MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP (MRCSP)

"Managing Climate Change and Securing a Future for the Midwest's Industrial Base"

Third Semi-Annual Progress Report

Period starting October 1, 2004 and ending March 31, 2005

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DISCLAIMER

[1] These are organizations that are members of the MRCSP and are actively involved in carrying out the research described in the statement of work. This list does not include additional members of the MRCSP that participate as sponsors and members of our industry advisory team.

ABSTRACT

This is the third semiannual report for Phase I of the Midwest Carbon Sequestration Partnership (MRCSP). The project consists of nine tasks to be conducted over a two-year period that started in October 2003. The makeup of the MRCSP and objectives are described. Progress on each of the active Tasks is also described and where possible, for those Tasks at some point of completion, a summary of results is presented.

TABLE OF CONTENTS

Midwest Regional Carbon Sequestration Partnership (MRCSP) 1

Subcontractors 2

DISCLAIMER 2

ABSTRACT 3

TABLE OF CONTENTS 4

EXECUTIVE SUMMARY 5

EXPERIMENTAL 9

RESULTS AND DISCUSSION 9

Task 1: Characterization of the Carbon Intensity of the Midwest Region 10

Task 2: Characterization of Candidate CO_2 Sinks in the MRCSP Region 11

Task 2.1 Characterization of Geologic Sinks 12

Task 2.2 Characterization of Terrestrial Sinks 13

Task 3: Characterization of Potential Capture and Transport Technologies 14

Task 4: Development of a CO_2 Sequestration Cost Methodology 17

Task 5: Identification of Regulatory and Carbon Sequestration Monitoring and Verification Issues 18

Task 6: Public Involvement and Education 20

Task 7: Identification of Sequestration Opportunities 21

Task 8: Development of Phase II Plan 26

Task 9: Project Management and Reporting 26

Conclusion 28

Plans for next Period 28

Appendix A: Nomenclature 29

EXECUTIVE SUMMARY

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is one of seven Partnerships in DOE's Carbon Sequestration Program. The MRCSP's mission is to be the premier resource in identifying the technical, economic, and social infrastructures needed to create viable pathways to deploy, if needed, geologic and terrestrial CO_2 sequestration technologies in its Region. The MRCSP Region consists of the states of Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, and West Virginia.

This is the third semiannual report for the MRCSP's Phase I project (DOE Award No. DE-FC26-03NT41981). It describes progress during the period October 2004 through the end of March 2005.

The MRCSP team consists of 38 organizations as listed below in Table ES-1 with Battelle acting as prime contractor for the Phase I project:

Table ES-1: MRCSP Team Members

Research Team	Sponsoring Partners
Battelle (prime contractor)	AES Warrior Run[2]
CONSOL Energy	Alliance Resource Partners (Mettiki Coal)[2]
Indiana Geological Survey	American Electric Power
Kentucky Geological Survey	Arch Coal
Keystone Center	Baard (Nordic) Energy
Maryland Geological Survey [2]	Babcock & Wilcox [3]
Michigan State University[2]	British Petroleum (BP)
National Regulatory Research Institute	Center for Energy and Economic Development (CEED)[4]
Ohio Division of Geological Survey	Cinergy
Ohio Environmental Council	Constellation Energy[2]
Penn State University	Detroit Edison[2]
Pennsylvania Geological Survey	First Energy
Purdue University	Maryland Energy Administration[2]
The Ohio State University	Monsanto[3]
University of Maryland[2]	Ohio Corn Growers Association[3]
West Virginia Geological Survey	Ohio Coal Development Office
West Virginia University	Ohio Forestry Association[3]
Western Michigan University[2]	Ohio Soybean Council[3]
	Ohio Turfgrass Foundation[2]
	Scotts Miracle-Gro[3]

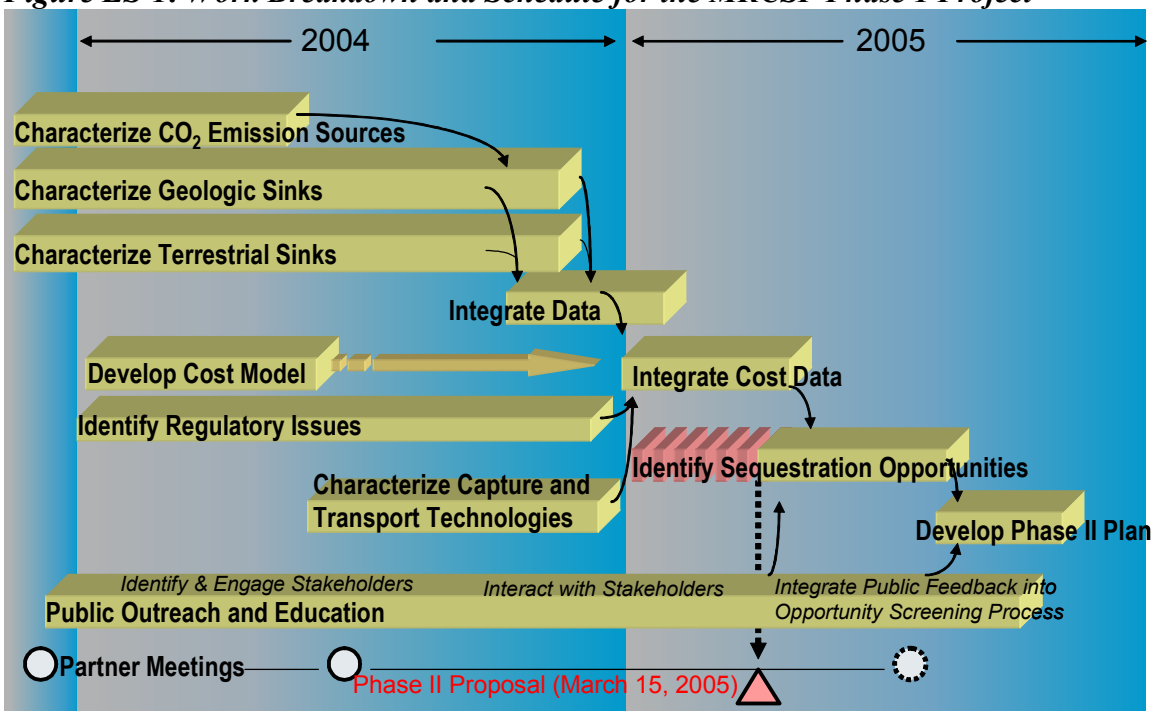
As footnoted in Table ES-1, nine new members were formally added to the MRCSP in June 2004 as a result of expanding the region from the original five states to also include the states of Maryland and Michigan. This expansion of the project and impact on scope

[2] Members added as part of formal expansion of the partnership adding Maryland and Michigan to the original five state region (see proposal CP058746 dated March 26, 2004 and resulting contract modification)
[3] Members added to the partnership since the formal expansion from five to seven states
[4] CEED joined the partnership shortly after inception of the Phase I project (prior to the formal expansion)

and funding is described in full in Battelle's proposal number CP058746 dated March 26, 2004. Formal modification of the subject agreement was received on June 22, 2004.

The work breakdown structure and schedule for the Phase I project are shown in Figure ES-1 below. The following is a brief summary of activities on each of the nine tasks (Task 9, Management, is not shown in Figure ES-1):

Figure ES-1: Work Breakdown and Schedule for the MRCSP Phase 1 Project



Task 1, **Characterize CO_2 Emission Sources**. Data on existing distributed CO_2 sources have been compiled, including emissions from transportation, residential fuel use, waste disposal, agriculture and land use.

The MRCSP source database is focused on identifying and describing large stationary point sources having more than 100 kilo tonnes (kt) of annual emissions of CO_2. This dataset is regularly updated and will continue to be throughout the Phase I effort as new data becomes available. It includes power generation, cement kilns, ethanol plants, gas processing facilities, iron & steel mills, refineries, and other industrial plants in the region. We continue to fill in gaps in the data to account for missing point sources and to ensure that the source data is current and correct.

An updated report is in preparation for task 1, which will include a comprehensive discussion of the region's socioeconomic setting and the carbon intensities of each state and the region as a whole including Maryland and Michigan, states formally added to the MRCSP region in June of 2004.

Task 2, Characterize the Geologic and Terrestrial Sinks in the Region. This Task includes much of the MRCSP's research to characterize its Region.

- Task 2.1 is researching the potential for geological sequestration in the region. The geological task group includes state geological surveys from all seven MRCSP member states and is coordinated by the Ohio Division of Geological Survey (Larry Wickstrom, Task Leader).
- Task 2.2 is researching the potential for terrestrial sequestration in the region. The terrestrial task group includes leading universities in that field from the seven state region and is coordinated by The Ohio State University (Rattan Lal, Task Leader). The group includes, Michigan State University, Penn State University, Purdue University, University of Maryland, and West Virginia University.

The geological team is well along to completing its research to characterize the geological sequestration opportunities for the region. Mapping data have been obtained for the seven states for different classes of repositories and those data have been integrated into a coherent picture of the geological characteristics of the region. Preliminary estimates of the geological storage capacity of the region by reservoir type have been made and are presented in the body of this report. More refined calculations are in progress.

The terrestrial team has completed the majority of its research to characterize the region's terrestrial opportunities. Draft reports have been received from all terrestrial team members. Estimates of the CO_2 storage capacity of the region given different land types and assumptions for changes on land management practices have been made and are presented in the body of this report.

Task 3, Review of Capture Technologies and their Associated Costs. This task is being conducted by CONSOL Energy. A draft report has been completed and preliminary results from that report were presented at the NETL Capture Working Group meeting on March 30, 2005 and are summarized in the body of this report. The draft report is expected to be finalized during May 2005.

Task 4, Cost Model. An economic model, including a price-elasticity based methodology, has been developed and peer reviewed that will allow various sequestration options, both geological and terrestrial, to be compared on a common basis. Preliminary results using this model for the MRCSP region are summarized in the body of this report.

Task 5, **Identify Regulatory Issues.** This Task is being conducted by the National Regulatory Research Institute. Agencies that enforce pipeline transportation regulations in all seven states have been identified. Workshops involving state regulatory officials in each of the seven states have been conducted for Ohio and West Virginia and are planned for other states. The workshop in Indiana is planned during April 2005.

Task 6, **Outreach.** This Task overarches and integrates with the technical tasks with the objective to inform and educate the public and their elected representatives about carbon sequestration in general (including links to DOE sites) and the MRCSP in particular.

A significant outreach meeting was held on February 25 in Columbus Ohio organized by the Ohio Coal Development Office of the Ohio Air Quality Development Authority. In all, over 150 key stakeholders, mostly from the Ohio area attended.

The outreach effort and MRCSP activities in general are supported by a web site (www.mrcsp.org) which was launched shortly following the beginning of the Phase I project. In January 2005 it was updated and made interactive (capable of posing questions and receiving comments from visitors to the site). Since then, visitation to the site has more than doubled and is now approaching about 900 visitors per month. The MRCSP key stakeholder database has also expanded from about 150 to almost 600 during this last six month period.

Tasks 7, Identification of Sequestration Options for the Region. This Task was kicked off following receipt of DOE's RFP for Phase II proposals in December 2004, which required definition of Phase II sequestration options. Multiple discussions and meetings were held with industry partners that had expressed interest in being host sites and consideration was given to geological and terrestrial characteristics and needs for the region based on Phase I research to define a portfolio of potential Phase II sequestration demonstration opportunities. These opportunities are described in more detail in the body of this report.

Task 8, Development of a Phase II Plan. This task has not yet formally begun.

Task 9, **Management.** A detailed review of the project status was presented at the DOE/NETL Annual Partnership Review in Pittsburgh PA on November 16, 2005.

Overall the MRCSP Phase 1 project is on schedule to complete overall efforts by September 2005 as previously planned and the project is on budget at this point.

EXPERIMENTAL

No experimental efforts were carried out during this reporting period and none are planned for the remainder of the project.

RESULTS AND DISCUSSION

This Phase 1 project is organized into nine tasks to be conducted over a two-year period as shown in Figure 1 below:

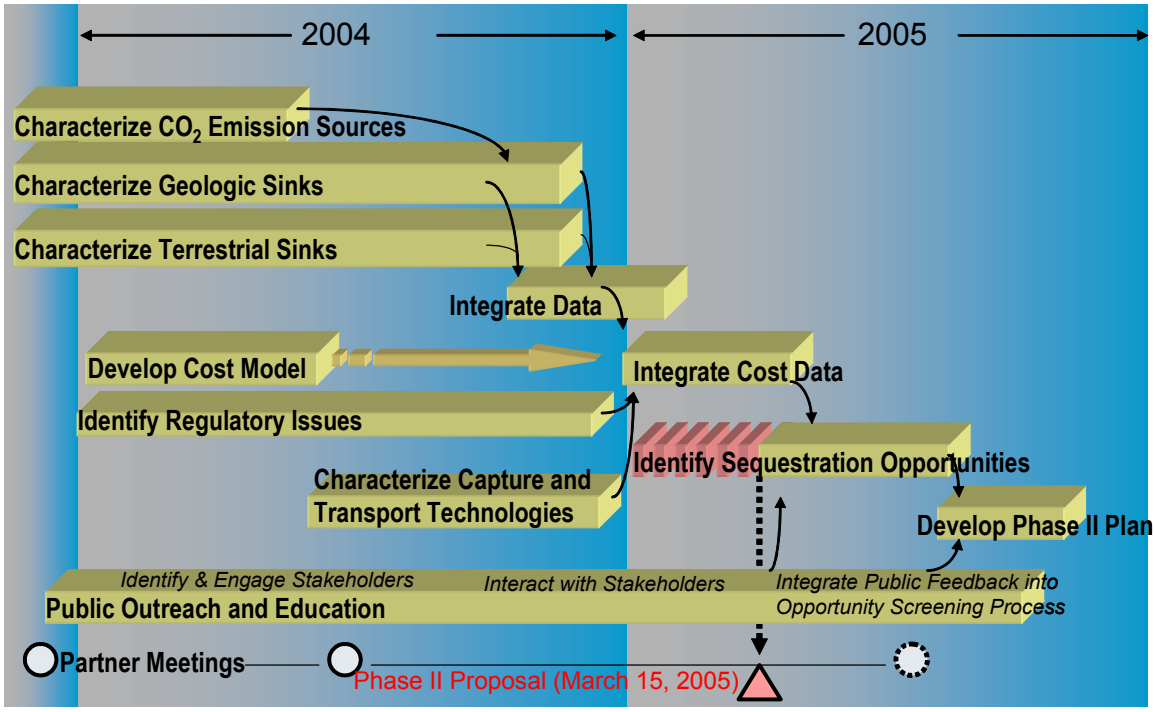


Figure 1: Work Breakdown Structure and Schedule for the MRCSP Phase I Project

The following is a summary of progress on each of the active tasks (those that are not yet active are reported as such). A summary of results for the past six months (since the inception of the project) is reported where appropriate.

TASK 1: CHARACTERIZATION OF THE CARBON INTENSITY OF THE MIDWEST REGION

Objective

The focus of Task 1 has been on compiling data to enable a characterization of the MRCSP region's carbon intensity. This has entailed gathering data on existing distributed and large stationary CO_2 and other greenhouse gas (GHG) sources in the region, as well as tracking possible future stationary point sources of CO_2.

Progress

Data on existing distributed CO_2 sources have been compiled, including emissions from transportation, residential fuel use, waste disposal, agriculture and land use. These were discussed in more detail in the previous semiannual report for this project.

We continue to fill in gaps in the data for the large point source portion of the source database, to account for missing point sources, and to ensure that the source data we currently have is correct. Part of this process of identifying additional point sources and correcting existing data will continue though the duration of the project.

The current database of large point sources (those exceeding 100 kT/year of CO_2 emissions) contains over 600 facilities at 274 locations around the region. Figure 2 shows the location and relative magnitude of CO_2 emissions from these 274 locations showing also the different categories into which they fall.

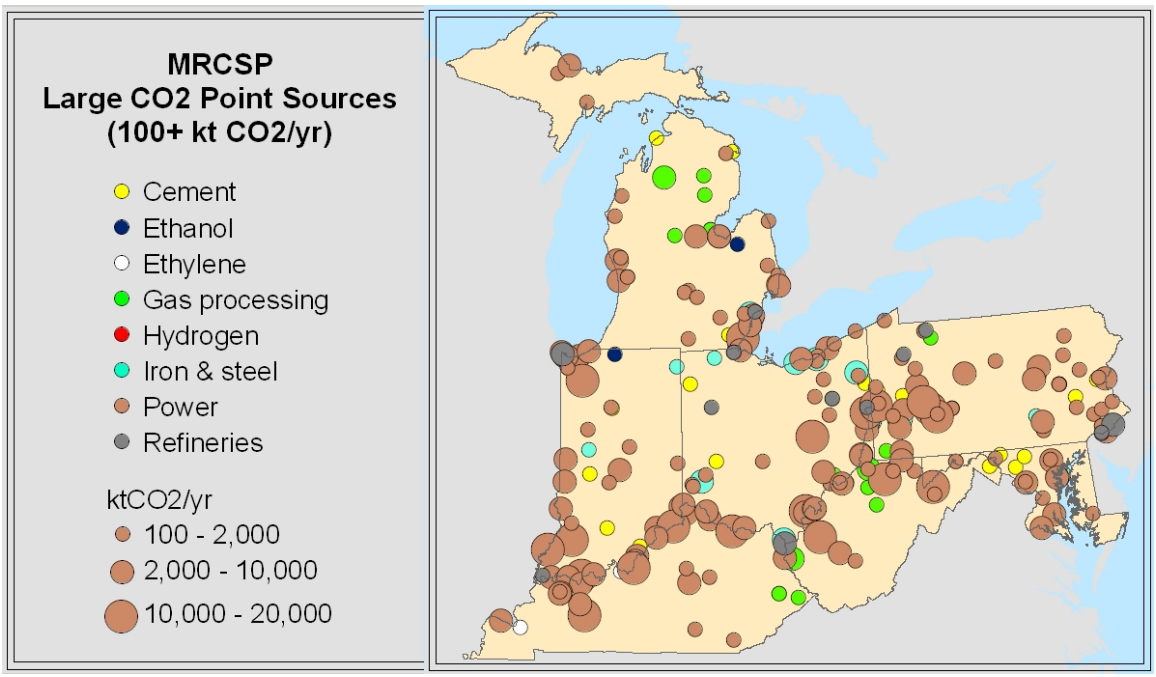


Figure 2: Locations of Large Anthropogenic Sources of CO_2 in the MRCSP Region

As can be seen in Figure 2, the MRCSP region is home to many large sources of CO_2 that are potential candidates for employing Carbon Capture and Storage (CCS) technologies in the future. Of the 274 large (i.e., more than 100kt CO_2/year) CO_2 point source locations within the Region, 80 percent of the CO_2 emissions come from only 31 percent (or 85) of the facilities. Of these 85 sources, all but 7 are in close proximity to at least one candidate CO_2 storage reservoir, and all but one are within 50 miles of one or more potential storage options. Clearly, CCS technologies offer the prospect of providing tremendous leverage for the Region's economy if deep reductions in greenhouse gases are needed.

The reader is also referred to the semiannual report immediately receding this one for additional data on the CO_2 sources in the region

TASK 2: CHARACTERIZATION OF CANDIDATE CO_2 SINKS IN THE MRCSP REGION

This Task is being conducted in two subtasks: 2.1 Characterization of Geologic Sinks and 2.2 Characterization of Terrestrial Sinks. The following discussion reports on each of those subtasks respectively.

Task 2.1 Characterization of Geologic Sinks

Objective

The objective of this task is to compile a coherent picture of the geologic CO_2 sequestration reservoirs (sinks) in the MRCSP. This includes the incorporation of geographic data for the various MRCSP states into an appropriate geographical information system (GIS) framework. Potential geologic reservoirs to be characterized include oil and gas reservoirs, gas storage fields, unmineable coal seems, and deep saline reservoirs. This work is being carried out and coordinated by the Ohio Division of Geological Survey (ODGS) with support from state geological entities representing each of the other six MRCSP member states: Indiana, Kentucky, Maryland, Michigan, Pennsylvania, and West Virginia.

Progress

All geologic maps have been completed and are in final review. Salinity, temperature and pressure data have been gathered and a grid created for use in CO_2 capacity calculations.

Preliminary estimates of geologic storage capacity have been made and are summarized below in Table 1.

State	Estimated Geologic Storage Capacity, Millions of tonnes CO_2					Number of Large CO_2 Sources	Annual CO_2 Emissions from Large Point Sources ($ktCO_2$)	Years of Storage Capacity
	Deep Saline Formations	Coal Basins	Depleted Gas Basins	Depleted Oil Plays	Total			
IN	30,640	200	50	30	30,920	46	162,208	191
KY	17,340	142	110	30	17,622	30	101,711	173
MD	4,920	40	10	20	4,990	17	37,637	133
MI	45,890	20	290	100	46,300	44	93,542	495
OH	34,810	437	260	150	35,657	44	148,405	240
PA	14,420	922	380	80	15,802	66	126,779	125
WV	13,580	1,246	220	60	15,106	27	96,340	157
MRCSP Total	~162,000	~3,000	~1,300	~470	~167,000	~274	~766,000	>200

Table 1 Preliminary Estimates of Geologic Storage Capacity for the Region

As can be seen from this table, the geologic reservoirs in the region are vast and represent the potential for storing a substantial portion of the regions CO_2 emissions from large point sources for many years to come. The estimates above are preliminary and are being refined by the geologic team. The refinement includes a review of the calculation methodology used to arrive at the estimates. A geologic team meeting will be held in May to perform a final face-to-face review of all maps, calculation methodologies, and discuss needs for final reports, and internet maps.

An interactive web-based map service has been designed and tested internally by the Ohio Geological Survey. Once all GIS files are received and finalized, the system will be loaded for review by MRCSP partners and evaluation for public outreach.

Task 2.2 Characterization of Terrestrial Sinks

Objective

The objective of this task is to assess the potential for terrestrial sequestration in the MRCSP region specifically evaluating four key regional land-uses namely: marginal lands, grazing and eroded lands, agricultural lands, and degraded mine lands.

Progress

The research portion of the terrestrial characterization effort was largely completed prior to the preceding semiannual report and summarized there.

As an update to that earlier report, Figure 3 shows the various land types evaluated and estimates of the carbon sequestration capacity

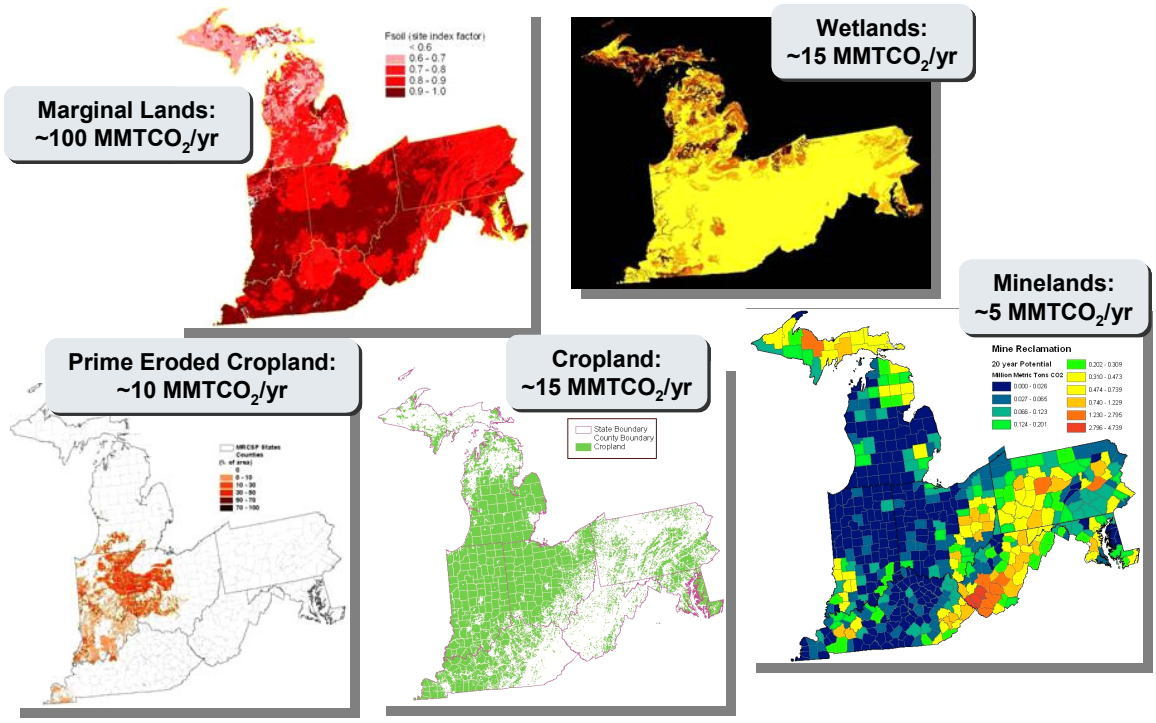


Figure 3 Land Types Evaluated and Estimated Terrestrial Sequestration Capacity

This figure shows that the MRCSP team has comprehensively evaluated a number of land types prevalent in the region. Using modified land management practices studied by the MRCSP team these land types together represent a potentially significant sequestration potential totaling an estimated 145 $MMTCO_2$/year or about 20% of the roughly 766 $MMTCO_2$/year emitted from the region's large point sources.

TASK 3: CHARACTERIZATION OF POTENTIAL CAPTURE AND TRANSPORT TECHNOLOGIES

Objective

The primary objectives of this task are to evaluate potential issues related to development of a CO_2 transport network in the study area and to evaluate the most applicable options for capture of CO_2 from point sources.

Progress

A draft report covering capture technologies and the economics of their application to sources in the MRCSP region was completed under subcontract to CONSOL Energy. The report is currently undergoing revision following internal review prior to being sent to selected MRCSP industry partners for subsequent review. Following that review process it is expected to be released as a MRCSP report.

Based upon the review conducted by CONSOL of more than 150 journal articles, conference proceedings papers, and web pages, the following candidate capture technologies were identified:

- Amine Scrubbing – CO_2 is selectively absorbed by chemically reacting with an aqueous amine solvent. The solvent is regenerated by applying heat.
- Alkaline Salt Solution Scrubbing – CO_2 is selectively absorbed by chemically reacting with an aqueous solution of an alkaline salt (e.g., potassium carbonate). The solvent is regenerated by applying heat.
- Ammonia Scrubbing – CO_2 is selectively absorbed by chemically reacting with an aqueous ammonia solvent. The solvent is regenerated by applying heat.
- Physical Absorption – CO_2 is selectively absorbed by physically dissolving in a liquid solvent at high pressures and/or low temperatures. The solvent is regenerated by pressure reduction and/or heating.
- Hybrid Absorption – CO_2 is selectively absorbed by physically dissolving in and chemically reacting with a blended solvent. The solvent is regenerated by pressure reduction and/or heating.
- Gas Separation Membranes – CO_2 is separated from other gaseous components because it selectively permeates across a membrane in the presence of a partial pressure driving force.

- Gas Absorption Membranes – Permeable membrane is used to provide a large surface area for contact between CO_2-laden feed gas and a liquid absorbent. CO_2 is selectively captured by the absorbent; regeneration occurs by altering process conditions as in a typical wet scrubbing process.
- Physical Adsorption – CO_2 is selectively adsorbed onto the surface of a solid sorbent because of intermolecular forces. The sorbent is regenerated by altering pressure or temperature, or by the application of an electrical current or use of a regeneration gas.
- Solid Chemical Absorption – CO_2 is selectively absorbed by chemically reacting with a solid sorbent. The sorbent is regenerated by altering process conditions.
- Cryogenic Separation – CO_2 is captured by condensation or sublimation at low temperatures and elevated pressures.
- Hydrate Formation – CO_2 is captured by adding water at low temperatures and high pressures to form carbon dioxide hydrate crystals.
- Electrochemical Separation – CO_2 is captured using a carbonate ion pump or proton pump.
- Biochemical Separation – Enzymes or photosynthesis are employed for CO_2 capture.

The advantages, limitations, and commercial or developmental status of each of these technologies were assessed, and factors affecting the applicability of each technology, including equipment and material requirements, operating temperature and pressure, feed gas composition and flow rate, and carbon dioxide separation efficiency, were considered.

Technical and economic considerations regarding the application of CO_2 capture technologies to each type of point source listed above were explored. For power plants, four different CO_2 capture configurations were assessed:

- Post-Combustion Capture from the Flue Gas of a Coal-, Gas-, or Oil-Fired Steam Cycle Unit, GT Unit, or NGCC Unit
- Oxyfuel Combustion with CO_2 Recycle
- Pre-Combustion Capture from the Shifted Syngas of an IGCC Unit or Gas-Fed Partial Oxidation Combined Cycle Unit
- Chemical Looping Combustion

Important technical considerations included:

- Process Configuration and Options for Integrating the CO_2 Capture System
- Quantity of Gas to be Treated
- Quality of Gas to be Treated (i.e., composition and conditions, especially CO_2 partial pressure)
- Energy Penalty
- Retrofit Difficulty

Important economic considerations included:

- Capital Costs
- Cost per Unit Mass of CO_2 Captured and/or Avoided
- Cost of Electricity (for Power Plants)
- Retrofit Installation vs. New Construction
- Fuel Price and Availability
- Possible Opportunities for Reducing Costs

A preliminary ranking of the various capture technologies according to their technology readiness is shown in the following table

Source Type	Point of Capture	Amine Scrubbing	Ammonia Scrubbing	Physical Absorption	Gas Separation Membrane	Gas Absorption Membrane	Oxyfuel + Drying/Compression	Simple Drying/Compression
Power Plants Post-Combustion	Flue Gas	L	A	--	A	A	A	--
Power Plants Pre-Combustion	Shifted Syngas	--	--	L	A	--	--	--
Iron / Steel Facilities	Blast Furnace Gas (~60-70% of total CO_2)	L	--	L	A	S	--	--
Refineries	Heater/Boiler Flue Gas (~65-85% of total CO_2)	L	S	--	A	S	A	--
Cement Plants	Kiln Flue Gas	L	S	--	S	S	S	--
Gas Processing Plants	Vented CO_2	--	--	--	--	--	--	L

Likely (L); Attractive (A); Speculative (S)

Table 2 Categorization of Capture Technologies for Sources in the MRCSP Region

The final version of the capture report is expected to be sent to MRCSP partners in May 2005 and produced as a MRCSP report in September 2005.

TASK 4: DEVELOPMENT OF A CO_2 SEQUESTRATION COST METHODOLOGY

Objective

The objectives of this task are 1) to develop a cost methodology for estimating the cost of the various potential terrestrial and geological sequestration options, 2) implement the methodology using the data collected on the various reservoirs, and 3) create a cost based listing of the MRCSP region's terrestrial and geologic sequestration options.

Progress

A preliminary cost curve for the region has been drafted. The curve integrates results for geologic and terrestrial storage options into a common economic framework using a detailed economic model. The curve is shown in Figure 4

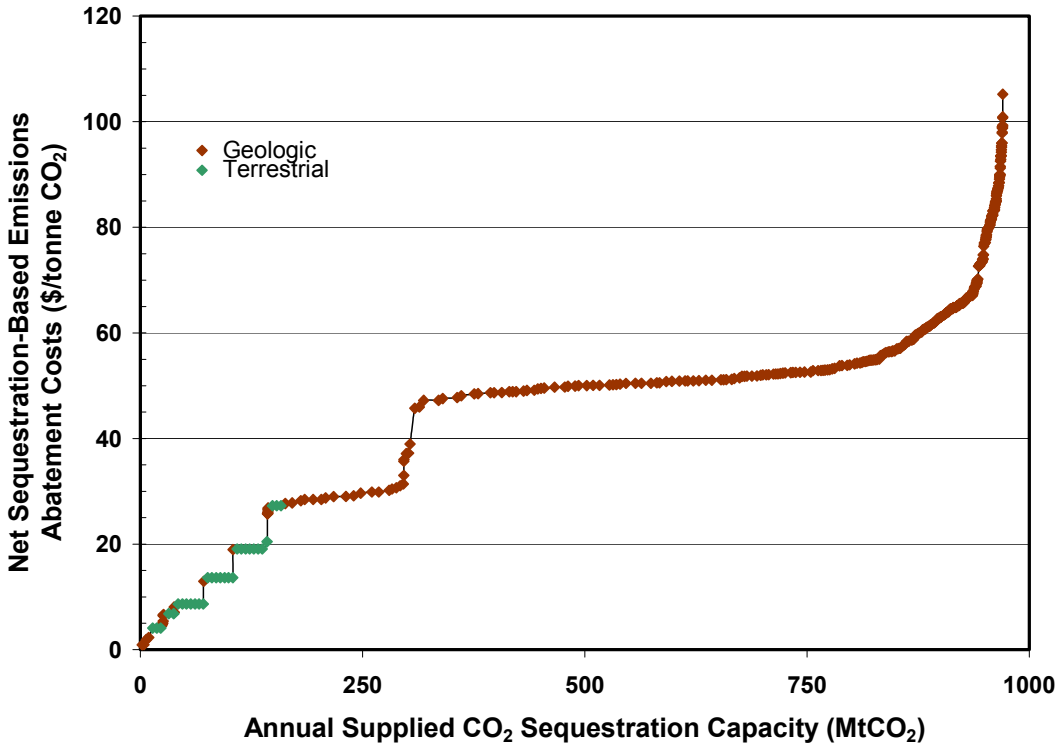


Figure 4 Preliminary Cost Curve for the MRCSP Region

The geologic portion of the curve was created as a result of competitive matching of sources and the region's candidate storage reservoirs. This was performed by estimating net cost of CCS (including capture, compression, pipeline transport, injection, any revenue from recovered hydrocarbons, and MMV) for every storage option within 100 miles of each source. Sources then competed for storage capacity based on net cost and

the ability to store their CO_2 in the reservoir for at least 20 years. This constraint ensures that each storage reservoir's capacity is not oversold and represents not only the finite nature of individual reservoir capacity, but the need for individual sources to reserve storage capacity for their CO_2 for a number of years into the future. In this preliminary analysis we also modeled sources that lie just outside of the MRCSP region to see what type of demand for storage capacity may come from outside the region's borders.

Costs for the geologic components of the curve are impacted by a number of factors, including the purity and pressure of CO_2 in the flue gas or process stream, the size of the source (annual emissions), the characteristics of the storage reservoir (depth, injectivity, and any hydrocarbon recovery response from EOR and ECBM), and distance between source and reservoir. Combined, these characteristics can have a large impact on the overall cost of CO_2 capture, compression, transport, and storage.

At this point we have only modeled the first 20 year time period here. However, this does not mean that this represents all of the available storage capacity in the region. The X-axis is in million metric tons of CO_2 captured, transported, and stored (for geologic) in each year of that first 20-year period (essentially storing all of the CO_2 from the region's large CO_2 sources). Future analyses will examine the costs and ability of the region's candidate storage reservoirs to store the region's CO_2 over longer time frames.

For the terrestrial portion of the curve, the annual storage potentials estimated for each of the different applications considered for the region (cropland, marginal land, mineland, wetland/peatland) were assigned preliminary representative costs, and integrated with the geologic results on the cost curve. Next steps for the terrestrial components include improving the parameterization of net costs for each type of terrestrial sequestration application within the region.

TASK 5: IDENTIFICATION OF REGULATORY AND CARBON SEQUESTRATION MONITORING AND VERIFICATION ISSUES

Objective

The objective of this Task is to identify regulatory and institutional barriers in the MRCSP region that may inhibit the economical and efficient deployment of carbon sequestration technologies and to recommend appropriate solution strategies. The scope includes terrestrial, geological, and other regulatory issues applicable to the MRCSP region and the work is being conducted by the National Regulatory Research Institute (NRRI).

Progress

Analogous regulatory models as well as regulations governing transportation of hazardous and nonhazardous liquids and the injection and storage of hazardous and nonhazardous industrial waste have been examined to help determine the likely regulatory regime for CO_2 sequestration as well as determine the liability treatment of CO_2 should it escape from the pipeline or geological sequestration. The current regulatory environment for geological and terrestrial carbon sequestration have been documented.

The Department of Transportation has regulations of pipeline transportation of CO_2. These regulations include minimum right-of-way standards. (Acquiring right-of-ways can either be done voluntarily on a property holder by property holder basis or by means of condemnation. Condemnation of CO_2 pipeline rights-of-way is available as an option in several states in the region. In the case of geologic sequestration the regulations examined included state and federal environmental and transportation and safety regulations, siting and condemnation of pipelines, as well as the licensing and permitting of injection wells. In the case of terrestrial sequestration these regulations deal mainly with natural resource, agricultural, and forestry regulations.

In addition, the appropriate regulatory agencies that would provide licensing, permitting, and direct or indirect regulation of terrestrial and geologic carbon sequestration were identified within each state. Regulators from these regulatory agencies in each state are being convened to proactively discuss their concern as to the safety, monitoring, testing, validation, and efficacy of both geologic and terrestrial carbon sequestration, as well as to identify potential regulatory approaches that might streamline regulatory approvals.

On November 8th a meeting/seminar/workshop was held with Ohio Regulators and on November 29 the same was done with West Virginia regulators. The participants in those meetings included the following:

Ohio

- Kim Wissman, Ohio Power Siting Board
- Klaus Lambeck, Ohio Power Siting Board & Public Utilities Commission of Ohio
- Kirk Hines, Ohio Department of Natural Resources, Division of Soil & Water Conservation
- Mark Ervin, Ohio Department of Natural Resources, Division of Forestry
- Lindsay Taliaferro, Ohio Environmental Protection Agency, Underground Injection Class Program Manager
- Chuck Lowe, Ohio Environmental Protection Agency, Division of Drinking & Ground Water

West Virginia

- Paul Stewart, West Virginia Public Service Commission, Utilities Division, Manager
- Earl Melton, West Virginia Public Service Commission, Engineering Division Director

- David Bassage, West Virginia Department of Environmental Protection, Administrator of the Office of Innovation
- David Watkins, WVDEP, Regulatory Program Section Manager
- Mike Lewis WVPSC, Office of Oil & Gas, UIC Program Director

In March plans were made to convene similar meetings in Indiana and other states. The Indiana meeting is scheduled for April 28 in Indianapolis

TASK 6: PUBLIC INVOLVEMENT AND EDUCATION

Objective

The objective of this task is to prepare the public and their elected representatives to make informed decisions about the future use of geologic and terrestrial sequestration technologies by engaging the public in open dialogue. This task was begun at the beginning of the Phase I project and will run throughout the conduct of the two-year project. It is being conducted by Battelle.

Progress

The primary emphasis of the outreach work has been on communication and awareness building. The outreach team planned their work in three primary phases that were generally linked to the overall project activities:

- An initial, foundation-building step of developing information and contacts, corresponding with the technical activities of data collection and need to coordinate with PEIS activities.
- A second, follow-up phase of consolidating and expanding information and contacts via an interactive web site, corresponding with the technical team's activities of data analysis and integration.
- A final phase of initiating more direct interaction and communication with key state officials, corresponding with development of the Phase II proposal and selection of candidate sites and projects.

During the initial phase, the outreach focus was on developing information materials, creating an initial web site to post fact sheets and reports, and opening lines of communication with key stakeholders across the region. Information materials included a series of fact sheets on climate change, terrestrial and geologic sequestration, the MRCSP and other related topics, as well as a briefing package for use by partners. The outreach team worked with communication contacts from each of the partner organizations to develop a database of nearly 150 stakeholders in the region from government, industry, environmental group and other civic organizations. They sent a

mass mailing that included an introductory letter and a subset of fact sheets, along with a link to the website, to all the people in the data base.

Toward the end of the initial phase in the summer of 2004, the outreach team conducted a series of informal discussions with key stakeholders to obtain feedback and to develop ideas for effective outreach. It was agreed that, at this stage of the project, a web site that allowed for feedback would be more cost-efficient and effective in reaching a large number of stakeholders than conducting town meetings.

The enhanced, interactive website, which was introduced during the second outreach phase and launched in January 2005, is modeled after a few interactive sites found on the internet that cover scientific and technical issues. In its first revision, it is designed to introduce carbon sequestration and solicit feedback on a broad set of issues. Visitors move through a series of screens that are primarily based on the fact sheets, although a navigation bar allows the user to jump around at will. They are invited to offer responses to questions on seven topics that seek to identify the level of desired information, attitudes about carbon sequestration in general and both terrestrial and geologic sequestration in particular. In addition, visitors are encouraged to offer any other feedback they wish or ask additional questions. To date, feedback received from the site has primarily concerned additional questions rather than reactions to the questions posed by the team. This is one aspect of the website that the MRCSP intends to develop further as they move forward.

The response to the enhanced website has been positive and instructive. During the period mid-January through March 2005, the database of stakeholders has increased by about 150 (from an initial 430 to almost 590); web traffic more than doubled; and more than 2,660 came to the site and downloaded almost 300 copies of the fact sheets. The MRCSP followed the email announcement with reminder calls to roughly 100 stakeholders. The web visitation tracking showed an increase in traffic surrounding these calls. The MRCSP has also conducted briefings for state officials and other stakeholders. Again, visitation to the website increased after each of these briefings.

MRCSP outreach is now entering the third phase of initiating more direct interaction with state officials and industry partners across the region. While continuing the web site, outreach staff have been accompanying technical team members on briefings to Pennsylvania, Ohio and Maryland officials and accompanying regulatory team members on briefings and discussions with regulatory officials in all seven states.

TASK 7: IDENTIFICATION OF SEQUESTRATION OPPORTUNITIES

A portfolio of candidate sequestration test sites have been identified over the December through March time period in conjunction with preparation of the MRCSP's Phase II proposal. A number of these sites have been offered by major industrial sponsors of MRCSP and facility owners of other sites have also shown interest in becoming host sites.

The sites are distributed across the seven-state MRCSP Region and have been put forward as candidates because they will allow the MRCSP to validate the most important geologic storage reservoirs and terrestrial land types and management practices within our Region.

Geologic Opportunities

The three candidate geologic projects offered as host sites by MRCSP industrial sponsors for consideration for MRCSP Phase II geologic sequestration field tests are:

- **Saline Reservoir Tests at a Cinergy Site along the Ohio River, south of Cincinnati** – Two locations, one an operational power plant and one a greenfield site for a potential future power plant, have been offered by Cinergy for an injection test. This area represents the uplifted arches geologic province that separates the Illinois Basin from the Appalachian Basin. The most likely injection zone in this area is the Mt. Simon Sandstone (~300 ft thick and ~4,000 ft deep) although other high permeability zones are likely to be present above (Knox Dolomite) or below (Middle Run Formation) this interval. There is excellent containment in this area and overall injectivity should be very high. The site is representative of a large part of the MRCSP Region and an explicit linkage to current or potential future power plants makes it attractive for deployment at full-scale in the future.

- **Saline Reservoir Test at a DTE Gas Processing Location in Michigan Basin** – DTE has offered one of its gas processing plants in the northern part of the Michigan Basin as a host site for CO_2 injection and also has offered to provide high purity CO_2 from this site. In addition to the Mt. Simon Sandstone, this area has shallower injection intervals with high permeability in the Sylvania Sandstone and the Bois Blanc Dolomite at depths greater than 2,500 ft and thickness between 200 to 300 ft, and caprocks consisting of very low permeability anhydrite and salt layers. There is a large amount of geologic data and potential for using existing wells for injection/monitoring in this area.

- **Saline Reservoir Injection in the Appalachian Basin in Eastern Ohio, Western Pennsylvania, or Northern West Virginia** – FirstEnergy plans to test an enhanced version of the PowerSpan technology (which is currently optimized to remove SO_x, NO_x, and Hg) that would be capable of capturing CO_2 at their RE Burger plant in eastern Ohio during 2007. This will provide an ideal opportunity to test an integrated CO_2 capture, handling, and injection system in this tri-state area of the Appalachian Basin. The injection zones in this area are likely to be the Berea Sandstone, the Oriskany Sandstone, the Clinton Sandstone, or the high permeability zones in carbonate layers. There is sufficient containment and the area has a large concentration of power plants, making it critical for future evaluation of CO_2 storage potential.

Preliminary consideration of the geology and other factors in each of these site areas indicates that the results of these tests will have broader applicability to the region as a whole

In addition to the three projects listed above, other promising geologic projects for testing storage in different geologic sinks have been put forward. Below is a selection of these other candidate projects, which will be further evaluated for their storage potential, scientific benefits, and importance to MRCSP stakeholders.

- **Northern Michigan Basin EOR Tests** – There is currently ongoing enhanced oil recovery in the Niagaran Pinnacle Reef Trend (dolomites with high thickness, porosity, and permeability) using very pure (>99 percent) CO_2 from gas processing plants in northern Michigan. The infrastructure for CO_2 injection (e.g., processing, pipelines, equipment) already exists. There is a very large suite of geological and geophysical data along with an operator willing to discuss cooperation with the MRCSP. There is significant co-benefit to using this site in terms of additional oil recovery, however, it remains to be seen how this opportunity can be tailored to evaluate CO_2 retention in the oil field. It may be possible to use this site for a case study for EOR sequestration in the Region rather than an actual field injection project. Other opportunities in the Michigan Basin include the oil fields in Dundee Formation that may have a significant CO_2 storage and EOR potential due to large areal extent and associated saline reservoir parts of the formation.

- **Deep Saline Formation and EOR Storage Test Opportunities in Eastern Ohio** – Several counties in eastern Ohio (e.g., Coshocton, Tuscarawas, Carroll, Stark) have an active oil and gas industry resulting in availability of a large amount of geologic data. It also may be possible to use existing wells in oil and gas fields to evaluate and potentially conduct field test injection for EOR (e.g., East Canton Field) or deep saline formations (e.g., Copper Ridge Dolomite, Rose Run Sandstone, Clinton Sandstone, Lockport Dolomite, Bass Island Dolomite) and thousands of feet of caprock. This area also has promising potential sources for CO_2, including Baard Energy's soon-to-be-completed ethanol plant and FirstEnergy's plans to test PowerSpan CO_2 capture unit at their RE Burger Plant. There is also potential economic co-benefit from potential CO_2 EOR (estimated at 40 million additional barrels for East Canton field alone).

- **Injection Tests in Northern Appalachian Basin Sites** – Two locations in this Region have been identified for potential injection tests. Greene County in southwestern Pennsylvania has numerous potential injection zones in deep saline formations (e.g., Oriskany and Tuscarora Sandstones, Lockport Dolomite), deep coal seams at depths from 1,500 to 2,000 ft, and coal bed methane production areas. The source for this could be a gas processing plant operated by CONSOL Energy in the area that produces high-purity (~90 percent) CO_2. The second opportunity is in the western panhandle of Maryland, where a coal-fired plant with an existing CO_2 capture unit could provide food-grade CO_2. The storage reservoirs in this area include the Oriskany Sandstone and the organic rich Mandata Shale.

The rocks are folded into a series of anticlines and synclines with up to 200 ft of sandstone. If Mandata Shale proves to contain sufficient organic matter for CO_2 storage and methane, there will be a co-benefit in the form of methane production. Similar injection potential close to sources of CO_2 (e.g., a natural CO_2 source near Charleston, WV or another CONSOL gas processing plant in western West Virginia) is also present in the Appalachian Basin in West Virginia and Kentucky and these options will be further evaluated for feasibility of conducting the field tests.

- **Organic Shale Injection Potential in the Appalachian Basin** – The Kentucky Geological Survey has been conducting research on the potential of organic rich shales, which are extremely widespread in MRCSP Region, to store CO_2 through adsorption in Devonian Shale. The initial results are promising however continued research on the implementation aspects is needed. There are several potential opportunities to conduct limited field tests and/or focused laboratory analysis to make further progress on this option. For example, there is large production from several fields in an area known as the Big Sandy along the Kentucky-West Virginia border and it is highly likely that some of the existing wells could be used for injection and monitoring. At a minimum, an effort will be made to further characterize the shale zones for their organic carbon content, sorption properties, and retention potential.

Finally, MRCSP proposes to supplement the field validation tests described above with further characterization of other reservoirs through the following mechanisms:

- Continued refinement of maps prepared during Phase I, preparation of new maps for horizons that were not mapped separately during Phase I, and compilation of injectivity data to assist in storage capacity calculations

- Characterization of deep coal seams for CO_2 adsorption potential in collaboration with CONSOL Energy

- Characterization of deep saline reservoirs through collaboration with ongoing commercial oil and gas drilling in the Region (e.g., Mt. Simon Sandstone in Michigan Basin, basal sandstone in Appalachian Basin, and carbonate formations throughout the Region)

- Assessment of the CO_2 storage potential of two to three representative oil and gas fields in the Region, based on existing geologic, oil composition, and production data and possibly with simplified reservoir simulations.

Terrestrial Opportunities

While there are numerous potential opportunities to address terrestrial sequestration within an area as large as the MRCSP, we have decided to focus, in Phase II, on demonstrating soil carbon sequestration in agricultural soils and reclaimed minelands as

there is strong commercial interest in these areas, coupled with the potential for large-scale emissions abatement and an opportunity to advance research in this area. Adoption of recommended management practices (RMPs) on cropland and the restoration of minelands affords a unique opportunity to demonstrate soil carbon sequestration techniques, which can assist us in addressing climate change over the long-term, and to deliver immediate benefit to the local environment (e.g., reduced runoff and low risks of water pollution) by stabilizing these anthropogenically disturbed lands. In collaboration with Corn and Soybean Growers Associations and CONSOL, we will demonstrate how a number of promising soil/terrestrial carbon sequestration techniques can offset fossil fuel emissions and reduce the net increase in atmospheric concentration of CO_2 while improving quality of soil and water resources.

The Corn and Soybean Growers Associations and CONSOL Energy have offered the MRCSP the use of farmlands and reclaimed minelands, respectively, on property they own in the MRCSP. Near the end of Phase I and early in Phase II, we will visit these landholdings to downselect to the actual test plots that we will focus on in our Phase II field validation tests. Final sites will be chosen based on: (1) similarity of soils, bedrock geology, slope, and aspect; (2) known history of land use and management on croplands, and mining dates and reclamation technique; (3) known land use history (hay, forest, cropland) and soil/vegetation management (manuring, mulching, fertilizer); (4) a range of tree and forage species; and (5) mineland sites reclaimed prior to 1977 and post-1980. By choosing sites based on these criteria, we can extrapolate the results from our small field tests to the much wider set of potential circumstances encountered once these practices are commercially deployed. Practices to be demonstrated for carbon sequestration include:

- Cropland – no-till farming with cover crops and manuring

- Minelands – restoration with and without topsoil, and establishment of trees and pastures as post-reclamation land use.

Figure 5 further describes the various implementation opportunities listed above that have been identified thus far in Phase I for the region.

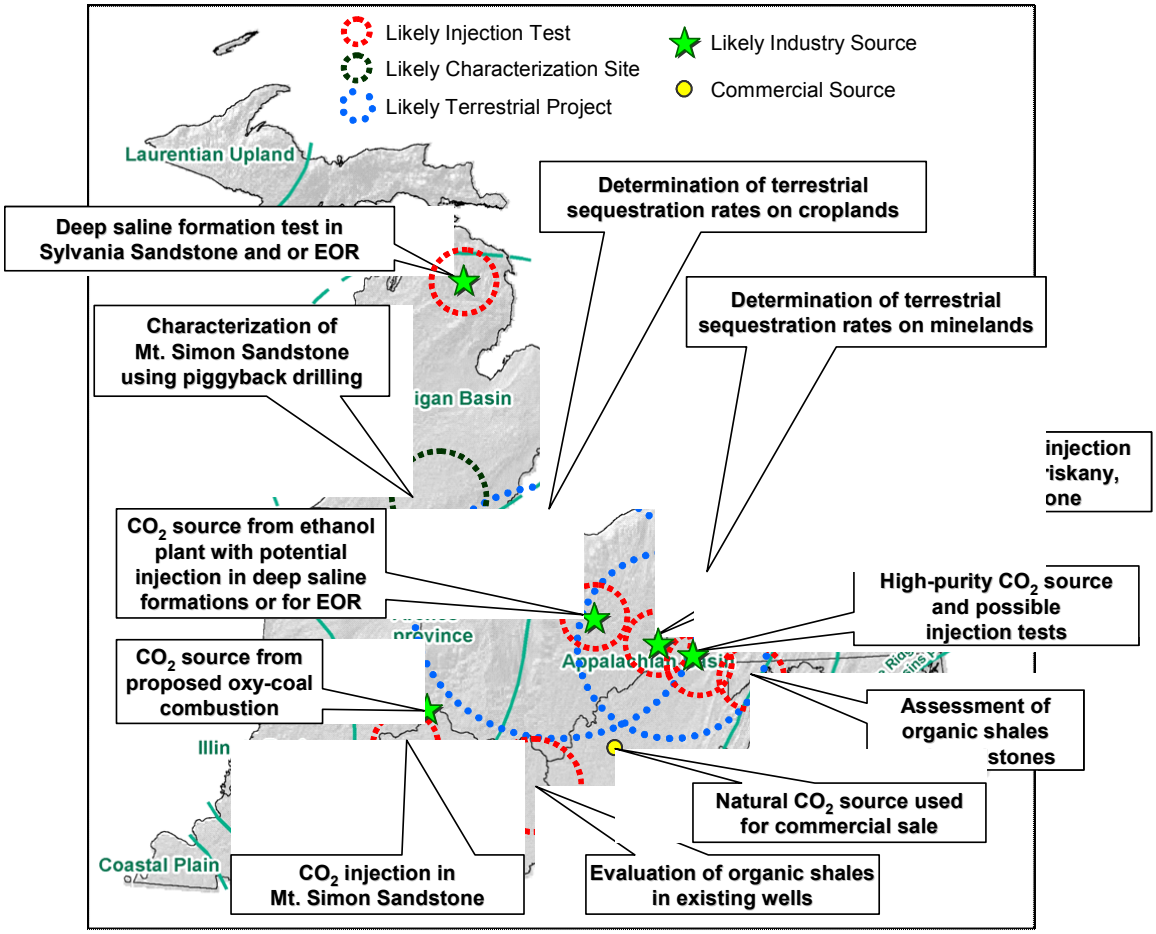


Figure 5 Geologic and Terrestrial Implementation Opportunities

The combined result of the portfolio of research projects identified thus far in Phase I and as proposed in Phase II will be a validation and demonstration of the geologic storage potential as well as development of a geologic framework required for systematic implementation of CO_2 storage in the MRCSP Region.

TASK 8: DEVELOPMENT OF PHASE II PLAN

This Task is also not scheduled to begin until later in the project

TASK 9: PROJECT MANAGEMENT AND REPORTING

Objective

The objective for this Task is to provide management, coordination, and reporting for the MRCSP project.

Progress

During the previous six months the following presentations and other

- A detailed report on the status of the project was presented by Dave Ball, Steve Greb, and Mark Sperow at the DOE/NETL Annual Partnership Review meeting in Pittsburgh on November 16, 2004.
- Sumathi Iyappan of the University of Maryland presented a poster session on wetlands for carbon sequestration based on MRCSP results at the Soil Science Society of America in November 2004.
- Overview presentations, arranged through the auspices of the Ohio Coal Development Office, were made to the following groups during the quarter:
    - Ohio Air Quality Development Authority Board of Directors (October 12, 2004)
    - Ohio Consumers Counsel (October 12, 2004)
    - Ohio FutureGen Siting Taskforce (October 22, 2004)
    - Ohio Air Quality and Coal Research Symposium, Athens Ohio (December 2, 2004one by Eric Venteris of ODGS and one by Dave Ball of Battelle)
- A seminar for carbon sequestration was arranged under the auspices of the Ohio Coal Development Office on February 25, 2005 in Columbus Ohio. Presentations covering work in the MRCSP were given by Jim Dooley and Larry Wickstrom at that seminar. Approximately 150 key stakeholders in the state of Ohio were involved. This seminar also represented a key outreach opportunity.
- Neeraj Gupta presented a seminar on geologic sequestration of CO_2 including the MRCSP effort at the Ohio Geological Society meeting on February 25
- Dave Ball gave an overview of the MRCSP to a group of about 25 Pennsylvania state officials on January 6, 2005 at the Pennsylvania Department of Environmental Protection.
- Dave Ball gave an overview of the MRCSP to a group of about 20 attendees at the Ohio Gas Association Annual Meeting in Columbus Ohio on March 31, 2005.
- A presentation of capture technologies based on CONSOL's draft report was presented by Bruce Sass of Battelle to the NETL Capture Working Group in Illinois on March 30, 2005.
- Two abstracts, one describing the terrestrial and one the geological characteristics of the region, were submitted for consideration for the Fourth Annual Conference on Carbon Sequestration in Alexandria Virginia in May 2005.

CONCLUSION

The MRCSP region, including the addition of Maryland and Michigan, makes up a contiguous seven state region that represents 16 percent of the U.S. population and economy. The MRCSP Phase I project, which started in October 2003 and is scheduled to run for two years, is developing a coherent picture of the carbon sequestration opportunities in the MRCSP region. It is also developing the cost methodology and framework for evaluating the realistic potential for specific carbon sequestration projects as part of a Phase II plan.

Delays caused by the need to generate and assimilate data for Maryland and Michigan, as well as some other delays due to prolonged negotiations on certain subcontracts, have resulted in some delay in completing Task 2. However, other tasks are moving forward in parallel and, thus, we believe the impact of these delays on overall project schedule will be minimized with no negative impact on overall findings.

DOE's accelerated schedule for the Phase II proposal (submitted on March 15, 2005) has resulted in a need to accelerate some aspects of tasks associated with defining Phase II project opportunities, specifically Task 7. This is not expected to negatively affect the overall budget or schedule for the Phase I project.

Overall the MRCSP Phase I project is on schedule to complete its Phase I efforts by September 2005 as planned.

PLANS FOR NEXT PERIOD

During the next six month period plans are to complete all deliverables for Phase I. These deliverables will include a series of topical reports and published papers that together will make up a portfolio of published resources describing the sequestration technologies and opportunities relevant to the MRCSP's sequestration plans going forward.

The next meeting of the MRCSP team members is planned for the June timeframe.

APPENDIX A: NOMENCLATURE

Term	Definition
DSF	Deep Saline Formations
EHS	Environmental Health and Safety
EOR	Enhanced Oil Recovery
GHG	Green House Gas
GIS	Geographical Information System
IOGCC	Interstate Oil and Gas Compact Commission
MMTCE	Tons of carbon equivalent (equals tons of CO_2 divided by 3.667)
MRCSP	Midwest Regional Carbon Sequestration Partnership
NEPA	National Environmental Policy Act
NGO	Non Government Organization
NLCD	National Land Cover Data
NRI	National Resources Inventory
NRRI	National Regulatory Research Institute
OGS	Ohio Geological Survey
OSU	The Ohio State University
PDMS	Petroleum Well Data Management System
PEIS	Programmatic Environmental Impact Statement
SDWA	Safe Drinking Water Act
SOC	Soil Organic Carbon
SOCP	Soil Organic Carbon Pool
UIC	Underground Injection Control