Phase II Field Demonstration at Plant Smith Generating Station: Assessment of Opportunities for Optimal Reservoir Pressure Control, Plume Management and Produced Water Strategies

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U.S. Department of Energy
National Energy Technology Laboratory
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Presentation Outline

- Technical Status
  - Permitting
  - Design
  - Planning
- Accomplishments to Date
- Lessons Learned
- Synergy Opportunities
- Project Summary
- Appendix

Technical Status

Phase I Site Screening and Down Selection Resulted in Selection of Plant Smith

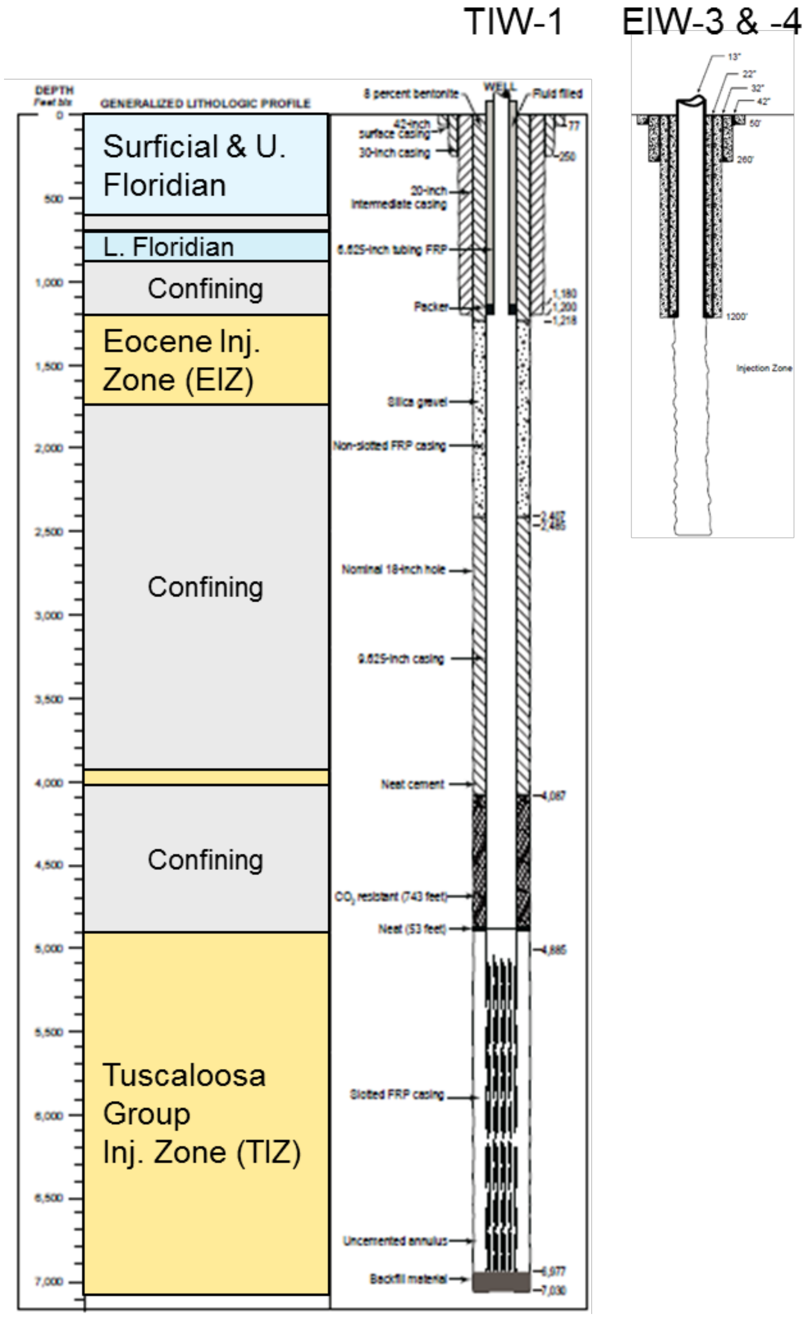
- Evaluated existing geologic, geophysical and hydrologic data in the vicinity of each site, including
  - Well records, logs, core data, regional structural and stratigraphic studies and subsurface production/injection data
- Examined existing surface infrastructure at each plant
- Gaged plant commitment to hosting the BEST project
- Selected Plant Smith

Plant Bowen, Euharlee GA
Plant Daniel, Escatawpa MS
Plant Gorgas, near Parrish AL
Plant Miller, near West Jefferson AL
Kemper Co Energy Facility, MS

Plant Smith Overview

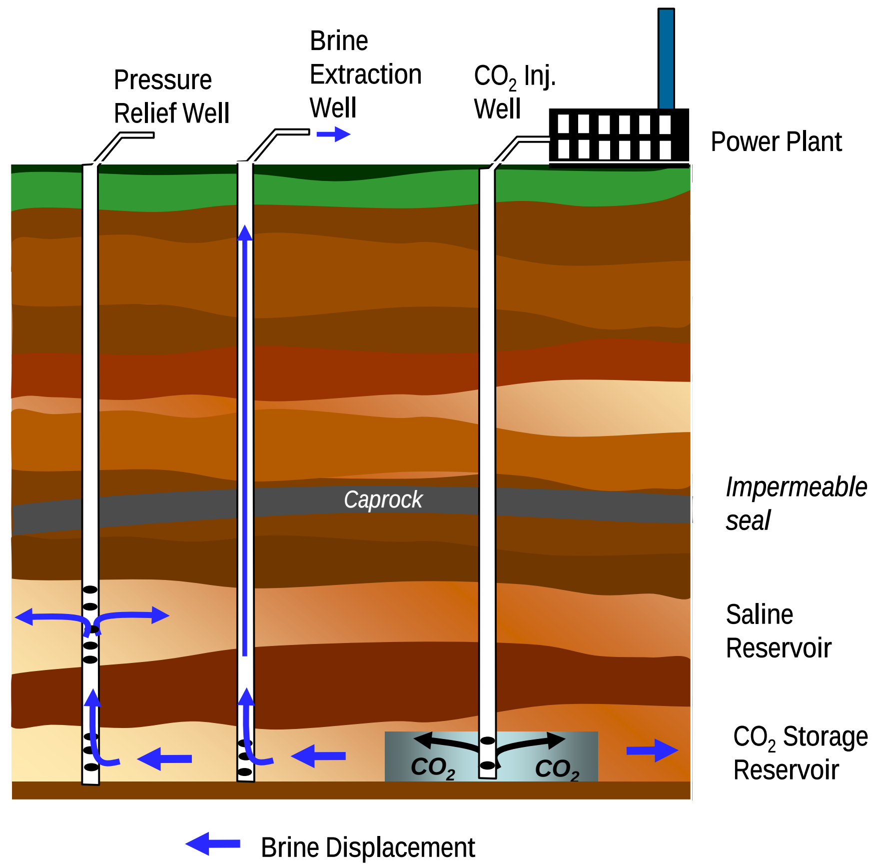
- Multiple confining units
- Thick, permeable saline aquifers
  - Eocene Series (870-2,360)
  - Tuscaloosa Group (4,920-7,050 ft)
  - Represent significant CO_2 storage targets in the southeast US
- Large Gulf Power Co. waste water injection project under construction (infrastructure)
- Water injection pressures will be managed as a proxy for CO_2 injection (~500k-1,000 gal/day)

No CO_2 injection will take place



Phase II Will Demonstrate Effectiveness of Passive and Active Pressure Management

- Passive pressure relief in conjunction with active pumping can reduce pressure buildup, pumping costs and extraction volume
- Existing “pressure relief well” and “new” extraction well will be used to validate passive and active pressure management strategies
- Test effectiveness of LBNL adaptive optimization methods and tools to manage overall reservoir system response using uncertain formation parameters



Hypothetical CO_2 storage project showing “active” extraction and “passive” pressure relief well

Pressure relief well reduces extraction volume by 40%

Permitting

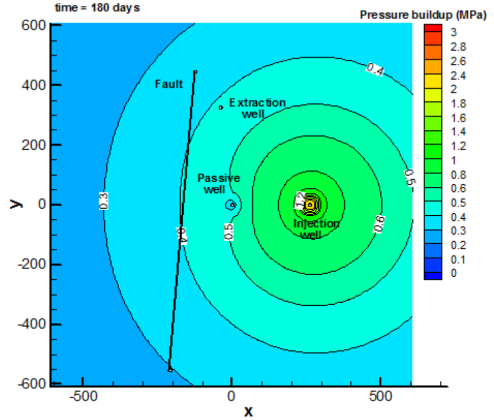
- Florida Department of Environmental Protection (FDEP) has primacy over Class I non-hazardous waste wells
- State has rigorous UIC standards to protect water resources
  - Well construction (casing/tubing diameters & thickness, cement thickness, materials of use)
  - Temporary monitoring wells to evaluate potential impacts during drilling
  - Permanent monitor well to evaluate potential impact from injection
  - Construction standards are being applied to BEST project's extraction well

Permanent monitor well installed within 150 ft of injection well is sampled quarterly for water quality impacts associated with injection

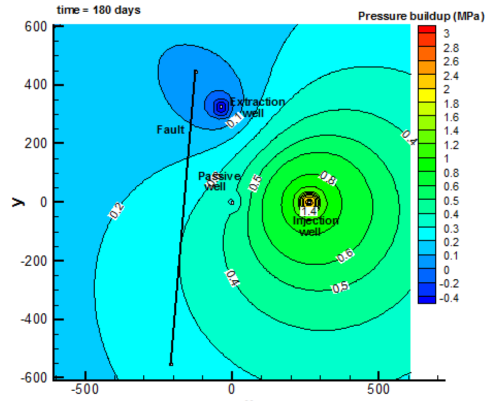
BEST submitted a minor modification to Gulf Power's existing well permit

Experimental Design

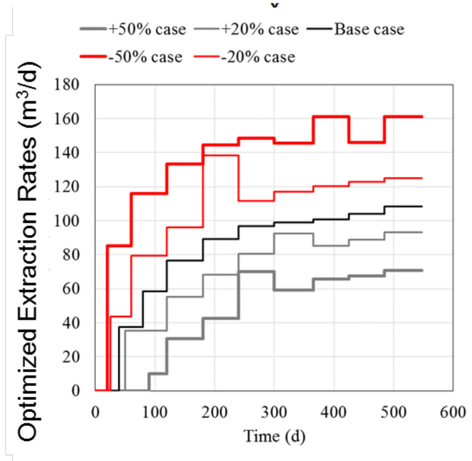
- Further refinement of the adaptive optimization algorithm
- 18-month injection at 1,090 m^3/d (200 gal/min) into two layers of the Lower Tuscaloosa creates radially extensive pressure plume
- Simulation of optimum extraction rates for test design, pump capacity and permitting
  - Sensitivity study to determine optimum range of pumping rates based on uncertainty in permeability (+/-20%, +/-50% variation around base case)
  - Optimized to prevent pressure buildup >0.3 Mpa on a hypothetical faults



Pressure distribution from active injection & passive pressure relief



Addition of extraction well reduces pressure on a hypothetical fault (line)



Optimized extraction rates for different permeability scenarios

Optimized extraction rates range from 4-12% of injection

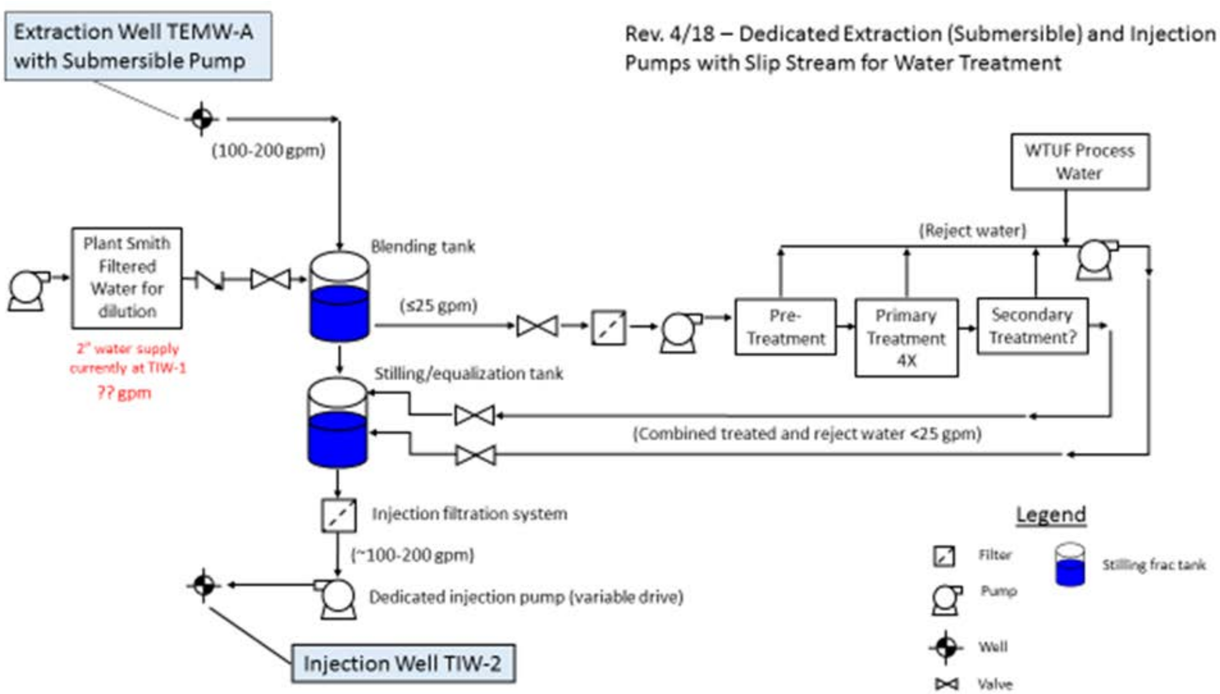
Well Field Infrastructure Design

- Developed detailed technical specifications for:
  - Well pads
  - Extraction well
  - Injection well including four casin/tubing options
  - Flowline
  - Submersible pump
  - Power requirements
- Plant Smith site visit and pre-bid meeting with perspective drillers
  - Four drilling firms attended
  - Only two Florida-based firms responded with bids
  - Large disparity between prices

BEST project infrastructure layout showing the proposed location of the extraction well (TEMW-A), injection well (TIW-2) and flowline, and the existing passive-relief well (TIW-1)

Water Treatment User Facility Design

- Preliminary design provides different water qualities for testing by DOE researchers and commercial water treatment vendors
  - High salinity (166,000 mg/L TDS) Tuscaloosa water only
  - Low salinity fresh or waste water (30-1,000 mg/L TDS) from Plant Smith
  - Intermediate salinity (30-166,000 mg/L TDS) by mixing in a blending tank



Flow diagram showing major components of the EPRI water treatment user facility

Accomplishments to Date

✓Permitting
– Submitted minor modification to existing permit (May 2017)
– Responded to FDEP request for information (July 2017)
– Permit approval pending (August 2017??)

✓Experimental Design
– Scoped extraction rates to select submersible pump size

✓Well field infrastructure design
– Developed design and technical specifications for infrastructure
– Selected qualified Florida certified driller

✓Water treatment user facility design
– Preliminary design and costs completed
– Vendor requirements are needed before completing design

Lessons Learned

- Project cost drivers
  - Each state has unique UIC regulatory requirements and guidelines that can impact well construction and project costs
  - Florida drilling market for waste-water injection wells is not very competitive as shown by the large disparity in bids ($6.9M vs. $11.0M)
  - Cost of small diameter extraction well drilled to 5,400 ft with 5-inch production casing is $2.8M. Much higher than expected!!!!

Project anticipated high injection well costs but not for the extraction well

Synergy Opportunities

- EPRI and EERC are developing water treatment user facilities to test and validate water desalination technologies
- EERC and EPRI jointly developed a technology screening questionnaire and selection criteria for hosting the water treatment technologies at the BEST project sites
- The BEST projects plan on holding annual or semi-annual meetings
  - Tech transfer and cross-fertilization of approaches and ideas
  - Provide project updates, technology transfer, lessons learned and experiences

Project Summary and Next Steps

- Summary
  - Budget Period (BP) 2 is nearing completion
  - Permit modification submitted and pending regulatory approval
  - Final well field infrastructure design is nearly complete
  - Preliminary design and costs were developed for the water treatment user facility (input from users/vendors is still needed)
  - Continuing application for BP3 submitted
- BP3 (2017-2019) plans include:
  - Installation of the well field infrastructure
  - Final design and installation of the water treatment user facility
  - Equipment commissioning
  - 2-3 months of injection followed by 15-16 months of injection and extraction
- BP4 (2019-2020) plans include:
  - Site restoration
  - Final reporting

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Appendix

Benefit to the Program

- Program Goals
  - Develop cost effective pressure control, plume management and produced water strategies that can be used to improve reservoir storage efficiency and capacity, and demonstrate safe, reliable containment of CO_2 in deep geologic formations with CO_2 permanence of 99% or better.
- Benefit Statement

  The project will…
  - Use optimization methods and smart search algorithms coupled with reservoir models and advanced well completion and monitoring technologies to develop strategies that allocate flow and control pressure in the subsurface.
  - Address the technical, economic and logistical challenges that CO_2 storage operators will face when implementing a pressure control and plume management program at a power station and increase our knowledge of potential storage opportunities in the southeast region of the U.S.
  - Contribute to the development cost effective pressure control, plume management and produced water strategies that can be used to improve reservoir storage efficiency and capacity, and demonstrate safe, reliable containment of CO_2 in deep geologic formations with CO_2 permanence of 99% or better.
  - And the operational experiences of fielding a water management project at a power station can be incorporated into DOE best practice manuals, if appropriate.

Project Overview—Goals and Objectives

- Objective : Develop cost effective pressure control, plume management and produced water strategies for: 1) Managing subsurface pressure; 2) Validating treatment technologies for high salinity brines

Pressure Buildup and Brine Displacement

Caprock Damage

Induced Seismicity

Interference Between Storage Sites

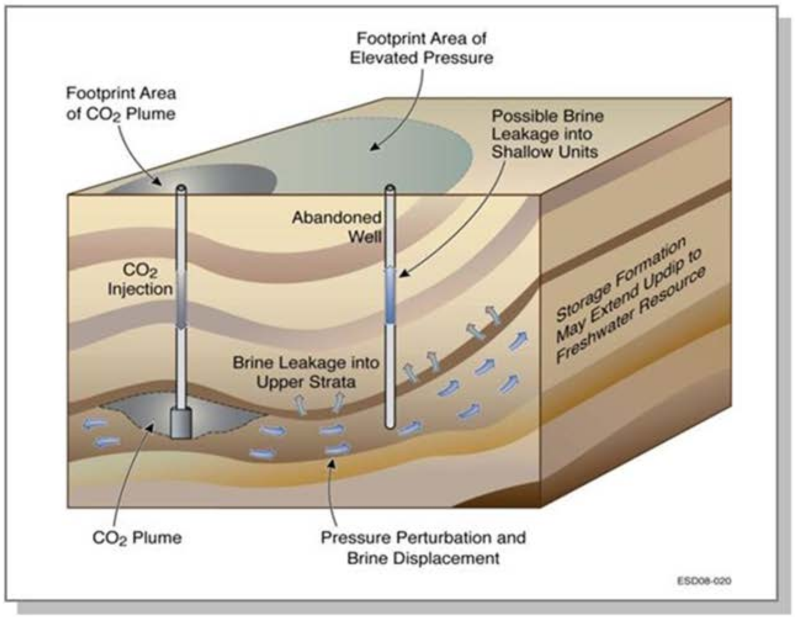
Effect on Other Georesources

Permitting and AoR

Reduced Storage Capacity

Reservoir Management Via Brine Extraction

Beneficial Use of Extracted Brine



Pressure management practices are needed to avoid risks identified in white boxes. Brine extraction is a possible remedy for reducing or mitigating risk requiring further research.

Organization Chart

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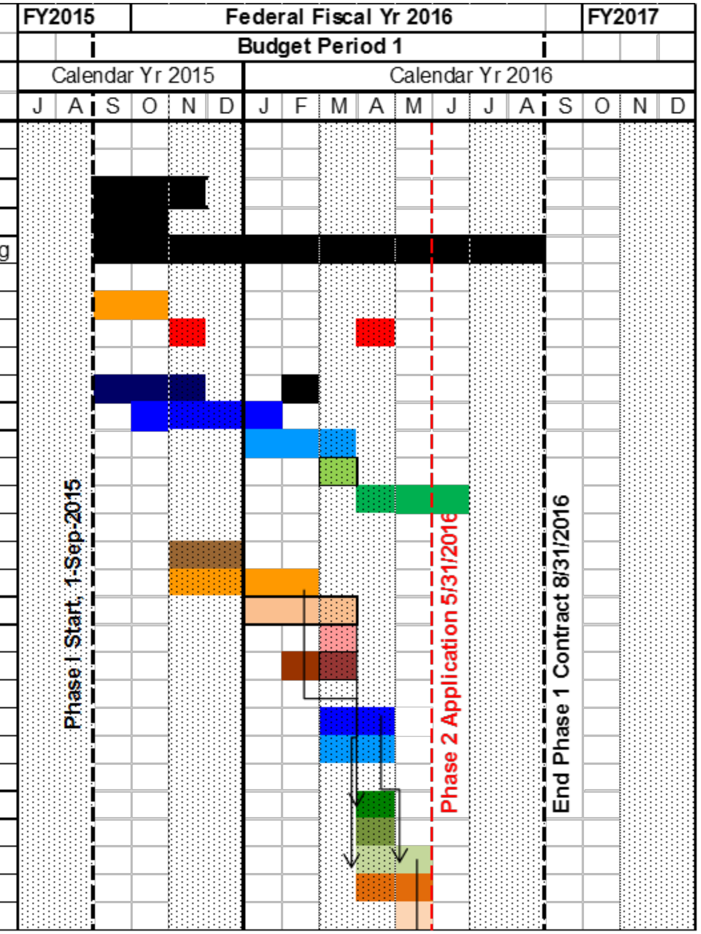
Gantt Chart

Phase I Project Schedule			
Description	**Start Date**	**End Date**	**Dur. Mos.**
Task 1.0 Project Management			
Revise Project Management plan	9/1/2015	11/30/2015	3
NEPA approval	9/1/2015	10/31/2015	2
Project management	9/1/2015	8/31/2016	Ongoing
Task 2.0 - Site Screening and Down-Selection			
2.1 - Regional and Local Data Availability	9/1/2015	10/31/2015	2
2.2 - Site Ranking and Selection	11/1/2015	4/30/2016	1.0
Task 3.0 - Produced Water Life Cycle Analysis			
3.1 - Define Finish Water Specifications	9/1/2015	2/28/2015	3.5
3.2 - Produced Water Extraction Scenario Development	10/1/2015	1/31/2016	4
3.3 - Water Treatment Technology Screening	1/31/2016	3/31/2016	3
3.4 - Transportation Infrastructure	2/1/2016	3/31/2016	1
3.5 - Integrated Economic Analysis	4/1/2016	6/30/2016	3
Task 4.0 - Pressure Control and Optimization Strategy			
4.1 - Static Geologic Model Development	11/1/2015	12/31/2016	2
4.2 - Reservoir and Geomechanical Predictions	11/1/2016	2/28/2016	4
4.3 - Development and Optimization of Pressure Management Strategies	1/1/2016	3/31/2016	3
4.4 - Predicting Detectability of Reservoir Response for MVA Planning	3/1/2016	3/31/2016	1
4.5 - Advanced Well Technology Feasibility Analysis	2/15/2016	3/31/2016	1.5
Task 5.0 - Advanced MVA Program			
5.1 - Injection Monitoring and Optimization	3/1/2016	4/30/2016	2
5.2 - Far-Field Monitoring Program	3/1/2016	4/30/2016	2
Task 6.0 - Develop Phase II Field Demonstration Work Plan, Cost & Schedule			
6.1 - Site Characterization Plan	4/1/2016	4/30/2016	1
6.2 - Drilling Plan	4/1/2016	4/30/2016	1
6.3 - Testing, Monitoring & Sampling Plan	4/1/2016	5/31/2016	2
6.4 - Surface Infrastructure & Implementation Plan	4/1/2016	5/31/2016	2
6.5 - Field Demonstration Cost and Schedule	5/1/2016	5/31/2016	1



Bibliography

- None