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Baseline Water Quality Characterization At Four USEPA Retrospective Case Study Areas

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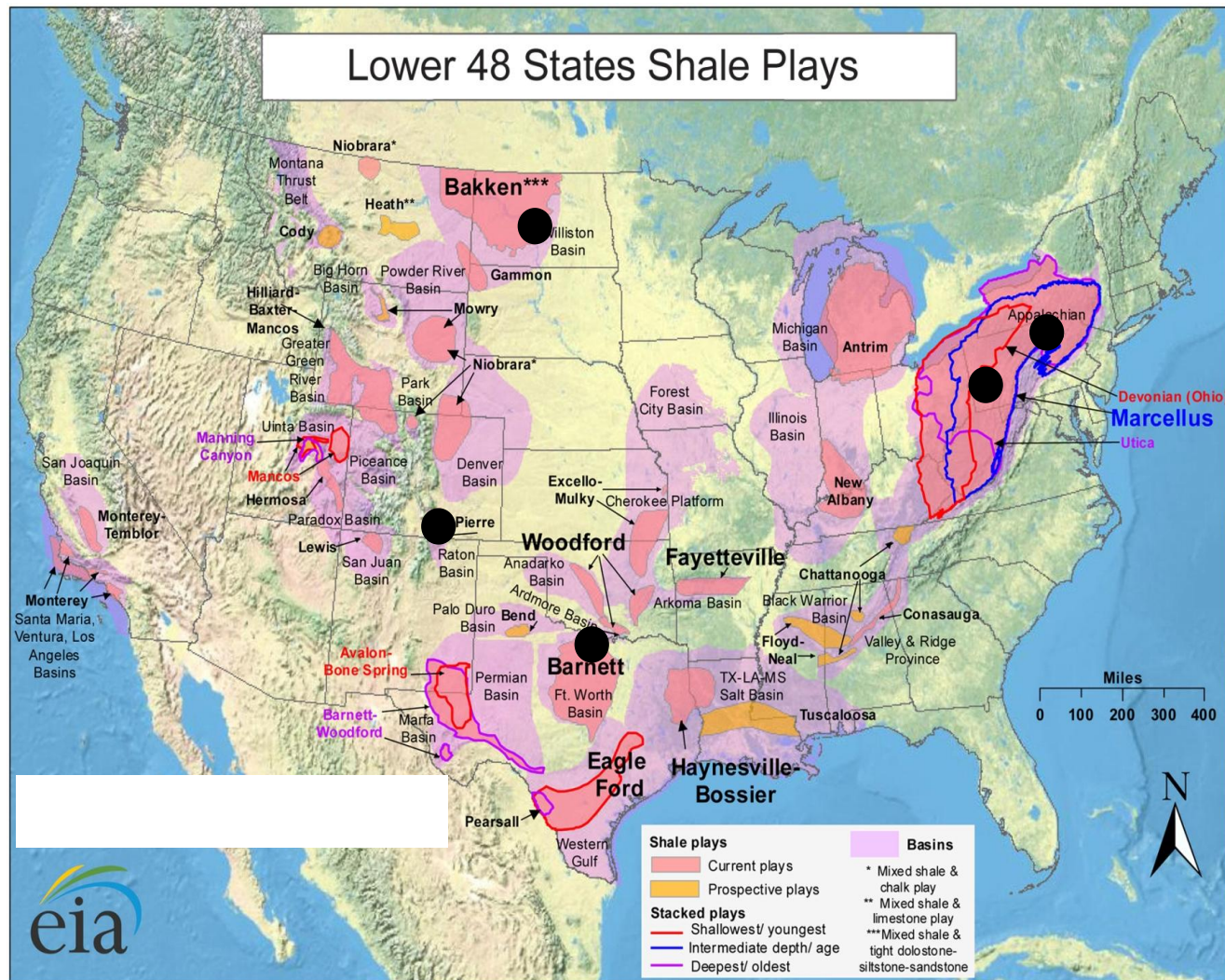
Battelle

Objectives

- Contribute scientifically to EPA's *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*
- Compile available historical water quality information around EPA's retrospective case study areas
- Characterize water quality prior to development of unconventional oil and gas resources in those areas
- Characterize historical land uses, activities and associated environmental impacts
- Summarize pre-unconventional oil and gas development background water quality against which post-development observations can be compared as a preliminary screening

Study Areas

- Washington County, PA
- Wise and Denton Counties, TX
- Dunn County, ND
- Bradford and Susquehanna Counties, PA
- Raton Basin, CO



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



Timeline for Water Quality Characterization & Rationale

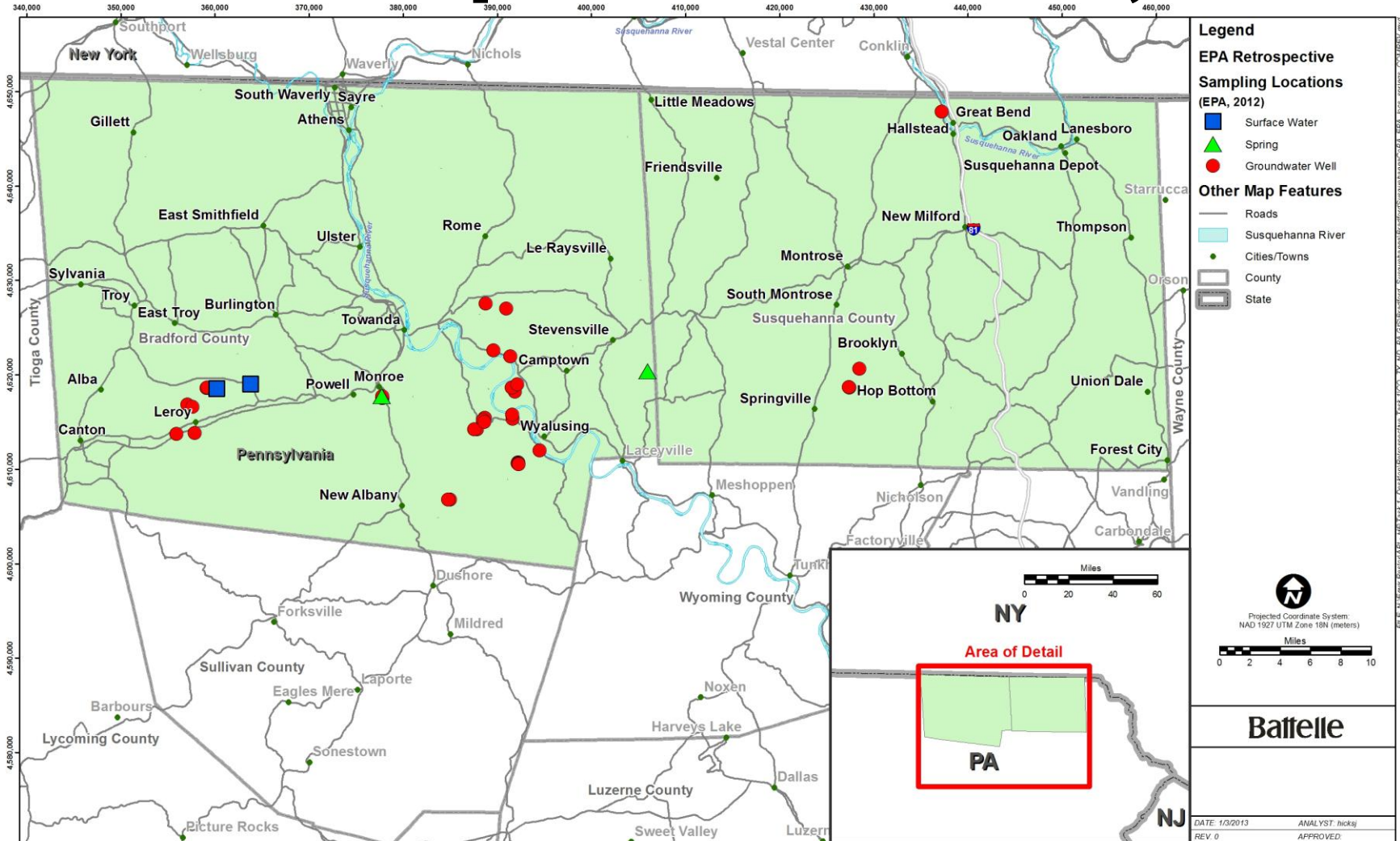
Study Area*	Date (pre-HF)	Rationale for Inclusion in EPA Study
Bradford-Susquehanna Counties, PA (Marcellus)	Pre-2007	Complaints of contaminated groundwater and drinking water wells; suspected surface water contamination from spill
Washington County, PA (Marcellus)	Pre-2005	Complaints concerning appearance, odors and taste associated with water in domestic supply wells
Wise-Denton Counties, TX (Barnett)	Pre-1998	Complaints concerning appearance, odors and taste from drinking water in domestic wells and concerns over leaks and spills
Dunn County, ND (Bakken)	Pre-2005	Blowout at Franchuk 44-20SWH well during hydraulic fracturing stage

*Raton Basin (coal bed methane) surface water and groundwater not included in this evaluation

Approach

- Describe regulatory framework
- Characterize historical water quality conditions based on readily available information
 - Land use (current and historical)
 - Known surface water impairments
 - Water quality data
- Compile analytical water quality database from federal and state sources utilizing the EPA DQO process
- Compare against water quality screening criteria
- Prepare statistics and maps
- Summarize findings and conclusions

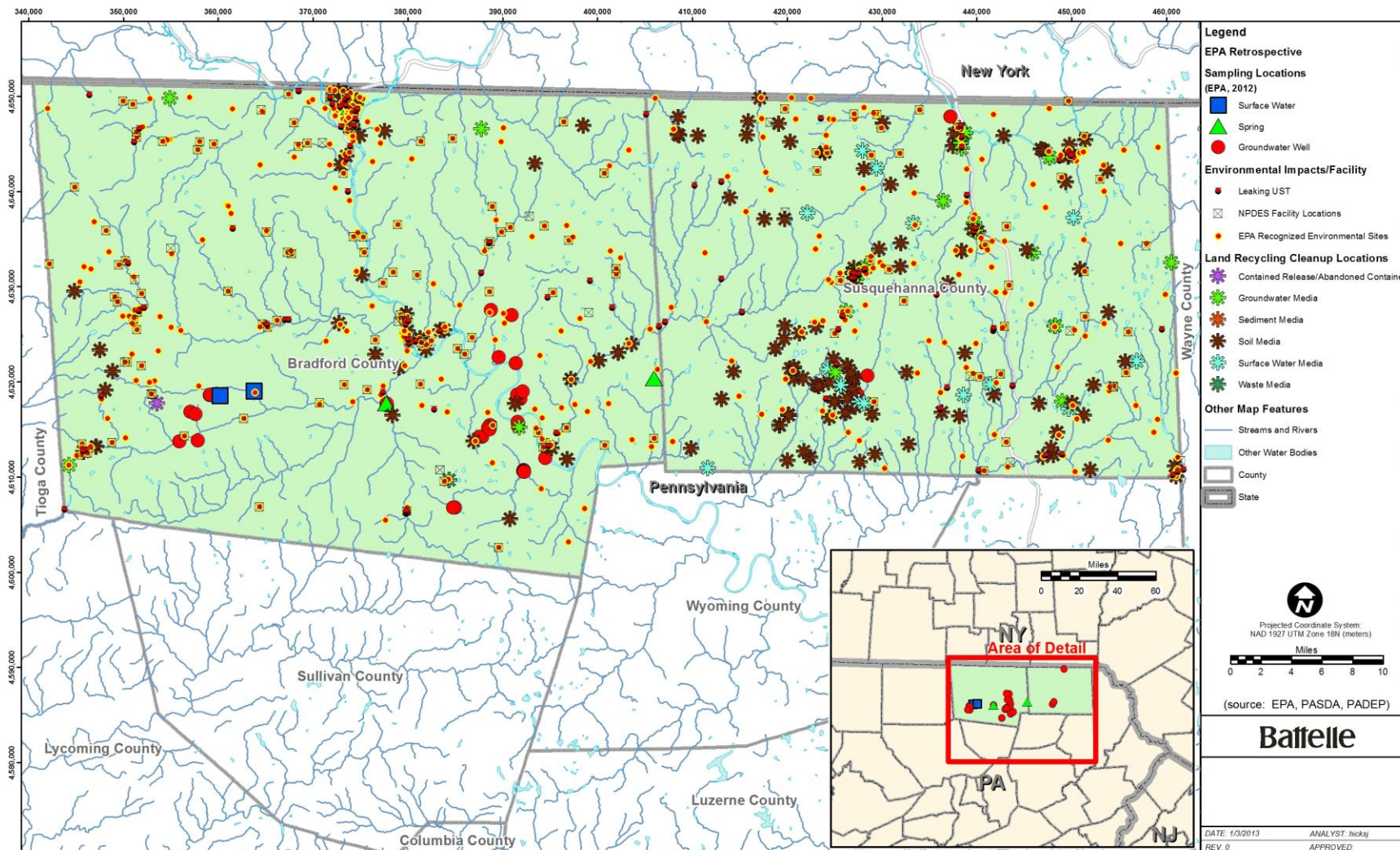
EPA Retrospective Sampling Locations Bradford-Susquehanna Counties, PA



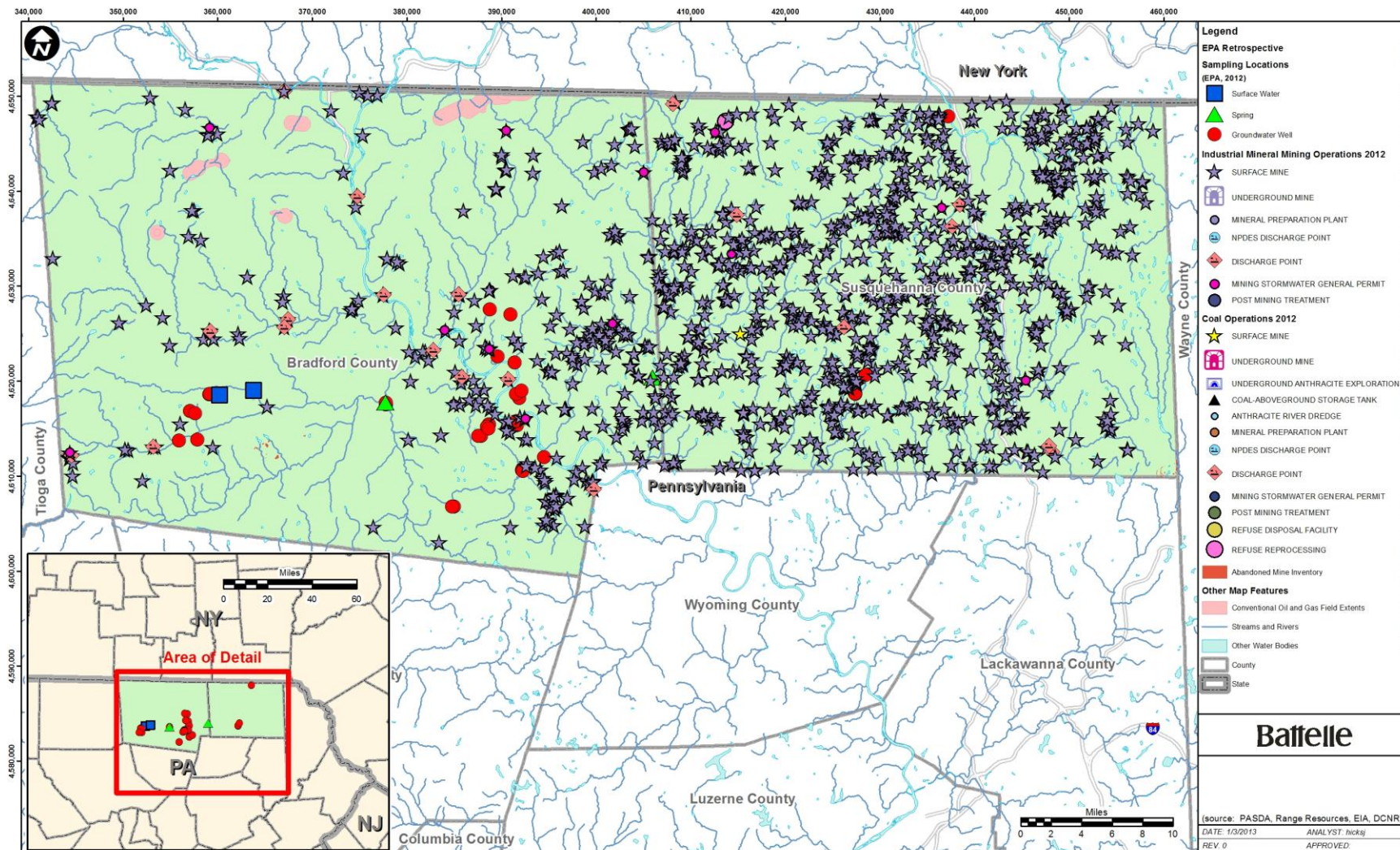
Land Use and Environmental Impacts

- Drinking water obtained primarily from groundwater with private wells typically less than 175 ft deep
- Recognized areas of poor natural groundwater quality
- Recognized issues with drinking water well completion
- 144 miles of surface water quality impairment
 - Primarily due to agriculture, road runoff, resource extraction (coal and other minerals), and waste discharges
 - Susquehanna River impaired by PCBs; advisories on fish consumption
- Limited extent of historic oil and gas development
- Documented historical presence of methane in groundwater
 - Existence of upper Devonian hydrocarbon-bearing formations
 - Dissolved methane concentrations closely correlated with hydrogeologic features (Molofsky et al., 2013)

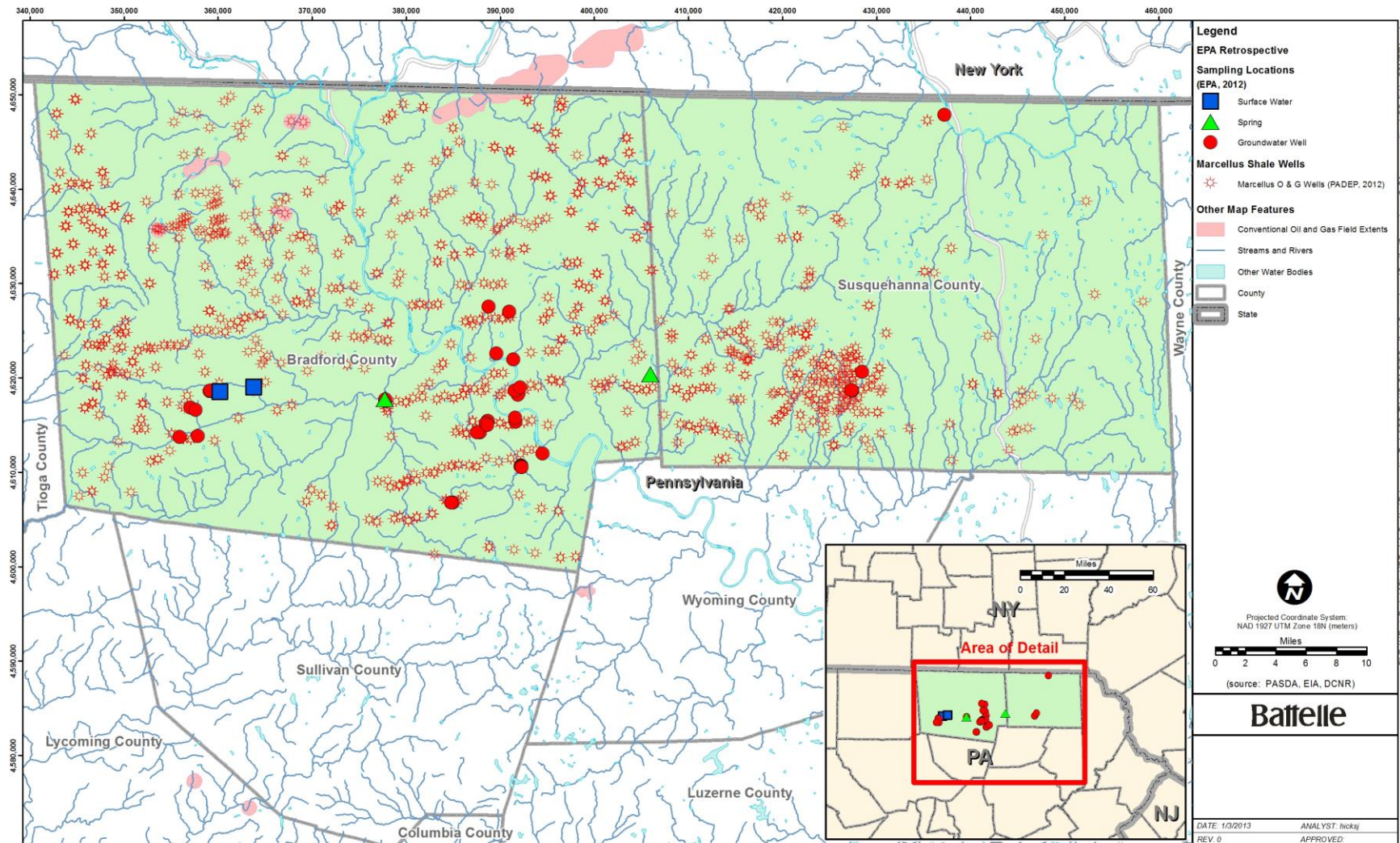
Environmental Impacts



Resource Extraction



Unconventional Oil and Gas Wells



Water Quality Data Sources

Data Source	Timeframe	Number of Monitoring Locations	Parameters
USGS National Water Information System (NWIS) ¹	1930 - 2007	249 wells 4 springs 24 surface water	Major Ions, Minor Ions, Nutrients, PAHs, Pesticides, Radionuclides, VOCs, Water Characteristics
EPA STorage and RETrieval Data Warehouse (STORET) ²	1982 - 2007	63 surface water	Major Ions, Minor Ions, Nutrients, PAHs, Pesticides, Radionuclides, VOCs, Water Characteristics
USGS National Uranium Resource Evaluation (NURE) ³	1977	285 wells 90 springs 266 surface water	Major Ions, Minor Ions, Radionuclides, Water Characteristics
USGS report - PADEP – PA Ambient and Fixed Station Network and Others ⁴	1979 - 2006	117 wells 2 springs	Major Ions, Minor Ions, Nutrients, Water Characteristics

¹ <http://waterdata.usgs.gov/nwis/qw>

² <http://www.epa.gov/storet/>

³ http://tin.er.usgs.gov/geochem/doc/nure_analyses.htm

⁴ <http://pubs.usgs.gov/ds/314/>

Bradford-Susquehanna County, PA

- No documented instances where injecting hydraulic fracturing fluids into the subsurface has negatively impacted water resources
- Out of the 192 parameters EPA listed for evaluation, only 29 groundwater, 11 spring, and 23 surface water parameters have sufficient baseline characterization data (e.g., ≥ 8 sample locations)
 - Majority of data on general water quality parameters, inorganics, and nutrients
 - Limited data for organic compounds
- Methane naturally occurring in formations that also supply groundwater

Percentage of Parameters (Pre-2007) Above Screening Criteria in Bradford-Susquehanna Counties, PA

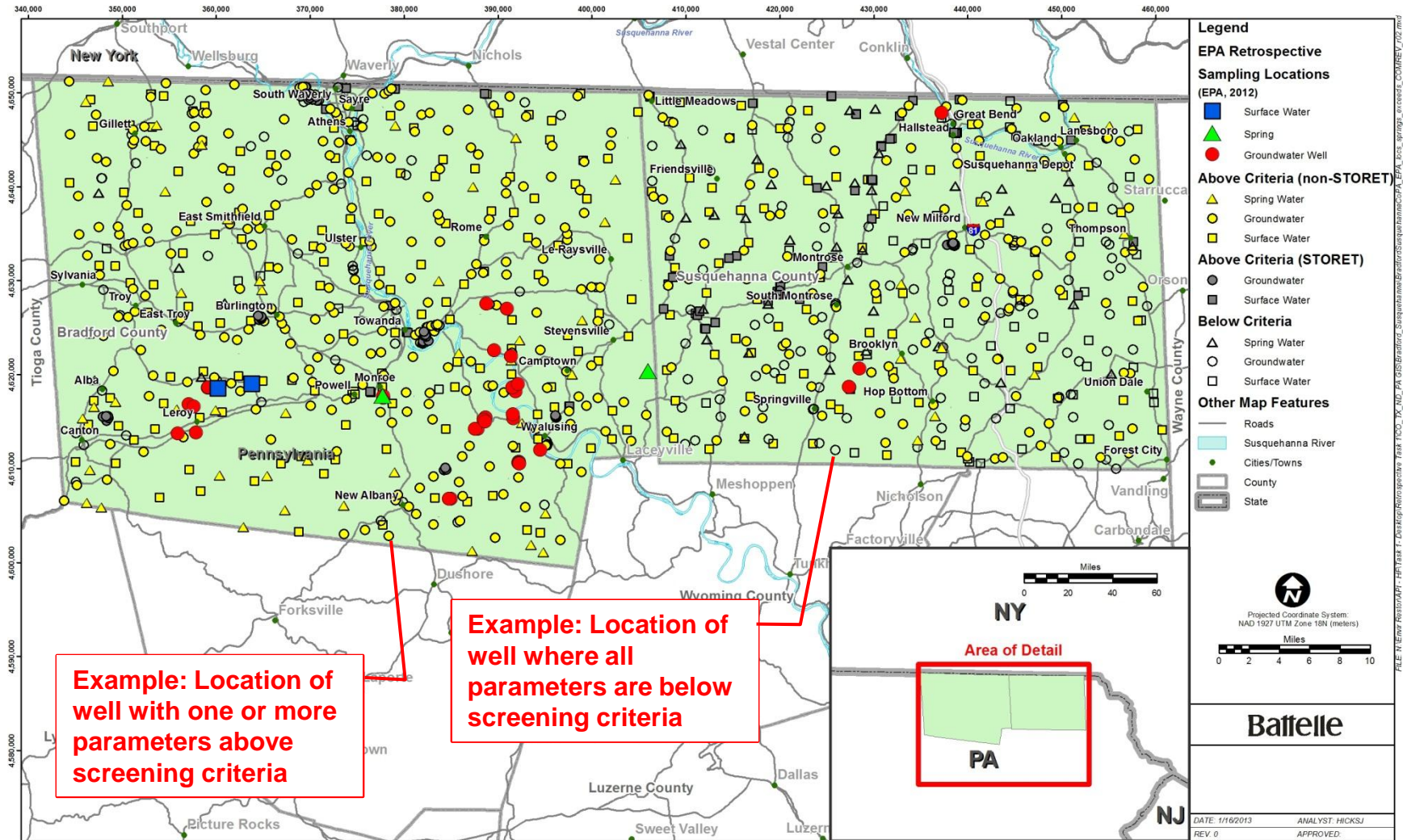
		Percent Detected Above One or More Screening Criteria*																	
		General Water Quality		Major Ions				Dissolved Metals								Nutrient			
	Total No. Sample Locations	pH (Field)		Total Dissolved				Aluminum	Arsenic	Barium	Chromium (VI)	Copper	Iron	Lead	Manganese	Strontium	Zinc	Nitrate (as N)	Nitrite (as N)
		Ground water	535	10	10	3	1	25	-	11	100	6	2	-	34	4	74	3	2
Surface Water	286	14	8	<1	-	-	<1	23	-	-	-	1	37	-	73	-	-	<1	<1
Springs	92	-	33	-	-	1	-	4	-	-	-	-	-	-	78	-	-	-	-

Total number of wells

Example: For groundwater, 11% of 400 samples tested for dissolved aluminum are above one or more water quality screening criteria

* Excludes STORET data; 3_{/502} = 3% of 502 samples; -- = No data above screening criteria; † = total metals value

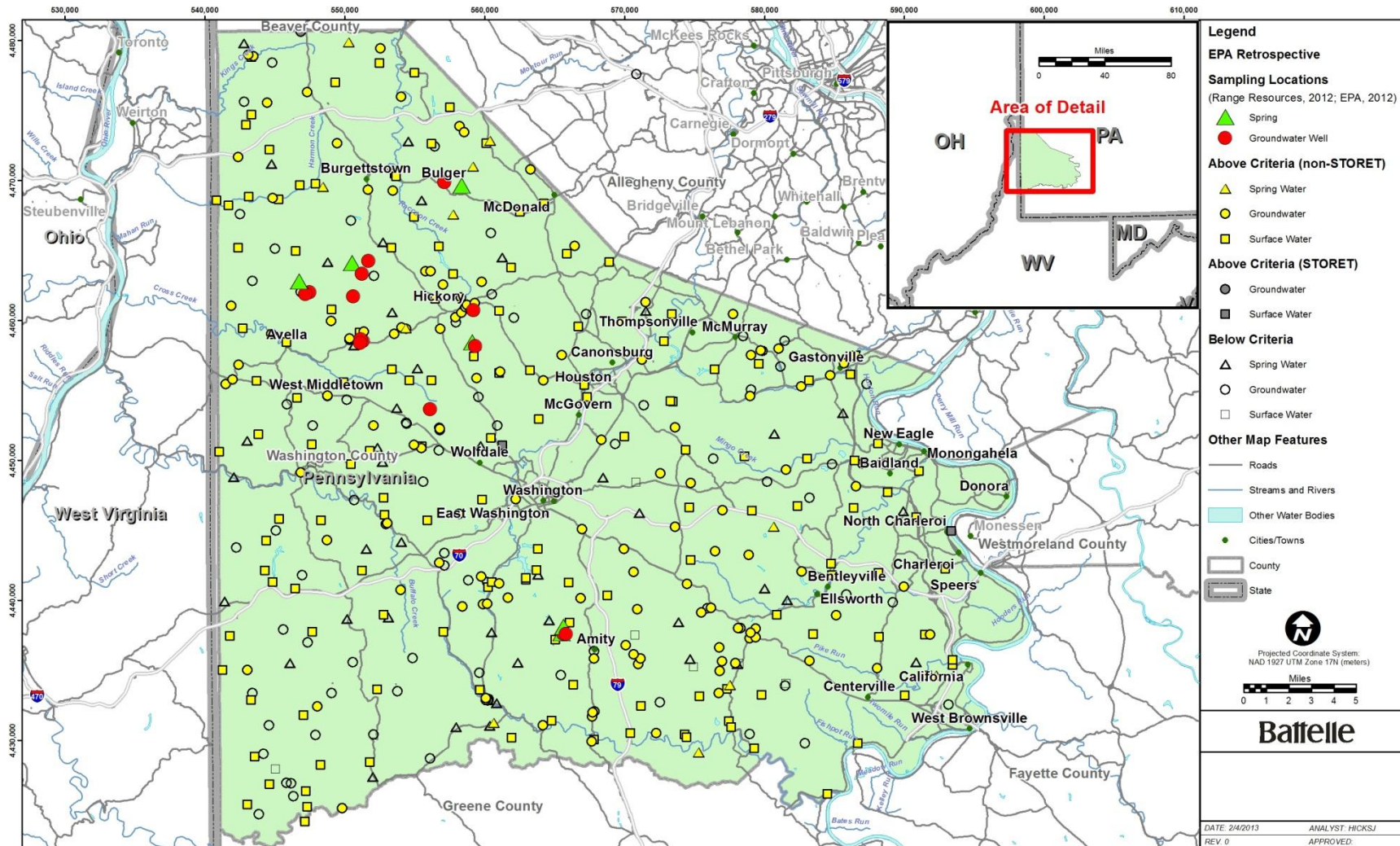
Locations of Parameters (Pre-2007) Above Screening Criteria in Bradford-Susquehanna Counties, PA



Washington County, PA

- Water quality data evaluated by Battelle for the pre-2005 timeframe prior to unconventional oil and gas development in the Marcellus shale
- More than 11,600 conventional O&G wells drilled historically
- Underground mining of coal has occurred in over 50% of the county and many other areas have been strip mined.
- 923 miles of streams are impaired by AMD; 1,146 miles of streams are impaired by runoff from agricultural areas, urban storm water, roads and residential areas
- No instances documented where injecting hydraulic fracturing fluids into the subsurface has negatively impacted water resources
- Out of the 196 EPA parameters, only 29 groundwater, 11 spring, and 21 surface water parameters have sufficient baseline characterization data

Locations of Parameters (Pre-2005) Above Screening Criteria in Washington County, PA

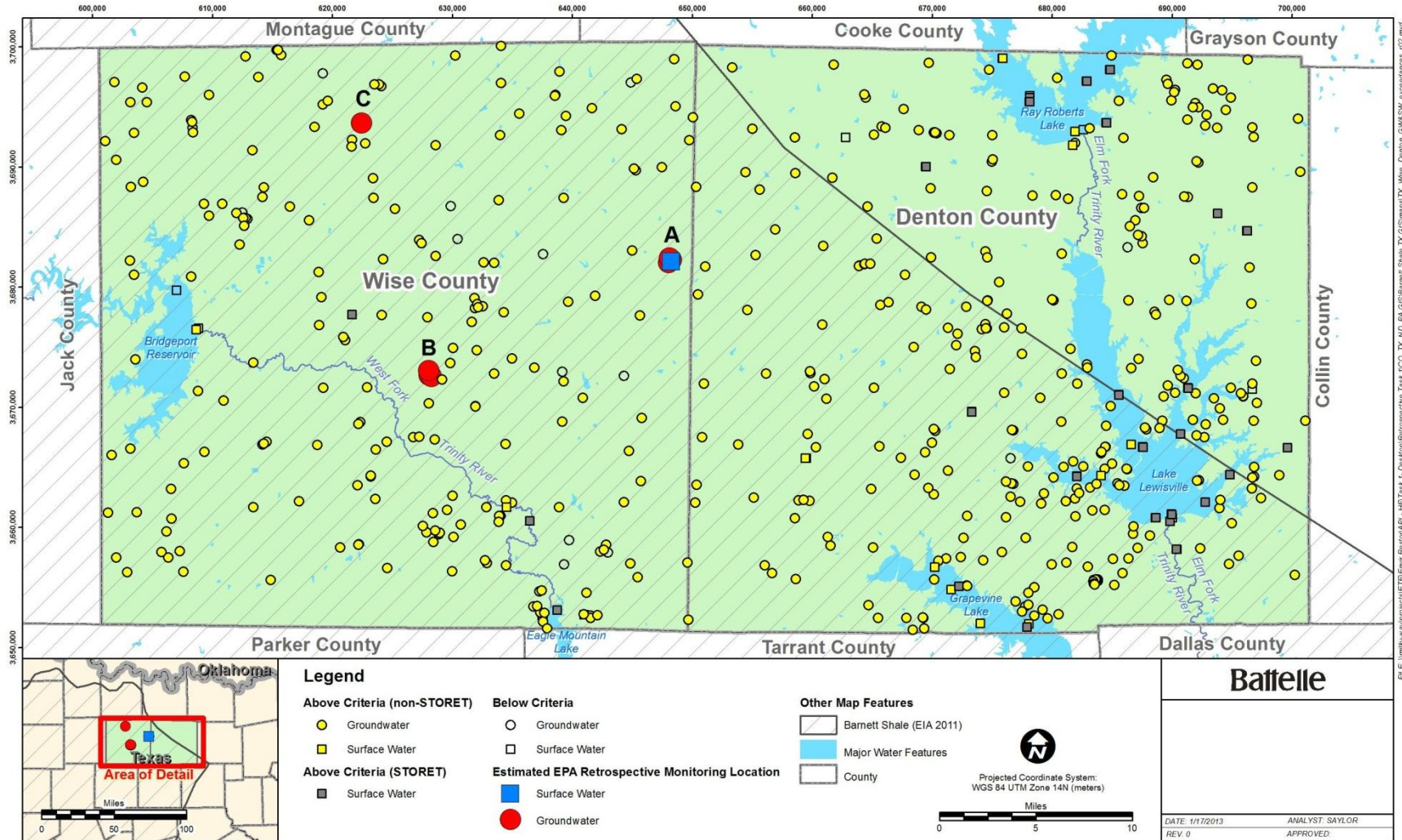


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Wise & Denton Counties, TX

- Water quality data evaluated for the pre-1998 timeframe prior to unconventional oil and gas development in the counties
- 18,000 conventional oil and gas wells; groundwater impacts reported by TRRC due to historical oil field activities
- Review of 16,000 shale gas wells drilled between 1993 and 2008 by the TRRC found no groundwater contamination associated with any of the production lifecycle stages of those wells
- Out of the 188 EPA parameters, only 71 groundwater and 24 surface water parameters have sufficient baseline characterization data

Locations of Parameters (Pre-1998) Above Screening Criteria in Wise & Denton Counties, TX

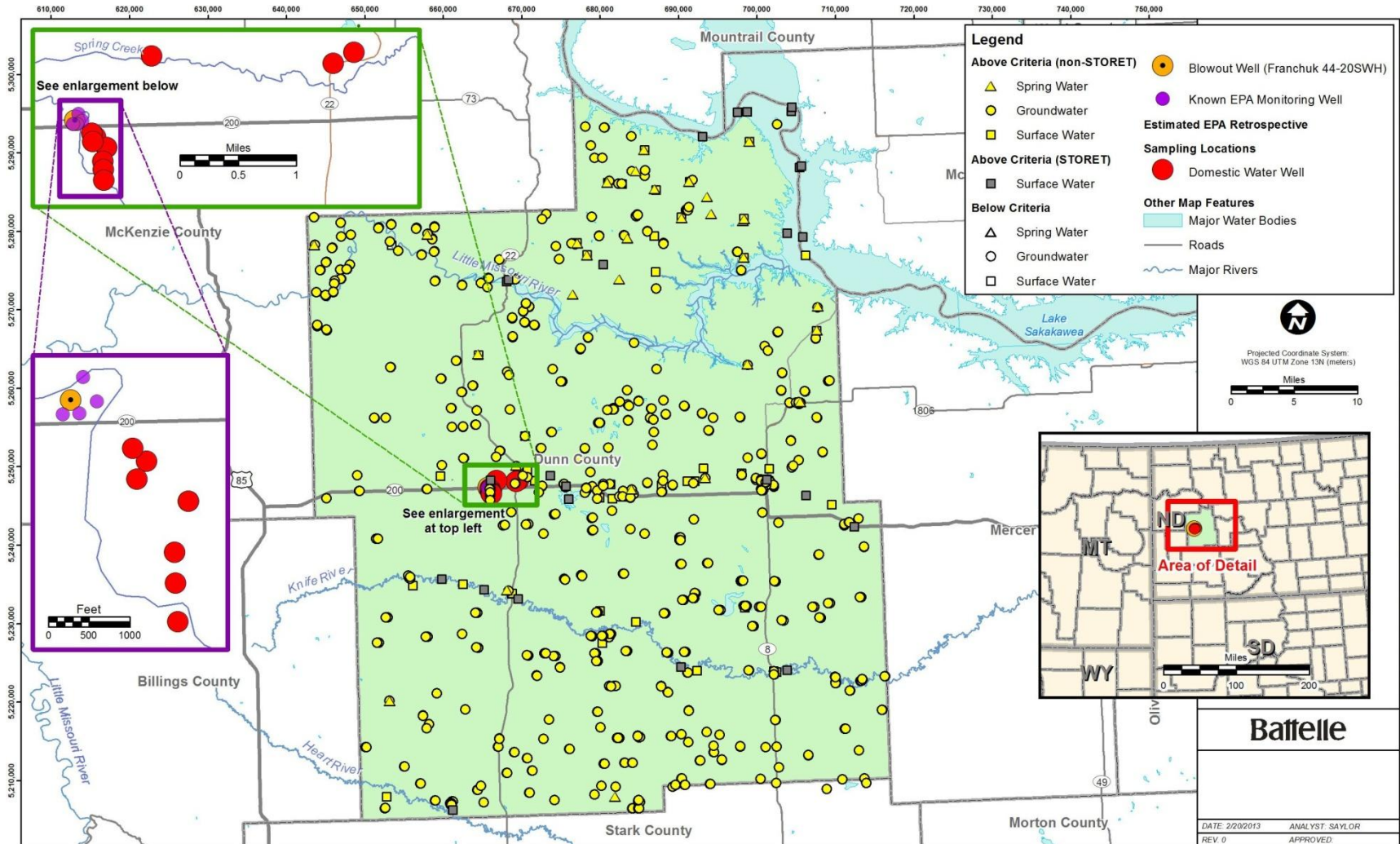


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Dunn County, ND

- Location associated with a well blowout (Sep. 2010) near Killdeer, ND
 - Released 84,000 gallons of HF fluids, largely captured by surface containment
 - Excavated and disposed impacted soils
 - Groundwater monitoring – no impacts to groundwater in the Killdeer aquifer indicating a release of petroleum or hydraulic fracturing fluid
 - No impacts to nearest surface water body – Spring Creek
- Water quality data evaluated for the pre-2005 timeframe prior to unconventional oil and gas development in the Bakken shale
- Out of the 237 EPA parameters, only 27 groundwater, 16 spring, and 28 surface water parameters have sufficient baseline characterization data

Locations of Parameters (Pre-2005) Above Screening Criteria in Dunn County, ND



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Summary Findings

- Extensive prior industrial and agricultural land use has occurred within the EPA study areas
- Historical background water quality data for some parameters are either absent or limited to a very small subset (comprising a few general water quality parameters, major ions, metals and nutrients) of EPA's full parameter list used for the retrospective case studies
- Deficiencies in historical water-quality for some parameters (e.g., methane pre-unconventional O&G development) are widely distributed across the retrospective study areas
- Regulatory programs reviewed by STRONGER – findings of sound to strong programs and systems in place
- Several in-depth studies (PA, TX, ND) found no evidence of HF-related operations impact on water quality

Conclusions

- Battelle's regional baseline water quality characterization studies provide a critical scientific contribution to EPA's retrospective case study program
- Readily available water quality data and land use information have been compiled that demonstrate the many other potential contamination sources that must be considered by EPA, state agencies and industry for reference and to inform future planning
- Limited or absent baseline water quality data for some parameters, historical land use and current EPA retrospective study design will constrain the ability to compare EPA sampling results to prior conditions and will limit the ability to draw meaningful conclusions
- EPA water quality observations will require rigorous scientific analysis and likely additional data to differentiate presumed impacts from pre-existing conditions

Documents Available Online

Technical Memo 4: Battelle Contract No. CON00011206

Bradford and Susquehanna County, Pennsylvania Retrospective Case Study Characterization Report

Submitted to:

American Petroleum Institute (API)
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America's Natural Gas Alliance (ANGA)
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February 2013

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