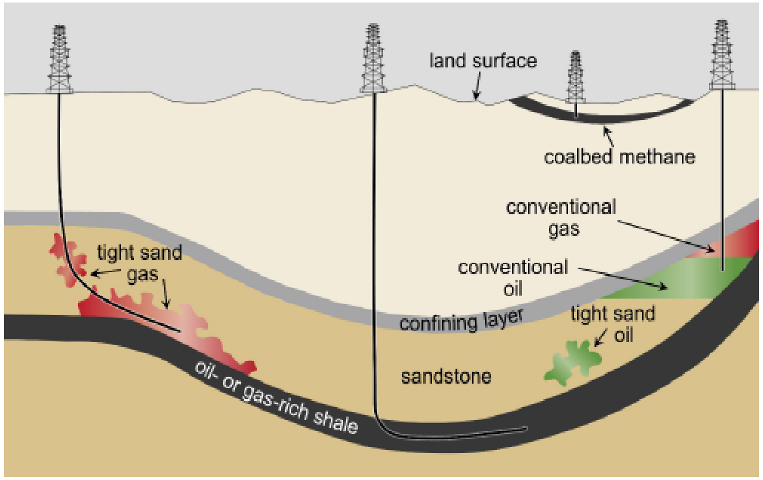
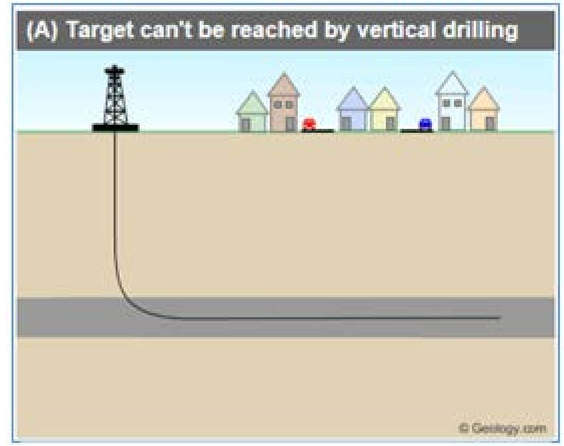
Assessing Impacts to Transportation Infrastructure from Oil and Gas Extraction in Rural Communities: A Case Study in the Mississippi Tuscaloosa Marine Shale Oil Play

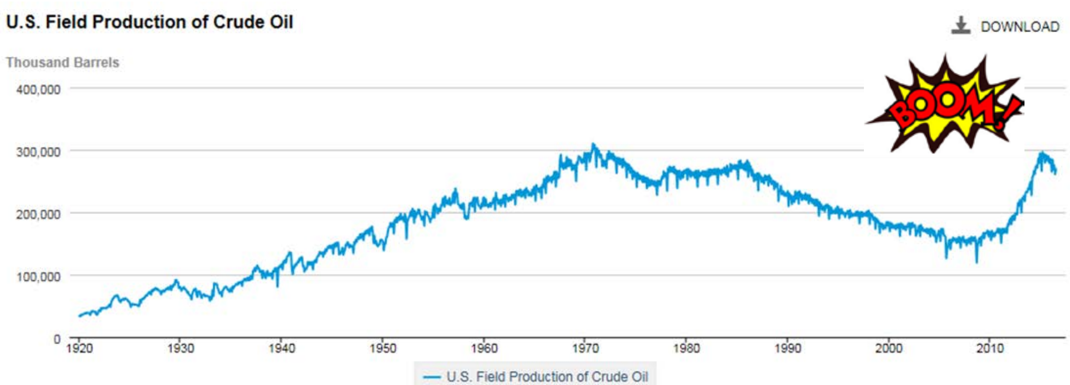
Leah A. Dundon, PhD Candidate
Dr. Mark Abkowitz
Dr. Janey Camp
Dr. Craig Philip
Vanderbilt University School of Engineering

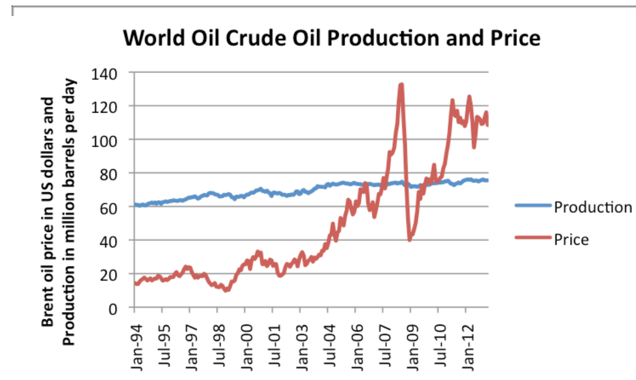
VANDERBILT School of Engineering

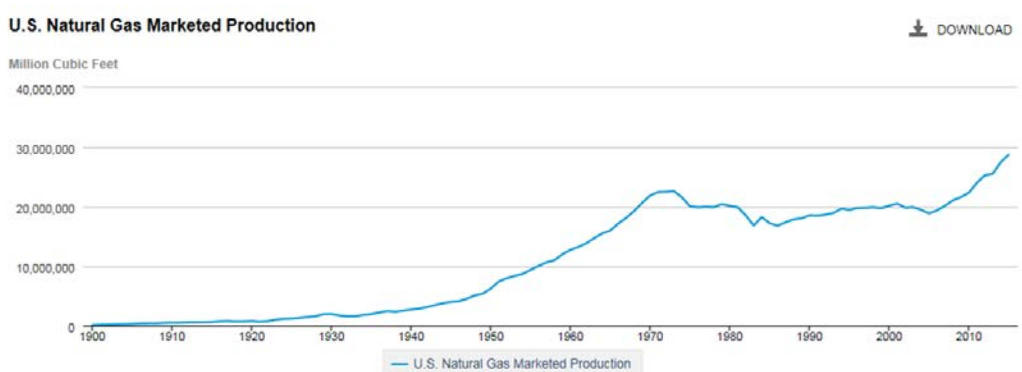
What are hydraulic fracturing and horizontal drilling and why are they important?

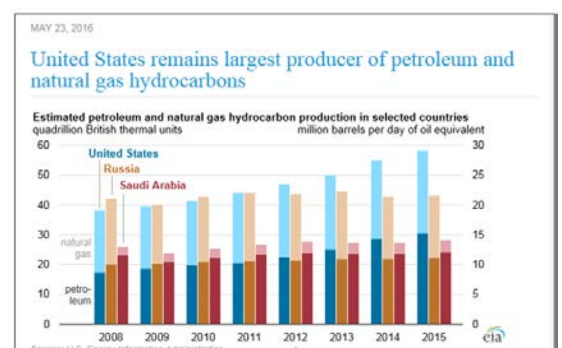






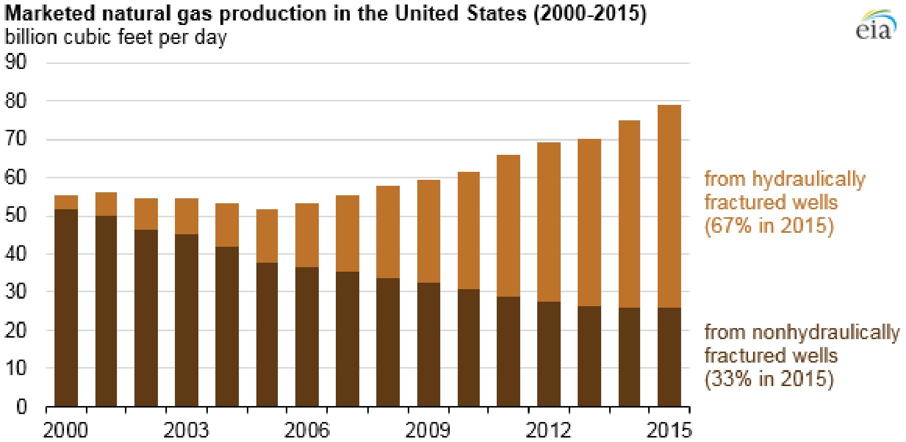






MAY 5, 2016

Hydraulically fractured wells provide two-thirds of U.S. natural gas production



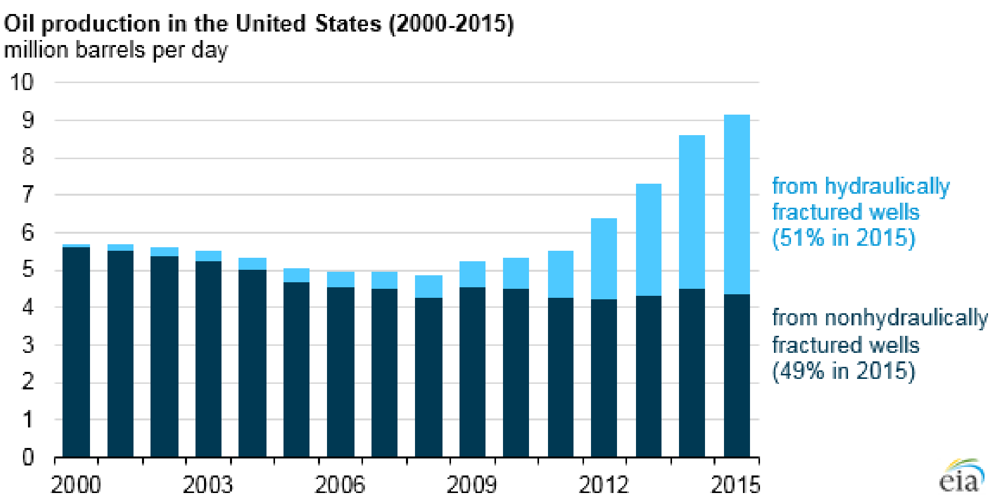
Source: U.S. Energy Information Administration, based on IHS Global Insight and DrillingInfo Inc.

Pounds of CO2 emitted per million British thermal units (Btu) of energy for various fuels:

Coal (anthracite)	228.6
Coal (bituminous)	205.7
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel and heating oil	161.3
Gasoline	157.2
Propane	139.0
Natural gas	117.0

MARCH 15, 2016

Hydraulic fracturing accounts for about half of current U.S. crude oil production



Source: U.S. Energy Information Administration, IHS Global Insight, and DrillingInfo

Well Traffic

Truck Traffic

Well Pad Activity	Horizontal Well		Vertical Well	
	Heavy Truck	Light Truck	Heavy Truck	Light Truck
Drill pad construction	45	90	32	90
Rig mobilization	95	140	50	140
Drilling fluids	45		15	
Non-rig drilling equipment	45		10	
Drilling (rig crew, etc.)	50	140	30	70
Completion chemicals	20	326	10	72
Completion equipment	5		5	
Hydraulic fracturing equipment	175		75	
Hydraulic fracturing water hauling	500		90	
Hydraulic fracturing sand	23		5	
Produced water disposal	100		42	
Final pad prep	45	50	34	50
Miscellaneous	-	85	0	85
Total one-way, loaded trips per well	1,148	831	398	507
Total Vehicle Trips Per Well	**3,950**		**1,810**	

Note: Light trucks have a gross vehicle weight rating that ranges from 0 to 14,000 pounds. Heavy trucks have a gross vehicle weight rating in excess of 26,000 pounds. The gross vehicle weight is the maximum operating weight of the vehicle, including the vehicle's chassis, body, engine, engine fluids, fuel, accessories, driver, passengers and cargo but excluding that of any trailers.
Source: ALL Consulting (2010) and Dutton and Blankenship (2010), as reported in NYSDEC (2011)

"[W]hen the energy sector moves into a new area, the impacts on infrastructure are extremely rapid; years of damage can occur in a few weeks"

-- Bierling, D., *et al.*, 2014. Texas A&M Transportation Institute, Energy Development Impacts on State Roadways: A Review of DOT Policies, Programs and Practices across Eight States, Final Report

BEFORE PHOTO
SR 3020 in Towanda Township
Bradford Country, PA

AFTER PHOTO
(photo/PennDOT Engineering District 4-0)

- Literature review – over 24 studies, virtually all recent, addressing impacts of oil and gas development on transportation infrastructure
- Gap – how do local, underfunded, rural communities access and use this information?

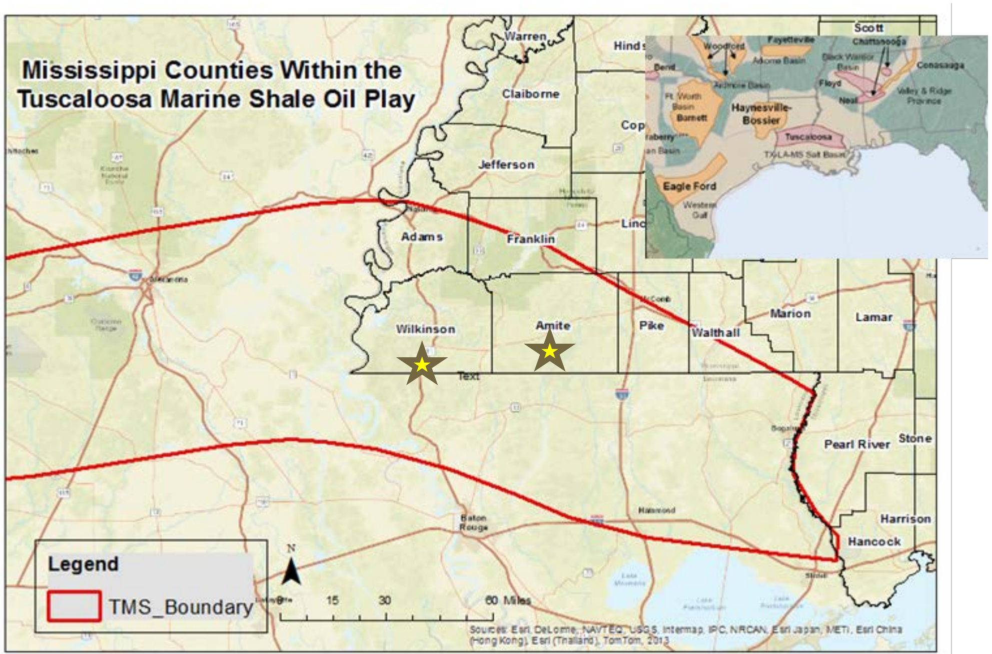


Figure 3. Boundary of Tuscaloosa Marine Shale oil play and included Mississippi counties. Insert: Gulf coast area shale plays, full extent of Tuscaloosa Marine Shale indicated.

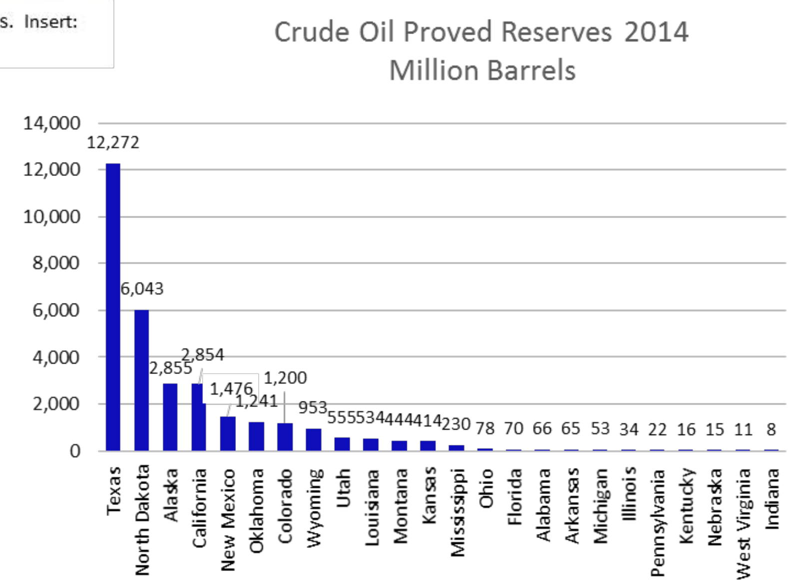


Figure 5. Proved Oil Reserves by State. Reflects volumes capable of being produced given current technologies and prices.

Source: Compiled from data available from United States Energy Information Administration

VANDERBILT School of Engineering

(Does not include produced water!)

Vehicle type	Range of trucks
Hydraulic fracturing water	400-600
Flow back water removal	200-300

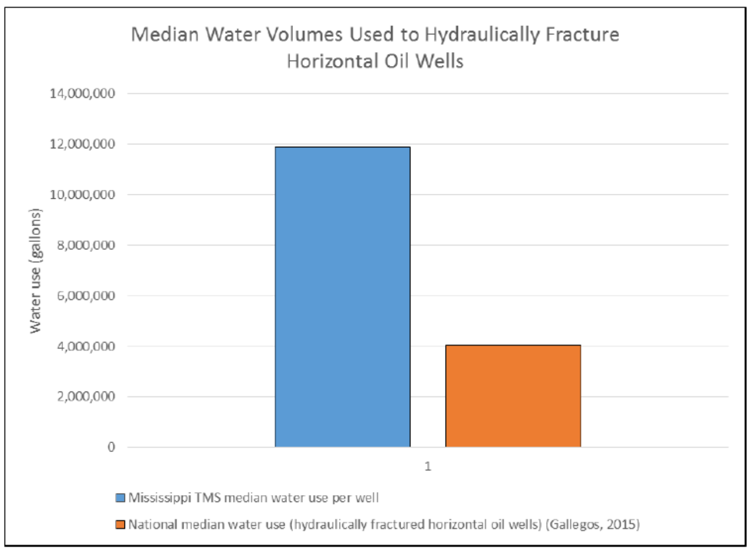


FIGURE 3 Comparison of median water volumes used to hydraulically fracture an oil well in the Mississippi TMS and nationally.

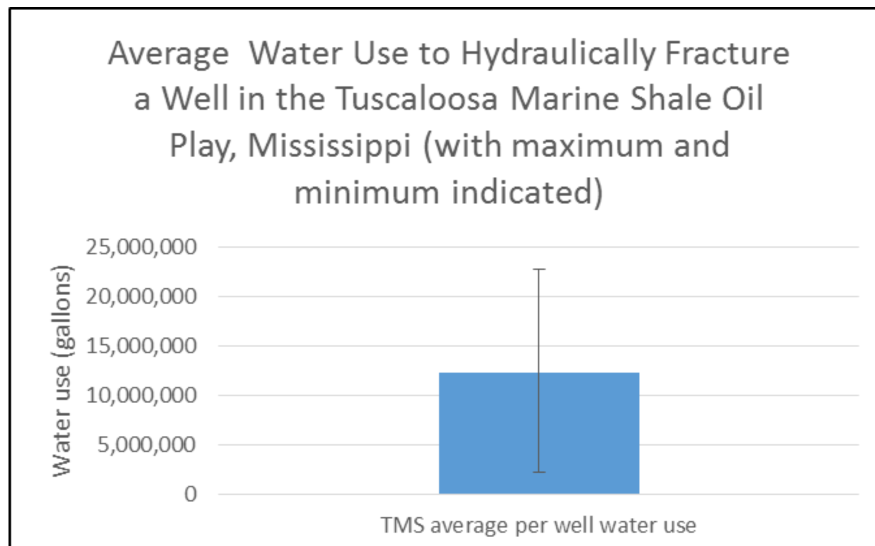
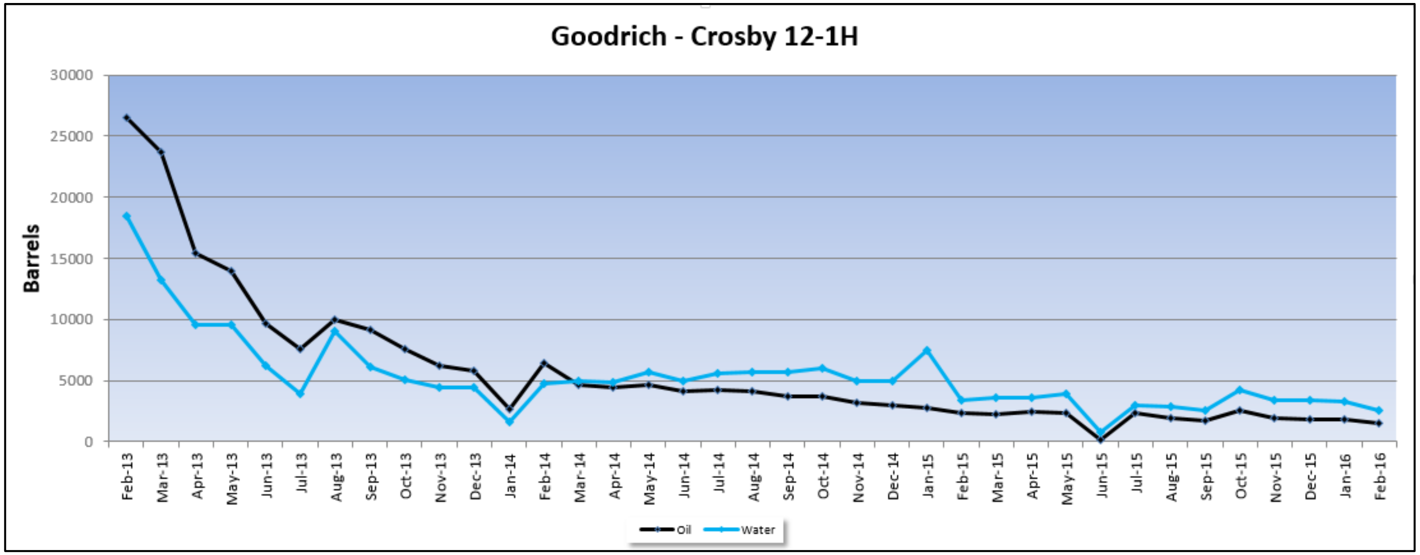
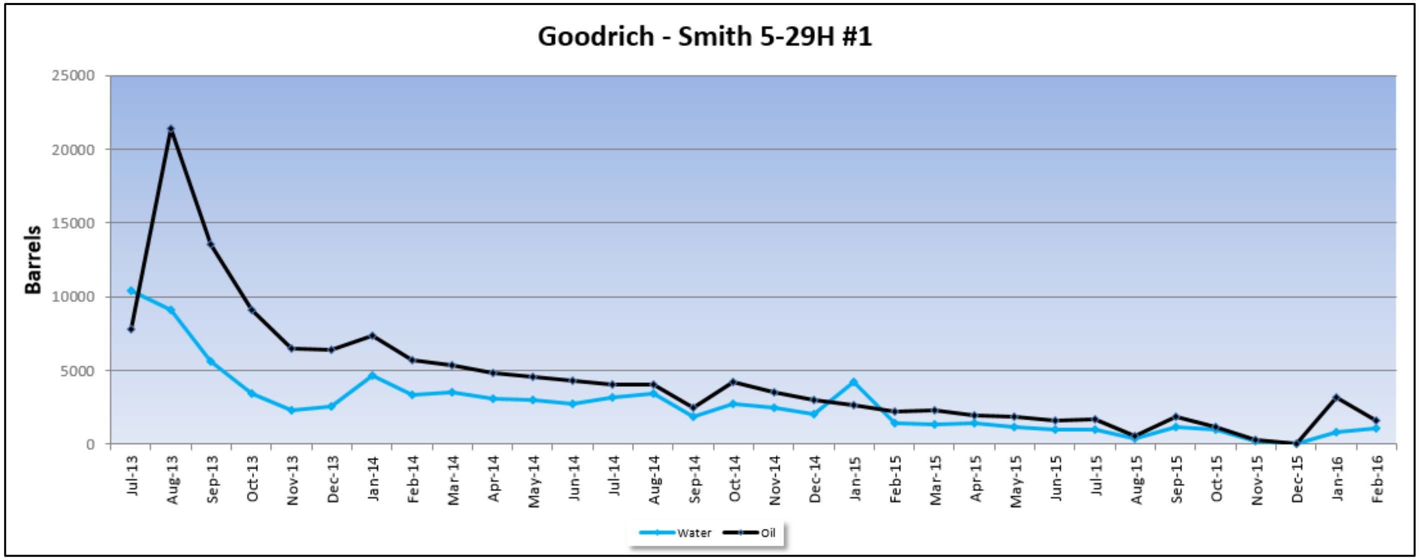


Figure 9. Average water volume used in hydraulically fracturing a well in the Mississippi TMS oil play.

VANDERBILT School of Engineering

Example oil / water output of wells in MS TMS





Data obtained from MS Oil and Gas Board

VANDERBILT School of Engineering

Mapping roads and bridges most vulnerable to increases in oil and gas development

Major Variables:

- Existing and potential well sites
- Salt water disposal wells
- Bridge conditions
- Road segments identified by responsible government entity

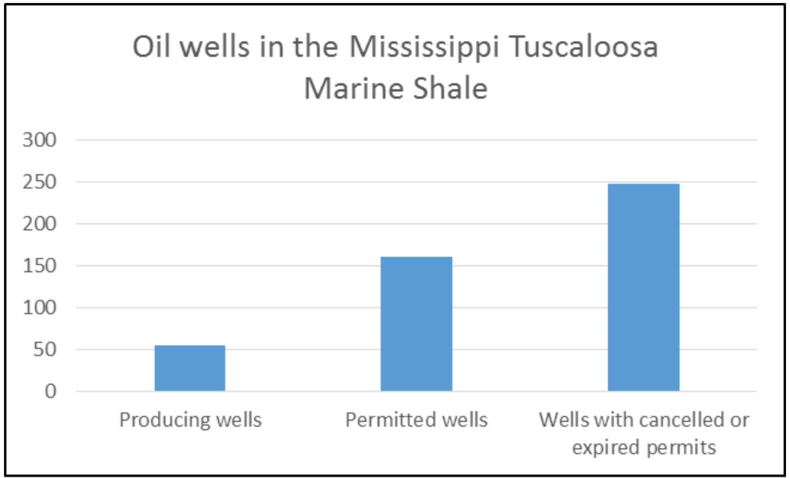


Figure 6. Comparison of the number of producing wells, permitted wells, and wells with cancelled or expired permits. Some wells may overlap if a new permit was applied for, or if a permitted well subsequently was constructed.
(Data Source: Mississippi Oil and Gas Board, current as of February 2016).

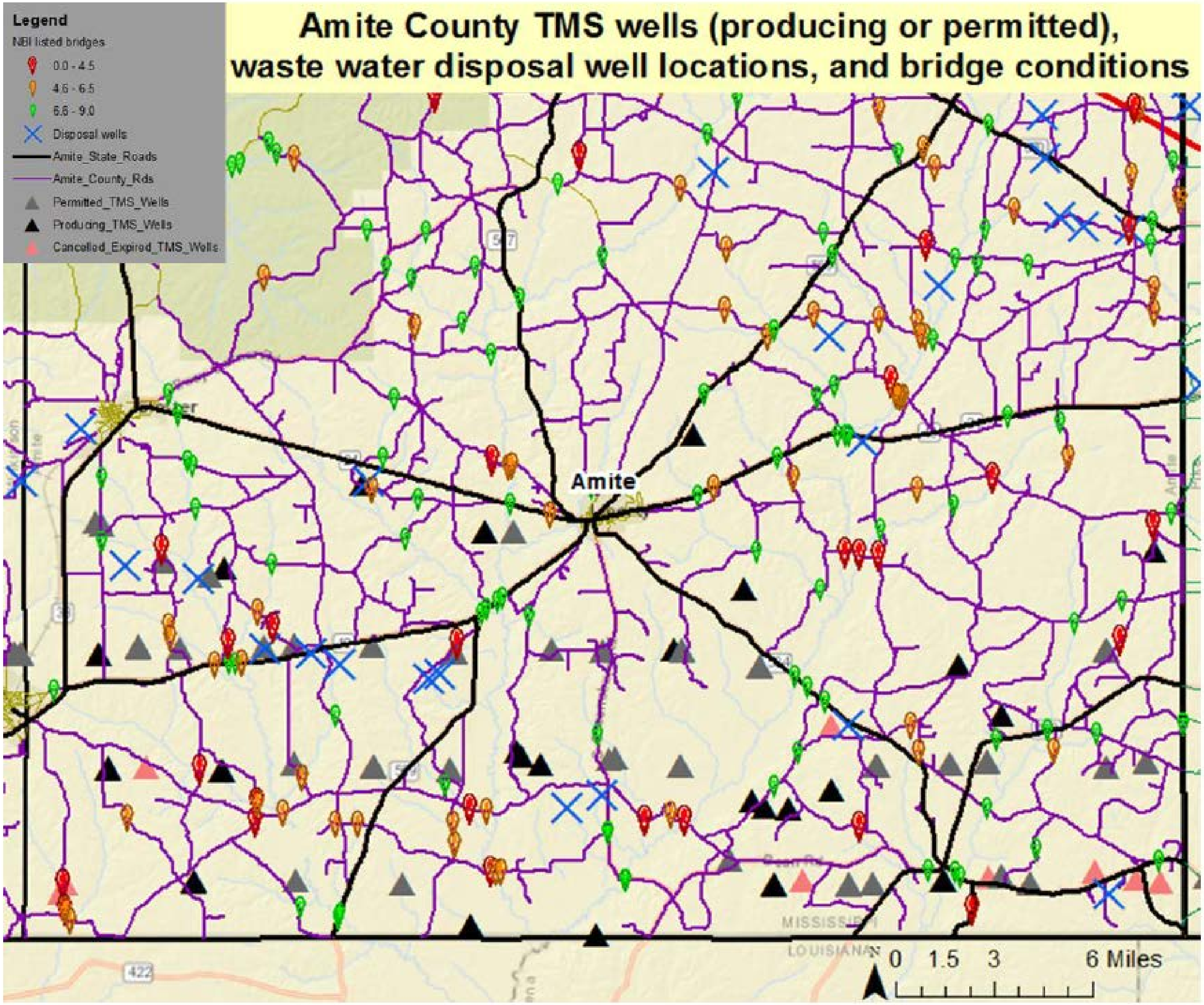
VANDERBILT School of Engineering

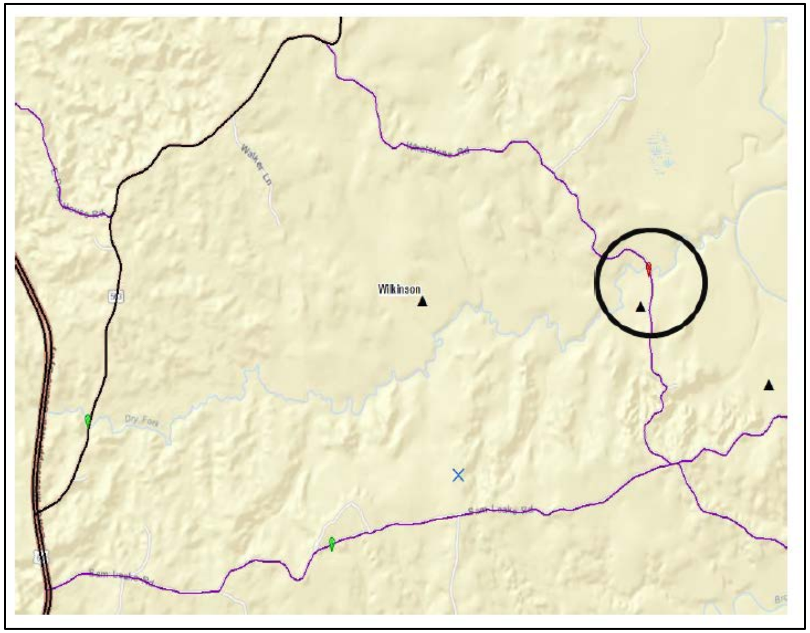
National Bridge Inventory

- Superstructure and Substructure ratings

N = NOT APPLICABLE
9 = EXCELLENT CONDITION
8 = VERY GOOD CONDITION - no problems noted.
7 = GOOD CONDITION - some minor problems.
6 = SATISFACTORY CONDITION - structural elements show some minor deterioration.
5 = FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4 = POOR CONDITION - advanced section loss, deterioration, spalling or scour.
3 = SERIOUS CONDITION - loss of section, deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present.
2 = CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1 = "IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put it back in light service.
0 = FAILED CONDITION - out of service; beyond corrective action

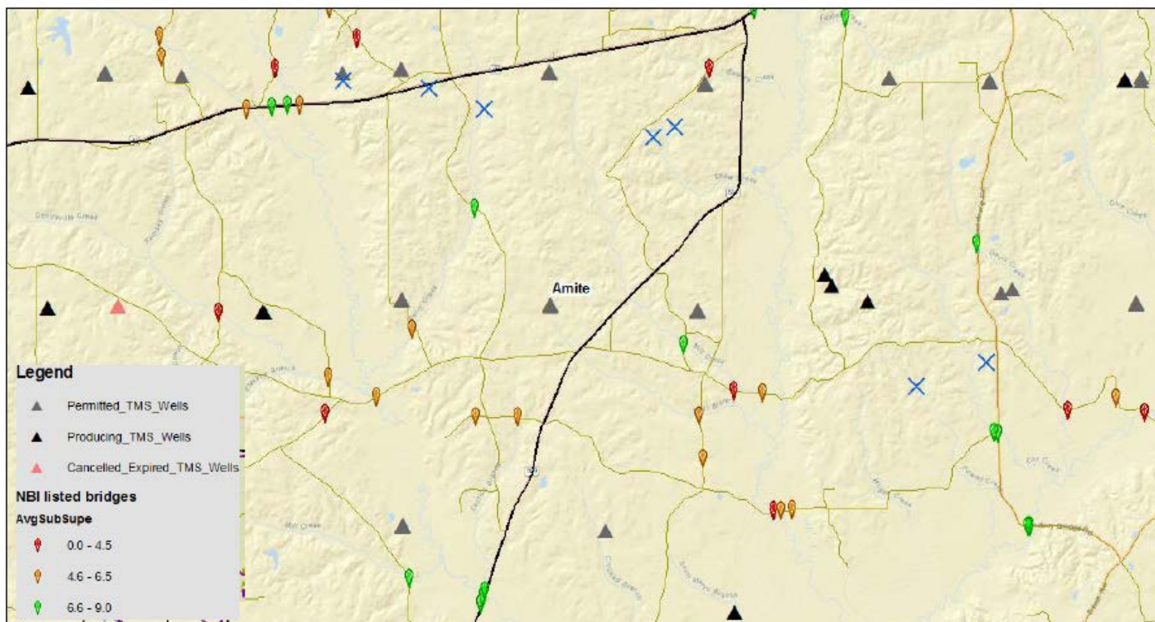
Bridge Point Color	Range of Final Average Ratings of Bridge Condition	Condition ratings scale (from NBI)	
Red	0-4.5	0 = failed	5 = fair
Orange	5-6.5	1 = imminent failure	6 = satisfactory
Green	7-9	2 = critical	7 = good
		3 = serious	8 = very good
		4 = poor	9 = excellent

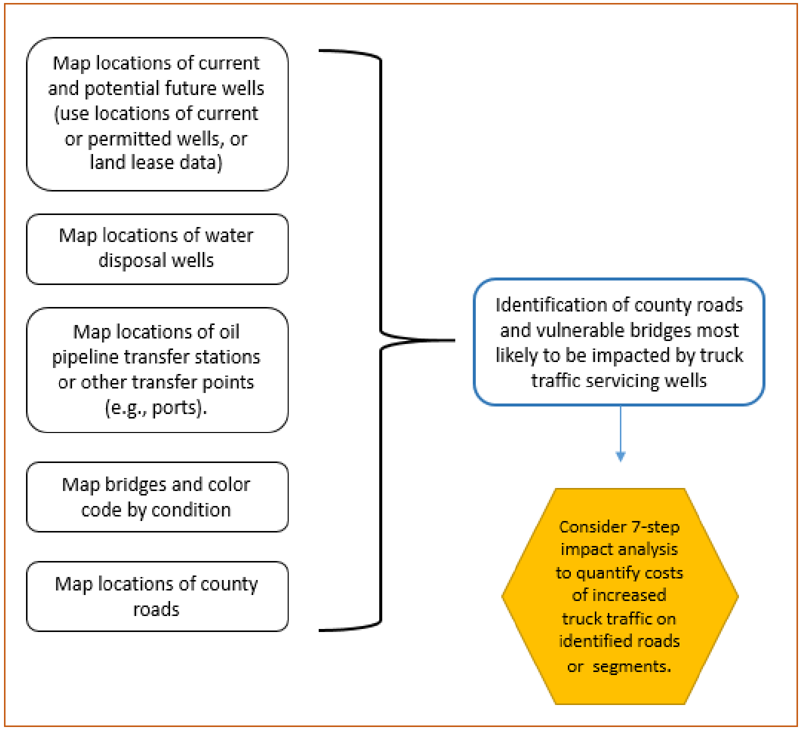

Amite County TMS wells (producing or permitted), waste water disposal well locations, and bridge conditions
Legend
NBI listed bridges
0.0 - 4.5
4.6 - 6.5
6.6 - 9.0
Disposal wells
Amite_State_Roads
Amite_County_Rds
Permitted_TMS_Wells
Producing_TMS_Wells
Cancelled_Expired_TMS_Wells
Amite
MISSISSIPPI
LOUISIANA
0 1.5 3 6 Miles
N



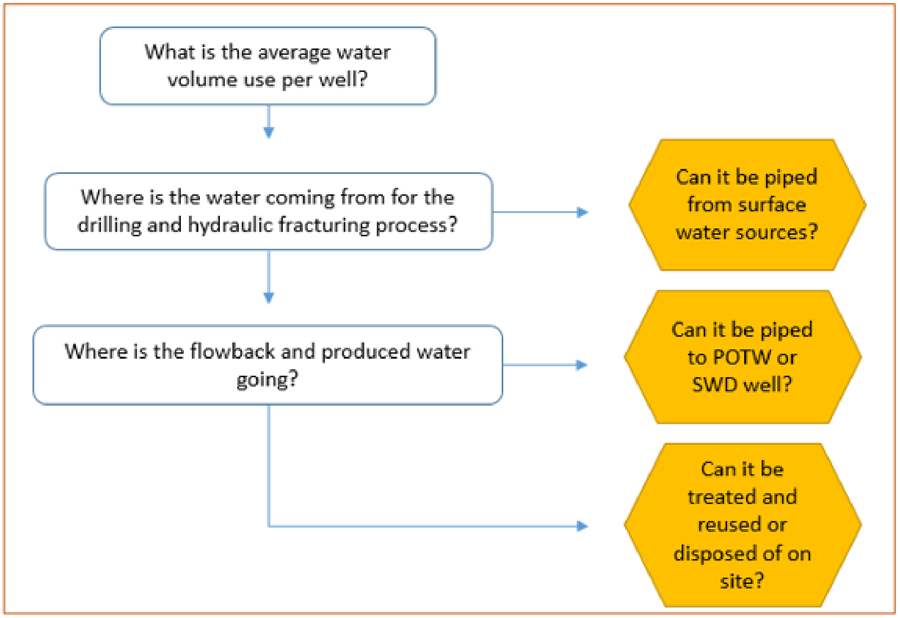
Wilkinson County well location (black triangle in circle) where shortest route to state road requires travel over sub-standard bridge.

Amite County area with significant numbers of potential or already producing wells along county road with numerous vulnerable bridges

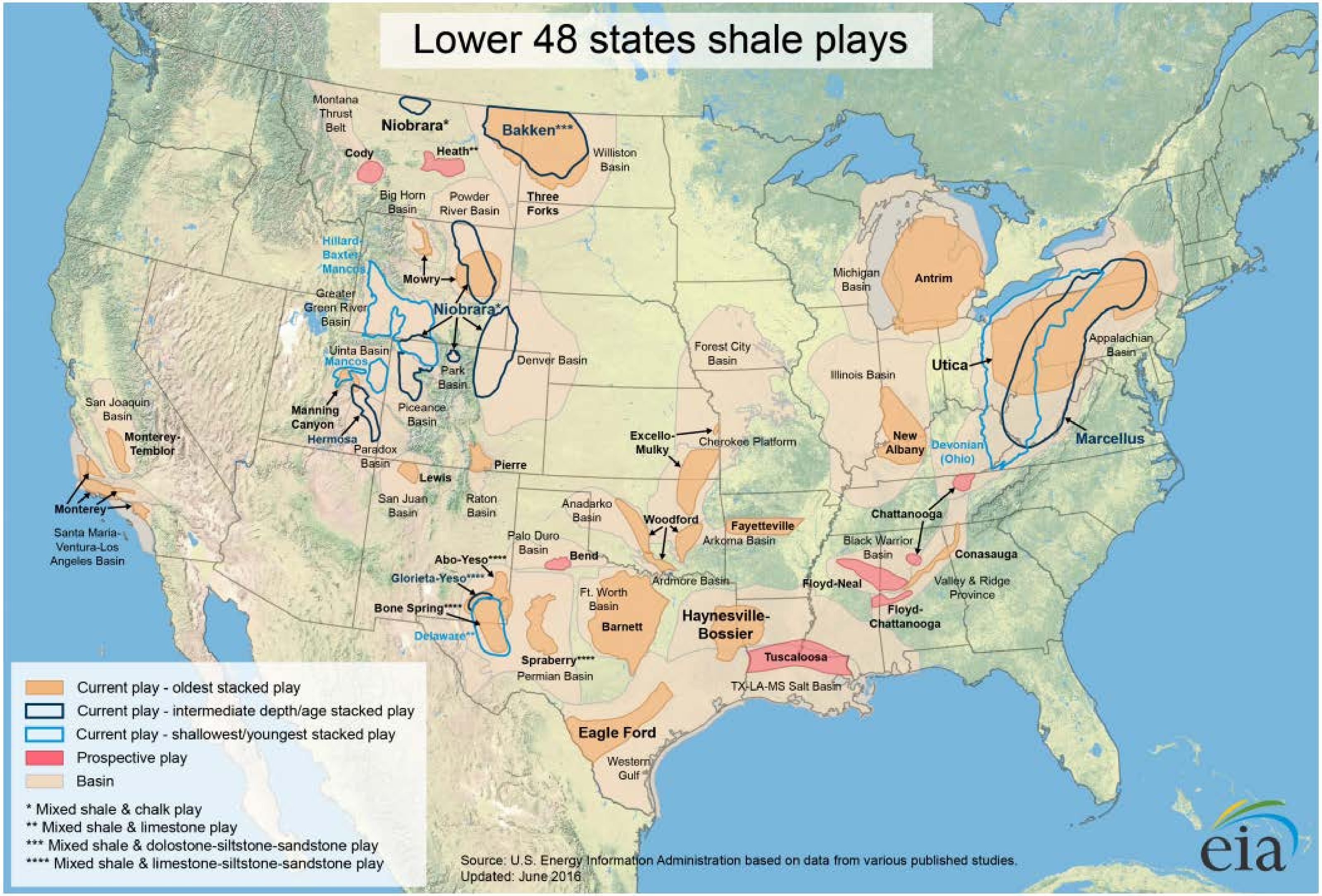




Method for identifying roads and bridges most likely to be impacted by increased energy development



Using knowledge of water volume use and transport to reduce truck traffic on local roads


Lower 48 states shale plays
Montana Thrust Belt
Niobrara*
Bakken***
Cody
Heath**
Williston Basin
Big Horn Basin
Powder River Basin
Three Forks
Hillard-Baxter-Mancos
Mowry
Greater Green River Basin
Niobrara*
Uinta Basin
Mancos
Park Basin
Denver Basin
Manning Canyon
Hermosa
Piceance Basin
Paradox Basin
Pierre
Lewis
San Joaquin Basin
Monterey-Temblor
Monterey
Santa Maria-Ventura-Los Angeles Basin
San Juan Basin
Raton Basin
Anadarko Basin
Palo Duro Basin
Bend
Abo-Yeso****
Glorieta-Yeso****
Bone Spring****
Delaware**
Spraberry****
Permian Basin
Ft. Worth Basin
Barnett
Woodford
Ardmore Basin
Excello-Mulky
Cherokee Platform
Forest City Basin
Fayetteville
Arkoma Basin
Haynesville-Bossier
Tuscaloosa
TX-LA-MS Salt Basin
Eagle Ford
Western Gulf
Michigan Basin
Antrim
Illinois Basin
New Albany
Utica
Devonian (Ohio)
Appalachian Basin
Marcellus
Chattanooga
Black Warrior Basin
Conasauga
Floyd-Neal
Valley & Ridge Province
Floyd-Chattanooga
Current play - oldest stacked play
Current play - intermediate depth/age stacked play
Current play - shallowest/youngest stacked play
Prospective play
Basin
* Mixed shale & chalk play
** Mixed shale & limestone play
*** Mixed shale & dolostone-siltstone-sandstone play
**** Mixed shale & limestone-siltstone-sandstone play
Source: U.S. Energy Information Administration based on data from various published studies.
Updated: June 2016
eia

Thank you!

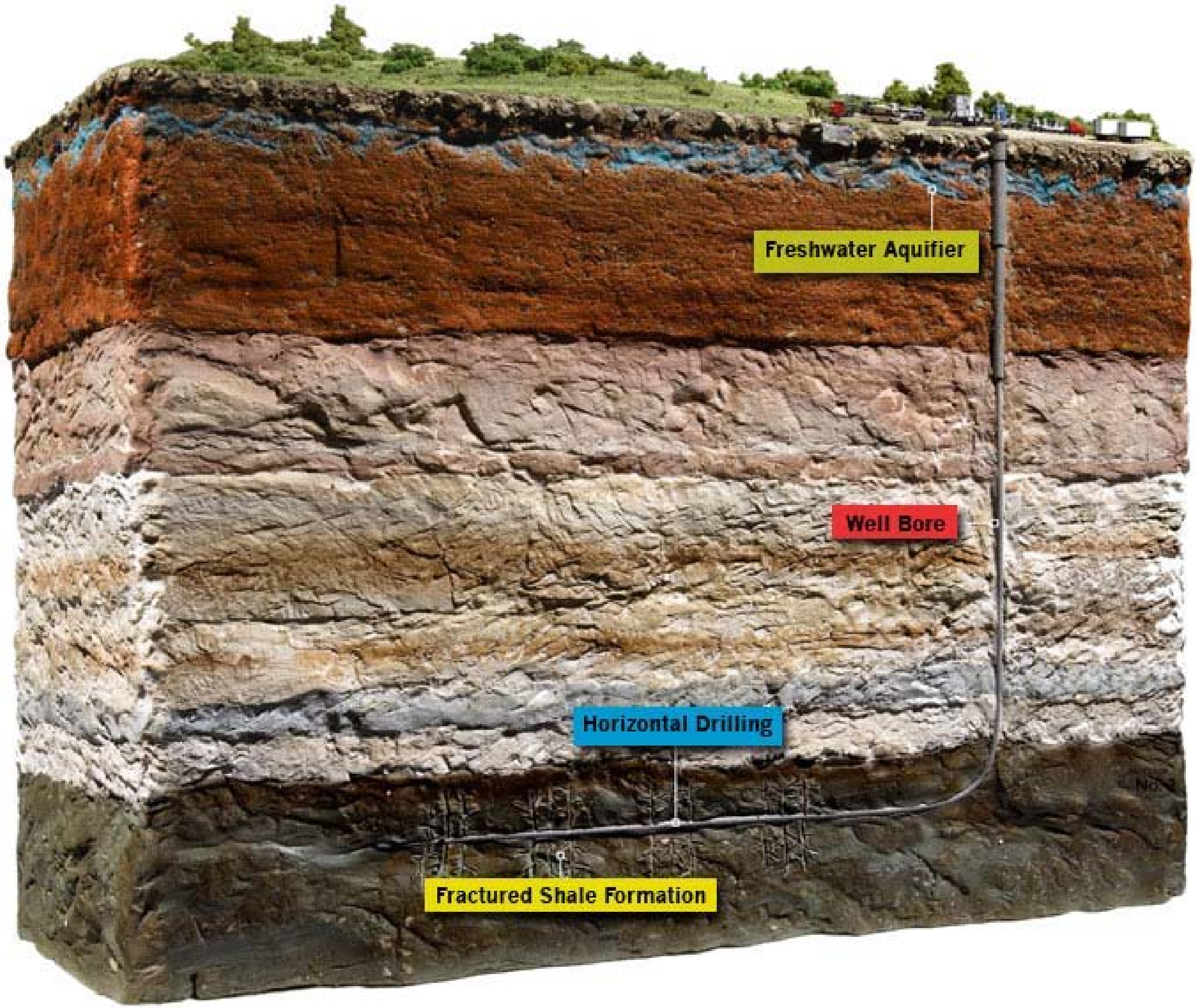
*Leah A. Dundon

Dr. Mark Abkowitz

Dr. Janey Camp

Dr. Craig Philip

*Leah.a.dundon@Vanderbilt.edu


Freshwater Aquifier
Well Bore
Horizontal Drilling
Fractured Shale Formation