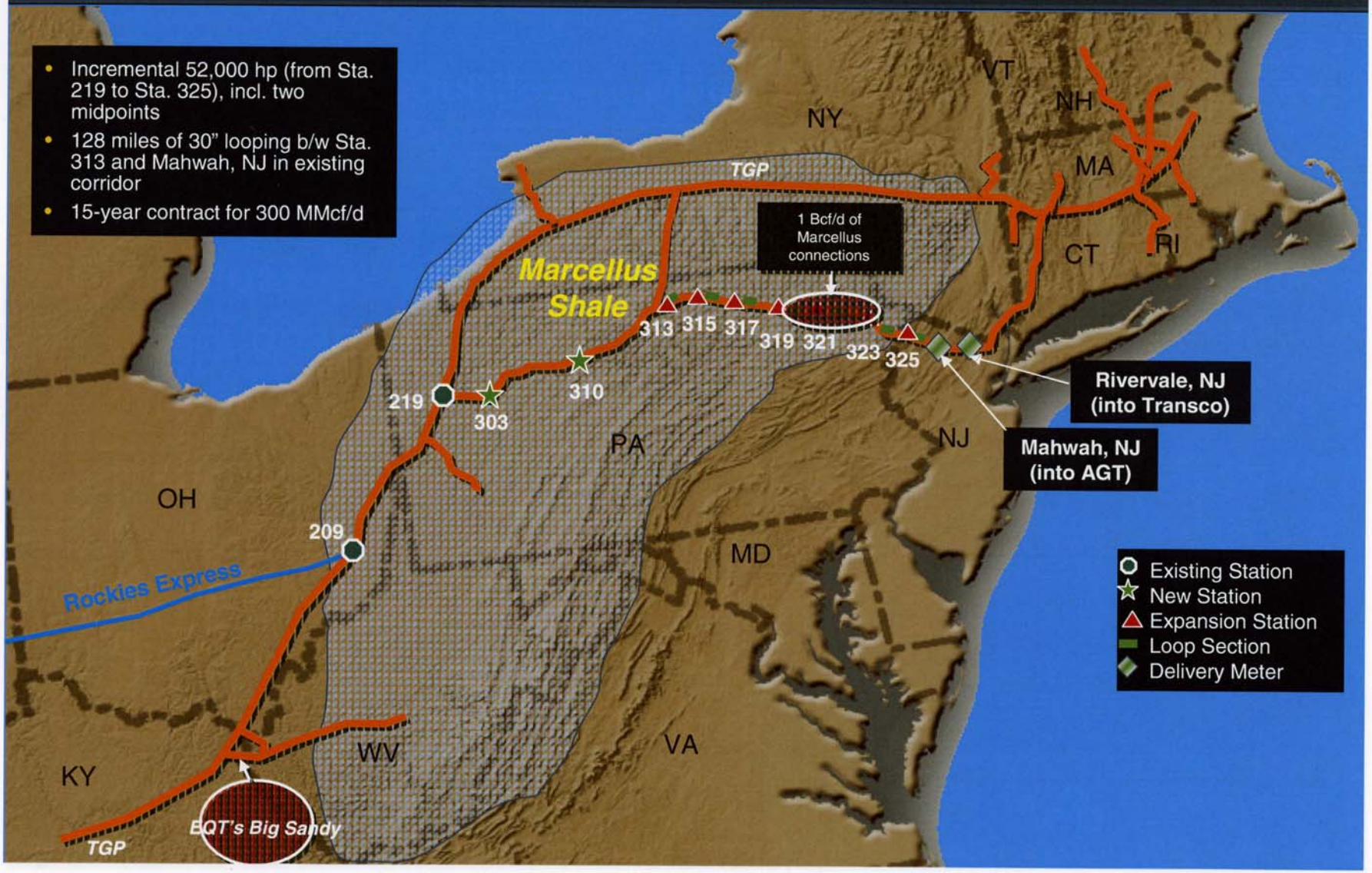
PERSPECTIVE

Salo #1 well blow-out preventer (BOP) being installed.

Current Growing and Future Plays

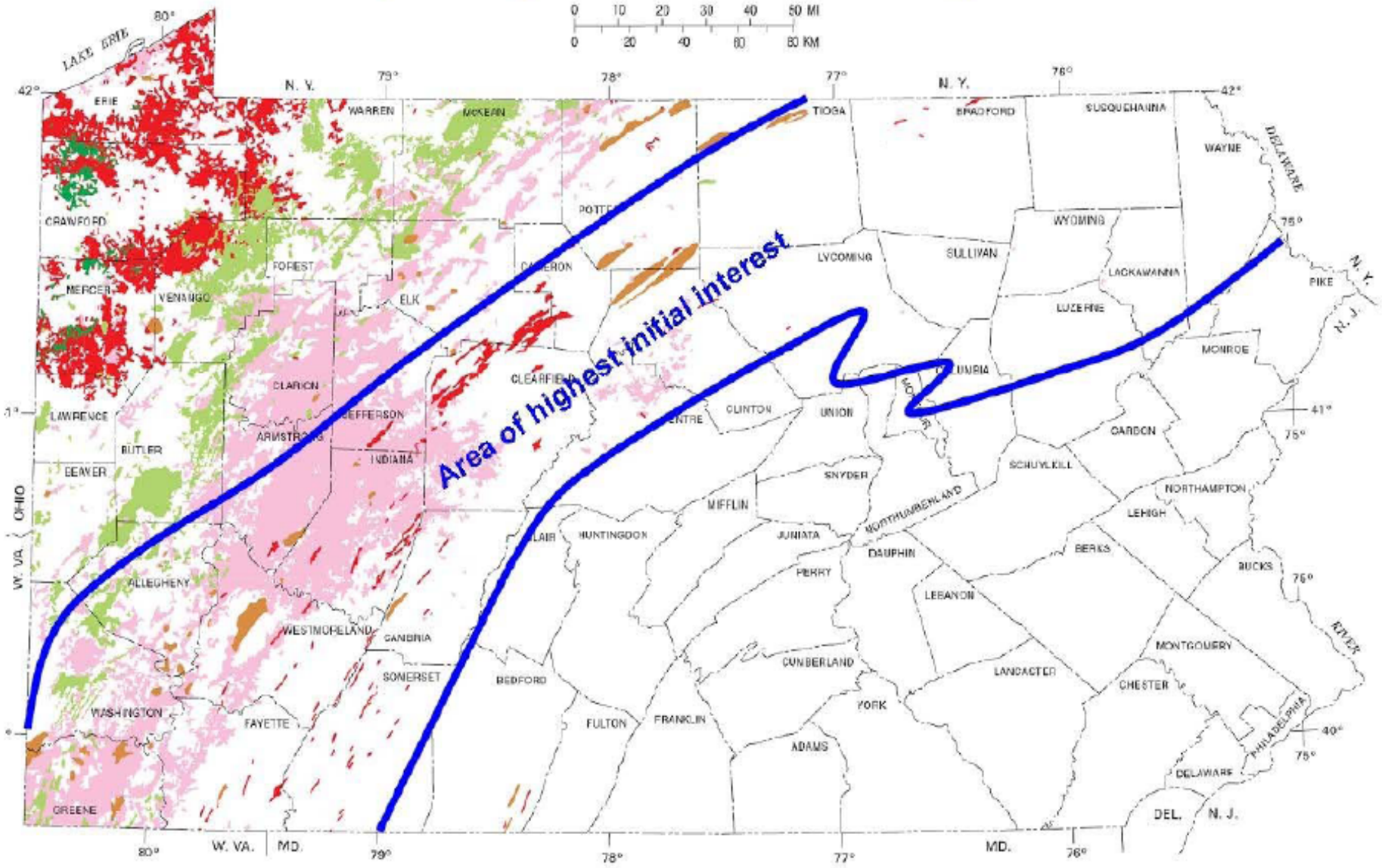


300 Line Expansion Project




Susquehanna River Basin
MARCELLUS SHALE OCCURRENCE
Upper Susquehanna Subbasin
Chemung Subbasin
Middle Susquehanna Subbasin
West Branch Susquehanna Subbasin
Juniata Subbasin
Lower Susquehanna Subbasin
MARCELLUS SHALE
Outcrop
Subsurface
72% of the Susquehanna River Basin is underlain by the Marcellus Shale
Susquehanna River Basin Commission

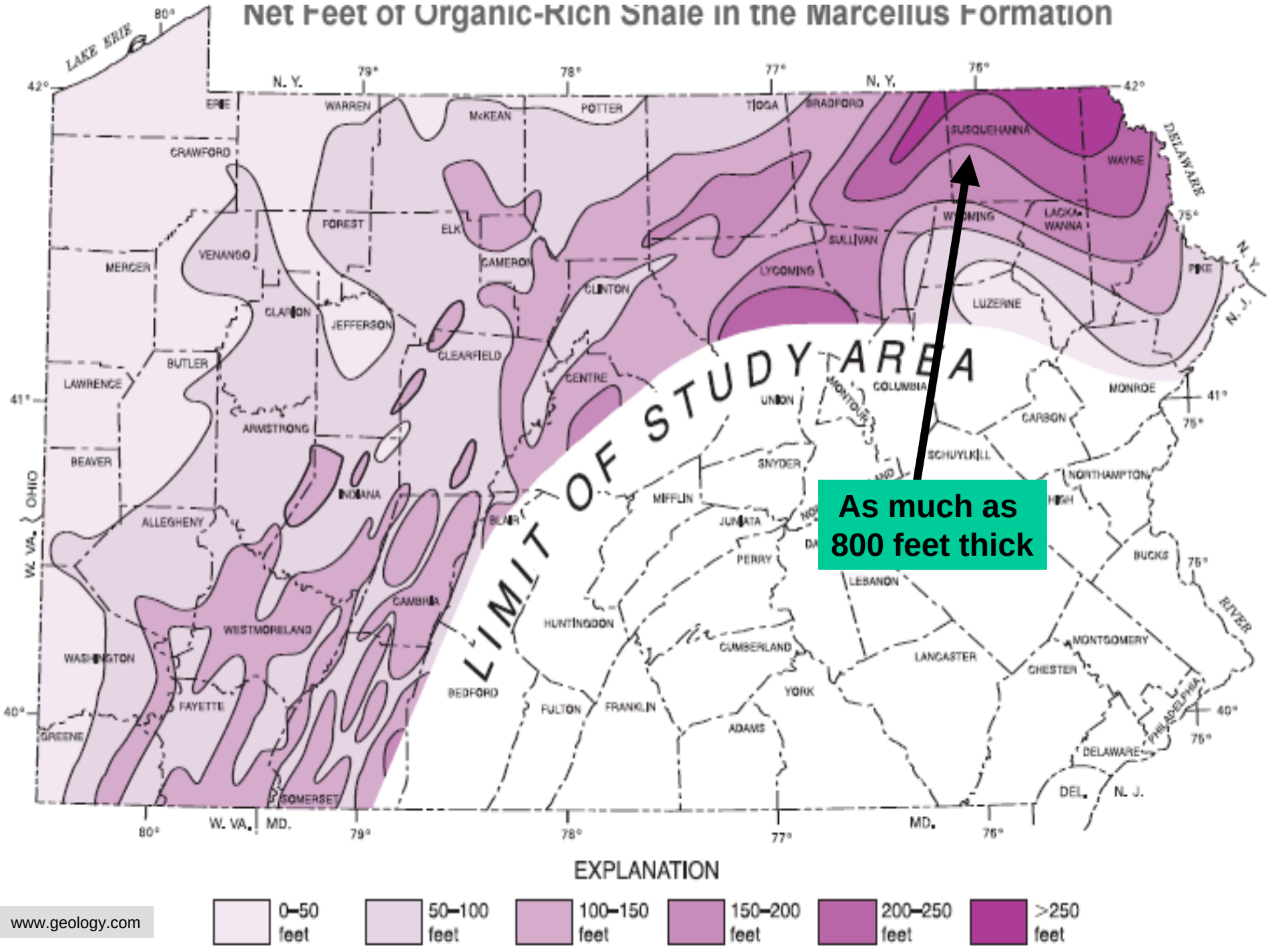
Map of Pennsylvania Oil and Gas Fields
Showing area of highest interest for Marcellus Shale exploration



Presented by the Independent Oil and Gas Association of Pennsylvania at the Pennsylvania State Association of Township Supervisors Annual Meeting, May 12, 2008, Hershey, PA

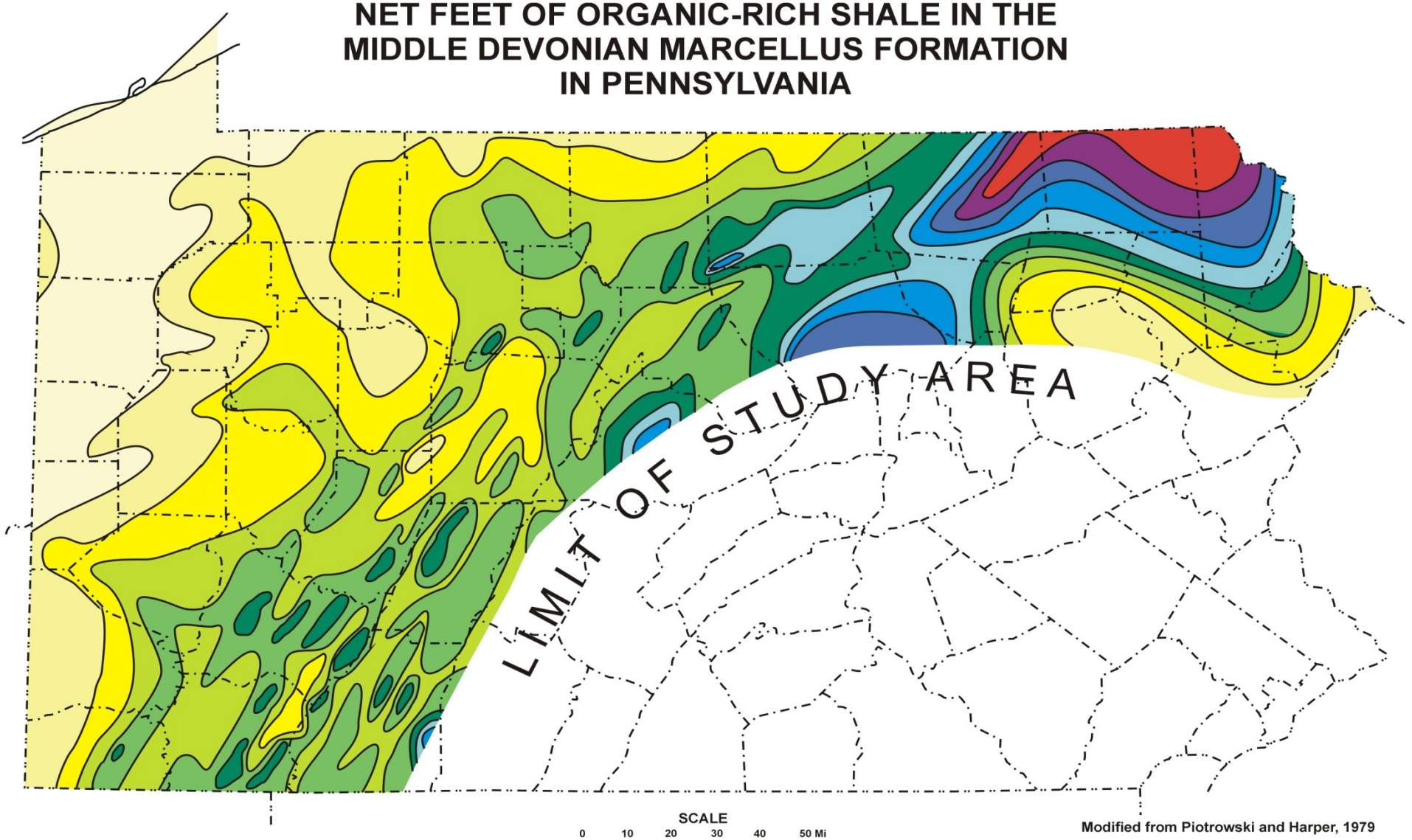
EXPLANATION

Shallow oil field | Deep oil field | Shallow gas field | Deep gas field | Gas storage area



www.geology.com

NET FEET OF ORGANIC-RICH SHALE IN THE MIDDLE DEVONIAN MARCELLUS FORMATION IN PENNSYLVANIA



Estimated Scope – Marcellus Shale

- **500 trillion cubic feet of reserves (last estimate)**
- **10% accessible with current technology**
  - **Worth estimated $1 trillion dollars**

Marcellus Shale Drilling

- Drilling is different than what has taken place in the Appalachian Basin over the last 150 years
- Marcellus Shale located at depths of 5,000 – 8,000 ft
- Larger drilling rigs
- Advanced technology

Presented by the Independent Oil and Gas Association of Pennsylvania at the Pennsylvania State Association of Township Supervisors Annual Meeting, May 12, 2008, Hershey, PA

Drilling – What to Expect

- Wells typically take 15 - 30 days to drill
- Drilling operations are 24/7
- Trucks moving equipment in and out
- Rig crews on-site all times until drilled
- Temporary inconvenience of noise and lights
- Some damage to local roads – that we will repair at the earliest opportunity

Survey the Site

Horizontal Drilling

- Can provide greater access with a smaller footprint
- Multiple horizontal wells from a single drilling pad could drain 200 - 400 acres

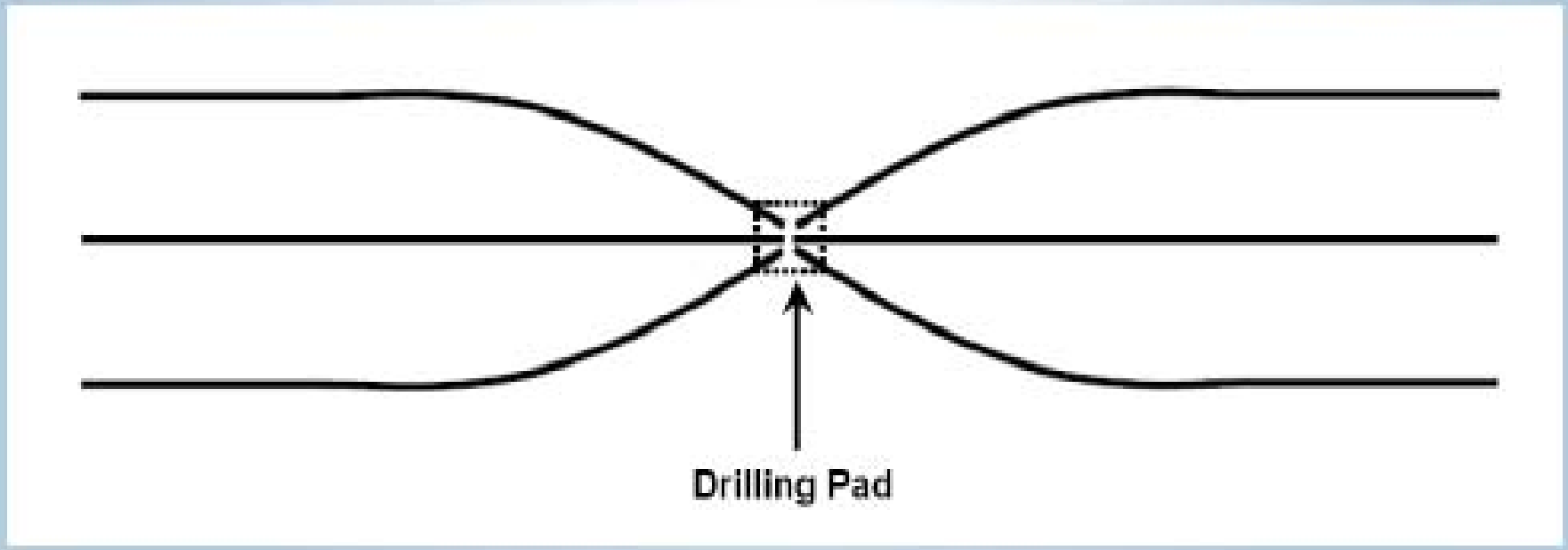
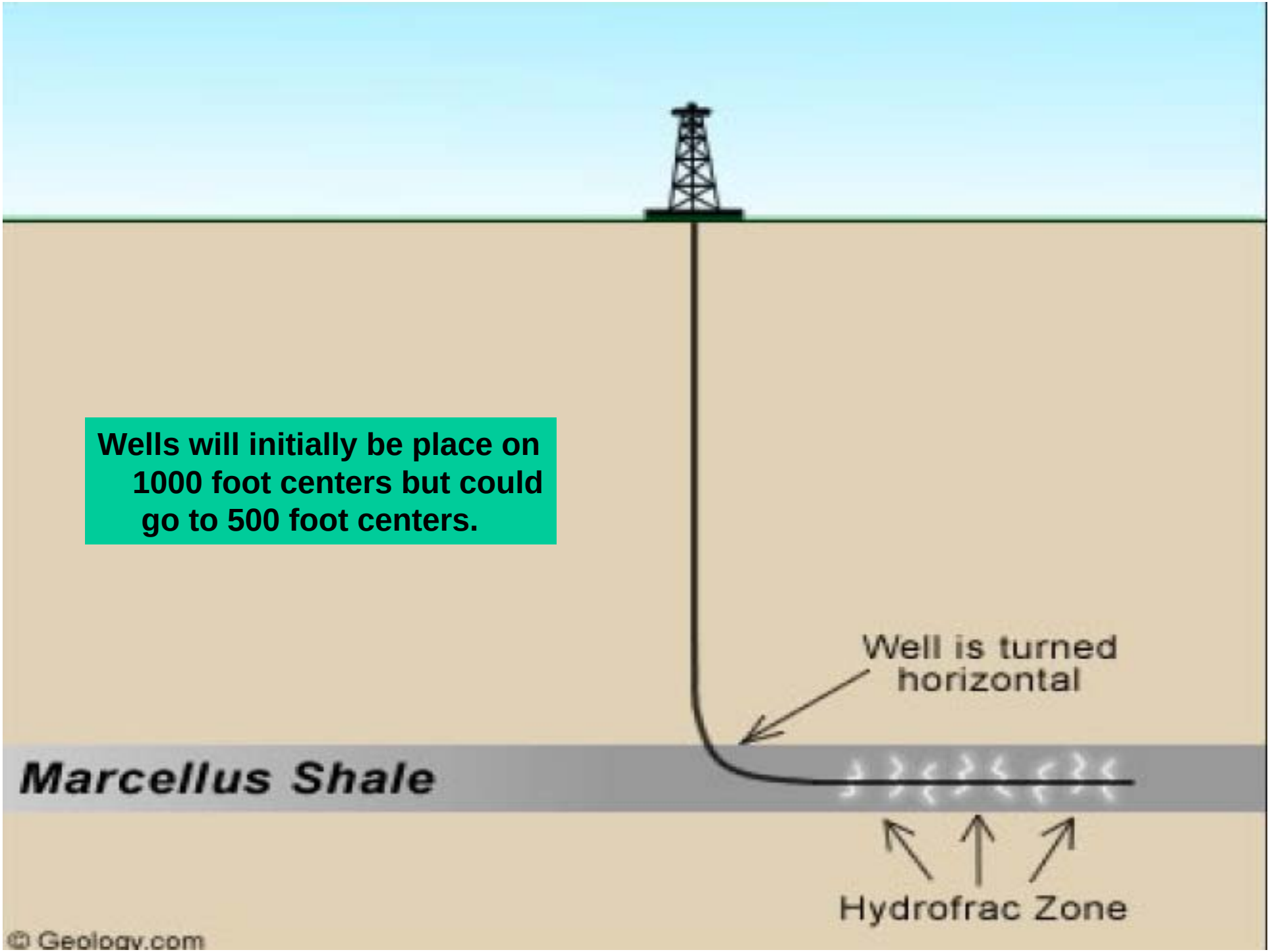
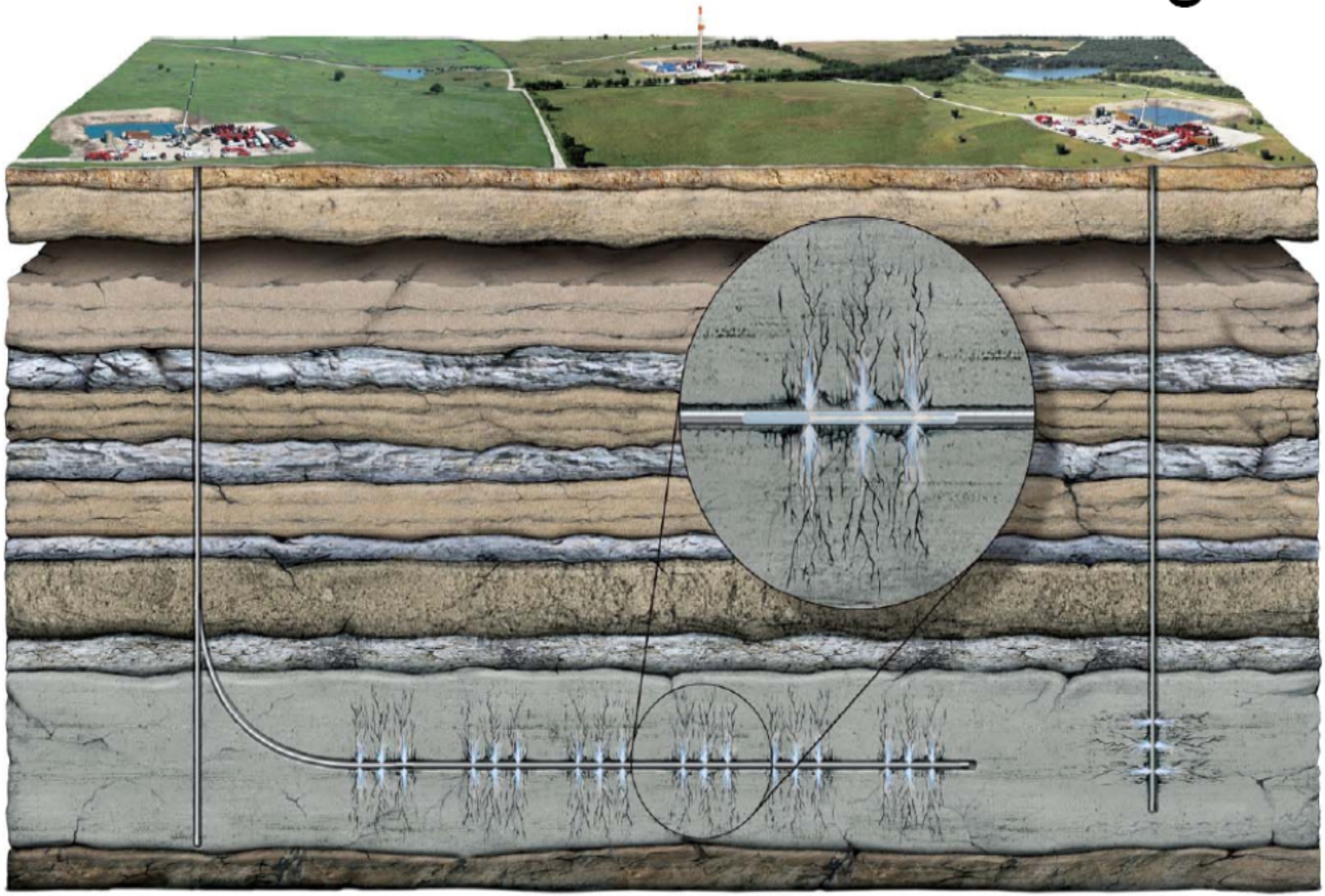


Illustration retrieved from: Independent Oil and Gas Association of Pennsylvania's *Drilling & Developing the Marcellus Shale*


Wells will initially be place on 1000 foot centers but could go to 500 foot centers.
Well is turned horizontal
Marcellus Shale
Hydrofrac Zone
© Geology.com

Vertical vs. Horizontal Drilling



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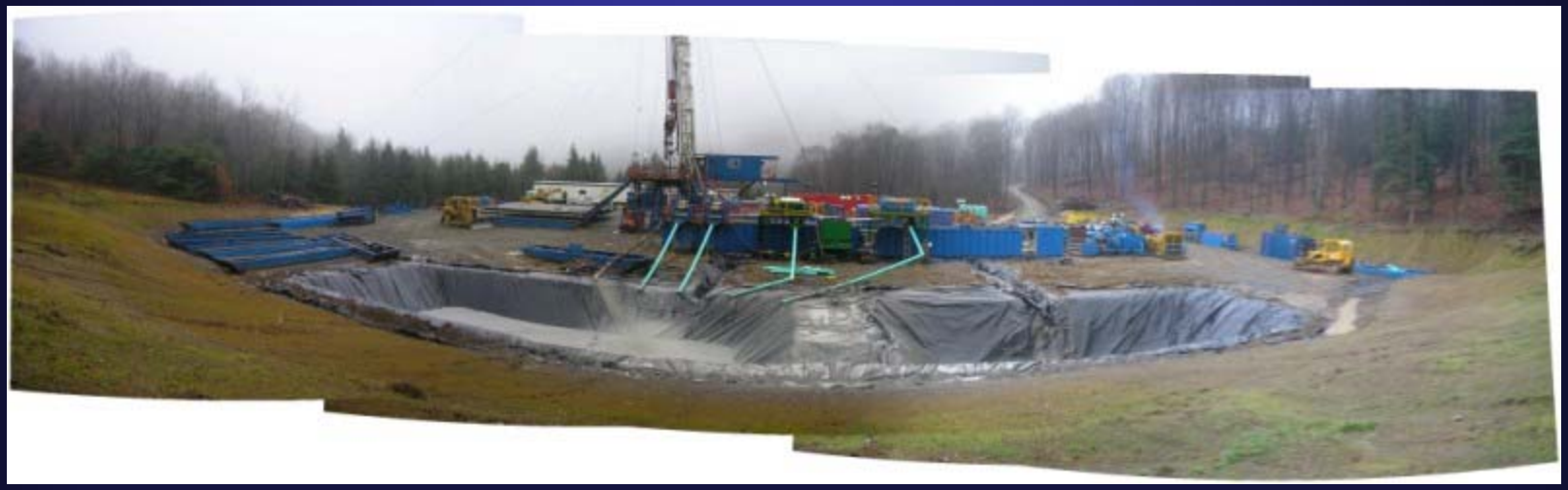
Build the Site



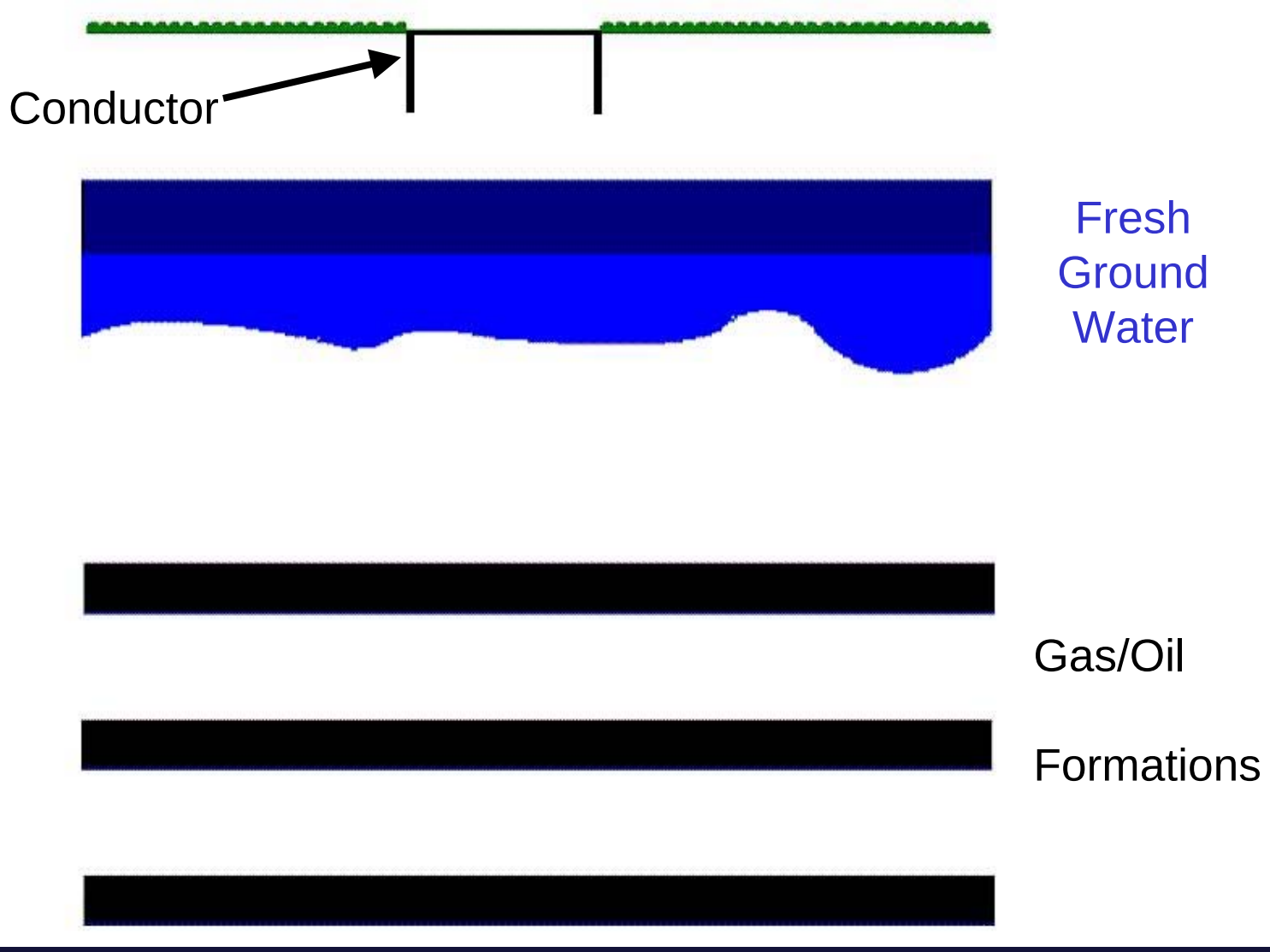
Drill the well

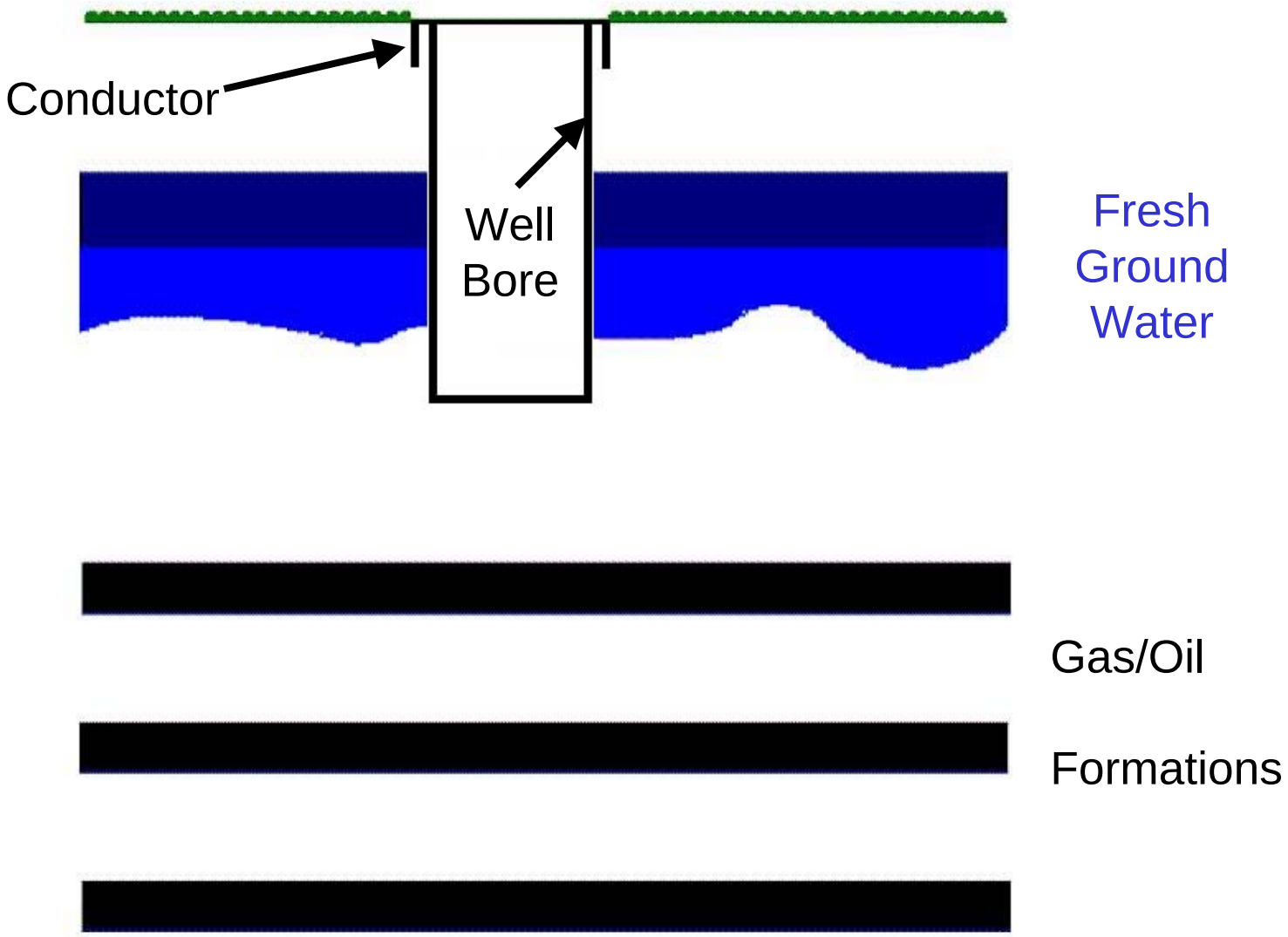
Well Site

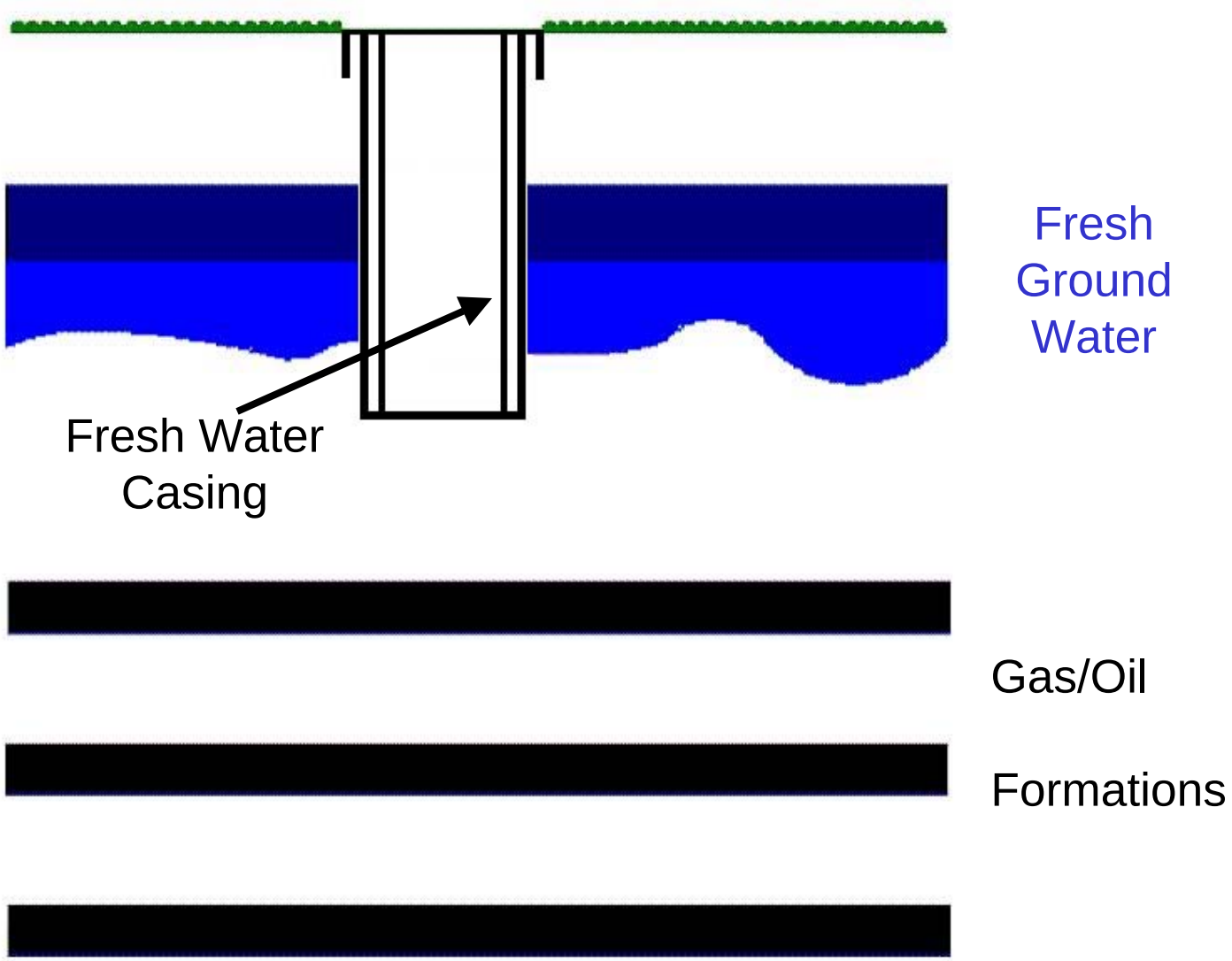
Heavy Equipment Intense

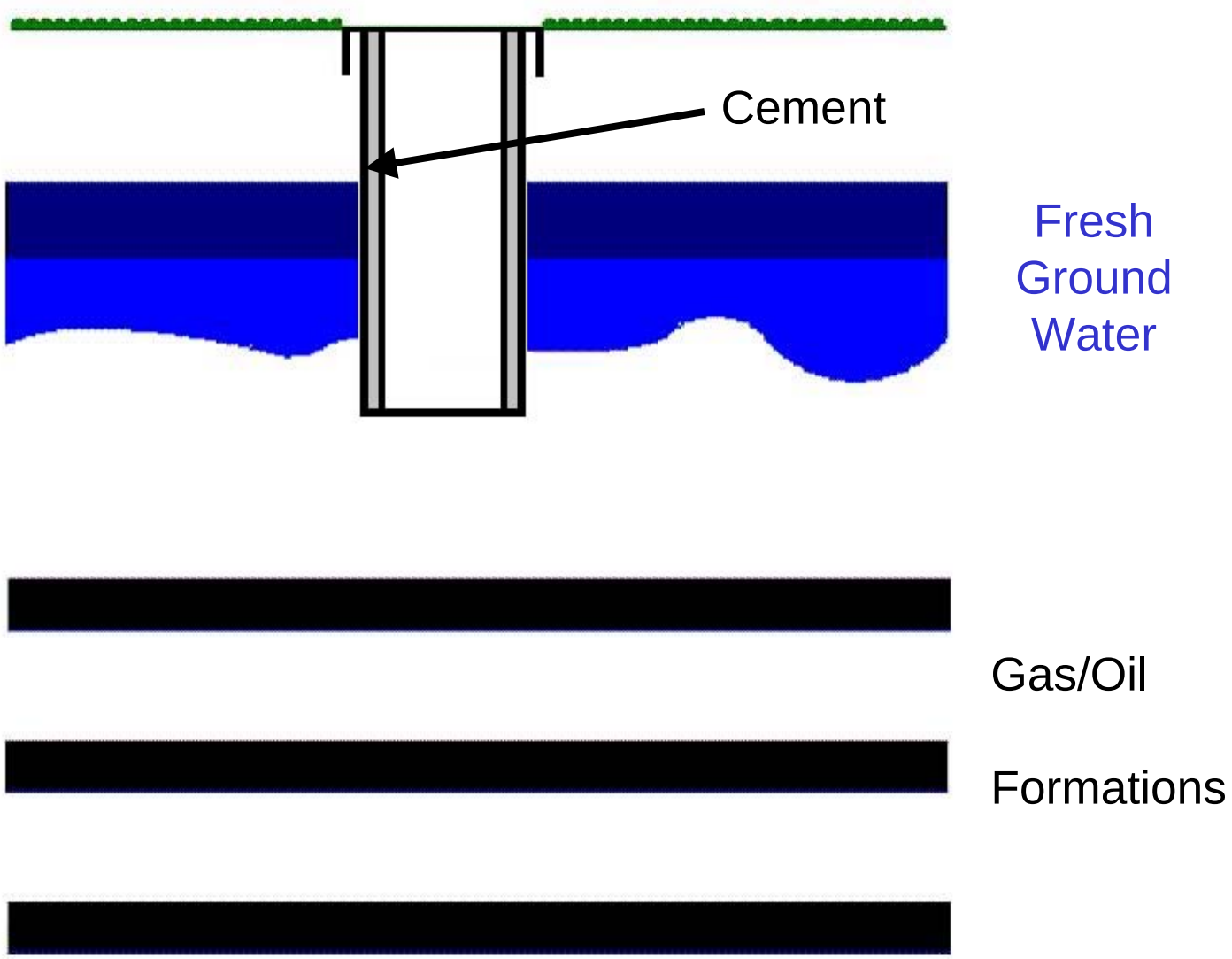
Can be Multiple Wells per Pad

Drilling the Well

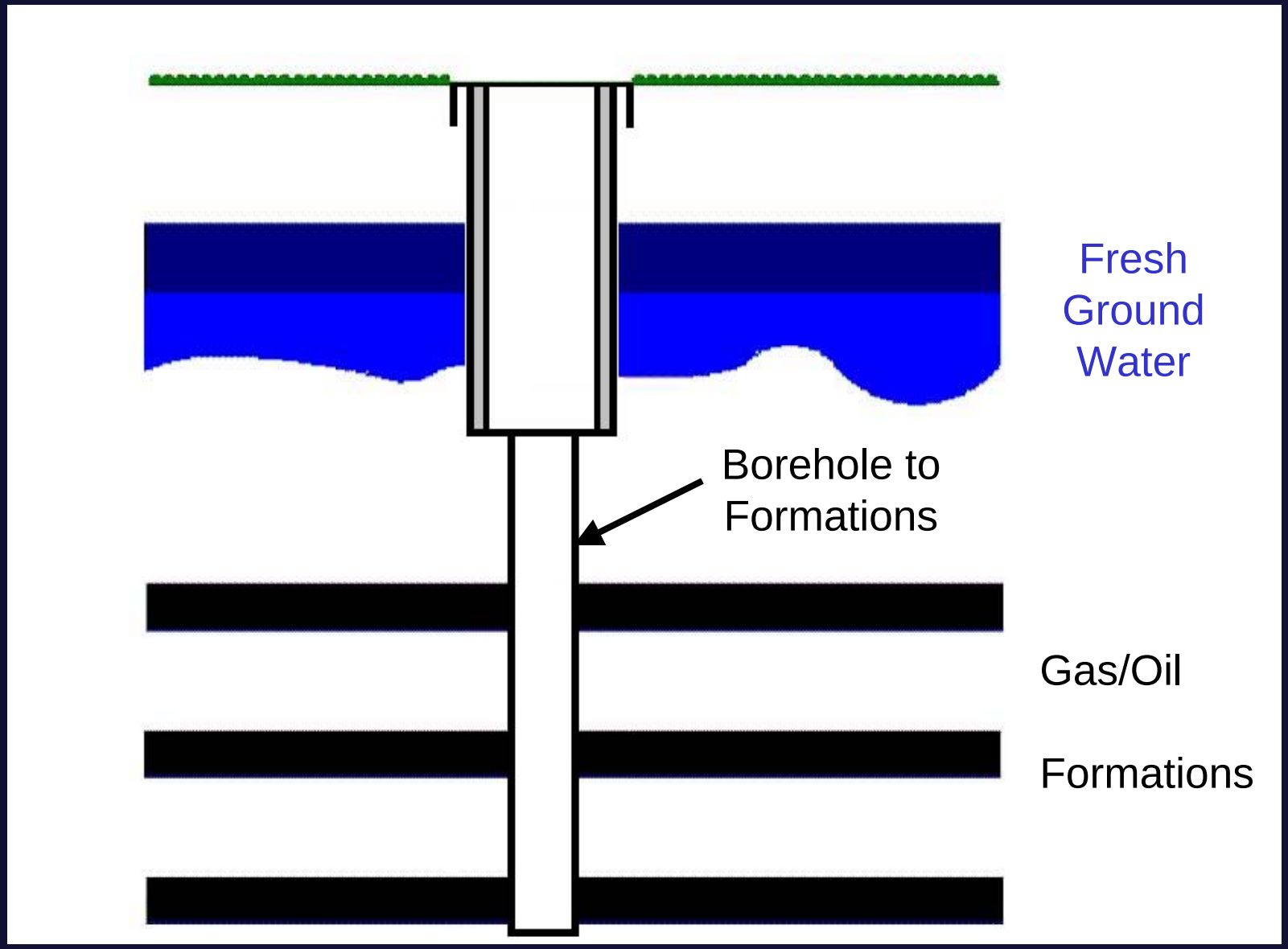

Conductor
Fresh
Ground
Water
Gas/Oil
Formations

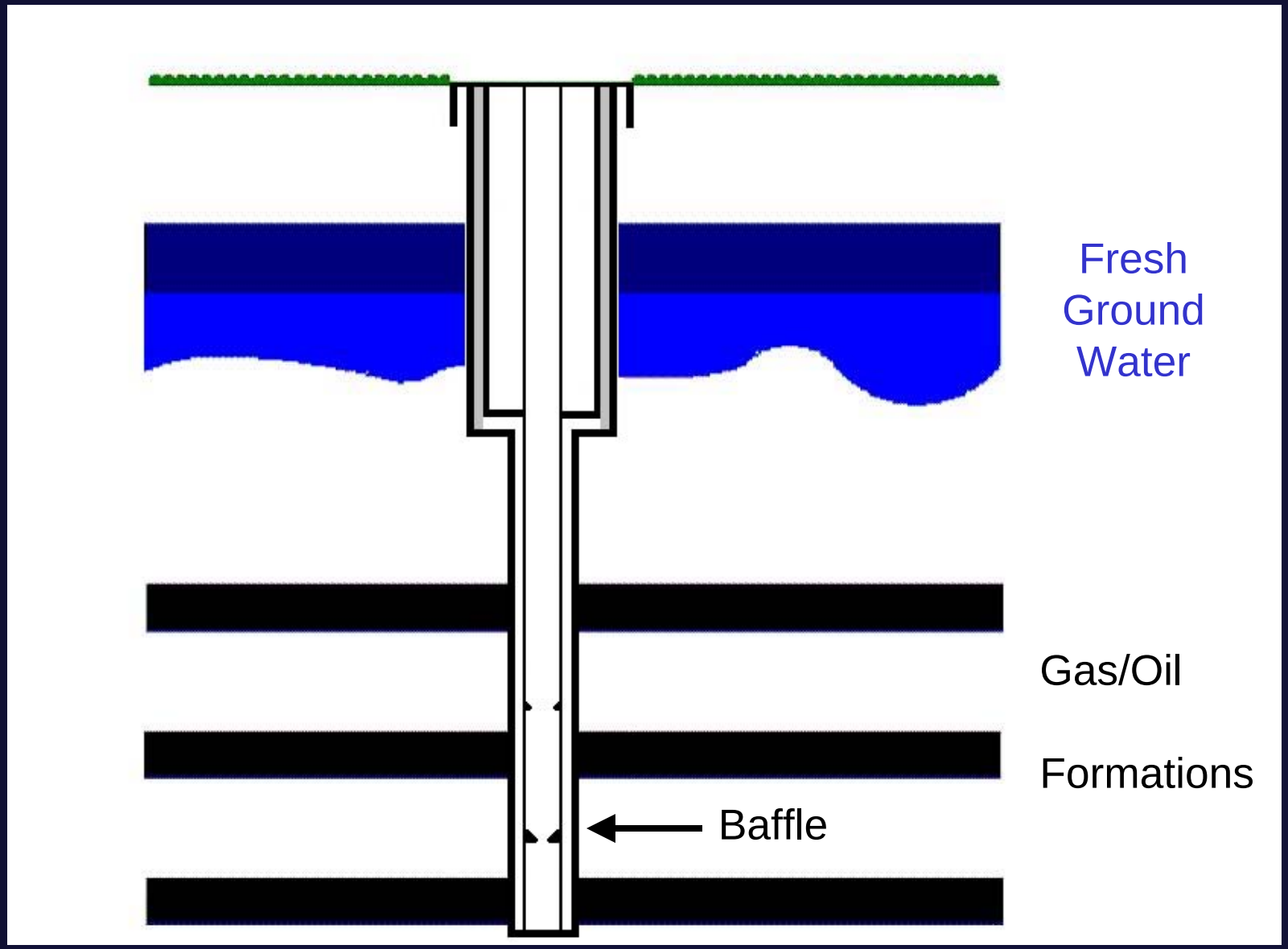

Conductor
Well
Bore
Fresh
Ground
Water
Gas/Oil
Formations

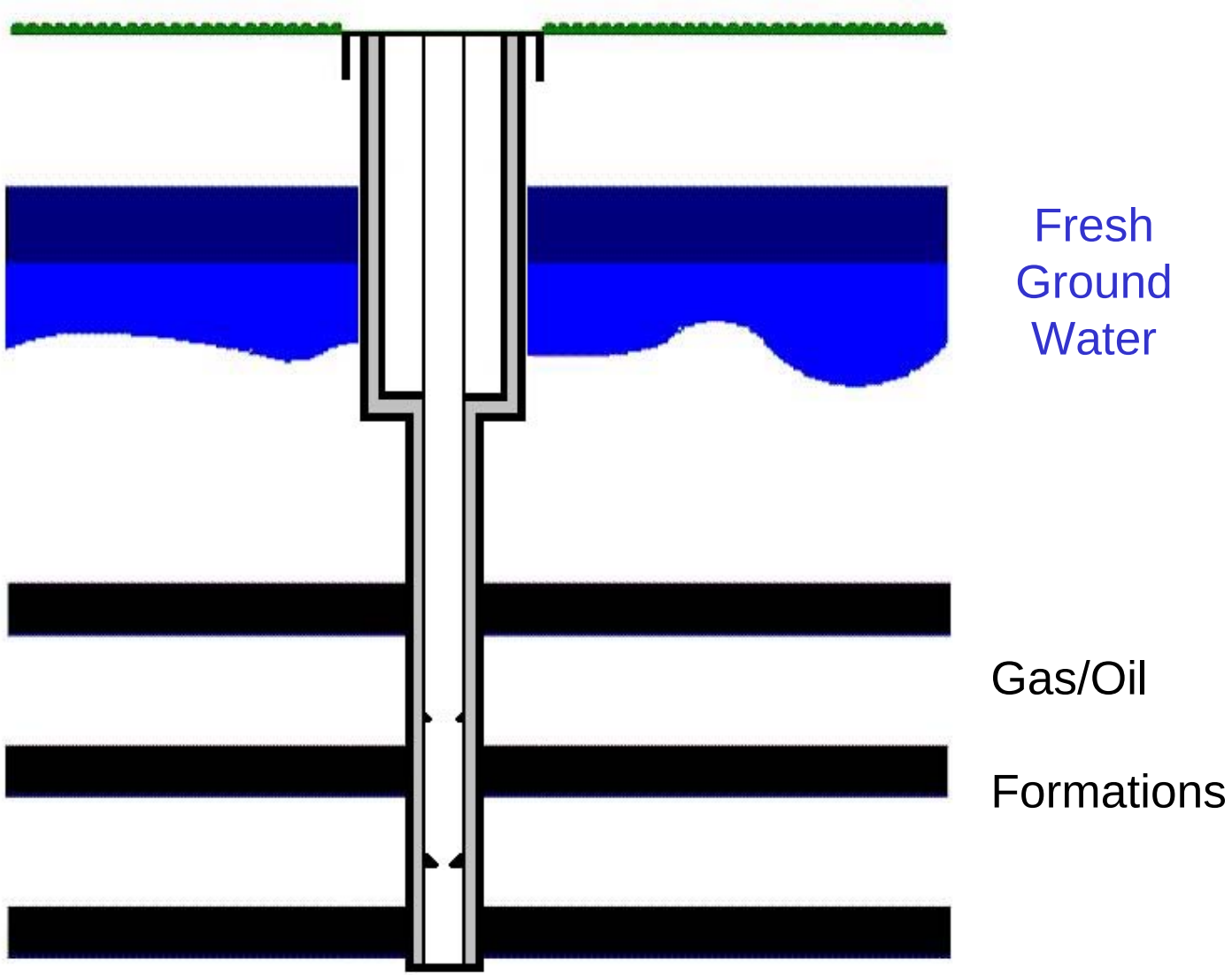

Fresh Ground Water
Fresh Water Casing
Gas/Oil
Formations


Cement
Fresh
Ground
Water
Gas/Oil
Formations

Cement Returns from the annular space


Fresh
Ground
Water
Borehole to
Formations
Gas/Oil
Formations


Fresh
Ground
Water
Gas/Oil
Formations
Baffle


Fresh
Ground
Water
Gas/Oil
Formations

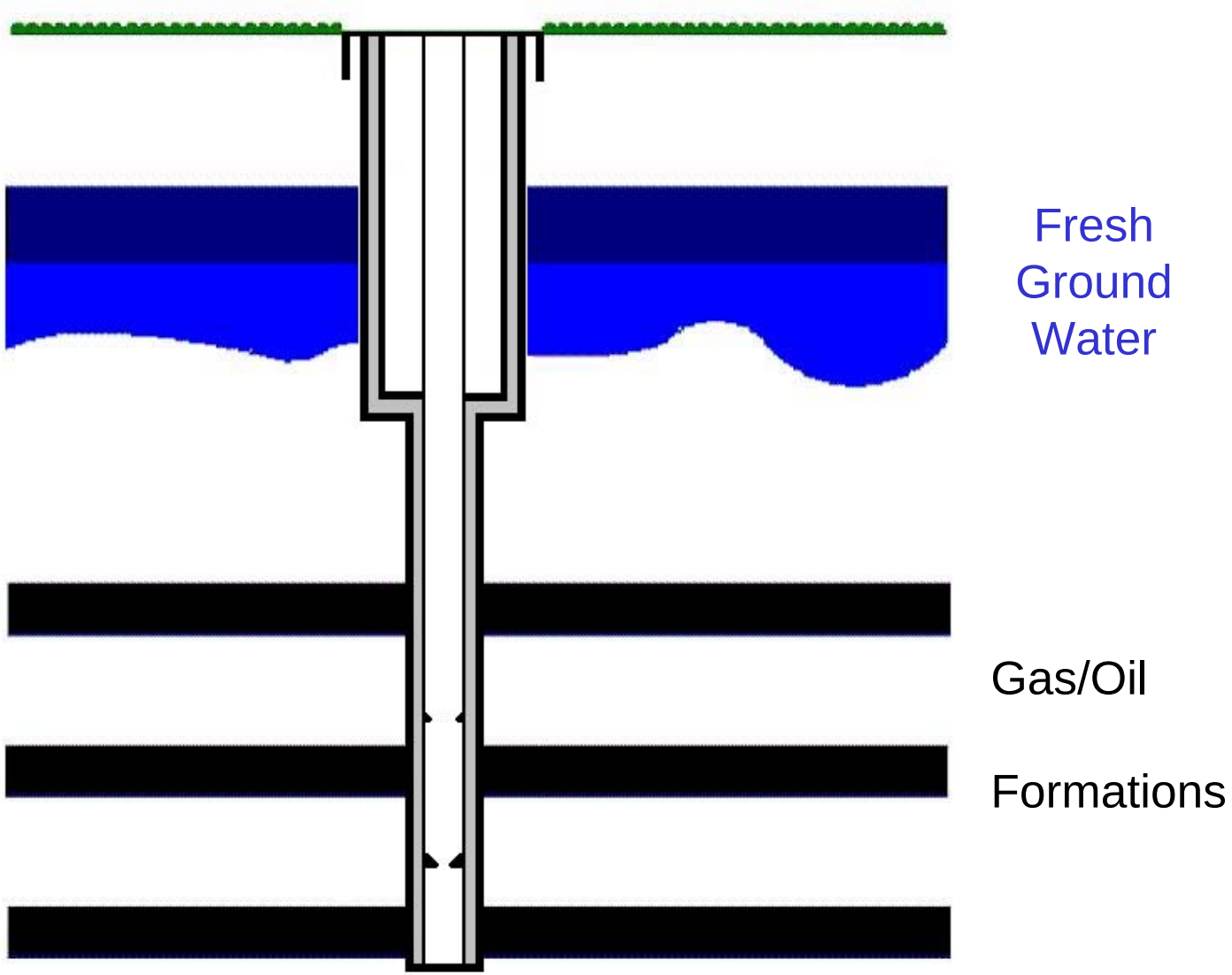
Fracing the Well

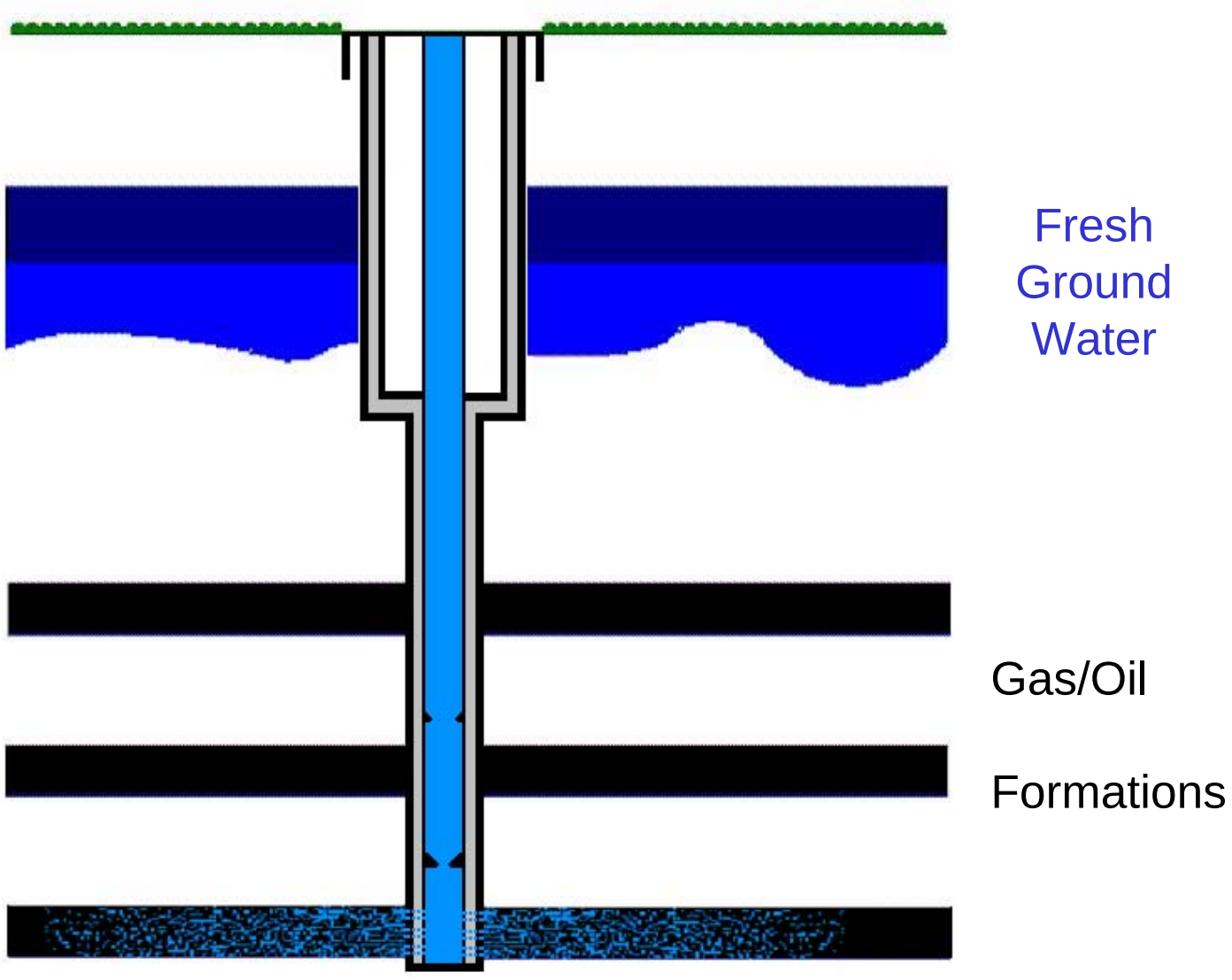
What is Fracing?

Hydraulic fracturing is the process in which fluid is pumped down a well and into a formation under pressure high enough to cause the formation to crack, or fracture, forming passages through which gas can flow into the well bore.

Upon completion of the frac this fluid is pumped from the formation into a lined sump and trucked to a permitted treatment facility.

Using Frac Tanks


Fresh
Ground
Water
Gas/Oil
Formations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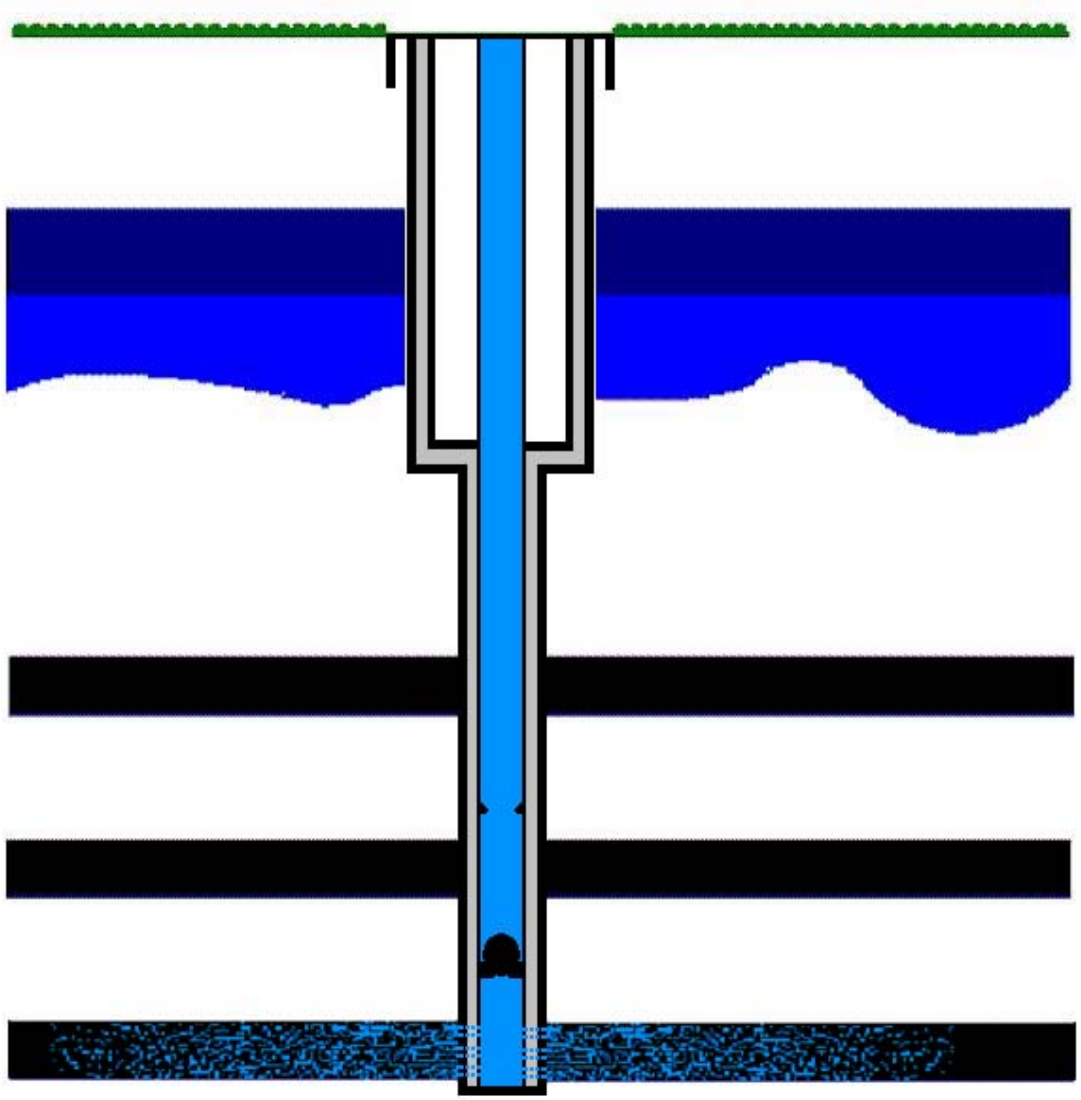
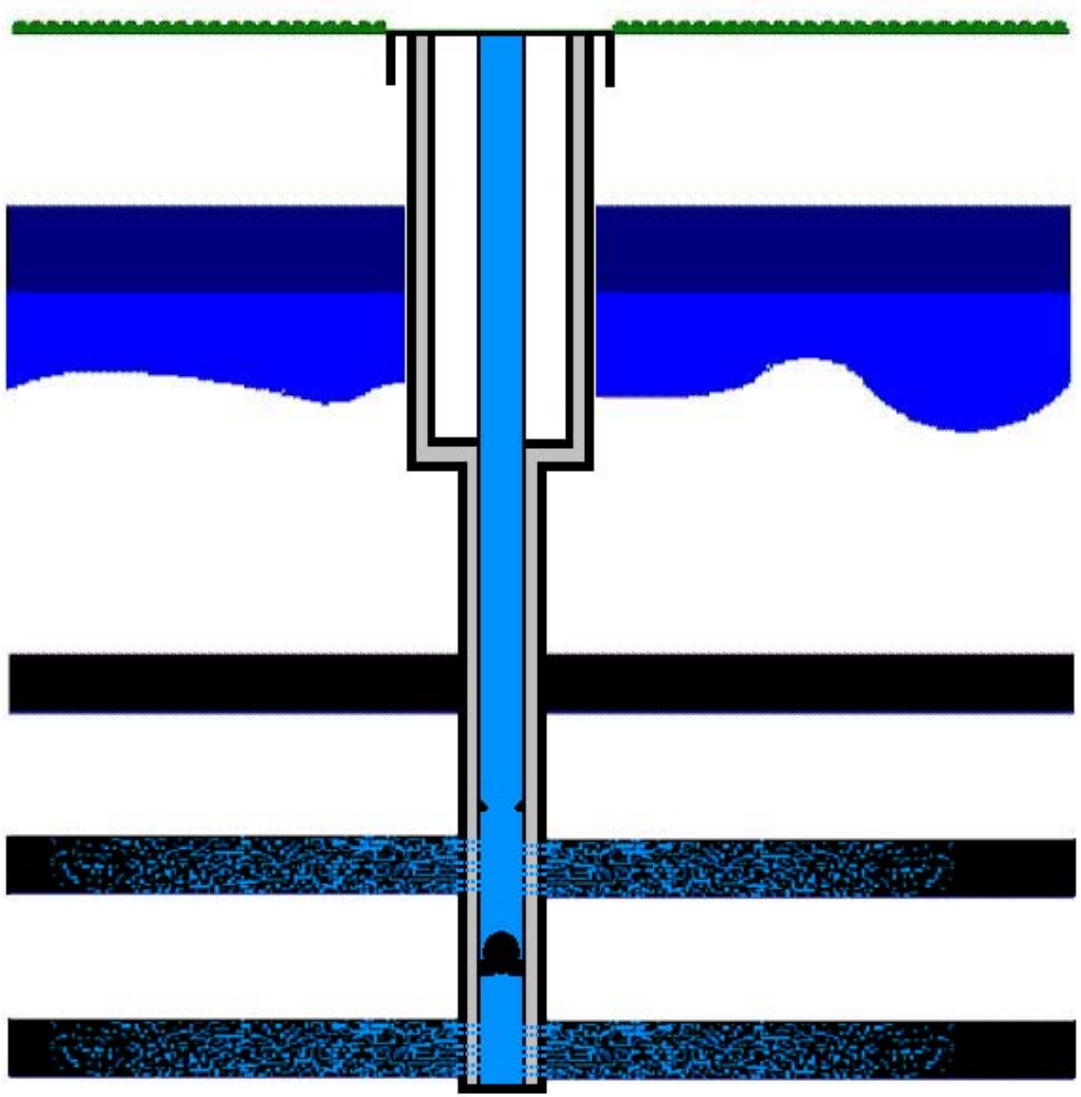
Water
Gas/Oil
Formations


Fresh
Ground
Water
Gas/Oil
Formations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Water
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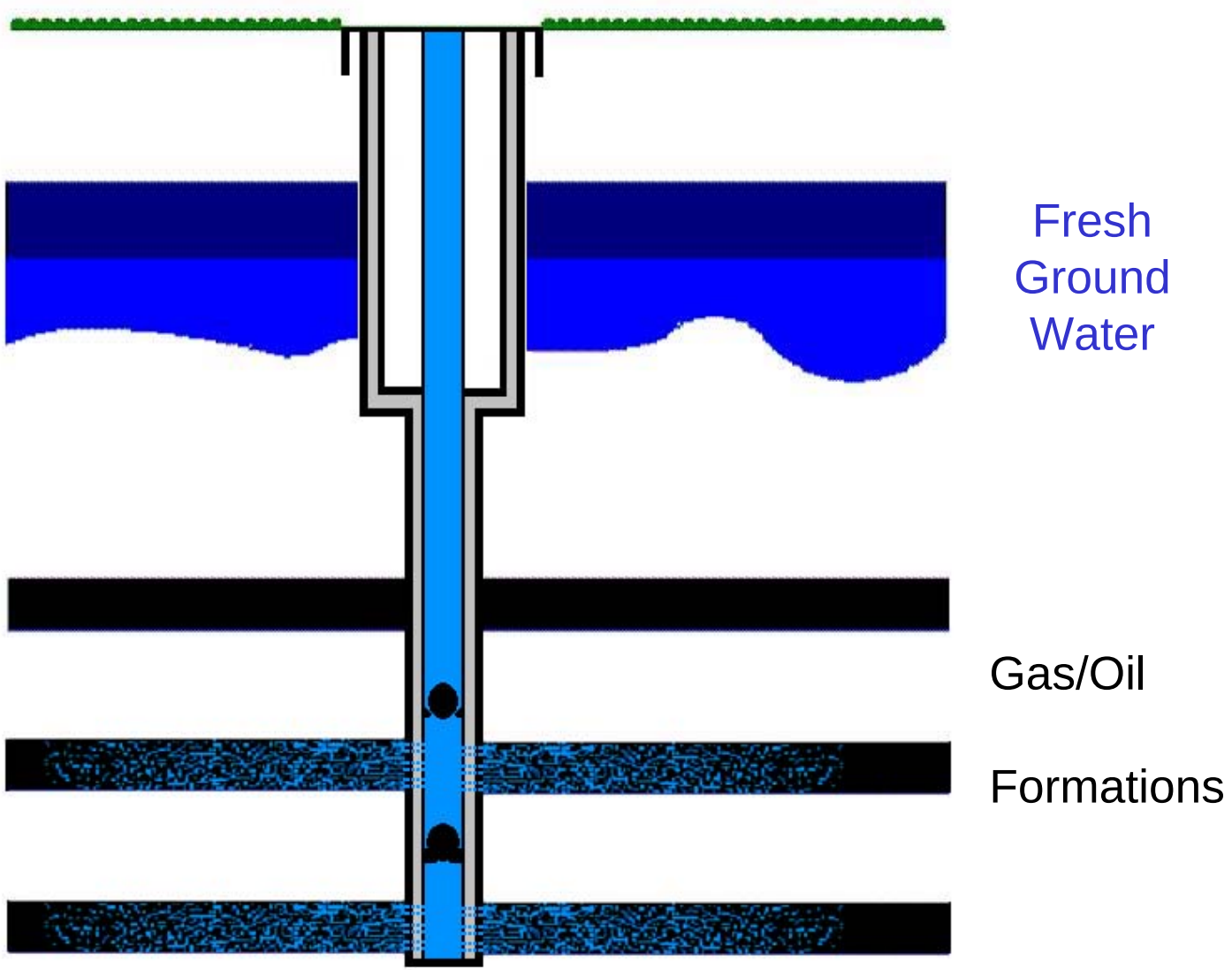
Formations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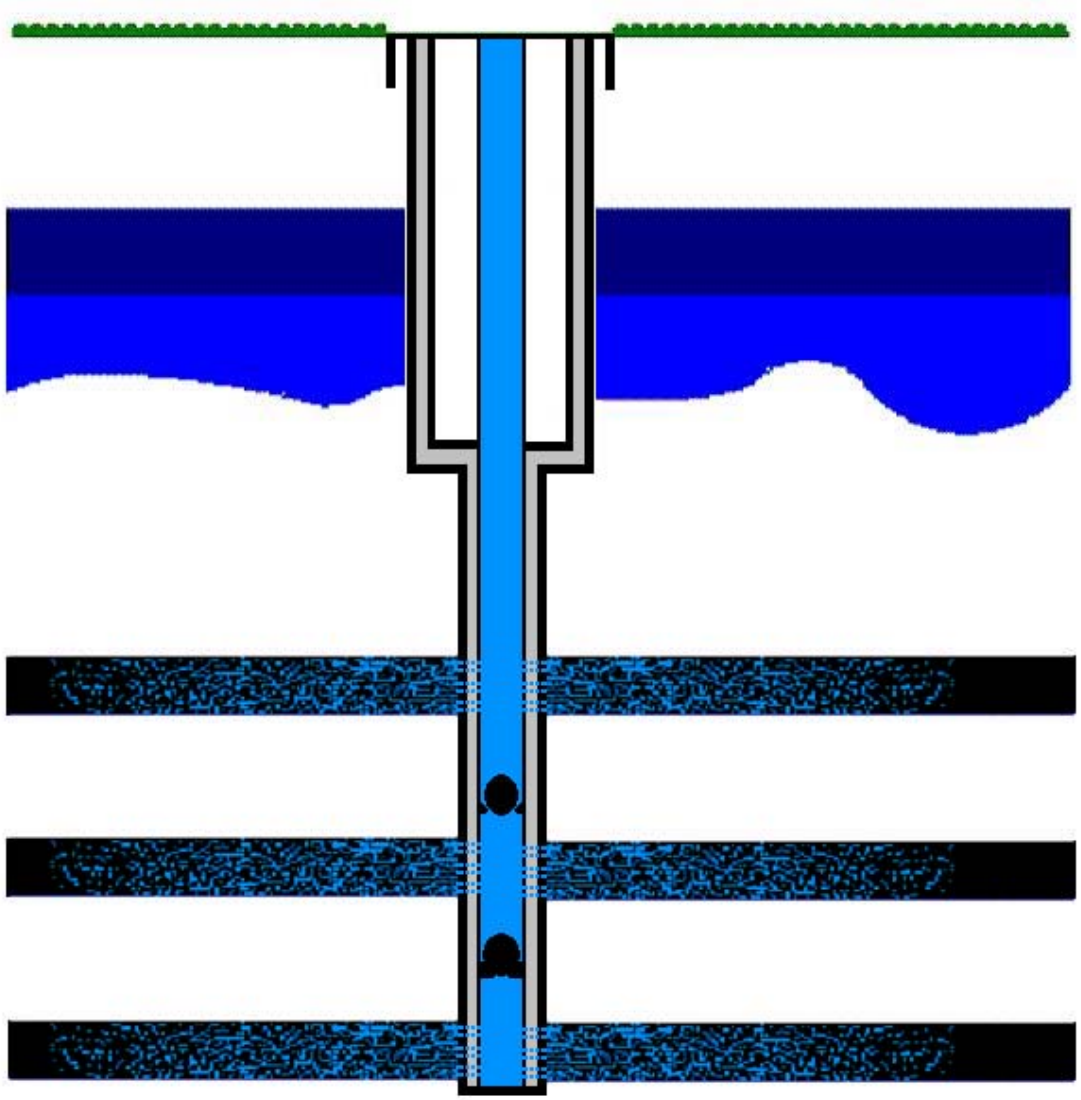
Ground
Water
Gas/Oil
Formations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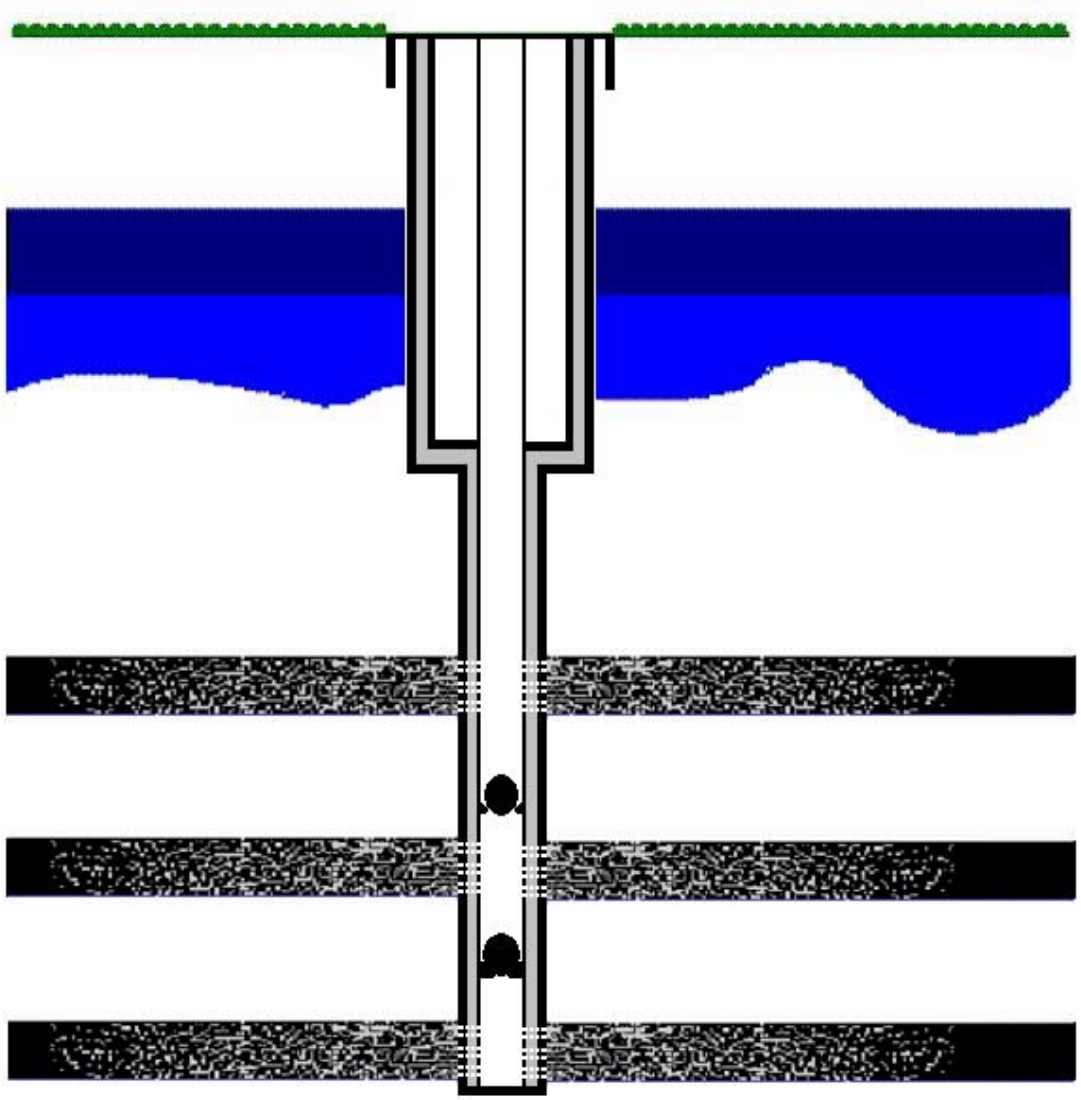
Ground
Water
Gas/Oil
Formations


Fresh
Ground
Water
Gas/Oil
Formations

Hydraulic Fracturing (Hydrofracing)

- Force a fracturing fluid (primarily water) into a sealed off portion of the borehole under high pressure
- The applied pressure causes the formation to fracture, allowing the fracturing fluid to enter further into the formation and extending the cracks
- Solid proppant (usually sand) is added to the fracture fluid to keep fractures open after the injection stops

Hydrofracing (cont'd)

- Hydrofracing typically requires millions of gallons of water
- Flowback water requires off-site treatment
  - Brine
  - Hydrocarbons
  - Metals
  - May be slightly radioactive

Simple Chemical Description

Fortuna Energy

- **Friction Reducer -** 0.5% of total Fluid composition - Similar to Canola Oil
  - **Definition:** A chemical additive that alters fluid properties to reduce friction created within the fluid as it flows through small-diameter tubular or similar restrictions. Generally, these polymers add viscosity to the fluid, which reduces the turbulence induced as the fluid flows.
- **Bactericide -** 0.025% of total fluid composition - Similar to Chlorine in a hot tub
  - **Definition:** An additive that kills bacteria. Bactericides are commonly used in water muds containing natural starches and gums that are especially vulnerable to bacterial attack. Bactericides can be used to control sulfate-reducing bacteria, slime-forming bacteria and iron-oxidizing bacteria. Bactericide is not required for our fracturing process, but is added as a protective measure to avoid contamination of the reservoir.
- **Micro Emulsion -** 0.1% of total fluid composition
  - **Definition:** clear, stable, isotropic liquid mixtures of oil, water and surfactant. The aqueous phase commonly contains salt(s), and the "oil" is a complex mixture of different hydrocarbons and olefins. Micro emulsions have many commercially important uses, for example, floor polishes and cleaners, personal care products, and cutting oils. This is added to our fracture fluid to ensure coating of the formation and effective fracture fluid recovery.

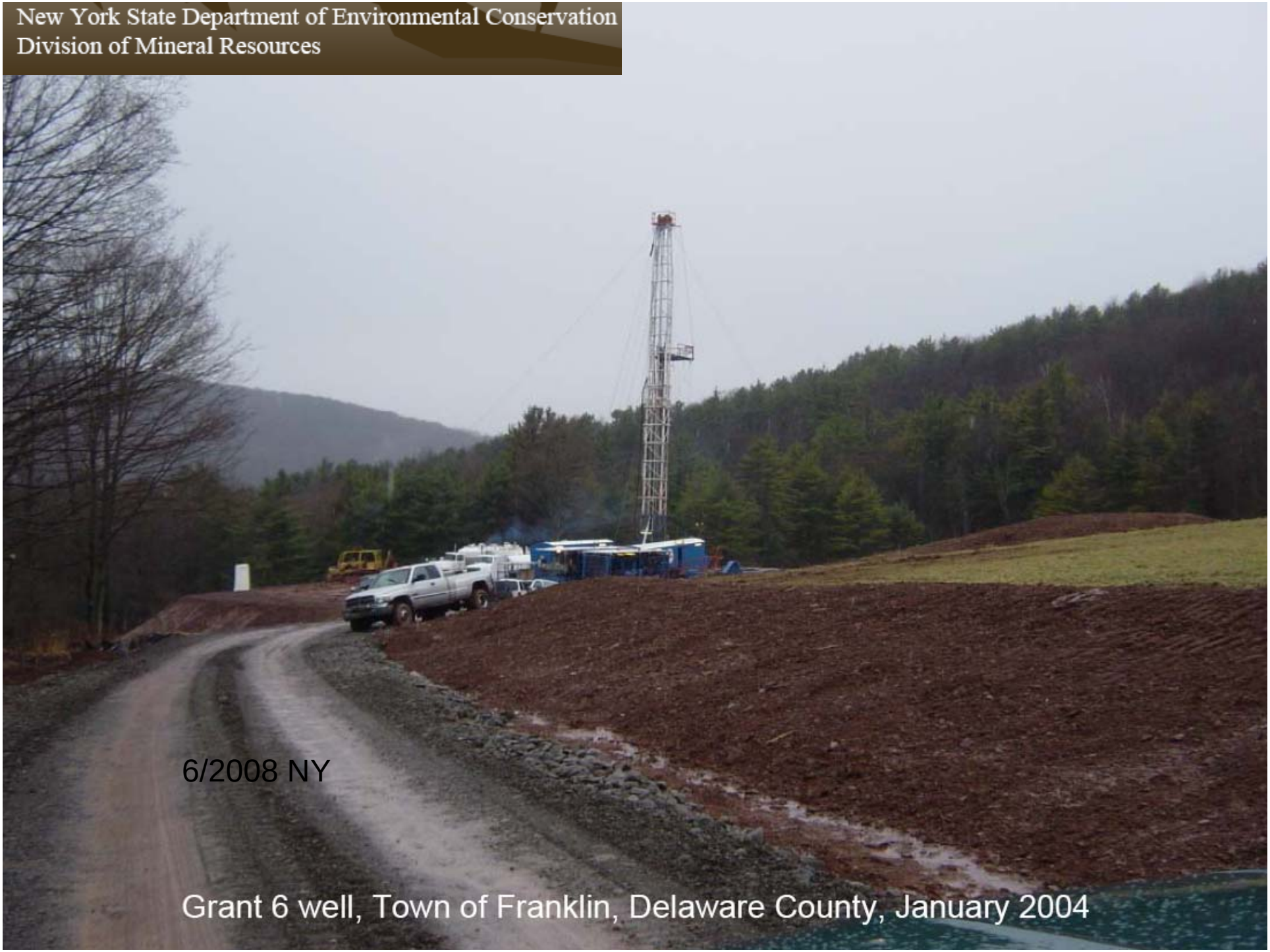
Simple Frac Fluid Composition

	Volume (bbl)	Percentage of Total Fluid Volume (%)
Fresh Water	14,210.6	99.375%
Friction Reducer	71.5	0.500%
Bactericide	3.6	0.025%
Micro Emulsion	14.3	0.100%
Total Fracture Fluid Volume	14,300.0	100.000%

New York State Department of Environmental Conservation
Division of Mineral Resources

Shipman 1A well being drilled, Town of Barton, Tioga County, 2006.

New York State Department of Environmental Conservation
Division of Mineral Resources



Typical Gas Well Site

Image retrieved from: Independent Oil and Gas Association of Pennsylvania's, Drilling & Developing the Marcellus Shale

John Gottschling; BJ Services Company, U.S.A.

John Gottschling; BJ Services Company, U.S.A.


06/01/2009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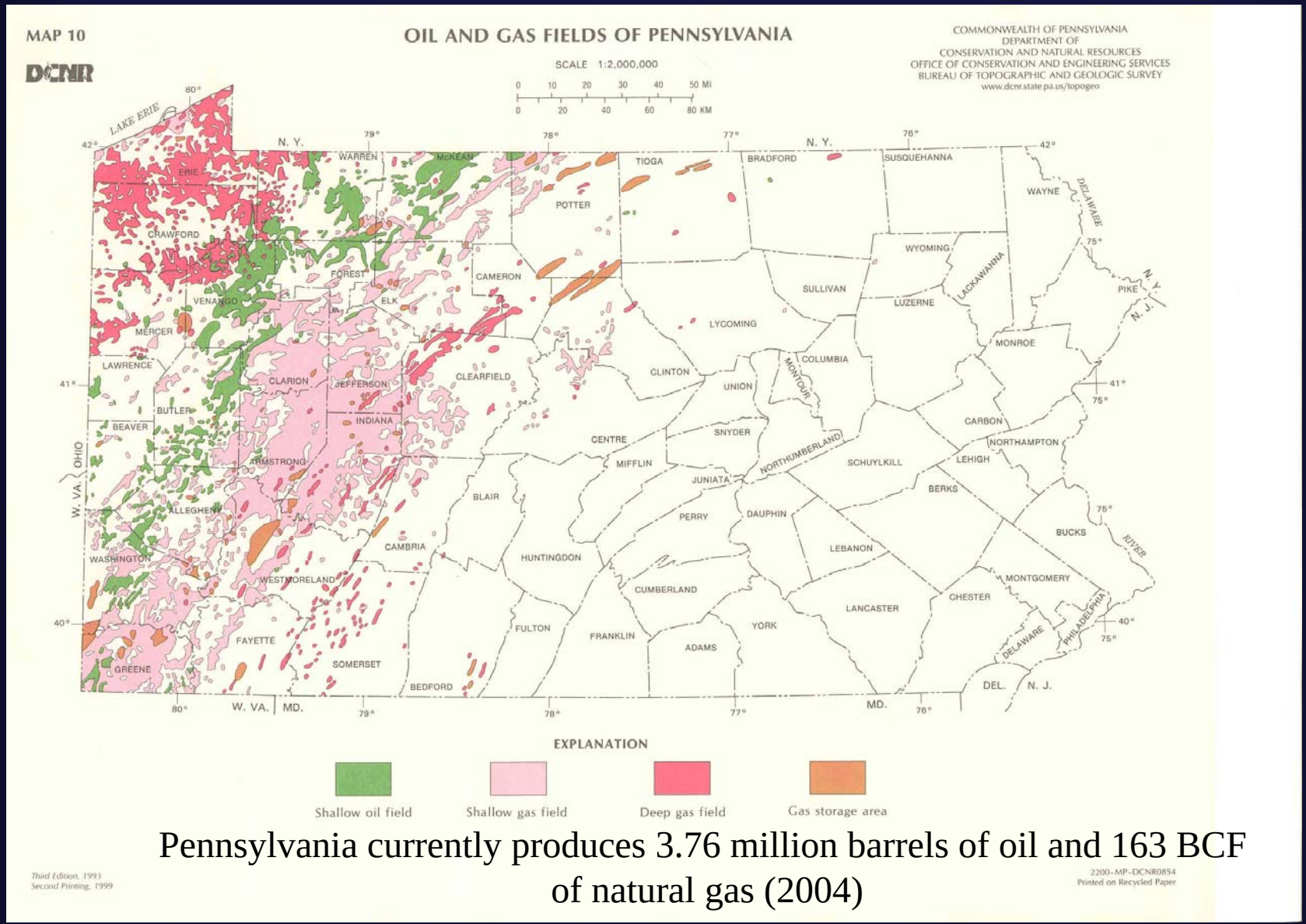
Pennsylvania Oil & Gas Patch



Pennsylvania currently produces 3.76 million barrels of oil and 163 BCF of natural gas (2004)

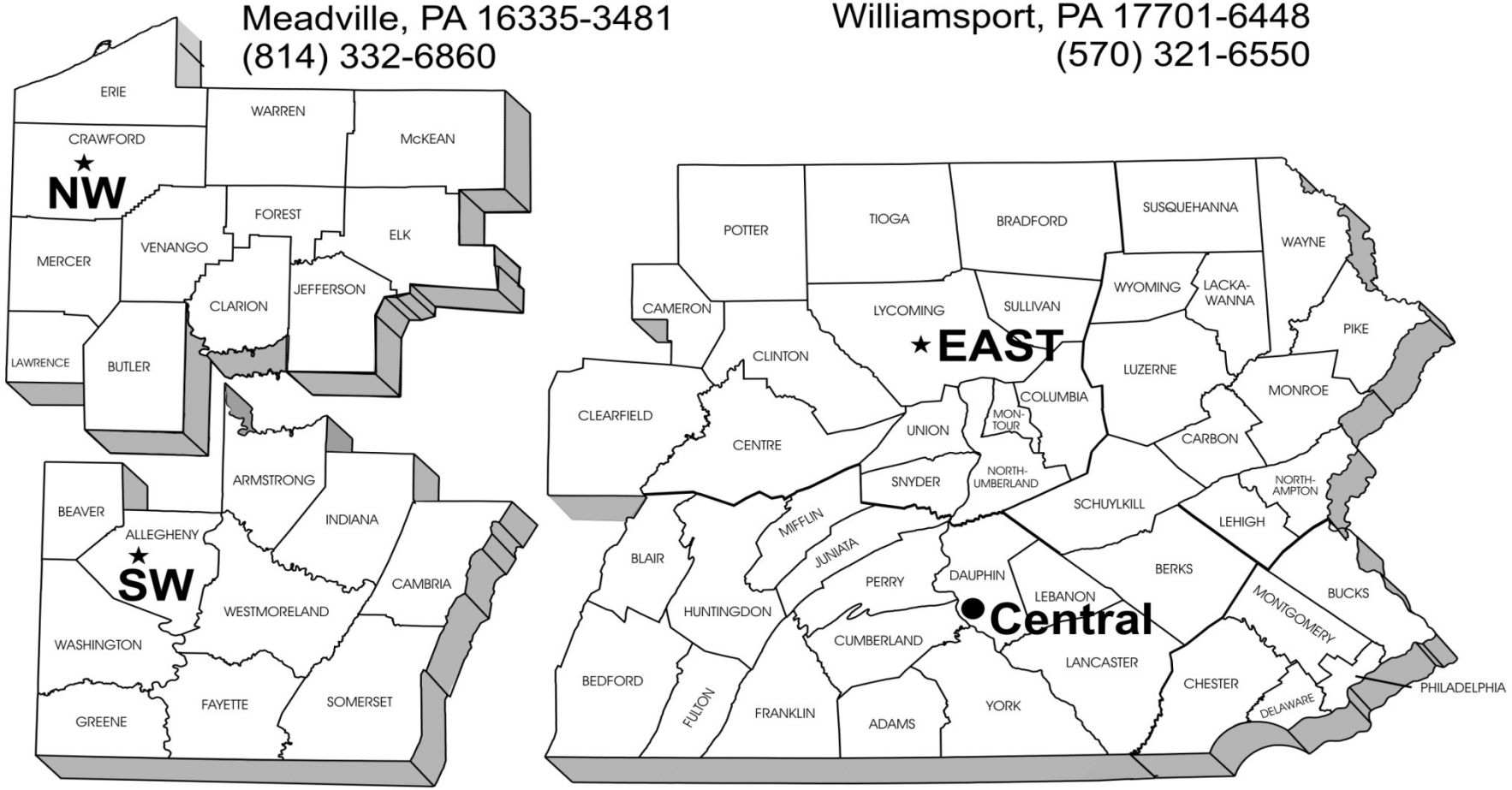
Oil and Gas Regions

★ Northwest Region

230 Chestnut Street
Meadville, PA 16335-3481
(814) 332-6860

★ Eastern Region

208 West Third Street
Williamsport, PA 17701-6448
(570) 321-6550



★ Southwest Region

400 Waterfront Drive
Pittsburgh, PA 15222-4745
(412) 442-4024

● Central Office

Bureau of Oil and Gas Management
PO Box 8765
Harrisburg, PA 17105-8765
(717) 772-2199

JN824

Program Authority

- **Oil and Gas Act**
- 25 Pa Code Chapter 78 – Oil and Gas Wells

- **Oil and Gas Conservation Law**
- 25 Pa Code Chapter 79 – Oil and Gas Conservation

- **Coal and Gas Coordination Act**

Program Authority

Dam Safety and Encroachment Act

- 25 Pa Code 105 – Dams and Waterways Management
- 25 Pa Code 106 – Flood Management

Solid Waste Management Act

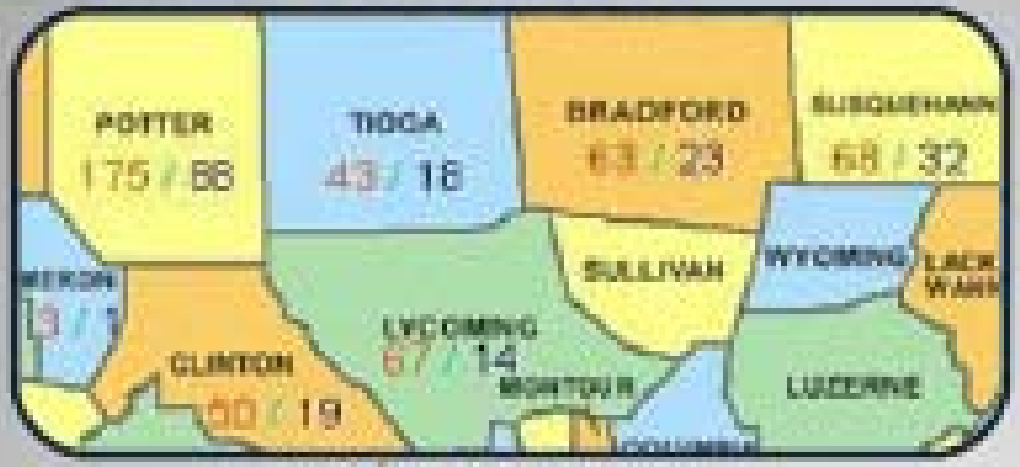
Program Authority

Clean Streams Law

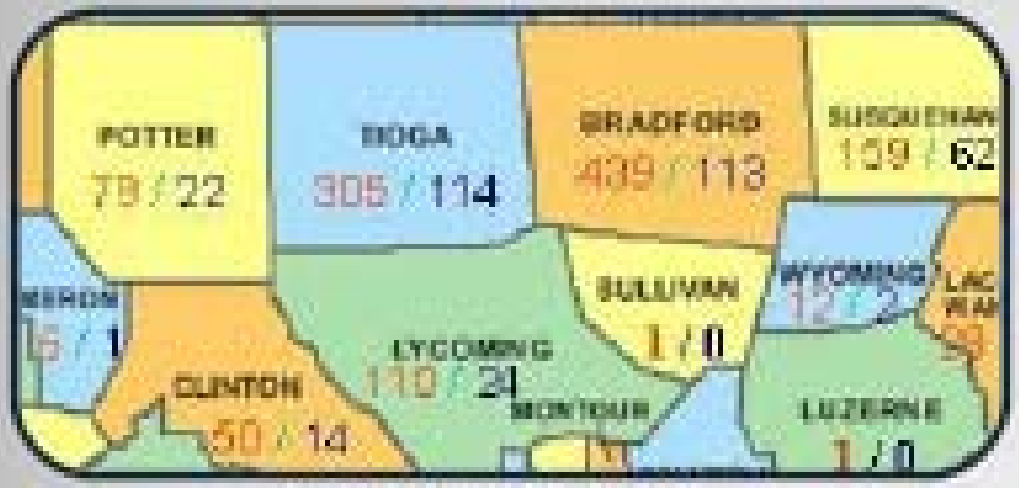
- 25 Pa Code 102 – Erosion and Sediment Control

- 25 Pa Code 91 – General Provisions
- 25 Pa Code 92 – NPDES Permitting, Monitoring and Compliance
- 25 Pa Code 93 – Water Quality Standards
- 25 Pa Code 95 – Waste Water Treatment Requirements
- 25 Pa Code 96 – Water Quality Standards Implementation

Our Status...



2008 thru January (DEP)



2008 thru January (DEP)

To Date

Approximately 1,400 permits have been issued in Bradford County

2008

63 Wells Permitted

23 Wells Drilled

2009

439 Wells Permitted

113 Wells Drilled

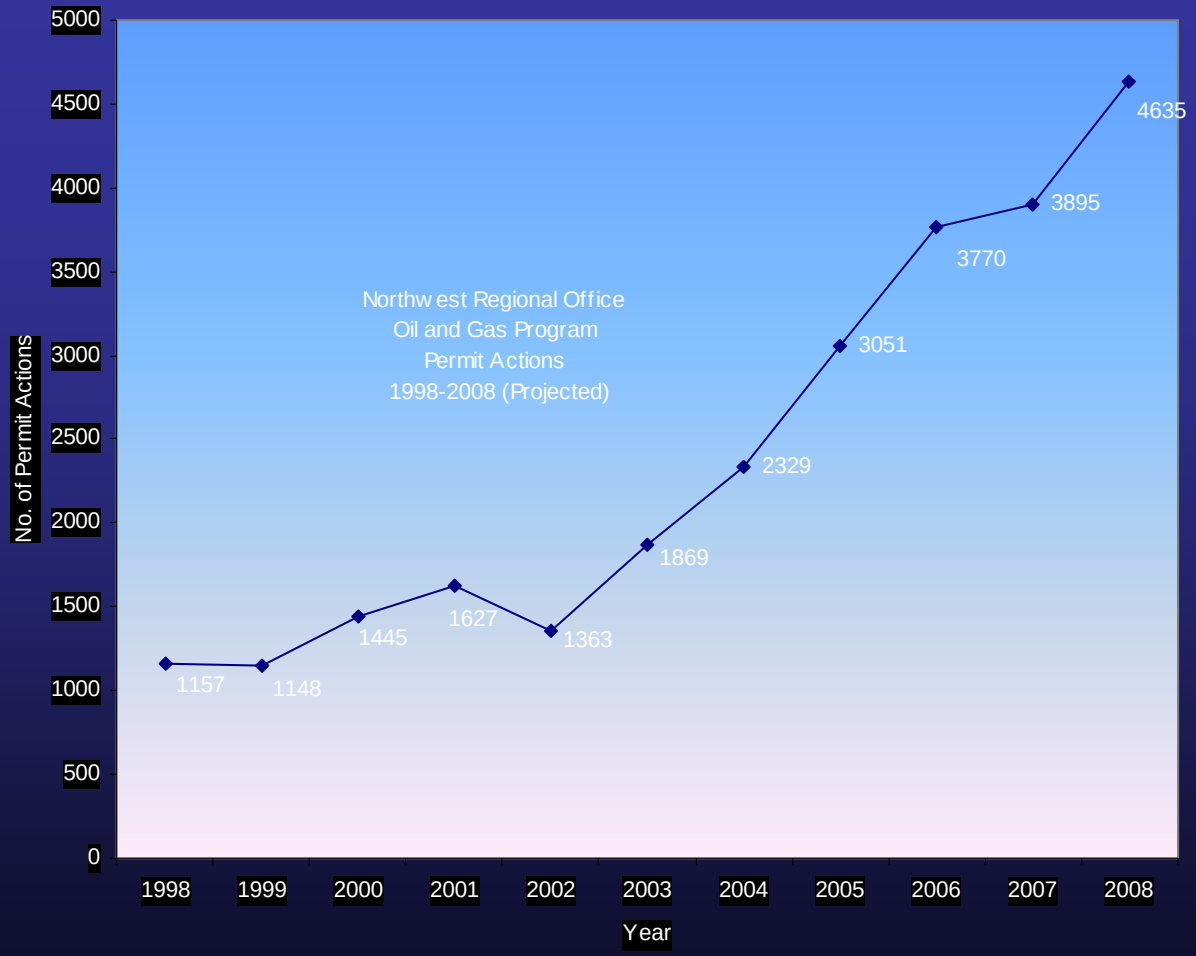
2010

29 well permits issued to Chesapeake, East, Southwestern, Talisman and Chief

In 2007, 7,241 permits were issued.

.

Explosion of Permits

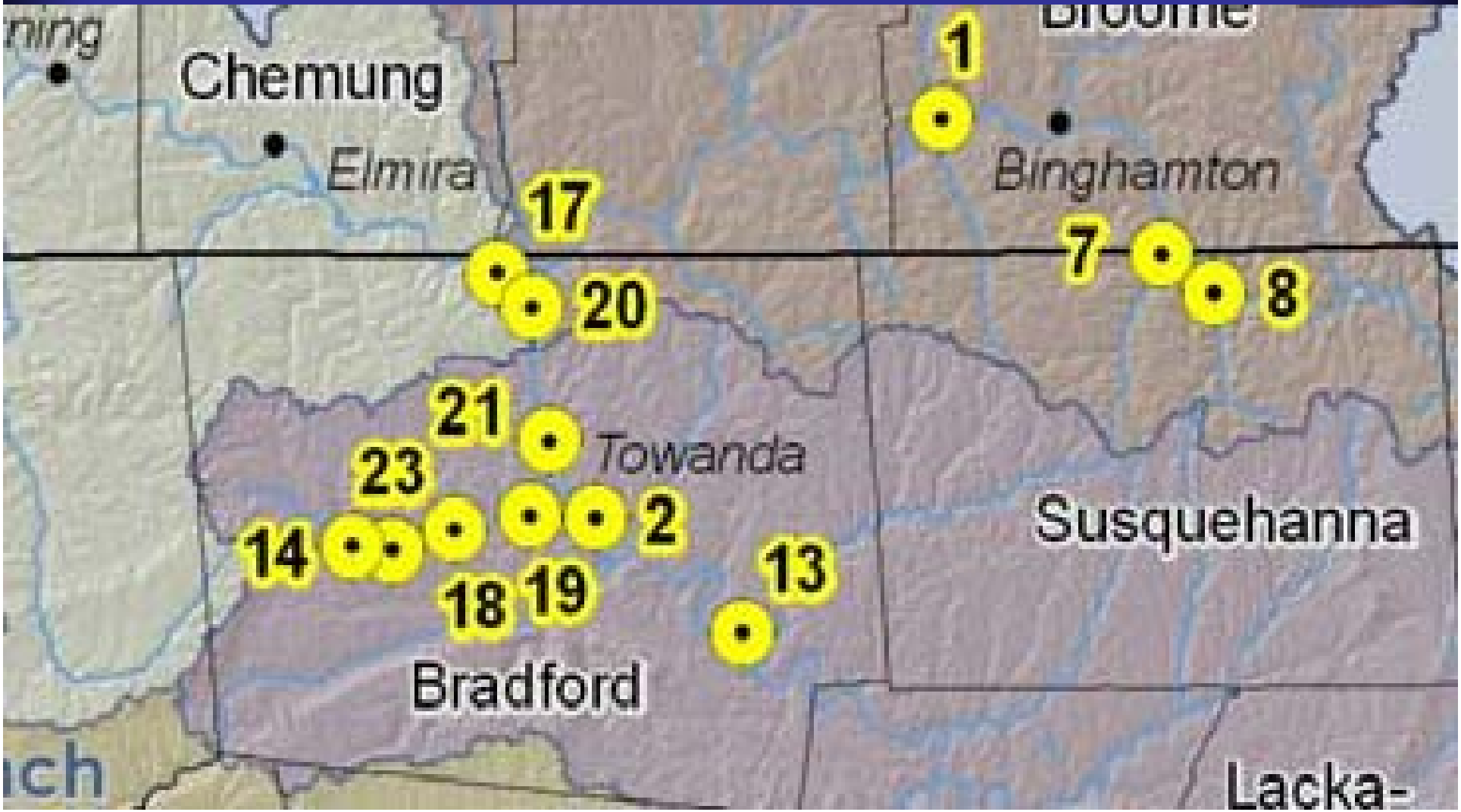


Challenges

- **Environmental / Water**
- **Infrastructure / Roads**
- **Social / Economic**

Sources of Water

SRBC Water Withdrawals
Approved (#) + Pending



Water Issues

- E & S
  - Huge well sites
  - 5 acres disturbed rule
  - New ESCGP-1
  - Some Gas Companies coming around

Water Issues

- Water Management Plans
  - New Well Drill Permit Application
  - Water --- from withdrawal to disposal
  - Reviewed by Watershed Management Program
  - Can’t drill until WMP is approved

Water Management Plan

- Element – Water Withdrawals
  - In conjunction with SRBC
  - Biological review
  - Allowable amounts depends on stream size and classification
  - Stay below 1/10 of Q 7,10 stream flow

Water Management Plan

- Element – Storage Impoundments
  - Big frac water impoundments – 3 to 10 MG
  - Now being reviewed to Dam Safety stds
  - Liner specs
  - Construction protocols

Water Management Plan

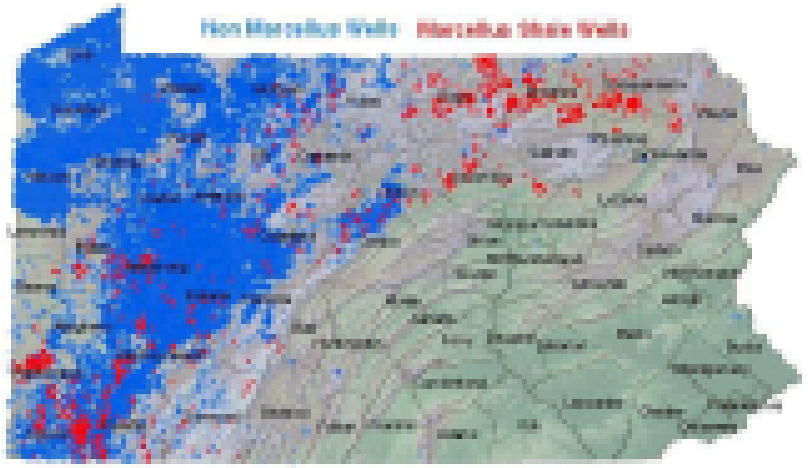
- Element – PPC plan
  - Now reviewed prior to site work
  - MSDS sheets for chemicals on site

Water Management Plan

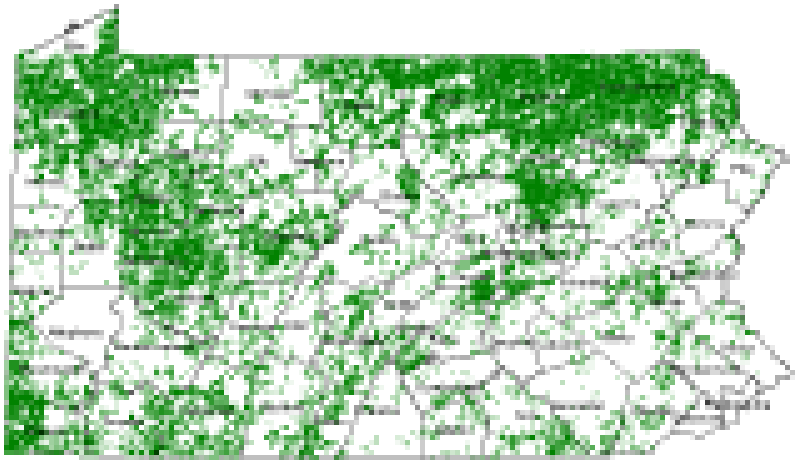
- Element -- Wastewater Disposal
  - Drill water, FRAC WATER, brine
  - Sewage Plants, Brine Plants
  - West Branch Susquehanna – limited assimilative capacity for TDS (salt)

Floodplain Regulation?

Marcellus Shale and Unpaved Roads

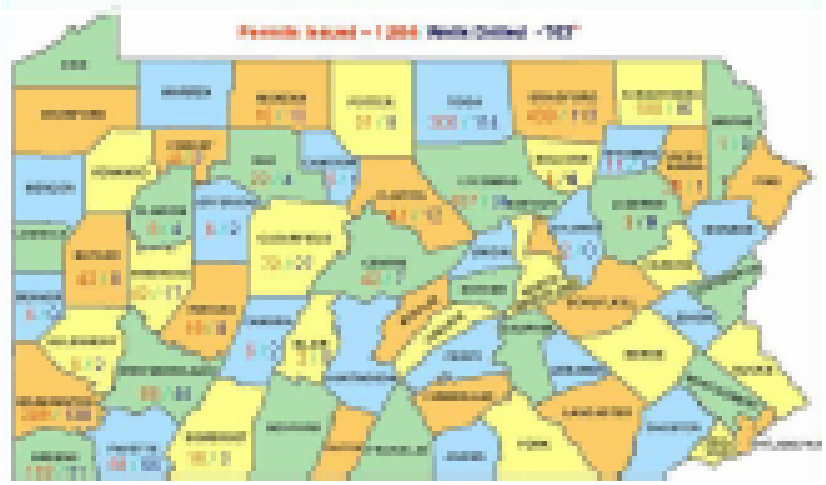


Wells Drilled as of 11/20/09 (Marcellus in red)



17,000 miles of unpaved public roads

State and National Forest Roads are not included



Marcellus Permits Issued and Wells Drilled by County: January – December 2009

As these maps show, the areas of highest unpaved road density are also "hotspots" for Marcellus drilling. Much of this activity is occurring in the poorest rural townships. Each well requires over 300 fully loaded water trucks, not to mention all the other equipment, that need to be hauled over rural roads that were never designed to carry these heavy loads.

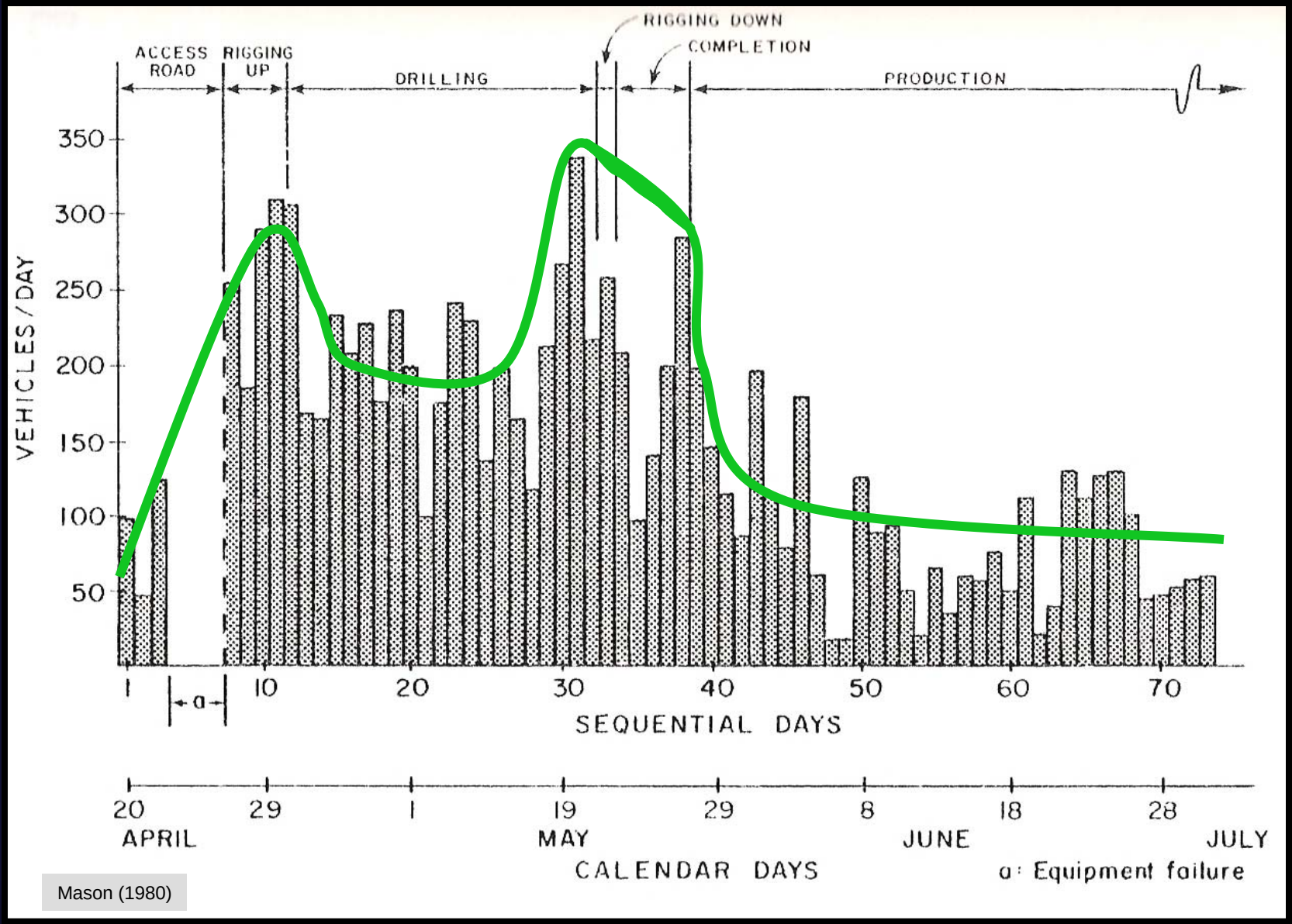
2/22/10 – PSU Center for Dirt and Gravel Road Studies 814-865-5355

Roads

Precedent for anticipated impact of gas field traffic on municipal roads:

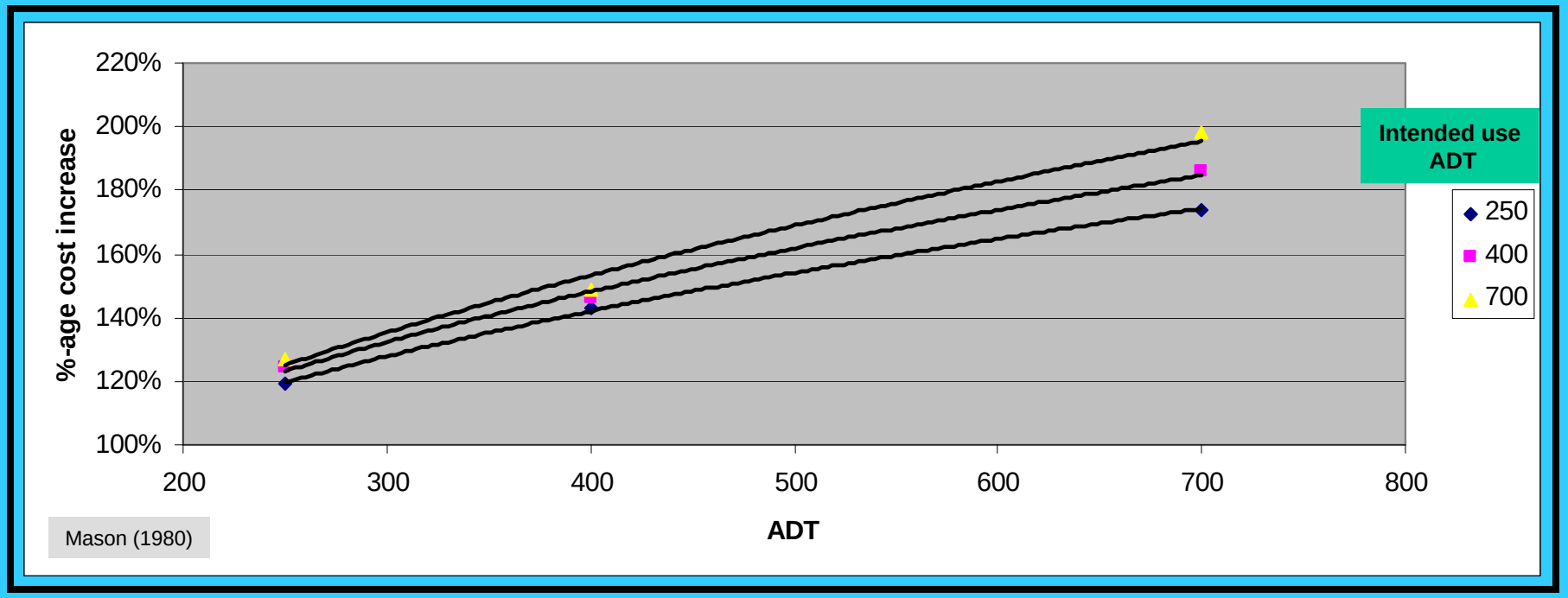
John M. Mason (1980) *"Investigation of the effects of oil field traffic on low volume roadways"* Ph.D., Texas A&M University.

Typical Vehicles/Day Count at Well Site



Mason (1980)

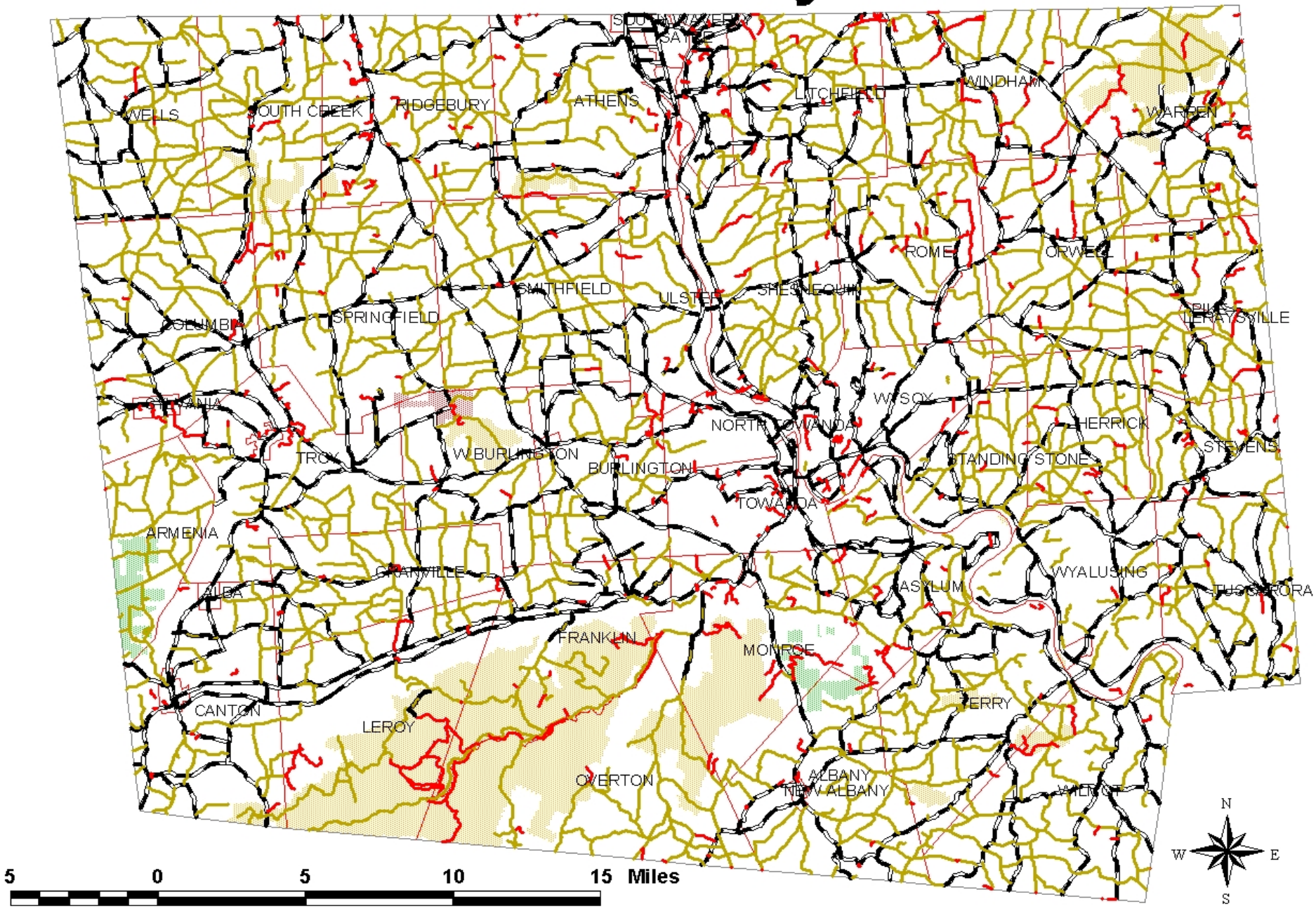
Additional Maintenance Costs for Tar & Chip Road Servicing 1, 2, and 3 Wells

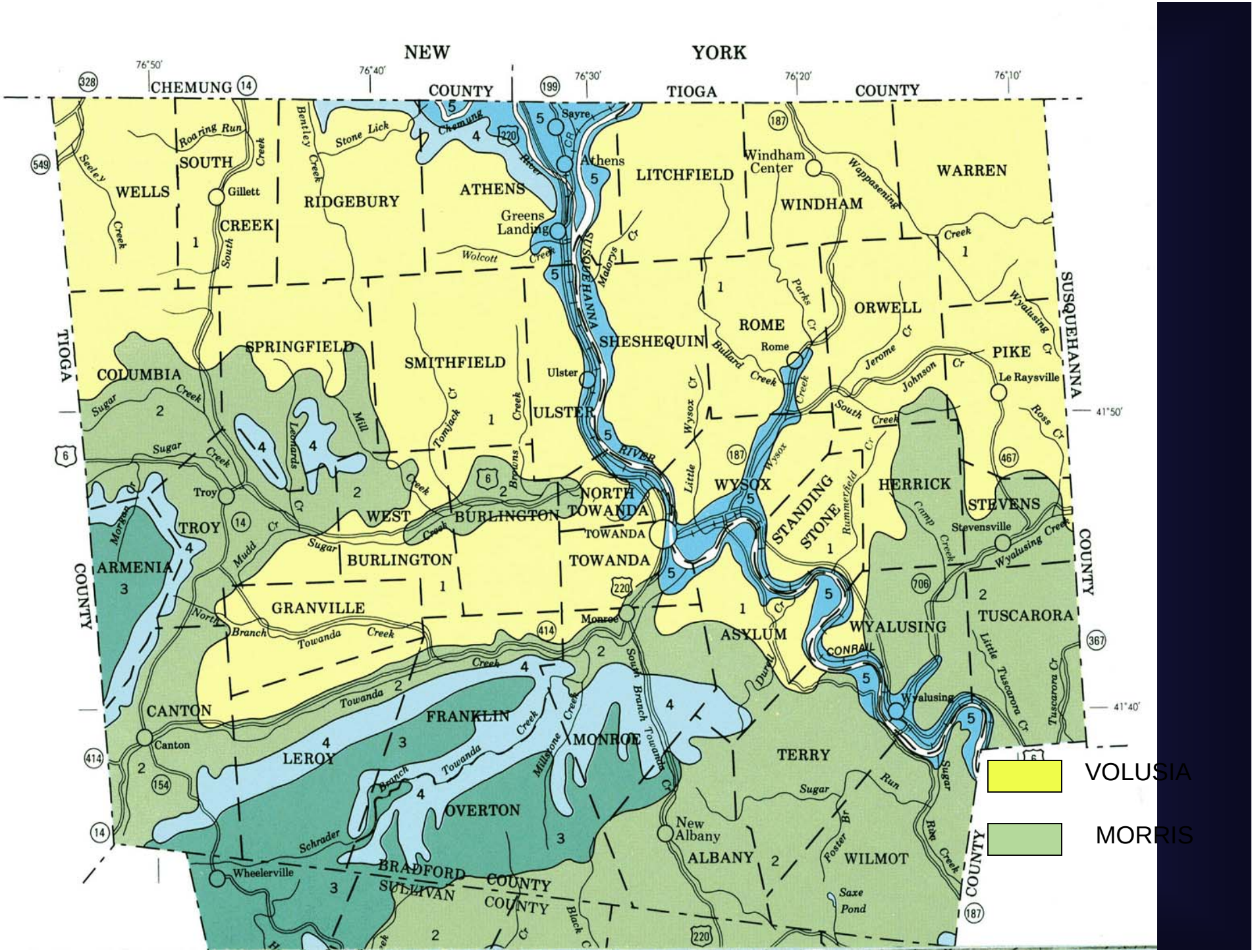


Assumptions:

- Tar & chip road
- 5% trucks in total vehicle 'intended use' calculations
- Escalated for traffic growth
- Escalated for current worth of money
- Based on AASHTO durability calculations
- Based on 1980 dollars
- Based on loss of service life from enhance traffic
- Based on duration of enhance traffic

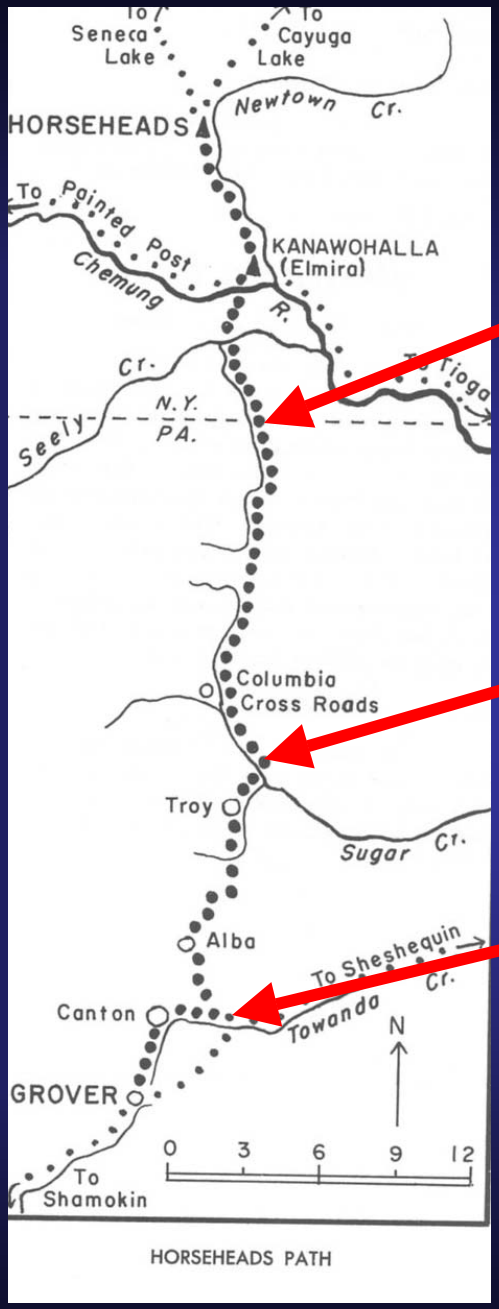
Bradford County Roads




NEW YORK
CHEMUNG COUNTY
TIOGA COUNTY
SUSQUEHANNA COUNTY
TIOGA COUNTY
BRADFORD COUNTY
SULLIVAN COUNTY
WELLS
SOUTH CREEK
RIDGEBURY
ATHENS
LITCHFIELD
WINDHAM
WARREN
ROME
ORWELL
PIKE
SHESHEQUIN
ULSTER
SMITHFIELD
SPRINGFIELD
COLUMBIA
TROY
ARMENIA
WEST BURLINGTON
BURLINGTON
NORTH TOWANDA
TOWANDA
GRANVILLE
WYSOX
STANDING STONE
HERRICK
STEVENS
TUSCARORA
WYALUSING
ASYLUM
CANTON
FRANKLIN
LEROY
MONROE
OVERTON
TERRY
ALBANY
WILMOT
Sayre
Athens
Windham Center
Greens Landing
Rome
Ulster
Le Raysville
Troy
Canton
Monroe
Stevensville
Wyalusing
New Albany
Wheelerville
Saxe Pond
Gillett
Roaring Run
Seeley Creek
Stone Lick
Bentley Creek
Chemung River
Wolcott Creek
Susquehanna River
Maloys Cr
Wappasening Creek
Parks Cr
Bullard Creek
Jerome Cr
Johnson Cr
Wyalusing Cr
South Creek
Ross Cr
Sugar Creek
Mill Creek
Leonards Cr
Tomjack Cr
Bryans Creek
Wysox Cr
Little Wysox Creek
Rummerfield Cr
Camp Creek
Morgan Cr
Mudd Creek
North Branch Towanda Creek
Towanda Creek
South Branch Towanda Creek
Millstone Creek
Durell Cr
Little Tuscarora Cr
Tuscarora Cr
Foster Br Sugar Run
Sugar Run Creek
Schrader Creek
Black Cr
CONRAIL
76°50'
76°40'
76°30'
76°20'
76°10'
41°50'
41°40'
328
14
199
187
549
6
220
467
706
414
154
367
VOLUSIA
MORRIS

SOIL SURVEY OF BRADFORD AND SULLIVAN COUNTIES PENNSYLVANIA

- Table 10 – Building Site Development
  - Local roads and streets
    - Volusia – “Severe: wetness and frost action”
- Table 12 – Construction Materials
  - Roadfill
    - Volusia – “Poor: wetness”


To Seneca Lake
To Cayuga Lake
Newtown Cr.
HORSEHEADS
To Painted Post
Chemung R.
KANAWOHALLA (Elmira)
Cr.
N.Y.
PA.
Seely
To Tioga
Columbia Cross Roads
Troy
Sugar Cr.
Alba
To Sheshequin
Towanda Cr.
Canton
GROVER
N
0 3 6 9 12
To Shamokin
HORSEHEADS PATH

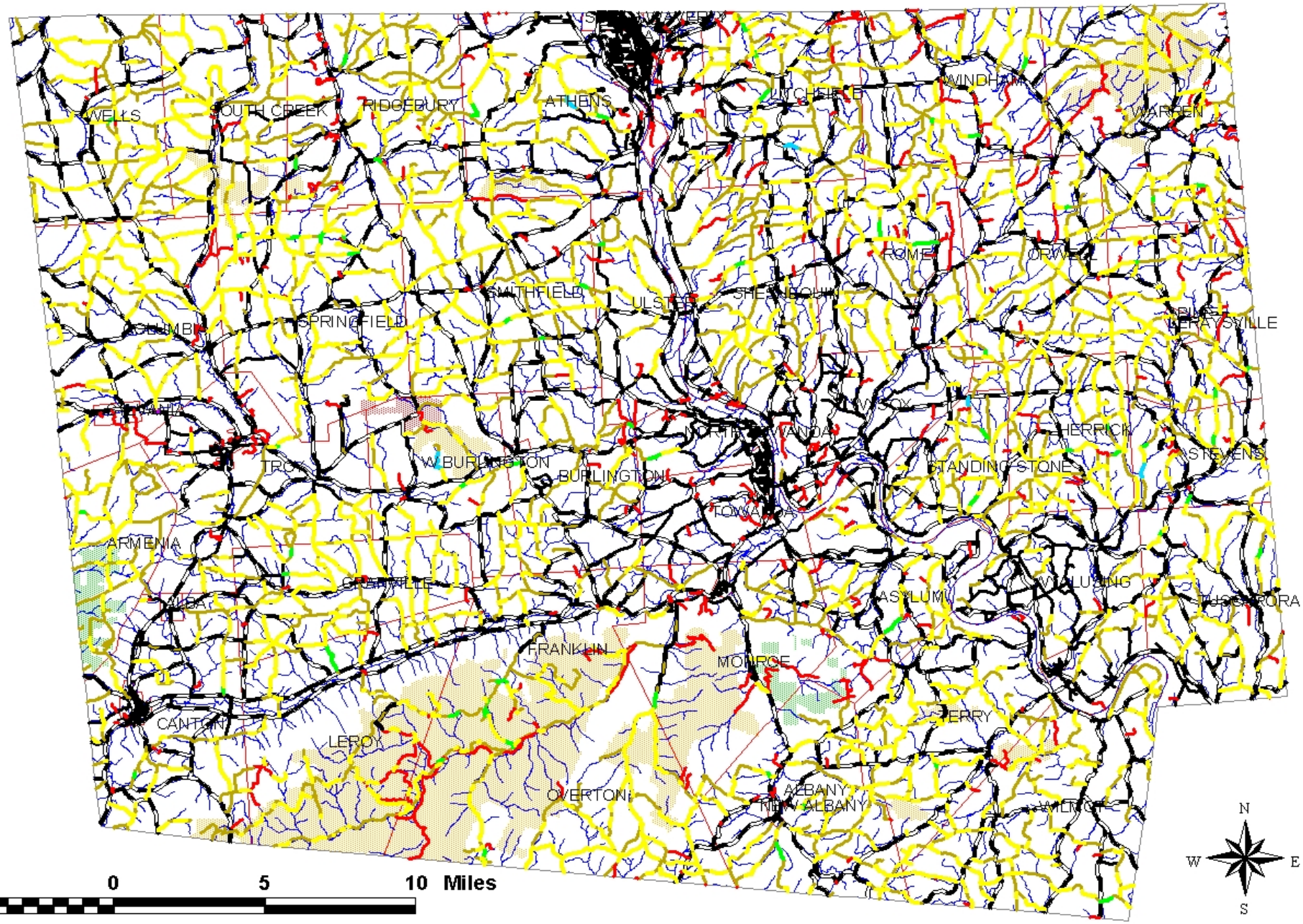

Southport
Webbs Mills
Seeley Creek
Wellsbu
Mosherville
Gillett
Center
Jobs Corners
Snedekerville
Big Pond
Roseville
Springfield
Austinville
Columbia Cross Roads
Leona
Wetona
162.55 MHz
Sylvania
Troy
East Troy
36
Granville Summit
Alba
COUNTY BRIDGE
East Canton
Le Roy
Towanda
Canton
Grover
DEVILS ELBOW
Creek
Wheelerville
Roaring Branch
Ellenton
Shunk
Ralston
OLD LOGGERS PATH
Lincoln Falls
WORLDS
Hillsgrove
134

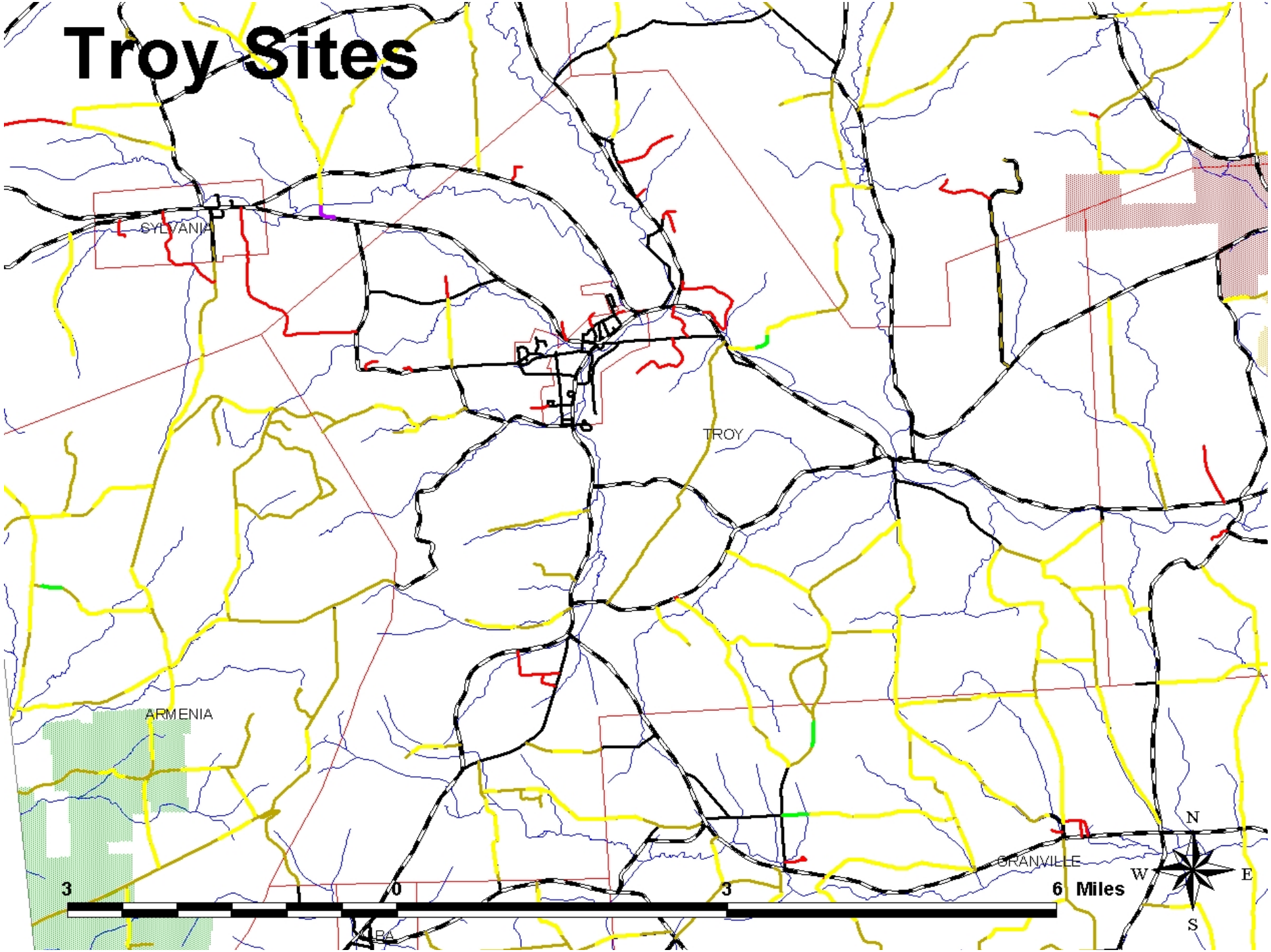
2008 Bradford County Dirt & Gravel Roads Program Inventory Summary

- 1554.7 miles of dirt & gravel roads in Bradford County
  - 50.95 miles in designated high quality watersheds
  - 85.55 miles in designated exceptional value watersheds

- 2016 Sites that have potential for adverse environmental (water quality) impacts
  - 626.1 miles

Bradford County Sites




Troy Sites
SYLVANIA
TROY
ARMENIA
GRANVILLE
3
0
3
6 Miles
N
W
E
S

7/16/08 Oil and Gas Roads Roundtable – survey summary

The following is a summary of answers to four questions asked via e-mail to registered roundtable attendees. Respondents were predominantly from Conservation Districts and other PA State Agencies such as DEP and PENNDOT.

- **What do you see as the biggest ROAD problem stemming from new well drilling operations?**

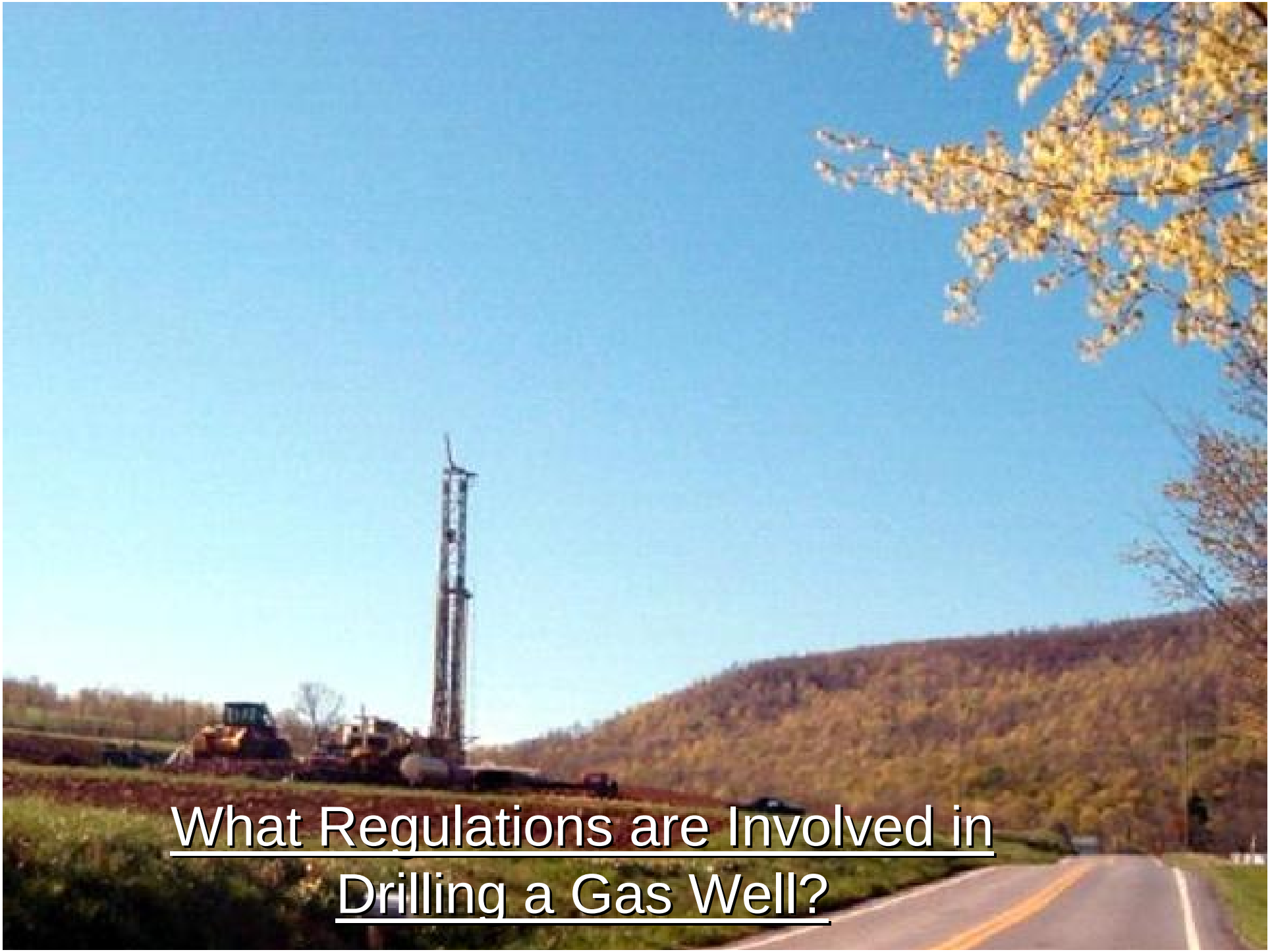
- **#1 response:** Damage caused to local roads due to heavy truck traffic.
- **#2 response:** Environmental impacts to streams from road runoff

Fire break and Gordon roads-RUA 2006

Road Management Strategies

- **Posting and Bonding of Roads**
  - In order to have a case in court, municipalities must post weight limits on roads prior to hauling activity. After posting, the municipality may permit heavier loads to be hauled on the road and may require a bond from the hauler.

- **Road Use/Maintenance Agreements**


What Regulations are Involved in Drilling a Gas Well?

Permits, Etc.

To drill a gas well in Pennsylvania the operator needs…

- **a drilling permit**
- **an E & S plan**

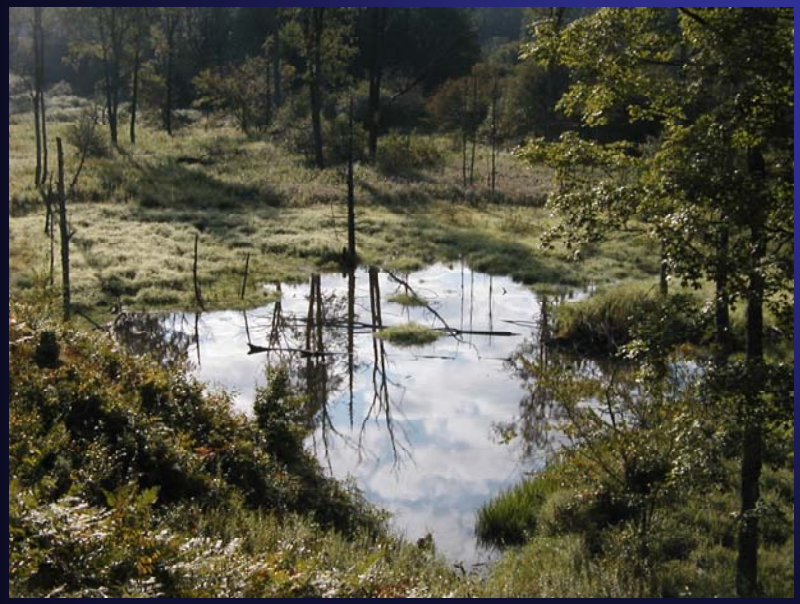
Additional permits and/or approvals may be needed

- **PennDOT highway occupancy permit**
- **Chapter 105 encroachment permit**
- **Stormwater Management permit for projects affecting more than 5 acres**

Protection of Streams and Wetlands

25 Pa. Code Chapter 105

Oil and Gas Act



Threatened & Endangered Species

PA's Game Commission

Responsibility: The Commission is responsible for managing all of Pennsylvania's wild birds and mammals specially the endangered ones .

PA's Fish & Boat Commission

Responsibility: Threatened and endangered fish, reptiles and amphibians

U.S. Fish & Wildlife Service

Responsibility: Responsible for managing & protecting the threatened and endangered species of Pennsylvania, and the rest of the United States. In particular the endangered species.

Department of Conservation and Natural Resources

Responsibility: It is responsible for plants and geological structures in Pennsylvania.

Commission Regulation

- Consumptive water use definition (§806.3)
  - The loss of water transferred through a manmade conveyance system or any integral part thereof (including such water that is purveyed through a public water supply system), due to transpiration by vegetation, incorporation into products during their manufacture, evaporation, ***injection of water or wastewater into a subsurface formation from which it would not reasonably be available for future use in the basin***, diversion from the basin, or other process by which the water is not returned to the waters of the basin undiminished in quantity.

Commission Regulation (cont'd)

- Projects requiring review and approval
  - Consumptive water use §806.4(a)(1)
    - 20,000 gpd/30-day average (600,000 gallons)
  - Water withdrawals §806.4(a)(2)(iii)
    - 100,000 gpd/30-day average (3,000,000 gallons)
    - Any project which involves a withdrawal from a groundwater or surface water source and which is subject to the requirements of §806.4(a)(1) regarding consumptive use.

Distance Restrictions:

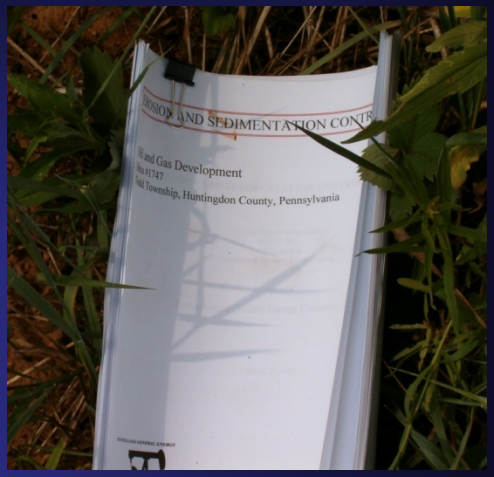
- 100 ft. - stream, spring or body of water identified on the most current 7 ½ minute USGS topographic map.
- 100 ft. must be maintained to any wetland greater than one acre in size.
- 200 ft from an existing building or water well without written consent of the owner.
- The department may grant a waiver to the distance restriction.

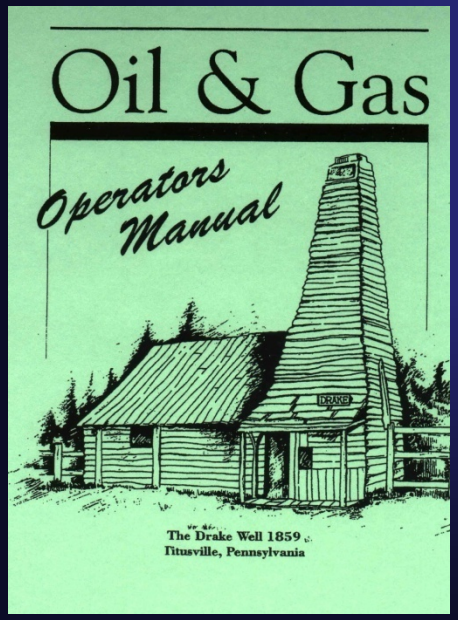
There is, however, no restriction on how close you can build your home to a gas well. Well…

Let's Make a Plan.

History

Sept 29, 1972 – 25 PA Code Chapter 102 adopted. Oil & Gas Operators were required to prepare Erosion and Sediment Control plans.





1981 – Department's First Erosion and Sediment Control Manual for oil & gas well operations (Now incorporated in the Oil and Gas Operators Manual.)

Erosion and Sediment Control Plan

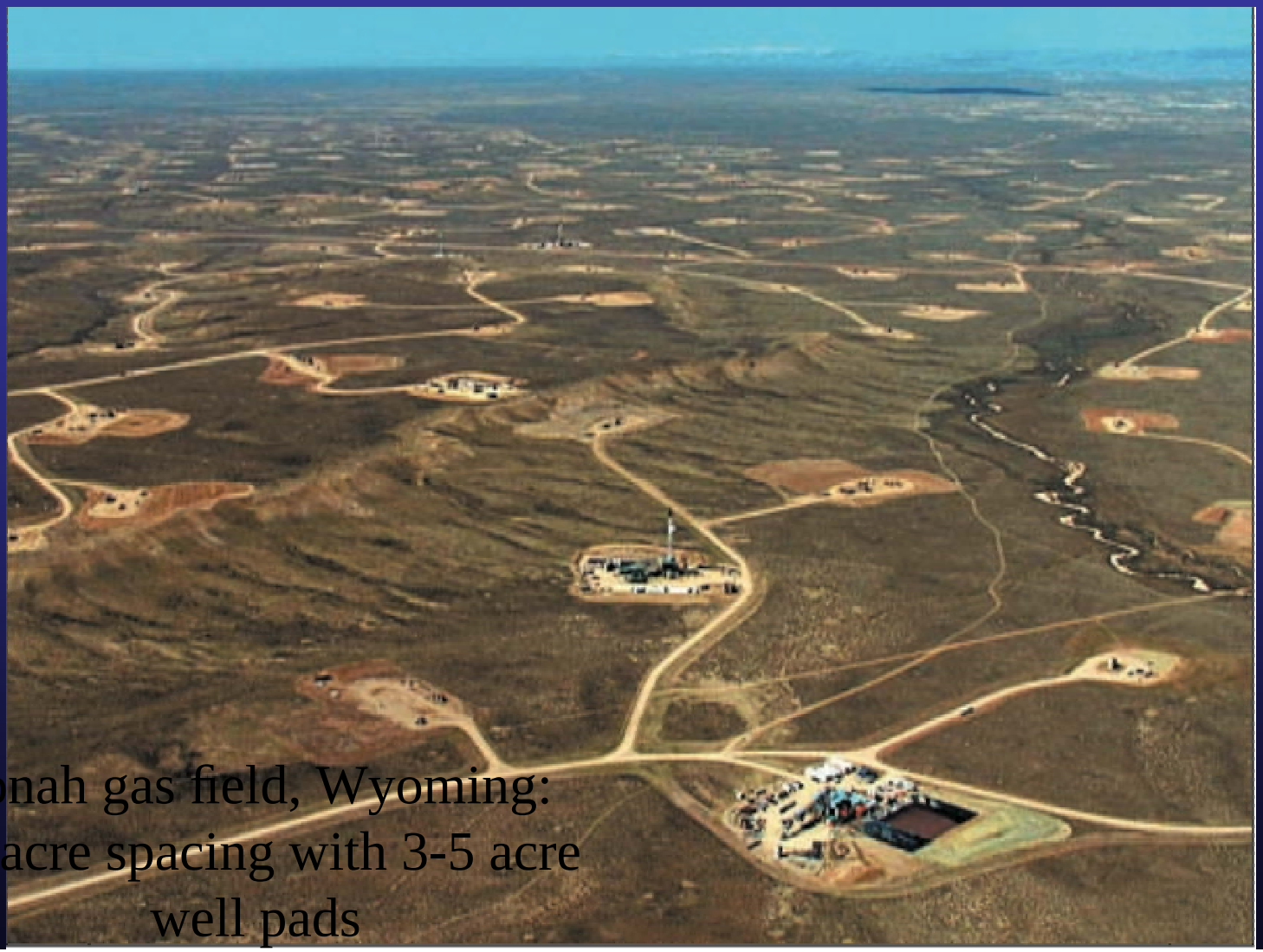
Erosion & Sediment Controls

(BMPs)_

Minimize the Disturbance

Pipeline Trenching

IMPACTS ON LANDSCAPES



Jonah gas field, Wyoming:
40 acre spacing with 3-5 acre well pads

8’ below the streambed

Pipeline Stream Crossings

220’ bore length

The End Result


MUSSER
FORESTS
INC

Bioretention / Infiltration Area

Stabilized road surface

You might see this…

Common Questions

Protection of Water Supplies

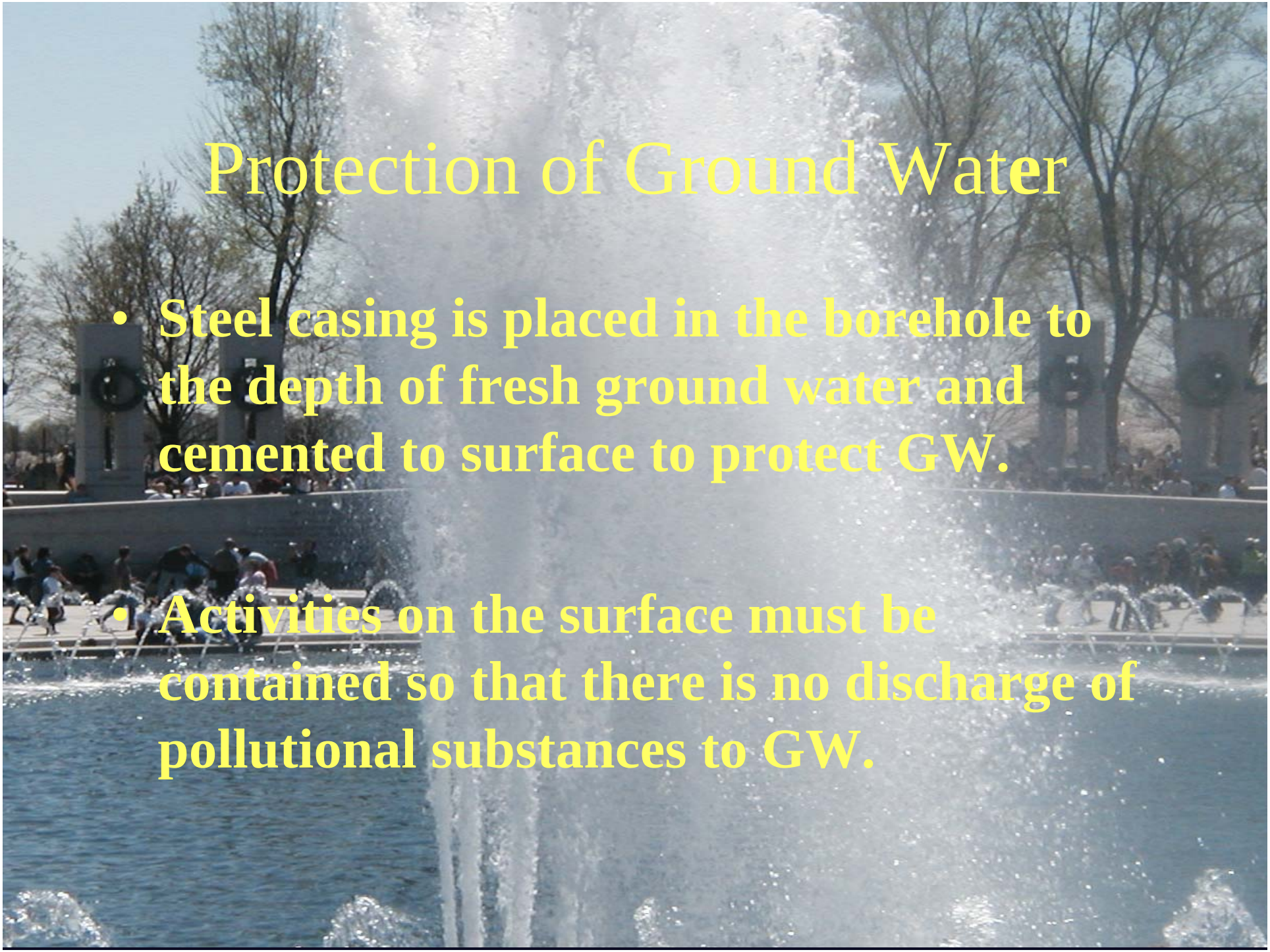
Water Supply Replacement

- Operator responsible for replacing water supply if quality or quantity affected
- Complaint – DEP has 10 days to investigate and 45 days to make a determination
- Issue orders as appropriate

Whenever a suspected gas/oil well related water loss or degradation occurs it should be reported to the Bureau of Oil & Gas Mgmt. regional office for further investigation.

“presumption of responsibility”

An operator is responsible for any degradation of a water supply within 1000 ft of the gas well that occurs within six months of the completion of drilling, unless the operator can prove otherwise.



Protection of Ground Water

- **Steel casing is placed in the borehole to the depth of fresh ground water and cemented to surface to protect GW.**
- **Activities on the surface must be contained so that there is no discharge of pollutional substances to GW.**

Will having a gas well or wells located on my farm jeopardize my involvement in agricultural land preservation?

The Agricultural Area Security Law (Act of June 30, 1981, P.L. 128, No. 43) (3 P.S. 901-915) was passed to help the Commonwealth preserve our rich agricultural heritage. Section 914.1(c) 6 of the Act states that an agricultural conservation easement shall not prevent the utilization of any coal, gas or oil rights by the owner of the land or the owner of the coal, gas or oil.

What happens to the fluids used during drilling and production?

All fluids encountered during the drilling and fracing of a gas well are collected in lined sumps.

The water encountered when drilling through the fresh water zones is commonly referred to as “top hole water”. If this water meets specific criteria for pH, conductivity and is not contaminated with any other substance it may be land applied and allowed to infiltrate back into the ground.

All other drilling, fracing and production fluid is hauled to a permitted treatment facility

Treatment would occur at a plant that has an NPDES permit that has specific discharge limits. An NPDES Permit issued by DEP satisfies state as well as USEPA requirements.

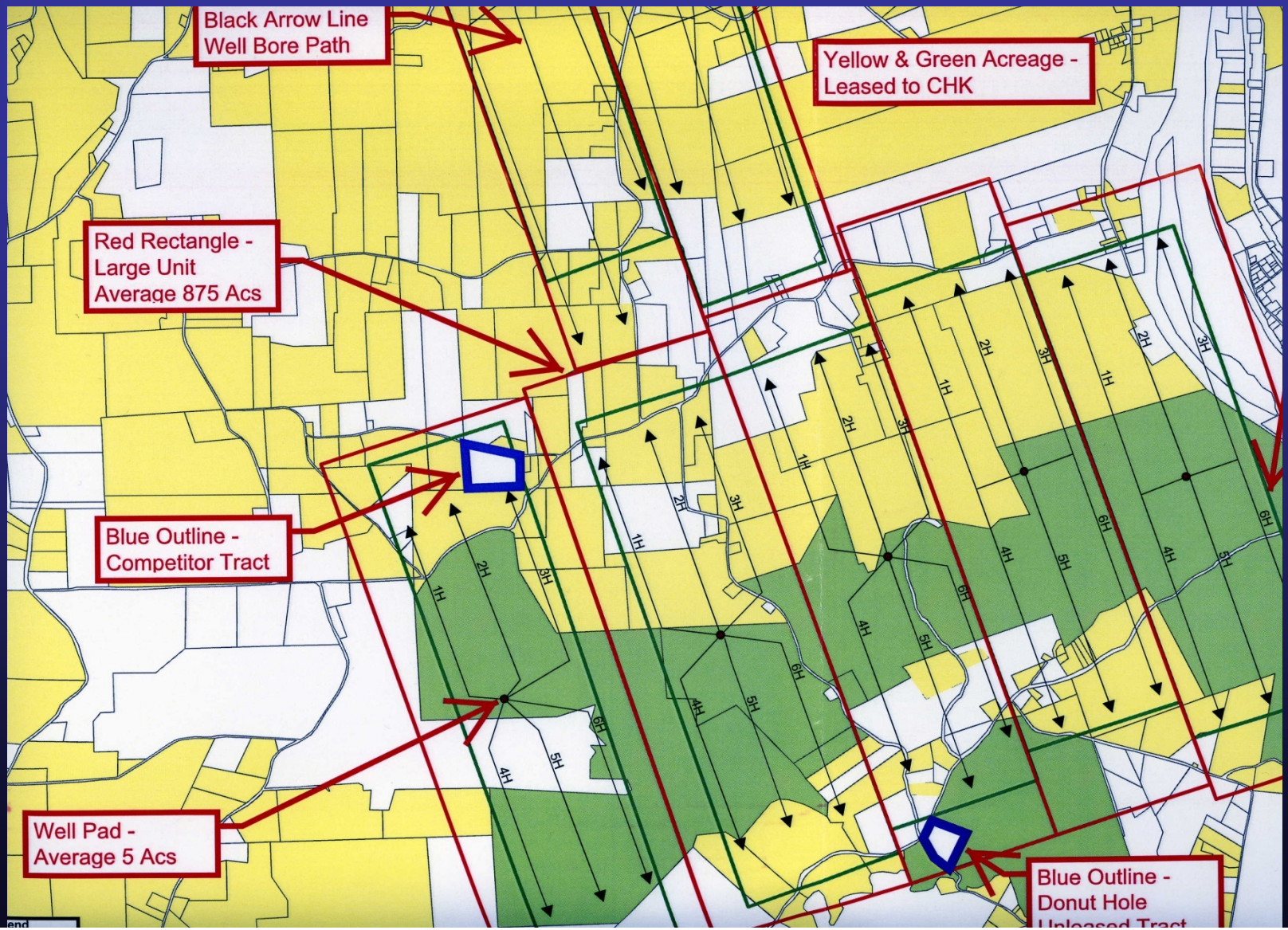
Be Smart Out There

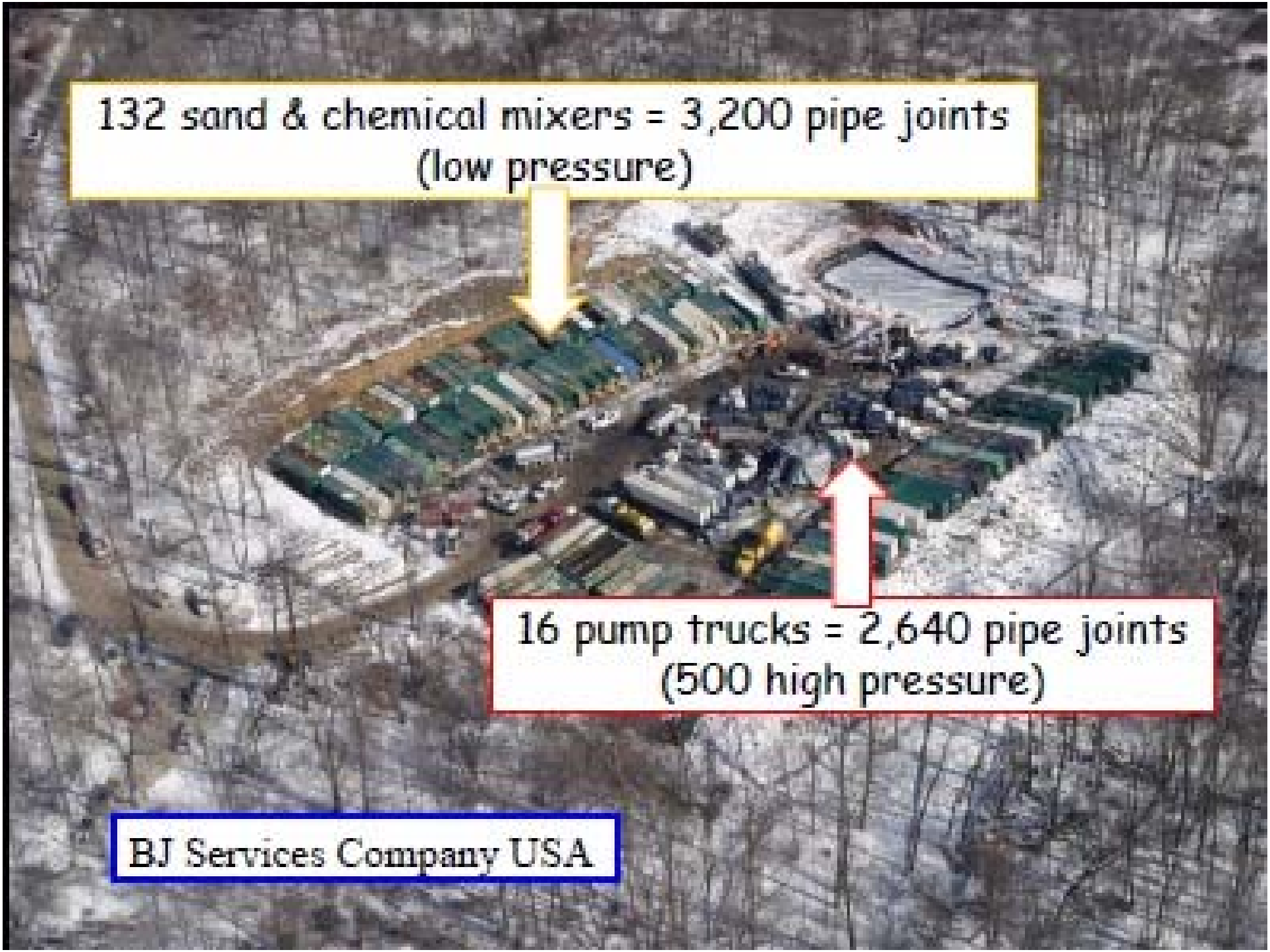
OTHER GAS RELATED ISSUES

- Water Quantity and Quality
  - Drilling Process
  - Withdrawals
  - Erosion & Sedimentation
- Waste Handling
  - Treatment Plants
  - Specialized Treatment
  - Injection Wells
- Landowners
  - Leases
  - Wells, Pipelines, Utilities, Compressor Stations, Injection Wells

Drilling Units

Drilling Units




132 sand & chemical mixers = 3,200 pipe joints
(low pressure)
16 pump trucks = 2,640 pipe joints
(500 high pressure)
BJ Services Company USA

OTHER GAS RELATED ISSUES

- Legal Assistance
- Local Industry
  - Labor competition
  - Gearing up to support
- Education
  - Skills & Knowledge to support new opportunities
- Bankers / Real Estate
  - Value of property?
  - With and without gas rights
  - Housing

OTHER GAS RELATED ISSUES

- Local Municipalities
  - Infrastructure needs
  - Lack of Income
- Counties
  - Tax issues
  - Infrastructure concerns

Possibilities in Pennsylvania?

- LOTS of dollars flowing into the local economy. How to keep ‘em here?
  - Jobs?
    - Locals HAVE the skills?
    - Or LEARN the skills?
    - Or get newcomers to move into county?
  - Business activities?
- Impacts on other sectors – tourism?

Impacts on Local Governments?

- *Little* local revenue impact
  - Natural gas is NOT subject to local taxes in PA
  - Earned Income Tax paid where people live
  - Corporate income tax goes to state
- Service impacts may be large
- If governments lease land – should view revenues as ‘Capital,’ not ‘Income’

Economic Impacts?

- Real estate market
  - Land available for sale?
  - Homes sold to industry transplants
  - Rental homes -trailers
- New business ventures
  - Frac services
  - Water hauling
  - Brine water remediation
  - Pipeline construction
  - New start-ups

Economic Impacts?

- Local contractors for site work
- Local fuel, stone, and site prep materials
- Equipment rentals
- Area surveyors, attorneys, abstractors, and other professional services
- Office and warehouse space
- Hundreds of landmen, drillers, and misc crews staying in area hotels for 2+ years
- Meals, services, and other retail purchases

Local Government: Issues

- Roads & Bonding
- Water
- Infrastructure
- Housing needs
- Schools
- Cultural change (conflicts?)
- Economic development
- Environmental impacts
- And....?

Bradford County Task Force

- Public Education Committee
- Government Relations Committee
- Industry Relations Committee
- Economic Development Committee
- Public Safety Committee
- Planning Committee
- Environmental Committee
- Infrastructure Committee

More Information

- **http://www.srbc.net/index.htm**
- **http://www.bradfordcountypa.org/Natural-Gas.asp**
- **http://naturalgas.extension.psu.edu/**
- **http://www.dep.state.pa.us/dep/deputate/minres/oilgas/new_forms/marcellus/marcellus.htm**
- **http://www.naturalgas.psu.edu**