Southeast Regional Carbon Sequestration Partnership (SECARB) Phase III Anthropogenic Test and Plant Barry Carbon Dioxide Capture and Storage Project

Presented to:
CSLF Technical Group Meeting
Washington, D.C., USA
05 November 2013

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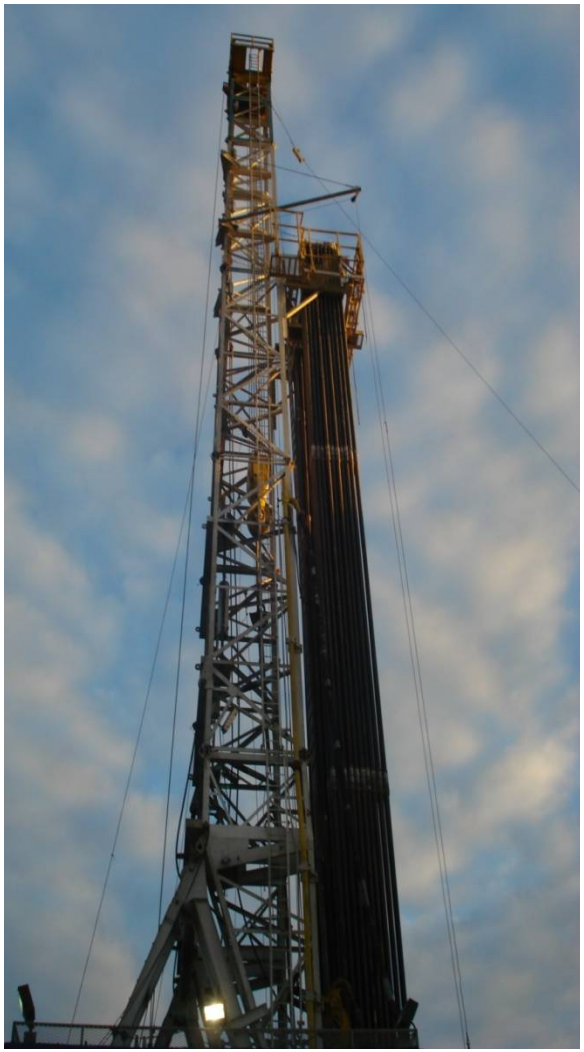
Acknowledgements

- This material is based upon work supported by the U.S. Department of Energy National Energy Technology Laboratory.
- Cost share and research support provided by the Southeast Regional Carbon Sequestration (SECARB) Carbon Management Partners.
- Anthropogenic Test CO_2 Capture Unit funded separately by Southern Company and partners.

Presentation Outline

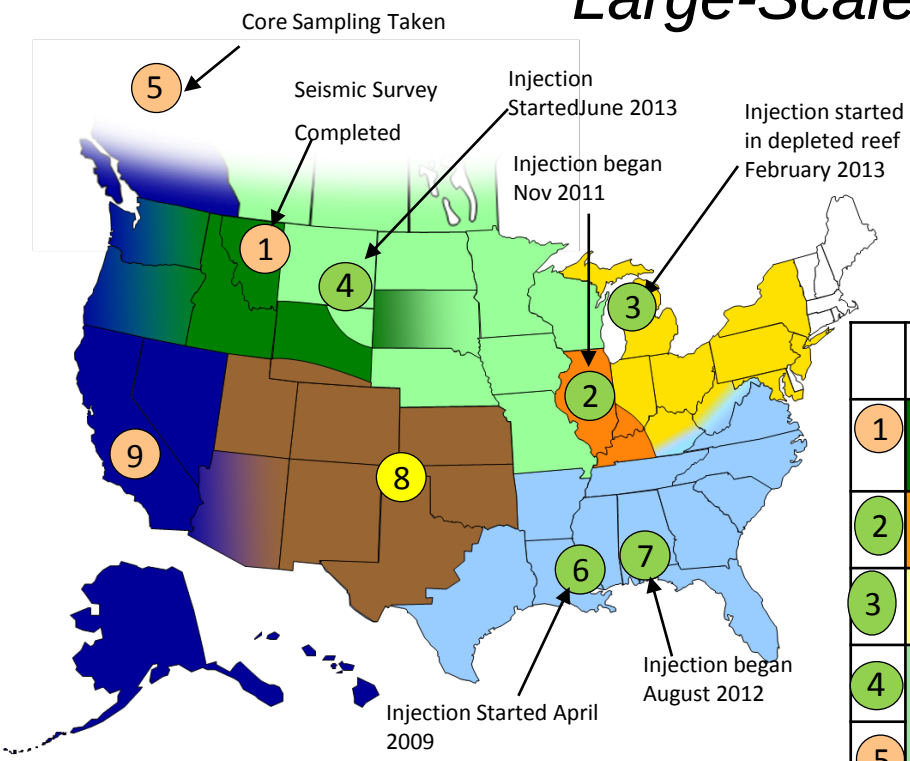
- Regional Carbon Sequestration Partnerships
  - Seven Regional Entities
  - SECARB Phase III Projects

- SECARB Anthropogenic Test
  - Plant Barry Capture Unit
  - Dedicated CO2 Pipeline
  - Injection & Monitoring Systems
  - Risk Management
  - Public Outreach and Education



RCSP Phase III: Development Phase

Large-Scale Geologic Tests



- Injection Ongoing
- 2013 Injection Scheduled
- Injection Scheduled 2013-2015

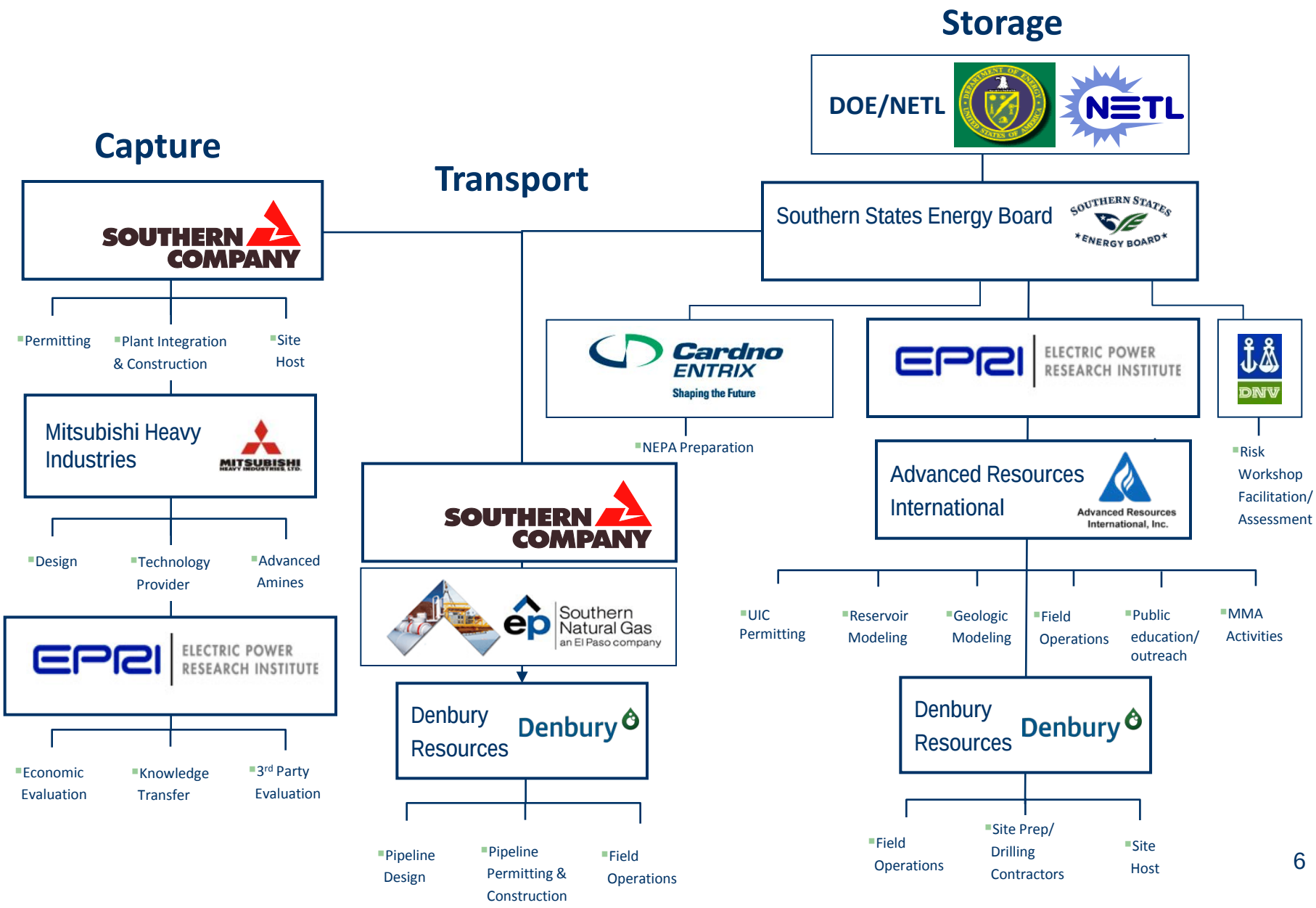
Note: Some locations presented on map may differ from final injection location

- ✓ *Large-volume tests*
- ✓ *Four Partnerships currently injecting CO_2*
- ✓ *Remaining injections scheduled 2013-2015*

	Partnership	Geologic Province	Target Injection Volume (tonnes)
1	Big Sky	Nugget Sandstone	1,000,000
2	MGSC	Illinois Basin-Mt. Simon Sandstone	1,000,000
3	MRCSP	Michigan Basin-Niagaran Reef	1,000,000
4	PCOR	Powder River Basin-Bell Creek Field	1,500,000
5		Horn River Basin-Carbonates	2,000,000
6	SECARB	Gulf Coast – Cranfield Field- Tuscaloosa Formation	3,400,000
7		Gulf Coast – Paluxy Formation	250,000
8	SWP	Regional CCUS Opportunity	1,000,000
9	WESTCARB	Regional Characterization	

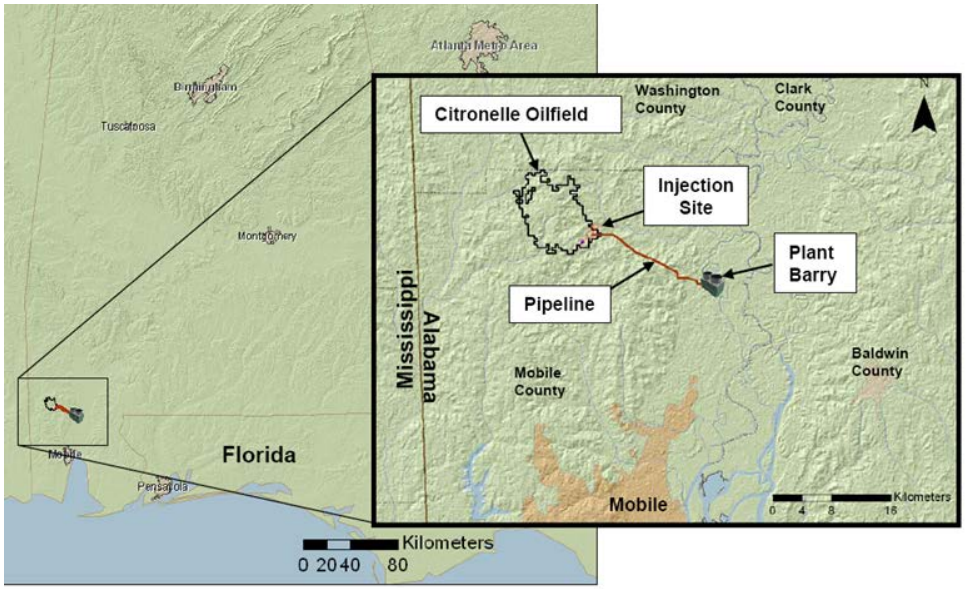
SECARB's Anthropogenic Test Citronelle, Alabama

Anthropogenic Test Organization Chart



SECARB Phase III Anthropogenic Test

- Carbon capture from Plant Barry equivalent to 25MW.
- 12 mile CO_2 pipeline constructed by Denbury Resources.
- CO_2 injection into ~9.400 ft. deep saline formation (Paluxy)
- **100,000 metric tons injected (29 October 2013)**
- Monitoring CO_2 during injection and 3 years post-injection.

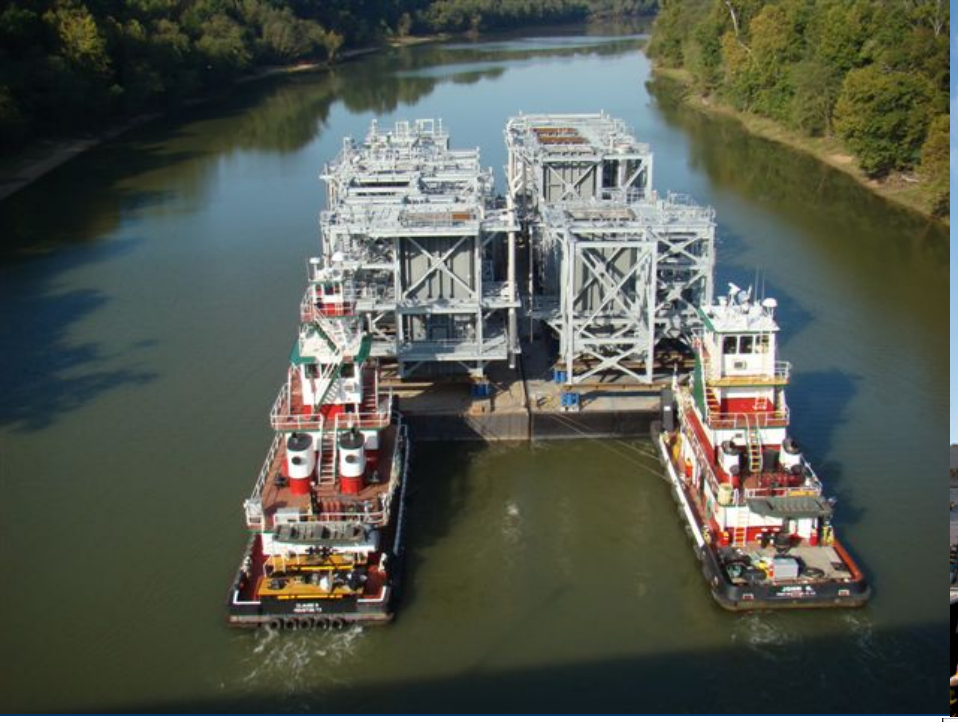



Power Plant


Capture


Transport


Storage

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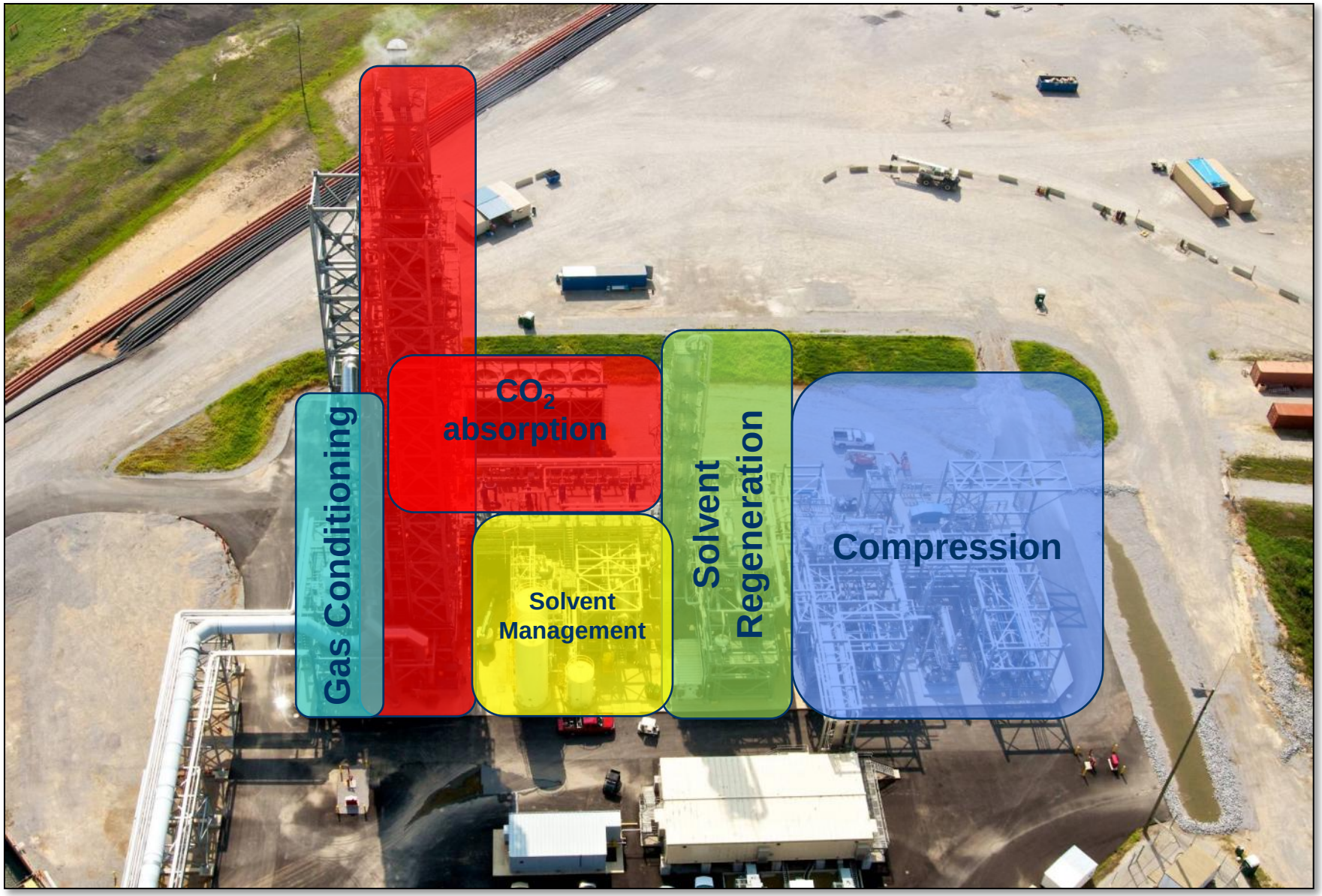
Plant Barry Capture Unit: 25MW, 500 TPD



NEPA/Permitting at SECARB's Integrated Project

- UIC Class V permit application
  - Submitted to Alabama Dept. of Env. Quality December 2010
  - Revise for EPA August 2011

SHPO Survey, April 14, 2010

- Environmental Assessment (EA)
  - Mitigation Requirements
    - 3 mi of wetlands (wetland mitigation planned)
    - 23 gopher tortoise burrows
  - Consultation with State and Federal Agencies
  - Public Outreach and Education

NEPA Finding of No Significant Impact (FONSI)

Directional drilling required to avoid disturbing Gopher Tortoise habitat

Images Courtesy Southern Company

CO_2 Pipeline and Measurement Design

- Applicable regulatory standard: US Depart of Transportation, 49 CFR Part 195 —Transportation of Hazardous Liquids by Pipeline
- 4-inch (10 cm) pipe diameter carbon steel pipe
- Normal operating pressure: 1,500 psig (10.3 MPa) maximum
- Buried average of 5 ft (1.5 m) with surface re-vegetation and erosion control

Handling pipe for horizontal directional drill

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CO_2 Pipeline Overview

- Typical Pipeline/Injection Operations
  - 1,448 psi and 90^0F at the transfer station
  - Rate: 9.64MMcfd (~480 tonnes/day) at 1,314 psi (wellhead) 63^0F.

- Typical CO_2 Purity

Component	%
N_2	0.011
O_2	0.010
CO_2	99.979

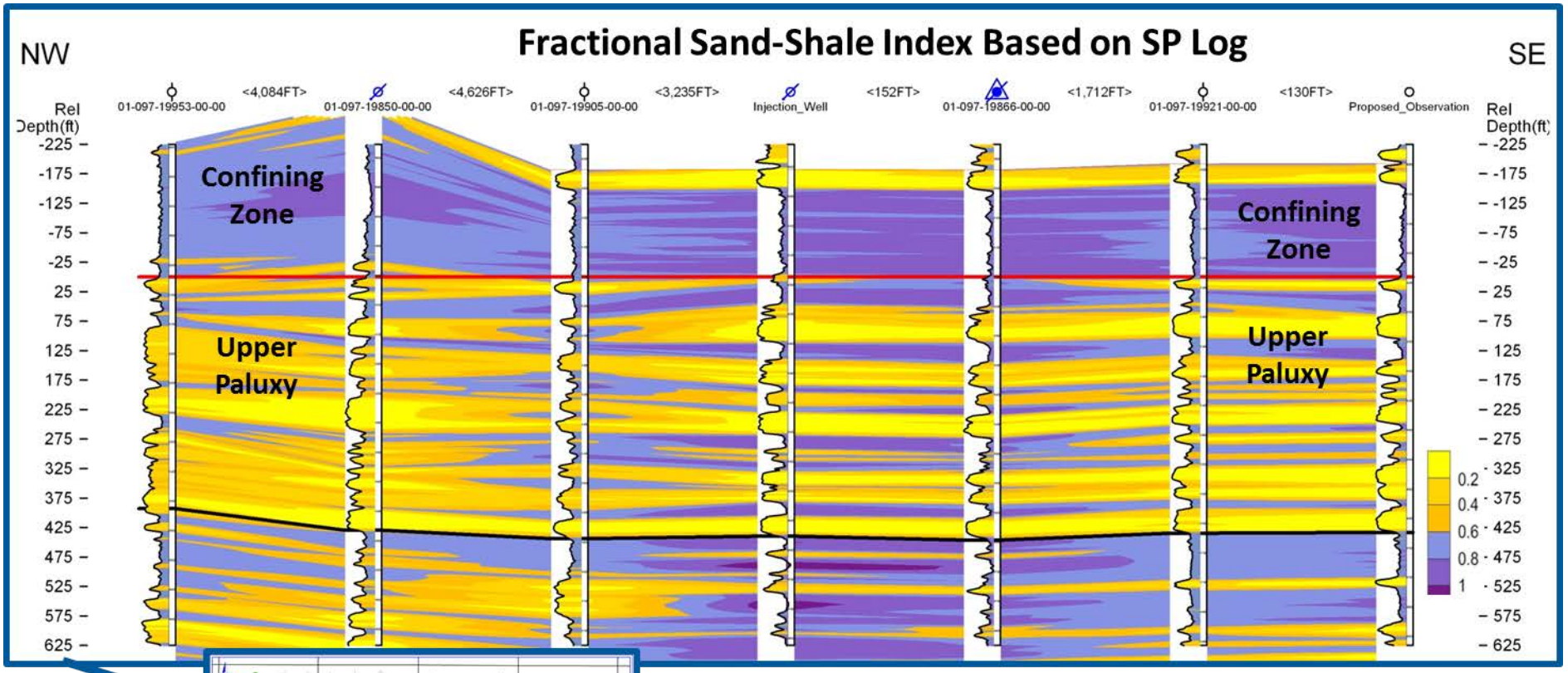
Detailed Characterization of the Injection Site

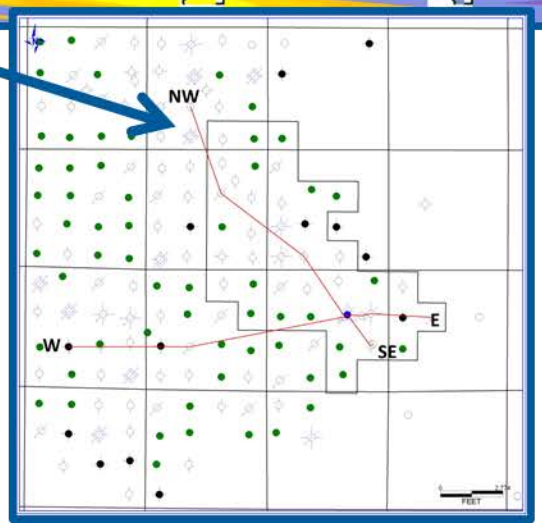
Characterization Well D9-8 #2 at Citronelle Field - Drilled (Dec. 2010/Jan. 2011)

Selecting a Good Storage Formation

System	Series	Stratigraphic Unit	Major Sub Units	Potential Reservoirs and Confining Zones
Tertiary	Plio-Pliocene		Citronelle Formation	Freshwater Aquifer
	Miocene	Undifferentiated		Freshwater Aquifer
	Oligocene		Chickasawhay 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
	Lower	Washita-Fredericksburg	Dantzler sand	Saline Reservoir
			Basal Shale	Primary Confining Unit
		Paluxy Formation	'Upper' 'Middle' 'Lower'	Injection Zone
		Mooringsport Formation		Confining Unit
		Ferry Lake Anhydrite		Confining Unit
		Donovan Sand	Rodessa Fm.	Oil Reservoir
			Upper' 'Middle'	Minor Saline Reservoir
			'Lower'	Oil Reservoir

- Proven four-way closure at Citronelle Dome
- Injection site located within Citronelle oilfield where existing well logs are available
- Deep injection interval (Paluxy Form. at 9,400 feet)
- Numerous confining units
- Base of USDWs ~1,400 feet
- Existing wells cemented through primary confining unit
- No evidence of faulting or fracturing (2D)





Extrapolated Continuity of Upper Paluxy Sandstones At Citronelle Southeast Unit Northwest - Southeast

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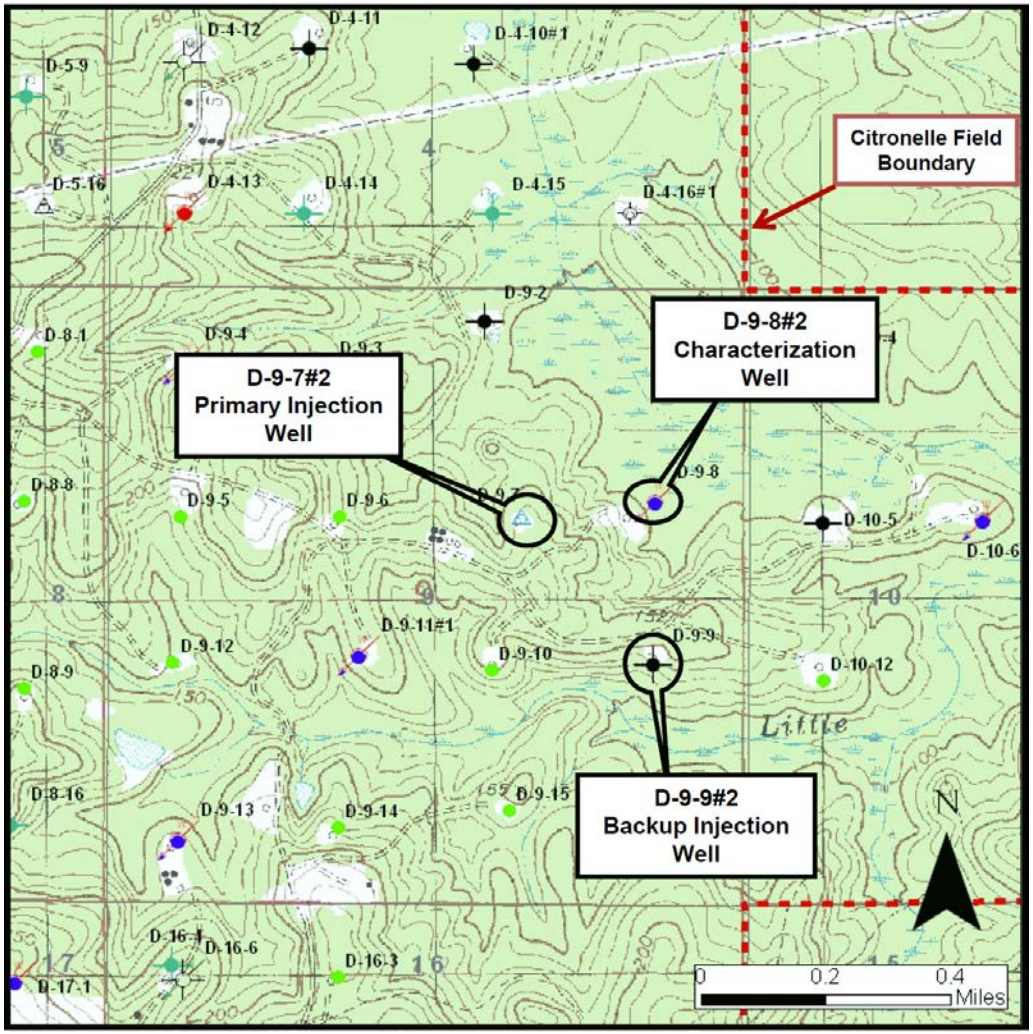
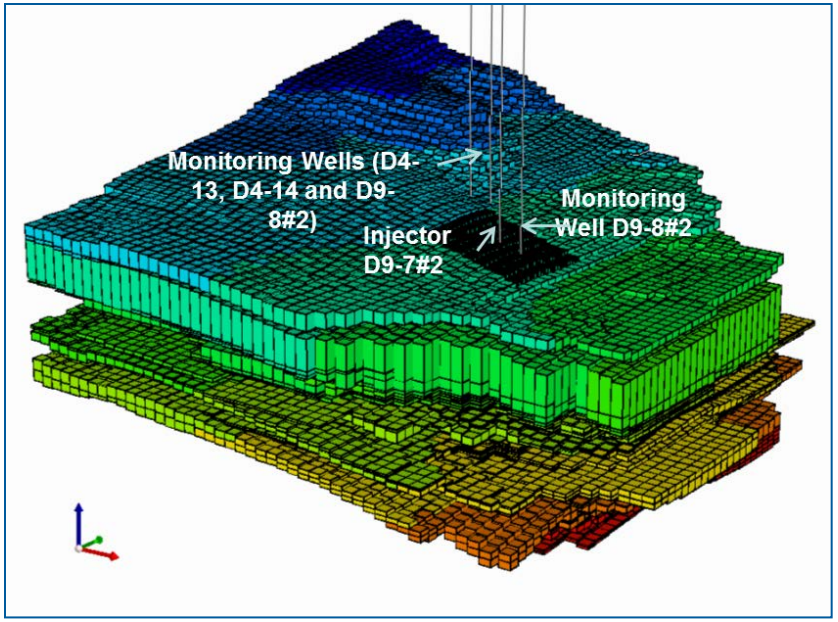
SECARB Citronelle: MVA Sample Locations



- One (1) Injector (D-9-7 #2)
- Two (2) deep Observation wells (D-9-8 #2 & D-9-9 #2)
- Two (2) in-zone Monitoring wells (D-4-13 & D-4-14)
- One (1) PNC logging well (D-9-11)
- Twelve (12) soil flux monitoring stations

Geology Summary for Simulation

- Injecting into Paluxy @ 9,400 feet
- >260 net feet of “clean” sand
- Average porosity of 19% (ranges from 14% to 24%)
- Average permeability of 300 md (ranges from 30md to 1,000 md)



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SECARB Citronelle: Top ranked risks

- Initially **June 2011** the top ranked risks related to:
  - **Permitting** – 30, 31
  - Injectivity and containment – 8, 9, 10, 11
  - Modelling and monitoring – 14, 32
  - Reliable operations – 1, 23, 24, 38,
  - Pipeline and wells – 3, 21, 34
- In **January 2012**, Class V permit had been granted and drilling of monitoring wells and pipeline construction had been completed. Top ranked remaining risks related to:
  - **Authorization to inject** – 31
  - Containment – 8, 9, 10 (low likelihood, but high consequence)
  - Reliability of operations – 23, 38
  - Pipeline or casing leak – 21, 29
- In **May 2013** project had been operating for 9 months. Top remaining risks related to
  - Possible loss of containment – 8, 9, 10
  - Reliability of operations – 23, 41
  - Post-injection MVA / **Authorization for closure** – 52

Public Outreach and Education

- Public Outreach Plan using DOE Best Practices Model
- Active Community Engagement, Open House Meetings and Tours
- Communicating Project Status
  - Local, Regional, International Outreach
  - Annual SECARB Stakeholders' Briefing
  - Dedicated Website
- Knowledge Sharing

Facebook Page: facebook.com/SECARB

Twitter Feeds: @SECARB1