Integrated Mid-Continent Stacked Carbon Storage Hub

Project Number DE-FE0029264

Andrew Duguid

Battelle

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

August 13-16, 2018

BATTELLE

Phase 1 Team

ADM

Battelle

Great Plains Energy

LANL

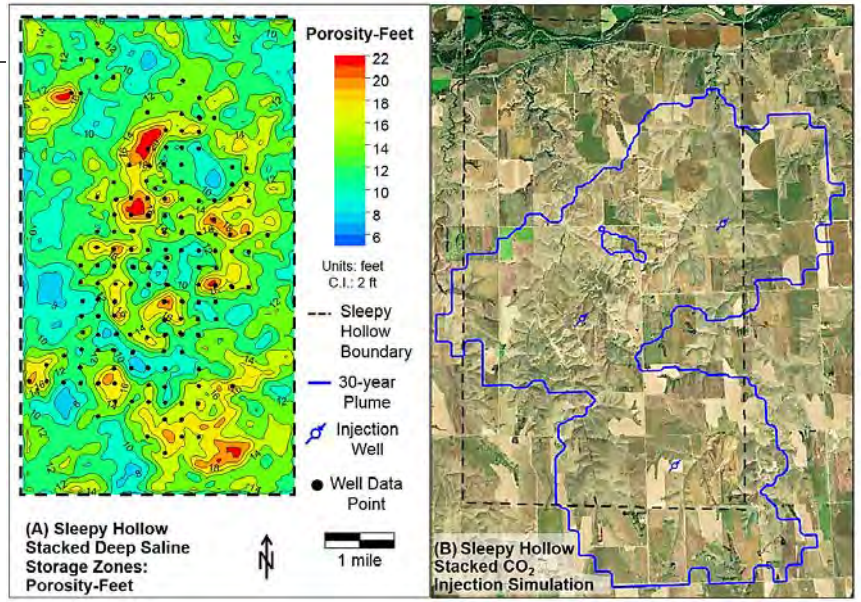
Nebraska CSD

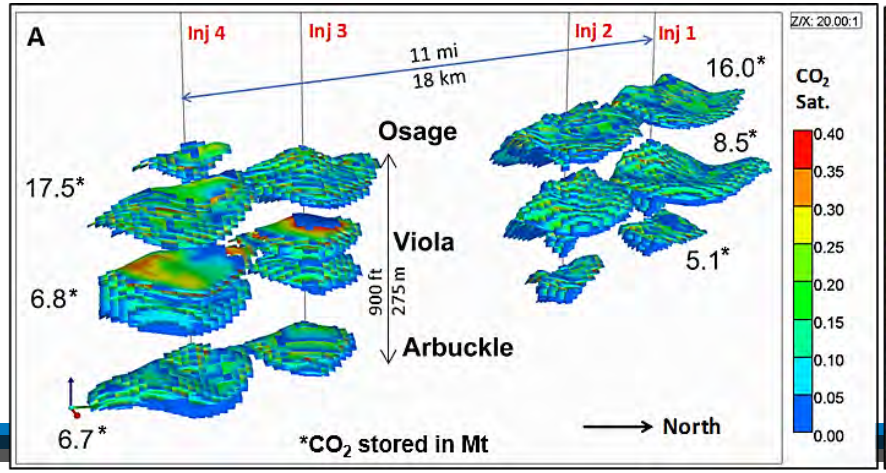
PNNL

Schlumberger (Carbon Services)

Presentation Outline

- Introduction
- Setting
- Team
- Corridors
- Capture
- Transport
- Storage
- Tasks
- Accomplishments
- Lessons Learned
- Synergy Opportunities





BATTELLE

Introduction

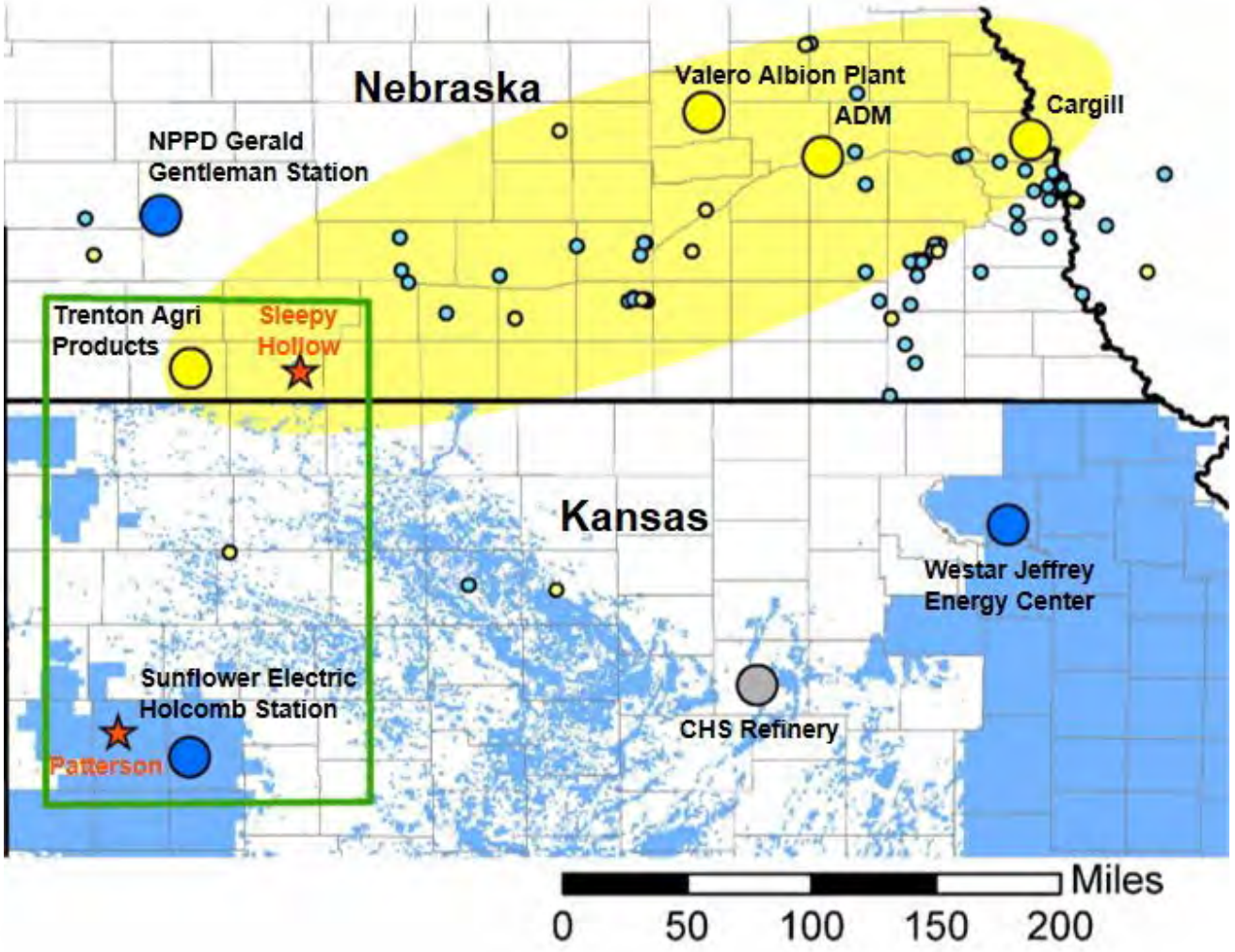
- The Integrated Midcontinent Stacked Carbon Storage Hub will gather CO_2 from eastern and central NE and transport it southwest toward Red Willow County, NE along a CO_2-source collection corridor. The CO_2 will then be piped south into central KS along a stacked storage corridor.

- Objective: Develop a midwestern carbon storage facility having multiple sites with a 50-Mt or greater capacity to safely, permanently, and economically store CO_2 by 2025.

Setting

- Nebraska and Kansas offer multiple near pure sources of CO_2 and multiple opportunities for both saline storage and storage associated with CO_2-EOR.
- The area offers a unique opportunity for early implementation of a CCS hub due to the large concentration of ethanol plants.
  - Nebraska has an ethanol production capacity of over 2 billion gallons per year which presents the opportunity to capture over 6 Mt of CO_2 from this source.
  - Implementation of CCS from ethanol production has been demonstrated by the two ADM projects in Decatur, IL.
- Nebraska and Kansas offer regionally continuous storage and caprock formations

Project Area



Legend

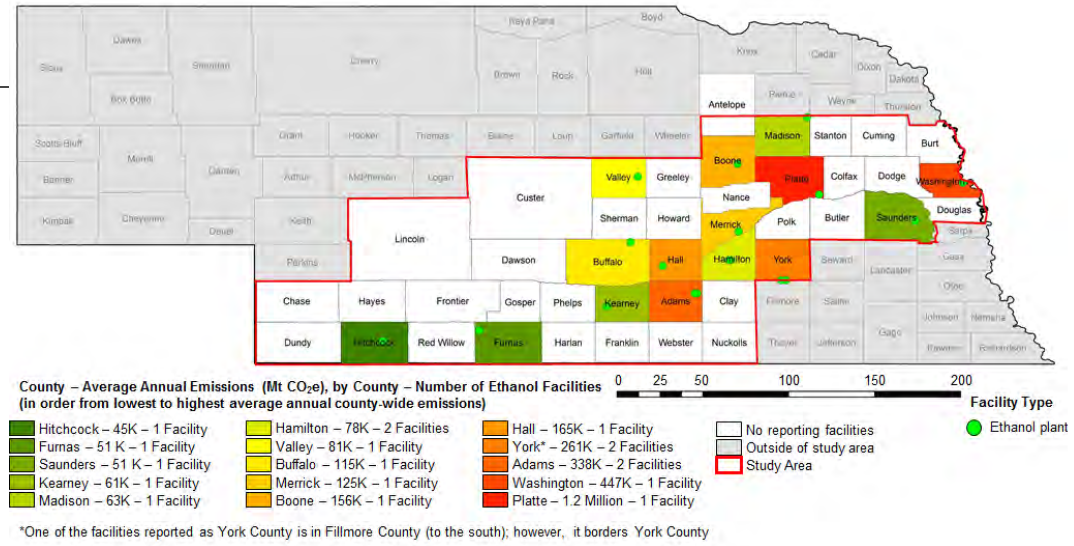
- Participating Power Plant
- Participating Ethanol Facility
- Other Participating Source
- Other Ethanol Facility
- Other Sources
- Ethanol Source Corridor
- Stacked Storage Corridor
- Study Area
- Oil Resource/Stacked Storage Resource
- State Line
- County Line

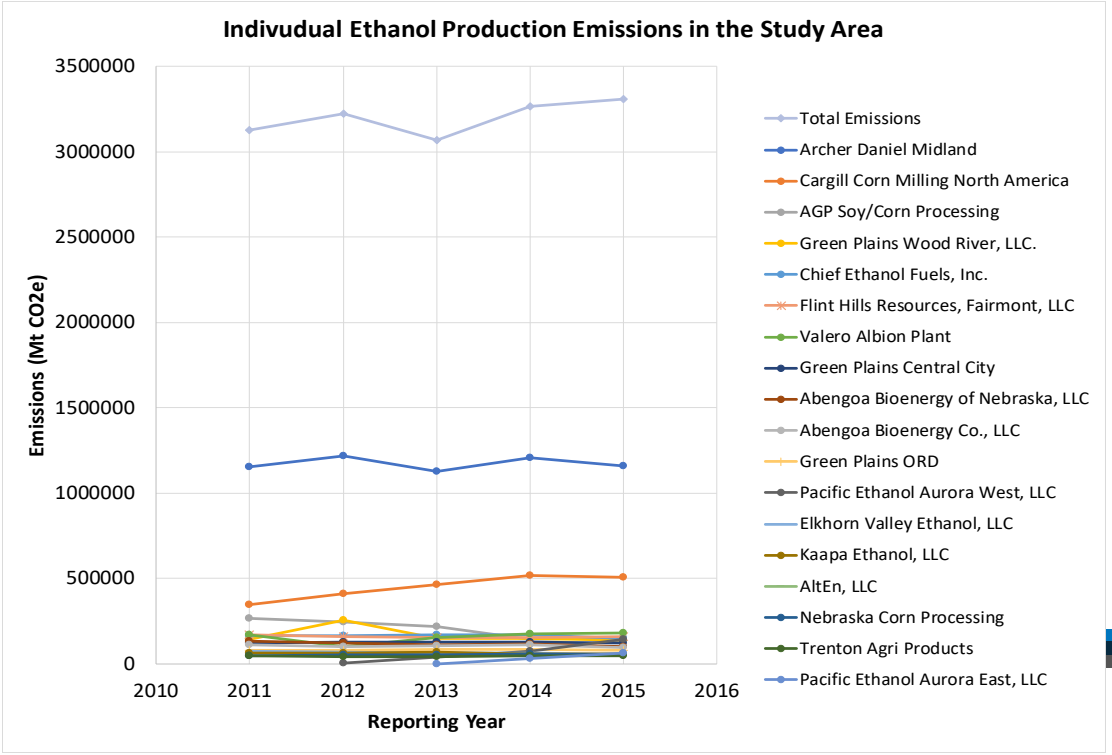
BATTELLE

Corridors

- Source Corridor (Initially Ethanol Derived CO_2)
  - Run from the Cargill ethanol plant at Blair, NE to SW NE
  - Optimize maximize the number of sources/amount of CO_2 to develop market and infrastructure for CCUS
    - 16 Ethanol plants in the corridor with annual emissions of 5 Mt
    - Bring in electric utility generated CO_2 as capture comes on line. Existing market from ethanol derived CO_2 will provide certainty that a utilization market and storage market exist for electric utilities
    - 5 other participating sources (4 electric utility and 1 refinery) with 20 Mt annual emissions
- Stacked Storage Corridor
  - Run from SW NE southeast into SW KS
    - Saline storage and CO_2 EOR
    - Co-locate infrastructure for Saline and CO_2 EOR.

Ethanol





- Ethanol plants selected based on cost of capture
  - $30/Tonne for capture and compression for ethanol (NETL 2014)
  - 57/Tonne for capture and compression for subcritical coal (NETL 2015)
- Generally a slight increase over the 2011-2015 period
- Ethanol plants throughout the source corridor

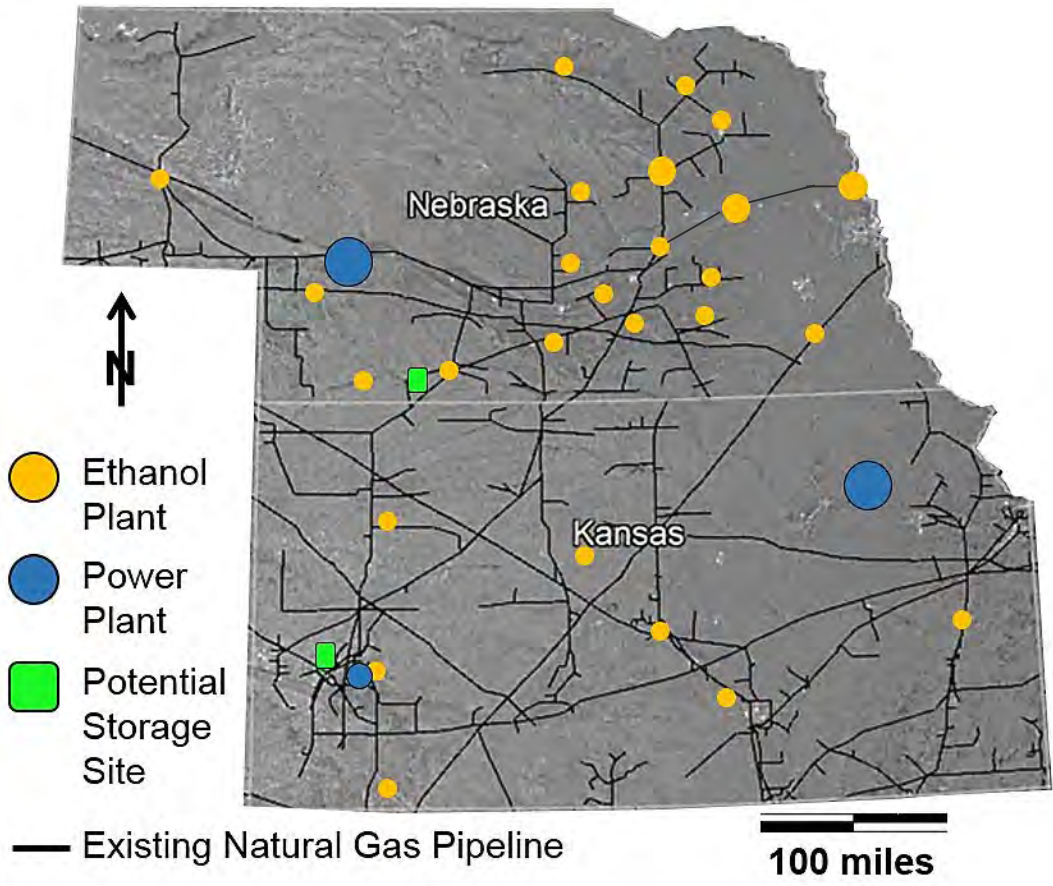
BATTELLE

Capture: CO_2 Sources

Ethanol Source	Annual CO_2 Emissions (t)	CO_2 Source	Annual CO_2 Emissions (t)
ADM	1,164,813	Holcomb Station	1,726,751
Cargill Corn Milling	592,278	Westar JEC	10,848,198
Valero Renewables	366,648	CHS Refinery	613,756
Trenton Agri Products	112,815	NPPD GGS	7,499,834
AGP Soy/Corn Processing	159,232	Kansas City Board of Public Utilities	1,184,453
Pacific Ethanol (3 plants)	1,130,968		
Green Plains (5 plants)	1,119,687		
Chief Ethanol Fuels (2 plants)	338,444		
Bridgeport Ethanol	47,856		
Total	**5,032,741**		**20,146,241**

Transport: Rights of Way

- Ethanol plants in the region use natural gas as a fuel for processing corn.
- Natural gas pipelines run to every ethanol plant in Nebraska and Kansas.
- These pipelines occur within 3 miles of each potential site in Nebraska and Kansas.



BATTELLE

Storage: Geology

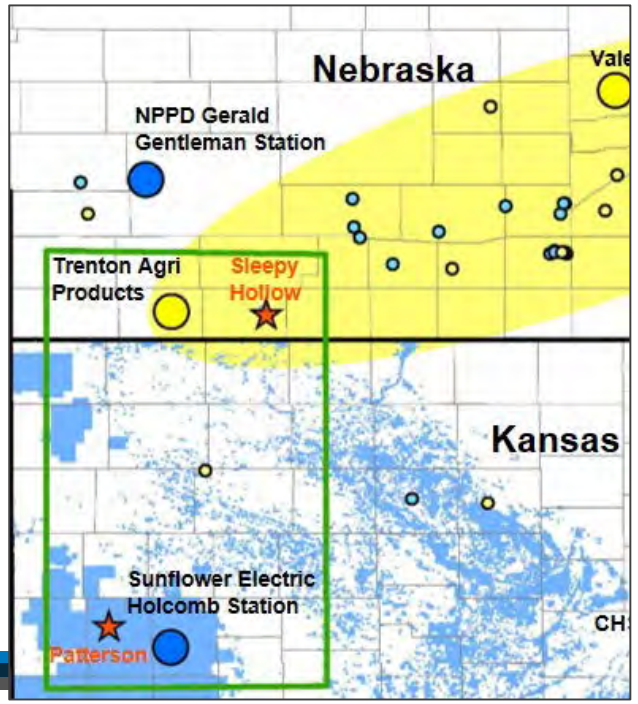
STRATIGRAPHY*

Era	Period	Southwest Nebraska		Southwest Kansas	
Paleozoic	Permian	Nippewalla	caprock	Nippewalla	caprock
		Sumner		Sumner	
		Chase	baffle	Chase	gas-bearing
	Pennsylvanian	Council Grove	caprock	Council Grove	
		Admire		Admire	baffle and deep saline
		Wabaunsee	deep saline	Wabaunsee	
		Shawnee		Shawnee	
		Douglas		Douglas	
		Lansing-Kansas City	oil-bearing	Lansing-Kansas City	oil-bearing
		Pleasanton	deep saline	Pleasanton	baffle and deep saline
		Marmaton		Marmaton	
		Cherokee		Cherokee	caprock
		basal sandstone	oil-bearing	Atoka	
				Morrow	oil-bearing
	Missippian			Chester	oil-bearing
				Meramec	baffle
				Osage	deep saline
				Kinderhook	baffle
	Devonian Silurian				
	Ordovic-ian			Viola	deep saline
				Simpson	
				Arbuckle	
	Cambrian			Reagan	bottom barrier
Precambrian		crystalline basement			

** formal lithostratigraphic group and stage names used unless otherwise noted; not to scale*

LEGEND:

- *shale + limestone*
- *shale + sandstone + limestone*
- *shale + limestone ± evaporite*
- *shale + sandstone*
- *limestone ± shale*
- *sandstone + limestone ± shale*
- *sandstone*
- *dolomite*
- *igneous and metamorphic rocks*
- *major unconformity*



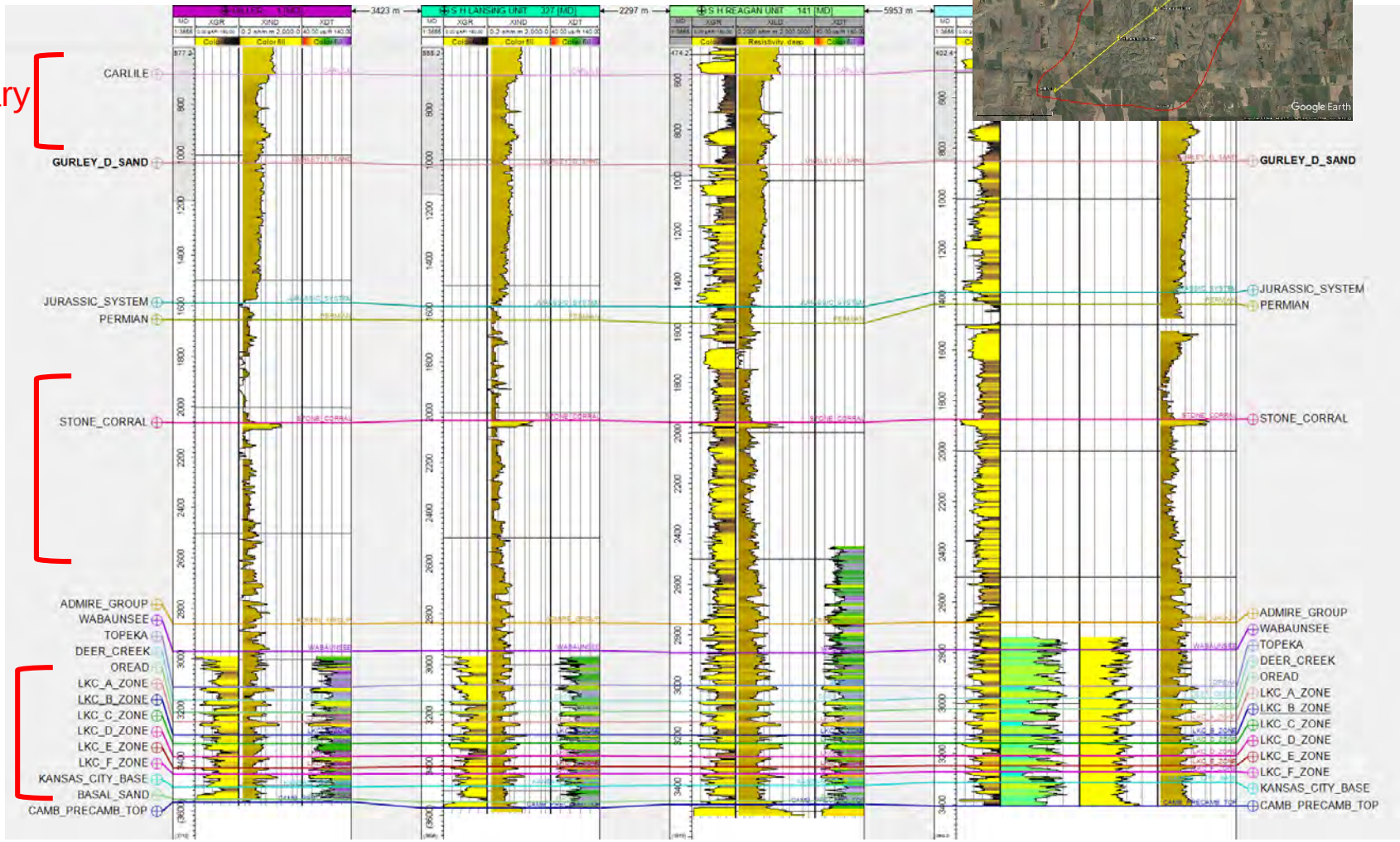
BATTELLE

Sleepy Hollow Field

Secondary Caprock

Primary Caprock

Potential Storage Zones



BATTELLE

Storage: Capacity

- The DOE-NETL volumetric methodology for deep saline formations was used to calculate the prospective storage resource of the deep saline storage zones at each potential site (DOE-NETL, 2010; Goodman et al., 2011, 2016).

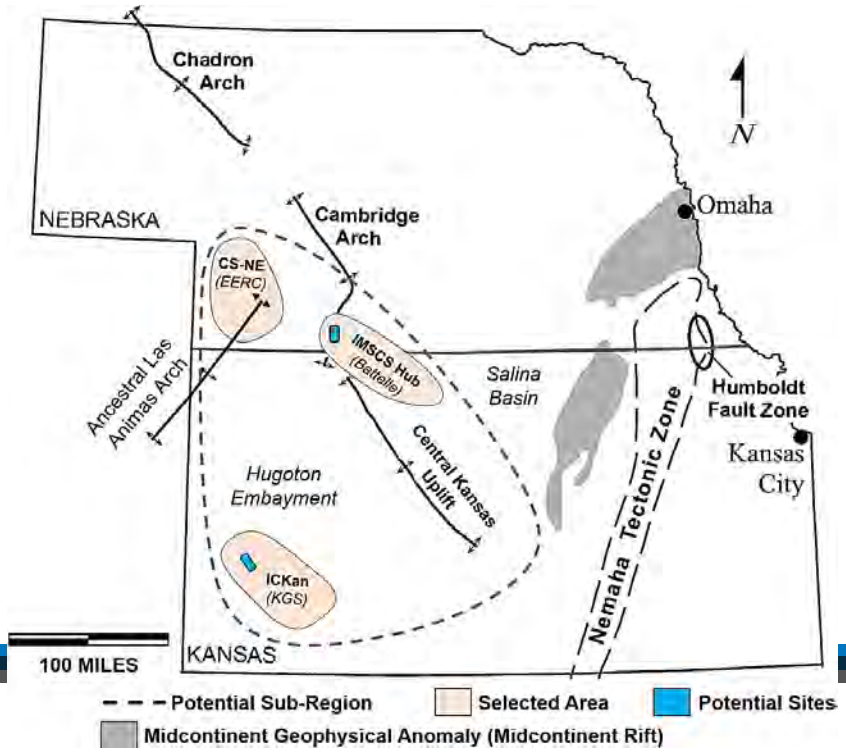
Selected Area	Deep Saline Storage Zone	Prospective Storage Resource (Mt)		
		P_{10}	P_{50}	P_{90}
SW Kansas (Patterson)	Osage	12.3	24.6	49.0
	Viola	9.9	16.7	28.1
	Arbuckle	7.8	19.2	47.5
	Total	**30.0**	**60.4**	**124.6**
SW-Central Nebraska (Sleepy Hollow)	Wabaunsee	14.0	27.7	48.9
	Topeka	5.9	11.0	17.2
	Deer Creek-Oread	5.7	11.7	23.3
	Lansing-Kansas City A	2.5	7.0	13.9
	Lansing-Kansas City D-F	16.4	25.9	37.4
	Pleasanton-Marmaton	5.2	10.7	19.0
	Total	**49.7**	**94.0**	**159.6**

Accomplishments to Date

- Completed Phase 1
  - Identified regional sources and transport operators.
    - Over 5 Mt/Year CO_2 from ethanol sources in Nebraska, over 20 Mt/Year CO_2 from other sources.
    - Pipeline rights of way from every ethanol plant to within three miles of each potential storage site
  - Estimated CarbonSAFE-scale storage capacity at fields in Nebraska and Kansas.
    - Multiple fields have sufficient capacity strengthening the case for a regional hub in the area.
  - Final Report being completed
- Selected for Phase 2
  - Combined with two other regional Phase 1 projects

Phase 1 Projects Represented

- This proposal is based on the combination of three Phase 1 CarbonSAFE projects:
  - IMSCS-HUB led by Battelle,
  - The Nebraska Integrated Carbon Capture and Storage Pre-Feasibility Study led by EERC, and the
  - Integrated Carbon Capture and Storage for Kansas (ICKan) led by KGS.



BATTELLE

Phase 2 Team

ADM

ARI

Battelle

Berexco

Conservation and Survey Division, SNR, UNL

DGR&M

Energy and Environment Research Center

Great Plains Energy

Great Plains Institute

Improved Hydrocarbon Recovery

Kansas Geologic Survey

LANL

Loudon Technical Services

PNNL

Schlumberger

Lessons Learned

- Much industry and state interest in the region for bringing CO_2 to oil and gas fields in Nebraska and Kansas
  - Strong support from ethanol plants, oil and gas operators, and state agencies
- Relatively little CCS data readily available for Nebraska
  - However, oil and gas and other exploration projects in the region provide data for pre-feasibility estimates
- Old fields require extra time to get available data into usable formats
  - Legacy well data of varying quality: requires thorough QAQC
  - Digitization of non-digital log and core data takes a lot of effort

Synergy Opportunities

- Five other Phase 2 CarbonSAFE projects
- Regional Carbon Sequestration Partnerships
- Regional oil and gas companies and pipeline operators
- State Agencies

Thank you!

Andrew Duguid

Battelle

614-424-3516

Duguid@battelle.org

BATTELLE

Appendix

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

Benefit to the Program

- This project addresses four DOE Carbon Storage R&D Program Goals:

1. Develop and validate technologies to ensure 99 percent storage permanence.

2. Develop technologies to improve reservoir storage efficiency while ensuring containment effectiveness.

3. Support industry's ability to predict CO_2 storage capacity in geologic formations to within ±30 percent.

4. Develop best practice manuals for monitoring, verification, accounting (MVA), and assessment; site screening, selection, and initial characterization; public outreach; well management activities; and risk analysis and simulation.

Benefit to the Program

- This project addressed U.S. DOE Funding Opportunity Announcement-1584 Phase I: Integrated CCS Pre-Feasibility.
- The project studied integration carbon capture and storage in this area with a dense concentration of ethanol, electric power, and other industrial sources by constructing source and stacked storage corridors.
- This core project team has substantial experience with developing CO_2 storage projects, which contributed to the Phase 1 study for the establishment of a safe, economic, and effective commercial-scale carbon storage hub.
- Results of the work support DOE goals on storage permanence, reservoir efficiency, storage resource predictions, and best practices through the completion of a CarbonSAFE pre-feasibility plan for the Midwest.

Project Overview: Goals and Objectives

- Objective: to conduct a pre-feasibility study leading to the development of a commercial-scale integrated stacked storage hub in the Midwest consisting of a source and stacked storage corridor.

- The project concentrated on identifying specific sources and stacked storage sites in southwest Nebraska and central Kansas. The project assessed capture, transport, and storage potential and developed plans for a subsequent Phase II Storage Feasibility Study.
  - The study aids DOE in meeting their program goals by developing industry capacity and know-how, technologies and best practices for Nebraska and Kansas.

Project Organization

Project Management and Planning (Task 1)
Task Leader: Dr. Andrew Duguid (Battelle)

Source Identification (Task 2)
Task Leader: Mr. Scott McDonald (ADM)

Sub-Basinal Geological Assessment (Task 3)
Task Leader: Dr. R.M. Joeckel (Nebraska CSD)

Injection/Storage Assessment (Task 4)
Task Leader: Dr. Si-Yong Lee (Schlumberger)

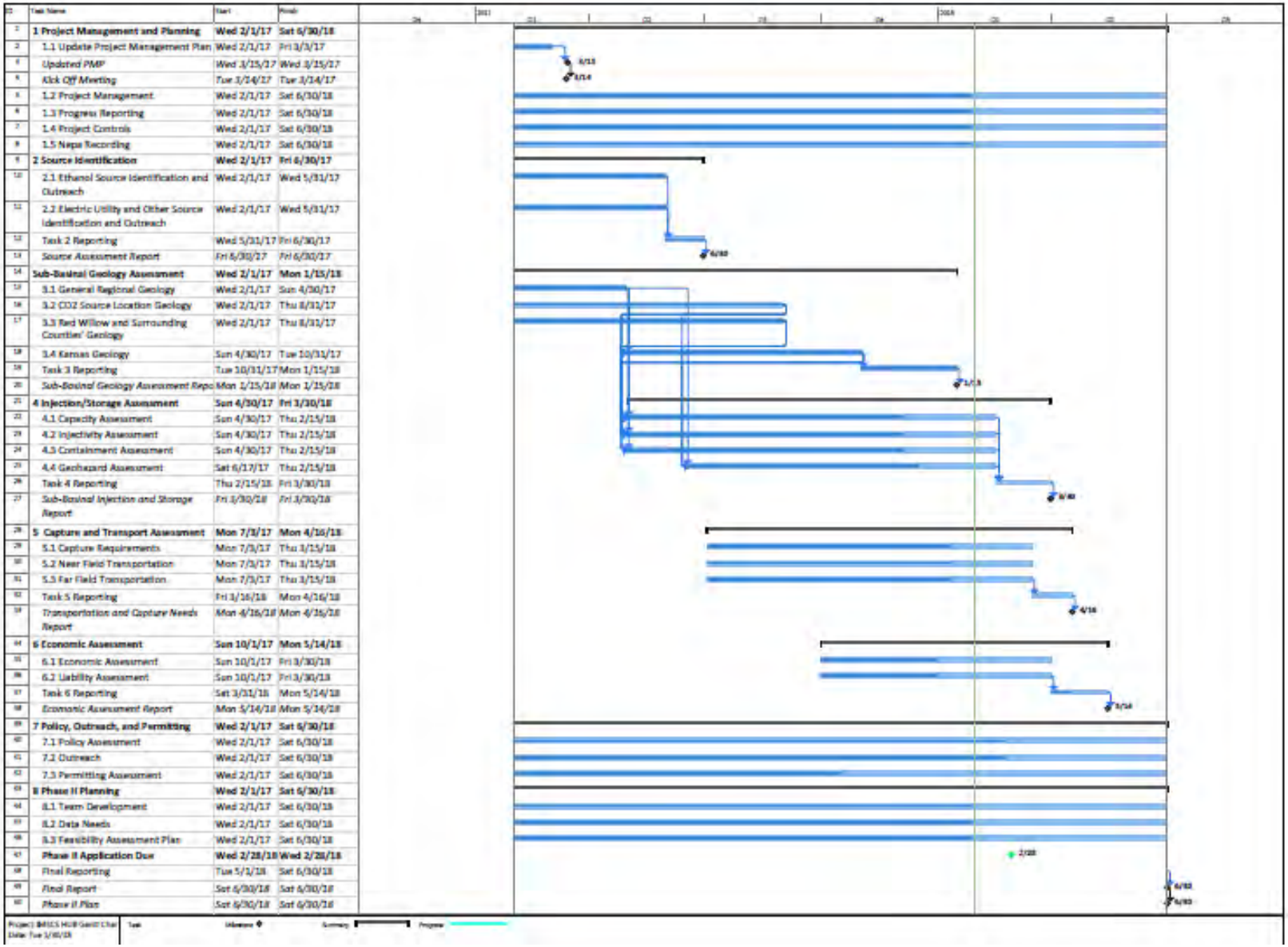
Capture and Transportation Assessment (Task 5)
Task Leader: Mr. Jared Hawkins (Battelle)

Economic and Liability Assessment (Task 6)
Task Leader: Ms. Isis Fukai (Battelle)

Policy, Outreach, and Permitting (Task 7)
Task Leader: Mr. Scott McDonald (ADM)

Phase II Planning (Task 8)
Task Leader: Dr. Andrew Duguid (Battelle)

Gantt Chart



	Task Name	Start	Finish
1	**1 Project Management and Planning**	**Wed 2/1/17**	**Sat 6/30/18**
2	1.1 Update Project Management Plan	Wed 2/1/17	Fri 3/3/17
4	*Updated PMP*	*Wed 3/15/17*	*Wed 3/15/17*
5	*Kick Off Meeting*	*Tue 3/14/17*	*Tue 3/14/17*
6	1.2 Project Management	Wed 2/1/17	Sat 6/30/18
8	1.3 Progress Reporting	Wed 2/1/17	Sat 6/30/18
7	1.4 Project Controls	Wed 2/1/17	Sat 6/30/18
9	1.5 Nepa Recording	Wed 2/1/17	Sat 6/30/18
9	**2 Source Identification**	**Wed 2/1/17**	**Fri 6/30/17**
10	2.1 Ethanol Source Identification and Outreach	Wed 2/1/17	Wed 5/31/17
11	2.2 Electric Utility and Other Source Identification and Outreach	Wed 2/1/17	Wed 5/31/17
13	Task 2 Reporting	Wed 5/31/17	Fri 6/30/17
13	*Source Assessment Report*	*Fri 6/30/17*	*Fri 6/30/17*
14	**Sub-Basinal Geology Assessment**	**Wed 2/1/17**	**Mon 1/15/18**
15	3.1 General Regional Geology	Wed 2/1/17	Sun 4/30/17
16	3.2 CO2 Source Location Geology	Wed 2/1/17	Thu 8/31/17
17	3.3 Red Willow and Surrounding Counties' Geology	Wed 2/1/17	Thu 8/31/17
18	3.4 Kansas Geology	Sun 4/30/17	Tue 10/31/17
19	Task 3 Reporting	Tue 10/31/17	Mon 1/15/18
20	*Sub-Basinal Geology Assessment Repo*	*Mon 1/15/18*	*Mon 1/15/18*
21	**4 Injection/Storage Assessment**	**Sun 4/30/17**	**Fri 3/30/18**
22	4.1 Capacity Assessment	Sun 4/30/17	Thu 2/15/18
23	4.2 Injectivity Assessment	Sun 4/30/17	Thu 2/15/18
24	4.3 Containment Assessment	Sun 4/30/17	Thu 2/15/18
25	4.4 Geohazard Assessment	Sat 6/17/17	Thu 2/15/18
26	Task 4 Reporting	Thu 2/15/18	Fri 3/30/18
27	*Sub-Basinal Injection and Storage Report*	*Fri 3/30/18*	*Fri 3/30/18*
28	**5 Capture and Transport Assessment**	**Mon 7/3/17**	**Mon 4/16/18**
29	5.1 Capture Requirements	Mon 7/3/17	Thu 3/15/18
30	5.2 Near Field Transportation	Mon 7/3/17	Thu 3/15/18
31	5.3 Far Field Transportation	Mon 7/3/17	Thu 3/15/18
32	Task 5 Reporting	Fri 3/16/18	Mon 4/16/18
33	*Transportation and Capture Needs Report*	*Mon 4/16/18*	*Mon 4/16/18*
34	**6 Economic Assessment**	**Sun 10/1/17**	**Mon 5/14/18**
35	6.1 Economic Assessment	Sun 10/1/17	Fri 3/30/18
36	6.2 Liability Assessment	Sun 10/1/17	Fri 3/30/18
37	Task 6 Reporting	Sat 3/31/18	Mon 5/14/18
38	*Economic Assessment Report*	*Mon 5/14/18*	*Mon 5/14/18*
39	**7 Policy, Outreach, and Permitting**	**Wed 2/1/17**	**Sat 6/30/18**
40	7.1 Policy Assessment	Wed 2/1/17	Sat 6/30/18
41	7.2 Outreach	Wed 2/1/17	Sat 6/30/18
42	7.3 Permitting Assessment	Wed 2/1/17	Sat 6/30/18
43	**8 Phase II Planning**	**Wed 2/1/17**	**Sat 6/30/18**
44	8.1 Team Development	Wed 2/1/17	Sat 6/30/18
45	8.2 Data Needs	Wed 2/1/17	Sat 6/30/18
46	8.3 Feasibility Assessment Plan	Wed 2/1/17	Sat 6/30/18
47	**Phase II Application Due**	**Wed 2/28/18**	**Wed 2/28/18**
48	Final Reporting	Tue 5/1/18	Sat 6/30/18
49	*Final Report*	*Sat 6/30/18*	*Sat 6/30/18*
50	*Phase II Plan*	*Sat 6/30/18*	*Sat 6/30/18*

BATTELLE