

SYSTEMATIC ASSESSMENT OF WELLBORE INTEGRITY  
FOR GEOLOGIC CARBON STORAGE PROJECTS USING  
REGULATORY AND INDUSTRY INFORMATION

DE-FE0009367

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U.S. Department of Energy  
National Energy Technology Laboratory  
Carbon Storage R&D Project Review Meeting  
Developing the Technologies and  
Infrastructure for CCS  
August 20-22, 2013

# Presentation Outline

- Statement of the Problem
- Benefit to the Program
- Project Overview
- Project Objectives
- Technical Status
- Accomplishments to Date
- Summary / Results and Conclusions
- Appendix

# Statement of the Problem

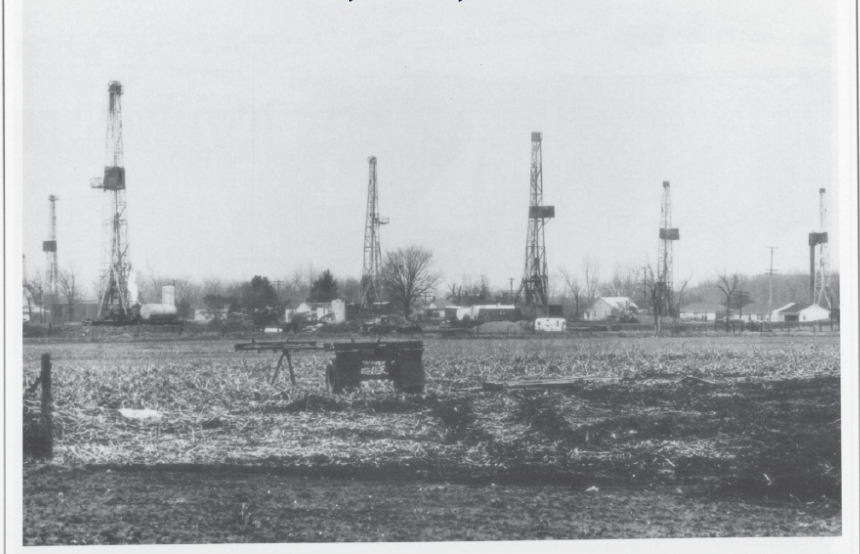
- Areas in the Midwest have perceived risk for carbon capture utilization and storage (CCUS) due to long drilling history.
- However, many of the old wells may not present high risk for CCUS because they are shallow or effectively plugged and abandoned.

**Titusville, PA, 1865**



Source: Drake Well Museum.

**Morrow Co., OH, 1964**



13. Cardington, Ohio, U. S. Route 42, looking east-southeast, c. February 1964. A companion to Photograph Number 10.

Source: Morrow County Oil Boom. 1994. Ohio Geological Society.

# Benefit to the Program

- Existing and plugged and abandoned wellbores are one of the greatest risks for CO<sub>2</sub> migration pathways
- This project will provide a methodology to identify risks and recommend mitigation procedures
  - Develop and validate technologies to ensure 99 percent storage permanence and develop technologies to improve storage efficiency while ensuring containment effectiveness (goals)
- The project will utilize available industry and regulatory data to evaluate well integrity and it will develop effective technology to account for wellbore issues from field evaluation to CO<sub>2</sub> storage field siting

# Project Overview

- The project is funded by the U.S. DOE / National Energy Technology Laboratory under their program on technologies to ensure permanent geologic carbon storage (Contract DE-FE0009367).
- Co-funding provided by Ohio Development Services Agency Agreement CDO-D-13-01.
- Project is a three year effort from October 2012-September 2015.
- Project team includes Battelle, BP Alternative Energy, and NiSource
- Project Manager - Dawn Deel, NETL Sequestration Division



U.S. DOE/NETL

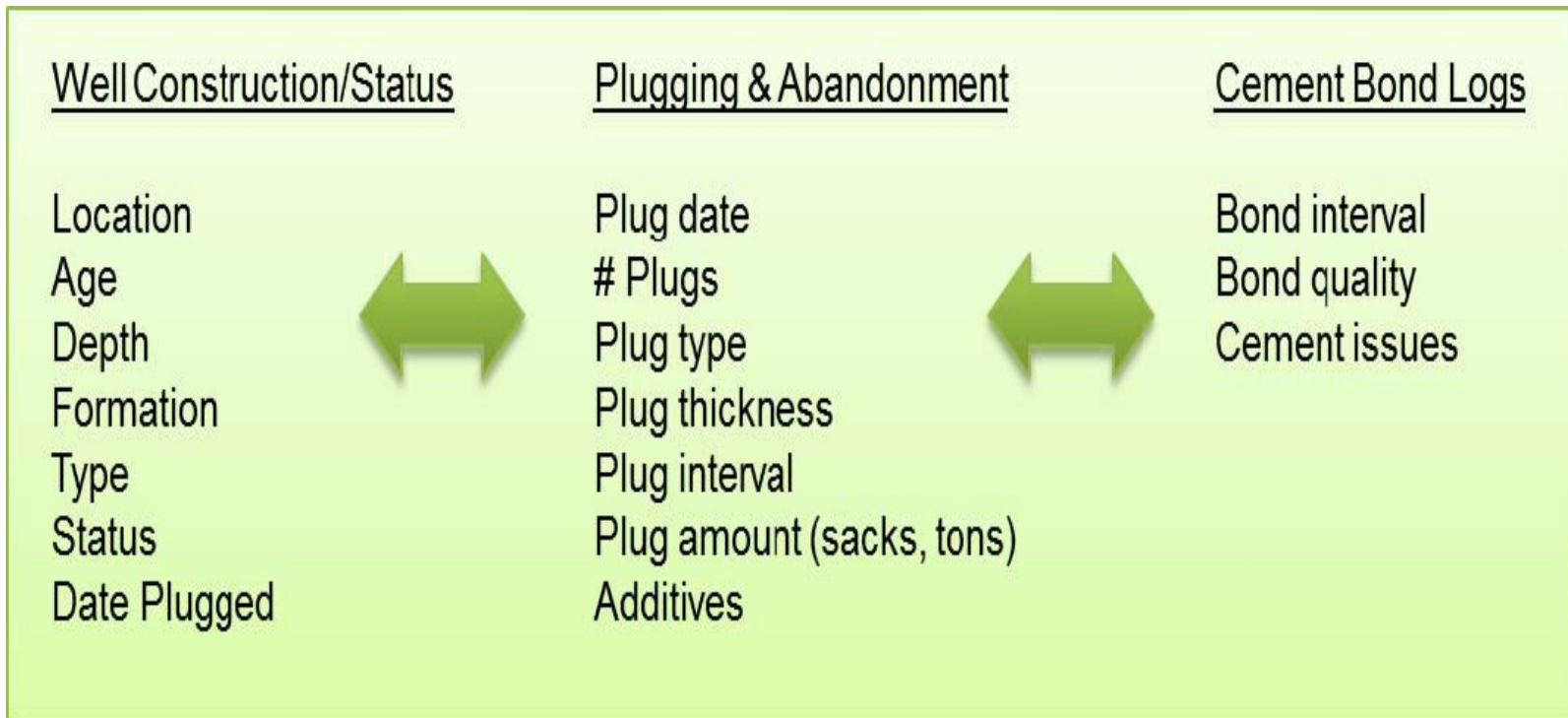


# Project Objectives

- The objective of the project is to complete a systematic assessment of wellbore integrity using regulatory and industry information.
- The project will determine the distribution of wellbores in a study area through collection and analysis of well records.
- The data review will be linked to analysis of well casing annulus pressure data as they relate to well condition.
- Project results will identify and develop methodologies that can indicate future wellbore integrity risks from available public domain data with high confidence.

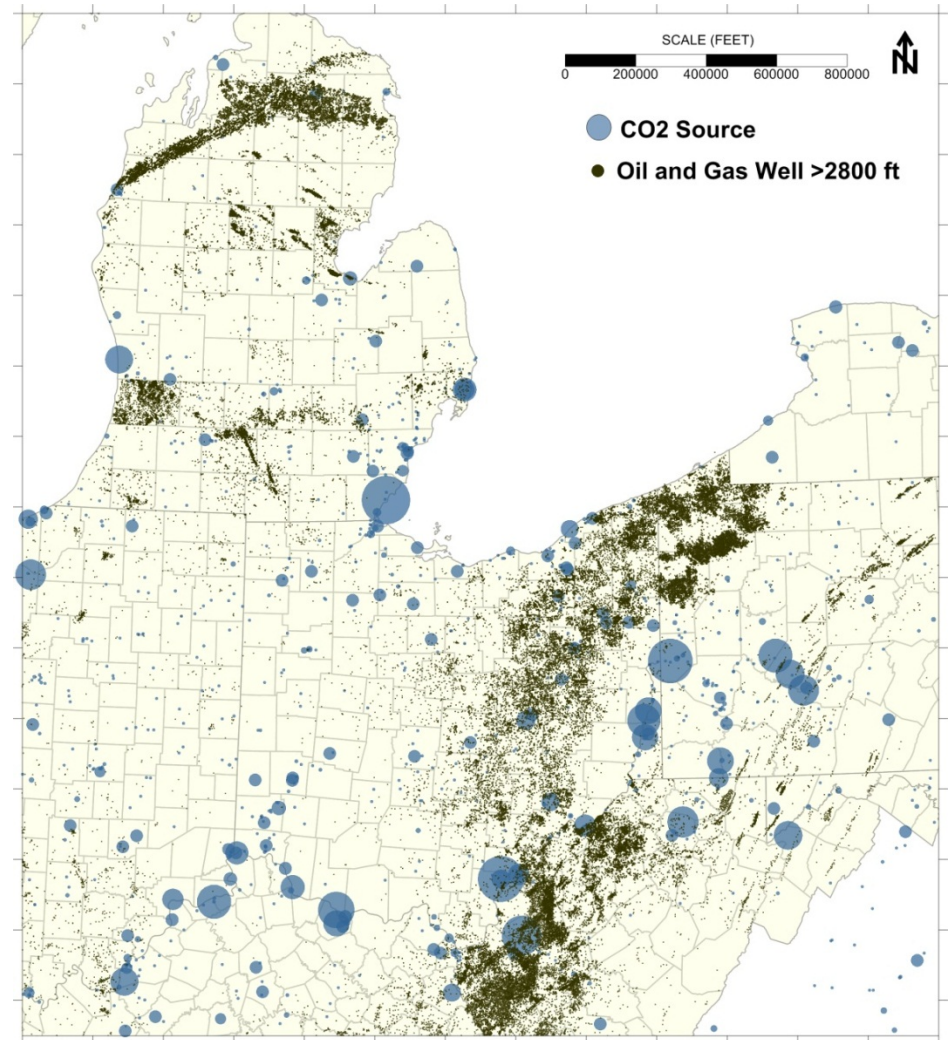
# Project Objectives

- This project is designed to meet objectives of the DOE/NETL research goals on CO<sub>2</sub> storage with a combination of field work and technical analyses.



# Project Objectives

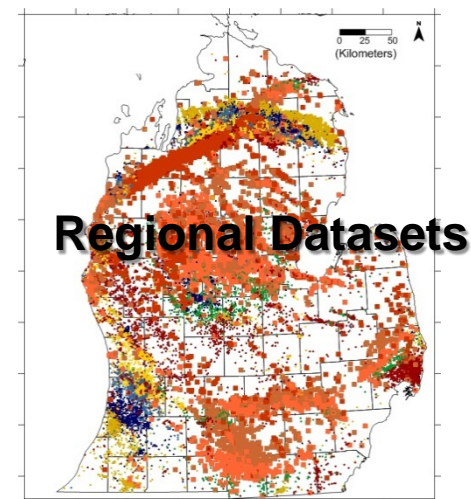
- The project will summarize remediation and plugging methods, costs, and level of effort for potential CO<sub>2</sub> storage zones.
- Based on the well integrity evaluation, guidance will be developed for siting CO<sub>2</sub> storage applications.
- Key storage targets will be identified with least risk from abandoned wells.
- Technology guidance will be provided for well completion and abandonment applications.





# Technical Approach/Organization

- The project will consist of five technical tasks over a 3-year period:
  - Task 2 – Well Record Collection
  - Task 3 – Well Record Analysis
  - Task 4 – Sustained Casing Pressure Analysis
  - Task 5 – Well Integrity Analysis
  - Task 6 – CO2 Storage Assessment
- Period of performance: October, 2012 through September, 2015.

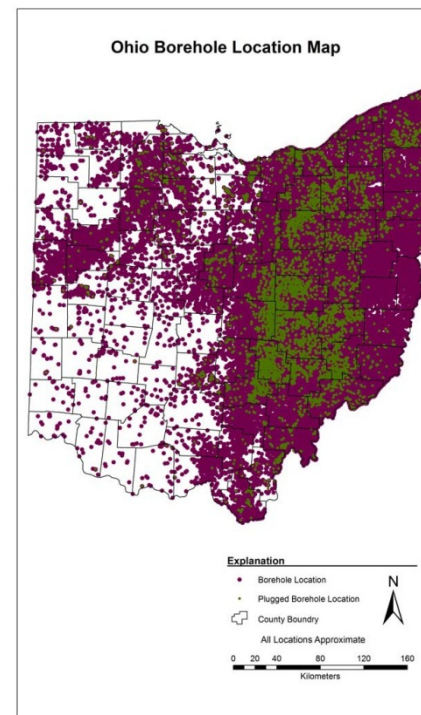
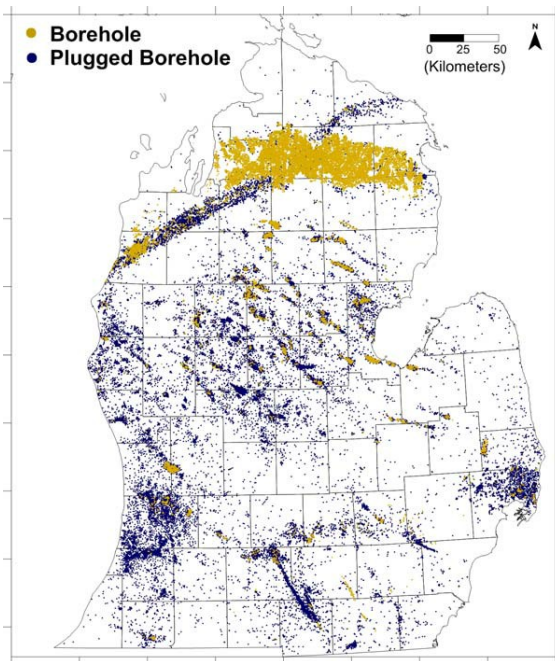


# Technical Status

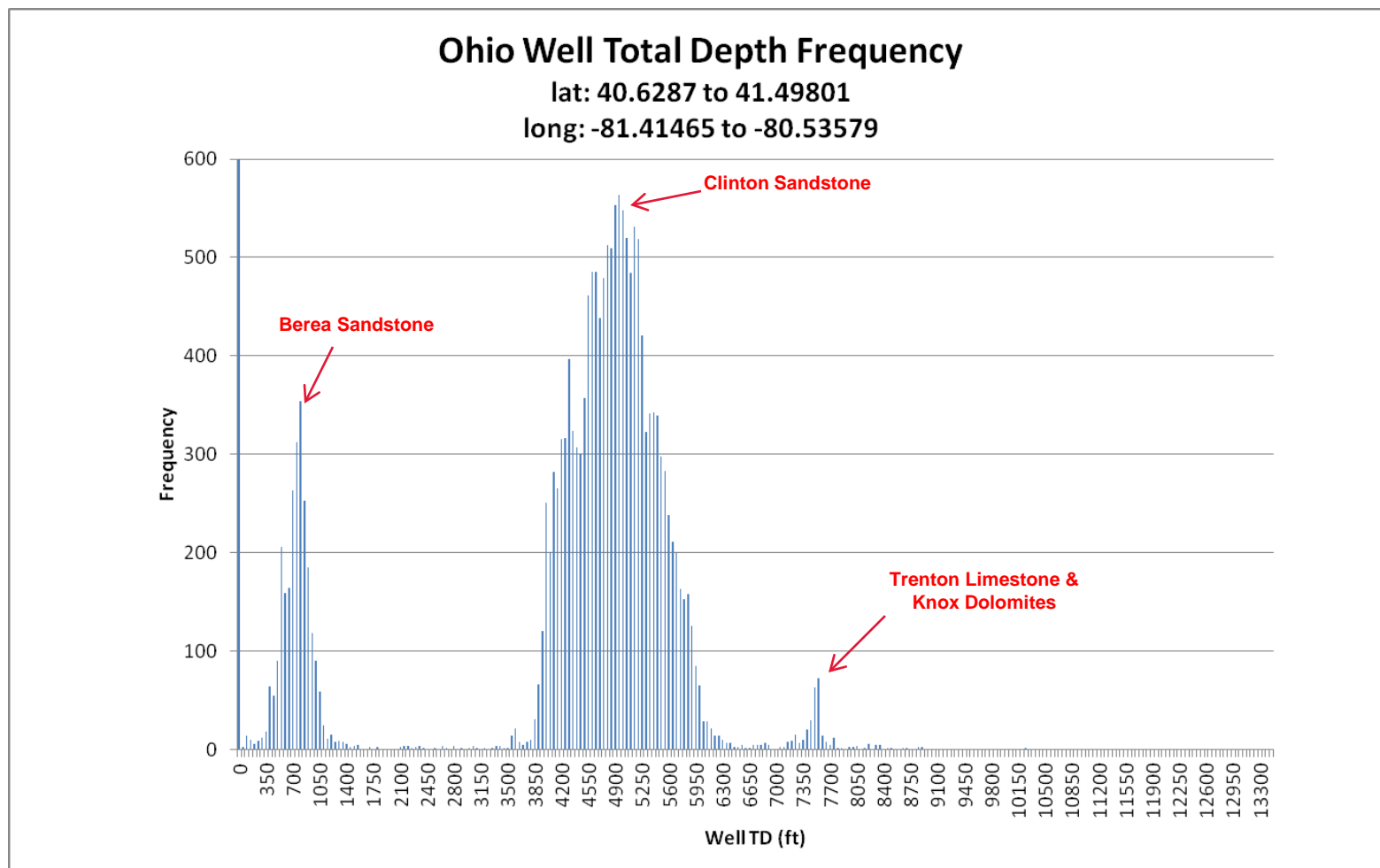
- This project is on schedule to meet objectives
- The regional well data collection task was completed on June 20, 2013. Oil and gas well records for Ohio and Michigan were collected in three categories:
  - Well construction information,
  - Plugging and abandonment details, and
  - Cement bond logs.
- The dataset includes over 4 million items related wellbore construction in Ohio and Michigan.

# Technical Status

- A total of 53,825 oil and gas well records were acquired from the Michigan Department of Environmental Quality, of which a total of 34,612 wells (66%) are listed as plugged and abandoned
- A total of 229,992 oil and gas well records were acquired from the Ohio Department of Natural Resources database, of which 102,246 (44%) were listed as plugged and abandoned

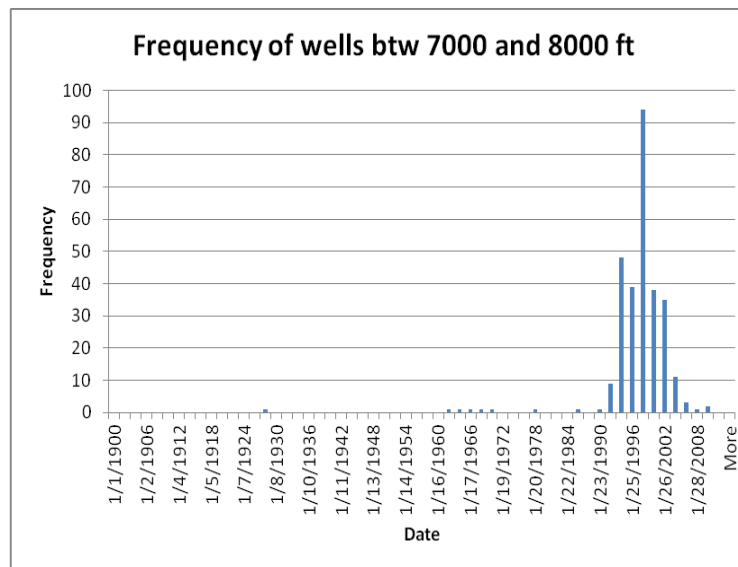
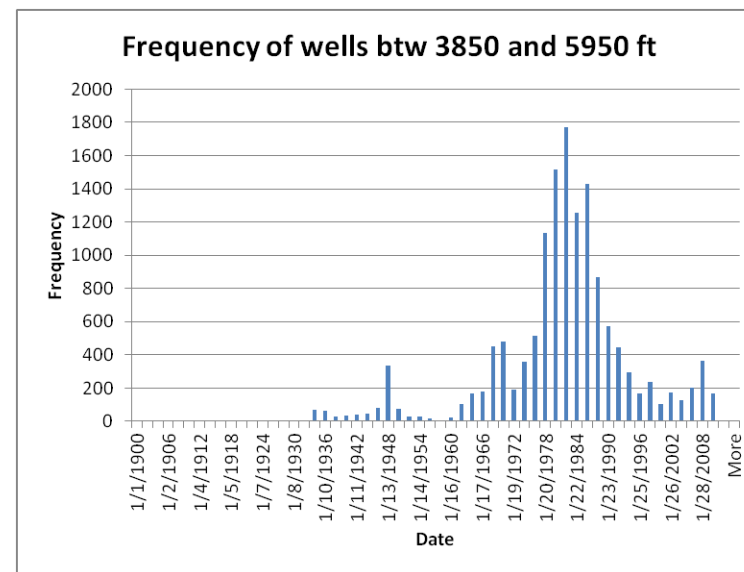
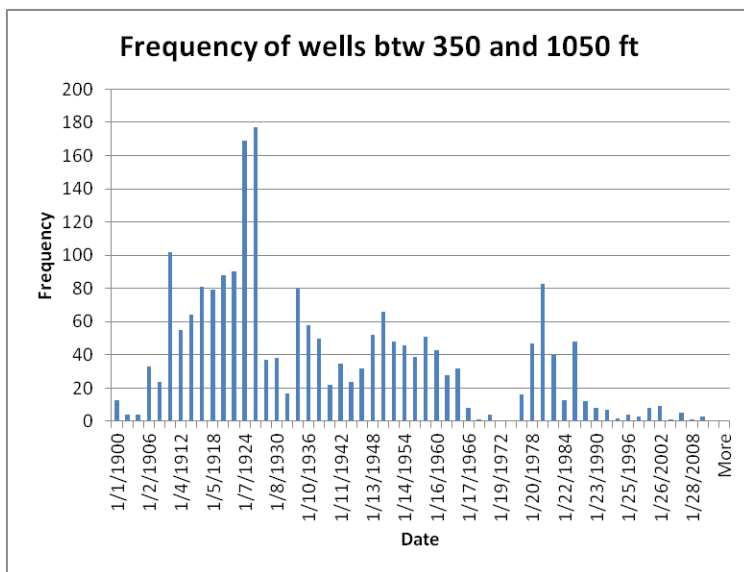


# Well History Review- NE Ohio



Number of wells drilled per depth range

# Well History Review- NE Ohio



Majority of vintage wells were drilled to shallow producing formations which pose little risk of CO2 leakage from deep storage wells.

Majority of deep wells were recently drilled and constructed under modern regulations which reduces there risk of leakage pathways.

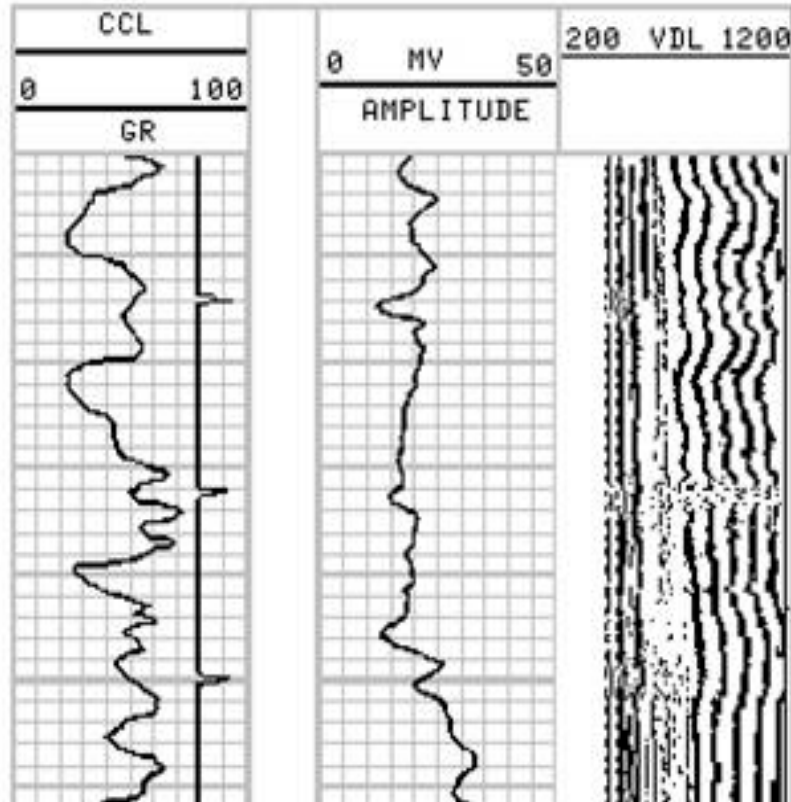
# Plugging and Abandonment Well Records Analysis

- Michigan plugging and abandonment records were collected and a random subsample of 5% was generated.
- Plugging and abandonment records for these 1730 wells were tabulated.
- Ohio plugging and abandonment records were available from 6390 wells.
- A quality assurance/quality control (QA/QC) review of the dataset was completed to identify errors in data entry.

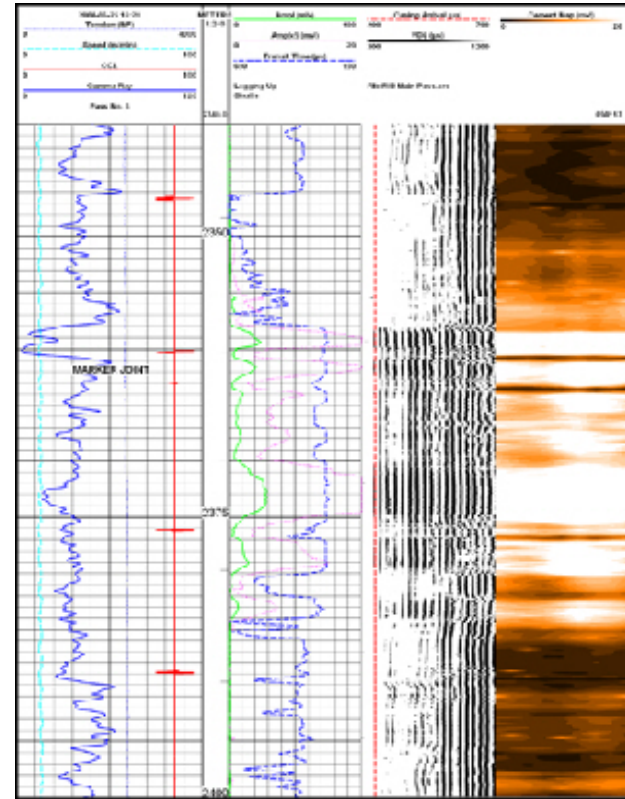
# Analyzing Cement Bond Log Data

- Current work includes developing a systematic procedure for consistency in interpreting CBLs.
- Cement bond logs were reviewed for Michigan and Ohio. All of the public cement bond log data was mapped and a 5% subset (145 logs) was assembled for the study
- A total of 1,720 cement bond logs were available for Michigan and 1,060 cement bond logs were available for Ohio.
- These records were randomly sub-sampled to obtain 5% of the logs. The 5% subset was collated with well records for further analysis.

# Cement Bond Logs



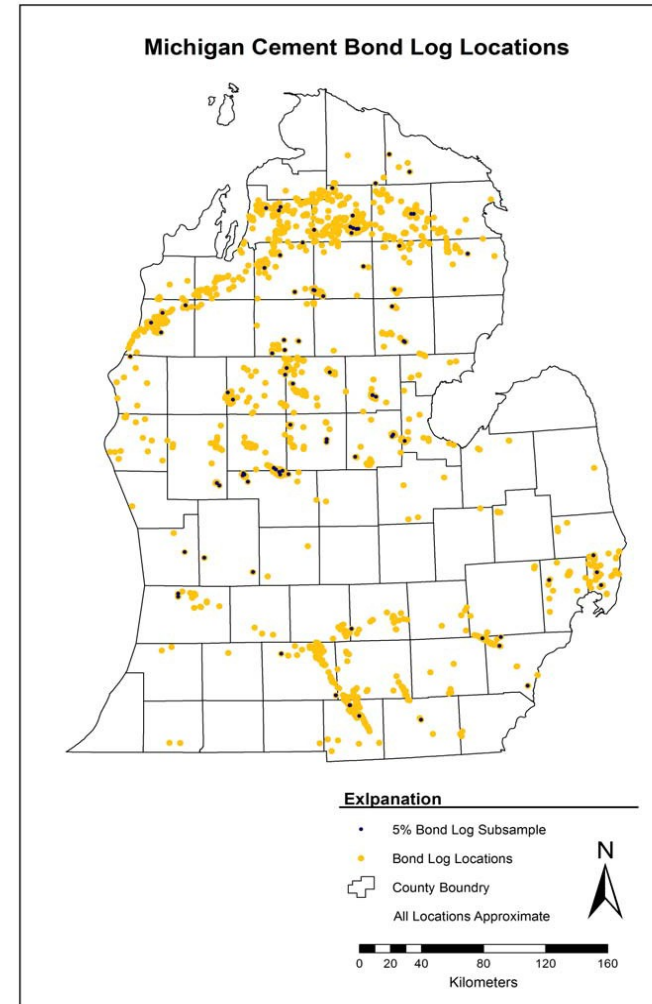
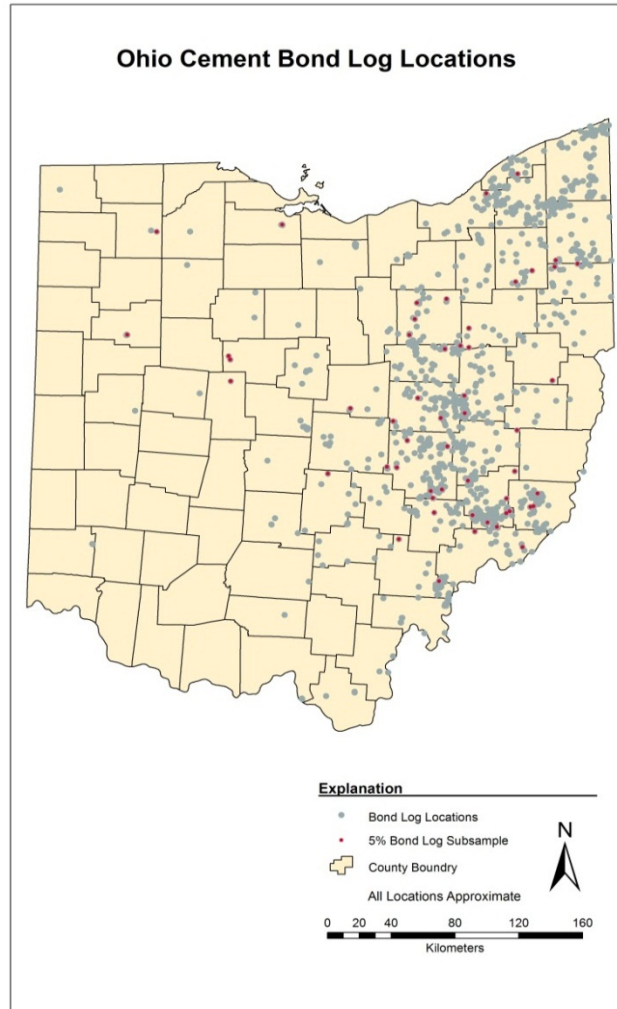
Simple CBL with VDL Display



CBL/VDL with Cement Map



# Ohio & Michigan Cement Bond Log Sub-Sets

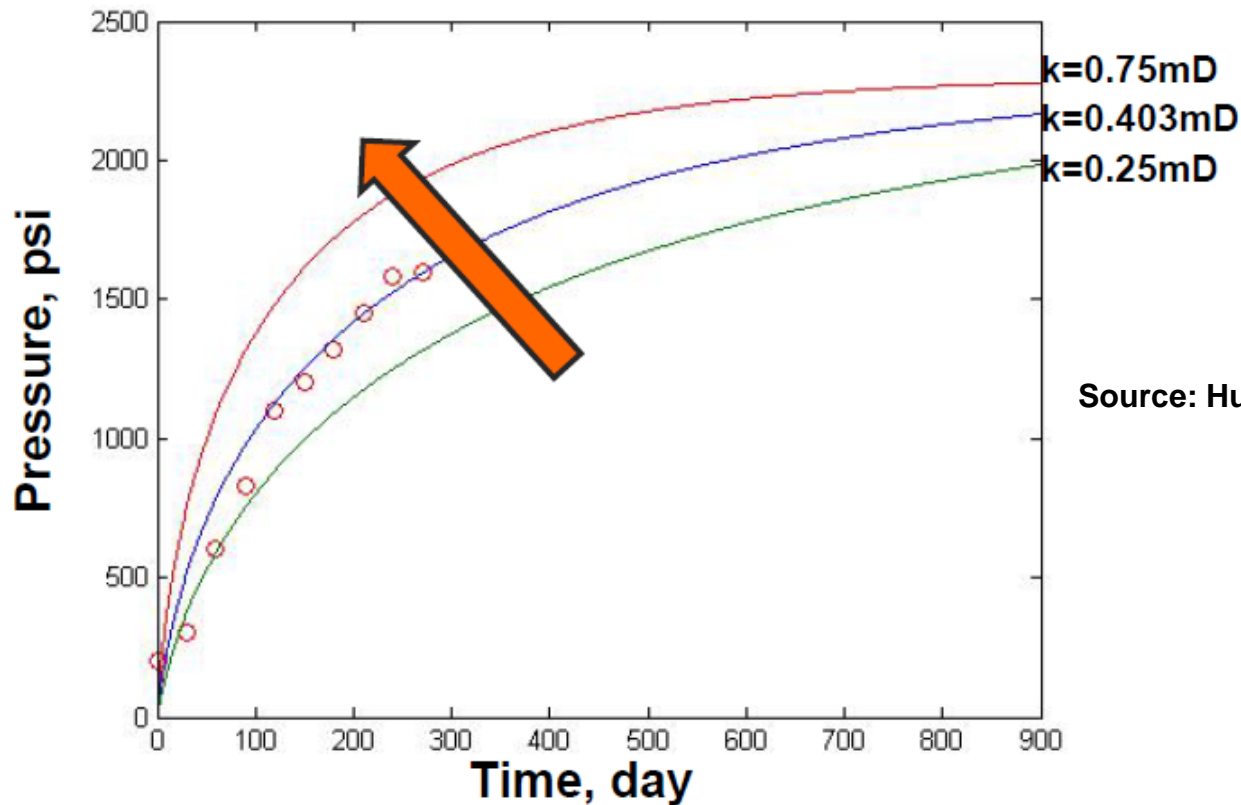


# Sustained Casing Pressure (SCP) Analysis

- Casing annulus pressure can occur from thermal expansion of the annular fluid. However, once the annular pressure is bled down to atmospheric pressure and the valve is closed, the annular pressure should remain at atmospheric pressure. If the casing annulus pressure builds after the valve is closed, then the well is said to exhibit SCP.
- A SCP monitoring program is planned for a gas storage field in Eastern Ohio.
  - Initial review of records and geologic setting was completed for the field.
  - Eight (8) SCP candidate wells were selected for data gathering

# Sustained Casing Pressure (SCP) Analysis

- SCP casing pressure buildup over time can be analyzed to determine cement permeability, location of leak and the nature of the migration pathway.

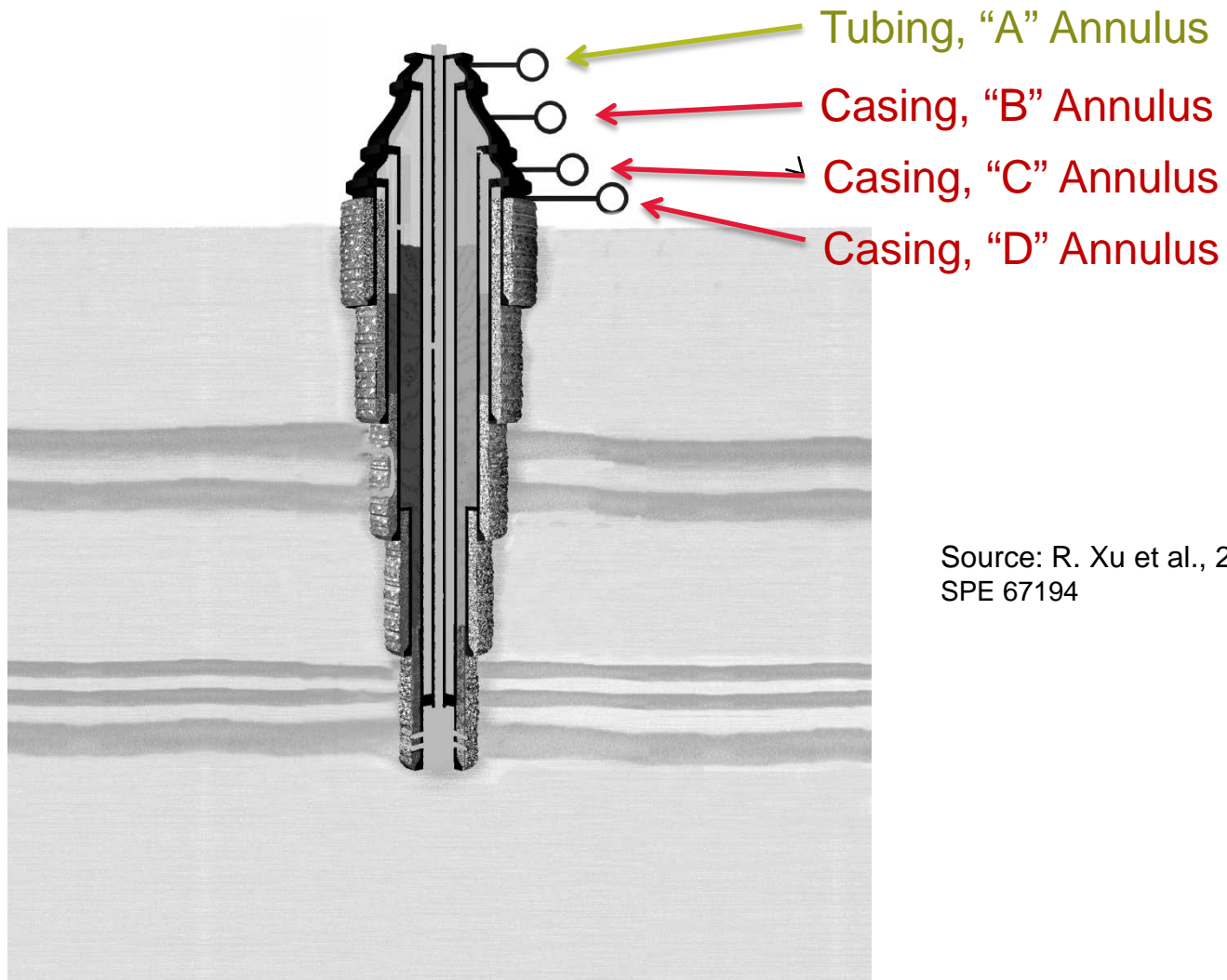


Source: Huerta et al., 2010

# Sustained Casing Pressure (SCP)

Pressure on the tubing "A" annulus is normal and expected.

Pressure on the "B", "C", or "D" casing annulus is not expected and is considered SCP



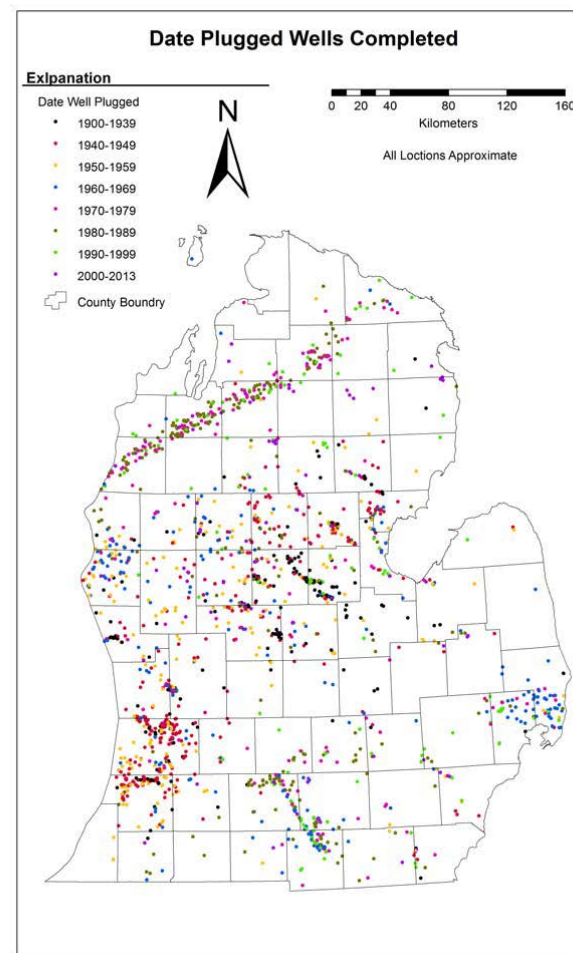
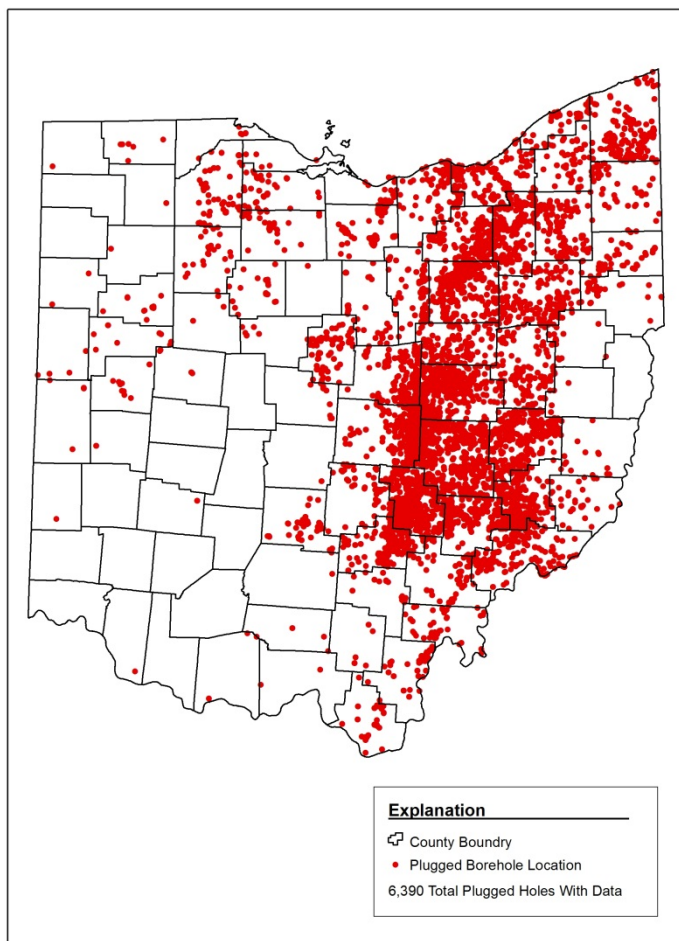
Source: R. Xu et al., 2001  
SPE 67194

**Simplified Well Schematic**

# Accomplishments to Date

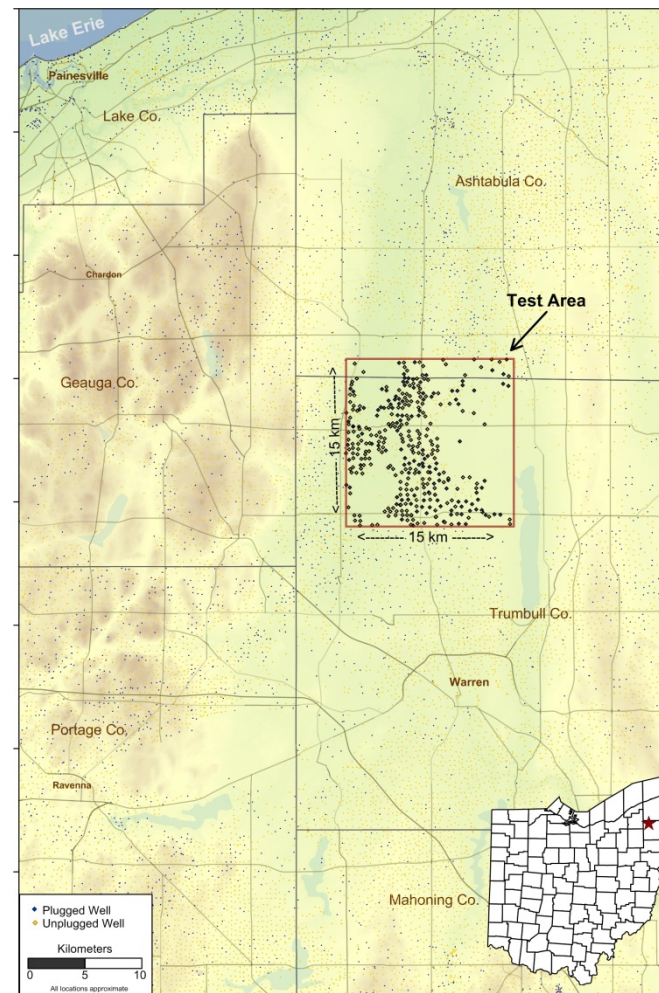
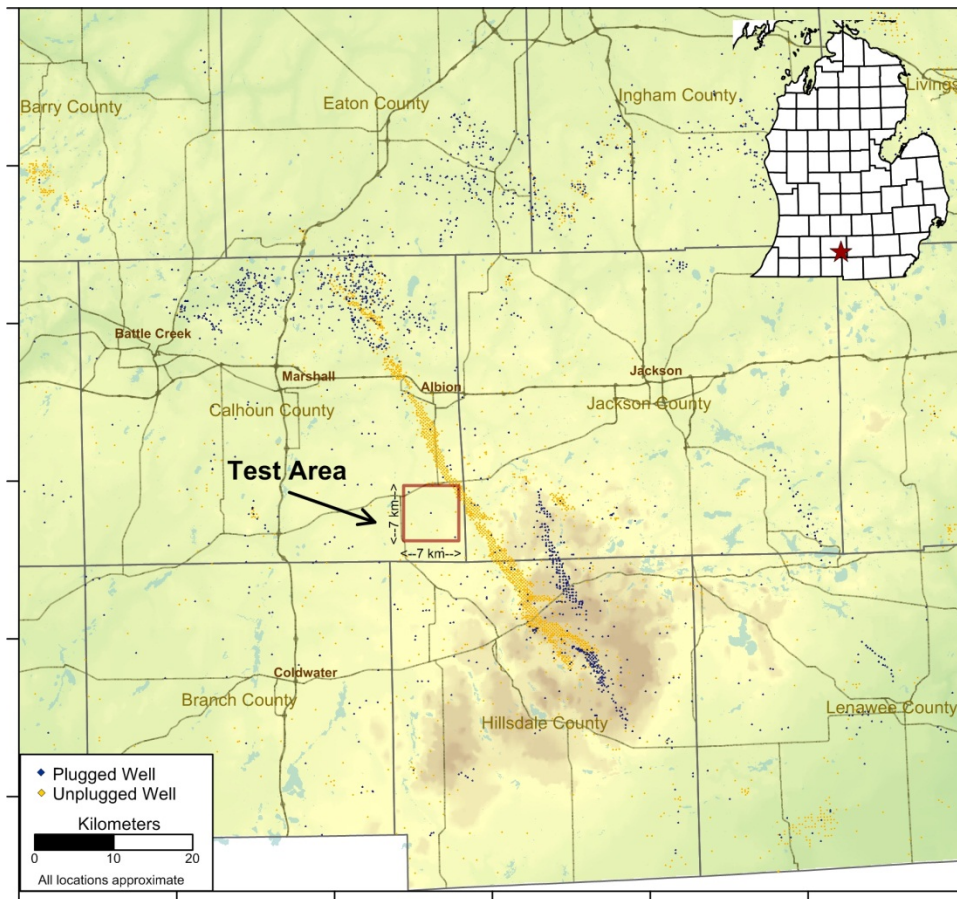
- Collaborated with BP Alternative Energy and NiSource to develop technical approach for well record collection, sustained casing pressure analysis, cement bond log analysis and field monitoring locations
- Well data from Ohio and Michigan was summarized with maps and graphs illustrating well status, age, formation, and total depth.
- Plugging and abandonment information was compiled for Michigan and Ohio.
  - These datasets include information on number of plugs, plug depth, plug material, additives, and date. Data was summarized with graphs and maps.

# Ohio & Michigan Plugged Wells



# Project Study Areas

- Proposed CO<sub>2</sub> storage assessment test areas in southern Michigan and northeast Ohio will be examined as if a CO<sub>2</sub> storage site by finding vulnerable boreholes, remedial options, and costs.



# Lessons Learned

- Data gathering can be a slow and laborious process
  - Public well information prior to 1940 is inconsistent in accuracy and content
  - QA/QC is required due to data entry errors and inconsistencies in data
  - Old well files are sometimes handwritten and hard to interpret
  - Lots of data in well files is not pertinent to the project
- Vintage data requires manual data entry and processing
- Many Vintage wells have little or no public data



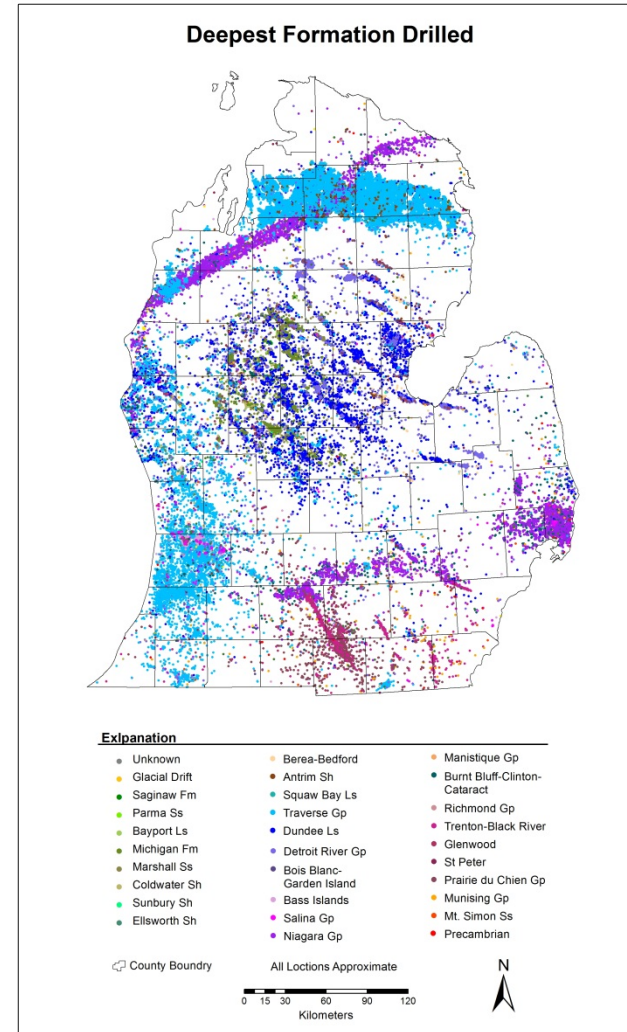
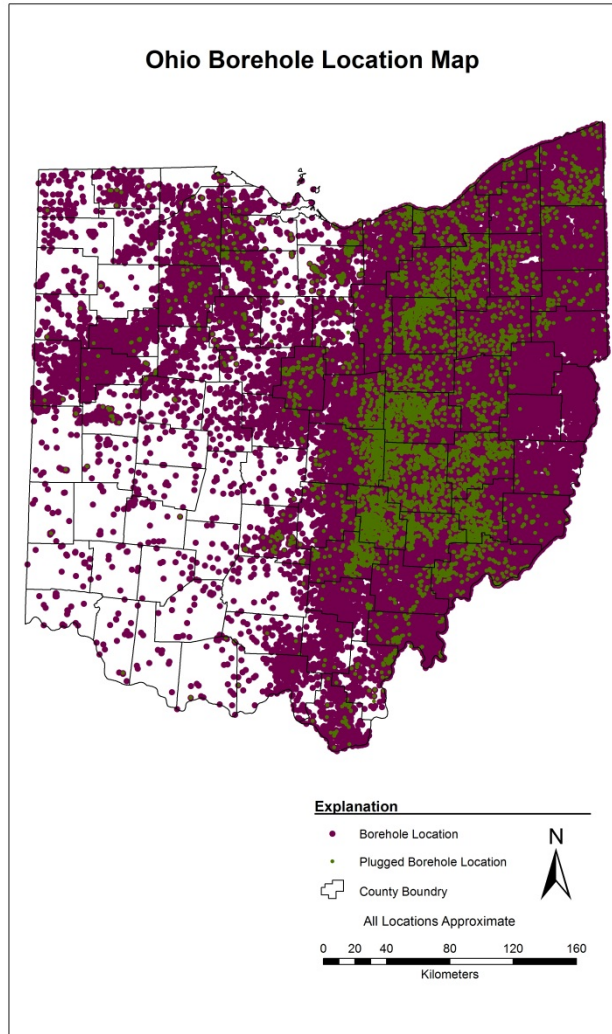
# Summary - Results/Conclusions

- This project is in its preliminary stage.
- Well status and construction information was analyzed for Ohio and Michigan.
- Records indicate 53,800 oil and gas related wells in Michigan. 65% are listed as plugged.
- Records indicate 229,992 oil and gas related wells in Ohio. 44% are listed as plugged.
- Few sustained casing (SCP) pressure measurements are available from the region.
- Future work will include:
  - field pressure monitoring of SCP, and
  - applying this data to the larger regional dataset to evaluate geologic CO<sub>2</sub> storage zones.

# Technology Transfer

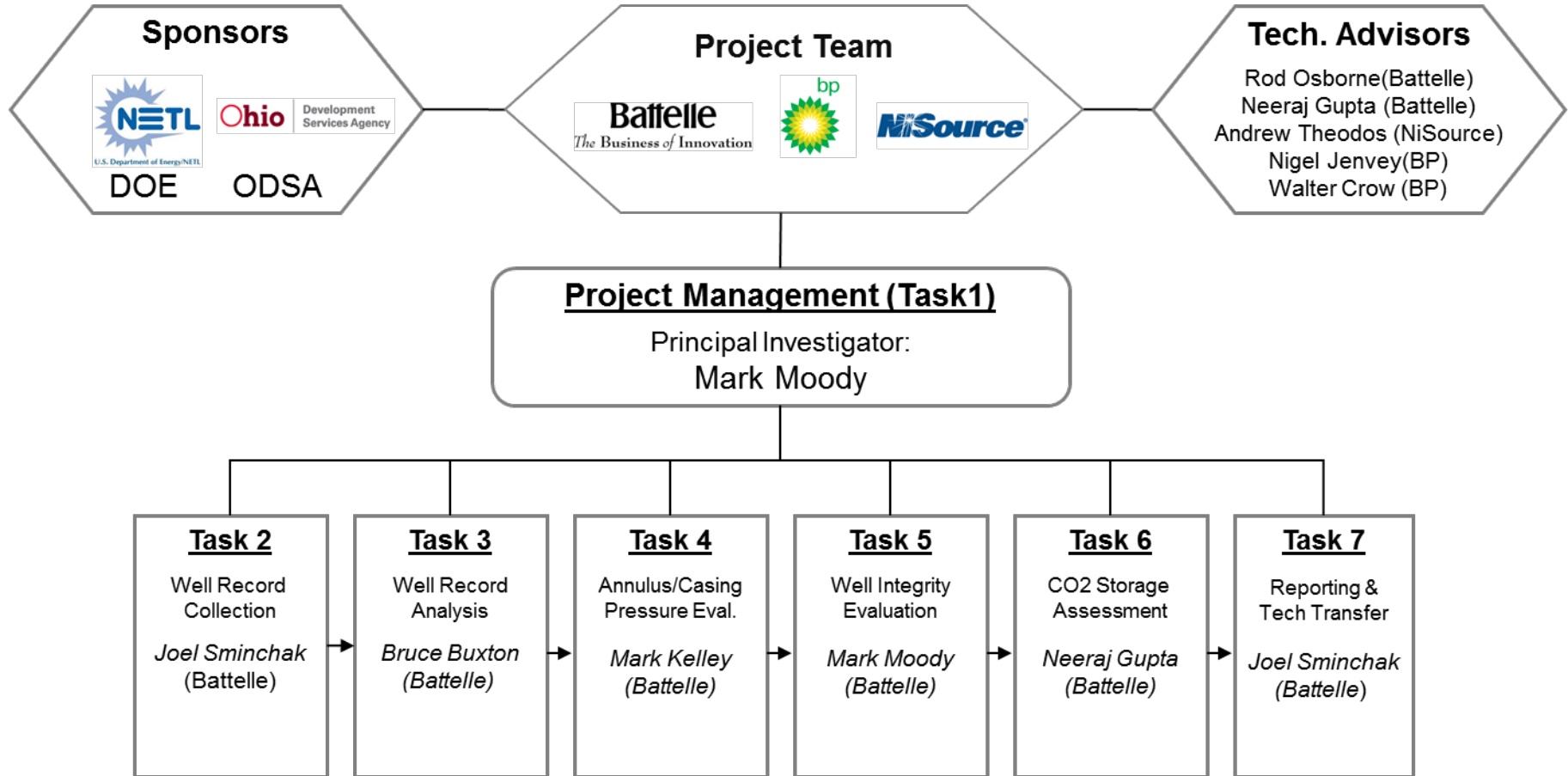
- A presentation was given at the Groundwater Protection Council 2013 UIC Conference: *Abstract 18: Systematic Assessment of Wellbore Integrity for CO2 Geosequestration in the Midwestern U.S.* - Joel Sminchak, Neeraj Gupta, and Mark Moody.
- A presentation is scheduled to be given to the PTTC / EFD Wellbore Integrity – Improving Zonal Isolation Practices Conference in Pittsburgh in September, 2013: *Systematic Assessment of Wellbore Integrity Using Regulatory and Industry Information.* Mark Moody.

# Questions???



# Appendix

## Project Organization Chart





# Bibliography

- Huerta, Nicolas, and Checkai, Dean, and Tao, Qing, and Bryant, Steven, 2010, Sustained Casing Pressure Analysis as an Analog for CO2 Leakage Along a wellbore: Case Study Results and Limitations, 6<sup>th</sup> Annual Wellbore Integrity Network Meeting, Noordwijk Aan Zee, The Netherlands, April 29, 2010.
- Sminchak, J., Gupta, N., and Moody, M., 2013, Systematic Assessment of Wellbore Integrity for CO2 Geosequestration in the Midwestern U.S., Groundwater Protection Council 2013 UIC Conference, Jan 22-24, 2013, Abstract 18.
- Xu, R., and Wojtanowicz, A. K., 2001, Diagnosis of Sustained Casing Pressure from Bleed-off/Buildup Testing Patterns, SPE 67194, Production and Operations Symposium, Oklahoma City, OK, March 24 -27, 2001