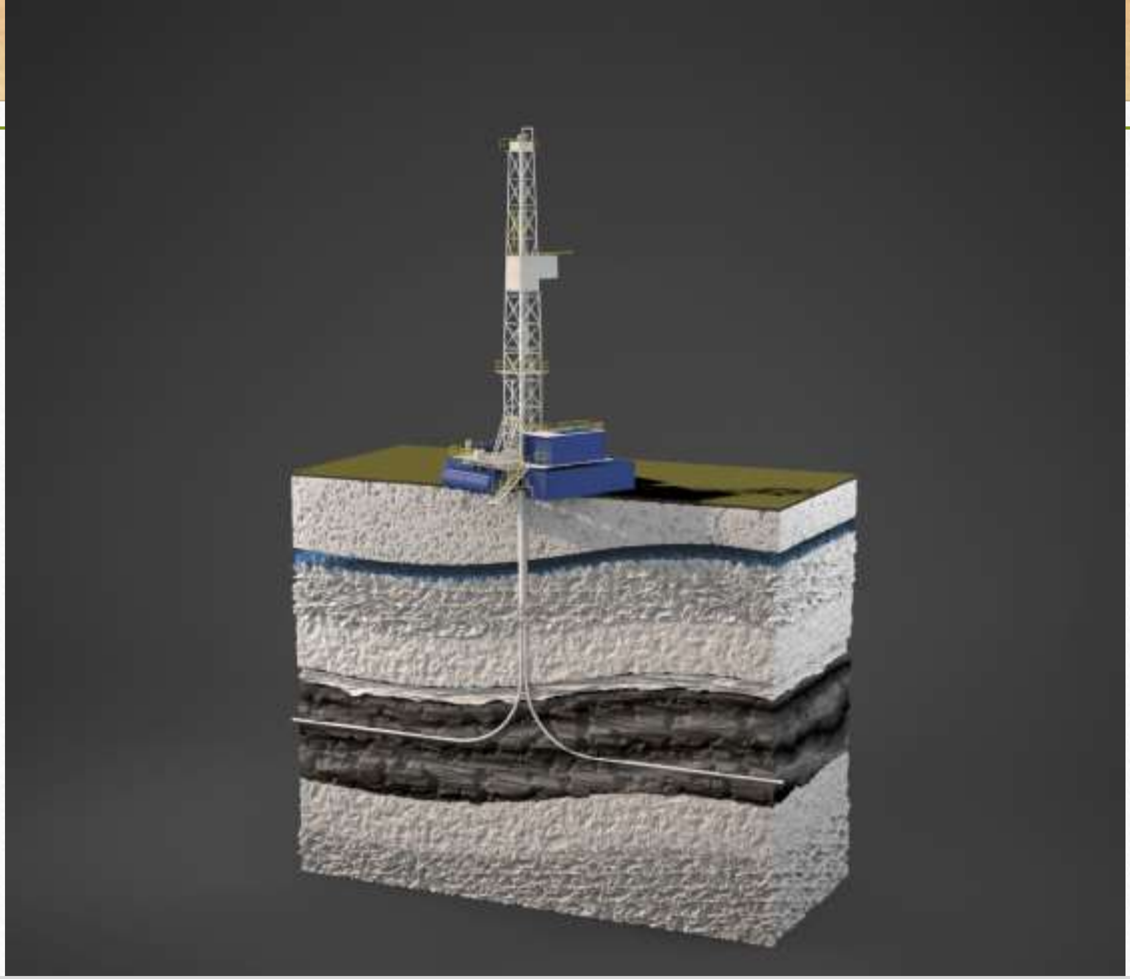


Unconventional (Constrained Shale Bed) Natural Gas Resource Considerations and Conditions for Chatham County, North Carolina

June 2017

This presentation

- A component of on-going Comprehensive Planning for Chatham County

- Emphasis is on potential landscape, land use and community development aspects of unconventional (hydraulic fracturing) natural gas development in the County.

Before we go on – a working definition…..

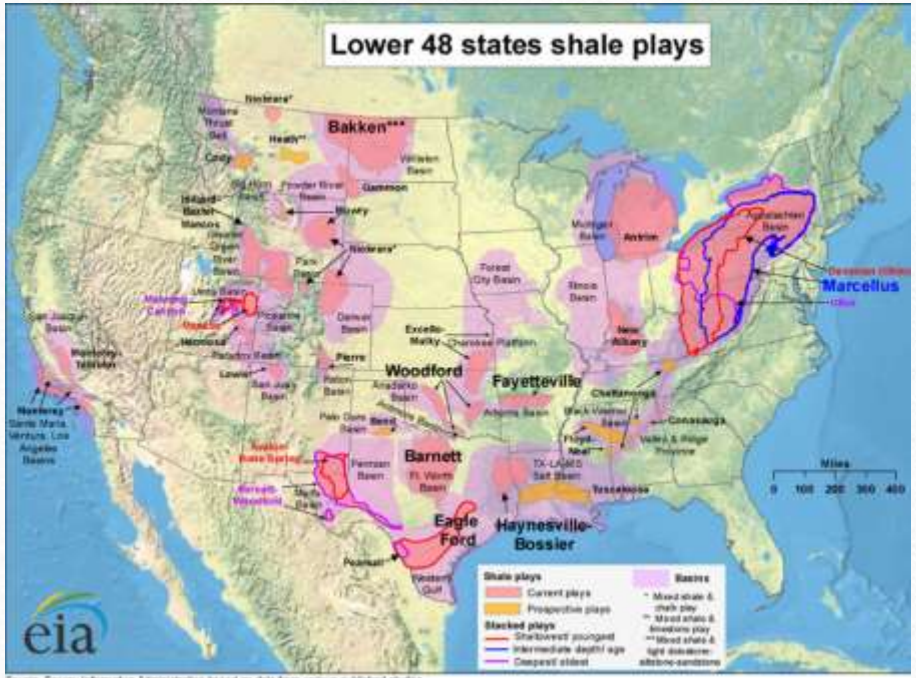
- Hydraulic Fracturing or fracking (will continue with this term) is drilling into the earth before a high-pressure water mixture is directed at the rock to release the gas or oil inside. Water, sand, and chemicals are injected to the rock at very high pressures which allows the gas to flow through the formation out to the head of the well.
- Fracking has gained significance as the nation has turned to natural gas as a preferred fuel.

Presentation Organization

- A basic review – will be brief
- Environmental issues most often associated with fracking
- Fracking 2017 – advances over recent years
- A case study from Pennsylvania
- Fracking and Chatham County
- Questions

Fracking – some background and important relevant terms

- Fracking has been around since 1947.
- Has become important with the recognition of the natural gas available in major basin shales.
- Emphasis has been on larger basins but a great deal of fracking occurs in smaller shallow basins and rift basins

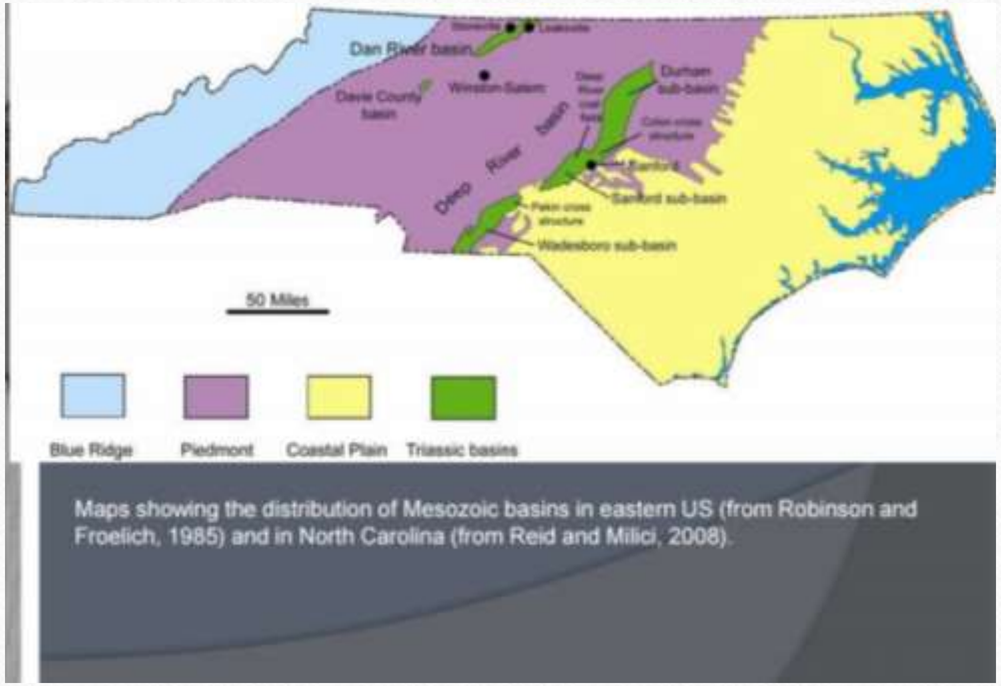


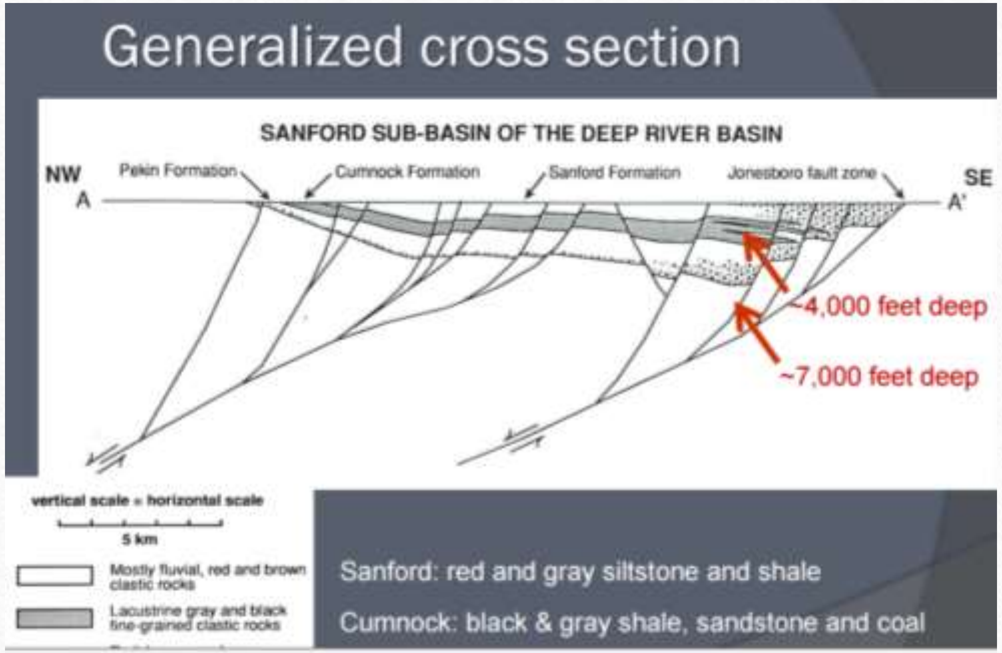
Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Extent of fracking

- Active fracking in 21 states with 5 more poised for fracking in the near future
- 34 states have laws and regulations on the books to facilitate fracking
- Three states have bans or moratoriums – Vermont, Maryland, and New York
- One multi-state region has a fracking moratorium – The Delaware River Basin (a primary water supply watershed for NYC). However, that moratorium is expected to be lifted.
- Another state (Michigan) with significant fracking activity (12,000 wells) has a fracking ban to be likely on the ballot in 2018.

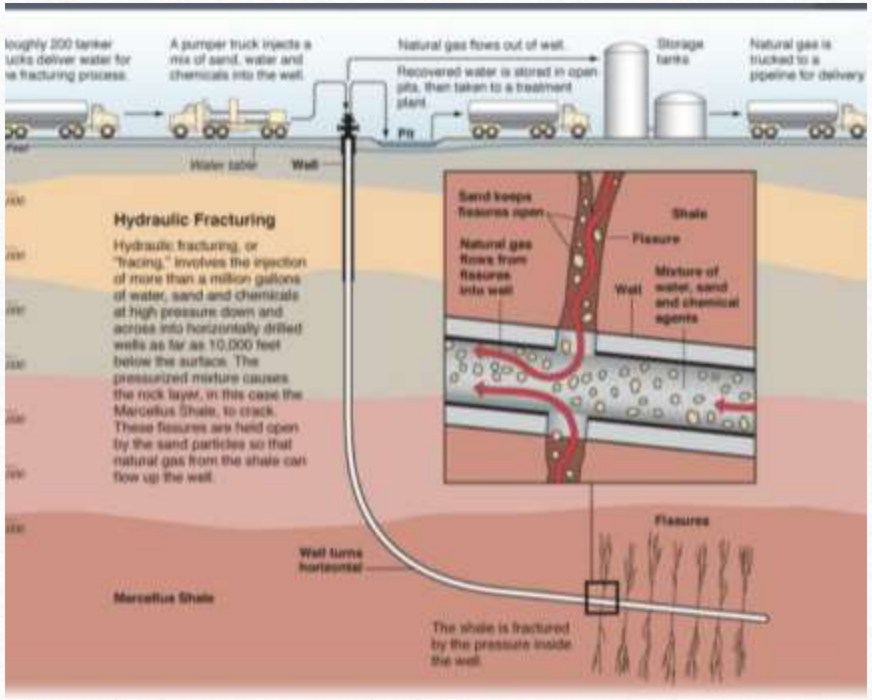
The rift basins of North Carolina with a cross section through the Deep River Basin

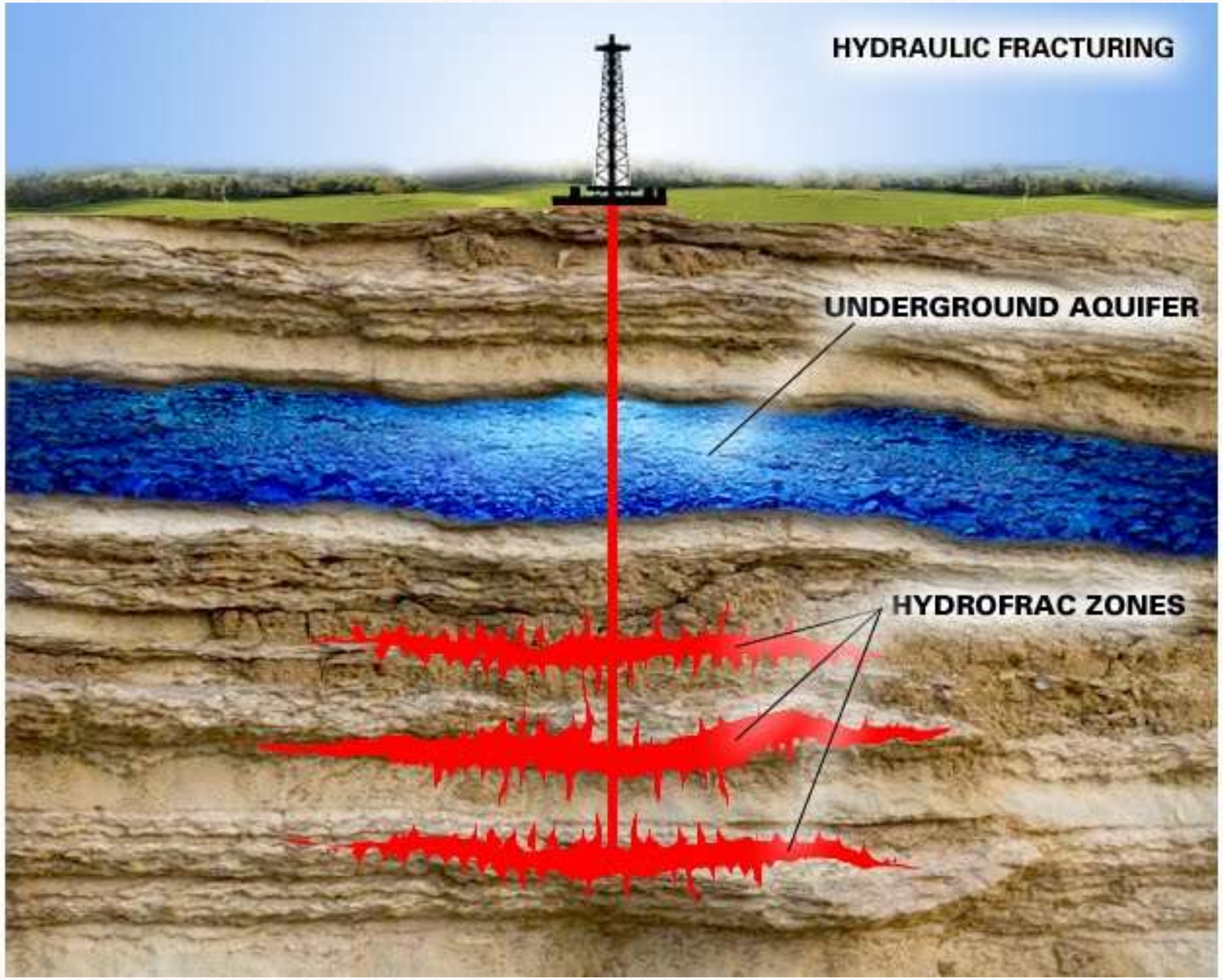




The basic process

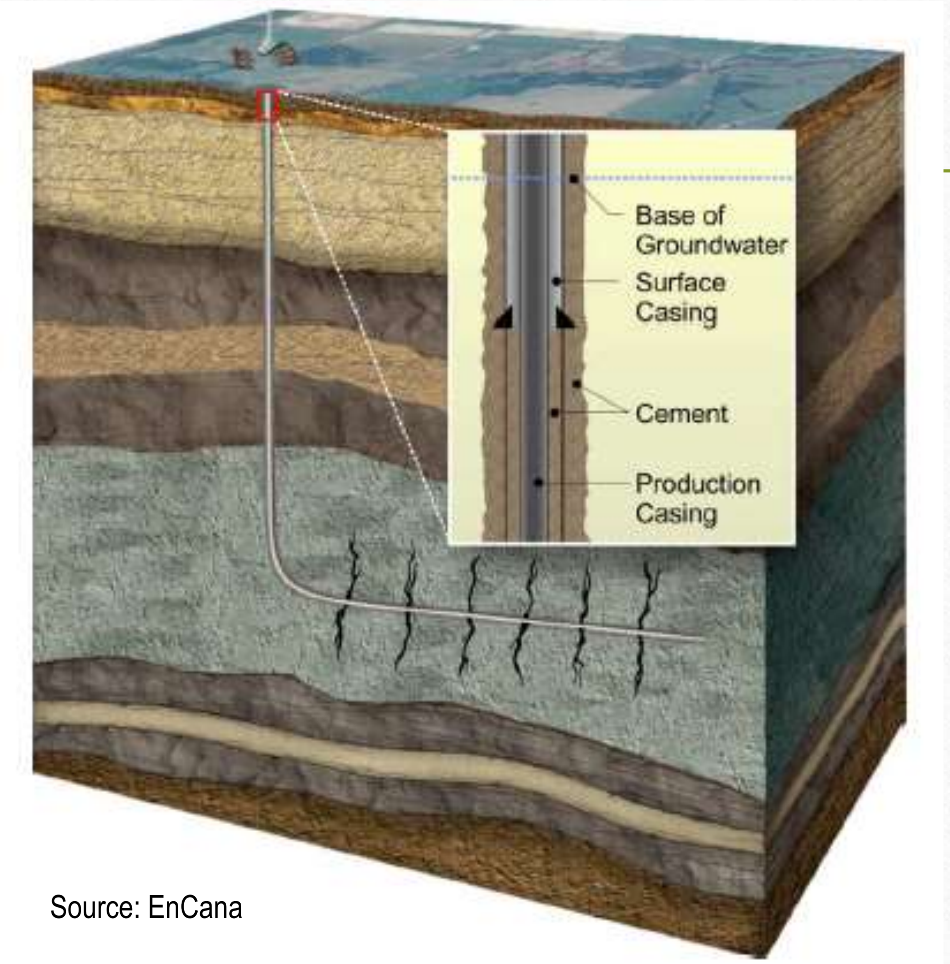
- Prospecting
- Locate potential well locations
- Fracking can be
  - Horizontal drilling
  - Vertical shaft fracking
  - Deep fracking
  - Shallow fracking – will be relevant in later discussions (fracking formations less than 3,000 feet deep).
  - The process complexity is the source of many potential problems




HYDRAULIC FRACTURING
UNDERGROUND AQUIFER
HYDROFRAC ZONES

What Changed the Game?

Horizontal Well with Multi-Stage Fracturing



Source: EnCana

- Natural gas production from <u>shallow, fractured shale formations</u> not new
  - First shale well drilled in Fredonia, NY in 1821
  - First fractured well in 1947
  - 2.5 million fractures to date worldwide; > 1 million in U.S.
- What "changed the game" was the recognition that one could "create a permeable reservoir" and high rates of gas production by using intensively stimulated horizontal wells

So fracking is a high-energy introduced process

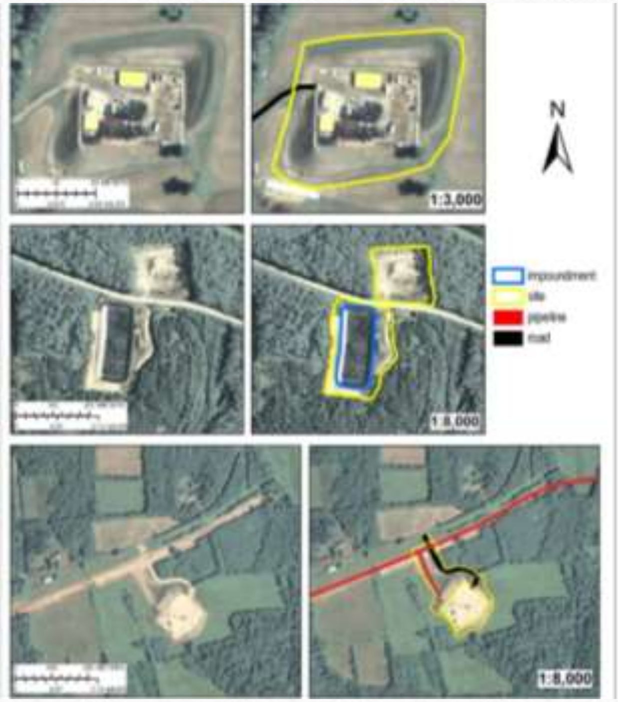
- Fracking is used where formations (primarily shale) are "tight" with little or no natural fracturing and openings with little opportunity to utilize pressure differentials to move gas up the shaft to the wellhead.
- Typically fracking introduces new pressures down the borehole in excess of 10,000 psi.
- It is the fracking fluid/mixture (water, sand or ceramics, and chemicals) that is pressurized.
- A variety of chemicals are used for a variety of reasons – improve slickness, reduce or destroy bacteria, reduce corrosion in the metal well casing, etc.
- Sand is used to deliver fracking fluid mixtures and to maintain openings in the shale.

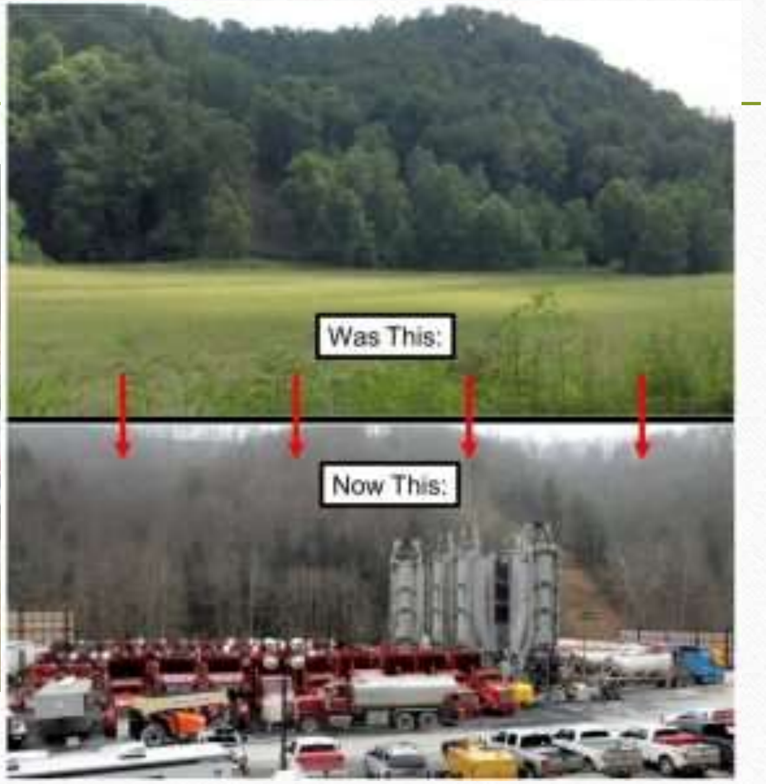
Fracking chemicals

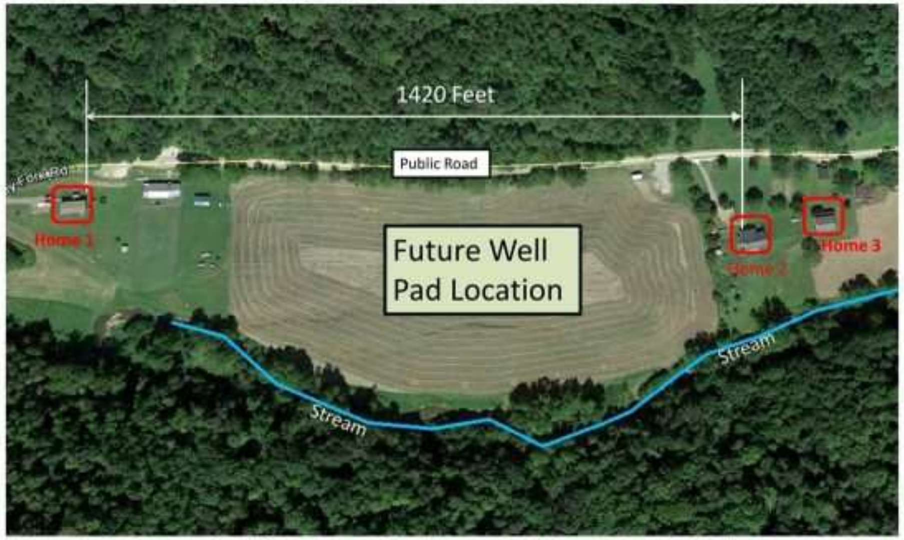
- Specific listings are protected as trade secrets… but analysis has shown that what are referred to as volatile organic chemicals are heavily utilized.
- Over 750 different chemicals have been detected many of which pose potential human health risks.**
  - Biocides
  - Corrosion inhibitors
  - Friction reducers
  - Iron control
  - pH adjusting compounds

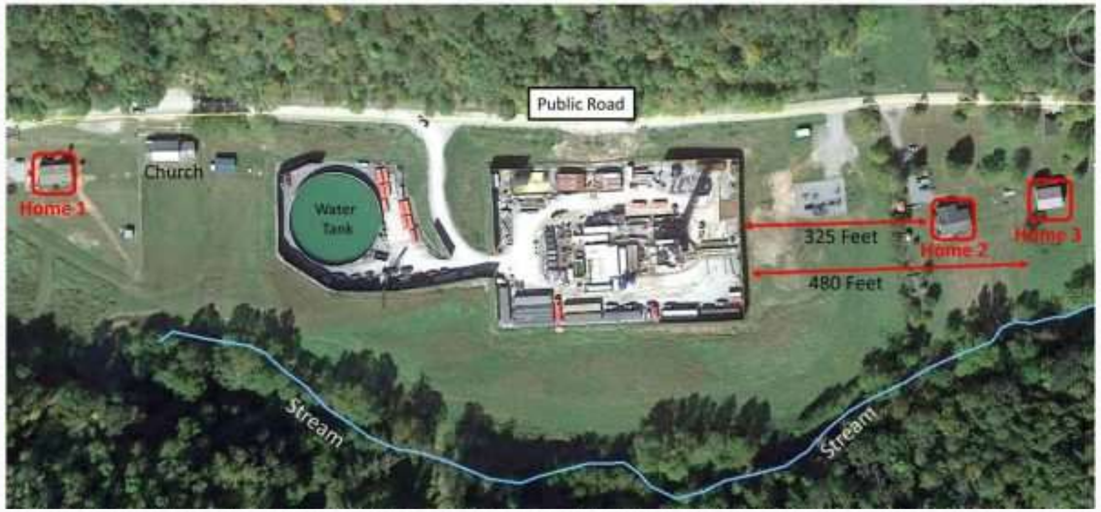
  - **major chemicals will be listed in the final report.

What does it look like in the landscape?




Was This:
Now This:


1420 Feet
Public Road
Home 1
Future Well
Pad Location
Home 2
Home 3
Stream
Stream


Public Road
Home 1
Church
Water
Tank
325 Feet
480 Feet
Home 2
Home 3
Stream
Stream

Logistics yard, paved road impacts, and flaring

Before we move on it is important to introduce a few important legal / regulatory components

- Amendments to the CWA (Clean Water Act) in 2005 remove fracking well location and aspects of fracking from state implementation of the CWA pushing fracking to the states.
- The **Halliburton** exemption partially removes injection wells from Federal / state injection well regulations – for Class II injection wells.
- The above combine to provide a regulatory framework for fracking. Note: fracking operators and injection well operators are often different in that injection wells often take water from numerous different well operators.
- **Forced or mandatory pooling – a quick discussion**
  - Old concept - 38 states have forced pooling regulations
    - Originated in the Midwest and Great Plains with the Public Land Survey.
  - Pennsylvania and West Virginia do not – both states rely on aspects of pooled leases
  - North Carolina does not have a current mandatory pooling law.

Some relevant Federal regulations and associated exemptions.

Federal Law	Applicable to Oil and Gas Development	Exemptions or Limitations	Source of Exemption Exemption or Limitation
Safe Drinking Water Act	• Underground Injection Control Program • Imminent and Substantial Endangerment Provision	• Hydraulic fracturing fluids other than diesel fuels do not require Underground Injection Control Permit	Statutory – 2005 Energy Policy Act
Clean Water Act	• National Pollutant Discharge Elimination System program • Spill reporting and spill prevention and response planning requirements	• Federal stormwater permits not required for uncontaminated stormwater at oil and gas construction or well sites	Statutory - 1987 Water Quality Act and 2005 Energy Policy Act
Resource Conservation and Recovery Act	• Non-exempt wastes present at well sites may be regulated as hazardous • Imminent and Substantial Endangerment Provision	• Oil and gas exploration and production wastes not regulated as hazardous waste	1988 Regulatory/EPA decision
Comprehensive Environmental Response, Compensation, and Liability Act	• Hazardous substance release reporting • Imminent and Substantial Endangerment Provision for releases of a pollutant or contaminant	• Liability and reporting provisions do not apply to injections of fluids authorized by state law for production, enhanced recover, or produced water • Petroleum releases not covered	Statutory – 1980
Emergency Planning and Community Right-to-Know Act	• Reporting on use, inventories, and releases into the environment of hazardous and toxic chemicals above threshold quantities	• Oil and gas well operations not required to report releases of listed chemicals to Toxics Release Inventory	1997 Regulatory/EPA decision

One more area worth discussing – mineral rights

- Connected and severed mineral rights – can become complex situations
- Severed mineral rights can and are often subdivided
  - For example in the case of heirs
  - Can be split spatially or by formation vertically
- In the case of severed rights most legal deference is with the mineral owner in that the mineral owner generally has full access to the benefits of mineral ownership
  - Drilling and development
  - Secondary development
  - Pipelines can be a bit more complex

Also important

- State law limits local governments from implementing ordinances that regulate oil and gas development.
- However, moratoriums can be implemented and continued so long as such moratoriums are of fixed durations.

On the ground fracking operations are designed as systems

- Access roads
- Drill sites which become drill pads
- Well pads and supporting technology and environmental control features including various ponds and excavated areas for storage / evaporation of return and produced water. Ponds are used for water storage and as evaporation ponds so that potentially toxic solids can be removed and transported offsite for landfilling or other disposal.
    - Fluid mixing and warming equipment
    - Vapor control measure equipment
    - Storage
- May have on-site or nearby injection wells
- Pipelines
- Compressor stations and gathering compressors
- Existing infrastructure – roads, landfills

The process………..

- **Drill to below depths of concern and case in metal and concrete**
- **Continue drilling into formations of interest – typically the above are a ten day process**
- **Once drilling is complete then fracking can be initiated – typically a two to three day process**
- **Wells may have up to 20 fracs**
- **Once fracking is complete the fracking equipment is removed and the site is prepped for production**

A typical well site and well pad

- 8 to 15 acres
- Total area
  - 60% can be restored after construction and well development – revegetation, water control, and other mitigation
  - Well pad – 25% of area will remain disturbed –
  - Pipelines 4% remains disturbed after revegetation
  - Ponds 5%
  - Roads 7%

Typical timeline for a hydraulically fractured gas well.

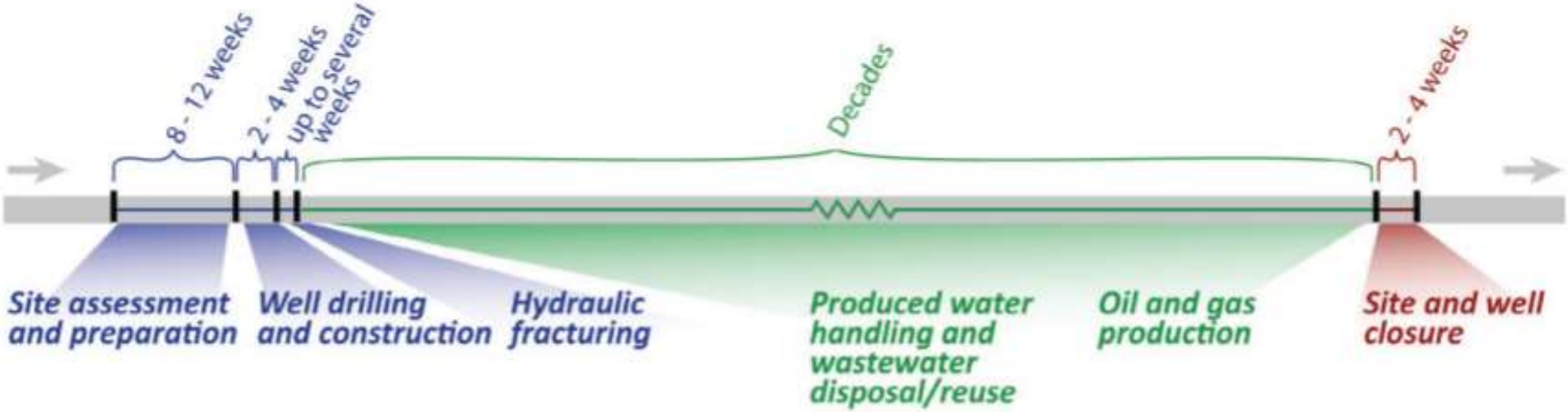


Figure ES-1. General timeline and summary of activities at a hydraulically fractured oil or gas production well.

Source: USEPA 2016.

Potential environmental impacts

- Site preparation and drilling
  - Seismic – minor issues
  - Well pad, roadway and pipeline construction – governed by state regulations
    - Erosion and sedimentation
  - Local roads – heavy vehicles and raw materials haulage
  - Drilling cuttings disposal – treated as hazardous waste – removed to offsite for disposal or treatment.
  - Accidents / equipment failures
    - Surface water pollution
    - Accidents generally impact surface water and borehole failures impact groundwater

Fracking impacts

- Water use – one to four million gallons of water per frac – water is from local surface and / or groundwater sources
  - 200 or more tanker trucks per frac
- Potential leakage of fracking chemicals
  - Typically 30 trucks sand and 10 chemicals trucks per frac
- Leakage in aquifers is generally due to well casing or concrete failures
- Leakage in storage facilities generally impacts surface water

- Produced / flow water treatment and disposal
  - Injection
  - Storage, evaporation and landfilling
  - Treatment using specialized treatment facilities – water can be recycled
- Methane and other fugitive gas
  - Condensers
  - Flaring – limited usage

Gas production impacts

- Gas leakage
- Noise – primarily from traffic and compressors – compressor noise can be significant
- Fugitive gases from compressor stations
  - Fugitive leaks in compressor hardware
  - Pollution emitted by compressors
- Continued well defects – monitoring has greatly improved

A couple of notes

- **Seismic impacts have received a great deal of notoriety – however drilling and fracking have proven to have negligible impacts – significant impacts have been due to injection wells**
- **Methane gas has received a great deal of press as well – negligible methane escape during drilling and fracking – during well operation fugitive methane releases have been a common occurrence.**

Some often overlooked impacts

- **Well pads, roads, and pipelines result in significant landscape fragmentation**
  - **Loss of quality forests**
  - **Loss of interior forests**
  - **Loss of quality forest edges**
  - **Fragmentation of agricultural fields**
- **Community impacts**
  - **Perceptions of community health**
  - **Perceptions about environmental quality and health**
  - **Residential structures and land not being leased decreased in value**

Fracking 2017

- **Methane flaring use is on the decline with improved hardware removing 98% of the methane produced that typically escapes. Example in Pennsylvania wells can now flare a maximum of 30 days a year encouraging use of improved hardware.**
- **Injection well usage is on the decline with specialized treatment options on the rise.**
- **Specialized landfills are being developed to handle the most hazardous wastes once water and solids have been separated**

A Case Study – Washington County PA

- **Marcellus Shale**
- **Heavy hydraulic fracturing in the County**
- **Location of a number of major problems and fracking related issues**

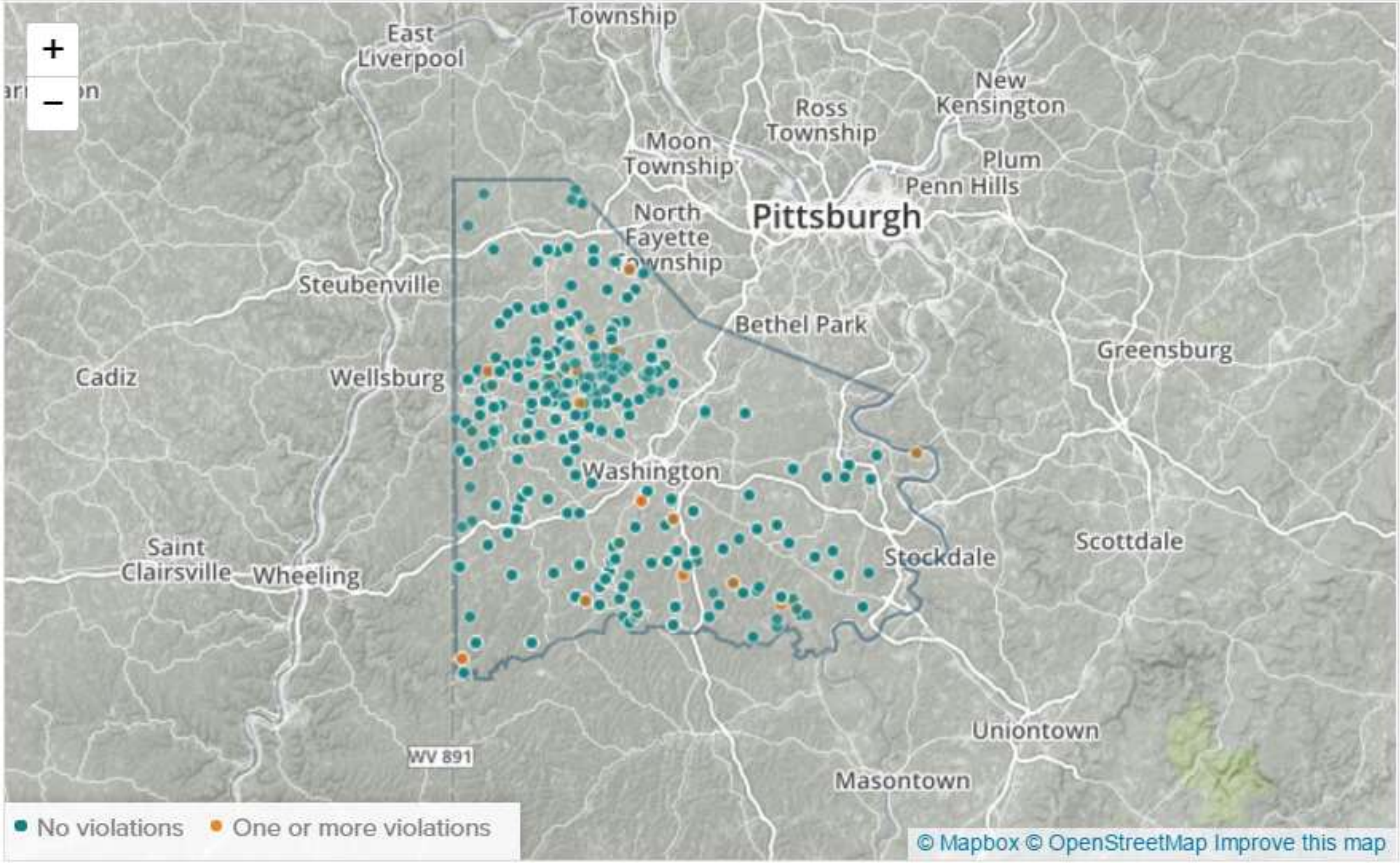
Washington County

ACTIVE WELLS

1,146

VIOLATIONS

153



Site preparation





BEST LINE



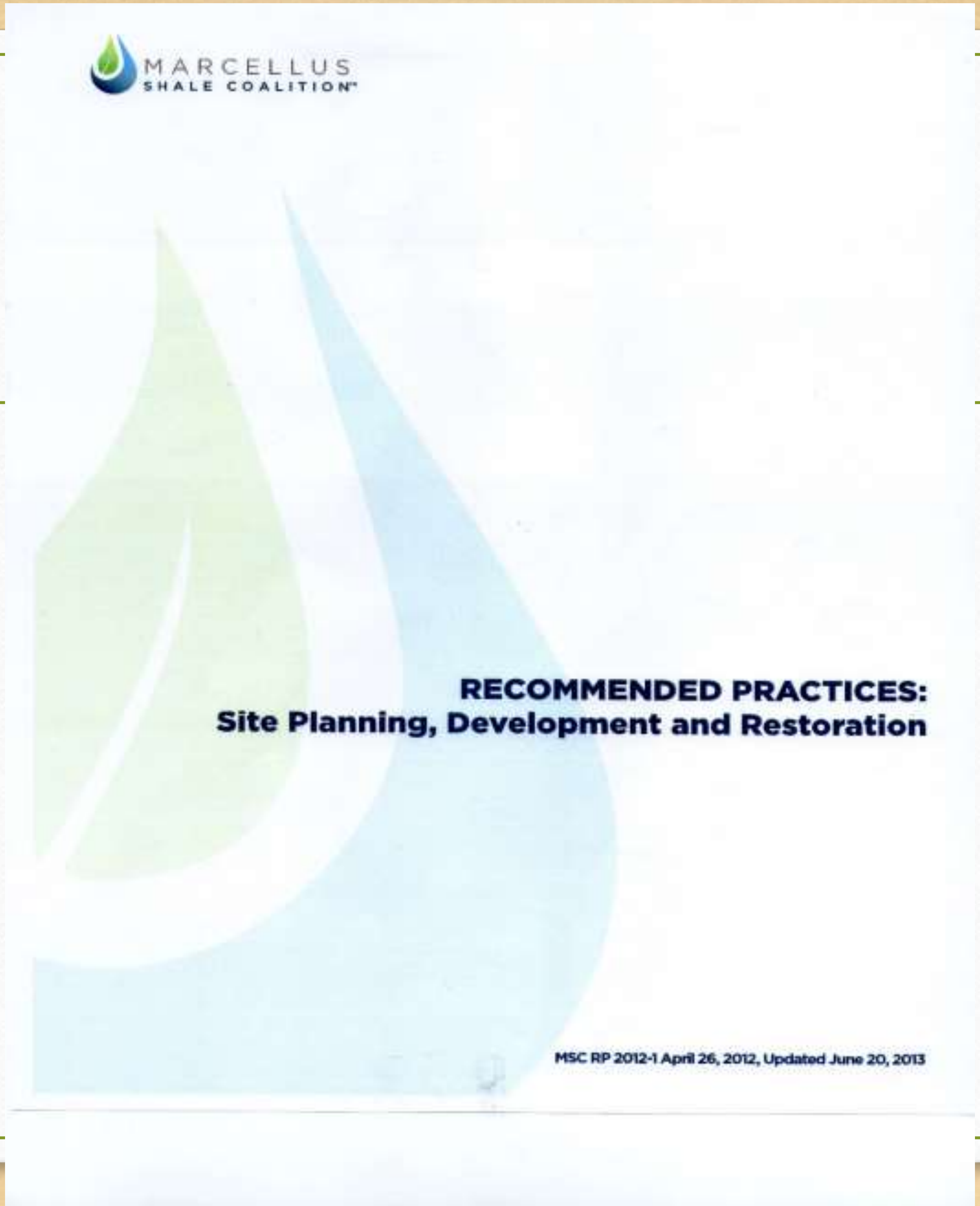


A storage / evaporation basin and a compressor / gathering facility

Washington County summary

- Major companies
  - Range Resources
  - Chevron
  - Chesapeake Appalachia
  - Noble Energy
  - EQT
- Issues
  - A number of violations – drinking water well damage – over 100 complaints since 2015 with fewer violations.
  - Number of spills and accidents with resultant short-term surface water and shallow ground water damage
  - One township – East Findlay – without pubic drinking water wells since 2015.
  - A major well pad fire in January 2017. Fire was rapidly extinguished though limited evacuations were required – hardware malfunction. Human error accidents are rare

While we are in Washington County – one more topic to discuss – site restoration


MARCELLUS
SHALE COALITION™

RECOMMENDED PRACTICES:
Site Planning, Development and Restoration

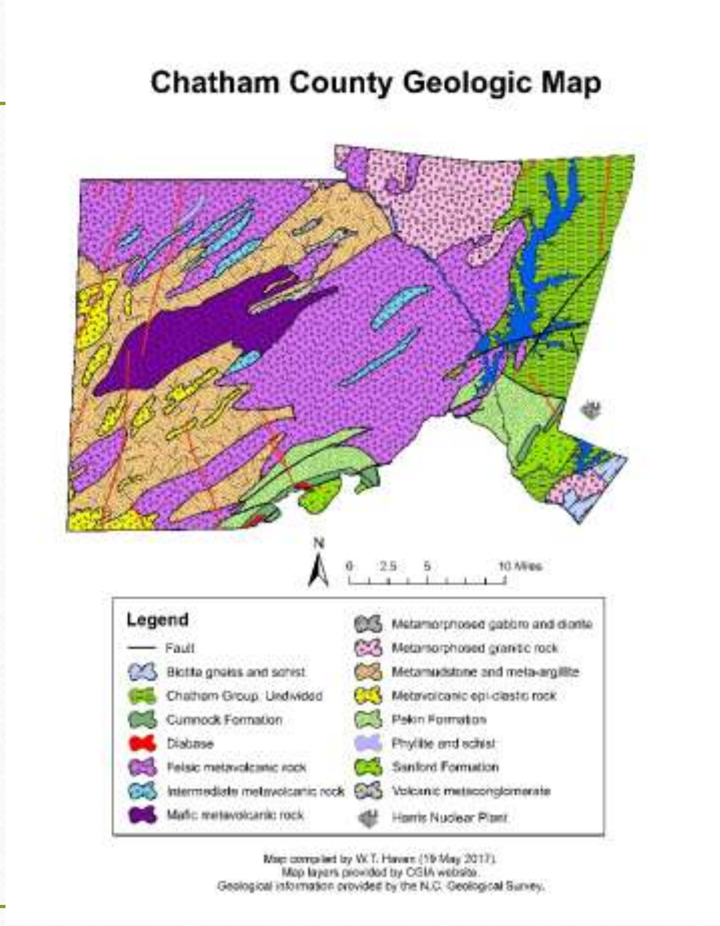
MSC RP 2012-1 April 26, 2012, Updated June 20, 2013

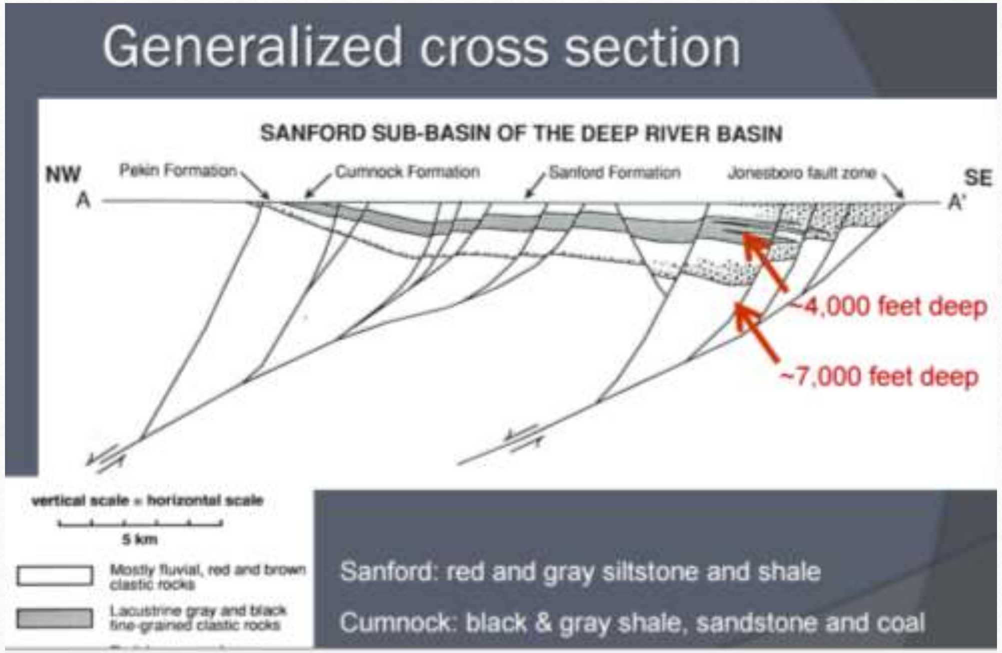
Table 2-1. Site Planning, Development and Restoration Process Recommended Practices

Each step in the following table may be implemented as appropriate.

Major Steps in the Process	Elements for Reducing Impacts, and for Improving Restoration and Final Reclamation Outcomes
Identify Local Need for Site	Determine the operational needs and ideal location(s) for well pad(s), access road(s), pipelines, gas compression and processing facilities, water pipelines and impoundments, and other necessary facilities.
Generate Unconstrained Conceptual Site Plan	Prepare an unconstrained conceptual site plan free of potential landowner, regulatory or environmental constraints based on what would be ideal from an operational perspective.
Conduct a Constraints Analysis	Conduct fact-finding to identify constraints including regulatory/zoning/siting constraints, landowner and local community desires/preferences, environmental and public resource constraints, highway access constraints and the presence of other sensitive locations.
Refine Concept	Adjust the conceptual site plan to account for known constraints. Consideration should be given to minimizing surface disturbance. Impacts may be reduced by using brownfield or industrial areas and previously cleared land, if practical. It may be possible to use existing logging roads and trails when planning access roads or pipeline right of ways. Another option is to plan for pipelines adjacent to existing roads. In addition, there may be opportunities for coordination of infrastructure with other companies, for example: use of shared right of ways for pipeline corridors, pooling of mineral rights to optimize the number of well pads, etc.
Discuss Plans with Surface Owner(s); Alter Site Concept as Needed	Welcome input from the surface owner(s) and consider changes to the overall design. This may include a discussion of the refined concept plan and how this concept would fit within their existing and planned future uses of the site, making adjustments as appropriate.
Identify Site Features to Retain or Protect	Identify features to be retained – including timber, stumps, slashing, mulch, topsoil, ponds or stock watering devices, access roads, etc. – and account for retention of these items in site planning.
Prepare Final Site Plan from Previous Concepts; Highlight Retained Features	Prepare context-sensitive site plan while accounting for potential future oil and gas extraction from other formations.
Implement E&S and Other Environmental Controls	Build the site. Ensure that planned erosion and sedimentation (E&S), stormwater and other environmental controls are installed and maintained. Consider using permanent controls such as sedimentation basins, with potential future use, over temporary measures that can be damaged and may require multiple replacements over time.
Implement Partial Restoration During Operational Life	Reclaim portions of the site that will not be needed during the post drilling, production phase so as to minimize the impact of the project. Try to avoid additional disturbance of stable soils while minimizing soil compaction and new disturbances required to access other formations. Note that the original development phase of well pads, as well as of pipelines, gas compression and processing facilities, often requires a larger footprint than operational phases.
Implement Final Restoration Conducive to Surface Owner's Plans and Objectives	Conduct final restoration upon completion of the project. Well pads will be in use for decades, whereas surface disturbances for buried gathering or transmission pipelines can be fully reclaimed soon after installation. In re-contouring a site, control erosion and storm water runoff, minimize site compaction, apply lime and fertilizer as necessary, seed with use-adapted mix, mulch appropriately, and plant trees and shrubs as appropriate.
Conduct Site Monitoring, Maintenance and Repair	Conduct site monitoring, maintenance and repair throughout the life of the project. Although listed last in this process, site monitoring, maintenance and repair begins with initial site development and continues until the site is fully restored and the site is permanently closed. Critical elements include repair of access controls and gates, security fencing, ruts or washouts (often caused by uncontrolled all-terrain vehicle access), and revegetation of areas where initial efforts did not yield desired results.

To our interest – Chatham County





Some background

- **The County has been concerned about potential fracking since 2009**
- **The USGS and NCGS have been focused in the region with current estimates being about 1.7 tcf of gas in the Deep River Basin**
- **The Cumnock Formation is the primary potential gas bearing formation in the Basin.**
- **This means**
  - **The gas bearing formation is extremely shallow in the County**
  - **The formation also is in less than 5% of the County.**

Introducing a new concept – shallow fracking

- Shallow fracking – less than 3,000 foot depths – some as shallow as 100 feet. Shallow fracking places fracking closer to potential formations of concern such as aquifers.
- Generally vertical borehole fracking with limited horizontal fracking.
- Water usage is only minimally reduced
- Construction and fracking can occur more rapidly

- Shallow wells typically have a higher percentage of aquifer leakage
- If fracking ever occurs in Chatham County it will be shallow fracking due to the relatively shallow depths of the Cumnock Formation.

Shallow wells

- Many times do not have the depth for horizontal fracking – horizontal drilling can turn only 1 to 4 degrees per 50 feet of depth so up to 500 feet of additional well depth is required for horizontal drilling.

- Fracking with vertical wells does reduce well spacing – often on 40 acre or less spacings. Spacing is generally a function of geology and well performance which can be estimated from a test well.

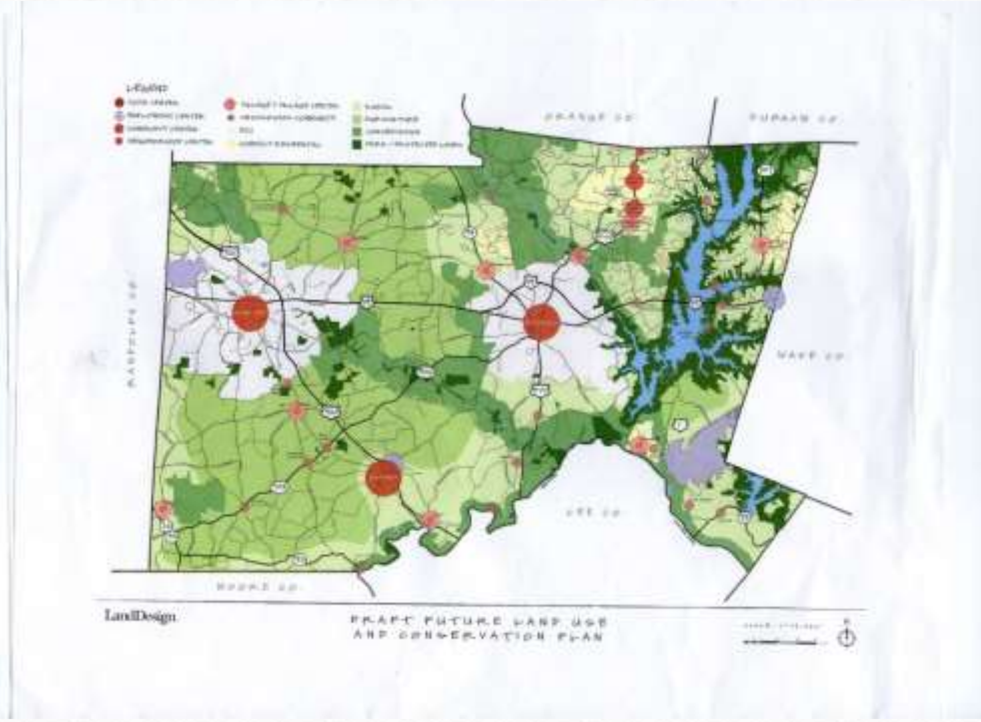
Shallow wells

- Most feasible in areas with deep fracking or existing convention gas infrastructure in place.
- May be in smaller basins over the large deeper basins.

The Cumnock Region of the County

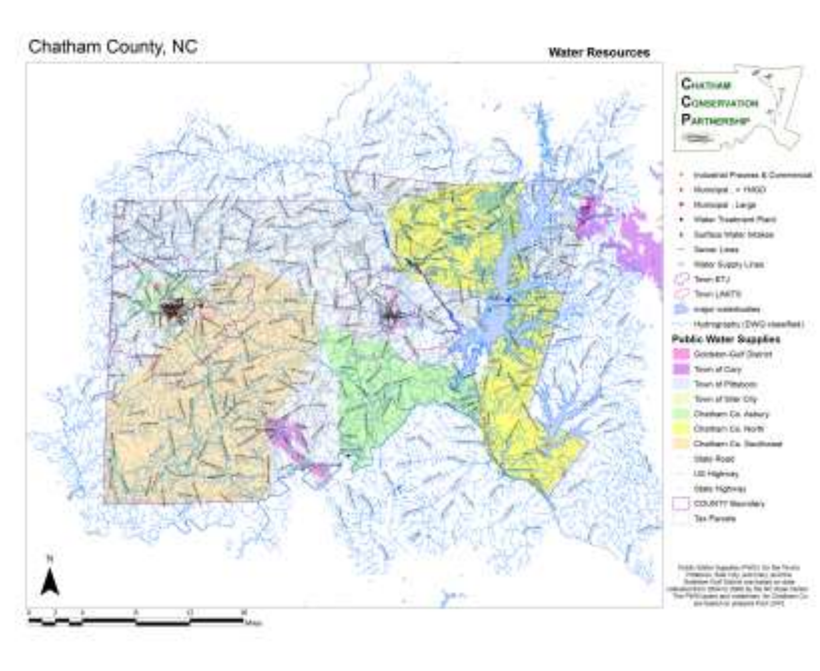
- The Duke Power Station eliminates a significant area for fracking – 5 mile radius around the plant that can be expanded by the NRC.
- Public lands in that portion of the County eliminate much of the area for fracking.
- Landscape values as illustrated in the following maps are of moderate to high importance when compared with much of the county.
- Most Cumnock areas in the county are either outcrop areas (where the shale is at the surface of the ground) or extremely shallow – generally too shallow for the development of hydraulic fracture wells.
- A cursory GIS analysis identified less than 1,000 acres that could be fracked.

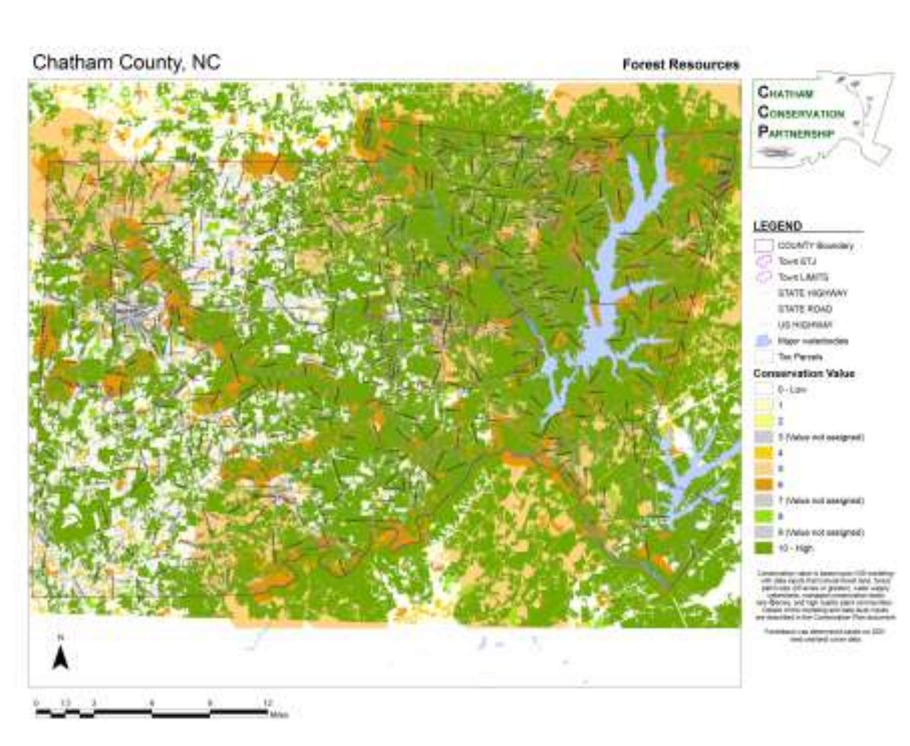
The County has had and is in the midst of comprehensive planning efforts

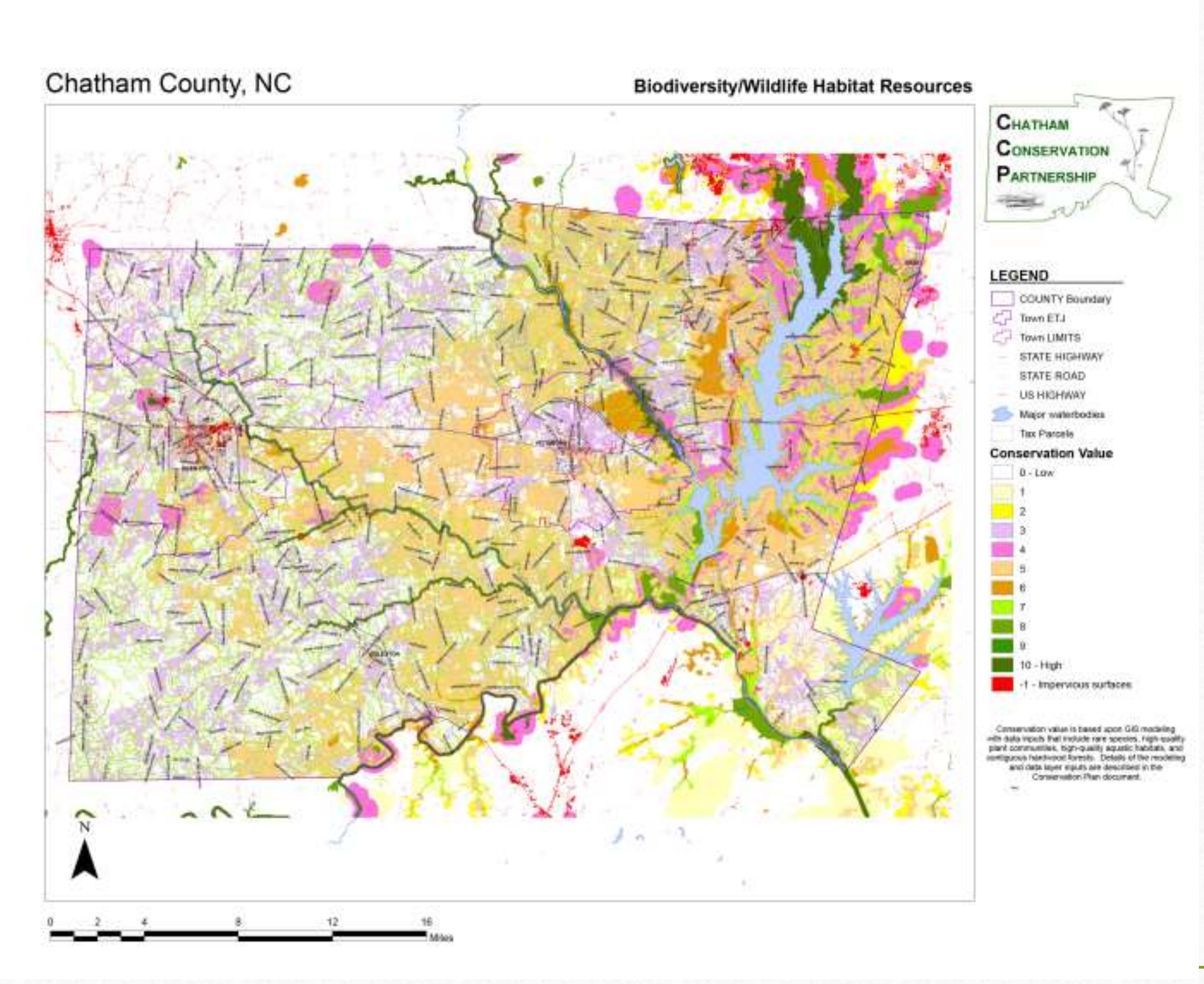


- From the comprehensive planning effort – the Cumnock region in the southern portion of the County is being planned as conservation, industrial, and mixed rural and agriculture.

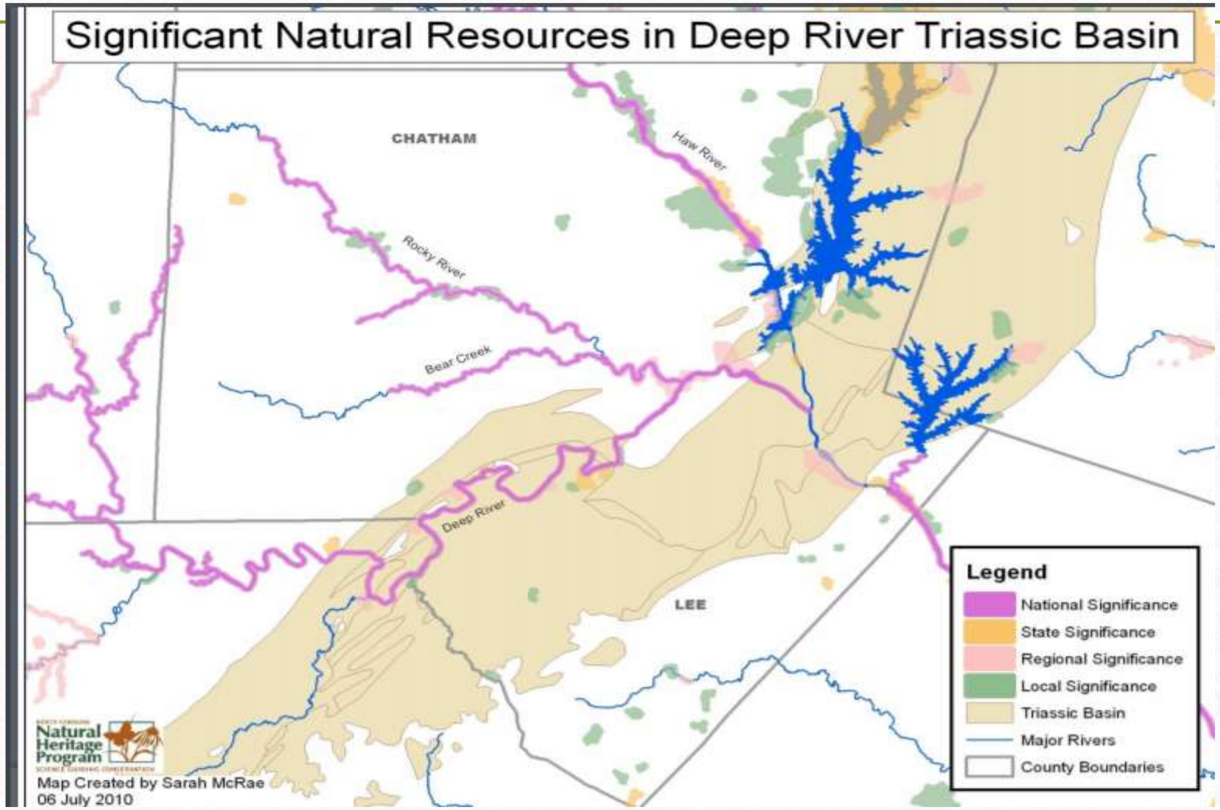
The Cumnock regional context



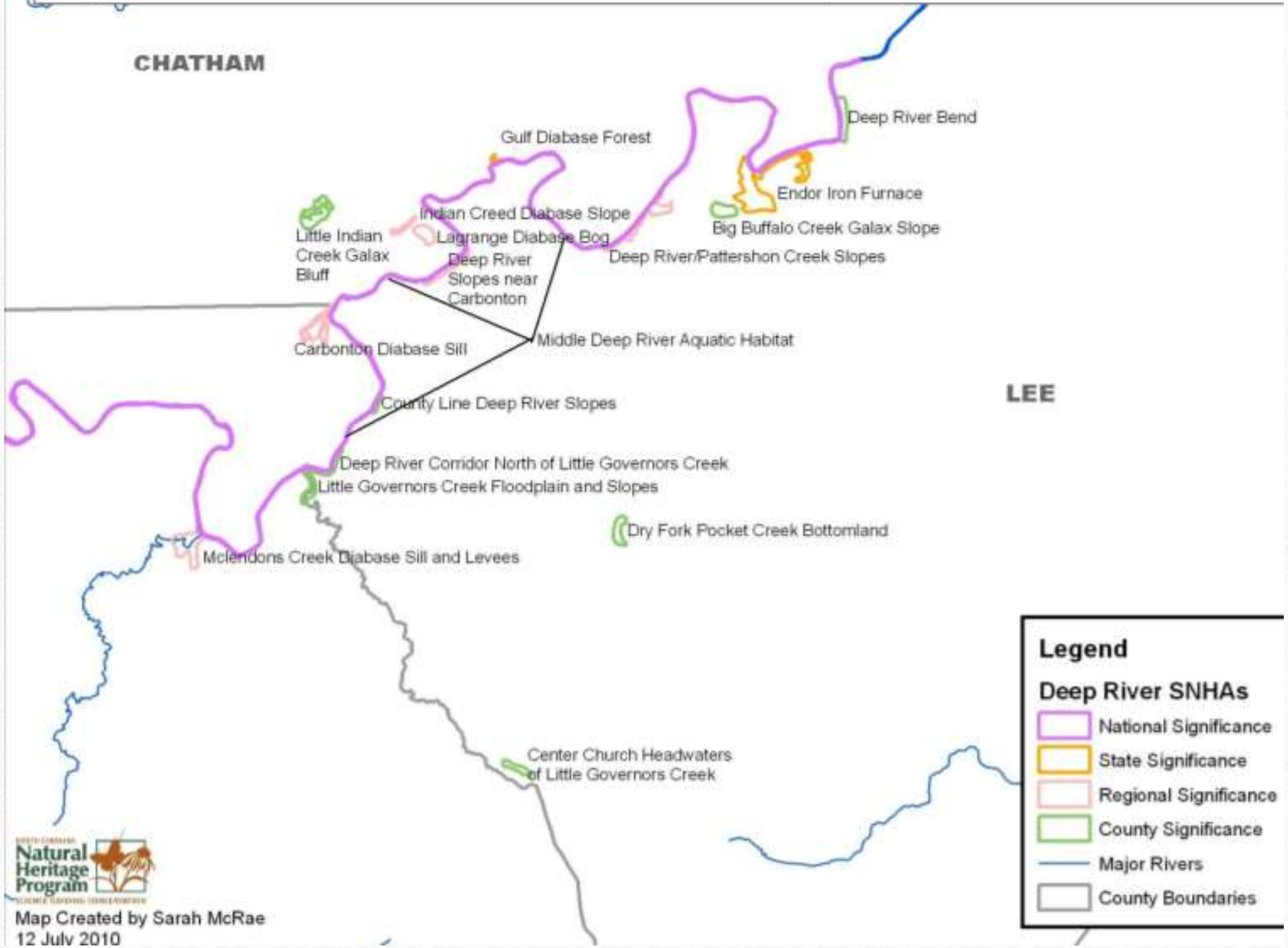



Chatham County, NC
Biodiversity/Wildlife Habitat Resources
Chatham Conservation Partnership
LEGEND
COUNTY Boundary
Town ETJ
Town LIMITS
STATE HIGHWAY
STATE ROAD
US HIGHWAY
Major waterbodies
Tax Parcels
Conservation Value
0 - Low
1
2
3
4
5
6
7
8
9
10 - High
-1 - Impervious surfaces
Conservation value is based upon GIS modeling with data inputs that include rare species, high-quality plant communities, high-quality aquatic habitats, and contiguous hardwood forests. Details of the modeling and data layer inputs are described in the Conservation Plan document.
N
0 2 4 8 12 16
Miles

North Carolina State Heritage Program identified significant environmental resources in the Basin



Significant Natural Resources in Deep River Triassic Basin



A brief summary

- Fracking in Chatham County is unlikely but possible in a very small area of the County – probably less than 1,000 acres – acres are spread over a number of non-contiguous areas so fracking feasibility is extremely low based on shale depth and surface ownership and conditions. A more detailed spatial analysis could be completed with the available geologic data, available Lidar data, updated land use, and exclusion zones such as the power station buffer.
- The Cumnock deepens while maintaining formation thickness clearly making Lee County more attractive for development. Due to the infrastructure requirements of the fracking process it would be conceivable that small portions of Chatham County could be developed from infrastructure developed in Lee County.

Recommendations

- Formation of a multi-county working group focusing on larger geographic issues of unconventional shale development.
- Develop voluntary guidelines for shale gas development in the County similar to those developed by the working group in the Marcellus region.
- Modify land use regulations to include a conditional use permitting process that is consistent with state laws targeting protection of water quality.

For more reading – I would suggest the following references

- Physicians for Social Responsibility. Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking Unconventional Gas and Oil Extraction. November 2016.
- United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources n the United States. December 2016.
- Any readings on shallow fracking.
- Chatham County Geologic Map – May 2017.

A special thanks

- Walt Haven and the NC Geologic Survey for providing up to date geologic mapping and data as well as personal observations.

Summary and questions

- Final comprehensive report with responses to questions /comments will be prepared
  - Outline
    - Summary of potentials and issues associated with fracking in Chatham County
    - Responses to all questions with relevant citations
    - Appendices – environmental issues, infrastructure issues, health and safety issues, ecological issues, and community issues
- Additional questions can be submitted through June 16 to by email address – jason.sullivan@chathamnc.org .

- Questions