Shallow Carbon Sequestration Demonstration Project

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U.S. Department of Energy

National Energy Technology Laboratory
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Developing the Technologies and Building the Infrastructure for CO_2 Storage

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Presentation Outline

- Benefits to the Program
- Project Overview
- Project Organization
- Project Sites
  - John Twitty Energy Center
  - Thomas Hill Energy Center
  - Sioux Power Plant
  - Iatan Electric Generating Station

Presentation Outline

- Project Completion
- Project Accomplishments
- Summary

Benefit to the Program

- Program goal being addressed:
  - Develop technologies that will support industries' ability to predict CO_2 storage capacity in geologic formations to within +/- 30 percent.
- Project benefits:
  - The research team is assessing CO_2 storage capacity at four Missouri power plant sites. The research will determine the feasibility of carbon sequestration in Missouri and fill a gap in the Program's database.

Project Overview:
Goals and Objectives

- Project Goal - Determine the suitability for carbon sequestration in Missouri.
- Project Objectives:
  - Characterize four Missouri power plant sites.
  - Drill a characterization well at each site to determine the reservoir properties of the target formation, competency of the confining layer, and storage mode.
  - Estimate the storage capacity and maximum sustainable injection rate of CO2 into the target formation.

Project Overview: Goals and Objectives

- How the Project Goals & Objectives relate to the Program Goals & Objectives:
  - Project results will support the ability of City Utilities of Springfield, Ameren Missouri, Associated Electric Cooperative, Inc., Kansas City Power & Light, and The Empire District Electric Company to predict CO2 storage capacity in geologic formations beneath their individual power plant sites to within +/- 30 percent.

Project Overview: Goals and Objectives

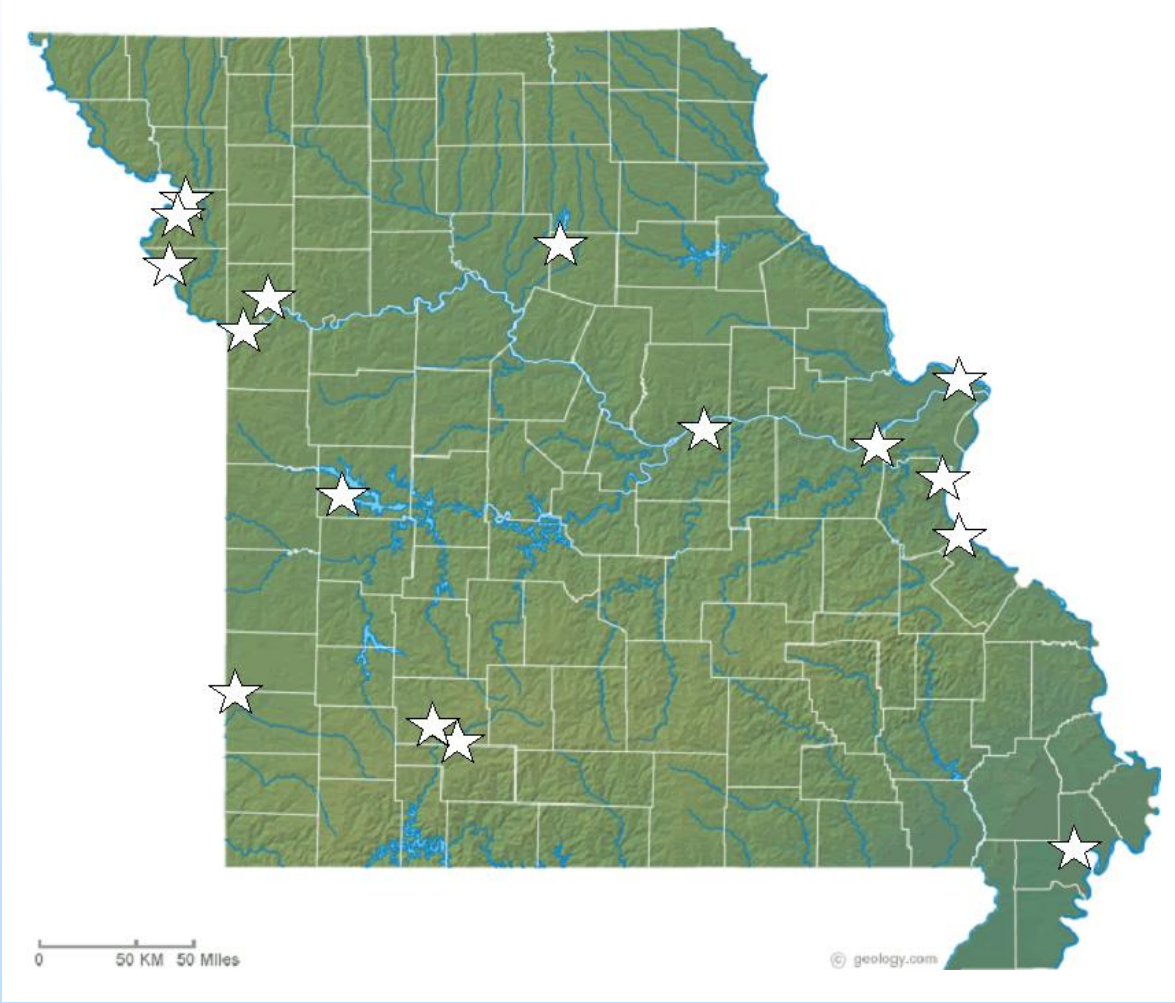
- Identify the Success Criteria for determining if a Goal or Objective has been met.
  - Criteria includes:
    - Successful completion of four characterization wells.
    - Successful extraction of core from the confining layer and target formation.
    - Determination of target formation water quality.
    - Determination of target formation reservoir properties.
    - Determination of confining layer competency.
    - Estimation of storage capacity and maximum sustainable injection rate.

Project Organization

- Research Members
  - City Utilities of Springfield
  - Missouri Department of Natural Resources
  - Missouri University of Science & Technology
  - Missouri State University
- Utility Members
  - Ameren Missouri
  - Associated Electric Cooperative, Inc.
  - City Utilities of Springfield
  - Kansas City Power & Light
  - The Empire District Electric Company
- Supporting Organizations
  - Missouri Energy Development Association
  - Missouri Public Utility Alliance

Project Organization

- Missouri's electric utilities and Missouri's citizens have large stake in the project.
- The 5 member utilities operate 16 coal-fired power plants and collectively provide electricity to 90% of Missouri's farms, families and businesses.



Project Sites

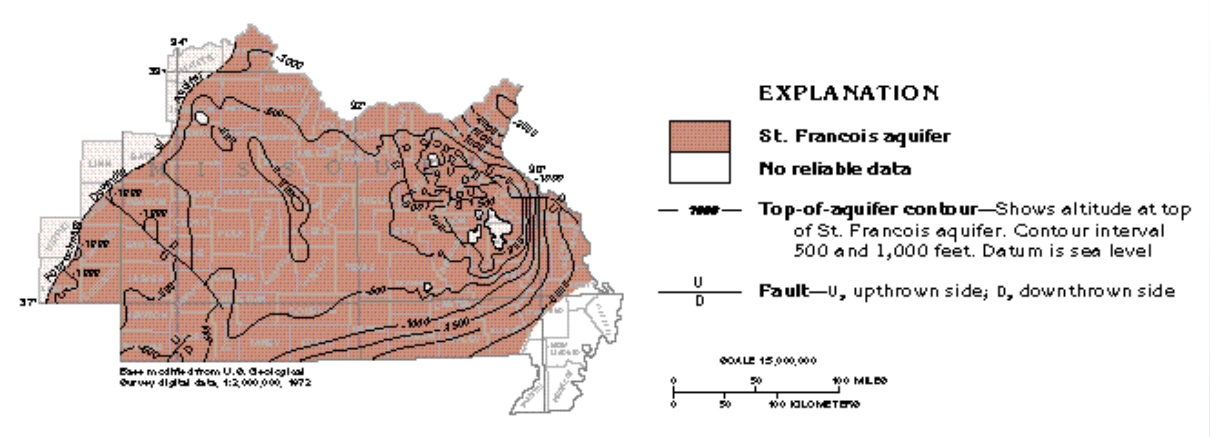
- The four project sites represent all five member utilities and provide good geographic and geologic distribution.
- The four boreholes should provide good characterization of carbon sequestration in Missouri, and fill a Program data gap.

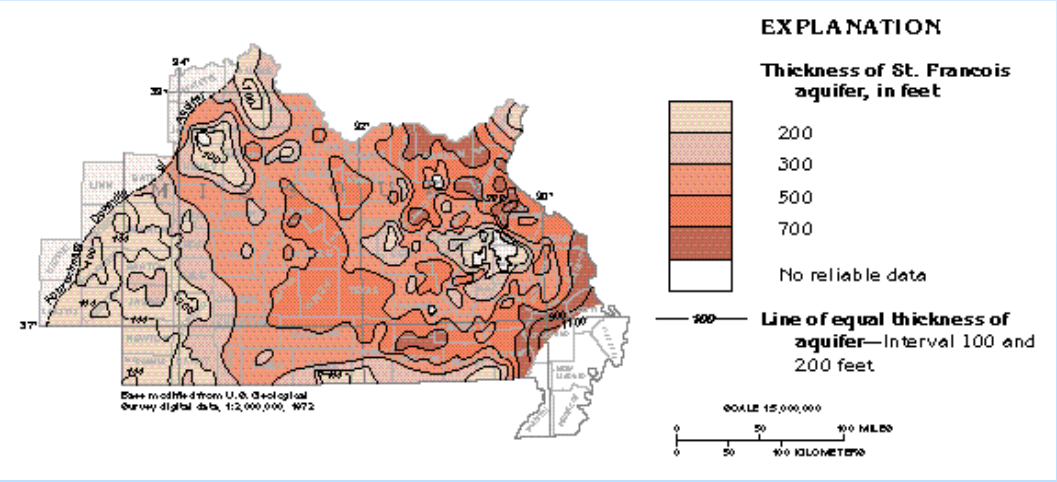
Project Sites

- Borehole #1, John Twitty Energy Center, 503 megawatts, located on Springfield Plateau.
- Borehole #2, Thomas Hill, 1,153 megawatts, located at 30,000-acre mine-mouth site.
- Borehole #3, Iatan, 1,501 megawatts, located on flank of Forest City Basin.
- Borehole #4, Sioux Power Plant, 986 megawatt, located on flank of Illinois Basin.

Target Formation

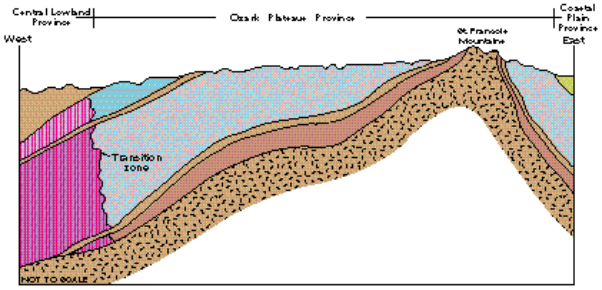
- St. Francois Aquifer comprised of basal Lamotte Sandstone and overlying Reagan Sandstone.
- Lamotte Sandstone is lateral equivalent of Mt. Simon.
- Thickness of St. Francois Aquifer varies greatly, but ranges up to 700 feet.
- St. Francois Aquifer extends over entire state.





Confining Layer

- Derby-Doerun/Davis confining layer separates St. Francois Aquifer from overlying Ozark Aquifer.
- Derby-Doerun/Davis consists of thinly-bedded dolomite and shale.
- Permeability of confining layer very low.



Modified from Imes, J.L., and Emmett, L.F., 1994, Geohydrology of the Ozark Plateaus aquifer system in parts of Missouri, Arkansas, Oklahoma, and Kansas: U.S. Geological Survey Professional Paper 1414–D, 127 p.

EXPLANATION

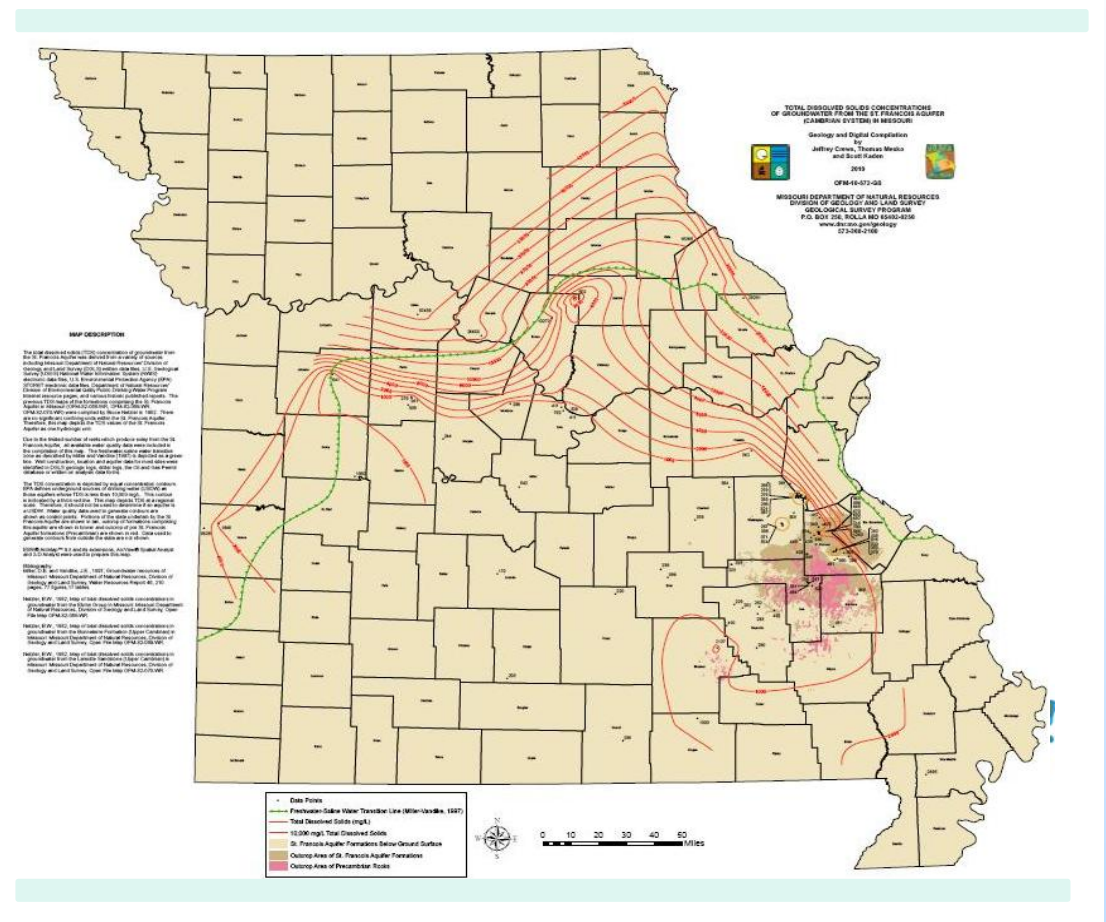
- Mesozoic and younger sediments
- Western Interior Plains aquifer system
  - Upper aquifer unit
  - Lower aquifer units
- Confining unit
- Ozark Plateaus aquifer system
  - Springfield Plateau aquifer
  - Ozark aquifer
  - St. Francois aquifer
- Basement confining unit

John Twitty Energy Center

- Original project scope contemplated an injection test at the site.
- Borehole #1 completed to TD of 2,186 feet.
- 731 feet of core obtained from the confining layer and target formation.
- Water samples obtained from the Reagan and Lamotte sandstone units yielded TDS concentrations of 152 mg/L and 208 mg/L, respectively.
- Plans for an injection test were abandoned and project re-scoped to provide characterization wells at three additional power plant sites.

St. Francois Aquifer TDS

- Based on available data, TDS concentrations at the three additional drilling sites are expected to occur in the range of 20,000 to 45,000 mg/L.



Redirection of Project

- Closeout of John Twitty Energy Center work.
- Selection of additional drilling sites.
- Preparation/submittal of revised budget and SOPO.
- Preparation/submittal of revised PMP.
- Preparation/submittal of NEPA questionnaires.
- Revision of MOU with utility members.
- Amendment of subcontracts with research team.
- Determination of need for temporary APCP permit.
- Preparation of bid documents for additional sites.
- Bidding and award of drilling contracts.

Thomas Hill Energy Center

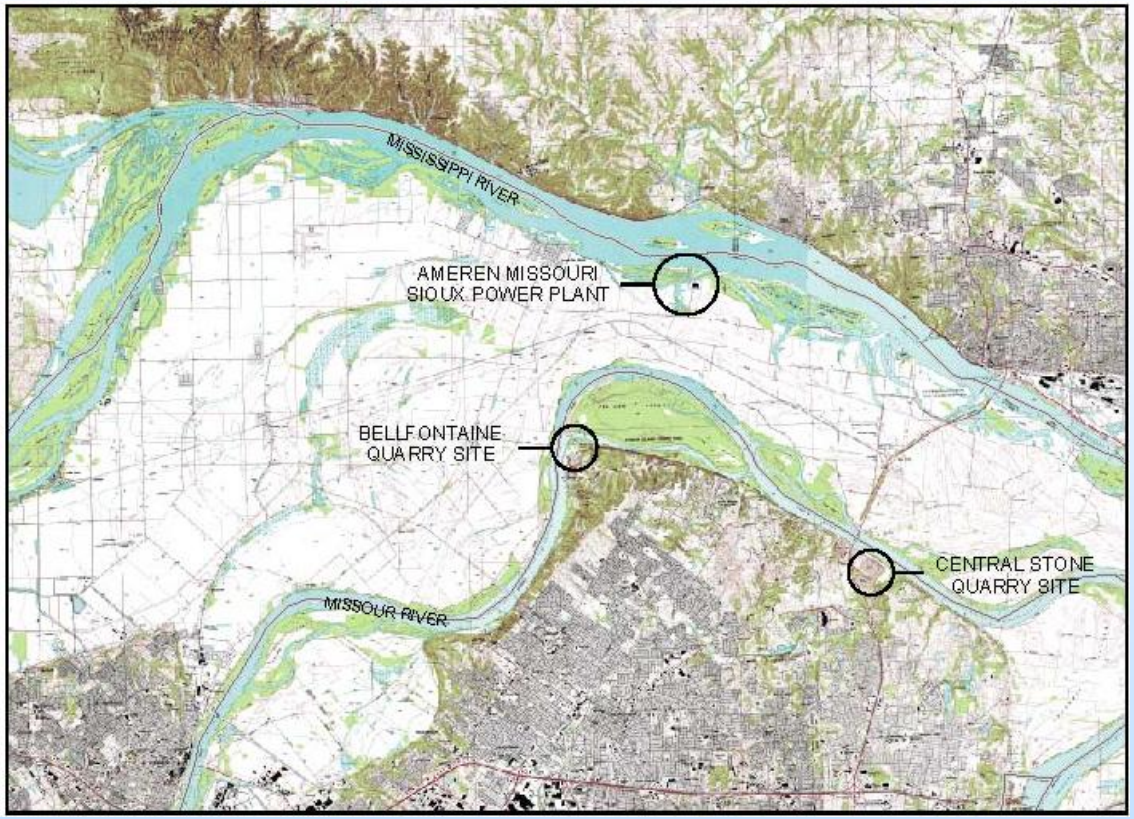
- Drilling at Thomas Hill commenced in February 2012.
- Very little deep well log data existed in the area. Cable tool log from 20 miles away suggested there might be 700 feet of Lamotte.
- Top of confining layer encountered at 1,950 feet.
- Top of target formation encountered at 2,083 feet.
- Top of Pre-Cambrian basement rock encountered at 2,530 feet.
- Confining layer thickness found to be 133 feet.
- Target formation thickness found to be 447 feet.

Thomas Hill Energy Center

- Wireline logging completed.
- Preliminary results of target formation water sampling yielded TDS concentration (evaporation method) of 55,452 mg/kg.
- Rock core transferred to MO Division of Geology and Land Survey McCracken Core Library.
- MSU and MS&T researchers selected core intervals for testing on August 1, 2012.
- Lamotte core appears porous and permeable. Davis core appears very tight.
- Pressure testing and well closure on hold pending determination of remaining funds.

Sioux Power Plant

- Sioux Power Plant is located in floodplain between Mississippi and Missouri Rivers.
- Drilling sites were evaluated and site secured at former Bellfontaine Quarry Site.



Sioux Power Plant

- Bellfontaine Quarry will provide flood protected drilling site.
- Water management plan provides for discharge of produced water to the quarry pit.
- Drilling contract has been bid and awarded.
- Driller will mobilize to the site before the end of August 2012.
- Based on available data, top of confining layer expected at 2,850 feet, top of target formation at 3,030 feet, and top of Pre-Cambrian at 3,220 feet.

Iatan Electric Generating Station

- Drilling contract bid and awarded.
- Mobilization anticipated in December 2012.
- Based on available date, top of confining layer expected at 2,585 feet, top of target formation at 2,670 feet, and top of Pre-Cambrian at 2,745 feet.

Project Completion

- Following completion of drilling, coring, downhole geophysical logging, and water sampling at Iatan, remaining funding can be quantified and decisions made regarding the level of pressure/fracture testing which can be performed in Characterization Wells #2, #3 and #4.
- Following completion of testing, the wells will be cemented and research at MSU, MS&T, and MDNR completed.
- Project end date is September 30, 2013.

Accomplishments to Date

- Teaming arrangements established with five major electric companies, two universities, and state DNR.
- Internal team established to manage technical, financial, and logistical aspects of the project, along with media, community, and governmental relations.
- Characterization of Site 1 complete.
- Internal team successfully managed total re-scoping of the project.
- Drilling and coring of Site 2 complete.
- Project remains on schedule and within budget.

Summary

– Key Findings

- Geology/hydrology of southern Missouri is unacceptable for carbon sequestration.
- Geology/hydrology of northern Missouri more favorable for carbon sequestration.
- Davis Shale appears to be a competent confining layer.
- Lamotte Sandstone is highly variable due to multiple facies. Suitability for carbon sequestration will be site-specific.

Summary

- Lessons Learned
  - Creative thinking and ability to adapt are important.
  - The structure, process and scope of the Missouri project are transferrable to other states interested in assessing the feasibility of carbon sequestration.
- Future Plans
  - If certain of the Missouri sites are found to be suitable for carbon sequestration, additional funding may be sought for comprehensive site characterization.

Questions

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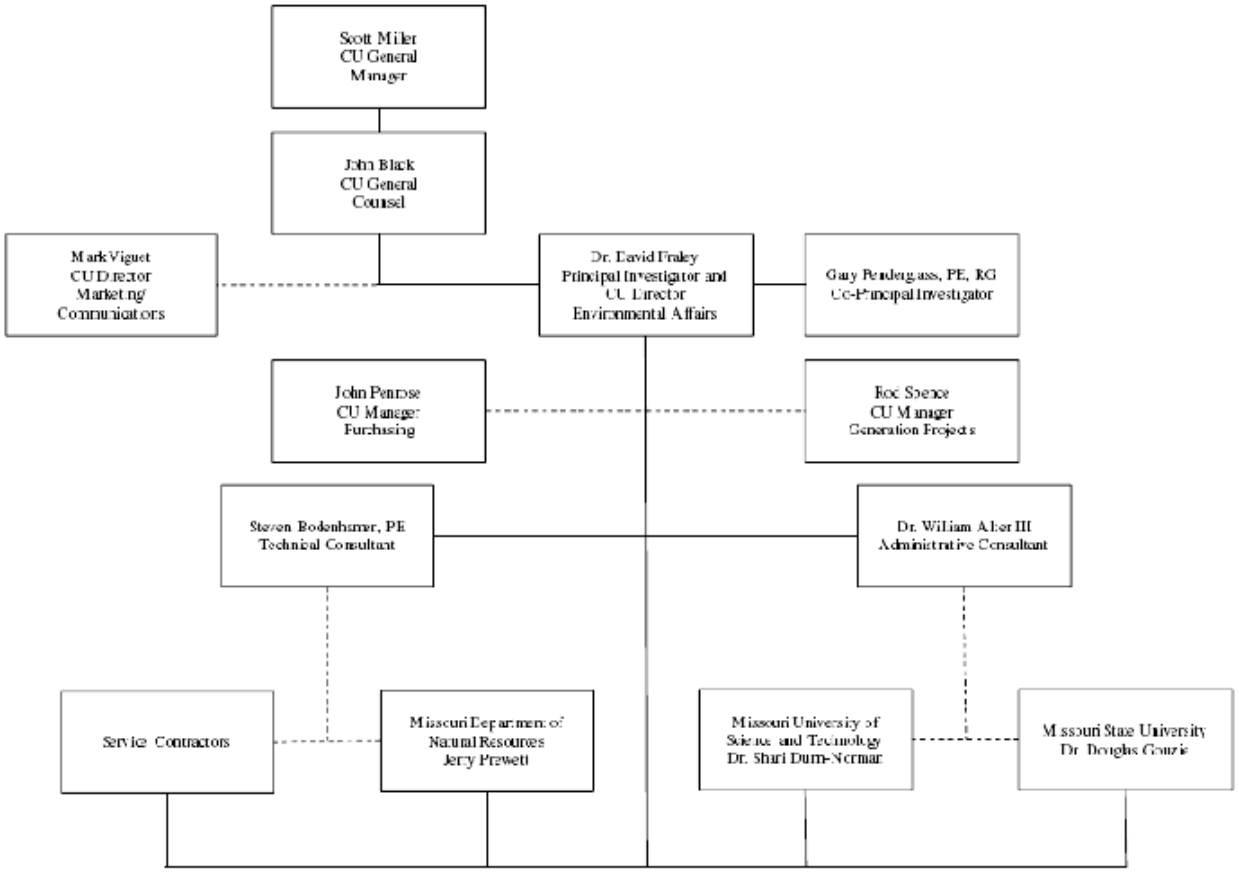
Appendix

– These slides will not be discussed during the presentation, but are mandatory

Organization Chart



Gantt Chart

Table 4 - Milestone Status Report

CALENDAR YEAR / QUARTERS / MONTHS	Task Number	2008 Q1 Oct-Dec	2009 Q2 Jan-Mar	2009 Q3 Apr-Jun	2009 Q4 Jul-Sept	2009 Q5 Oct-Dec	2010 Q6 Jan-Mar	2010 Q7 Apr-Jun	2010 Q8 Jul-Sept	2010 Q9 Oct-Dec	2011 Q10 Jan-Mar	2011 Q11 Apr-Jun	2011 Q12 Jul-Sep	2011 Q13 Oct-Dec	2012 Q14 Jan-Mar	2012 Q15 Apr-Jun	2012 Q16 Jul-Sept	2012 Q17 Oct-Dec	2013 Q18 Jan-Mar	2013 Q19 Apr-Jun	2013 Q20 Jul-Sept	Revised Planned Start Date	Revised Planned End Date	Actual Start Date	Actual End Date	Comments
	1	Management and Planning																								
John Twitty Energy Center site: prepare and Submit NEPA Questionnaires to DOE.	b	A																					10/01/08	04/24/09	10/01/08	04/24/09	Complete. Mod 01 issued 04/24/09.
John Twitty Energy Center site: permit Applications to Missouri Air Pollution Control Program.	c	B																					10/01/08	10/19/09	10/01/08	10/19/09	Complete. Permit No. 102009-006.
Thomas Hill Energy Center site: prepare and Submit NEPA Questionnaires to DOE.	b													C									08/05/11	01/15/12	09/28/11	01/12/12	Complete. Mod 05 issued 01/12/12.
Thomas Hill Energy Center site: permit Applications to Missouri Air Pollution Control Program.	c													D									09/21/11	11/29/11	09/21/11	11/29/11	Complete. No Permit Req'd.
Iatan Generating Station site: Prepare and Submit NEPA Questionnaires to DOE.	b													E									08/05/11	01/15/12	09/28/11	01/12/12	Complete. Mod 05 issued 01/12/12.
Iatan Generating Station site: permit Applications to Missouri Air Pollution Control Program.	c													F									09/21/11	03/31/12	09/28/11	03/06/12	Complete. No Permit Req'd.
Luecte Quarry site: prepare and Submit NEPA Questionnaires to DOE.	b													G									02/01/12	03/31/12	02/28/12	03/23/12	Complete Mod 06 issued on 3/23/12
Luecte Quarry site: permit Applications to Missouri Air Pollution Control Program.	c													H									03/31/12	05/31/12	09/28/11	03/06/12	Complete No Permit Req'd
Explore and leverage outside knowledge to include review of data from other sites that are exploring the suitability of carbon sequestration.	d														I								12/01/11	06/01/13	12/01/11		
	2	Site Characterization																								
John Twitty Energy Center site: complete existing information and provide descriptions of general geology.	a	J																					10/01/08	07/21/11	10/01/08	07/21/11	Complete. Report from MDNR dated 07/21/11.
John Twitty Energy Center site: perform a 3D Seismic Reflection Survey.	b	K																					10/01/08	05/03/11	10/01/08	12/02/11	Complete. Report from GeoEngineers dated 12/02/11.
John Twitty Energy Center site: determine the hydrology of the Ozark Aquifer.	c	L																					10/01/08	09/15/10	10/01/08	07/19/10	Complete. 6th Quarter Progress Report dated 07/19/10.
John Twitty Energy Center site: determine the baseline water chemistry of the target formation.	d	M																					10/01/08	09/30/11	10/01/08	11/23/11	Complete. 12th Quarter Progress Report dated 11/23/11.
Thomas Hill Energy Center site: complete existing information and provide descriptions of general geology.	a														N								01/15/12	09/30/12	02/20/12		Due to delay in receiving Mod 05 - NEPA exclusion for this site
Thomas Hill Energy Center site: determine the baseline water chemistry of the target formation.	d													O									02/01/12	05/30/12	07/01/11	08/31/12	Data Received from MDNR
Luecte Quarry site: complete existing information and provide descriptions of general geology.	a														P								08/01/12	02/28/13			Revised due to delay in obtaining lease for Luecte Site
Luecte Quarry site: determine the baseline water chemistry of the target formation.	d													Q									05/30/12	10/31/12	07/01/11	08/31/12	Data Received from MDNR
Iatan Generating Station site: complete existing information and provide descriptions of general geology.	a																	R					10/01/12	04/01/13			Revised due to plan to overlap work at two sites
Iatan Generating Station site: determine the baseline water chemistry of the target formation.	d													S									10/31/12	03/31/12	07/01/11	08/31/12	Data Received from MDNR
	3	Physical Suitability of the Confining Layer & Target Formation for Carbon Sequestration at the Four Missouri Power Plant Sites																								
John Twitty Energy Center site: complete drilling, coring, and logging of borehole; retrieve representative samples from the confining layer and target formation; conduct pressure testing of confining layer and target formation; retrieve fluid samples from the target formation.	a, c, d, e								T														10/01/08	09/30/11	05/20/10	07/25/11	Borehole closure completed.
John Twitty Energy Center site: determine petrologic and mineralogic characteristics of the confining layer and target formation.	b								U														10/01/08	09/30/11	07/18/10	12/15/11	Reports received from MSU & MS&T
Thomas Hill Energy Center site: complete drilling, coring, and logging of borehole; retrieve representative samples from the confining layer and target formation; conduct pressure testing of confining layer and target formation; retrieve fluid samples from the target formation.	a, c, d, e														V								01/15/12	05/30/12	02/20/12		Due to delay in receiving Mod 05 - NEPA exclusion for this site
Thomas Hill Energy Center site: determine petrologic and mineralogic characteristics of the confining layer and target formation.	b														W								02/01/12	11/30/12			Revised due to delays in drilling at Thomas Hill Site
Luecte Quarry site: complete drilling, coring, and logging of borehole; retrieve representative samples from the confining layer and target formation; conduct pressure testing of confining layer and target formation; retrieve fluid samples from the target formation.	a, c, d, e																	X					08/01/12	01/31/13			Revised based on re-assessment of time to complete task
Luecte Quarry site: determine petrologic and mineralogic characteristics of the confining layer and target formation.	b																		Y				11/01/12	03/31/13			Revised based on re-assessment of time to complete task
Iatan Generating Station site: complete drilling, coring, and logging of borehole; retrieve representative samples from the confining layer and target formation; conduct pressure testing of confining layer and target formation; retrieve fluid samples from the target formation.	a, c, d, e																			Z			10/01/12	03/31/13			Revised due to plan to overlap work at two sites
Iatan Generating Station site: determine petrologic and mineralogic characteristics of the confining layer and target formation.	b																					AA	12/15/12	06/30/13			Revised due to re-assessment of time needed to complete task
	4	Lab-based Characterization of the Confining Layer and Target Formation																								
John Twitty Energy Center site: determine porosity, permeability, grain size distribution, pore throat size and shape, and minerals present in representatives core samples.	a, b																		BB				08/15/09	06/30/11	08/15/09	01/15/12	Reports received from MSU and MS&T
Thomas Hill Energy Center site: determine porosity, permeability, grain size distribution, pore throat size and shape, and minerals present in representatives core samples.	a, b																					CC	09/01/12	06/01/13			Revised due to delay in start of drilling work at Thomas Hill Site
Luecte Quarry site: determine porosity, permeability, grain size distribution, pore throat size and shape, and minerals present in representatives core samples.	a, b																					DD	10/01/12	06/01/13			Revised due to delay in obtaining lease for Leucte site
Iatan Generating Station site: determine porosity, permeability, grain size distribution, pore throat size and shape, and minerals present in representatives core samples.	a, b																					EE	01/01/13	06/01/13			Delay due to delay in completing drilling tasks.

Milestones A through EE

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- Presentation, single author:
  - Starkey, M., 2009 Geochemical Variation of the Lamotte Sandstone in Southwest Missouri. U.S. Geological Society of America – Annual Meeting in Portland, Oregon.
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  - Starkey, M. and Gouzie D., 2011. Bulk Elemental Analysis of the Lamotte Sandstone using Non-Destructive X-Ray Fluorescence. U.S. Geological Society of America – North Central/Northeast Section Meeting in Pittsburgh, Pennsylvania.
  - Rovey, C. and Rono, N., 2011. Suitability of the St. Francois Confining Unit as a Caprock above CO2 Injection Zones in Missouri. U.S. Geological Society of America – North Central/Northeast Section Meeting in Pittsburgh, Pennsylvania.