Integrated CCS for Kansas (ICKan)

Project Number FE0029474

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U.S. Department of Energy

National Energy Technology Laboratory

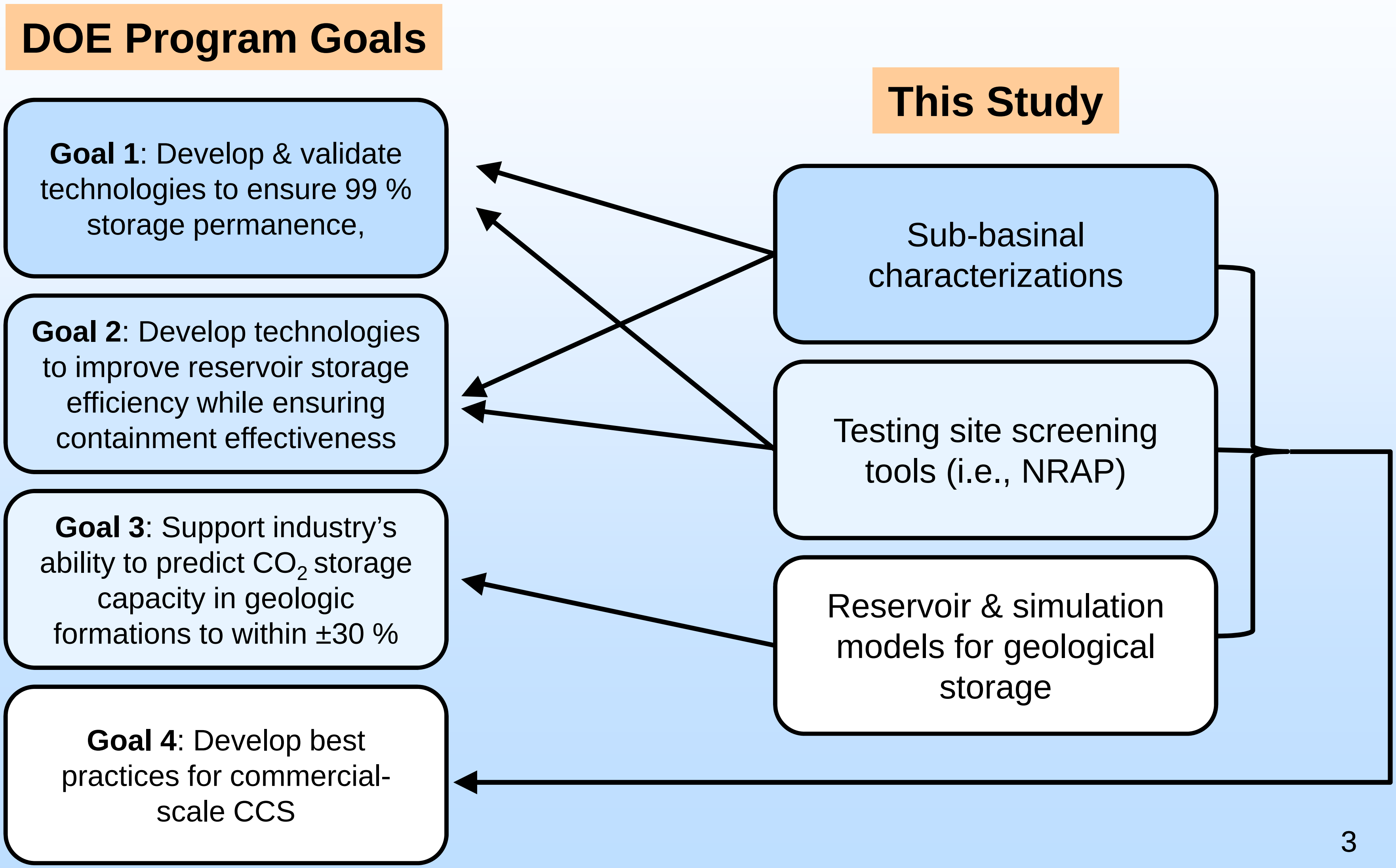
DE-FOA0001584 Kickoff Meeting

March 14 – 15, 2017

Presentation Outline

- Program benefits
- Project overview: goals and objectives
- Research methodology
- Expected outcomes
- Organization and communication
- Tasks and Subtasks
- Deliverables and milestones
- Project risks (Phase I and Phase II)
- Schedule
- Summary
- Appendix

Benefit to the Program



Benefit Statement

ICKan will address the handling of CO_2 emissions from the source and transport them to the storage site utilizing the combined knowledge and experience of The Linde Group including their own research on post-combustion 2nd Generation CO_2 capture currently sponsored by the DOE, the electrical utilities, refinery, and the latest R&D efforts such as DOE's Carbon Capture Simulation Initiative. The knowledge, experience, and lessons learned by the KGS regarding regional studies, site characterization, monitoring, EPA Class VI permitting, and incorporating NRAP models and tools will be bring best-practices to bear on proving up a commercial-scale carbon storage complex that is safe and dependable. In this Phase I: Integrated CCS Pre-Feasibility Study, ICKan will complete the formation of the CCS Coordination Team who will deliver a plan and strategy to address the technical and non-technical challenges specific to commercial-scale deployment of a CO_2 storage project utilizing the experience and the expertise of the Team. A development plan will address technical requirements, economic feasibility, and public acceptance of an eventual storage project at the primary source-sink site at Westar Energy's Jeffrey Energy Center. High-level technical evaluations will also be made of sub-basin and potential CO_2 sources utilizing prior experience and methodologies developed previously and for this project. The ICKan and CCS Coordination Team will generate information that will allow DOE to make a determination of the proposed storage complex's level of readiness for additional development under Phase II, based upon the findings for commercial-scale capture, transportation, and storage sites identified as part of this investigation. Information acquired will be shared via the NETL-EDX data portal.

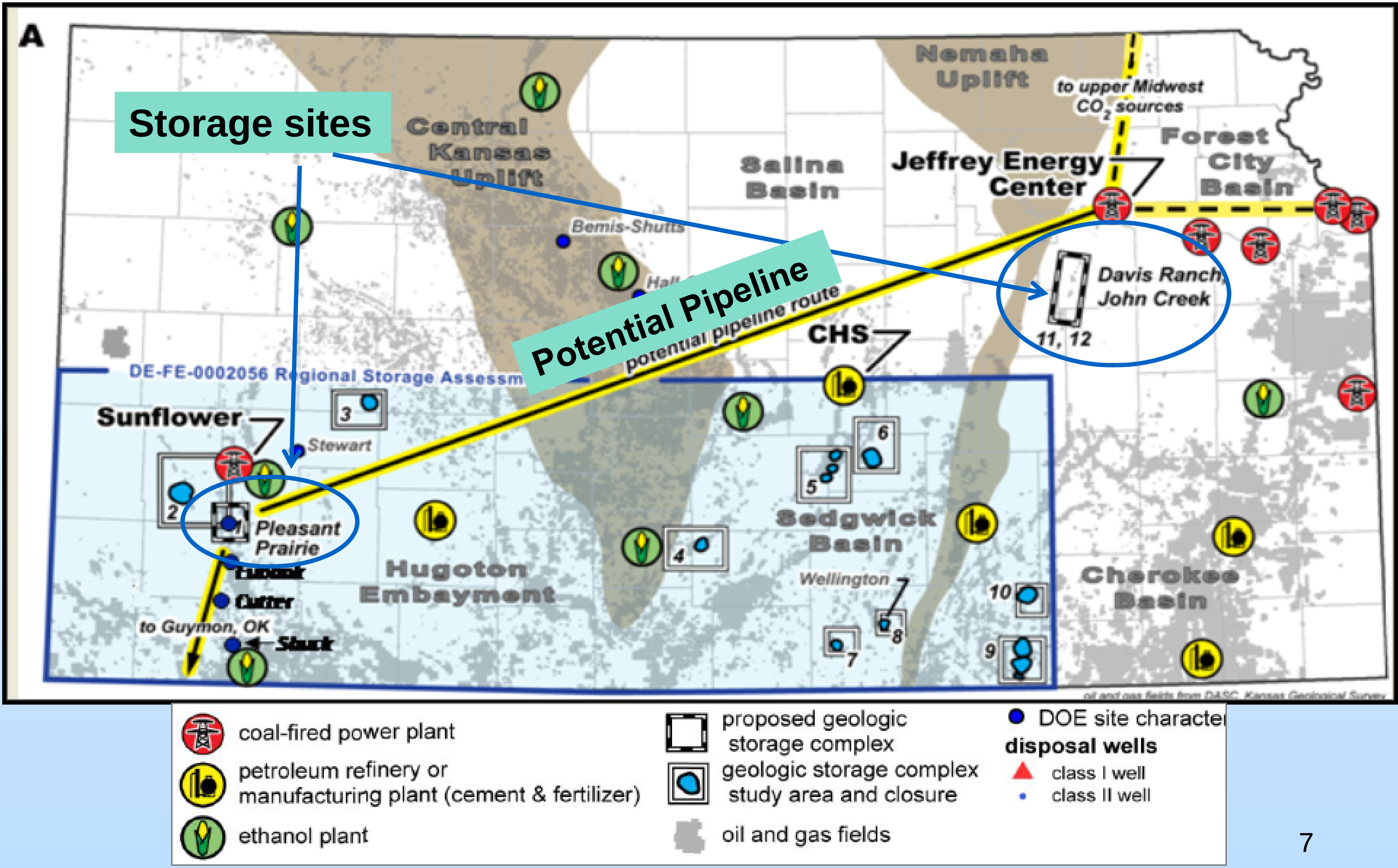
Project Overview: Goals & Objectives

- Identify and address major **technical and nontechnical challenges** of implementing CO_2 capture and transport and establishing secure geologic storage for CO_2 in Kansas
- Evaluate and **develop a plan and strategy** to address the challenges and opportunities for commercial-scale CCS in Kansas

Project Overview: Base Case Scenario

- **Capture 50 million tonnes CO_2** from one of three Jeffrey Energy Center's 800 MWe plants over a 20 year period (2.5Mt/yr)
- Compress CO_2 and **transport 300 miles to Pleasant Prairie Field** in SW Kansas.
  - Alternative: 50 miles to Davis Ranch and John Creek Fields.
- Inject and permanently **store 50 million tonnes CO_2 in the Viola Formation and Arbuckle Group**

Jeffrey to SW Kansas



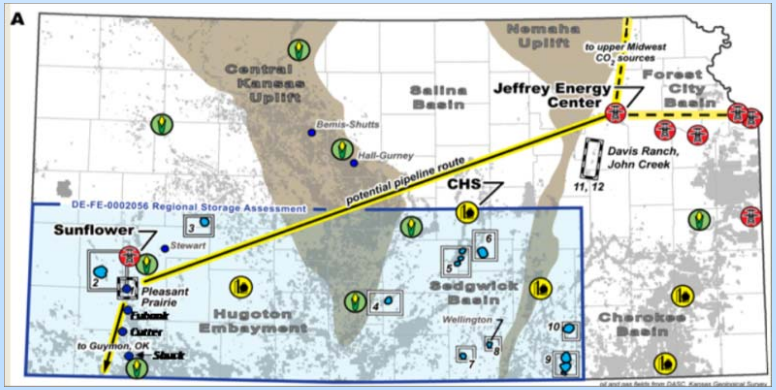
Base Case + Ethanol CO_2

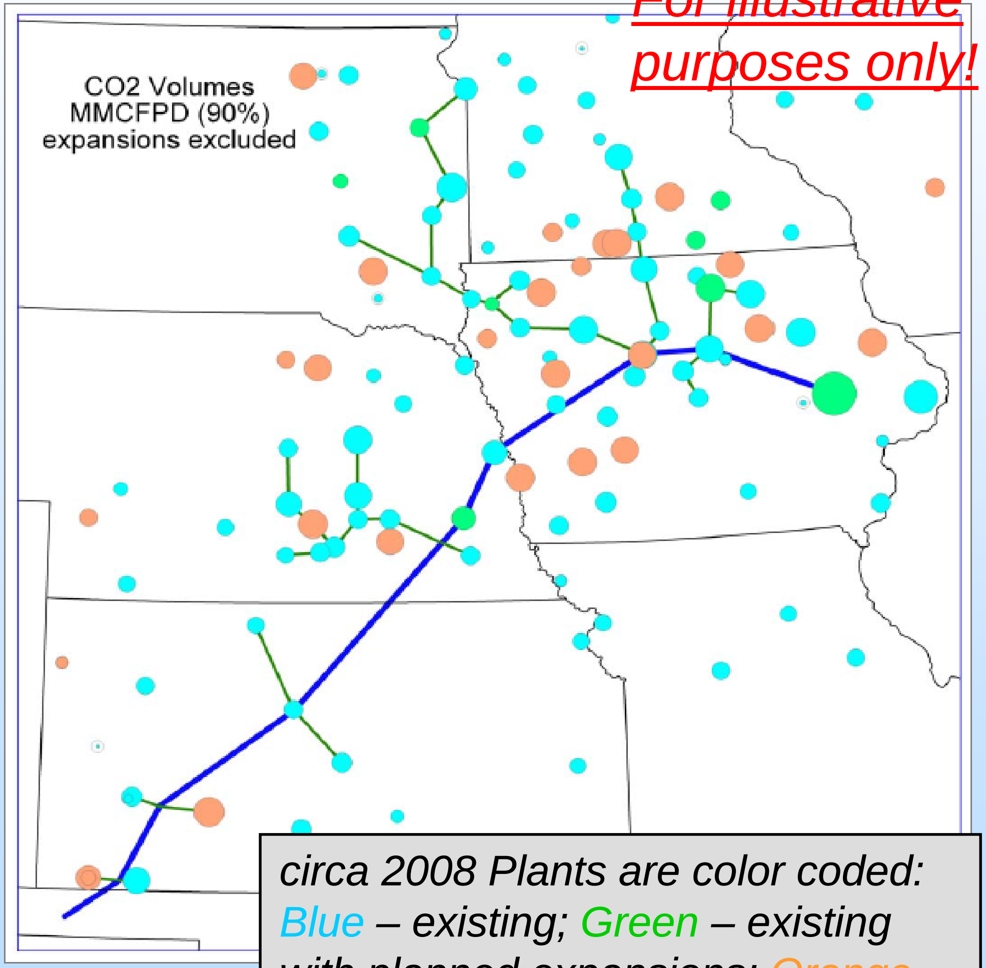
January 2008 private study

Gathering system connecting 44 ethanol plants

Could reduce net cost through scaling and tariffs

- Capture Ethanol CO2
- Build extensive gathering system
- Join trunk line and transport to SW Kansas and possibly to Permian Basin for EOR
- Collect tariffs for transporting Ethanol CO2





<u>For illustrative purposes only!</u>

circa 2008 Plants are color coded: Blue – existing; Green – existing with planned expansions; Orange – proposed or under construction.

Technical Evaluations

Sub-Basinal Evaluations

Pleasant Prairie

- 170 Mt storage
- Viola & Arbuckle
- CO_2-EOR reservoirs
- Adequate data (core)
- Unitized; single operator

Davis Ranch-John Creek

- 50 Mt storage
- Simpson and Arbuckle
- Proximity to JEC
- CO_2-EOR reservoirs
- Adequate data
- Two operators

CO_2 Source Assessments ⇔ CO_2 Transportation

CO_2 Source Assessments

Westar Jeffrey Energy Center

- 2.4 GW & 12.5 million tonnes of CO_2

Sunflower's Holcomb Plant

CHS McPherson Refinery

KC Board of Public Utilities

CO_2 Transportation

Pipeline

- 300 mile trunk line
- Connect to Midwest ethanol CO_2 gathering system
- Connect to Permian through Oklahoma Panhandle

Non-Technical Evaluations

Implementation Plan

Economics

- Capture & transportation economic feasibility (with or w/o ethanol component)
- Financial backing
- Financial assurance under Class VI
- State incentives
- Federal tax policy

Legal & Regulatory

- Pore space property rights including force unitization
- CO_2 ownership & liability
- MVA requirements under UIC Class VI
- Varying stakeholder interests
- Right-of-ways
- Utility rate-payer obligations

Public Policy (Public Acceptance))

- Identify stakeholders
- Foster relationships
- Public perception
- Political challenges
- Injection-induced seismicity

Success Criteria

- ✓ CCS Coordination Team
- ✓ Reservoirs characterized
- ✓ CO_2 source assessments
- ✓ CO_2 transportation assessment
- ✓ Implementation plan

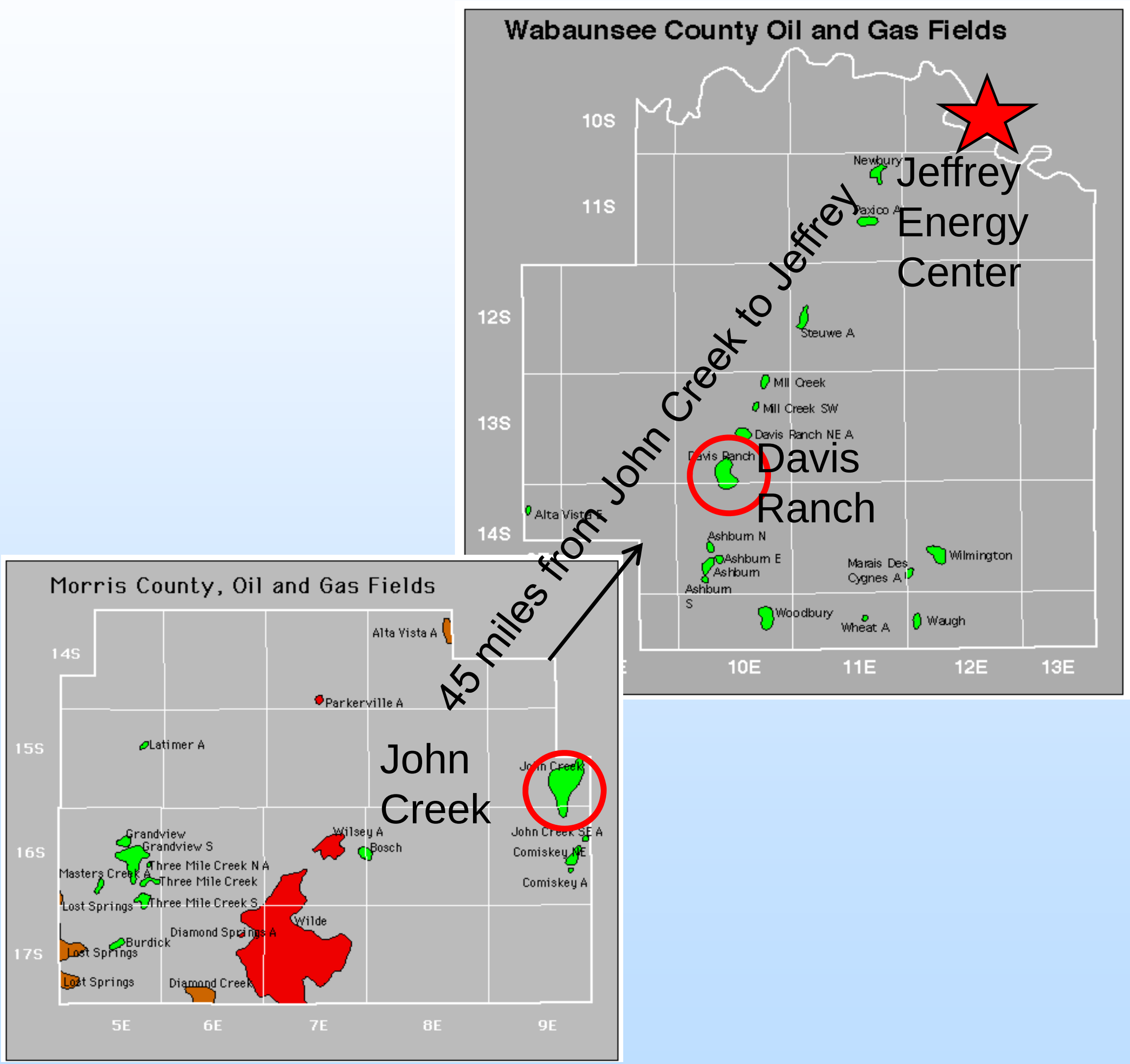
- Go-No Go decision point in November 2017
- Tied to application for Phase II of CarbonSAFE

Methodology – Task 4: High level technical sub-basinal evaluation

Subtasks

1. **Review storage capacity** of geologic complexes identified in this proposal and consider alternatives
2. **Conduct high-level technical analysis** of suitable geologic complexes using NRAP IAM- CS and other tools for integrated assessment.
3. **Compare results using NRAP** with methods used in prior DOE contracts including regional and sub-basin CO2 storage and Class VI.
4. **Develop an implementation plan** and strategy for commercial-scale, safe and effective CO2 storage.

Davis Ranch and John Creek Fields in the Forest City Basin (FCB)

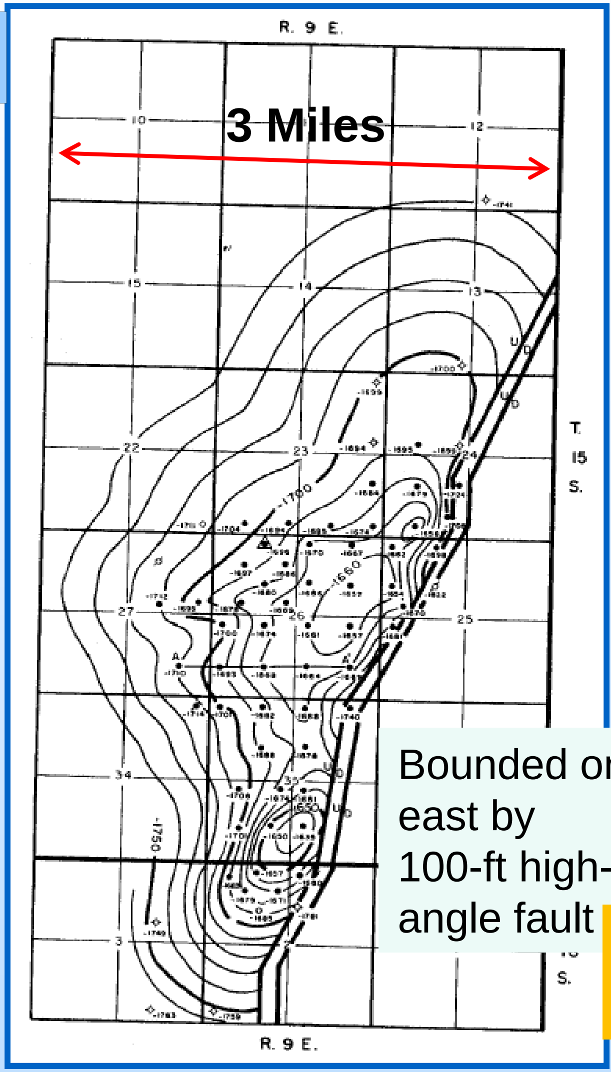


- Davis Ranch and John Creek
- Largest oil fields in the area
- Close proximity to Jeffrey
- Combined they may be capable of storing 50+Mt CO2

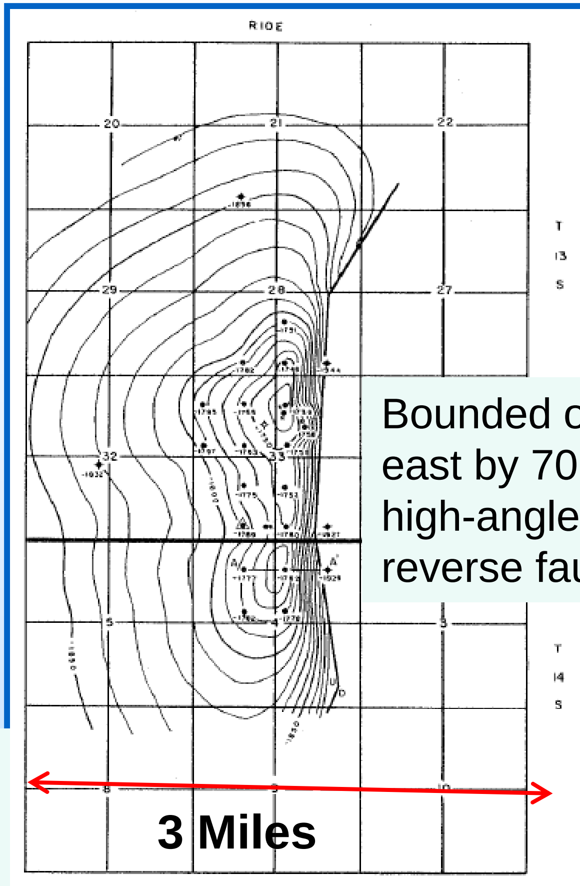
John Creek Davis Ranch

	John Creek	Davis Ranch
Discovered	1953	1949
Prod (mmbo)	10.3	9.1
Closure h (ft)	120	140
Prod Zone	Vi 3050'	Vi 3150'
CO2 Inj Zone	Sp 3150'	Sp 3250'
	Arb 3250'	Arb 3350'
Reservoir P	1200 psi	1200 psi
Storage Cap.	30 Mt	20 Mt

Vi - Viola
Sp -Simpson
Arb - Arbuckle



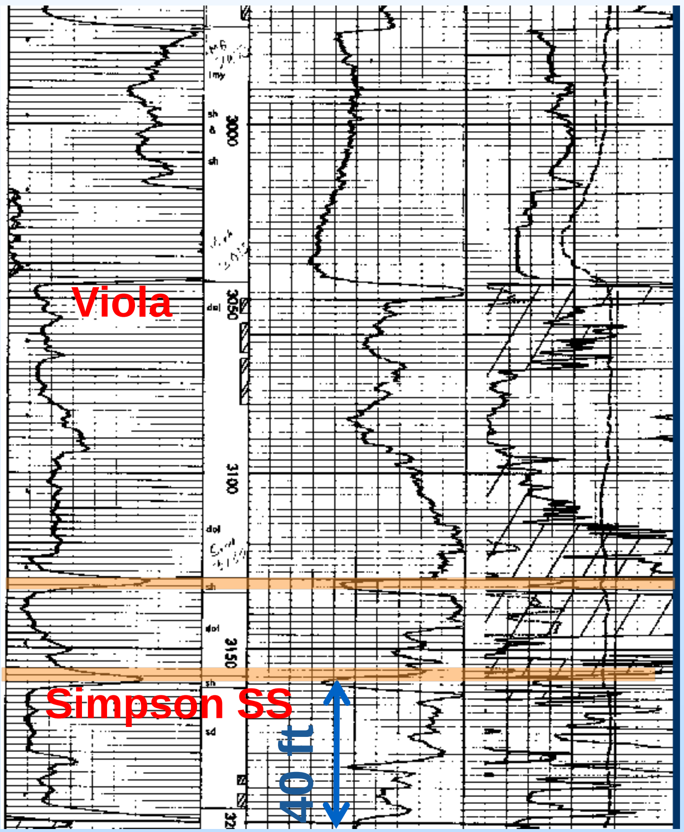
Bounded on east by 100-ft high-angle fault

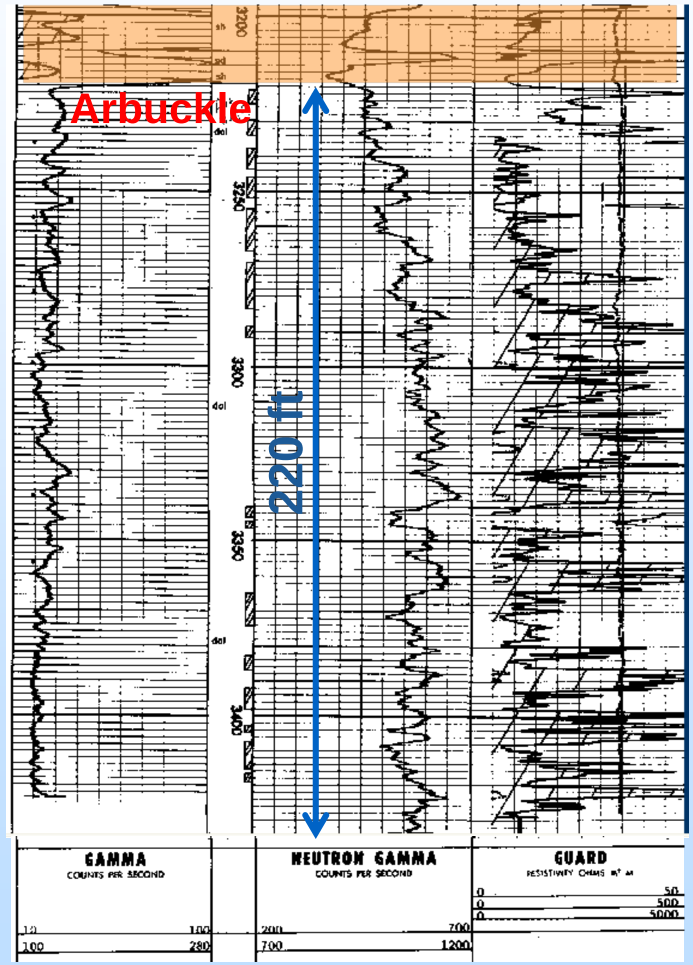


Bounded on east by 70 ft high-angle reverse fault

Viola Structure Maps CI=10ft
KGSociety Fields Volume 3

Key well in John Creek
Holaday #2 SWDW in the Arbuckle

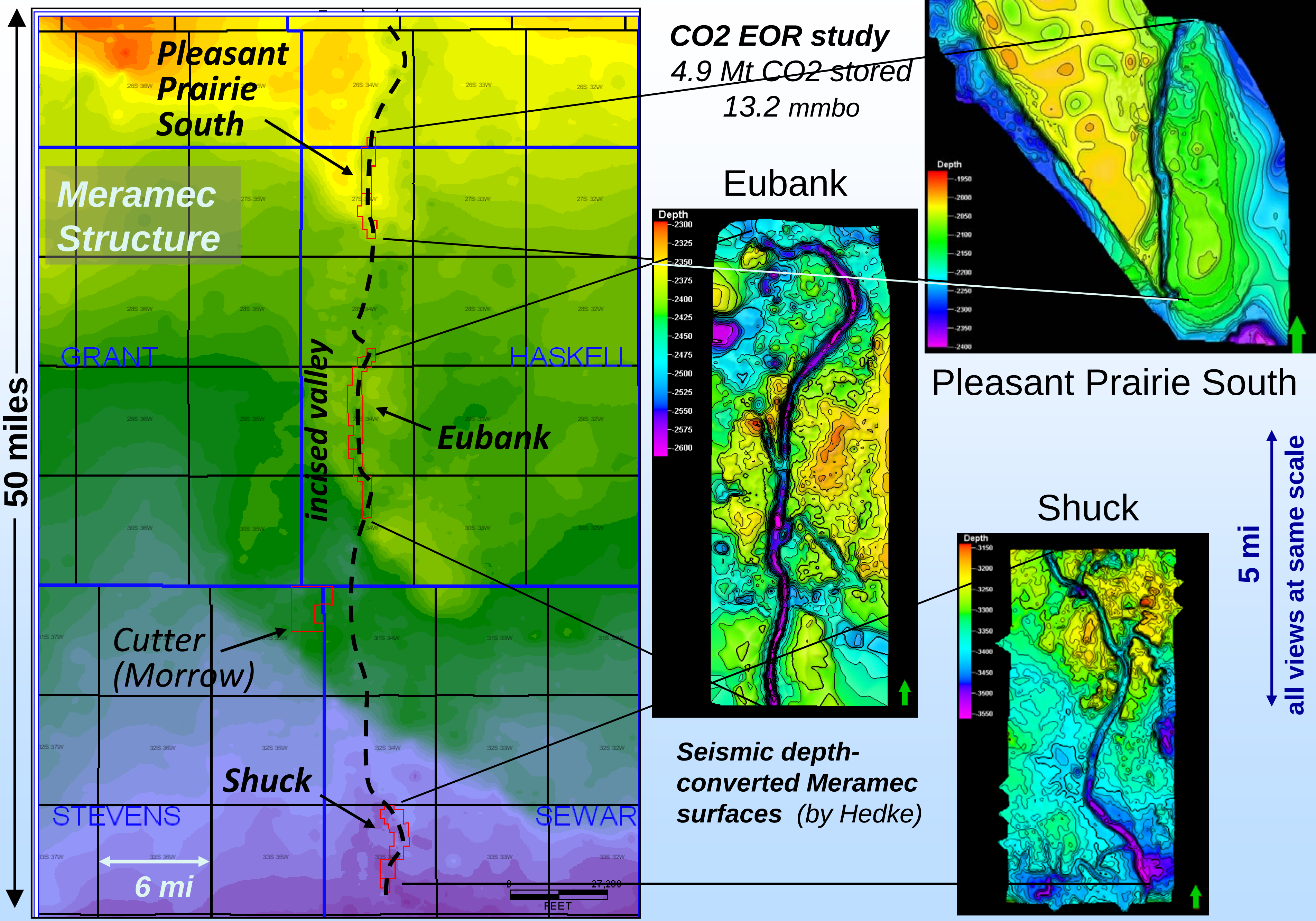




<u>Data is limited in FCB fields</u>

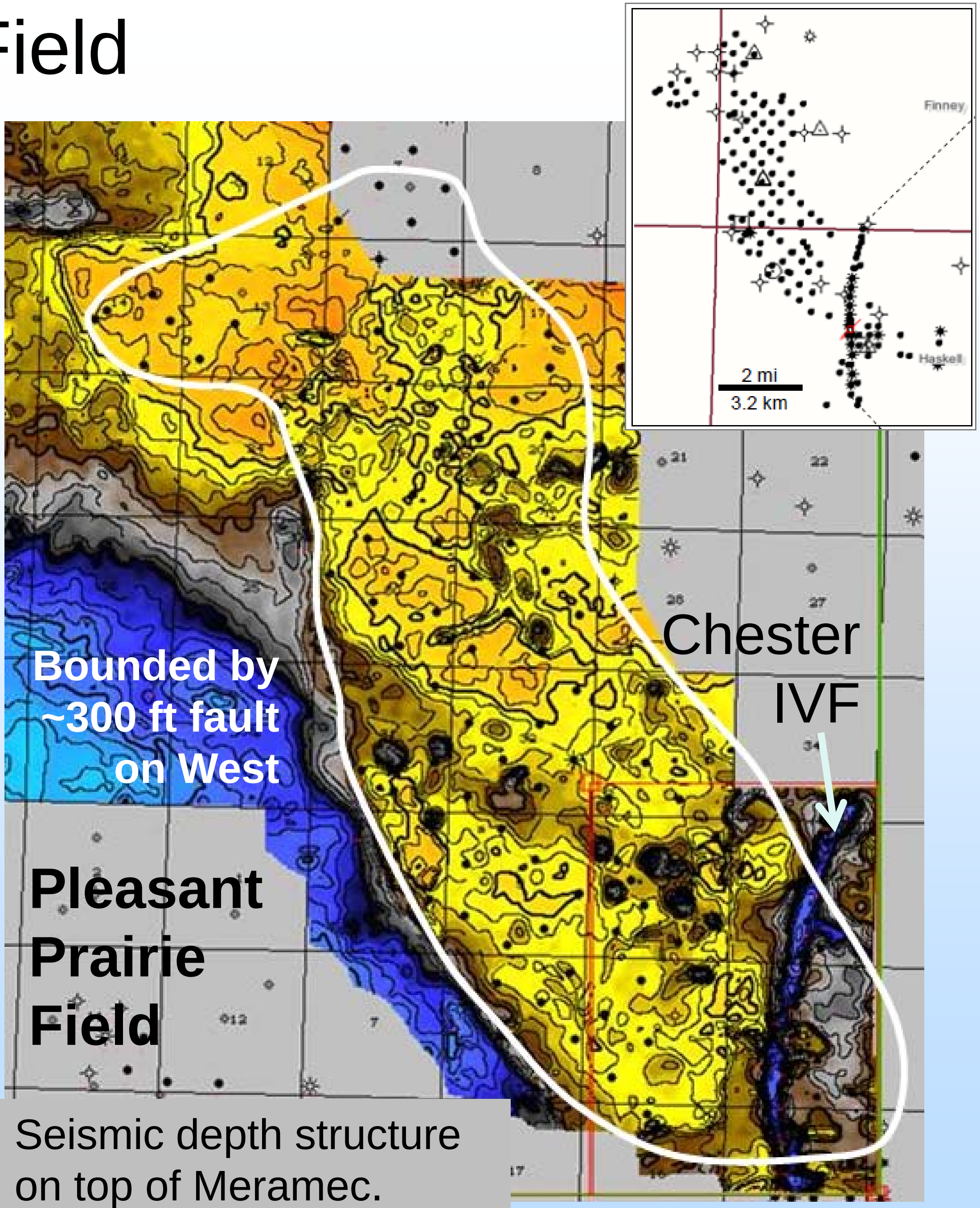
- Few modern logs
- Very few Arbuckle penetrations
- No core data
- Minimal pressure data
- No 3D seismic
- Will need to collect additional data in later phases

SW Annex of DE-FE2056



Pleasant Prairie Field

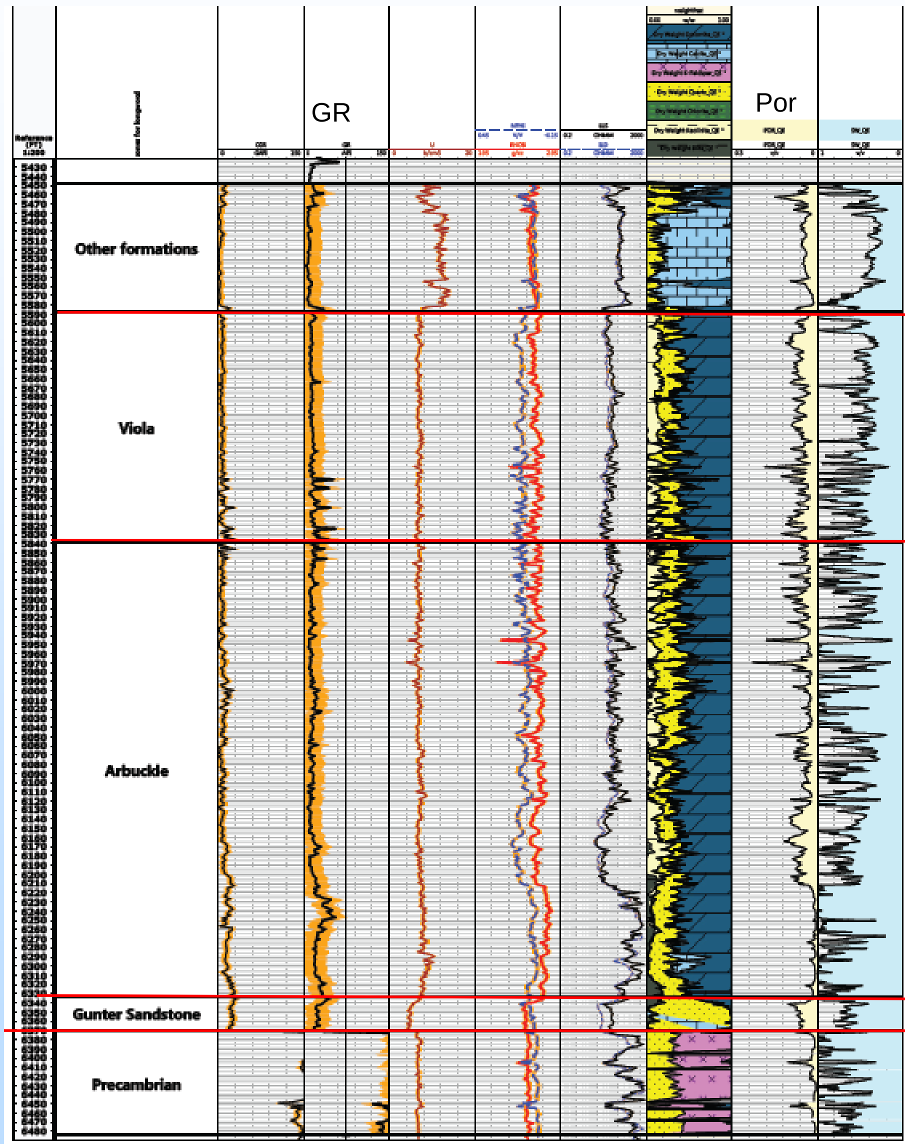
- Discovered 1954
- Cumulative: 34.9 mmbo, 2.6 BCF
- Multizone; primarily Miss. Meramec and Chester
- 18.5 mi^2 closure, faulted on the west
- Operated by Casillas Petroleum
- Target storage zones: Viola – 5800-6000’ and Arbuckle – 6000-6800’
- BHP 2100psi, BHT 125
- Preliminary storage capacity estimate = 170 Mt



Seismic depth structure on top of Meramec. Dubois et al, 2015

Pleasant Prairie area well

Longwood 2 well



- Very few Arbuckle penetrations but with modern logs
- 3D seismic coverage
- Core: KGS Cutter #1

Preliminary petrophysical work by Mina Fazelalavi

Methodology - High-level technical analysis of suitable geologic complexes

Reservoir seals
Characterize primary and secondary seals (NRAP's NSealR)

3D cellular geologic model
Utilize existing well and engineering data, 3D seismic, to build cellular static models (Petrel)

Fault reactivation induced seismicity
Map faults, characterize stress, fault slip and dilation tendency analysis (NRAP's STSF)

Reservoir simulation model
Import cellular static models for simulating injecting and storing 50Mt. With GEM compositional simulator analyze capacity, injection rates, and pressure constrained by reservoir seal, fault and seismicity risk and wellbore risk studies. Compare with NRAP's REV

Wellbore risk
Evaluate existing and plugged well construction, plugging records, and estimate risk. (NRAP's WLAT)

Utilize NRAP's DREAM for design risk
and IAM-CS for accessing the integrated CCS project

Methodology – Task 5: High level technical CO_2 source assessment for capture.

1. **Review sources for suitability**
    - Confirm volumes and conditions with operators

2. **Collaborate with source operators**
    - Site visits for establishing relationships, evaluating siting, optimization
    - Minimize existing plant operations disruption

3. **Determine capture technology**
    - Coal-fired power - newer generation of amine (solvent-based) capture
    - Hydrogen reformers – post-combustion solvent-based *or* sorbent-based (pressure or vacuum swing adsorption) capture from syngas or purge gas

4. **Determine optimization opportunities**
    - Coal-fired power - Reduce parasitic load. Multiple waste-heat sources targeted for steam generation for solvent regeneration
    - Hydrogen reformers - Combine with expansion of refinery steam generation to gain efficiencies

5. **Preliminary engineering design**
    - Design for optimal scenario: economics and CO_2 capture
    - Optimize for overall most cost effective for capture and existing operations

Site visits on Feb 15 in conjunction with ICKan kick-off meeting

Power plant capacity:

– 3 x 800 MWe power plants located in St. Marys, KS with a total nameplate annual CO_2 emissions of 12.5 million tonnes.

Capture opportunity:

– Partial CO_2 capture (~350 MWe flue gas) can satisfy the entire ICKan CO_2 ICCS 50Mt+ over a 20 years project period

Optimization opportunities for capturing waste heat identified

Steam Methane Reformer H_2 plant capacities:

– Two ~40,000 Nm3/hr PSA (Pressure swing adsorption) H_2 plants

– SMR furnace flue gases ~760,000 Tonnes/year. (30% of the ICKan CO2 ICCS needs)

Capture opportunity:

– Solvent based post-combustion capture from the reformer furnace flue gas would maximize CO_2 emissions reduction (~90% of total emissions).

Optimization opportunities for efficiency gains through centralized steam generation possible.

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Methodology – Task 6: High level technical assessment for CO_2 transportation

1. Review current technology and research/studies on large-scale CO_2 pipeline systems
2. Consider variety of business model options
   - Single point to point
   - Multiple points to single point
   - Inclusion of an ethanol CO_2 gathering system in middle Midwest
3. Cost analysis and economic modeling
   - Utilize FE/NETL Transport Cost Model (Morgan and Grant)
   - Modify for local conditions

Economics – *from paper studies*

Estimated costs to capture, compress, transport CO2

- $50-60/tonne from coal-fired power
- $38/tonne from ethanol plants

Costs per Tonne		Mohan etal (2008)	NEORI (2012)	Linde (today)	*Proprietary Study (2008)
CAPTURE	Coal-fired power	$51	$50	$40	
CAPTURE	Refineries	$45			
CAPTURE	Ethanol	$9	$28		$26
TRANSPORTATION (Pipeline)			$10		$13

Mid -case for Mohan etal (2008) and NEORI (2012)

** Proprietary Study (2008): 3.4 MT/yr from 14 ethanol plants ,470 miles of pipeline*

ICKan: Economic analysis of integrated project

1. Capture and compression: develop in-house model
2. Transportation: FE/NETL Transport Cost Model (Morgan and Grant)
3. Storage site preparation and operations: consider FE/NETL Saline Storage Cost Model (Grant and Morgan)

Expected Outcomes

Outcome	Results
Comprehensive development and implementation plan encompassing technical requirements, economic feasibility and public acceptance of an eventual CCS project	Detailed injection, storage, and monitoring plan. Legal regulatory and public policy challenges identified and plan prepared for addressing the challenges.
Formation of a CCS team to address technical and non-technical challenges for commercial-scale deployment of a CO2 storage project	Expand Phase I research team and partners/stakeholders for CarbonSAFE Phase II, Storage Complex Feasibility, DE-FOA-0001450
High-level technical **evaluation of sub-basin geologic sites**	Identification of geologic sites likely to be capable of safely storing 50Mt+ CO2
High-level technical **evaluation CO2 sources and transportation**	Technical evaluations for CO2 capture from a coal-fired power plant and refinery hydrogen reformers optimized for economics. Economic analysis of transportation scenarios to reduce CO2 transportation for CCS.

Expected Outcomes - Products

Product	Utility for CCS community
Economic model for Carbon Capture from flue gas from a **retrofitted coal-fired power plant**	Augment, validate and/or improve upon other similar studies of large-scale projects
Economic model for Carbon Capture from **retrofitted hydrogen reformers**	Augment, validate and/or improve upon other similar studies
Data sets, results of **analyses using NRAP tools** (REV, NRAP-IAM-CS, NSealR, WLAT, DREAM), and comparison with traditional tools	Test cases for the NRAP tools for validation and/or improvements and modifications
Data set and results from project pipeline economic **analysis using FE/NETL Transport Cost Model** (Morgan and Grant)	Test case for the modeling tool and, potentially, useful modifications and enhancements
Comprehensive economic analysis for **CO2 capture and transportation system for Midwest ethanol plant**	Though discussed in many "whitepapers" and the subject of private engineering studies, few rigorous analyses are available to the public

Organization: Phase I Research Team

18 team members, four subcontractors and KGS staff

Project Management & Coordination, Geological Characterization

Kansas Geological Survey
University of Kansas
Lawrence, KS

Tandis Bidgoli, PI, Assistant Scientist
Lynn Watney, Senior Scientific Fellow
Eugene Holubnyak, Research Scientist
K. David Newell, Associate Scientist
John Doveton, Senior Scientific Fellow
Susan Stover, Outreach Manager
Mina FazelAlavi, Engineering Research Asst.
John Victorine, Research Asst., Programming
Jennifer Hollenbah - CO2 Programs Manager

Improved Hydrocarbon Recovery, LLC
Lawrence, KS

Martin Dubois, Joint-PI, Project Manager

CO2 Source Assessments, Capture & Transportation, Economic Feasibility

Linde Group (Americas Division)
Houston, TX

Krish Krishnamurthy, Head of Group R&D
Kevin Watts, Dir. O&G Business Development

Energy, Environmental, Regulatory, & Business Law & Contracts

Depew Gillen Rathbun & McInteer, LC
Wichita, KS

Christopher Steincamp, Attorney at Law
Joseph Schremmer - Attorney at Law

Policy Analysis, Public Outreach & Acceptance

Great Plains Institute
Minneapolis, MN

Brendan Jordan, Vice President
Brad Crabtree, V.P. Fossil Energy
Jennifer Christensen, Senior Associate
Dane McFarlane, Senior Research Analysist

Organization: Phase I Industry Partners

Four CO_2 Sources

CO2 Sources
Westar Energy
Brad Loveless, Exec. Director Environ. Services
Dan Wilkus, Director - Air Programs
Mark Gettys, Business Manager
Kansas City Board of Public Utilities
Ingrid Seltzer, Director of Environmental Services
Sunflower Electric Power Corporation
Clare Gustin, V.P. Member Services & Ext. Affairs
CHS, Inc. (McPherson Refinery)
Richard K. Leicht, Vice President of Refining
Rick Johnson, Vice President of Refining

Regulatory
Kansas Department of Health & Environment
Division of Environment
John W. Mitchell, Director
Bureau of Air
John W. Mitchell, Director

Five Oil Gas Companies

Kansas Oil & Gas Operators
Blake Production Company, Inc.
(Davis Ranch and John Creek fields)
Austin Vernon, Vice President
Knighton Oil Company, Inc.
(John Creek Field)
Earl M. Knighton, Jr., President
Casillas Petroleum Corp.
(Pleasant Prairie Field)
Chris K. Carson, V.P. Geology and Exploration
Berexco, LLC
(Wellington, Cutter, and other O&G fields)
Dana Wreath, Vice President
Stroke of Luck Energy & Exploration, LLC
(Leach & Newberry fields)
Ken Walker, Operator

Communication Plan

- **Periodic scheduled meetings**
  - Monthly team meetings
  - Quarterly all-teams meeting
  - Biannual all-hands meetings (teams + participants)
- **Communicate project status**, confirm schedule, and reiterate upcoming deliverables.
- Ensure data and information are appropriately collected, integrated, modeled, and simulated
- Ensure decisions that critically impact the project are made in informed fashion and will meet the short- and long-term project goals.
- **Communicate regularly with the DOE Project Manager**

Task 1: Project Management and Planning Integrated CCS for Kansas (ICKan)

Subtask		Description	Comment
1.1	Fulfill requirements for NEPA		Completed
1.2	**Conduct ICKan project kick-off meeting**	CCS team and 7 industry partners. Acquainted with project/tasks and each other.	**2/14 Attended by 32 individuals . Site visits 2/15**
1.3	**Regularly scheduled meetings and update tracking**	Scheduled meetings: Team - monthly; Subteam - set by subteam; "All hands" - quarterly	
1.4	Monitor/control scope	PIs review monthly, aided by monthly and quarterly meetings. Add risk/mitigation as identified	Additional risks identified in ICKan kick-off meeting
1.5	Monitor/control schedule		
1.6	Monitor/control risk		
1.7	Maintain/revise DMP	Data to NETL-EDX	
1.8	Revisions to the PMP		Completed in negotiation period
1.9	Submit quarterly and other reports	Reports and auditing prescribed by Federal Assistance Reporting Checklist	
1.10	**Develop integrated strategy for commercial-scale CCS**	Build on and modify initial strategy throughout project life	

ICKan Kick-off Meeting, Feb 14

“All-Hands” meeting to jump-start the project

- 31 participants in day-long meeting
  - o 7 industry partners – sources and storage sites
  - o All four 4 research team subcontractors
  - o KGS staff
- Comprehensive review, breakout work sessions
- Source site visits on second day

One of the more interesting discussions

Significant reductions in coal-fired power generation

- Westar and KCBPU are down to 52% carbon-fueled power generation
- Westar wind is ~33% exceeding Kansas 2009 mandate for 20% from renewables by 2020.
- Southwest Power Pool set a record 52% of energy from wind on February 12

Tasks 2 and 3

Subtask		Description	Comment
Establish a Carbon Capture and Storage (CCS) Coordination Team			
2.1-3	**Identify and recruit additional team members and stakeholders**	***Expand team to cover gaps in CCS coordination team required for Phase II.***	Additional team member disciplines and stakeholders were identified by Phase I CCS team in kick-off meeting
2.4	Meeting for Phase I team and recruited Phase II team members and stakeholders		

Develop a plan to address challenges of a commercial-scale CCS Project

Identify challenges to CCS and develop a plan to address them

3.1	Capture from anthropogenic sources	***Work with project's CO2 sources and oil industry partners to identify technical and legal, regulatory and policy issues and develop plans to address them (in concert with Tasks 4, 5, and 6)***	Initial discussions with CO2 sources in kick-off meeting (2/14) and site tours (2/15).
3.2	Transportation and injection of CO2		
3.3	CO2 storage in geologic complexes		Initial discussions with oil operators in kick-off meeting (2/14).

Tasks 4 and 5

Subtask			Description	Comment
Perform a high-level technical sub-basinal evaluation				
4.1	**Review storage capacity** of geologic complexes and consider alternatives		**Confirm storage capacity and if <50Mt consider alternatives**	
4.2	High-level **technical analysis of geologic complexes**		Use traditional methods and tools to analyze capacity, and injection rates, constrained by seal and fault limits	
4.3	**Compare NRAP tools with traditional methods**		Using same data set utilize NRAP tools and compare results	
4.4	Develop an **implementation plan and strategy**		Constrained by seal breech and seismicity risk, develop an implementation plan	
Perform a high-level technical CO2 source assessment for capture				
5.1	Review current technologies and selected CO2 sources for suitability		**Collect and analyze data** from sources and determine best technology	**Site visits on 2/15** - data collection; define and discuss optimization options with source staffs
5.2.	Determine novel technologies or approaches for CO2 capture		**Define and evaluate optimization options**	
5.3	Develop an implementation plan and strategy		In collaboration with sources **develop plan for optimal capture**	

Tasks 6 and 7

Subtask			Description	Comment
Perform a high-level technical assessment for CO2 transportation				
6.1	Review current technologies		Current technologies: compression to supercritical and pipeline transportation are best option.	
6.2	Consider novel technologies or approaches		Novel approaches could reduce costs: **Economies of scale and tariffs** from transporting ethanol CO2. **Existing ROWs**.	
6.3	Develop a plan for cost-efficient and secure infrastructure		**Sensitivity studies involving scaling, financial and business options**	
Technology Transfer				
7.1	**Maintain website on KGS server**		Public side for dissemination of public data and reports. Private side to facilitate data exchange within the team.	***http://www.kgs.ku.edu/PRS/ICKan/index.html***
7.2	**Public presentations**		Periodic public presentations to variety of audiences to promote awareness, public acceptance, and industry interest	
7.3	**Publications**		Contribute to the growing body of CCS knowledge with peer-reviewed publications	

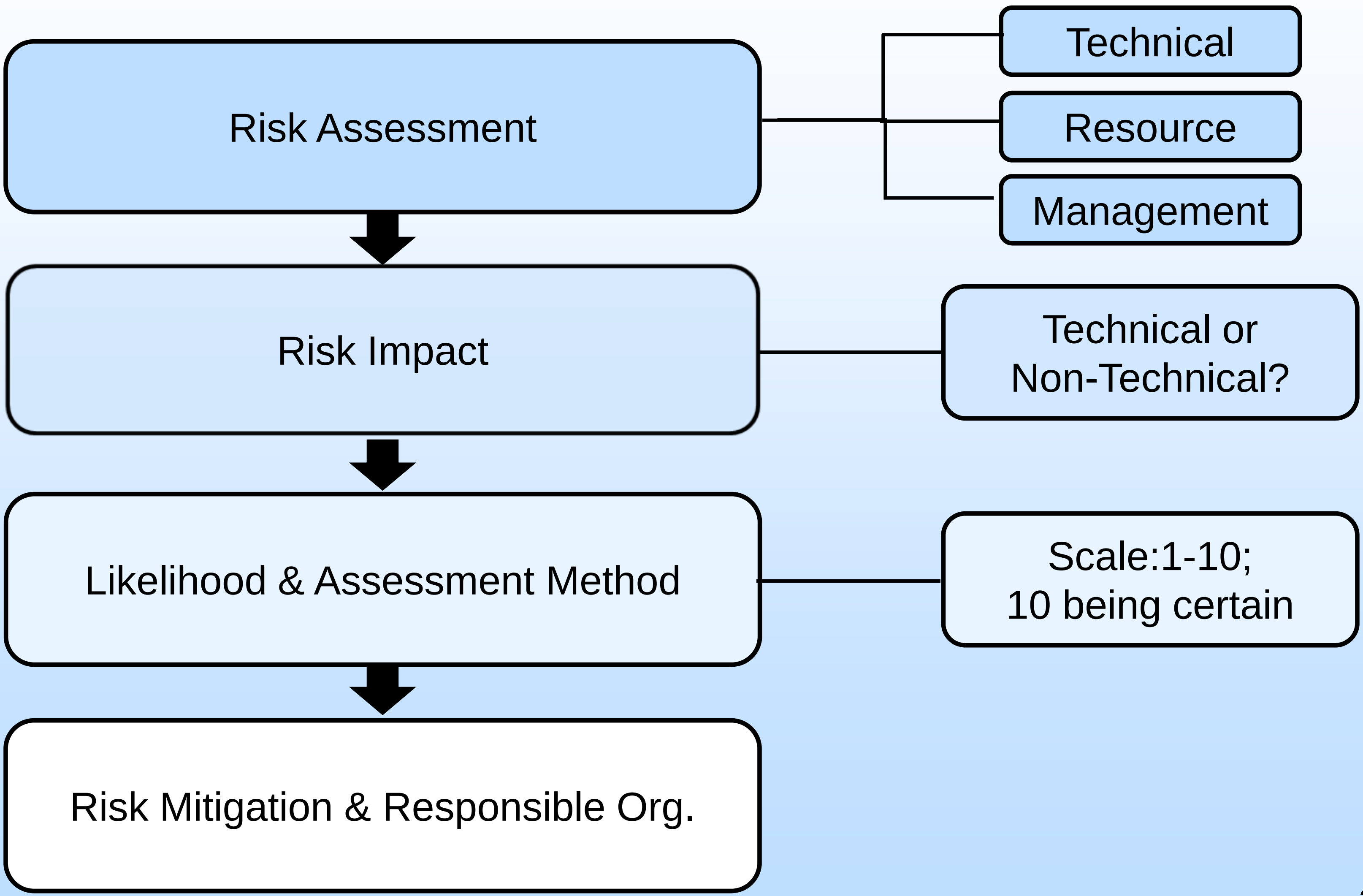
Milestones, Timeline and Criteria

Milestone	Completion Date	Verification
Finalize Project Management Plan	1/31/2017	Filed with DOE
ICKan project kickoff meeting	1/31/2017	Attendance roster and related files
Integrated strategy for commercial scale CCS	6/30/2018	Filed with the DOE
Application to DOE for Phase II	11/30/2017	Filed with the DOE (not part of Phase I)
Establish full CCS Coordination Team	10/31/2017	File with commitment letters with DOE
Meeting between Phase I and committed Phase II	10/31/2017	Attendance roster and related files

Deliverables and Relevance

Deliverable	Description	Relevance
Report: **Integrated Strategy** for Commercial-Scale CCS Project	Comprehensive strategy for integration of technical and non-technical components	Phase I Goal
Commitment letters from fully-formed CCS Coordination Team	Commitment to participate in Phase II study	Phase I Goal
Report: **Plan to Address Challenges** for Commercial-Scale CCS	Defined challenges and detailed plans to efficiently address them	Phase I Goal
Report: High-Level **Sub-Basinal Evaluations**	Identify and evaluate sites capable of safely storing >50Mt CO_2	Phase I Goal
Report: High-Level CO_2 **Source Assessment for Capture**	Characterize sources capable of supplying >50Mt CO_2 and develop preliminary engineering design for	Phase I Goal
Report: High-Level Assessment for **CO_2 Transportation**	Economic analysis of business and transportation scenarios to reduce CO_2 transportation for CCS	Phase I Goal

Risk Matrix


Risk Assessment
Technical
Resource
Management
Risk Impact
Technical or
Non-Technical?
Likelihood & Assessment Method
Scale:1-10;
10 being certain
Risk Mitigation & Responsible Org.

Risk Matrix

Phase 1: Prefeasibility

Risk	Impact	Likelihood	Mitigation	Organization
Technical Risks				
Building & Maintaining CCS Team	Unable to form team	1	Foster public acceptance	KGS, IHR, GPI
Political climate prevents participation				
High cost limits participants				
Injection-induced seismicity & public acceptance				
KCP&L acquisition of Westar	Loss of CO_2 source	3	Evaluate other CO_2 sources	KGS, IHR
Resource Risks				
Personnel changes or overcommitments	Delay in schedule	3	Skill overlaps among team	KGS
Management Risks				
Conflicts between participants	Delay in schedule	1	History of collaboration	KGS, IHR

Risk Matrix

Phase II: Storage Complex Feasibility

Non-technical risks:

- **Economic risks** (i.e., high cost or feasibility of project)
- Gaining **public acceptance**
- Legal aspects of **pore space** and **long-term liability**
- **Site access** issues for field work
- **Obtaining permits** (federal and state) and right-of-ways
- Schedule and **cost overruns**

Technical risks:

- Long-term **viability of coal-fired CO2 sources**
- Adequacy of the site characterization
- **Class VI** permit
- Drilling and installation of wellbore and other instrumentation
- **CO2 leakage risks**
- **Injection-induced earthquakes**
- Detecting & locating CO2

Proposed Schedule

		2017												2018					
Task	**Task Name**	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Task 1.0	**Project Management & Planning Integrated CCS for Kansas (ICKan)**																		
Subtask 1.1	Fulfill requirements for National Environmental Policy Act (NEPA																		
Subtask 1.2	Conduct a kick-off meeting to set expectations																		
Subtask 1.3	Conduct regularly scheduled meetings and update tracking																		
Subtask 1.4	Monitor and control project scope																		
Subtask 1.5	Monitor and control project schedule																		
Subtask 1.6	Monitor and control project risk																		
Subtask 1.7	Maintain and revise the Data Management Plan including submital of data to NETL-EDX																		
Subtask 1.8	Revisions to the Project Management Plan after submission																		
Task 2.0	**Establish a Carbon Capture & Storage (CCS) Coordination Team**																		
Subtask 2.1	Identify additional CCS team members																		
Subtask 2.2	Identify additional stakeholders that should be added to the CCS team																		
Subtask 2.3	Recruit & gain commitment of additional CCS team members identified																		
Subtask 2.4	Conduct a formal meeting that includes Phase I team & committed Phase II team members																		
Task 3.0	**Develop a plan to address challenges of a commercial-scale CCS Project**																		
Subtask 3.1	Identify challenges & develop a plan to address challenges for CO2 capture from anthropogenic sources																		
Subtask 3.2	Identify challenges & develop a plan to address challenges for CO2 transportation & injection																		
Subtask 3.3	Identify challenges & develop a plan to address challenges for CO2 storage in geologic complexes																		
Task 4.0	**Perform high level sub-basinal evaluations using NRAP & related DOE tools**																		
Subtask 4.1	Review storage capacity of geologic complexes identified in this proposal & consider alternatives																		
Subtask 4.2	Conduct high-level technical analysis of suitable geologic complexes using NRAP-IAM-CS & other tools for integrated assessment																		
Subtask 4.3	Compare results using NRAP with methods used in prior DOE contracts including regional & subbasin CO2 storage & Class VI permit																		
Subtask 4.4	Develop an implementation plan & strategy for commercial-scale, safe & effective CO2 storage																		
Task 5.0	**Perform a high level technical CO2 source assessment for capture**																		
Subtask 5.1	Review current technologies & CO2 sources of team members & nearby sources using NATCARB, Global CO2 Storage Portal, & KDM																		
Subtask 5.2.	Determine novel technologies or approaches for CO2 capture																		
Subtask 5.3	Develop an implementation plan & strategy for cost effective & reliable carbon capture																		
Task 6.0	**Perform a high level technical assessment for CO2 transportation**																		
Subtask 6.1	Review current technologies or CO2 transportation																		
Subtask 6.2	Determine novel technologies or approaches for CO2 capture																		
Subtask 6.3	Develop a plan for cost-efficient & secure transportation infrastructure																		
Task 7.0	**Technology Transfer**																		
Subtask 7.1	Maintain website on KGS server to facilitate effective & efficient interaction of the team																		
Subtask 7.2	Public presentations																		
Subtask 7.3	Publications																		

Summary

Well qualified technical and non-technical team assembled for Phase I

- Excellent industry participation - CO_2 sources and storage sites
- Off to a good start with kick-off meeting and source site visits

Phase I work will identify key challenges and risks and develop plans to address the challenges and reduce risk impacts. Key challenges and risks for CCS (from coal-fired power) include:

- Economics without incentives
- Change in administration and policy
- Seismicity and fault reactivation
- Class VI well application process
- Reliability of CO_2 supply from coal-fired power plants in 2025

Phase I team focuses:

- Source assessment - optimization of site-specific conditions
- Geologic studies - seismicity risk; storage and injection capacity
- Transportation - potential cost efficiencies in transporting ethanol CO_2
- Legal, regulatory, and public policy - issues prioritized and plans to address

Appendix: Funding Tables

Funding: Project Costs By Task

Total Proposal: 1/1/2017 - 6/30/2018			
Task	DOE	Cost Share	Total
1	160,093	9,640	169,733
2	165,482	18,436	183,918
3	209,430	30,954	240,384
4	248,407	5,260	253,667
5	80,375	10,844	91,219
6	80,375	10,844	91,219
7	242,339	211,617	453,956
Total	1,186,502	297,594	1,484,096

Funding: Project Costs By Task

		T1				T2				T3				T4			
Name	**Job Title**	MN	$	DOE	KGS	MN	$	DOE	KGS	MN	$	DOE	KGS	MN	$	DOE	KGS
Lynn Wateny	Sr. Scientist Fellow	0.12	1,563	1,563	-	0.08	969	969	-	0.12	1,563	1,563	-	0.12	1,563	1,563	-
Tandis Bidgoli	Assistant Scientist	1.30	10,004	10,004	-	0.65	4,886	4,886	-	1.30	10,004	10,004	-	1.30	10,004	10,004	-
Eugene Holubnyak	Associate Researcher	1.02	6,315	6,315	-	0.72	4,393	4,393	-	1.02	6,315	6,315	-	1.02	6,315	6,315	-
Jason Rush	Sr. Associate Researcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dave Newell	Associate Scientist	-	-	-	-	0.60	4,910	4,910	-	-	-	-	-	1.20	10,066	10,066	-
John Doveton	Sr. Scientist Fellow	-	-	-	-	1.00	5,535	5,535	-	-	-	-	-	1.75	9,894	9,894	-
John Victorine	Research Engineer	1.50	9,183	9,183	-	-	-	-	-	-	-	-	-	-	-	-	-
Mina FazelAlavi	Sr. Assistant Researcher	-	-	-	-	-	-	-	-	-	-	-	-	1.50	6,672	6,672	-
Susan Stover	Outreach Manager	1.45	9,063	6,922	2,141	0.45	2,813	672	2,141	1.45	9,063	6,922	2,141	-	-	-	-
Project Coordinator	Project Coordinator	7.00	32,175	32,175	-	4.00	18,000	18,000	-	-	-	-	-	-	-	-	-
GRA-Academic	GRA-Academic	-	-	-	-	-	-	-	-	-	-	-	-	9.00	35,474	35,474	-
GRA-Summer	GRA-Summer	-	-	-	-	-	-	-	-	-	-	-	-	1.50	5,754	5,754	-
GRA-Academic	GRA-Academic	-	-	-	-	-	-	-	-	-	-	-	-	4.50	17,262	17,262	-
GRA-Summer	GRA-Summer	-	-	-	-	-	-	-	-	-	-	-	-	1.50	5,754	5,754	-
Total Personnel		12.39	68,303	66,162	2,141	7.50	41,506	39,365	2,141	3.89	26,945	24,804	2,141	23.39	108,758	108,758	-
Fringe Benefits																	
Senior Personnel			23,906	23,157	749		12,590	11,840	749		9,431	8,681	749		13,643	13,643	-
Staff (50%-89% FTE)			-	-	-		2,214	2,214	-		-	-	-		2,214	2,214	-
GRA (75% or less) - Academic			-	-	-		-	-	-		-	-	-		1,208	1,208	-
GRA (75% or less) - Summer			-	-	-		-	-	-		-	-	-		3,289	3,289	-
Total Fringe Benefits			23,906	23,157	749		14,804	14,054	749		9,431	8,681	749		20,354	20,354	-
Total Payroll including Benefits		12.39	92,209	89,318	2,890	7.50	56,310	53,419	2,890	3.89	36,375	33,485	2,890	23.39	129,112	129,112	-
Linde Group		-	-	-	-	-	16,250	13,000	3,250	-	27,917	22,333	5,583	-	-	-	-
Great Plains Institute		-	-	-	-	-	26,496	21,197	5,299	-	55,030	44,024	11,006	-	-	-	-
Depew Gillen Rathbun & McInteer, LC (DGR&M)		-	-	-	-	-	11,375	9,100	2,275	-	23,625	18,900	4,725	-	-	-	-
Improved Hydrocarbon Recovery LLC		-	26,302	21,042	5,260	-	16,162	12,930	3,232	-	26,302	21,042	5,260	-	26,302	21,042	5,260
Total Subcontractors		0	26,302	21,042	5,260	0	70,283	56,227	14,057	0	132,874	106,299	26,575	0	26,302	21,042	5,260

Funding: Project Costs By Task

		T5				T6				T7				Total			
Name	**Job Title**	MN	$	DOE	KGS	MN	$	DOE	KGS	MN	$	DOE	KGS	MN	$	DOE	KGS
Lynn Wateny	Sr. Scientist Fellow	0.12	1,563	1,563	-	0.12	1,563	1,563	-	0.12	1,563	1,563	-	0.79	10,349	10,349	-
Tandis Bidgoli	Assistant Scientist	1.30	10,004	10,004	-	1.30	10,004	10,004	-	1.30	10,004	10,004	-	8.46	64,913	64,913	-
Eugene Holubnyak	Associate Researcher	-	-	-	-	-	-	-	-	1.02	6,315	6,315	-	4.80	29,651	29,651	-
Jason Rush	Sr. Associate Researcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dave Newell	Associate Scientist	-	-	-	-	-	-	-	-	1.20	10,066	10,066	-	3.00	25,043	25,043	-
John Doveton	Sr. Scientist Fellow	-	-	-	-	-	-	-	-	1.75	9,894	9,894	-	4.50	25,323	25,323	-
John Victorine	Research Engineer	-	-	-	-	-	-	-	-	1.50	9,183	9,183	-	3.00	18,366	18,366	-
Mina FazelAlavi	Sr. Assistant Researcher	-	-	-	-	-	-	-	-	1.50	6,672	6,672	-	3.00	13,345	13,345	-
Susan Stover	Outreach Manager	-	-	-	-	-	-	-	-	1.45	9,063	6,922	2,141	4.80	30,000	21,436	8,564
Project Coordinator	Project Coordinator	-	-	-	-	-	-	-	-	7.00	32,175	32,175	-	18.00	82,350	82,350	-
GRA-Academic	GRA-Academic	-	-	-	-	-	-	-	-	-	-	-	-	9.00	35,474	35,474	-
GRA-Summer	GRA-Summer	-	-	-	-	-	-	-	-	-	-	-	-	1.50	5,754	5,754	-
GRA-Academic	GRA-Academic	-	-	-	-	-	-	-	-	-	-	-	-	4.50	17,262	17,262	-
GRA-Summer	GRA-Summer	-	-	-	-	-	-	-	-	-	-	-	-	1.50	5,754	5,754	-
Total Personnel		1.42	11,568	11,568	-	1.42	11,568	11,568	-	16.84	94,935	92,794	2,141	66.85	363,583	355,019	8,564
Fringe Benefits																	
Senior Personnel			4,049	4,049	-		4,049	4,049	-		31,290	30,541	749		98,957	95,960	2,997
Staff (50%-89% FTE)			-	-	-		-	-	-		2,214	2,214	-		6,642	6,642	-
GRA (75% or less) - Academic			-	-	-		-	-	-		-	-	-		1,208	1,208	-
GRA (75% or less) - Summer			-	-	-		-	-	-		-	-	-		3,289	3,289	-
Total Fringe Benefits			4,049	4,049	-		4,049	4,049	-		33,504	32,755	749		110,096	107,099	2,997
Total Payroll including Benefits		1.42	15,616	15,616	-	1.42	15,616	15,616	-	16.84	128,439	125,549	2,890	66.85	473,678	462,117	11,561
Linde Group		-	27,917	22,333	5,583	-	27,917	22,333	5,583	-	-	-	-	-	100,000	80,000	20,000
Great Plains Institute		-	-	-	-	-	-	-	-	-	-	-	-	-	81,526	65,221	16,305
Depew Gillen Rathbun & McInteer, LC (DGR&M)		-	-	-	-	-	-	-	-	-	-	-	-	-	35,000	28,000	7,000
Improved Hydrocarbon Recovery LLC		-	26,302	21,042	5,260	-	26,302	21,042	5,260	-	26,302	21,042	5,260	-	173,975	139,180	34,795
Total Subcontractors		0	54,219	43,375	10,844	0	54,219	43,375	10,844	0	26,302	21,042	5,260	0	390,501	312,401	78,100

Funding: By Recipient Organization

	DOE Cost	Non-Federal Cost Share	Total
KU/KGS	$ 462,119	$ 11,562	$ 473,681
Supplies	-	-	-
Equipment	-	-	-
Other	31,082	-	31,082
Tuition	27,648	-	27,648
KU Total	520,849	11,562	532,411
Linde Group	80,000	20,000	100,000
GPI	65,221	16,305	81,526
DGR&M	28,000	7,000	35,000
IHR	139,180	34,795	173,975
F&A	353,252	5,954	359,206
Software	-	201,978	201,978
Total	$ 1,186,502	$ 297,594	$ 1,484,096

Funding: By Source & Quarter

Funding Source	Type	Total
DOE	Cash	$ 1,186,502
KU	In-kind	17,516
Linde Group	In-kind	20,000
GPI	In-kind	16,305
DGR&M	In-kind	7,000
IHR	In-kind	34,795
Schlumberger	In-kind	201,978
Total		$ 1,484,096

	2017	2018
Q1 (Jan-Mar)	$ 182,046	$ 219,966
Q2 (Apr-Jun)	200,433	219,966
Q3 (Jul-Sep)	200,433	-
Q4 (Oct-Dec)	163,659	-
Total	$ 746,570	$ 439,931

Appendix: Bibliography