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Southeast Regional Carbon Sequestration Partnership (SECARB)

Phase III Anthropogenic CO_2 Injection Field Test

Field Test Location and Amount/Sources of CO_2

Anthropogenic Test

Alabama Power's Plant Barry

- *100,000 to 150,000 tonnes of CO_2 per year*
- *Coal-Fired Power Plant (Commercial/Anthropogenic Source)*

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Field Test Partners

Primary Sponsors

U.S. Department of Energy

National Energy Technology Laboratory

Southern States Energy Board

Industrial Partners

(in alphabetical order)

Advanced Resources International

Alabama Power

Denbury Resources, Inc.

Electric Power Research Institute

Geological Survey of Alabama

Southern Company

Southern Natural Gas

About SECARB

SECARB is one of seven Regional Carbon Sequestration Partnerships (RCSP) established by the U.S. Department of Energy (DOE) in 2003. The seven partnerships form a national network of more than 400 organizations covering 43 states and four Canadian provinces. The SECARB program spans 13 states in the southeastern United States and is funded by DOE and cost-sharing partners.

Summary of Field Test Site and Operations

Past work by Southeast Regional Carbon Sequestration Partnership's (SECARB) has identified that a series of thick, regionally extensive saline formations with high-quality seals exist within the Gulf Coastal Region. These saline formations have the potential to hold large volumes of carbon dioxide (CO_2). One such formation, the Cretaceous-age Paluxy Formation sandstone, is the target for the SECARB Anthropogenic CO_2 storage test**, Figure 1**.

The Anthropogenic CO_2 storage field test is being performed in southwest Alabama near the town of Citronelle in northern Mobile County. The CO_2 source for the test is a newly constructed post-combustion CO_2 capture facility at Alabama Power's existing 2,657 MW Barry Electric Generating Plant (Plant Barry). A small amount of flue gas from Plant Barry (equivalent to the amount produced when generating 25 MW of electricity) will be diverted from the plant and captured using a process developed by Mitsubishi Heavy Industries to produce highly pure CO_2. Plant Barry is a coal- and natural gas-fired electrical generation facility located in Bucks, Mobile County, Alabama, **Figure 2**. (Alabama Power is a subsidiary of Southern Company.)

The CO_2 storage site is located within the Citronelle Dome geologic structure. The Citronelle Dome, which provides secure four-way closure free of faults or fracture zones, is located approximately 15 kilometers west of Plant Barry. A pipeline was constructed in 2011 to link the CO_2 capture system with the Paluxy Formation, a major reservoir containing saline water (i.e. water that is too deep and salty to serve as a drinking water supply). The Paluxy occurs at a depth of 3,000 to 3,400 meters. The Paluxy is overlain by multiple geologic confining units that serve as vertical flow barriers and will prevent CO_2 from escaping from the storage reservoir, **Figure 1**.

Three new wells will be drilled during the test; a reservoir characterization well, an observation/backup injection well, and a dedicated CO_2 injection well. The characterization well, the first deep well drilled at Citronelle since the 1980's, was completed in January 2011 (**Figure 3)**. Modern characterization data were collected on the injection zone, confining zones and the oil reservoir. The primary injection well was drilled in December 2011 and the backup injector was drilled in January 2012. In addition to the new wells, the project will utilize several existing idle oilfield wells surrounding the CO_2 injection site to monitor injection operations and to ensure public safety.

Beginning in 2012, between 100,000 and 150,000 metric tons per year of CO_2 captured from the pilot facility at Plant Barry will be transported to the storage site. CO_2 injection will continue for a period of two to three years.

During the injection period, multiple CO_2 monitoring technologies will be deployed to track the CO_2 plume, to measure the pressure front, to understand CO_2 trapping mechanisms of the Paluxy saline formation, and to monitor for potential leakage. Three years of post-injection monitoring are planned. Site closure is expected to occur in 2017. The wells will either be plugged and abandoned per state regulations or re-permitted for CO_2-enhanced oil recovery operations in a deeper mineral formation.

System	Series	Stratigraphic Unit	Major Sub Units	Potential Reservoirs and Confining Zones
Tertiary	Plio-Pleistocene		Citronelle Formation	Freshwater Aquifer
	Miocene	Undifferentiated		Freshwater Aquifer
	Oligocene		Chicasawhay Fm.	Base of USDW
		Vicksburg Group	Bucatunna Clay	Local Confining Unit
	Eocene	Jackson Group		Minor Saline Reservoir
		Claiborne Group	Talahatta Fm.	Saline Reservoir
		Wilcox Group	Hatchetigbee Sand	Saline Reservoir
	Paleocene		Bashi Marl	
			Salt Mountain LS	
		Midway Group	Porters Creek Clay	Confining Unit
Cretaceous	Upper	Selma Group		Confining Unit
		Eutaw Formation		Minor Saline Reservoir
		Tuscaloosa Group	Upper Tusc.	Minor Saline Reservoir
			Mid. Tusc. Marine Shale	Confining Unit
			Lower Tusc. Pilot Sand Massive sand	Saline Reservoir
Cretaceous	Lower	Washita-Fredericksburg	Dantzler sand	Saline Reservoir
			Basal Shale	Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'	Proposed Injection Zone
		Mooringsport Formation		Confining Unit
		Ferry Lake Anhydrite		Confining Unit
		Donovan Sand	Rodessa Fm. 'Upper'	Oil Reservoir
			'Middle'	Minor Saline Reservoir
			'Lower'	Oil Reservoir

Figure 1. Citronelle Dome Stratigraphy.

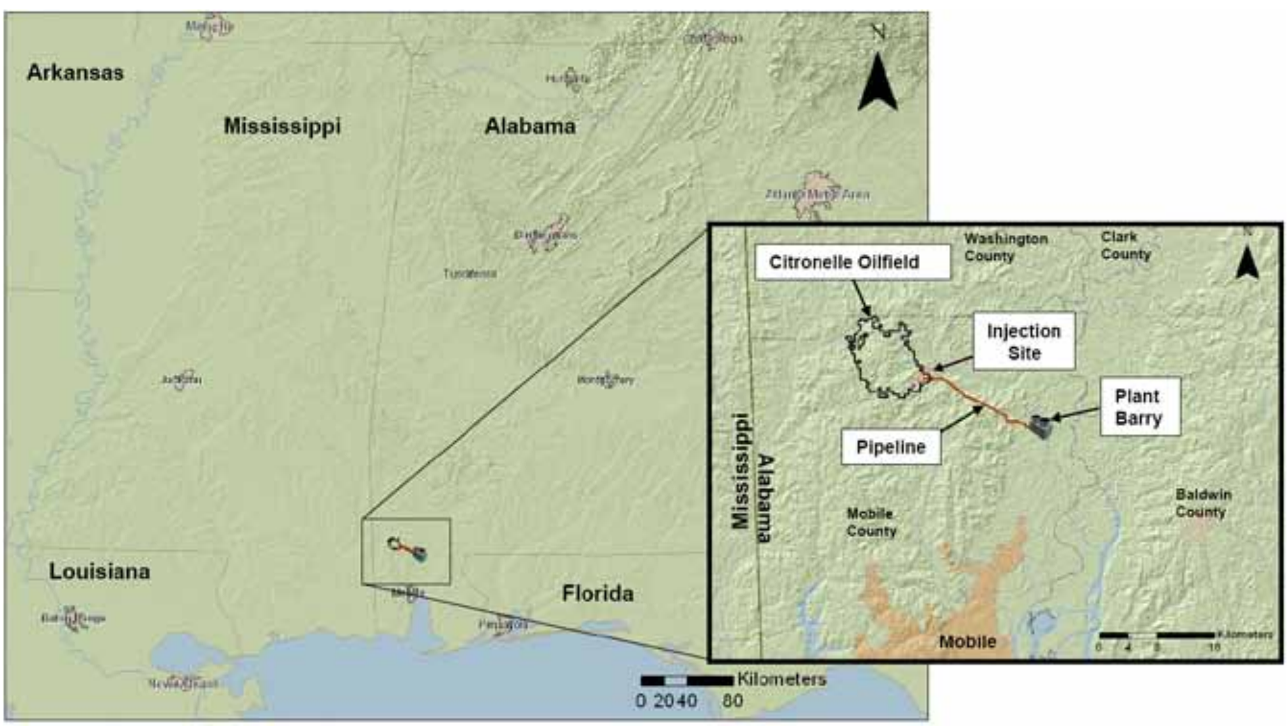

Figure 2. Geographic Location of the SECARB Phase III Anthropogenic Test.

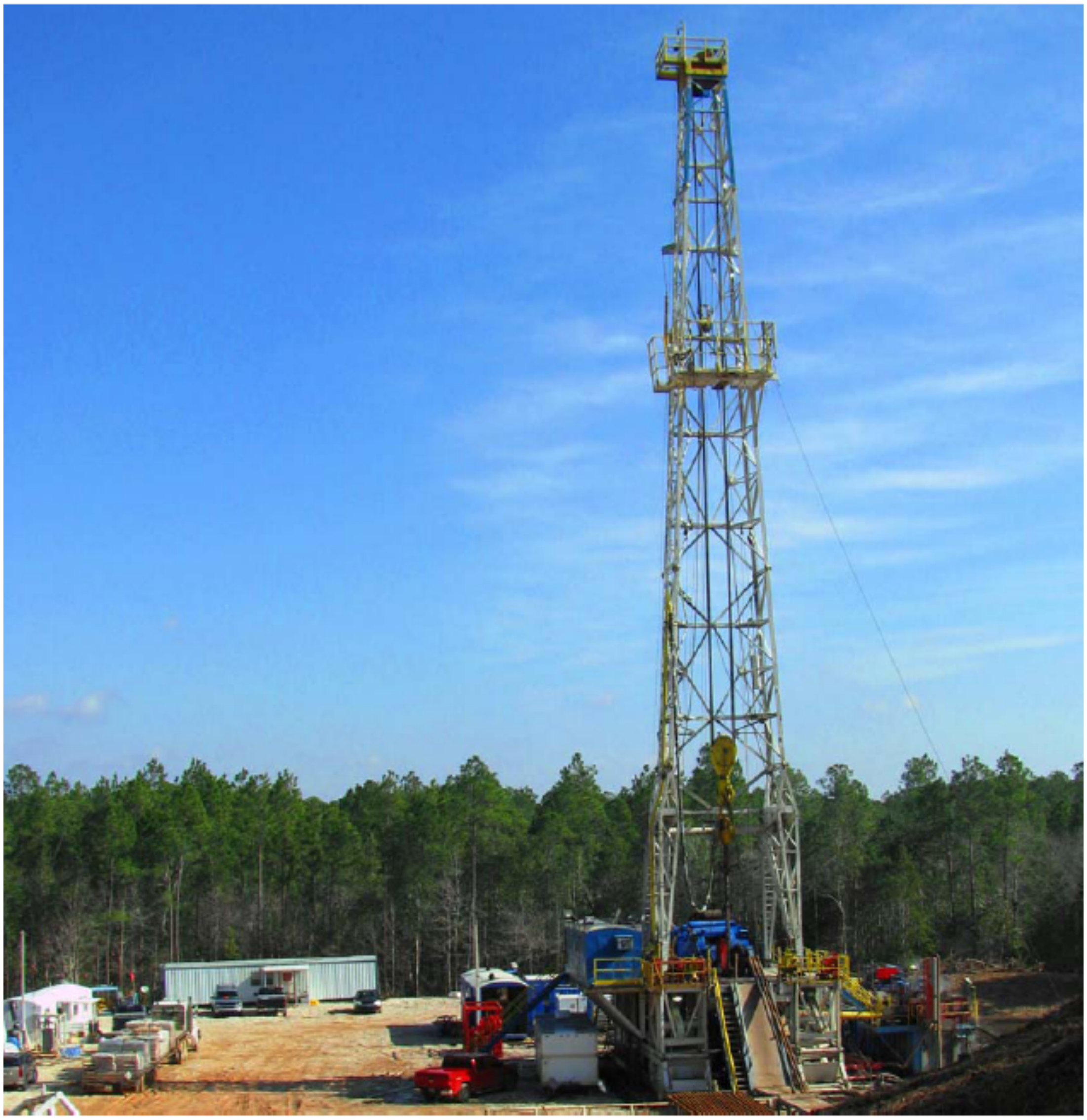

Figure 3. D-9-8#2, Characterization Well Drilling

Research Objectives

The purpose of the SECARB Phase III project is to test and demonstrate safe, secure CO_2 injection and storage in significant, regionally extensive saline reservoirs. Phase III will draw from and build on the Phase II sequestration "lessons learned" and will work to validate sequestration technologies of well design and integrity, monitoring protocols, injection operations as well as regulatory, permitting and outreach. The multi-partner collaborations developed during Phase I and II continued in Phase III.

In the Anthropogenic Test, the R&D objectives are to: 1) test the CO_2 flow, storage and CO_2 trapping mechanisms of the Paluxy Formation; 2) evaluate injection and storage capacity of a major saline reservoir in the Gulf Coast; 3) evaluate the integration of power plant CO_2 capture, transportation, injection and long-term geologic storage; 4) understand how the saline reservoir's internal architecture (the interplay between the reservoir flow units, seals and baffles) can be effectively used to maximize available CO_2 storage capacity and minimize the areal extent of the CO_2 plume; 5) test commercially available, but not yet utilized, "off-the-shelf" and experimental CO_2 monitoring technologies; and 6) evaluate the effect of anthropogenic CO_2 captured from a coal-fired power plant on the geochemistry of a saline reservoir.

Summary of Monitoring and Modeling, Verification and Accounting (MVA) Efforts

The MVA strategy at the Anthropogenic Test is designed to test commercially available "off-the-shelf" technologies in a manner not utilized before to better understand their performance and future application as listed in the table below.

Table 1. Measurement Technologies to be Deployed at the Anthropogenic Test.

Measurement Technique	Measurement Parameters	Application
Bottom-hole pressure	Pressure transducers deployed down hole near the injection interval	Key measurement for assessing the reservoir's, injectivity, capacity and pressure field.
Cased-hole logging (pulsed neutron capture)	CO_2 and water saturations	CO_2 saturation buildup near new and existing wellbores to monitor for leakage along wellbores and to confirm models.
Time-lapse crosswell and vertical seismic imaging	Change from baseline sonic velocity and amplitude	Distribution of CO_2 plume vertically and horizontally to monitor for migration out of zone and to confirm reservoir models.
Above-zone pressure and fluid geochemical monitoring	Monitor for changes in pressure and deep saline water geochemistry (i.e., pH, metal concentrations)	Monitoring for CO_2 buildup above the primary confining unit.
Tracers introduced in the CO_2 stream	Measure tracer levels around area oilfield wells	Monitor for the presence of tracer buildup near new and existing wellbores which would suggest leakage of vertical CO_2 along the well annuli.
Drinking water aquifer monitoring	Monitor for changes in a wide suite of parameters (i.e. pH, alkalinity, cations and anions).	Monitoring of area freshwater aquifers for geochemical changes related to shallow CO_2 leakage.

Accomplishments to Date

- A major geologic characterization effort was conducted on the injection reservoir and confining units using existing well and seismic data. Detailed maps of the Paluxy Reservoir sand units and multiple overlying confining units were created.
- The Environmental Impact Statement prepared by the project to fulfill the requirements of the National Environmental Protection Act resulted in a Finding of No Significant Impact.
- The project team has secured minerals and surface rights for the CO_2 storage test.
- The project's first characterization/observation well was drilled in December 2010-January 2011. Data from this well will be used to refine the geologic model.
- The Underground Injection Control permit application was submitted to the Alabama Department of Environmental Management for the two injection wells in December 2010. Permits were issued in November 2011.
- In 2011, Denbury completed construction of a 12-mile pipeline to transport the CO_2 from Plant Barry to the injection well in the Citronelle oilfield.
- Injection well drilling began in December 2011, and the observation/backup injection well is being drilled in January 2012.
- Currently finalizing the Test Site risk assessment and evaluating mitigation strategies.

Target Sink Storage Opportunities and Benefits to the Region

Gulf Coast Cretaceous-age formations are key components of a larger, regional group of similar formations, in terms of deposition and character, called the Gulf Coast Wedge. The wedge of sediments spans the entire SECARB region and includes the largest capacity saline sinks in the United States. CO_2 storage capacity estimates for the SECARB Gulf Coast Wedge range from 850-11,700 billion metric gigatons (Gt). In comparison, annual stationary point-source emissions of CO_2 for the region have been estimated to be 1.085 Gt. Using the range of reported CO_2 storage capacities, the saline formations in the Gulf Coast Wedge may have the capacity to accommodate these emissions for over 800 years.

Project Cost and Key Dates

PHASE III PROJECT COST*			KEY PROJECT DATES	
	Dollars	Percent	ANTHROPOGENIC TEST	
DOE Share	$76,981,260	69.10%	**Drilling Operations Begin**	12/2010 (characterization well) 12/2011 (injection wells)
Non-DOE Share	$34,432,171	30.90%	**Pre-Injection MVA Begins**	8/2011
Total Value	$111,413,431 (includes $2,444,000 for Federal Laboratories)		**Injection Operations Begin**	3/2012
*Includes all Tasks for the Phase III Program			**Injection Operations End**	2014
			Post-injection MVA Ends	2017

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