Southeast Regional Carbon Sequestration Partnership (SECARB)

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Disclaimer

Abstract

The Southeast Regional Carbon Sequestration Partnership (SECARB) is on schedule and within budget projections for the work completed during the first year of its two year program.

Work during the semiannual period (third and fourth quarter) of the project (April 1 – September 30, 2004) was conducted within a “Task Responsibility Matrix.” Under Task 1.0 Define Geographic Boundaries of the Region, Texas and Virginia were added during the second quarter of the project and no geographical changes occurred during the third or fourth quarter of the project. Under Task 2.0 Characterize the Region, general mapping and screening of sources and sinks has been completed, with integration and Geographical Information System (GIS) mapping ongoing. The first step focused on the macro level characterization of the region. Subsequent characterization will focus on smaller areas having high sequestration potential. Under Task 3.0 Identify and Address Issues for Technology Deployment, SECARB has completed a preliminary assessment of safety, regulatory, permitting, and accounting frameworks within the region to allow for wide-scale deployment of promising terrestrial and geologic sequestration approaches. Under Task 4.0 Develop Public Involvement and Education Mechanisms, SECARB has conducted a survey and focus group meeting to gain insight into approaches that will be taken to educate and involve the public.

Task 5.0 and 6.0 will be implemented beginning October 1, 2004. Under Task 5.0 Identify the Most Promising Capture, Sequestration, and Transport Options, SECARB will evaluate findings from work performed during the first year and shift the focus of the project team from region-wide mapping and characterization to a more detailed screening approach designed to identify the most promising opportunities. Under Task 6.0 Prepare Action Plans for Implementation and Technology Validation Activity, the SECARB team will develop an integrated approach to implementing and setting up measurement, monitoring and verification (MMV) programs for the most promising opportunities.

During this semiannual period special attention was provided to Texas and Virginia, which were added to the SECARB region, to ensure a smooth integration of activities with the other 9 states.

Milestones completed and submitted during the third and fourth quarter included:

- Q3-FY04 – Complete initial development of plans for GIS.
- Q4-FYO4 – Complete preliminary action plan and assessment for overcoming public perception issues.

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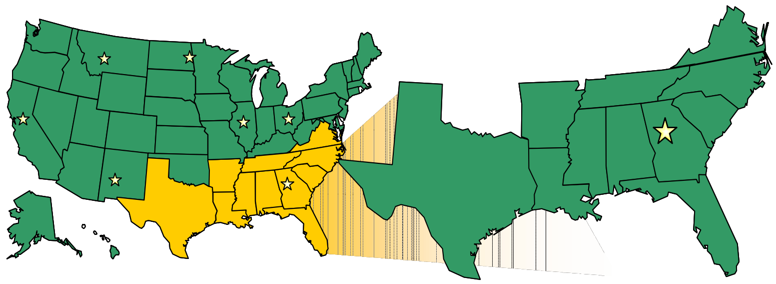


The SECARB region includes eleven states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia.
Map courtesy of the U.S. DOE/NETL.

On November 21, 2002, Energy Secretary Spencer Abraham announced a new phase of the United State's Department of Energy (DOE) research program solely devoted to the development and deployment of viable carbon sequestration technologies. Less than one month later, the Department issued Phase I of a solicitation aimed at creating a nationwide network of regional carbon sequestration partnerships (RCSPs).

Given the Southern States Energy Board's (SSEB) existing carbon management initiative, the SSEB immediately began facilitating discussions with state and federal agencies, policy makers, industry representatives, research entities and other non-governmental organizations to determine a regional response to the solicitation. On August 16, 2003, the Department announced the winners of the Phase I solicitation. The result is a network of seven regional carbon sequestration partnerships, including the Southern States Energy Board's Southeast Regional Carbon Sequestration Partnership.

SECARB work is being managed and administered by the Southern States Energy Board. SSEB is the only interstate compact in the United States that is constituted by both federal and state laws, that has governors, state legislators, and a Presidential appointee comprising its board of directors, and is empowered by its charter to address energy and environmental issues. Among the Technical Team partners are: SSEB; Electric Power Research Institute (EPRI); a Mississippi State University (MSU) team led by the Diagnostic Instrumental Analysis Laboratory (DIAL); Augusta Systems, Inc.; Massachusetts Institute of Technology (MIT); the University of Texas at Austin, Bureau of Economic Geology (TX BEG); the Virginia Polytechnic Institute and State University (Virginia Tech); Winrock International; Geological Survey of Alabama; Advanced Resources International (ARI); Applied Geo Technologies, Inc., a business of the Mississippi Band of Choctaw Indians; the Tennessee Valley Authority (TVA); RMS Strategies; and, The Phillips Group.

SECARB is a collaboration covering eleven U.S. states under a United States Department of Energy initiative to develop regional approaches to carbon sequestration in support of President George W. Bush's Global Climate Change Initiative. The SECARB will evaluate options and potential opportunities for regional carbon sequestration, promote the development of a framework and infrastructure necessary for the validation and deployment of carbon sequestration technologies and produce implementation plans for pilot-scale projects to test and validate approaches and technologies. In addition, the SECARB will focus on engaging stakeholders from diverse constituencies in the planning and implementation of the SECARB activities to ensure that all constituencies are well represented in this collaboration.

Executive Summary

The SECARB region has a diverse partnership composition that encompasses state executive and legislative leadership; electric utilities and associations; sequestration and GIS research centers; energy producers and associations; and natural resource advocates. Also, the region has a diverse portfolio of carbon dioxide (CO_2) sources, potential CO_2 transport networks and sequestration options.

> SECARB Technical Team and Technology Coalition Members
>
> Lead: Southern States Energy Board (SSEB)
> Electric Power Research Institute (EPRI)
> Mississippi State University (MSU) Diagnostic Instrumentation and Analysis Laboratory (DIAL)
> Massachusetts Institute of Technology (MIT)
> Winrock International
> Augusta Systems, Inc.
> AGL Resources
> American Electric Power
> Arkansas Oil and Gas Commission
> BP America
> Center for Energy and Economic Development
> ChevronTexaco Corporation
> Clean Energy Systems, Inc.
> Dominion
> Duke Power
> Edison Electric Institute
> Entergy Services
> Florida Power & Light Company
> Geological Survey of Alabama
> Georgia Environmental Facilities Authority
> Georgia Forestry Commission
> Gulf Coast & Carbon Center, University of Texas at Austin
> Interstate Oil and Gas Compact Commission
> Louisiana Department of Environmental Quality
> North American Coal Corporation, The North Carolina State Energy Office
> Nuclear Energy Institute
> Oak Ridge National Laboratory
> Old Dominion Electric Cooperative
> Progress Energy
> SCANA Corporation
> South Carolina Public Service Authority/Santee Cooper
> Southern Company
> Tampa Electric Company
> Tennessee Valley Authority (TVA)
> Virginia Center for Coal and Energy Research
> Virginia Polytechnic Institute and State University

Work during the semiannual period (third and fourth quarter) of the project (April 1 – September 30, 2004) was conducted within a "Task Responsibility Matrix." Under Task 1.0 Define Geographic Boundaries of the Region, Texas and Virginia were added during the second quarter of the project and no geographical changes occurred during the third or fourth quarter of the project. Under Task 2.0 Characterize the Region, general mapping and screening of sources and sinks has been completed, with integration and GIS mapping ongoing. The first step focused on the macro level characterization of the region. Subsequent characterization will focus on smaller areas having high sequestration potential. Under Task 3.0 Identify and Address Issues for Technology Deployment, SECARB has completed a preliminary assessment of safety, regulatory, permitting, and accounting frameworks within the region to allow for wide-scale deployment of promising terrestrial and geologic sequestration approaches. Under Task 4.0 Develop Public Involvement and Education Mechanisms, SECARB has conducted a survey and focus group meeting to gain insight into approaches that will be taken to educate and involve the public. SECARB technical team members are participating in the U.S. Department of Energy/National Energy Technology Laboratory (NETL) Communications Workshop Series. In addition, the SECARB website is operating and is a work in progress. The web site address is www.secarbon.org.

Work during this reporting period (semi-annual) of the project concentrated on collection of data to characterize the region and input of that data into the GIS system. Efforts continued to improve the data collected for source characterization. Work was ongoing in environmental risk evaluation. Terrestrial efforts continued to assimilate data for Georgia and to provide methodology guidelines for the data collection efforts in Virginia and Texas. In addition, work was ongoing to develop the costing algorithms for the region.

SECARB's Geologic Sequestration Working Group (GSWG) established a logical step-wise process to collect data and information to characterize the region, identify the potential target areas for sequestration, and define the most promising targets for Phase II project work. The first step focused on characterization at the macro level for the region. Subsequent characterization steps focused on refining the initial data, identifying gaps in the data, and narrowing the field investigation to smaller areas having high sequestration potential.

Initial, minimum data sets were established to include geographical parameters to aid in locating the potential sinks. From public databases, the smallest geographical entity most consistently available for establishing data location was the county name, so initial maps were developed on a county basis.

Initial priority technical parameters, i.e., relevant geologic parameters, were defined which included formation depth, thickness, and porosity. Additional data were collected simultaneously on permeability, formation fluid saturations, pressures, productive areas, and area geology when available.

As expected, many data gaps were apparent across the very large 11-state region during the initial characterization effort. Information should be sufficient, however, for identifying areas with significant potential for sequestration. The Geologic Sequestration Working Group established a logical step-wise process to collect data and information to characterize the region, identify the potential target areas for sequestration, and define the most promising targets for Phase II project work.

The first step was a macro-level, dimensional, geographic identification of areas and particular geologic formations with sequestration potential. These areas and their associated geological formations comprised the targets for geologic data-mining. Three primary data sets were developed from public data, each set focusing on one of the main types of geologic sinks for sequestration, namely saline formations, coal seams, and oil & gas reservoirs.

Several thousand data records have been collected to date, and data continue to be gathered, refined, and synthesized in an attempt to acquire the most-relevant datasets possible. The data have been and continue to be incorporated into a GIS database for use in identification of priority areas for conducting Phase II activities.

State geological surveys are providing additional data, but we expect gaps to continue to exist in the database. Some areas, for example, have not been adequately studied and, therefore, little or no data are available. The expectation, however, is that the data will be adequate to focus detailed evaluation efforts on a number of areas within the region. Figure ES – 1, for example, shows a preliminary map indicating large areas in the region with multiple oil or gas producing formations present. Figure ES – 2 illustrates the extent of saline formations across the SECARB area. Figure ES - 3 shows the coal areas of the SECARB region, prior to Texas and Virginia joining the Partnership.

Figure ES-1. Number of Oil and Gas Formations in the Southeast Region by County.

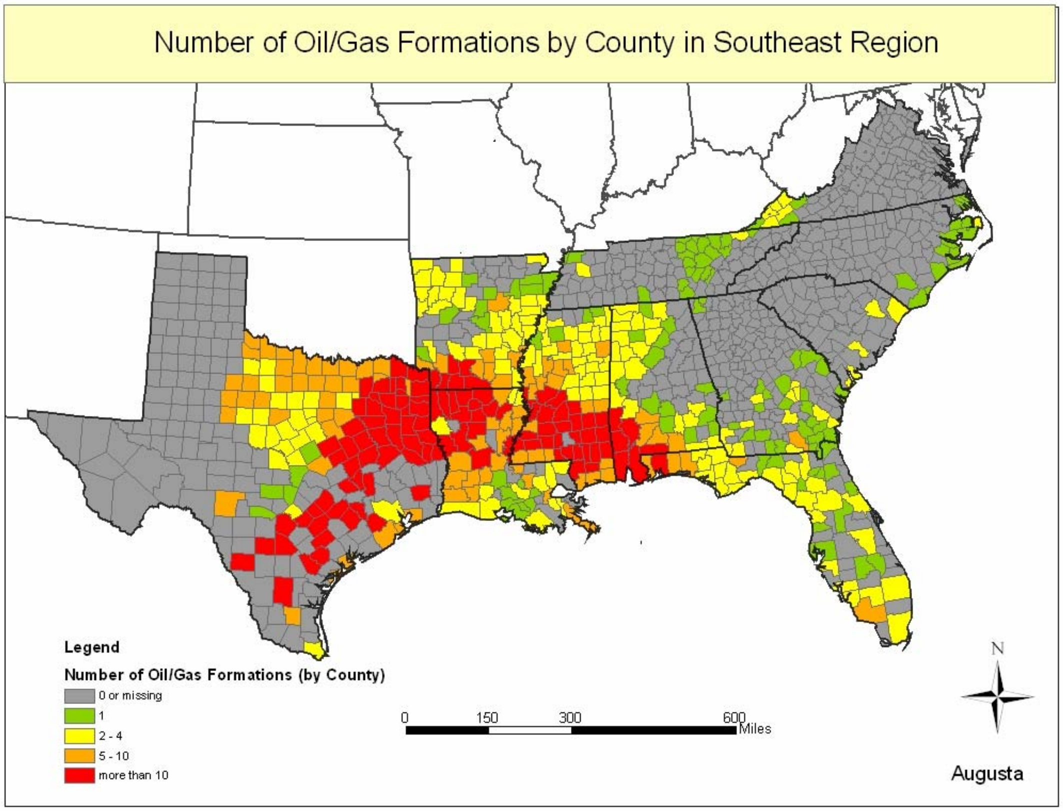


Figure ES–2. Saline Formations in the Southeast.

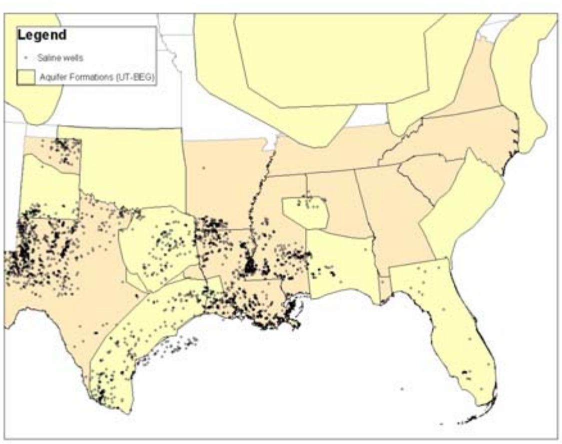
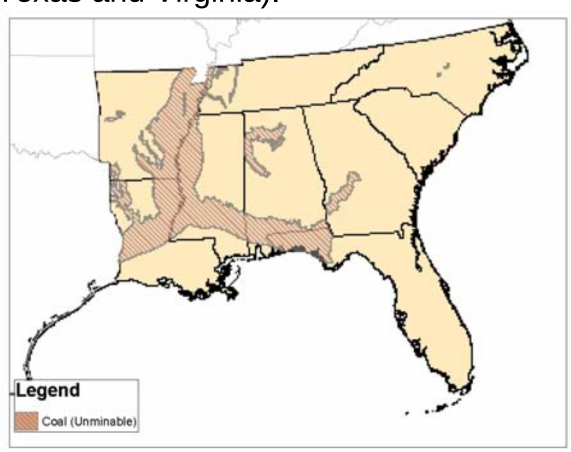


Figure ES–3. Coal Formations in the SECARB region (prior to adding Texas and Virginia).



The SECARB region is a very large region to characterize on the whole at the same precision necessary for selection of specific sequestration targets. Thus, the stepwise approach to narrow the focus to areas warranting further investigation is a more practical approach. The next steps will refine and evaluate the geological information in conjunction with carbon sources and infrastructure analysis, and will allow SECARB to identify areas of opportunity for effective sequestration activities.

Virginia Tech joined SECARB in April 2004. Research conducted at Virginia Tech supports the objectives of the SECARB project to explore solutions for the capture, transport and storage of anthropogenic fossil fuel carbon dioxide emissions in the southeast region.

The primary focus of the Virginia Tech effort is to characterize the carbon dioxide sources, sequestration sinks and transport options for the Commonwealth of Virginia. The eventual goal of this project is to identify the most promising terrestrial and geological carbon sequestration options within Virginia.

The terrestrial characterization portion of this research is progressing according to the submitted schedule. Model runs of the “modified” Winrock method and Tier 1 land management options are currently proceeding, while model runs for Tiers 2 and 3 are in progress.

The geological characterization objectives of the project are conducted in a joint effort by the Virginia Center for Coal and Energy Research, Virginia Tech and Marshall Miller and Associates.

Preliminary analyses of this work indicate that coalbeds in southwest Virginia have significant potential for carbon sequestration, particularly in Buchanan, Dickenson and Wise counties. Regional mapping also suggests carbon sequestration potential in adjoining West Virginia and Kentucky counties.

Work has also been completed towards the development of a transportation infrastructure database, including a network of commercial pipelines, power lines, roads and railroads throughout the Commonwealth. In addition, the U.S. Environmental Protection Agency’s (EPA) eGRID2002 database was analyzed for power plants near potential carbon sequestration sites.

Future work will focus on completing the regional geologic mapping of the southwest Virginia coalfields, with particular emphasis and detail on the target high carbon sequestration potential counties. Work will also expand into the characterization of conventional natural gas reservoirs and saline aquifers that may have sequestration potential within the Commonwealth.

The Texas Bureau of Economic Geology has completed activities in fulfillment of its scope and tasks during this semiannual period. These activities supported the SECARB’s work in completing the DOE objectives focusing on exploring solutions for the capture, transport and storage of anthropogenic fossil fuel carbon dioxide emissions in the southeast region**.** Major completed efforts during this semiannual period have been the geological characterization of Texas oil and gas reservoirs. These have been created as GIS data layers to add to the previously created brine formation data layers. Continued progress is expected in the next quarter in terms of finalizing the subcontracts to Louisiana Geological Survey (LGS) and Mississippi Mineral Resource Institute (MMRI) to initiate geological characterization of Louisiana and Mississippi oil and gas reservoirs. Terrestrial sequestration potential will also be examined in the next quarter. Participation in SECARB and DOE activities such as meetings and national CO_2 sequestration forums will continue during the next year.

As part of its mission, SECARB has a goal to develop action plans to overcome the issues identified in the preliminary assessment of safety, regulatory, permitting, and accounting frameworks within the region to allow for wide-scale deployment of promising terrestrial and geologic sequestration approaches, including, with reference to geologic sequestration, specific capture, transport, injection, and storage approaches. During its first year, SECARB has worked to advance this goal and the overall mission.

Project team members have performed research and analysis of the relevant state and federal statutes and regulations applicable to sequestration regulatory, permitting, and safety matters. This research involved direct examinations of applicable statutes and regulations related to both geologic and terrestrial sequestration applications, as well as interaction with state legislators and regulators responsible for enacting and implementing regulatory regimes. Also, SECARB team members are working with the Interstate Oil and Gas Compact Commission (IOGCC) Task Force on Geologic Carbon Sequestration to ensure that SECARB approaches would converge with recommended national approaches. In addition, the project team investigated emerging, potentially SECARB-applicable, greenhouse gas (GHG) accounting frameworks.

To meet the public outreach and education goals of SECARB, year one efforts sought to conduct a preliminary assessment of public perception regarding the SECARB effort and develop a follow-on plan focused on undertaking in-depth research that would serve to assist in the development of the formal action plans for public outreach and education required for successful completion of the Phase I activities.

Areas of the report focus on: Baseline Research and Training Activities; Early Stage Meetings and Briefings; the SECARB Integrated Outreach Strategy; and, Stakeholder Needs Analysis: In-Depth Survey Research Activities. These activities were performed to meet the requirements of SECARB Subtask 3.2, which focused on performing a preliminary assessment of public perceptions of carbon sequestration and developing a strategy and plan for advancing the development of a formal action plan for outreach under SECARB Subtask 6.5.

Experimental

Due to the nature of the project, no experimental methods, materials or equipment are necessary.

Results and Discussion

The primary tasks in the Partnership's Phase I scope of work are: (1) Define the Geographic Boundaries; (2) Characterize the Region; (3) Identify and Address Issues for Technology Deployment; (4) Develop Public Involvement and Education Mechanisms; (5) Identify the Most Promising Capture, Sequestration and Transport Options; and (6) Prepare Action Plans for Implementation and Technology Validation Activity.

Task 1: Define Geographic Boundaries

The geographic boundaries of SECARB were expanded by two states (Virginia and Texas) during the previous semiannual reporting period. Special attention is being given to the integration of Virginia and Texas activities into the overall SECARB region. The geographical boundaries currently include the states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas and Virginia.

Task 2: Characterize the Region

As part of the ***Regional Characterization Activities***, SECARB is reviewing its initial CO_2 emissions inventory and verifying the accuracy of source data going into the inventory. Identifying power plant sites that the Partnership will concentrate on is an immediate priority. SECARB continues to review pre-combustion, post-combustion and oxygen-fired technologies for separating and capturing CO_2 emissions.

Work continues to determine purity requirements for pipelines, enhanced oil recovery (EOR), coalbed methane (CBM) recovery and deep saline formations. During the next quarter SECARB will receive and analyze data from the EPRI Test Center Program (based upon a current list of approximately four candidate test center host-company/location options).

The Massachusetts Institute of Technology continues to receive data and check it locally. Source data on the MIT server has been linked to the DOE National Carbon Database (NATCARB), a national database covering all regional carbon sequestration partnerships.

The main work on ***transport options*** is completed and is related to an EPRI project on CO_2 Test Centers where several power plants in the region have been characterized for transport options.

SECARB is working with MIT to utilize GIS tools that have been developed or are currently under development by the MIT research group for carbon sequestration analysis. These tools include algorithms for: (1) calculating CO_2 storage capacity; (2) estimating CO_2 injectivity and injection cost; (3) estimating CO_2 pipeline transportation cost; and (4) matching CO_2 sources and sinks.

Models are under development at MIT that enable the SECARB team to link various potential source and sink locations. The model is used as a demonstration tool for optimizing pipeline routings for source-to-sink interconnections.

SECARB continues to compile geologic data on ***potential sinks for CO_2***, including coal seams, gas and oil fields and deep saline formations. The process allows for an informed characterization of the region which then will allow the SECARB to identify the potential target areas that pose the optimum sequestration opportunities as well as define the most promising target areas for Phase II field work. Criteria for data criticality and data precision criteria have been developed and are being implemented. Overlay development is being coordinated with the MIT GIS project.

Regional Sources

This report summarizes the current status of the CO_2 database for the SECARB GIS. Eight major stationary source categories are being characterized and quantified for the project: power plants, oil and gas processing, refineries, ammonia plants, hydrogen production, ethylene and ethylene oxide plants, iron and steel plants and cement plants. These sources were characterized for the original SECARB member states plus Virginia and Texas. So far, we have focused on the three most important sources for the Southeast region: power plants, refineries and gas processing facilities. The status of each category is outlined in Table 1.

Data collected by ECOFYS was used as a preliminary dataset for the GIS database, except for power plants, which uses the 2002 EPA eGRID database. The work outlined in this report, focuses on replacing sections of this database with data sources that are more current and of higher detail. Many of the data sources used in the ECOFYS database were re-visited, including information from the Oil and Gas Journal Gas Processing Survey. In addition, information was collected from new sources, including the U.S. Geological Survey (USGS) Organic Geochemistry Database, and the DOE Energy Information Agency (EIA).

This report outlines the progress of updating the GIS database with new information sources. At the time of this report, the databases for refining and gas processing facilities have been revised and updated.

Table 1. Summary of CO_2 Source, Data Sources and Status.

CO_2 Source	Data Sources	Status
Power plants	US Environmental Protection Agency eGRID Database http://www.epa.gov/cleanenergy/egrid/index.htm	-Best data source identified -CO_2 emissions estimated -Plants located -Database to be updated when 2004 data released (expected spring 2005)
Refineries	US Department of Energy – Energy Information Administration http://www.eia.doe.gov/oil_gas/petroleum/data_publications/refinery_capacity_data/refcapacity.html	-Best data source identified -Plants located -Need method to estimate CO_2 emissions from capacity data
Gas processing facilities	Oil and Gas Journal Worldwide Gas Processing Survey (2003) http://orc.pennnet.com/surveys/aboutsurveys.cfm USGS Organic Geochemistry Database http://energy.cr.usgs.gov/prov/og/ (well CO_2 levels)	-Best data sources identified for gas processing capacity and well CO_2 levels -Majority of facilities located -Need method to estimate CO_2 emissions from capacity and well data
Ammonia plants	ECOFYS Report – Building the Cost Curves of CO_2 Storage, Part 1: Sources of CO_2 (July 2002)	-Best source to be determined
Hydrogen production	ECOFYS Report – Building the Cost Curves of CO_2 Storage, Part 1: Sources of CO_2 (July 2002)	-Best source to be determined
Ethylene and ethylene oxide plants	ECOFYS Report – Building the Cost Curves of CO_2 Storage, Part 1: Sources of CO_2 (July 2002)	-Best source to be determined
Iron and steel plants	ECOFYS Report – Building the Cost Curves of CO_2 Storage, Part 1: Sources of CO_2 (July 2002)	-Best source to be determined
Cement plants	ECOFYS Report – Building the Cost Curves of CO_2 Storage, Part 1: Sources of CO_2 (July 2002)	-Best source to be determined

Power Plants

The current database uses 2002 EPA eGRID data for refinery capacities, locations, and CO_2 emission rates. The EPA updates the eGRID database every 2 years; the last update (with 2002 data) was released May 2003. This data source is the best available for this category, and the database will be updated to 2004 data when available (expected spring 2005).

Oil and Gas Processing Facilities

The ECOFYS database used data from the 2001 Oil and Gas Journal Worldwide Gas Processing Survey. In addition to gas processing capacity, the ECOFYS database lists latitude/longitude locations for most gas processing facilities. The locations were determined with the use of the USGS Geographic Names Information System (GNIS). This system was used to convert place names associated with each gas processing facility into latitude/longitude coordinates.

The database for this project has been updated with the most recent (2003) Oil and Gas Journal Worldwide Gas Processing Survey. A summary of the 298 gas processing facilities listed in this survey is shown in Table 2.

Table 2. 2003 Oil and Gas Journal Gas Processing Facilities Data.

State	Number	Gas Capacity (MMCFD)			
		Total Capacity by State (annualized, per day)	Total Throughput by State (annualized, per day)	Individual Facility Capacity	
				Mean	Max
Alabama	13	1377	670	106	600
Arkansas	5	876	519	175	850
Florida	1	90	17	90	90
Georgia	0				
Louisiana	75	18811	11953	251	1850
Mississippi	9	1876	926	208	900
North Carolina	0				
South Carolina	0				
Tennessee	2	8	0	4	5
Texas	193	16686	11510	86	950
Virginia	0	0	0		
Total	298	39724	25595	133	1850

The spatial coordinates of the gas processing facilities were determined by cross-referencing with data in the ECOFYS database. The location of 262 of the 298 gas processing facilities were located using this method, and are plotted in Figure 1.

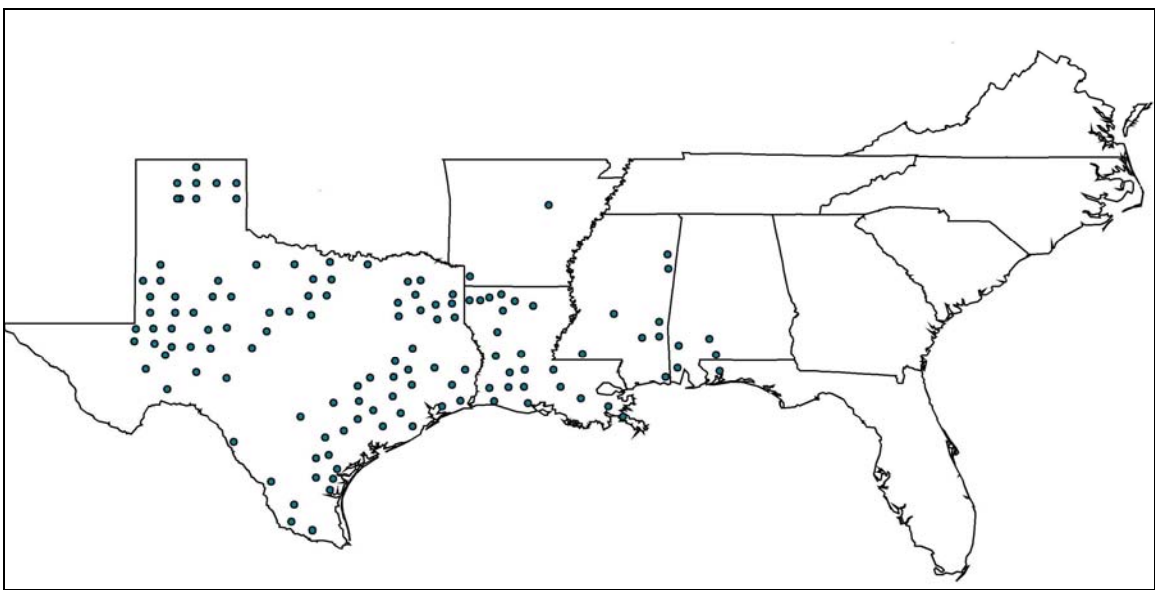


Figure 1. Locations of Gas Processing Facilities (several points represent multiple facilities).

The remaining 36 facilities that were not located by cross-referencing the ECOFYS database will be located by using the USGS GNIS system.

To determine CO_2 emission rates from each gas processing facility, the CO_2 concentrations of gas from wells within a specified radius of each facility is being evaluated. Preliminary information was obtained from the U.S. Geological Survey Organic Geochemistry Database, which lists gas properties for approximately 4400 gas wells that have been drilled in the study area. Figure 2 shows the location of all wells and Figure 3 shows the location of wells with CO_2 concentrations higher than 2.5 %.

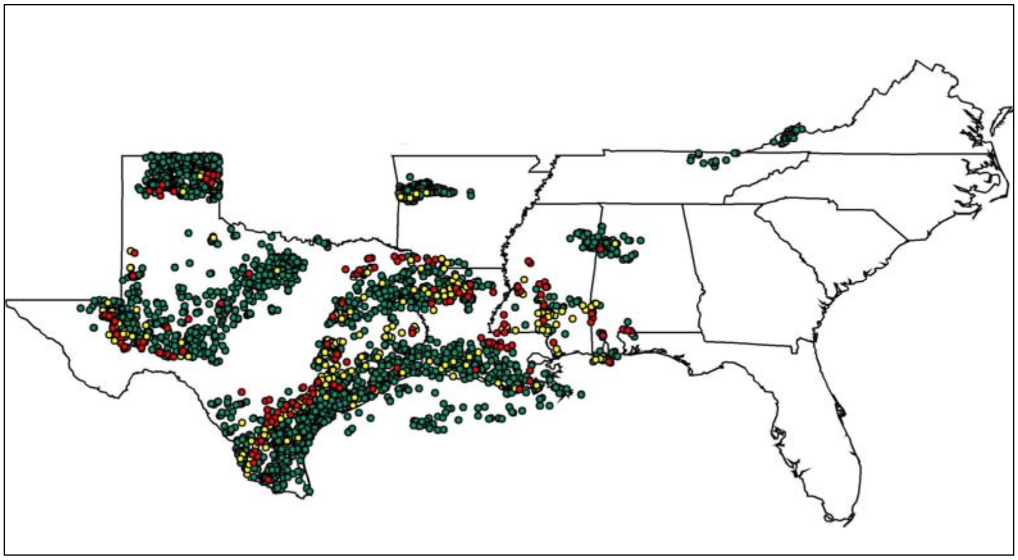


Figure 2. Location of All Gas Wells in Study Area.

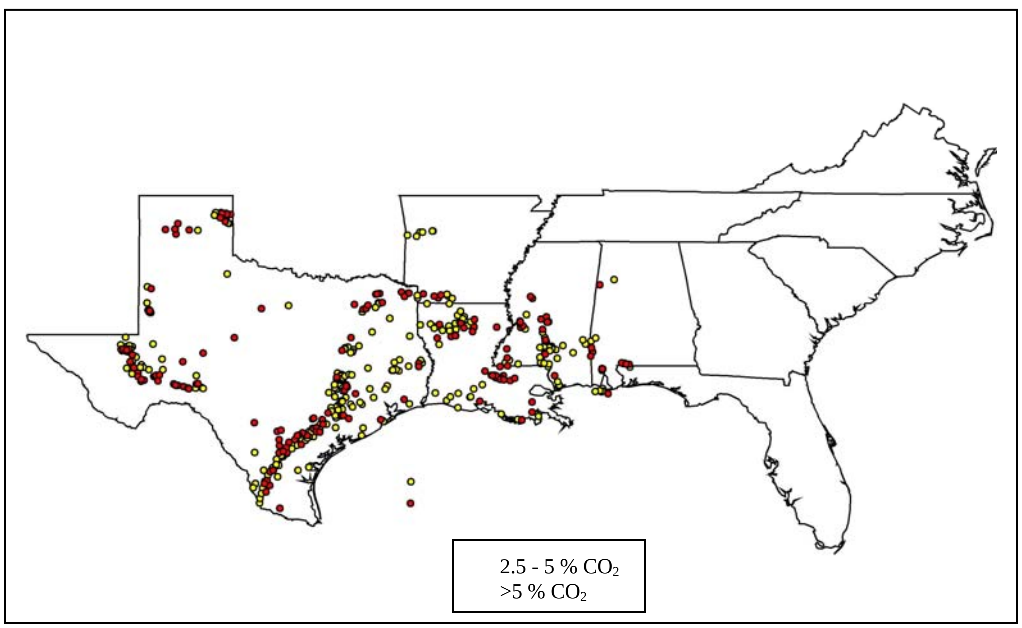


Figure 3. Location of Wells in Study Area with Higher CO_2 Concentrations.

Plants do not explicitly report CO_2 emissions. We will attempt to estimate the emission levels from each plant from the CO_2 concentration of gas from the wells surrounding each facility (see Figure 4). This method will identify the facilities with the highest potential CO_2 emissions, and allow us to contact these facilities directly to confirm actual CO_2 emission levels.

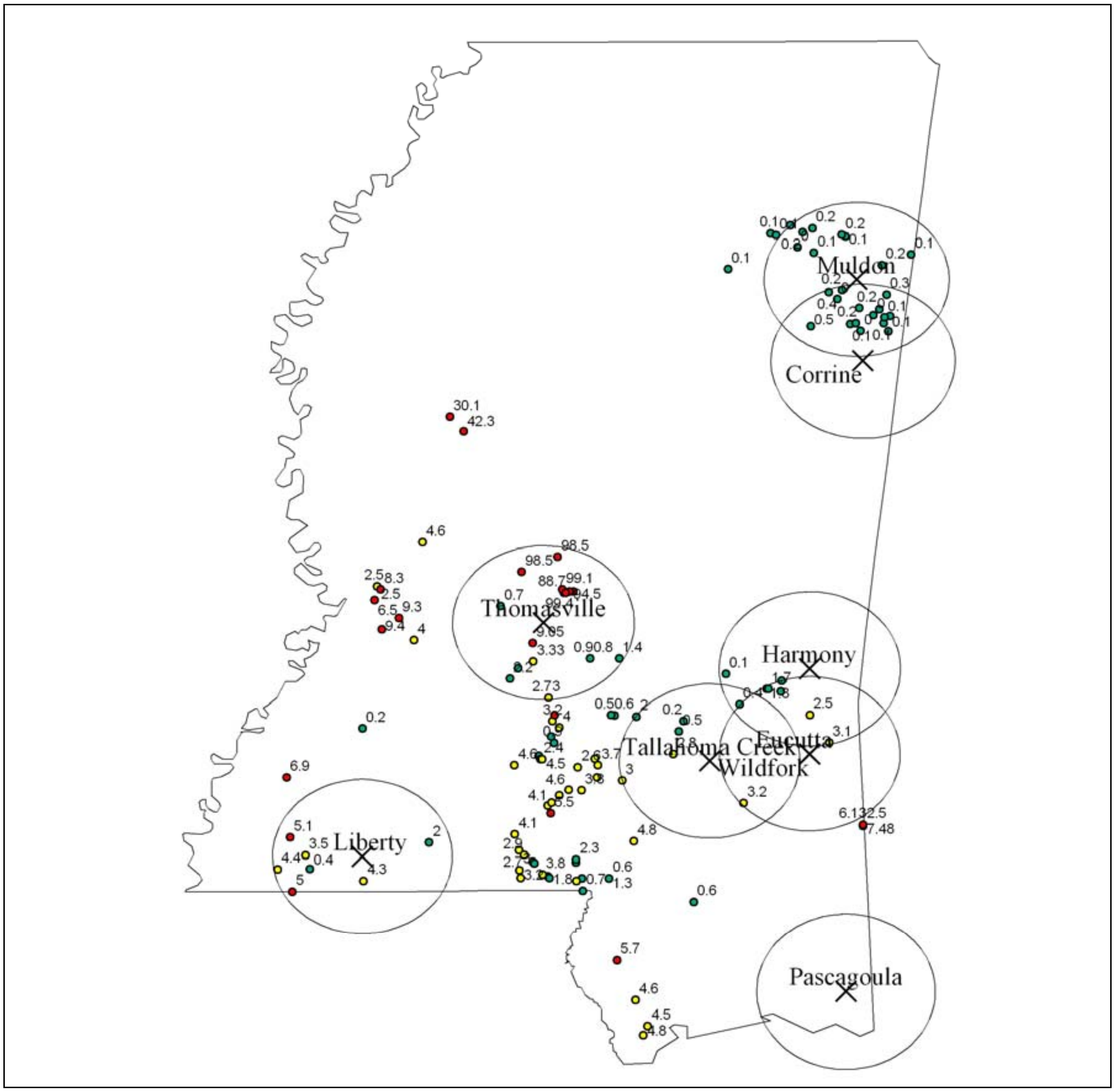


Figure 4. Location of Gas Wells, Processing Facilities, Well CO_2 concentrations and 25 mile radius markers for Mississippi (two facilities share common location).

Refineries

The ECOFYS database uses data from the 1999 Oil and Gas Journal Worldwide Refinery Survey for Refining Capacity. ECOFYS database lists latitude/longitude locations for most gas processing facilities. The locations were determined with the use of the USGS GNIS. This system was used to convert place names associated with each gas processing facility into latitude/longitude coordinates.

The GIS database was updated using 2004 DOE Energy Information Agency published data. A summary of the data is presented in Table 3.

Table 3. 2004 EIA Refinery Data.

State	Number of Refineries	Refining Capacity (barrels/day)			
		Total Calendar Day Capacity by State	Total Stream Day Capacity by State	Individual Refinery Calendar Day Capacity	
				Mean	Max
Alabama	3	130,200	140,500	43,400	80,000
Arkansas	2	69,800	74,800	34,900	63,000
Florida	0				
Georgia	2	33,400	40,000	16,700	28,000
Louisiana	17	2,753,320	2,885,355	161,960	493,500
Mississippi	4	364,800	393,300	91,200	325,000
North Carolina	0				
South Carolina	0				
Tennessee	1	180,000	182,000	180,000	180,000
Texas	24	4,468,490	4,705,980	186,187	557,000
Virginia	1	58,600	61,800	58,600	58,600
Total	54	8,058,610	8,483,735	149,234	557,000

The spatial coordinates of the gas processing facilities were determined by cross-referencing with data in the ECOFYS database. Forty-six of the 48 refineries in the study area were located using this method, and are shown in Figure 5.

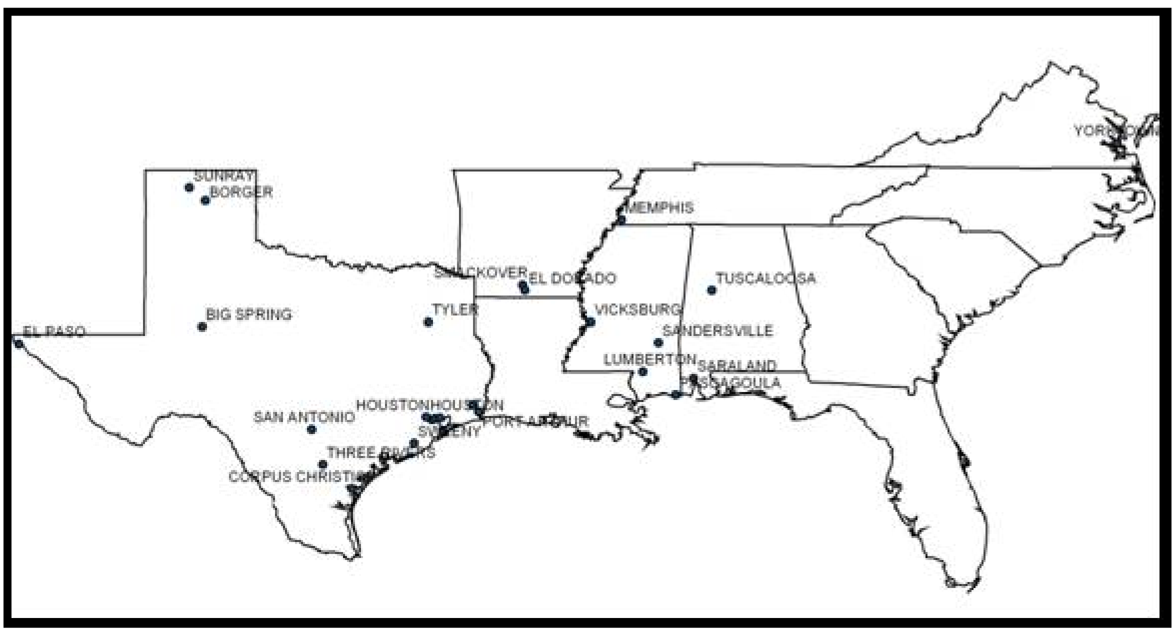


Figure 5. Location of Refineries (note – several points represent multiple facilities).

Further work is required for refineries in determining more appropriate CO_2 emission factors for each facility. The ECOFYS uses an emission factor based solely on total capacity, and does not provide any variation for the type of processes in use at each refinery.

Regional Sinks

Terrestrial Sequestration

In 2002, Winrock International began analysis on the terrestrial carbon sequestration opportunities in the three-state region of Arkansas, Louisiana and Mississippi. Detailed analyses using a GIS and extensive fieldwork across the forests and marginal agricultural lands of the Lower Mississippi River Valley region were conducted. The results were submitted to the Electric Power Research Institute and associated organizations (Winrock International 2003). Subsequently, a similar study and report is being developed to include the state of Georgia in this pilot work (Winrock International 2004). The four states (Arkansas, Louisiana, Mississippi and Georgia) analyzed with support from EPRI are hereafter referred to as the Pilot Region.

Winrock International was tasked by SECARB to extend the methods and lessons learned from the Pilot Region to the remaining five states (Region II) of Alabama, Florida, North Carolina, South Carolina and Tennessee (Figure 6) in order to conduct an assessment of the terrestrial carbon sequestration opportunities across the region. This document reports the progress thus far on the analysis of Georgia and the completion of the overall regional assessment. Texas and Virginia are depicted as the Expanded Region States in Figure 6.

Figure 6. SECARB States and Terrestrial Sequestration Analysis Schedule.

Carbon Sequestration Potential on Agricultural Lands

Two categories were developed for investigating the carbon storage potential of agricultural lands in the region: afforestation of marginal agriculture lands (including a separate component for grazing lands) and conversion to no-till land tenure systems. Marginal agriculture areas are prone to poor agriculture practices because they frequently flood, have a high slope or have other surface soil conditions that prohibit production. The amount of carbon that can be expected to be sequestered on lands for 20, 40 and 80-year projects is calculated. The analysis of no till tenure systems identifies the amounts of carbon that could be sequestered if the crops of corn, soy and wheat were converted to a no till land tenure system.

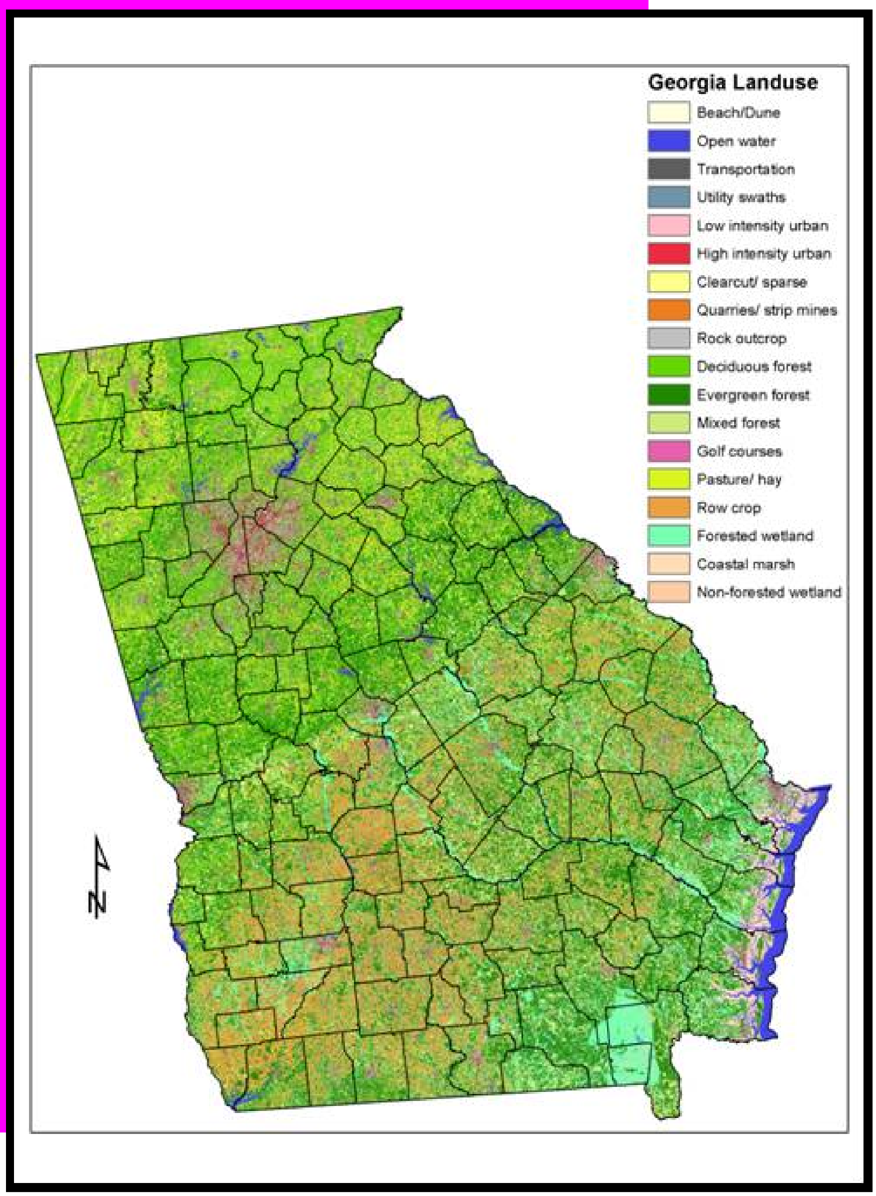


Figure 7. Map of Georgia showing the land-use/land-cover classes for 1998 (from University of Georgia, NARSAL classification).

Identification of Marginal Agricultural Lands

The analysis uses a mosaic of National Land Cover Dataset (NLCD) tiles (Figure 8), which includes row crops, small grains, grasslands and pasture/hay land-use types. In the case of Georgia an updated landcover map from 1998 was used (Natural Resources Spatial Analysis Laboratory or NARSAL - http://narsal.ecology.uga.edu/glut.html). Lands that are prone to frequent and long-term flooding, slopes over a 10% incline and soils that are either rocky or have hardpan close to the surface have been identified and classified as 'marginal' because of their decreased productivity and/or need for more expensive land management. A basic flowchart of the method used to categorize these marginal lands is depicted in Figure 8.

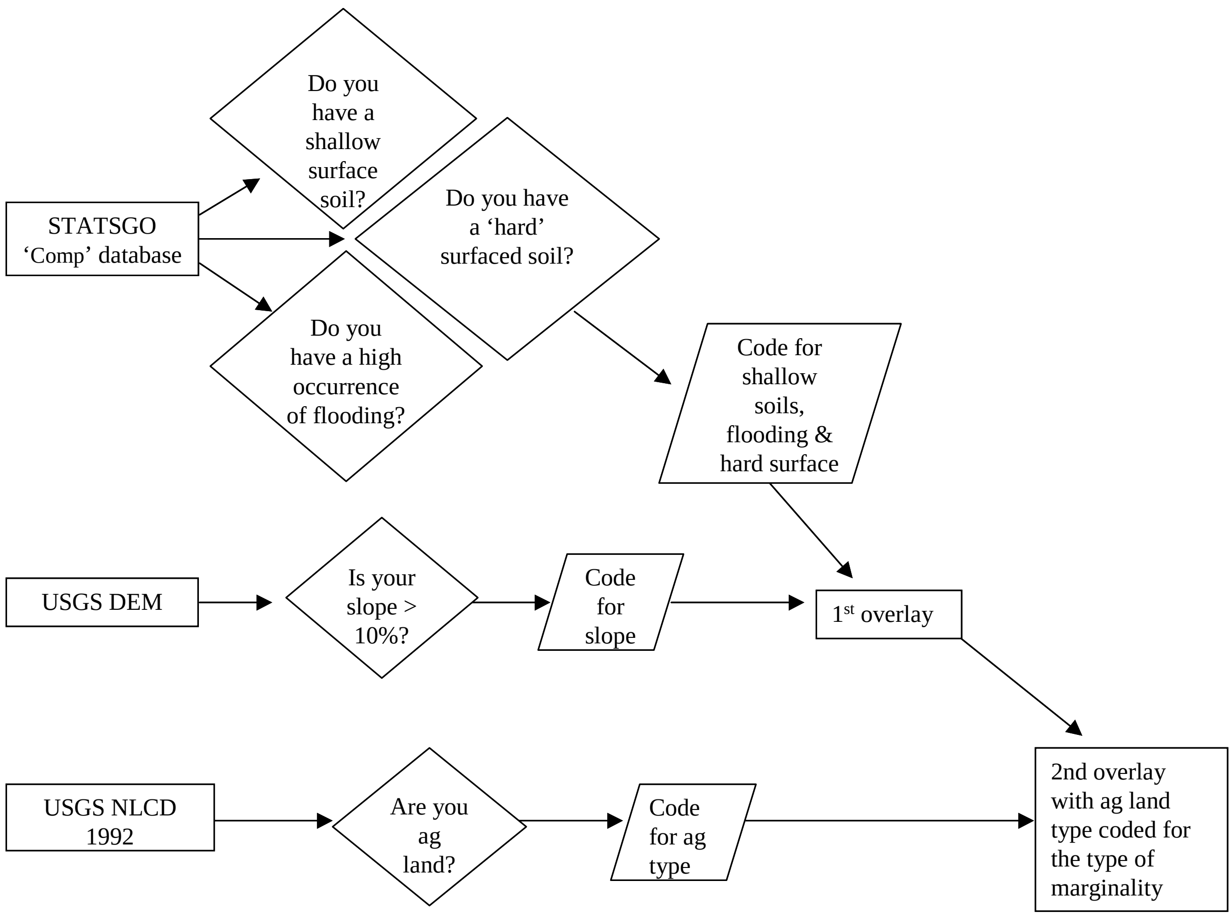


Figure 8. Flowchart of the Methodological Steps in Identifying Marginal Agricultural Lands Based on Flood Frequency and Duration, Soil Characteristics and High Slopes.

The model that identifies marginal agricultural lands combines data from the State Soil Geographic (STATSGO) database for soil characteristics, flood frequency and duration, a digital elevation model (DEM) and a land cover map. The model selects areas with high rock content soils, shallow soil, high slopes (greater than 10 %), and high frequency and duration of floods.

The STATSGO database was queried and selected for soil characteristics thought to have a negative impact on agricultural productivity. The soils having hardpan close to the surface (panhard = yes & pandeph = lt12) and the soils having a high rock content near the soil surface (rockhard = hard & rockdeph = lt12) were separated.

The STATSGO database was also used to delineate areas with high flood probability and long duration. Areas with highest flood frequency were identified with the attribute annflod = frequent or occasional. Duration was determined with the attribute anflodur = very long or long. Investigation concluded that areas with a high frequency and very long duration, high frequency and long duration and occasional frequency with very long duration could accurately depict marginal agricultural areas suitable for planting bottomland hardwood tree species (greater than 69%, as quantified by an overlay between flood frequency and predominant tree species). The areas of frequent flooding with very long duration, frequent flooding with long duration, and occasionally flooding with very long duration were identified as candidates.

A composite 7.5-minute DEM was acquired from USGS. Slope was calculated as the percent slope between adjacent cells with values ranging from 0 to 90%. This database was then reclassified for areas which had a greater than 10 % slope. The NLCD database was queried for those grid cells that had pasture/hay, row crop, small grains or grassland classes. The reclassified database had the classes of pasture/hay, row crop, small grains, grassland and a separate class that encompassed all non-agriculture classes.

Quantifying Carbon Sequestration Potential on Marginal Agricultural Lands

During this quarter, carbon sequestration data have been developed for Georgia from the interpretation of the data contained in the STATSGO database on predominant tree species and their site index and growth potential (http://water.usgs.gov/GIS/metadata/usgswrd/ussoils.html).

By using the predominant tree species, site index and potential yearly growth it was possible to develop growth curves that estimated carbon (or biomass) through time (20, 40 and 80 years). Allometric equations were prepared by Winrock International foresters using data gathered during field expeditions in bottomland hardwood stands in the region and a review of the pertinent literature sources. An example is shown in Figure 9 for 40 years.

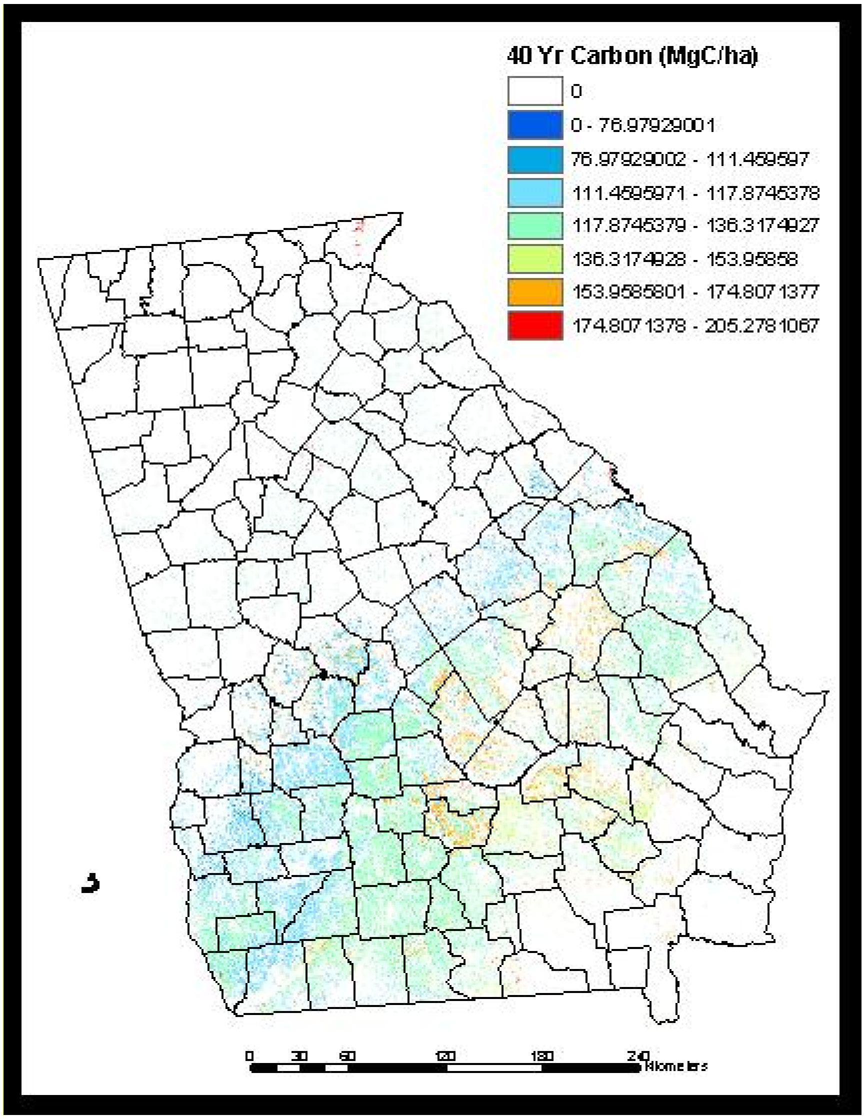


Figure 9. Map of Georgia showing the distribution of the amount of carbon sequestered after 40 years, in t C/ha, for afforestation activities on marginal aglands.

Grazing Management

One project category was developed for investigating the storage potential of grazing lands: afforestation. The methods are the same as those performed for afforestation of agricultural lands with the exception that they were applied to the grasslands and pasture/hay land-use types instead of the row crop/small grain designations used in the agriculture analysis. See Figure 10 for an example at 40 years.

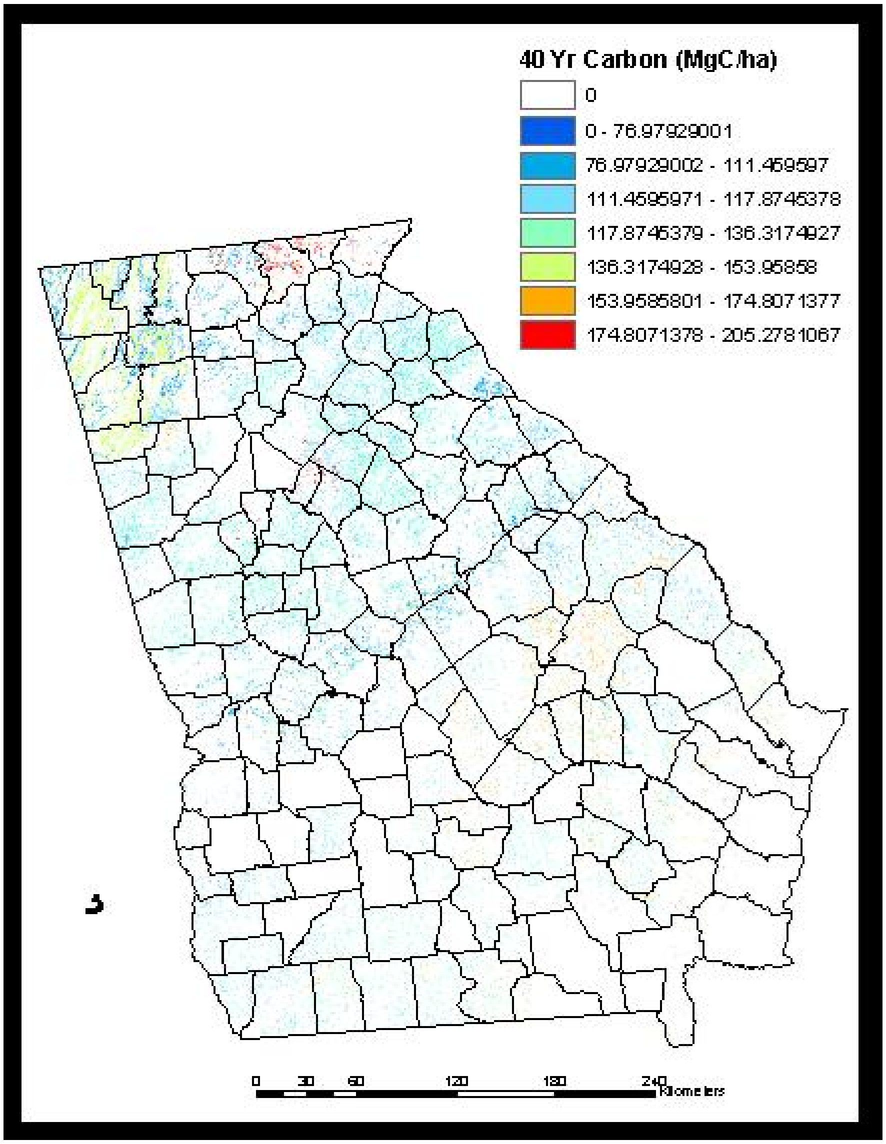


Figure 10. Map of Georgia showing the distribution of the amount of carbon sequestered after 40 years, in t C/ha, for afforestation activities on marginal grazing lands.

No-till Conversion

The total acreage of each crop type is available from the U.S. Department of Agriculture's (USDA) 1997 agriculture census (http://www.nass.usda.gov/census) at the county level only (Figure 11). Thus, to quantify carbon sequestered in the soil of row crops and small grains, a county-based analysis is being conducted. The carbon quantities are based on the 1997 county-level statistics and then applied to more spatially explicit land-use types (row crops/small grains). Post & West (2002) provide sufficient data to predict carbon sequestration from no-till conversion for the crops of corn, soybeans and wheat.

The amount of carbon sequestered by each crop type will be further adjusted with the texture of the soil on which the crop is located. Coarse soils sequester soil carbon at a decreased rate relative to finer textured soils. Thus, proportionate to their texture, soils received sequestration as measured in Post & West's 2002 report.

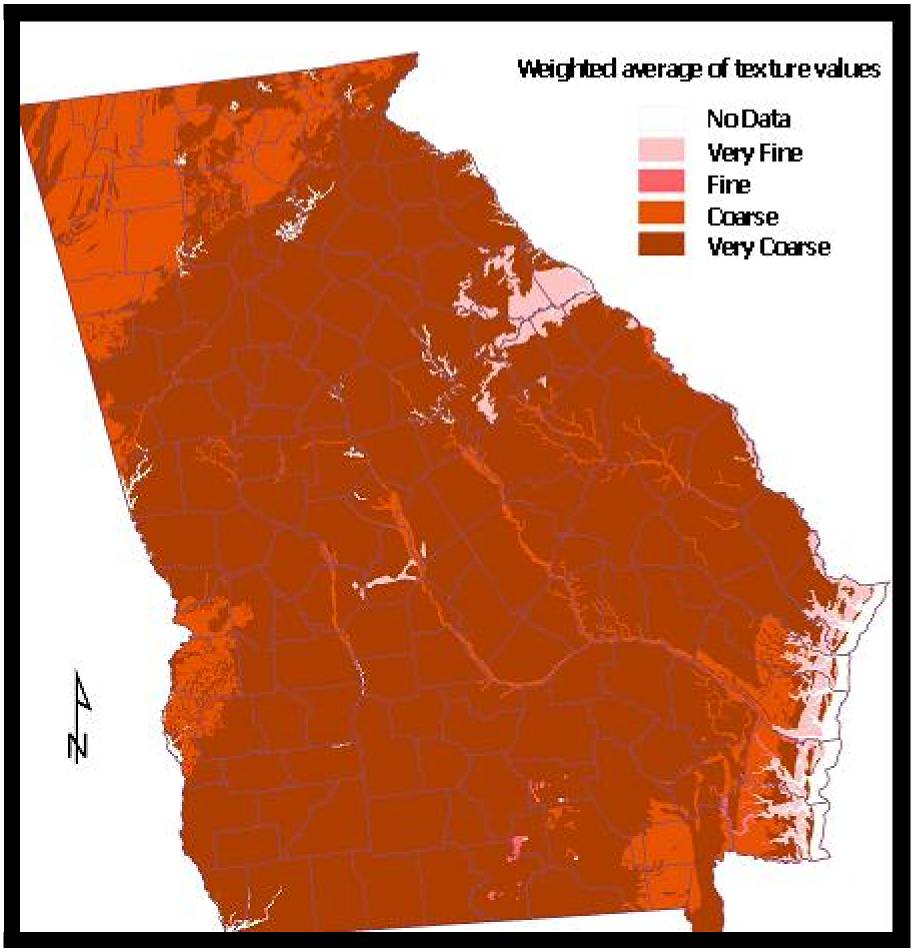


Figure 11. Soil texture map lumped into classes to be used to measure soil carbon sequestration.

<u>Terrestrial Sequestration Linked with Biomass Cogeneration</u>

In regions with marginal agricultural or grazing lands, afforestation activities could create potential new sources of fuel for biomass cogeneration at existing coal-fueled power plants. In areas of existing forest-cover, forest management activities could also contribute fuel for biomass cogeneration. The net carbon sequestration of planted trees would be added to the expected carbon benefits of reduced coal burning in the nearby power plants.

The eGrid dataset was acquired from Dr. Howard Herzog of the Massachusetts Institute of Technology's Lab for Energy and the Environment. Biomass and coal-burning plants have been mapped in the SECARB region. Winrock staff experimented with different methods for identifying the potential quantity of fuel that might be available from terrestrial sequestration activities around power plants.

Geologic Sequestration

SECARB's Geologic Sequestration Working Group established a logical step-wise process to collect data and information to characterize the region, identify the potential target areas for sequestration, and define the most promising targets for Phase II project work.

Step 1, initially completed during this reporting period, was a macro-level, dimensional, geographic identification of areas and particular geologic formations with sequestration potential. These areas and their associated geological formations comprised the targets for geologic data-mining. Three primary data sets were developed from public data, each set focusing on one of the main types of geologic sinks for sequestration, namely saline formations, coal seams, and oil & gas reservoirs. A minimum set of parameters were sought during this step, based at least in part on the information believed to be available. (Additional data were collected simultaneously as the opportunity presented itself.)

The minimum data sought initially included geographical parameters that would aid in locating the potential sinks (e.g.; state & county names; well location coordinates; oil, gas, or coal field names; formation names, etc.) Technical parameters included formation depth, thickness, and porosity as being most essential; while permeability, fluid saturations, pressures, productive areas, and area geology were placed at the next level of importance. The complete list of parameters and their priorities is shown in Figure 12, which uses the following indicators for data criticality and precision requirements:

- **U** -data parameter is "useful" but not "critical" to the function / step
- **VU** -data is "very useful"
- **C** -data is "essential" or "critical"
- **P1** -a relatively "low" level of "precision" is required of the parameter for this step
- **P2** -requires a "moderate" or "medium" level of precision
- **P3** -requires a "high" level of precision for this step
- **P4** -parameter should be "precise"

Figure 12. Data Requirements Analysis

Parameter	Criticality and Precision				
	Step 1	Step 2	Step 3	Step 4	Notes, Comments, Other
Field or Formation Name(s) or Identifier(s)	- - - - -	- - - - -	- - - - -	- - - - -	
Type (O, G, C, B)	C, P3	C, P3	C, P4	C, P4	
Pool	U, P2	VU, P2	VU, P3	VU, P4	
Field	U, P2	VU, P2	VU, P3	VU, P3	
Play	U, P2	VU, P2	VU, P3	VU, P3	
Formation	VU, P3	VU, P3	VU, P3	VU, P4	
Locale	- - - - -	- - - - -	- - - - -	- - - - -	
State	C, P4	C, P4	C, P4	C, P4	
County/Township/District	VU, P2	VU, P2	VU, P3	VU, P4	
Coordinates (eg, Lat-Long)	VU, P2	VU, P2	VU, P3	VU, P4	
Other (eg, x-y contours)	VU, P2	VU, P2	VU, P3	VU, P4	
Depth	U, P1	VU, P2	VU, P3	C, P3	
Depth Below Drainage (coal)	U, P1	VU, P2	VU, P3	C, P3	
Depth Map	U, P1	VU, P2	VU, P3	VU, P3	
Gross Thickness	U, P1	VU, P2	VU, P2	VU, P3	
Gross Thickness Isopach Map	U, P1	VU, P2	VU, P2	VU, P3	
Net Thickness	U, P1	VU, P2	VU, P3	C, P3	
Net Thickness Isopach Map	U, P1	VU, P2	VU, P3	VU, P3	
Cumulative Net Thickness (coal)	U, P1	VU, P2	VU, P3	C, P3	
Porosity	U, P1	VU, P2	VU, P3	C, P3	
Permeability	U, P1	VU, P2	VU, P3	VU, P3	
Heterogeneity (horizontal)	U, P1	U, P2	VU, P2	VU, P3	
Heterogeneity (vertical)	U, P1	U, P2	VU, P2	VU, P3	
Fluid Saturations	- - - - -	- - - - -	- - - - -	- - - - -	
Current O, G, W	U, P1	U, P1	VU, P2	VU, P3	
Residual Oil (Imbibition)	U, P1	U, P1	VU, P2	VU, P3	
Residual Oil (Drainage)	U, P1	U, P1	VU, P2	VU, P3	
Log, Pay Section & Overburden	U, P1	U, P1	VU, P2	VU, P3	
Reservoir Pressures	- - - - -	- - - - -	- - - - -	- - - - -	
Original	U, P1	VU, P2	VU, P2	VU, P3	
Current	U, P1	VU, P1	VU, P2	VU, P3	
Maximum	U, P1	VU, P1	VU, P2	VU, P3	
Fluid Production	- - - - -	- - - - -	- - - - -	- - - - -	
O, G, W - Individually	U, P1	U, P1	VU, P2	VU, P3	
O, G, W - Total	U, P1	U, P1	VU, P2	VU, P3	
Original Oil-in-Place	U, P1	U, P1	VU, P2	VU, P3	
Remaining Oil Reserves	U, P1	U, P1	VU, P2	VU, P3	
Number of Injection Wells	U, P1	U, P1	VU, P2	VU, P3	
Number of Production Wells	U, P1	U, P1	VU, P2	VU, P3	
Maximum Injection Rate	U, P1	U, P1	VU, P2	VU, P3	
Injected Fluid	U, P1	U, P1	VU, P2	VU, P3	
Oil Viscosity	U, P1	U, P1	VU, P2	VU, P3	
API Gravity	U, P1	U, P1	VU, P2	VU, P3	
Rock & Fluid Characteristics	- - - - -	- - - - -	- - - - -	- - - - -	
Salinity of brine	U, P1	U, P1	U, P2	U, P3	
Minerals (rock, brine)	U, P1	U, P1	U, P2	U, P3	
PVT data (brine, CO_2)	U, P1	U, P1	U, P2	VU, P3	
PVT data (oil, gas)	U, P1	U, P1	U, P2	VU, P3	
PVT data (oil, gas, CO_2)	U, P1	U, P1	U, P2	VU, P3	
Oil Formation Vol Factor	U, P1	U, P1	U, P2	VU, P3	
Formation Temperature	U, P1	U, P1	VU, P2	VU, P3	
Coal rank	U, P2	VU, P2	VU, P2	VU, P3	

Coal organic carbon content	U, P1	U, P1	VU, P2	VU, P3	
Coal ash content	U, P1	U, P1	VU, P2	VU, P3	
Coal CH4 Content	U, P1	U, P1	VU, P2	VU, P3	
Isotherms for CH4 , CO_2	U, P1	U, P1	VU, P2	VU, P3	
Geol risk / mitigation factors	- - - - -	- - - - -	- - - - -	- - - - -	
Regional faults	U, P1	VU, P2	VU, P2	VU, P2	
Reservoir, cap rock faults	U, P1	U, P1	VU, P2	VU, P2	
Regional stress orientation	U, P1	U, P1	VU, P2	VU, P2	
Cap rock permeability	U, P1	U, P1	VU, P2	VU, P2	
Cap rock thickness	U, P1	U, P1	VU, P2	VU, P2	
Total section thickness	U, P1	VU, P2	VU, P2	VU, P2	
Tot section formation types	U, P1	U, P1	VU, P2	VU, P2	
Nature of tot section seals	U, P1	U, P1	VU, P2	VU, P2	
Total section porosity(ies)	U, P1	U, P1	VU, P2	VU, P2	
Total section perm(s)	U, P1	U, P1	VU, P2	VU, P2	

Step 2 will involve refining the assessment initiated in Step 1 to eliminate obviously unacceptable areas/formations.

Step 3 will include assessing the availability and quality of essential data to identify "holes" in the existing data set and to enable the identification and ranking the target areas/formations which are most suitable for sequestration.

Step 4 will refine the data, i.e., will seek to acquire complete datasets, if possible, for the most promising sequestration opportunities. This step will be done in conjunction with source and infrastructure components of the project to identify the best combination(s) of CO_2 sources, sinks, and site attributes for constructing a sequestration test facility.

Several thousand data records have been acquired to date, and data continue to be gathered, refined, and synthesized in an attempt to acquire the most-relevant datasets possible. The data have been and continue to be incorporated into a GIS database for use in identification of priority areas for conducting Phase II activities.

The three primary datasets that were developed for SECARB initially were based on national public datasets that had been developed mainly for reasons other than sequestration; e.g., oil and gas exploration and production. For this reason, these national data sets, while containing a wealth of information, often contained only a minimum of information of direct value to the sequestration effort. The result was a substantial collection of data that could be used for a general characterization of the region, but having numerous "holes" or missing data points. This was not unexpected and additional data were sought and are being obtained from other public and private sources, primarily state databases.

Even with the additional data from the state geological surveys, it must be expected that gaps will still exist in the database. Some areas simply have not been adequately studied and, therefore, data are not available. The expectation, however, is that the data will be adequate to focus detailed evaluation efforts on a number of areas within the region. Figure 13 shows a preliminary map indicating large areas in the region with multiple oil or gas producing formations present. Data for saline formations and unmineable coal areas show similar large areas that may be suitable for geologic sequestration of CO_2. Note that Virginia and Texas were added to the region after the project was initiated and data are still being added to the database from these states.

Figure 13. Number of Oil & Gas Formations in the Southeast Region by County.

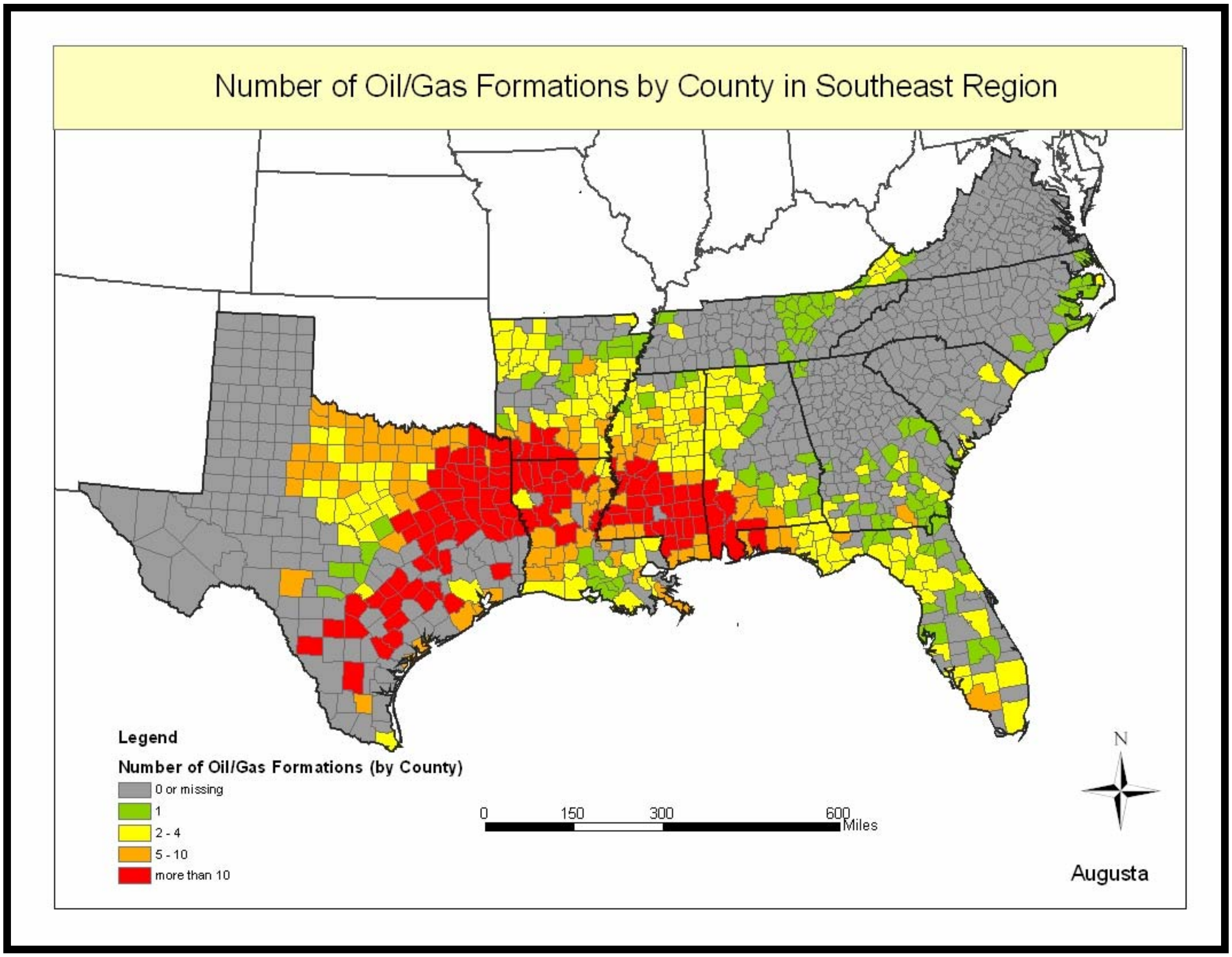


Figure 14 illustrates the extent of saline formations across the SECARB area. The large yellow blocks are based on the University of TX BEG database, while the small circles are individual well points from a U.S. Department of Energy database. The DOE database tends to confirm and extend the TX BEG data, and, together, they demonstrate a large potential for sequestration in regional saline formations.

Figure 15 shows the coal areas of the SECARB region, without Texas and Virginia, who joined the SECARB partnership after this map was generated. The coal trending westward out of Louisiana is known to extend well into Texas. Western Virginia is also an area with numerous coal deposits, coal mining activities, and coalbed methane production. Even without data from Texas and Virginia, the map shows an extensive area of coal deposits, many of which are likely candidates for sequestration.

Figure 14. Saline Formations in the Southeast.

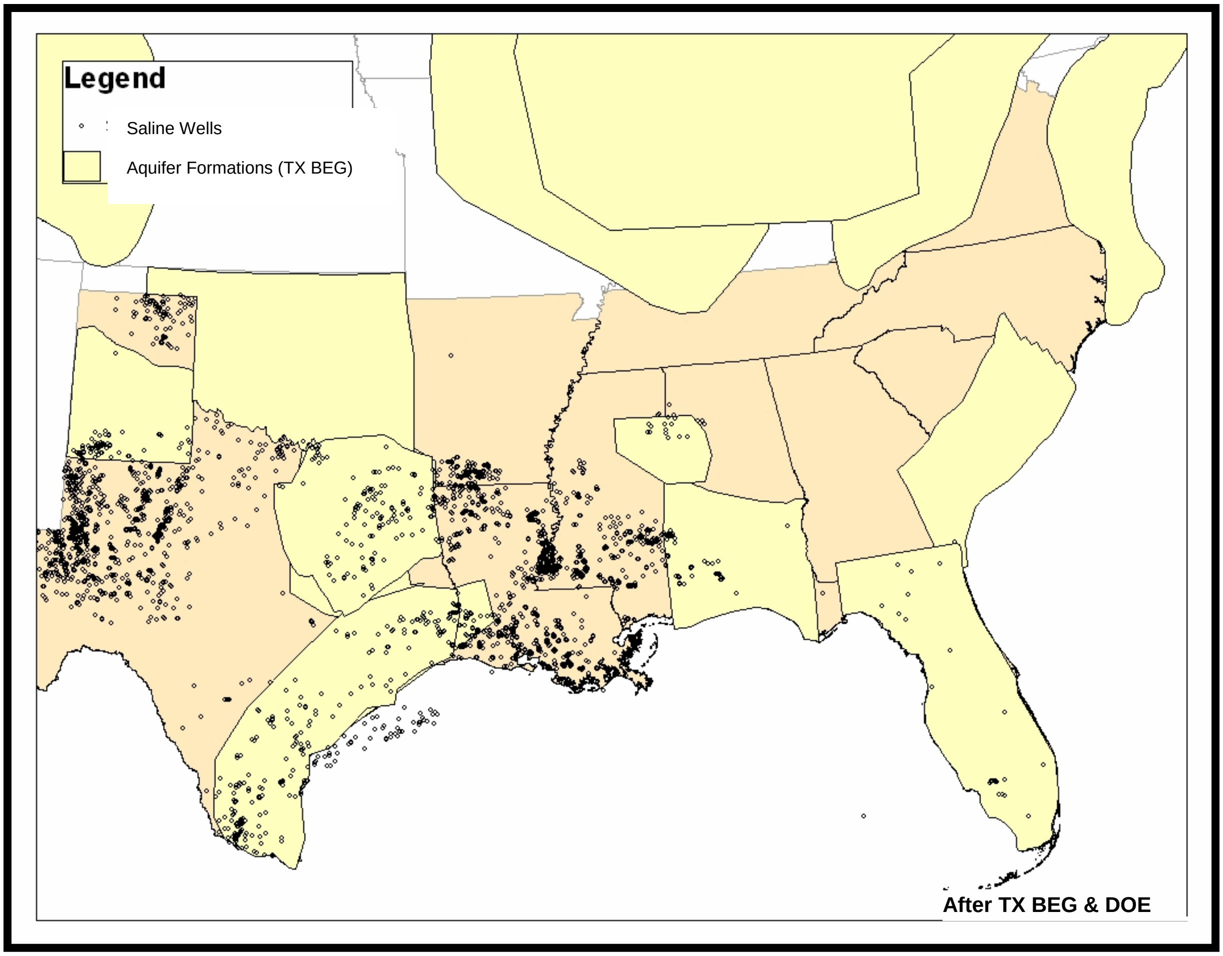
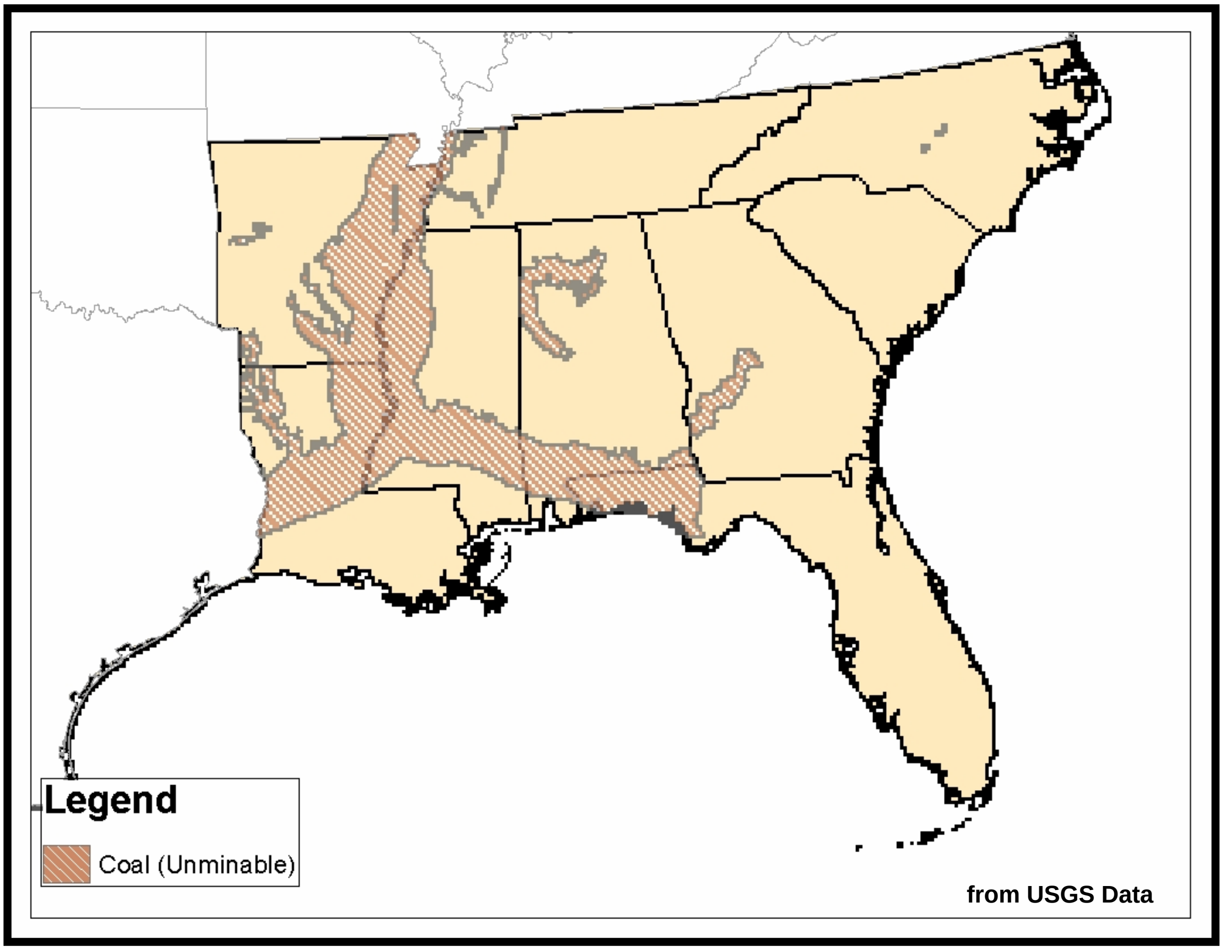


Figure 15. Coal Formations in the SECARB region (prior to adding Texas and Virginia).



Geologic Sequestration (Virginia)

Virginia Tech and Marshall Miller and Associates (MMA) have begun to characterize the Commonwealth of Virginia for potential carbon dioxide sinks, sources and transport options. The following sections outline the progress for this semiannual report ending September 2004.

Virginia Tech and Marshall Miller and Associates developed an approach to gather publicly available geologic data from the Commonwealth of Virginia and to mesh this information with proprietary data, in order to characterize coal seams, oil and gas reservoirs and saline aquifers. Significant progress has been made in identifying and collecting the publicly available data from the Virginia Division of Gas and Oil and the non-proprietary files of MMA. In order to protect confidentiality, in certain cases, final GIS data will be provided as contour lines without including individual point data.

Geologic Characterization and Assessment Approach of Carbon Sequestration Sinks (Virginia)

A geologic characterization model was developed for different levels of assessment, in order to identify areas of significant carbon sequestration potential. The characterization stages are as follows:

Macro-Level Assessment:

- Geographic Identification
- Regional Studies from Government Agencies
- Target Area Defined for Central Appalachian Basin

Regional–Level Assessment:

- Distribution of Prospective Coal-bearing Formations
- Current CBM Development
- Definition of a Target Area in Southwest Virginia

Detailed-Level Assessment:

- Data Acquisition and Processing
- Cross Section Analysis
- Regional Geologic Mapping
- Identification of Focus Areas in Virginia

Carbon Sequestration Resource Characterization Parameters for Southwest Virginia Coal Seams – Work Completed (Virginia)

A list of primary geologic indicators has been developed to assess carbon sequestration potential in coal seams. Data from the following list has been collected and archived in a GIS database:

- Coal rank
- Gas content
- Coal depth
- Reservoir thickness
- Structural setting
- Permeability

From the detailed-level assessment in the Southwest Virginia coalfields, the following maps have been prepared for the initial characterizations stage (Figures 16-24):

- Generalized stratigraphic columns of coals with sequestration potential
- Overview map of CBM wells in Virginia
- Regional coal rank map
- Regional gas content map
- Delineation of mined out areas

- Pocahontas No. 3 coal seam thickness isopachs
- Surface coal structure map
- Cross section location map

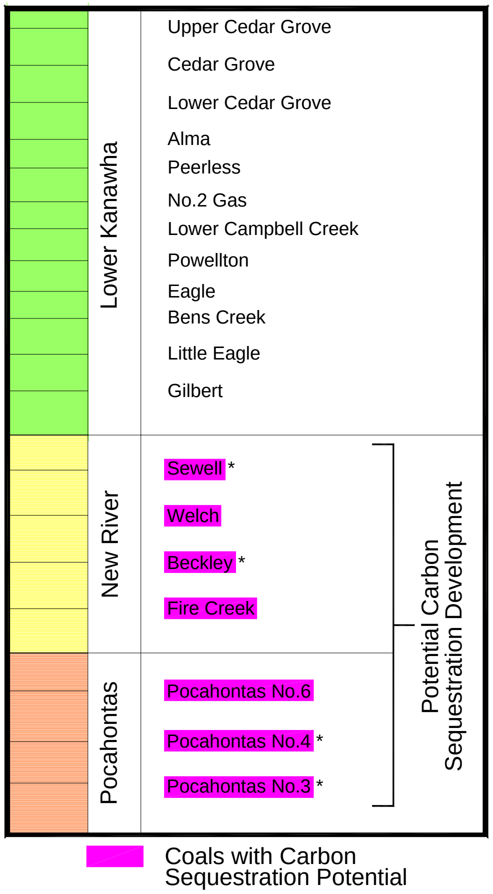


Figure 16. Central Appalachian Basin Generalized Stratigraphic Column.

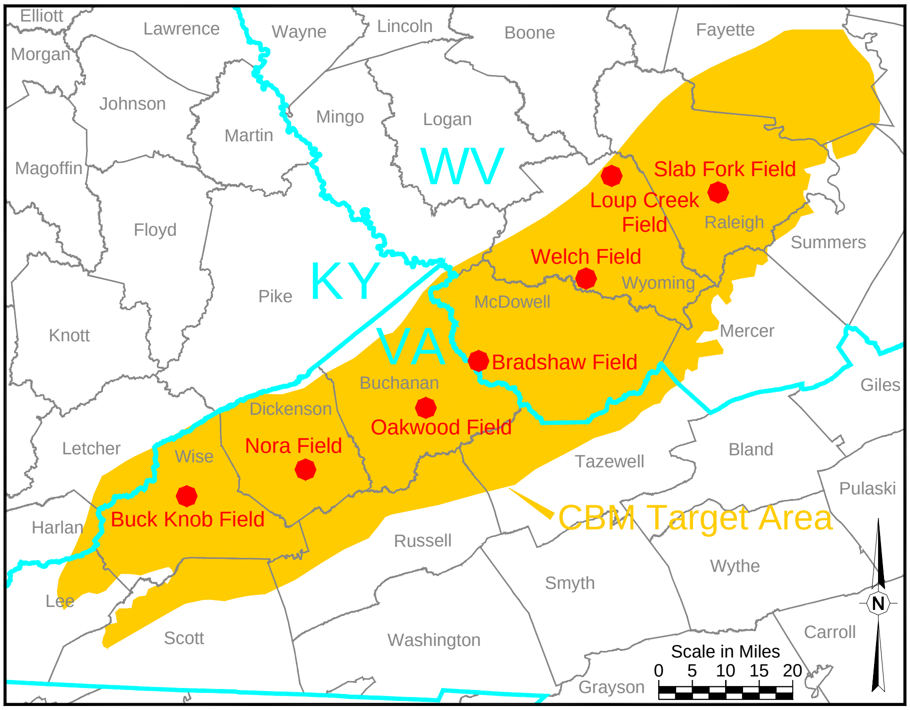


Figure 17. CBM Fields in Central Appalachian Basin.

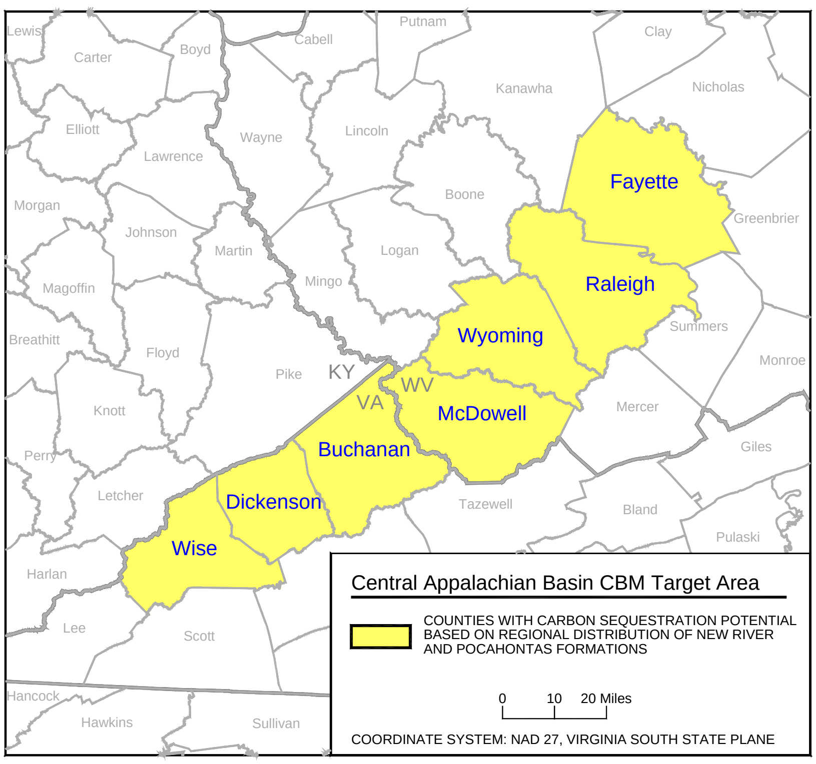


Figure 18. Regional-Level Assessment New River (Lee) and Pocahontas Formation.

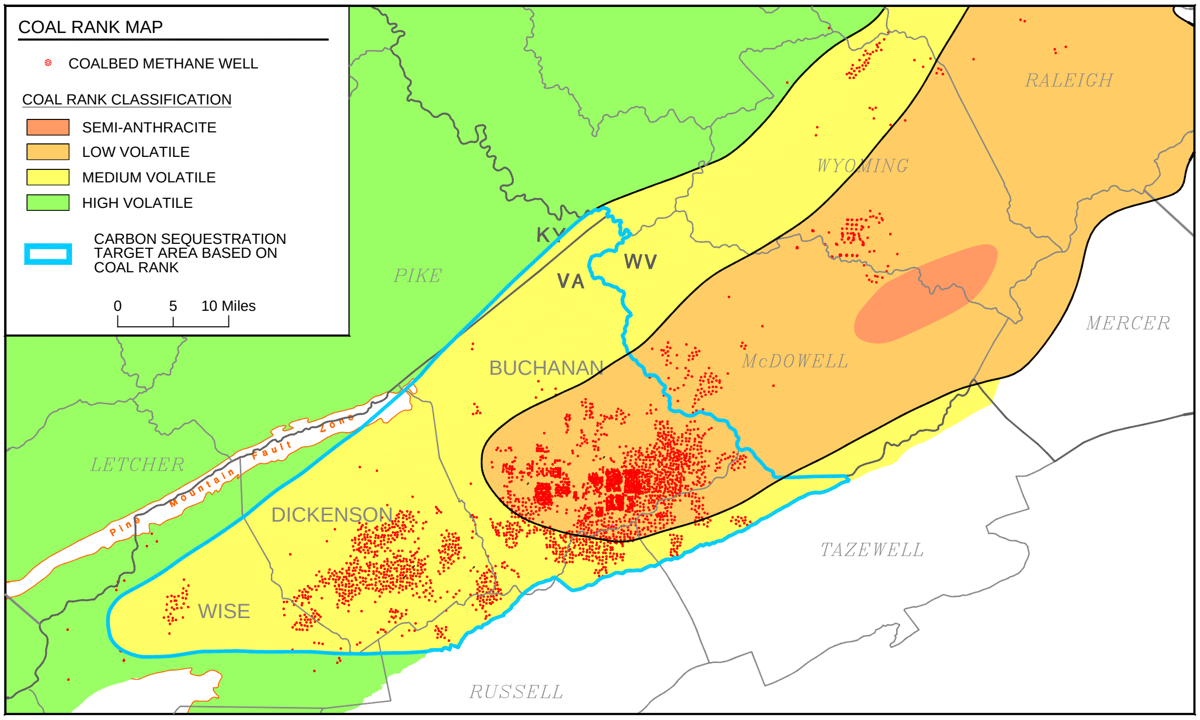


Figure 19. Central Appalachian Basin Coal Rank.

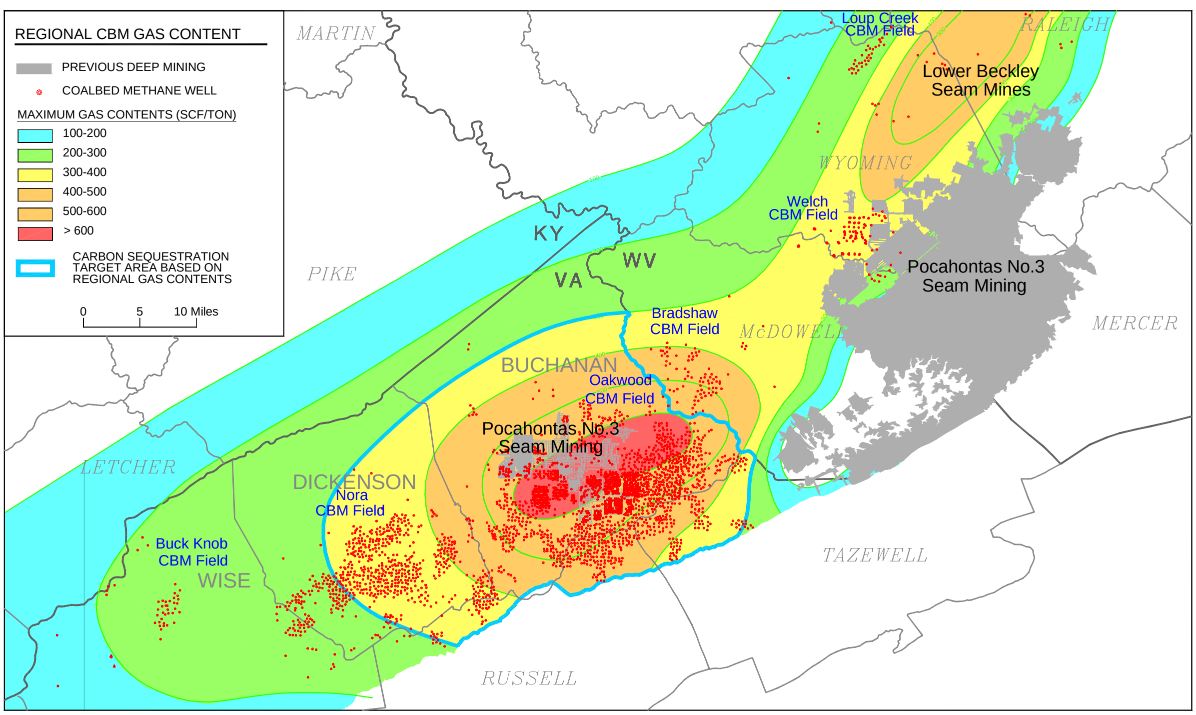


Figure 20. Regional CBM Gas Content.

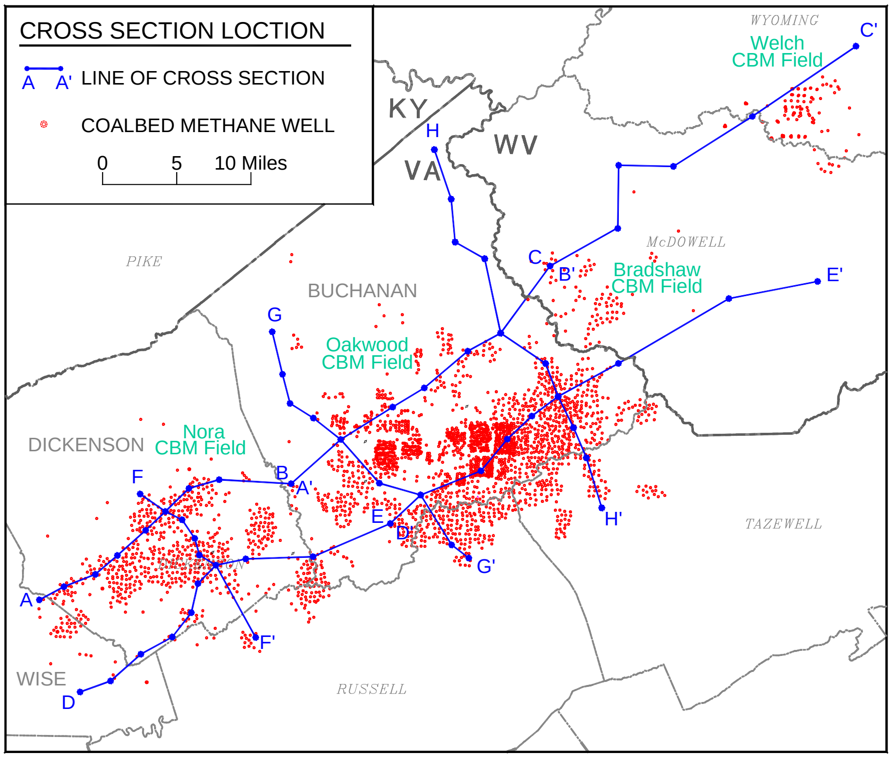


Figure 21. Cross Section Location.

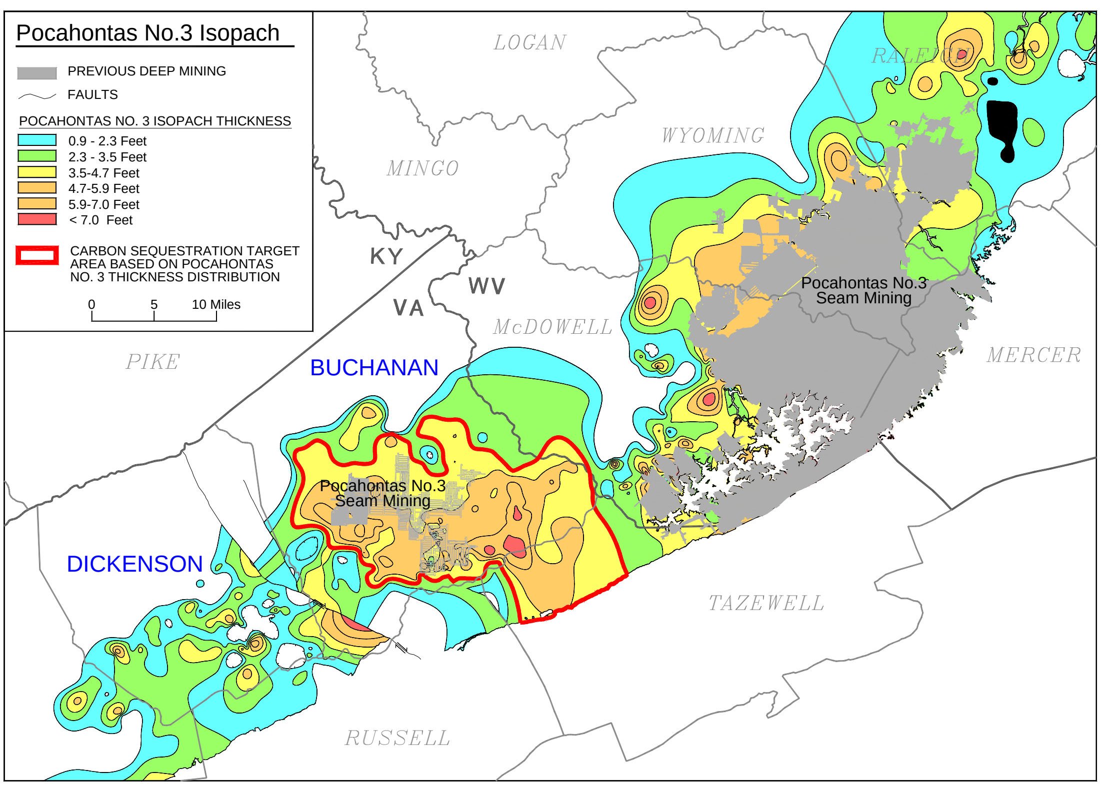


Figure 22. Pocahontas No. 3 Seam Thickness Isopachs.

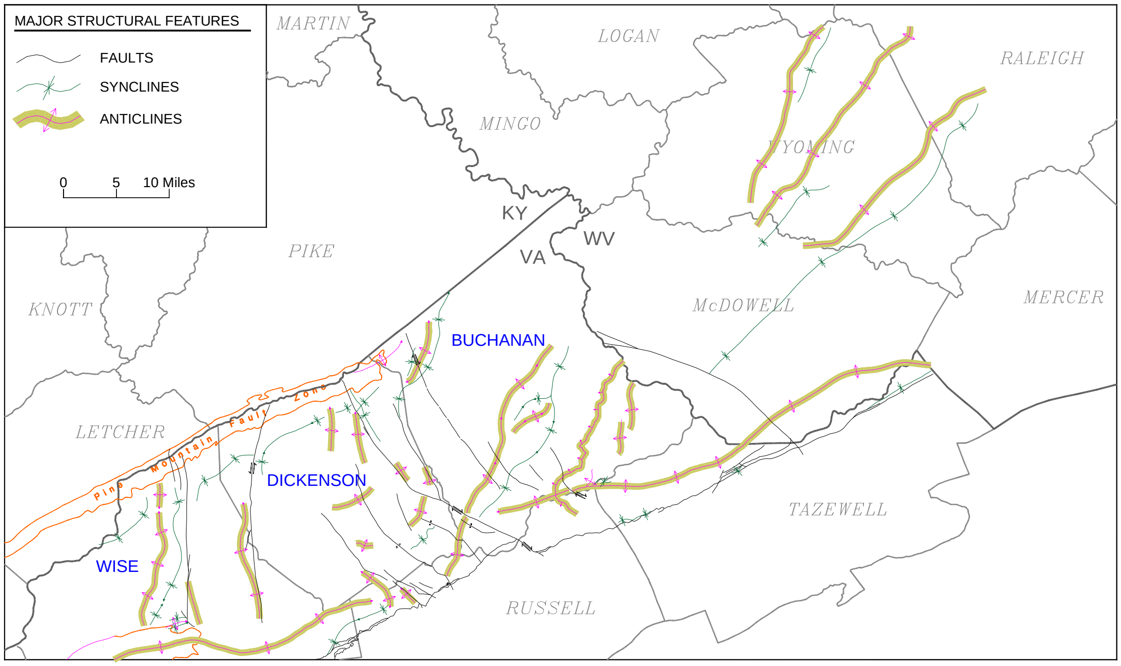


Figure 23. Major Structural Features.

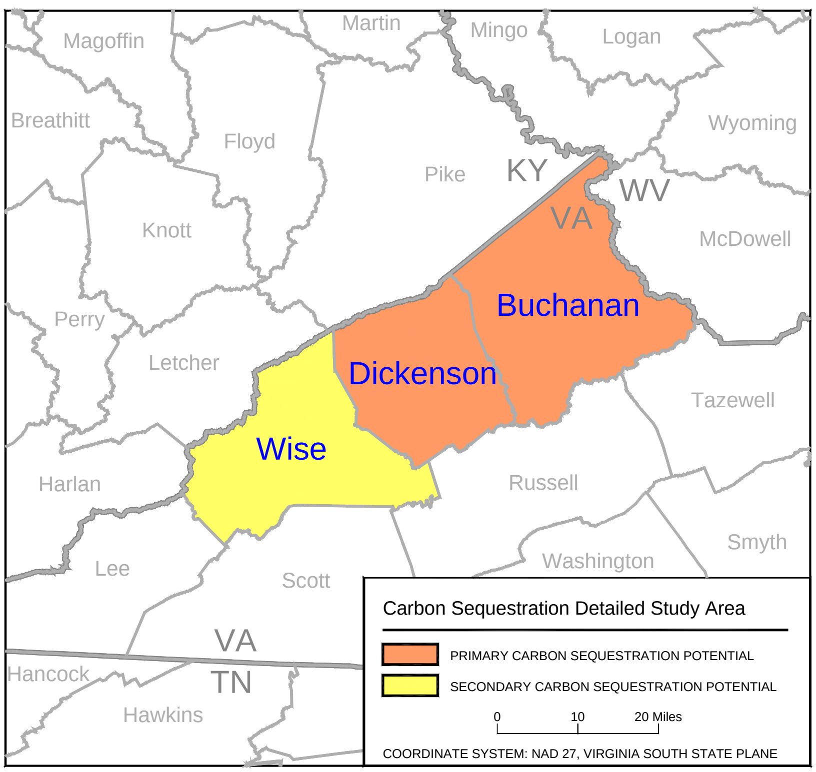


Figure 24. Carbon Sequestration Focus Areas for Regional Geologic Mapping.

From the detailed level assessment, a list of prospective coalbeds for carbon sequestration was developed. The list includes the following seams in the Upper, Middle and Lower Lee formations and the Pocahontas formation:

Upper Lee Formation

- Jawbone
- Tiller
- Upper Seaboard
- Middle Seaboard
- Lower Seaboard

Middle to Lower Lee Formation

- Upper Horsepen
- Middle Horsepen
- C-Seam (P-10)
- War Creek (P-11)
- Lower Horsepen
- X-Seam

Pocahontas Formation

- Pocahontas No. 6
- Pocahontas No. 5
- Pocahontas No. 4
- Pocahontas No. 3

Carbon Sequestration Resource Characterization Parameters for Southwest Virginia Coal Seams – Work in Progress and Future Tasks (Virginia):

Work in progress is continuing to complete the characterization of coal seams in Southwest Virginia and includes:

- Correlating coal seams for eight (8) regional stratigraphic cross sections
- Delineating Upper Lee, Middle to Lower Lee, and Pocahontas Formation boundaries on cross sections
- Processing geologic database for coal thickness information

Future work on coal seam characterization in Southwest Virginia will include:

- Complete cross section analysis
- Correlate formation boundaries for approximately 500 wells
- Determine composite coal thickness for Middle to Lower Lee Formation and Pocahontas Formations for approximately 500 wells
- Data entry of coal thickness values into geologic database
- Map composite coal thickness for Middle to Lower Lee and Pocahontas Formations

- Identify high potential areas and individual coal seams for carbon sequestration

Carbon Sequestration Resource Characterization Parameters for Other Geologic Sinks – Work in Progress and Future Tasks (Virginia):

Work has been initiated to characterize the sequestration potential of conventional natural gas reservoirs, saline aquifers, Valley coalfields and Richmond basin coalfields, including:

- Identifying prospective reservoirs
- Delineating depleted fields
- Developing oil and gas overview map with conventional wells and fields
- Determining prospective areas for Carbon Sequestration

<u>Geologic Sequestration (Texas)</u>

Develop Geographic Information System data layers characterizing geologic sinks in the Gulf Coast of Texas, Louisiana, and Mississippi.

Texas oil and gas reservoirs have been characterized by TX BEG through digitally compiling in GIS the following: the *Atlas of Texas Major Oil Reservoirs* (Galloway and others, 1983) and the *Atlas of Texas Major Gas Reservoirs* (Kosters and others, 1989) (Figure 25 and 26). The GIS data layers include the major oil and gas reservoirs of Texas, their attributes, and the geological plays that they can be grouped into. The data layers have been merged with the brine formation data layers from Hovorka, and others, (2000) imported in the previous quarter (Figure 27 and 28). Our subcontracts with the Louisiana Geological Survey and the Mississippi Mineral Resources Institute to compile data for the Gulf Coast region of Louisiana and Mississippi were delayed due to administrative issues, and are scheduled to be finalized next quarter.

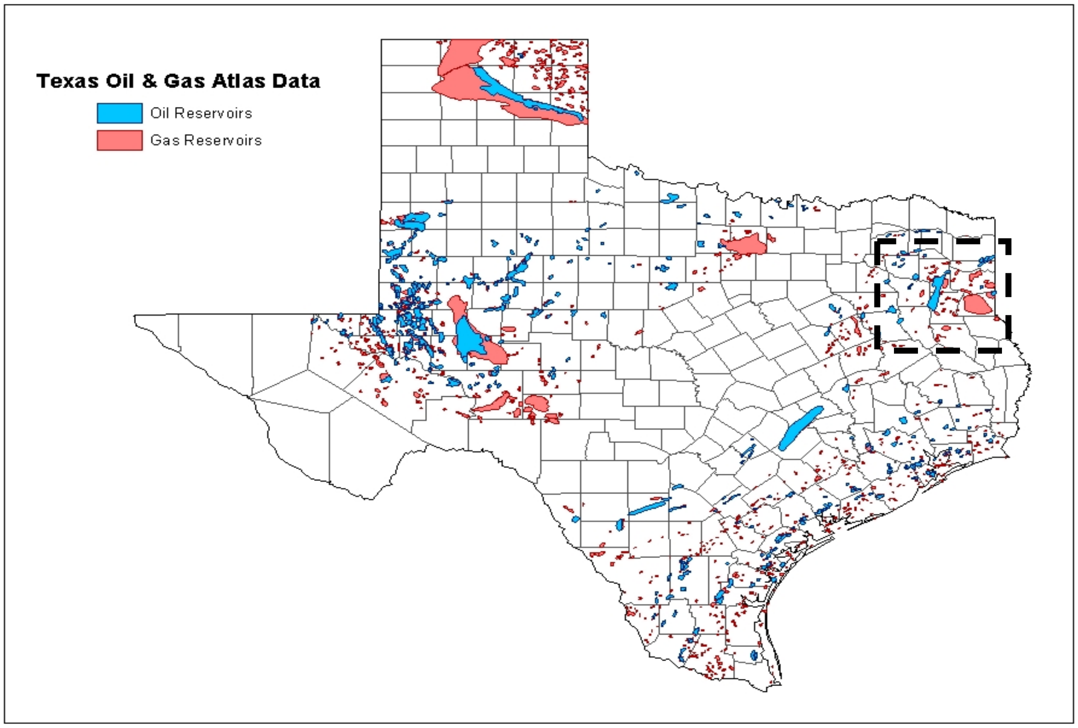


Figure 25. Geological sequestration opportunities in Texas oil and gas reservoirs.

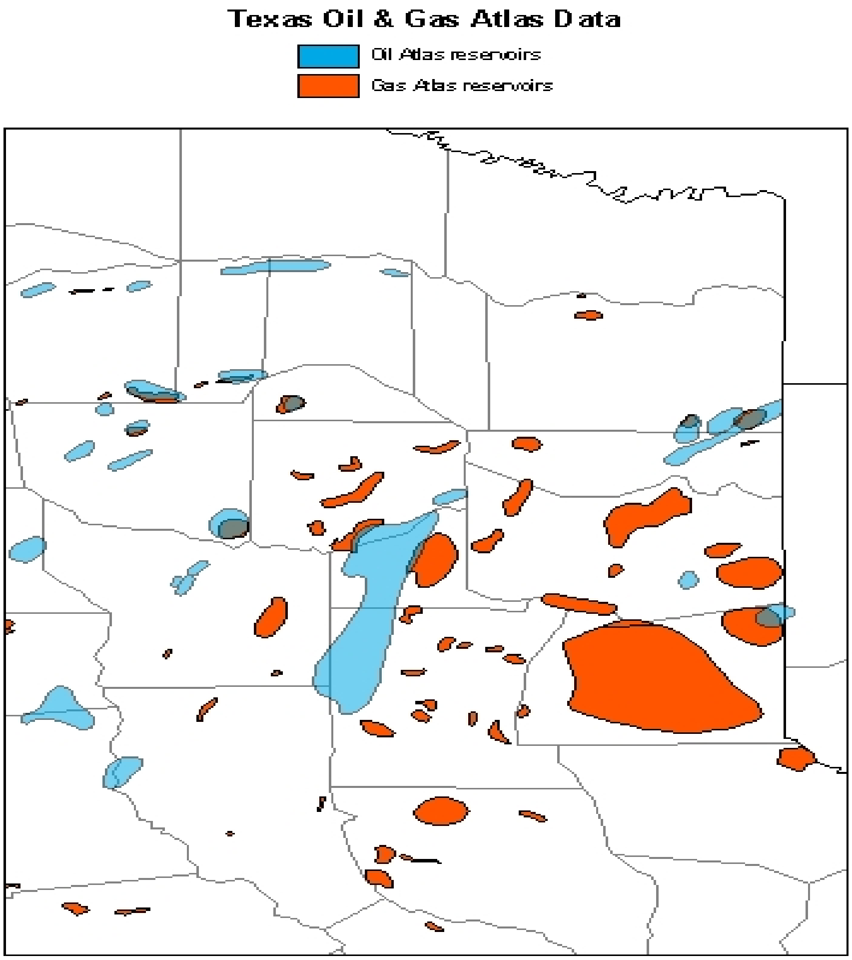


Figure 26. Texas oil and gas reservoir sample GIS data set.

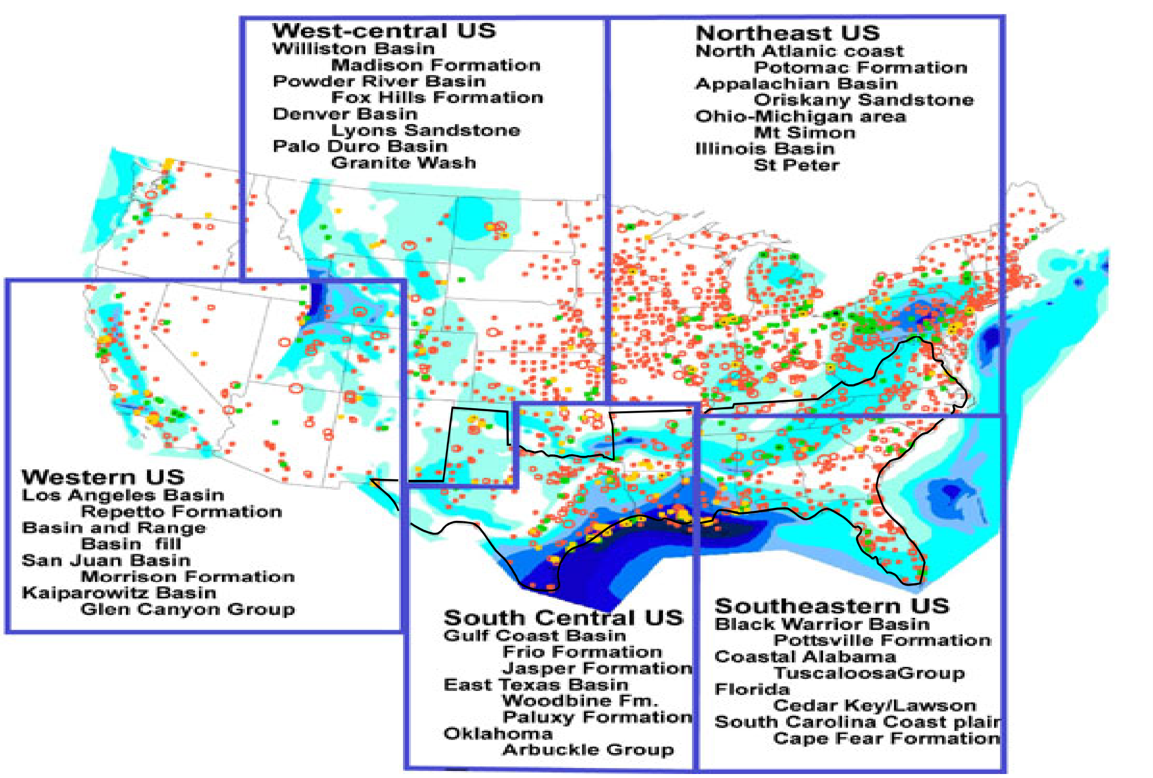
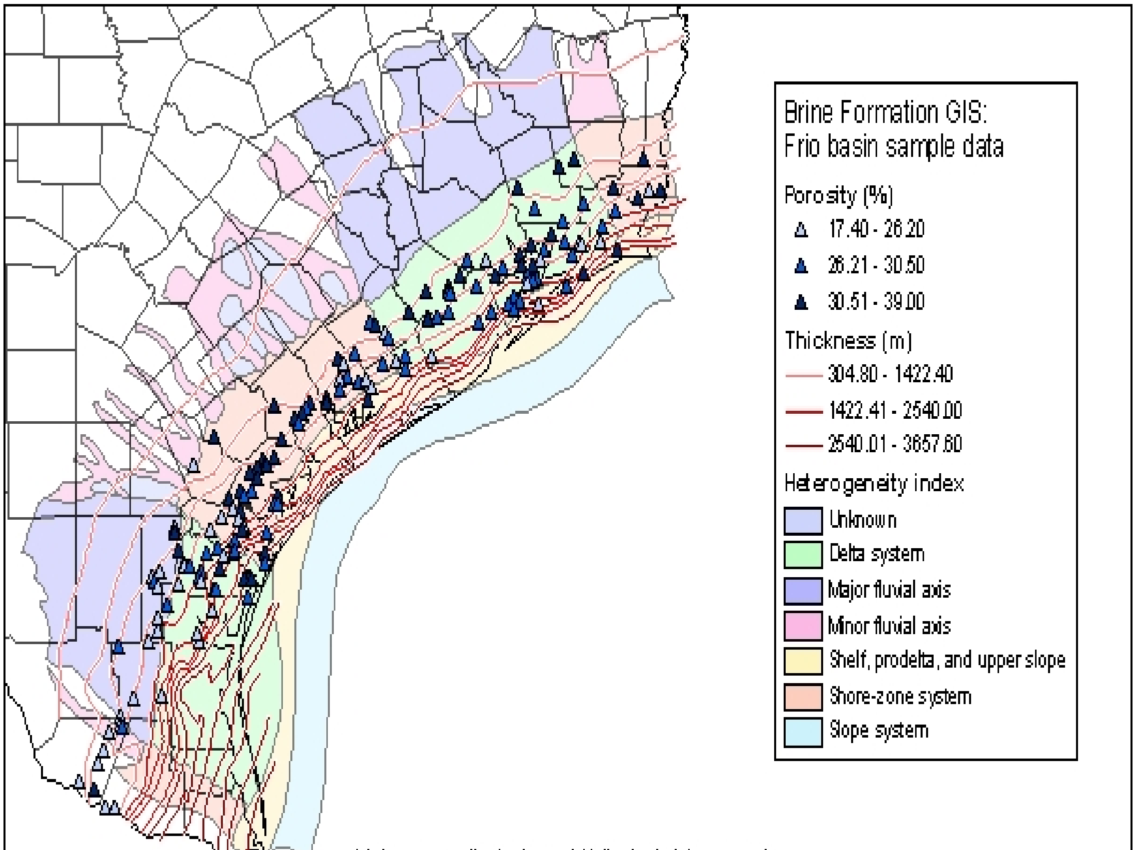


Figure 27. Geological sequestration opportunities in brine formations.



Heterogeneity index: Attribute table sample

DEPOSIT_6	DEPOSIT_6_I	TYPE	DESCRIP	SYSTEM	CNTY_NAME	STATE_NAME
8	0	5	Shelf, prodelta, and upper slope	HACKBERRY SLOPE SYSTEM	Cameron	Texas
8	0	5	Shelf, prodelta, and upper slope	HACKBERRY SLOPE SYSTEM	Cameron	Texas
23	0	4	Delta system	NORIAS DELTA SYSTEM	Cameron	Texas
23	0	4	Delta system	NORIAS DELTA SYSTEM	Willacy	Texas
23	0	4	Delta system	NORIAS DELTA SYSTEM	Willacy	Texas
23	0	4	Delta system	NORIAS DELTA SYSTEM	Hidalgo	Texas
22	0	1	Major fluvial axis	GUEYDAN FLUVIAL SYSTEM	Hidalgo	Texas
22	0	1	Major fluvial axis	GUEYDAN FLUVIAL SYSTEM	Starr	Texas

Figure 28. Frio basin brine formation sample GIS data set.

In Table 4 Beecy/ARI provide estimates of CO_2 geologic sequestration volumes (in million metric tons) depleting oil reservoirs, unmineable coalbeds and depleting gas reservoirs in Texas. These three sequestration options have been differentiated from the larger saline aquifer category due to the opportunities that exist for economic benefits.

CO2 Geologic Sequestration Volumes

	Estimated CO_2 Sequestration Volumes (Million Metric Tons)
Depleting Oil Reserves	50,000
Unmineable Coal Beds (L48)	100,000
Depleting Gas Reservoirs	100,000
Saline Aquifers	Large

Table 4. CO_2 Geologic Sequestration Volumes (Texas).

Extensive work by the Texas Bureau of Economic Geology reveals that, within the south central and southeastern areas of the SECARB region, opportunities exist for carbon sequestration with positive economic impacts. This can result from the deployment of enhance oil recovery initiatives that utilize anthropogenic CO_2. TX BEG noted that currently 2-billion cubic feet per day of CO_2 is injected for EOR in the United States. Anthropogenic sources account for approximately 20% of the total. Figure 29, is a map of current CO_2 – EOR projects in the United States. Currently this represents 66 active projects with 205,877 barrels of oil per day (approximately 4% of U.S. production). TX BEG estimates that sequestration volumes available in CO_2 – EOR (10% recovery) are 473 metric tons in Texas and 5763 metric tons in the United States.

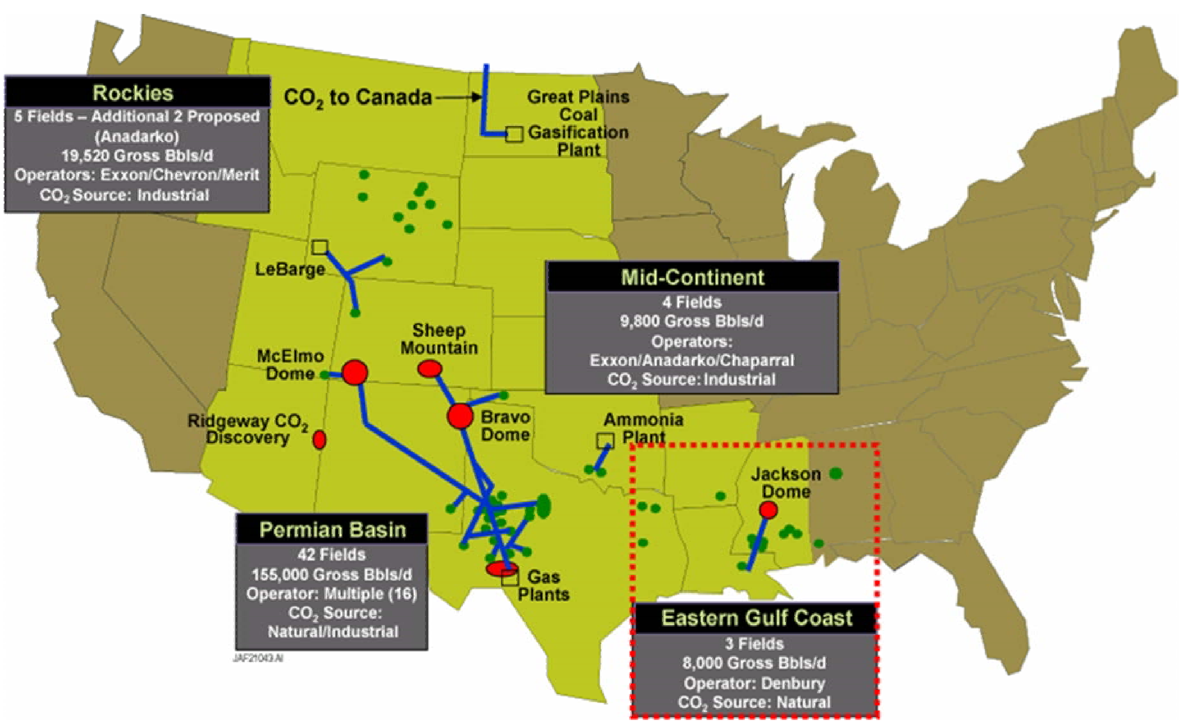


Figure 29. U.S. CO_2 Driven EOR Projects and Infrastructure.
Source: Denbury Resources, Inc., 2004

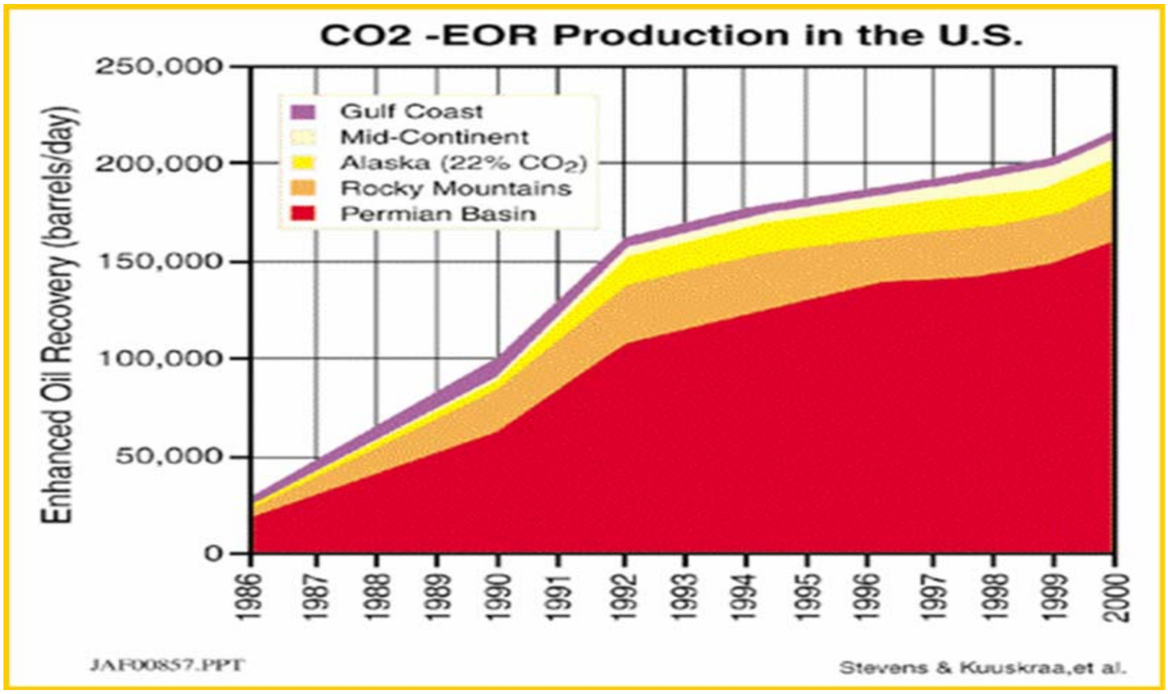


Figure 30. CO_2 EOR Production in the U.S.

In Figure 30 ARI/Kuuskraa and others also have determined increases in the levels of CO_2 – EOR production in the United States. It is evident from the chart that significant successes in the Permian Basin have accounted for steady increases in daily oil recovery. TX BEG has noted that, of the 66 active CO_2 – EOR projects, 50 are located in the Permian Basin.

Based upon initial applications of screening criteria, TX BEG has determined that opportunities exist for expanding CO_2 – EOR into east central and southeast Texas. Based upon the characteristics of reservoirs in the area designated by Denbury as "Eastern Gulf Coast", SECARB has designated this area as having Most Promising Opportunities for expanding the use of anthropogenic CO_2 for enhance oil recovery.

Transportation and Infrastructure Options

CO_2 Infrastructure

The CO_2 infrastructure in the SECARB region can best be described as nascent. Similar to other parts of the country, most of the CO_2 is shipped by truck or rail from point of generation to point of use. However, there is a growing pipeline network linking LA and MS, with long-term plans to stretch the network across the entire gulf coast region.

Uses

The largest single market at the present time is the beverage market, which makes up about 40% of the CO_2 usage in the SECARB region. Much of this is supplied via CO_2 taken from the Jackson Dome deposits in central Mississippi, because of the high purity of the deposits and the high purity required.

Food preservation and processing is the next largest segment in our region, using somewhat less than 40% of the CO_2 in the region. Industry consumes the remainder of the CO_2 used in the region. Both of these users have less critical requirements for purity, so less cleanup of CO_2 from combustion would be required.

There is tremendous potential for both enhanced coalbed methane (ECBM) recovery and enhanced oil recovery in our region. In southern Mississippi alone, Denbury Resources, Inc. (the largest oil producer in the area) estimates that southern Mississippi oil production could utilize the entire annual CO_2 output from a 1 GW coal burning utility. The CO_2 purity required for EOR is very low; however, transport of the CO_2 through pipelines introduces stringent corrosion controls on trace component content (e.g., H_2S, SO_2, and especially moisture). This implies that either:

- The CO_2 source and the EOR site must be closely coupled;
- More expensive materials of construction would be needed for the pipeline (but perhaps justifiable on a cost basis if oil remains at a high price point); or
- The pipeline is treated as expendable, and one-time use considered.

Similar considerations apply to ECBM. In this case, close coupling the source and the ECBM site is a more attractive option. Future Integrated Gasification Combined Cycle facilities in the region could easily implement such a scheme. In fact, a new facility being planned for Chester, Mississippi, could be an ideal proving ground for such a scheme.

Transport

As noted above, most of the CO_2 in the region is transported via direct shipment. However, Denbury Resources, Inc., (DRI) has developed a pipeline that connects the Jackson Dome to southeastern Louisiana, and is being extended further east into the Heidelberg oil field in eastern Mississippi. When completed, this will provide approximately 250 miles of pipeline. In the longer term, DRI foresees this pipeline potentially becoming a “public highway” for CO_2, albeit an expensive one – each mile costs about $500,000.

Database and GIS

Geologic

This section summarizes the GIS tools that have been developed or are currently under development by the MIT research group for carbon sequestration analysis. These tools include algorithms for: (1) calculating CO_2 storage capacity; (2) estimating CO_2 injectivity and injection cost; (3) estimating CO_2 pipeline transportation cost; (4) matching CO_2 sources and sinks.

Calculating CO_2 Storage Capacity

The generic formula for calculating reservoir volume is:

$$Q = V * p * e * \rho_{CO_2}$$

where

Q	= storage capacity of the reservoir ($MtCO_2$)
V	= total volume of reservoir (km^3)
p	= reservoir porosity (%)
e	= CO_2 storage efficiency (%)
ρ_{CO_2}	= CO_2 density (kg/m^3)

The reservoir volume and porosity are required inputs from the geologic datasets. The CO_2 density is calculated from the reservoir temperature and pressure (which are either obtained directly from geologic datasets or estimated from reservoir depth). The storage efficiency reflects the fact that CO_2 will flood only part of the reservoir. It has a typical range of between 2-30%. It can be obtained from detailed reservoir simulations. However, this is beyond the scope of our screening analysis, so default estimates will be obtained based on expert elicitations.

Estimating CO_2 Injectivity and Injection Cost

We have implemented a method into the GIS to calculate the injection costs. First, the CO_2 injectivity per well is calculated based on surface injection pressure, reservoir pressure, permeability, depth and thickness (based on the work of Law, D. and S. Bachu, "Hydrogeological and numerical analysis of CO_2 disposal in deep aquifers in the Alberta sedimentary basin," *Energy Convers. Mgmt*., **37**:6-8, pp. 1167-1174, 1996.). Reservoir permeability, depth and thickness are needed from the geologic data. Reservoir pressures can be obtained from the geologic data or estimated from depth. Injection pressure is set so as not to exceed the fracking pressure (or may be set by regulation in some cases). Second, using the CO_2 injectivity, the number of wells required for a given CO_2 flow rate is calculated. Finally, a set of capital and O&M cost factors are used to determine the cost based on well numbers. Details of this method can be found in: *Heddle, G., H. Herzog and M. Klett, "The Economics of CO_2 Storage," MIT LFEE 2003-003 RP, August (2003).* http://sequestration.mit.edu/pdf/lfee_2003-003_rp.pdf.

We recently have had discussions with Vello Kuuskraa and Scott Stevens of Advanced Resources International. We have decided to add an alternate methodology to Law and Bachu (1996) based on an ARI method. Both methods give similar results for initial injection rates. The advantage of the ARI model is that it reconciles the problem that CO_2 injectivity varies over time as the reservoir pressure rises due to the injection. The same reservoir parameters are used as input in both methods. Once implemented, we will provide further details on this methodology.

Estimating CO_2 Pipeline Transportation Cost

The transportation cost model takes the source-sink matching as a priori and estimates the CO_2 pipeline transportation cost at three levels: (1) one source to one sink; (2) many sources to one sink without route-sharing; and (3) many sources to one sink with route-sharing.

For the simplest case of one-source-to-one-sink connection, the estimation consists of three steps. First, the pipeline diameter is calculated based on the CO_2 flow rate. Second, the least-cost route is selected based on the relative cost factors assigned to various transportation obstacles for both economic and environmental concerns. The identified transportation obstacles include populated places, wetlands, national and state parks, waterways, railroads, and highways. Finally, the base case pipeline construction cost, additional obstacle crossing cost and O&M cost are assigned to estimate the levelized CO_2 transportation cost. More details are presented in Appendix K of this report. Note that we want to carry out some expert elicitations to better refine our cost parameters in the model.

Matching CO_2 Sources and Sinks

The source-sink matching analysis needs to take into account three factors: capacity, injection cost, and transportation cost (assuming CO_2 capture cost is source-specific and exogenous to the GIS system). We process our analysis by three levels: (1) starting from a particular source, search for the least-cost sink for this source; (2) starting from a targeted sink, search for a set of sources with the lowest overall cost to fill the sink's capacity; (3) for a set of multiple sources and multiple sinks in a study region, design a source-sink matching network to minimize the overall cost for CO_2 transportation and injection in the system.

Terrestrial

Analyzing Risks and Co-benefits to Carbon Sequestration Activities

Data-layers were collected from various sources to estimate the possible risks and co-benefits that carbon sequestration activities might incur or reap.

The risks that were analyzed for their possible detrimental effects on afforestation activities were identified and classed into four main groups: those related to weather events, those related to disease, those related to pests, and those related to wildfire. Based on knowledge of the region, wildfires were considered to be a significant risk to forests in Florida and additional information on fire will be prepared during the next quarter. For weather-related and disease-related risks the availability of spatial datasets was limited. In many cases, the data were only provided as county estimates. For pest-realted risks, further work will be carried out in the next quarter. For display and analysis purposes, in the cases where point data on occurrences were available, it was aggregated up to the county-level.

The weather-related risks analyzed were severe drought, hurricanes and tropical storms, tornadoes, hail and wind damage events. The disease-related risks analyzed were fusiform rust and oak decline.

Weather-related Risk Datasets

The number of months of severe drought (measured by the Palmer Drought Severity Index of <2) in the region, over a more than 50-year period was acquired from National Oceanic & Atmospheric Administration (NOAA) (http://www.noaa.gov/). Hurricanes and tropical storms data were acquired from NOAA's National Hurricane Center. Data on tornado touchdowns and hail and wind damage events in the area were acquired from NOAA's Severe Storm Laboratory. Results are shown in Figure 31.

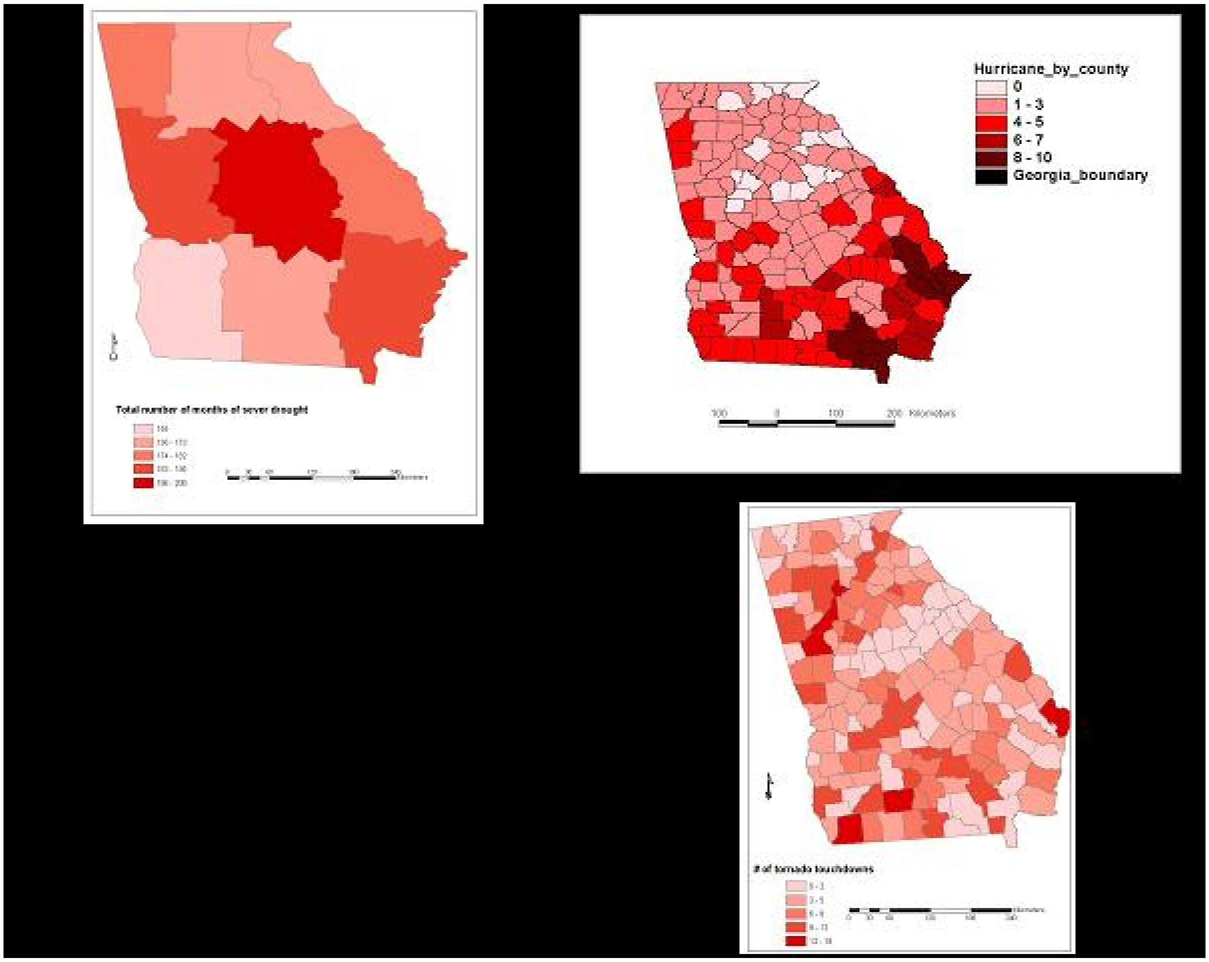


Figure 31. A. Spatial distribution of severe drought as indicated by duration; B. Spatial distribution of severity of hurricanes as indicated by number of tracks in each county; C. Spatial distribution of number of tornados per county over 45 years.

Disease-related Risk Datasets

The historical extent of fusiform rust disease and oak decline in the southeast was mapped by the USDA Forest Service Southern Forest Resource Assessment (http://www.srs.fs.usda.gov/sustain/). Results are shown in Figure 32.

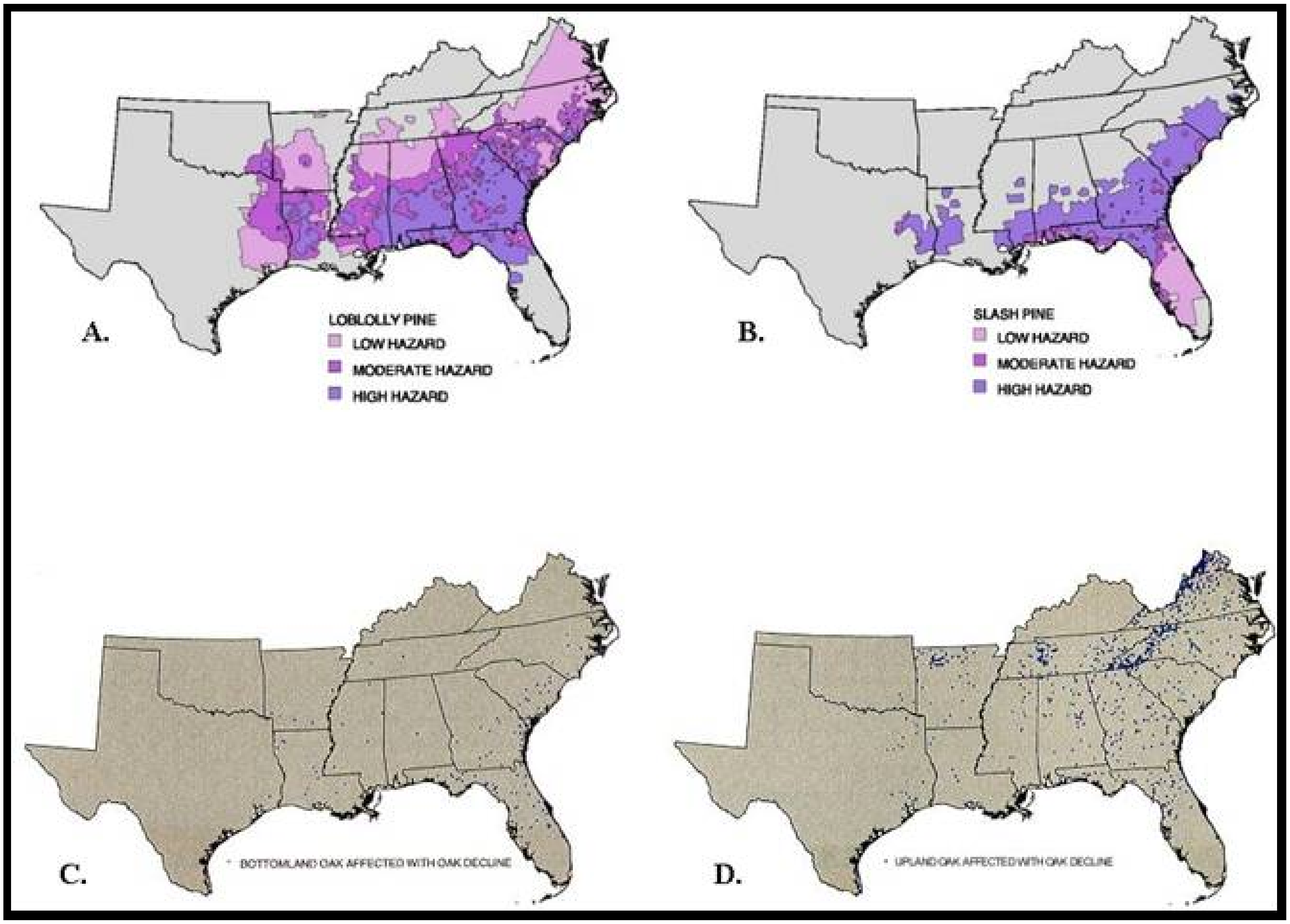


Figure 32. A and B show the spatial distribution of fusiform rust hazards to pines. C and D are areas affected with oak decline. [USDA Forest Service, Forest Health Protection, Southern Region (R8)]

<u>Biodiversity Co-benefits</u>

The principal co-benefit from afforestation activities that will be analyzed in a quantitative and spatial manner is the potential to "defragment" landscape through afforestation.

In the final report, the amount of carbon available and the cost for lands within buffers around existing protected areas will be estimated. These protected areas are those that have met the "Gap Analysis" standards (http://www.gap.uidaho.edu/default.htm) of having at least a sustainable management code and include lands owned by federal, state and private entities, but do not include the lands of Ducks Unlimited or the USDA Conservation Reserve Program. Afforestation on lands within buffers would provide biodiversity co-benefits by expanding the forest cover and reducing the area – perimeter ratio.

Cropland and grazing lands surrounding the protected areas are characterized according to their proximity to the 'park' boundary. 'Adjacent' lands are those that are within 100m of the park boundary; 'proximal' lands are those within 250m; and 'neighborhood' lands are those within 500m. See Figure 33.

All agricultural lands (crops and grazing lands) within these buffer zones around each protected area are identified and overlain on the carbon supply maps produced to estimate the total quantity of carbon available at different costs for 20, 40, and 80 year projects and in the different buffer zones.

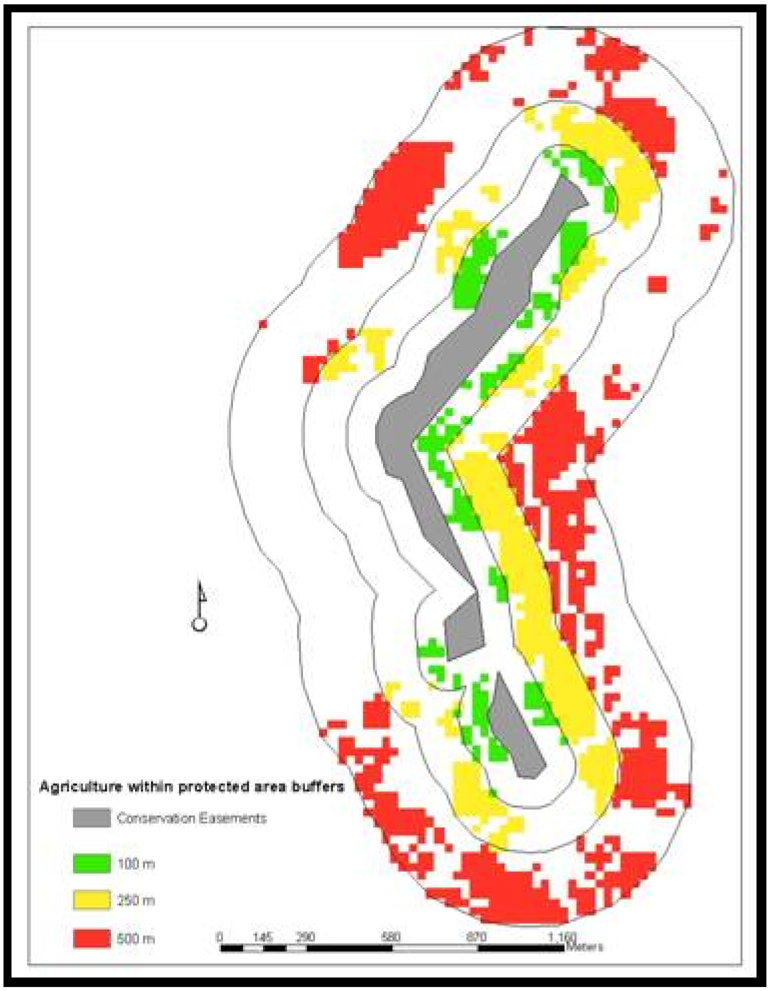


Figure 33. An example of protected areas in Georgia and the buffer zones around them. Agricultural lands (Ag.) are categorized according to their proximity to the reserve: within (w/in) 100m, 250m, and 500m.

Identification of Carbon Sequestration Pilot Projects for Application in the Region

During the next quarter, potential carbon sequestration pilot projects will be identified and defined. The consolidated list, together with preliminary details on projected feasibility and sequestration potential, will be submitted in the December 2004 status report. In consultation with SECARB partners, a subset of top priority pilot projects will be selected for subsequent in-depth analysis of carbon supply potential.

A Note on Progress in Virginia and Texas

SECARB has identified and tasked independent research teams in the states of Virginia and Texas and requested that Winrock share the methods being used for the regional analysis in other states so that the resulting assessments of carbon sequestration opportunities will be comparable across the entire region.

An expanded-region states methodology report was composed and passed along to Dr. Carl E. Zipper at Virginia Tech's Department of Crop and Soil Environmental Sciences on June 18, 2004 and additional support has been provided to Research Assistant, Jeff Galang in the form of literature citations and methodological clarifications. The same expanded-region states document was passed along to Dr. Eugene M. Kim at the Jackson School of Geosciences of the University of Texas at Austin on July 7, 2004.

Task 3: Identify and Address Issues for Technology Deployment

SECARB partners have a keen interest in ensuring that permitting and safety concerns of carbon sequestration are addressed. SECARB partners include state government agencies, research universities, energy companies, private consultancies, and nonprofit entities with presences and interests within the region.

As part of its mission, SECARB has a goal to develop action plans to overcome the issues identified in the preliminary assessment of safety, regulatory, permitting, and accounting frameworks within the region to allow for wide-scale deployment of promising terrestrial and geologic sequestration approaches, including, with reference to geologic sequestration, specific capture, transport, injection, and storage approaches. Through the efforts of the SECARB team, SECARB has worked to advance this goal and the overall mission during the first year of the regional carbon sequestration partnership initiative. As a result of the unique structure of the SSEB, which is the nation's only regionally-focused, federal-state energy compact, which engages state government entities and private businesses in sustainable dialogues on emerging energy and environmental technology issues, SECARB is well-positioned to research and develop regulatory, permitting, and accounting frameworks for and associated multi-year action plans to assist in the wide-scale deployment of carbon sequestration technologies and approaches. During its first year, the project team has worked to advance this goal and the overall mission.

The SECARB team has performed research and analysis of the relevant state and federal statutes and regulations applicable to sequestration regulatory, permitting, and safety matters. This research involved direct examinations of applicable statutes and regulations related to both geologic and terrestrial sequestration applications, as well as interaction with state legislators and regulators responsible for enacting and implementing regulatory regimes. This research and analysis on geologic sequestration related to direct carbon dioxide injection into geologic formations; enhanced hydrocarbon recovery using carbon dioxide; and, governance of the associated deep well injection classes. Also, SECARB participated with the Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force to ensure that SECARB approaches would converge with recommended national approaches.

Key analysis regarding terrestrial sequestration focused on permitting and regulatory barriers and/or incentives to various field applications that could be implemented. The research and analysis activity also used selected scholarly articles and papers related to regulatory and permitting issues for analogous practices.

In another effort to ensure that all regional partnerships, including SECARB, engaged in regulatory, permitting, safety, and accounting framework analysis and development activities with an appropriate base of background knowledge about carbon sequestration regulatory and legal activities, NETL coordinated and managed RCSP Regulatory Compliance and Liability Issues Working Group meetings. As a result of these quarterly meetings and calls, as well as the IOGCC-led effort, SECARB and the other partnerships are working to ensure that common regulatory and accounting approaches are being developed throughout the RCSPs.

Further, the project team investigated emerging, potentially SECARB-applicable GHG accounting frameworks. As no universally-accepted accounting standard exists for GHG emissions and emissions reduction accounting, this research focused on tracking the methodologies and protocols presently in practice internationally and nationally, with a focus on developed accounting standards, registry program requirements, and trading program rules. This study included the current requirements of and contemplated amendments to the DOE Voluntary Reporting of Greenhouse Gases Program (VRGGP), established under Section 1605(b) of the Energy Policy Act (EPact) of 1992. SECARB also examined methodologies and protocols under various international efforts, including the World Business Council for Sustainable Development and the World Resources Institute’s “Greenhouse Gas Protocol”; state greenhouse gas emissions and emissions reduction registry programs in the U.S; and the emerging voluntary greenhouse gas emissions reduction trading platforms.

This report documents the efforts of the SECARB regulatory and accounting team during the initial year of the Phase I SECARB activities.

Regulatory, Permitting, Safety Frameworks

Initial regulatory, permitting, and safety frameworks issues focused on two key areas – geologic sequestration and terrestrial sequestration. Activities in both areas are discussed below.

Geologic Sequestration

As terrestrial sequestration activities have been initiated and are beginning to emerge as a standard bearer for GHG emissions management projects, the relatively less well-known and less practiced domain of geologic carbon sequestration merits substantially more examination and analysis at this time to ensure that appropriate regulatory, permitting, and accounting frameworks emerge around the arena. To support this effort, DOE/NETL has provided funding support to the above-referenced IOGCC Task Force, which was formed by IOGCC with funding support from DOE and empowered with two primary objectives:

- Examine the technical, policy, and regulatory issues related to safe and effective storage of CO_2 in the subsurface (oil and natural gas fields, coal-beds and saline formations), whether for enhanced hydrocarbon recovery or long-term storage; and
- Produce a final report containing an assessment of the current regulatory framework likely applicable to geologic CO_2 sequestration and recommended regulatory guidelines and guidance documents. The Final Report and the documents contained therein will lay the essential groundwork for a state-regulated, but nationally consistent, system for geologic sequestration of CO_2 in conformance with national and international law.[1]

SECARB, has worked to support the IOGCC effort through idea generation, analysis, drafting, and technical editing, and, when possible, worked to adopt its anticipated recommendations. Thus, in many instances, this report will cite the IOGCC Task Force's draft report as it potentially provides a common platform for geologic sequestration regulatory, permitting and safety frameworks.

In an examination of geologic sequestration both under SECARB and the IOGCC effort, a clear question emerged regarding the future regulatory, permitting, and safety frameworks – How linked will geologic sequestration regulatory, permitting, and safety frameworks, especially with reference to the injection and long-term storage activities, be to the Federal Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) program? More specifically, there are four sub-level questions:

- Will CO_2 be defined as a commodity, waste, or pollutant under federal, state, or federal and state laws and regulations, including UIC regulations?
- Will geologic carbon sequestration injection and storage activities be wholly subject to existing UIC regulations?
- Will new UIC classes or definitions emerge to facilitate geologic sequestration injection and storage activities?

[1] Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force, Draft Report, October 2004.

- Will long-term geologic sequestration projects without enhanced hydrocarbon recovery components be subject to UIC at all?

Clearly, SECARB and even the IOGCC Task Force do not hold the final authority on this matter, or else the conclusions of this report could be more concrete. With the EPA holding authority for UIC rules, regulations, and interpretations, it seems that the EPA will be ultimate arbiter of these matters. To assist in defining the options for the SECARB region, and perhaps the nation, however, SECARB has produced this examination. A brief overview of the present regulatory, permitting, and safety environment for potential geologic sequestration activities follows.

<u>Natural Analogues</u>

It has been suggested that four analogues exist for regulatory guidance regarding geologic carbon sequestration – naturally occurring CO_2 contained in geologic formations; CO_2 enhanced oil recovery operations; storage of natural gas in geologic formations; and the injection of hydrogen sulfide (H_2S) into underground formations.[2] In some states, and more specifically states with hydrocarbon production and/or storage activities, there is a rich legacy of regulatory, permitting, and safety regimes in place that would assist in wide-scale deployment of geologic carbon sequestration approaches and technologies.[3]

Of these analogues, perhaps the most significant are those of the naturally occurring CO_2, which shows the capabilities of geologic formations to retain vast quantities of CO_2 over time, and the EOR operations, which demonstrate the safe and well-regulated transport and injection of CO_2 into geologic formations.

Although CO_2 is a non-hazardous gas at normal atmospheric conditions, CO_2 can exist in three forms:

- As the above-referenced gaseous state;
- As a supercritical fluid that has physical properties between a liquid and a gas at pressures greater than 1073 pounds per square inch (psi) at less than 87.7 degrees Fahrenheit; and,
- As a solid form most commonly referred to as dry ice, at temperatures below 109 degrees Fahrenheit.[4]

Given a situation in which normal geologic pressure and temperatures would exist, it has been assumed that deep injection of CO_2 (i.e. greater than 2,500 feet below the surface) would result in the CO_2 existing as a supercritical fluid. In other instances related to geologic sequestration (i.e. capture, transport, injection, and shallow storage,

[2] Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force, Draft Report, October 2004.
[3] Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force, Draft Report, October 2004.
[4] Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force, Draft Report, October 2004.

if ever), it is likely that CO_2 would be in a gaseous form. Thus, geologic sequestration regulatory, permitting, and safety frameworks would relate to the gaseous and supercritical fluid states.

Options for geologic sequestration abound, but the geologic sinks with the highest potential geologic carbon sequestration include deep unmineable coal seams, depleted or nearly depleted sandstone/limestone oil and gas reserves, oil and gas bearing shales, active and abandoned storage fields, saline formations, salt caverns/beds, and hydrates. Thus, the focus on regulatory, permitting, and safety analysis for geologic sequestration would be focused on these areas.

Examination of Regulatory, Permitting, and Safety Issues

More specifically, the regulatory, permitting, and safety framework analysis and action plan development would principally focus on four key areas:

- Capture;
- Transport;
- Injection; and,
- Storage.[5]

Capture of CO_2 from anthropogenic, or man-made, sources is presently being performed in the SECARB region, and in some instances with processing activities to enhance purity, to feed EOR and enhanced gas recovery (EGR) projects and can be anticipated to increase in frequency as geologic sequestration becomes deployed on a more significant scale. At present, the existing regulations are likely of limited utilization for future geologic sequestration, which will include elements of capture and separation of CO_2 from flue gas streams and other point sources. Thus, it would seem that the future of capture regulations will rely upon the answer to whether CO_2 will be defined as a commodity, waste, or pollutant under federal, state, or federal and state laws and regulations, including UIC regulations.

Transport - The arena of CO_2 transport is a little more complex today, but also more applicable to the future world of wide-scale geologic sequestration. Transport of CO_2 is currently conducted through pipelines, generally, and with the support of three primary mechanisms:

- High pressure, or supercritical phase (i.e. above 1180 psi);
- Lower pressure gas transmission; and,
- Refrigerated liquid transmission (also commonly used for rail and truck transport).

[5] These key areas of analysis have been selected both for reasons of sound regulatory analysis and practical considerations. For reference, the IOGCC Task Force and the Carbon Sequestration Leadership Forum Legal, Regulatory, and Financial Issues Task Force have both selected similar breakdowns for their analysis efforts.

The SECARB region is fortunate, and perhaps unique as compared to a number of other RCSPs, because the region already has a functioning CO_2 transport infrastructure. CO_2 pipelines exist in Louisiana and Mississippi. Denbury is selling CO_2 commercially (primarily to the food and beverage industry), and currently seems to be expanding its supply. DRI may also be a major consumer of CO_2 for enhanced oil recovery. Several SECARB Technology Coalition Members and others in the SECARB region have publicly expressed interest in the use of CO_2 for recovery of coalbed methane gas. The latter two are particularly important in the region because of the extensive oil production along the Gulf Coast, and the coal beds in Mississippi, Alabama, and Tennessee.

The CO_2 infrastructure in the region includes pipelines and other transportation infrastructure, separation and purification capabilities, and a network of equipment suppliers. These existing pipelines are regulated by the Office of Pipeline Safety (OPS) of the U.S. Department of Transportation (DOT).[6] U.S. States may also be involved in the regulatory process for these CO_2 pipelines under partnership agreements with OPS. In most instances, regulatory responsibilities of the smaller diameter gathering lines for the CO_2 tend to fall to the states. Moreover, rail and truck transportation tend to be regulated primarily by state entities.

While the existing SECARB infrastructure is robust, the opportunity to leverage this infrastructure may not be as significant. Presently, the CO_2 pipelines assets tend to be closely controlled, and without options for open access-based utilization.

<u>Injection</u> and <u>storage</u>, like transport, have a robust history, both in terms of practices and regulations, to rely upon for the future of sequestration. Due to the fact that the regulatory, permitting, and safety frameworks for injection and storage will likely be linked closely, these two topic areas will be discussed together.

In terms of practices, the American Petroleum Institute (API), American Gas Association and the American Society for Testing and Materials have established materials selection standards for well casing and down hole equipment, wellhead equipment, cement types and other relevant oilfield equipment and facilities that meet prevailing standards in states under UIC laws and regulations. Logically, these established practices and industry standards would adequately address materials standards for geologic carbon sequestration.

While clarity may exist with regard to industry standards for well construction, maintenance, and operation, less agreement is found regarding the rules and regulations for the potential geologic sinks. While present state regulations would generally permit injection of CO_2 into depleted oil and natural gas reservoirs, for EOR, EGR, and enhanced coalbed methane purposes, and into deep saline formations, the treatment of salt cavern utilization is less consistent. In fact, in some SECARB states, including Alabama, salt cavern storage would not be permitted by existing statutes.

[6] 49 C.F.R. 195.

Although the EPA has indicated that CO_2 regulation is beyond its mandate under the Clean Air Act, the EPA may play a significant role in voluntary GHG management programs as EPA could have the primary authority for structuring geologic sequestration program requirements, and in some instances, applying them. This would be dependent upon whether geologic carbon sequestration is governed under the UIC Program of the SDWA. Based upon the IOGCC Task Force recommendations and the general consensus of other interested parties, it seems that at a minimum the EPA will play this role, at least with respect to geologic sequestration activities related to enhanced hydrocarbon recovery. More details on the SDWA, the UIC Program, and their applicability to the arena of geologic sequestration follows.

The SDWA of 1974 requires that the EPA determine the need for and to promulgate regulations sufficient to protect underground sources of drinking water (USDWs). A USDW is any aquifer that contains a volume of water such that it is a present, or viable future, source for a public water system, contains water with less than 10,000 parts per million total dissolved solids, and is not exempted.[7] Section 1421 of the SDWA mandates that the EPA establish rules for UIC programs, which apply to certain types of wells for which five classes exist as shown in Figure 34 below.[8] Under SDWA Section 1423, states may, although need not, acquire primacy for enforcement.[9] The goal of the EPA UIC Program is to protect public health through the protection of USDWs.[10] EPA estimates indicate that the nation's most accessible freshwater is stored in geological formations, known as aquifers, which in many instances, EPA estimates indicate that these resources are utilized to recharge 41 percent of streams and rivers and serve as resources for 89 percent of public water systems in the U.S.[11] Underground injection is the practice of placing fluids underground, in porous formations of rock, soils, or rock and soils, through wells.

[7] United States Environmental Protection Agency (USEPA), Drinking Water Pocket Guide #2: Protecting Drinking Water Through Underground Injection Control, January 2002.
[8] SDWA § 1421; 42 U.S.C.A §300h.; 40 CFR Parts 144-148.
[9] SDWA § 1421; 42 U.S.C.A §300h-2; 40 CFR Parts 144-148.
[10] USEPA, "UIC Program Overview," Sequestration Workshop, February 2-3, 2004.
[11] USEPA, "USEPA's Program to Regulate the Placement of Waste Water and other Fluids Underground, December 1999.

Figure 34. Summary of UIC Well Class Applicability.

UIC CLASS	SUMMARIZED APPLICATION
Class I	Deep disposal of hazardous and non-hazardous fluids (including industrial and municipal wastes) beneath the lowermost USDW and are further regulated under the Resource, Conservation, and Recovery Act (RCRA)
Class II	Injection of brines and other fluids associated with oil and gas production, including crude oil (storage), drilling fluids, and drilling muds
Class III	Injection of fluids associated with solution mining of minerals with fresh water (salt), sodium bicarbonate (uranium), or steam (sulfur)
Class IV	Injection of hazardous or radioactive wastes into or above a USDW (which have been banned except as part of authorized clean up activities)
Class V	All underground injection not included in Classes I-IV, which generally inject non-hazardous fluids or above a USDW and are on-site disposal systems, such as storm water runoff, industrial wastewater, car wash water, sanitary waste, agricultural waste, and aquifer recharge, as well as experimental wells

Source: EPA, USEPA's Program to Regulate the Placement of Waste Water and other Fluids Underground, December 1999.

All injection wells are not waste disposal wells – some Class V wells inject surface water to replenish depleted aquifers or to prevent salt water intrusion.[12] Some Class II wells inject fluids for enhanced recovery of oil and natural gas (i.e. EOR and EGR), and others inject liquid hydrocarbons that constitute the nation's strategic fuel reserves, including the Strategic Petroleum Reserve.[13]

Of these five classes, only three are potentially applicable to the arena of geologic carbon sequestration – Class II, in cases of enhanced hydrocarbon recovery, and potentially Classes V and I, which are both invoked under the Frio Injection Project presently being conducted by the University of Texas, Bureau of Economic Geology invokes both approaches, which is explained in greater depth in this same section.

Responsibility for UIC regulation is divided between the federal government, as represented by the EPA, and state governments. The EPA roles include setting UIC Program requirements and national standards, approving and overseeing U.S. state delegations, providing assistance to state entities administering UIC activities, overseeing direct implementation programs in certain states, and supporting and advancing sound science. U.S. state and tribal roles for the 33 states, Guam, Commonwealth of the Mariana Islands and Puerto Rico have primacy authority for all or part of the UIC program, which includes responsibility for application, review, authorization and monitoring.[14] In seven other states, including SECARB state Florida, primacy is shared between the states and the EPA. In addition, the EPA administers UIC programs for the remaining 10 states, including SECARB states of Tennessee and

[12] USEPA, "USEPA's Program to Regulate the Placement of Waste Water and other Fluids Underground, December 1999.
[13] USEPA, "USEPA's Program to Regulate the Placement of Waste Water and other Fluids Underground, December 1999.
[14] USEPA, Drinking Water Pocket Guide #2: Protecting Drinking Water Through Underground Injection Control, January 2002.

Virginia, and all other federal jurisdictions and tribal lands.[15] Most of the minimum requirements that affect the siting of the injection well, the construction, operation, maintenance, monitoring, testing, and, finally, the closure of the well, are designed to address USDW functions. A detailed listing of the regulatory relationship between the federal government and the states in the SECARB region follows in Figure 35. For reference, these entities will play a crucial role in the development and implementation of regulatory, permitting, and accounting frameworks in the SECARB region.

Figure 35. SECARB State Regulatory Primacy for UIC Program.

SECARB STATE	PRIMACY	REGULATORS
Alabama	State	Classes I, III-V -- Alabama Department of Environmental Management Class II -- Alabama State Oil and Gas Board
Arkansas	State	Classes I, III-V -- Arkansas Department of Environmental Quality Class II -- Arkansas Oil and Gas Commission
Florida	Shared	Classes I, III-V -- Florida Department of Environmental Management Class II -- EPA Region 4
Georgia	State	Classes I-V -- Georgia Environmental Protection Division
Louisiana	State	Classes I, III-V -- Louisiana Department of Natural Resources Class II -- Louisiana Office of Conservation
Mississippi	State	Classes I, III-V -- Mississippi Department of Environmental Quality Class II -- Mississippi Oil and Gas Board
North Carolina	State	Classes I-V -- North Carolina Department of Environment and Natural Resources
South Carolina	State	Classes I-V -- South Carolina Department of Natural Resources
Tennessee	Federal	Classes I-V -- EPA Region 4
Texas	State	Classes I, III-V -- Texas Natural Resource Conservation Commission Class II -- Texas Railroad Commission
Virginia	Federal	Classes I-V -- EPA Region 3
Tribal Lands in SECARB	Federal	Classes I-V -- EPA Region 4 or 6 (in Arkansas, Louisiana, and Texas) (*Note: No Tribal Lands Region 3 SECARB state, Virginia)

Source: EPA, Drinking Water Pocket Guide #2: Protecting Drinking Water Through Underground Injection Control, January 2002.

[15] USEPA, "USEPA's Program to Regulate the Placement of Waste Water and other Fluids Underground, December 1999.

According to recent EPA estimates, there are between UIC 650,000 to 850,000 wells in the U.S. as of February 2004. For reference, approximate UIC well counts by SECARB state follows in Figure 36.

Figure 36. UIC Well Numbers by SECARB State.

SECARB STATE	NUMBER OF UIC WELLS
Alabama	797
Arkansas	1,247
Florida	75,674
Georgia	780
Louisiana	3,990
Mississippi	5,377
North Carolina	4,489
South Carolina	6,314
Tennessee	4,747
Texas	59,246
Virginia	16,267

Source: EPA, "UIC Program Overview," Sequestration Workshop, February 2-3, 2004.

Based upon existing rules and regulations, it seems logical that geologic carbon sequestration projects, which function as EOR and EGR activities, would be permitted under UIC as Class II wells. It is less clear, however, how other long-term storage carbon sequestration projects would be permitted. Viewpoints range from the IOGCC preference for regulating and permitting these sites under natural gas storage laws to restating EPA regulations regarding Class V well definitions or adding another UIC class.[16] Another less viable, and potentially more costly, option is the utilization of the Class I UIC definition, which appears to be preferred by another faction of geologic carbon sequestration scholars.[17] In fact, the Frio Injection Project presently being conducted by the University of Texas, Bureau of Economic Geology, as noted, invokes both approaches. While the project was permitted as a Class V UIC well due to its experimental nature, the consensus in Texas is that future, non-experimental long-term geologic carbon sequestration wells would be permitted under a UIC Class I regime.

In addition to the governing regime for the regulatory, permitting, and safety issues of geologic sequestration injection and storage, matters of long-term liability and stewardship exist which cannot be easily ignored. One approach to this matter could mirror the various state mine land restoration programs, which would require bonding or trust fund deposits to be posted with the relevant state regulatory agency to ensure that the long-term stewardship of geologic carbon sequestration sites would continue past the life of operating companies. Based upon early stakeholder input on this subject, it seems that this type of approach would address public concerns without undue harm to

[16] Interstate Oil and Gas Compact Commission Geological CO_2 Sequestration Task Force, Draft Report, October 2004.
[17] Wilson, Elizabeth J., David W. Keith, and Malcolm Wilson, "Considerations for a Regulatory Framework or Large-Scale Geological Sequestration of Carbon Dioxide: A North American Perspective," Presented at Vancouver, BC, Canada, September 2004.

the economics of geologic sequestration, and, in doing so, serve as an asset to wide-scale geologic sequestration deployment.

Terrestrial Sequestration

While the geologic sequestration regulatory, permitting, and safety frameworks will require substantial shepherding to ensure that the regulations protect the public interest and are at the same time not unduly burdensome on terrestrial sequestration project stakeholders, the arena of terrestrial sequestration regulatory, permitting, and safety frameworks is advancing without assistance from entities like SECARB. Witness, for example, the investments being made in the Lower Mississippi River Valley by power companies, including Entergy and American Electric Power, and nonprofit organizations, including the Conservation Fund, among others. This is not to say, however, that SECARB will not play a beneficial role in attempting to streamline various state enactments in this domain, as with its present mission, SECARB would do so.

In general, most laws and regulations related tangentially to terrestrial sequestration in the SECARB states provide limited guidance to regulatory, permitting, and safety practices, but instead focus on attempting to stimulate voluntary terrestrial sequestration activities. As a result, much of the guidance for terrestrial sequestration activities in the SECARB region results from state conservation policies or economic development enactments. As a result of the potential terrestrial sequestration options in the region, four areas that relate to potential terrestrial sequestration projects – mine reclamation, reforestation, farm practices, and brownfield restoration – were examined in greater depth.

Mine Land Reclamation

As a result of federal mining laws, all SECARB states have required mining companies to submit reclamation plans to the state governments explaining the post-mining utility of lands that have been excavated for mineral resources. These plans typically explain the vegetative cover that will be planted in the land and the man-made structures that will conserve water and land resources. Some of the states such as Florida and Arkansas have regulations on the type of plants and trees to be used in the reclamation process and the manner in which vegetation is to be planted. As terrestrial sequestration can be additional value-add options for mine land reclamation projects, states that are encouraging this practice could be helpful to the goal of wide-scale terrestrial sequestration.

Reforestation and Afforestation

Similar value-add opportunities exist for terrestrial sequestration in the area of reforestation and afforestation to combat emerging problems with land erosion resulting, in some instances, from development and industrial processes. To augment this situation, many SECARB states have employed programs to diminish the costs associated with replanting trees and conserving land resources. Therefore, the

SECARB states provide technical assistance services or provide cost-sharing grant opportunities to develop appropriate preliminary planning to implement reforestation and afforestation practices. For example, some SECARB states provide private land-owners with tree seedlings at the cost of planting the trees. Many of the state governments maintain tree nurseries for the rationale of diminishing the costs associated with developing immature trees. In addition, many SECARB states utilize the educational systems to develop reforestation technical assistance and site preparation. Further, these states provide, in some instances, technical assistance through "Stewardship Programs" for maintenance of forestry resources. This program is also used for information resources and networking for forest land owners to optimize the value of their resources.

Brownfield Restoration

SECARB states have also adopted a focus on brownfield restoration as a land management activity, which in some instances can positively impact terrestrial sequestration prospects. Most SECARB states, with North Carolina as a notable exception to the rule, have diminished the liability of associated hazardous waste for future generations following the initial clean-up process, which could include for purposes of terrestrial sequestration.

The incentives associated with brownfield redevelopment do not always apply to terrestrial sequestration activities in the SECARB states. Often, in terms of terrestrial sequestration, these governmental incentives are dependent on the definition of "development." Some of the states observe the creation of public parks as an activity worthy of these tax incentives. The development of public parks could sequester carbon, but the intention of these laws is often more focused on development of brownfields into commercial property, not necessarily GHG reduction projects. Thus, alterations to brownfield restoration laws could be required in order to allow this mechanism to become a more viable option for terrestrial sequestration.

Farm Practices

Moving to the domain of soil sequestration, select SECARB states have advanced programs that assist in on-farm, soil management-based terrestrial sequestration. While several SECARB states encourage agricultural management practices that enhance terrestrial sequestration, two SECARB states – Georgia and North Carolina – have provided incentives for farmers to employ conservation-oriented farm preparation activities, e.g. no-tillage farm practices, which can directly result in marketable, verifiable carbon sequestration achievements. For reference, the state governments provide capital equipment for farm owners using this form of site preparation. In addition, North Carolina state government also provides technical assistance for farmers that utilize no-tillage practices.

Other References to Terrestrial Sequestration

To date, SECARB state terrestrial sequestration enactments have focused on laws and regulations that provide opportunities for terrestrial sequestration, but that do not directly contemplate terrestrial sequestration. In limited instances, however, terrestrial sequestration projects are specifically referenced in state codes and forestry entities are empowered with the authority to assist private and public parties, in some instances, with terrestrial sequestration projects. For instance, the Arkansas Forestry Commission is endowed with these privileges under a recent enactment.[18] Other non-SECARB states, including Oklahoma, seem to have set the precedent for this approach with its "Carbon Sequestration Enhancement Act" from several years earlier.

While common approaches to terrestrial sequestration are developing, there remains a void in terms of a universal approach to terrestrial sequestration regulatory, permitting, and safety frameworks that would encourage such activities in the SECARB region.

Accounting Frameworks

Related to regulatory, permitting, and safety frameworks are accounting frameworks for carbon sequestration which allow for adequate recording, documentation, and verification of the carbon sequestration activities, whether terrestrial or geologic in nature. Presently, GHG accounting comes in two forms – voluntary or mandatory. In the SECARB region, to-date, voluntary reporting has been the universally accepted form of accounting practices, although mandatory approaches must also be assessed for consistency in case mandatory measures should arise locally, on a state basis, or nationally. Regardless of the compliance mechanism approach, it appears that the most significant issues regarding carbon sequestration accounting center on a few key elements – baselines, minimum legal requirements, additionality, measurement, monitoring, and verification.

Voluntary reporting is valuable as it provides a way to present information about an enterprise's GHG emissions and/or emissions reduction activities to its customers or constituents, who are interested in GHG emissions. The communication of voluntary reports and achievements can be valuable in that it provides public information that may influence future GHG policy formulation, and more importantly, prompt enterprises to pursue GHG mitigation projects in the years to come, including those focused on terrestrial and geologic carbon sequestration.

Under this research phase, SECARB partner Augusta Systems analyzed federal, state, and private sector accounting frameworks, including, most notably, the U.S. national voluntary GHG reporting program, the VRGGP of the U.S. Department of Energy, the new Georgia carbon sequestration registry legislation, and the emerging Chicago Climate Exchange and "Greenhouse Gas Protocol" of the World Business Council for Sustainable Development and World Resources Institute. Details of each analysis follow.

[18] Code of Arkansas, §22-5-506 (2003).

DOE 1605(b) Program

In 1992, the U.S. Congress established the VRGGP in order to meet U.S. commitments under the United Nations Framework Convention on Climate Change (UNFCCC). The VRGGP was established under Section 1605(b) of the 1992 EPact, which has become known as the 1605(b) program. The 1605(b) program provides a mechanism for reporting GHG emissions and emissions reductions, including those produced from carbon sequestration projects. Presently, the 1605(b) program is being revised to better meet the emerging needs of the voluntary GHG trading market and the expanding role of carbon sequestration in the GHG emissions management arena. As this national program would, potentially, impact accounting frameworks within the SECARB region, a summary of the present 1605(b) program will be presented, as well as information on the proposed revisions made public to-date.

Existing Program - Under the enacting legislation for the 1605(b) program, the DOE through its Energy Information Administration, and in collaboration with the U.S. Environmental Protection Agency, was required to publish procedures for the accurate voluntary reporting of information on: (1) GHG emissions on an annual basis for the baseline period 1987 through 1990, and for subsequent calendar years; (2) annual reductions of GHG emissions achieved through any measure; and, (3) reductions in GHG emissions achieved voluntarily, including via carbon sequestration, or as a result of plant or facility closings, or as a result of federal or individual state requirements.

Final guidelines and supporting materials were developed, with stakeholder input, for the six sectors identified by the 1605(b) program, which are: Electricity Supply; Residential and Commercial Buildings; Industrial; Transportation; Forestry; and, Agricultural. The initial guidelines provide reporting flexibility by allowing the participant to utilize existing GHG emissions and emissions reduction information, and to select appropriate quantification methods based upon the nature of their reduction or offset projects. To prompt action by participants, the support documents included examples of project analyses for the various sectors, appendices of conversion tables, and default emissions factors for various fuels and for electricity on a state-by-state basis.

Participants are encouraged to submit comprehensive reports, which can include information on GHG emissions levels and emissions reduction projects, including terrestrial and carbon sequestration projects. It is important to note that the present 1605(b) program definition of “carbon sequestration” is limited to terrestrial projects. Geologic sequestration projects are dealt with under another project type definition. For project reporting, every GHG emissions reduction project report must include specific information to assist in analyzing the benefits of the projects. For instance, it is required that every report provide an established reference case that serves as a basis for comparison with a specific project. Further, the report must provide identification of the effects of the project, and an estimation of the GHG emissions for both the reference case and the specific GHG emissions reduction for the carbon sequestration project.

To aid in the development of these data sets, the 1605(b) program guidelines and supporting documents provide detailed information regarding the appropriate processes under which an entity should obtain data and define the methods for estimating a specific project's effect on GHG emissions reduction and carbon sequestration results. The guidelines outline the acceptance of three types of data – physical, default, and reporter-generated. Based on these three categories of data, the guidelines recognize two categories of projects: standard projects, which rely on physical and default data, and reporter-designed projects, which use relative default data and measured, or engineering data, developed by the entity. The GHG emissions reduction outcomes or sequestered carbon emissions of an entity's project must be determined and recorded. By requiring these elements, the report contains detailed information relative to the impact of the project, which can be reviewed by a third party to determine the validity of the emissions reduction effort.

In summary, the 1605(b) program provides enterprises with an opportunity to record their GHG emissions reduction and carbon sequestration achievements, and communicate these achievements to colleagues, customers, and the general public. By nature of its voluntary and uncomplicated structure, the 1605(b) program provides an unrestrictive opportunity to encourage enterprises to engage in GHG emissions reduction activities. However, the 1605(b) program was not without its detractors, as the program's reporting mechanisms did not, in the eyes of many, truly allow for detailed accounting procedures and did not adequately address geologic sequestration project reporting and accounting. The following section describes the on-going efforts of the DOE, the USDA and the EPA to improve the 1605(b) program.

Emerging Changes to 1605(b) Program - During 2002, DOE, USDA and EPA initiated a series of actions to facilitate comments and suggestions for enhancements and improvements to the 1605(b) program from stakeholders. In July 2002, the three federal agencies initiated a call for public comments to improve the guidelines. In addition, the three federal agencies conducted a series of workshops to enable interested persons to help improve the 1605(b) program guidelines. Following these activities, the federal agencies moved forward to produce two levels of new proposed guidelines – Technical Guidelines and General Guidelines.[19]

The enhanced General Guidelines are intended to improve the accuracy and completeness of GHG emissions data in the national registry created by 1605(b) and have been released publicly. The Technical Guidelines will be proposed in the near future and both of these guidelines, when effective, will collectively modify and replace the current guidelines for the 1605(b) program. The Technical Guidelines will specify methods and factors to be used in measuring and estimating greenhouse gas emissions, emissions reductions, and carbon sequestration. Thus, these Technical Guidelines will play the most critical role of the two in the development of the accounting framework for SECARB.

[19] United States Department of Energy (USDOE), USDOE 1650(b) Program Enhancements Website, Proposed Guidelines, General Guidelines , *www.pi.energy.gov/enhancingGHGregistry/proposedguidelines/generalguidelines.html*

Due to the fact that these General Guidelines will provide the structure for the more specific Technical Guidelines, these initial proposed revisions are significant to the SECARB accounting framework research. The remainder of this document summarizes key elements of the proposal on which DOE will again solicit public comments on these specific issues at a later date. More specifically, these General Guidelines are summarized into sections examining entity reporting requirements, certification and verification, and reporting and registering emission reductions (including carbon sequestration).

With respect to entity reporting requirements, the General Guidelines feature two different mechanisms for differently sized entities. Large entities, i.e. those with average annual emissions over 10,000 tons of CO_2 equivalent (CO_2e), would be required to provide an inventory of total emissions and calculate net reductions associated with entity-wide efforts, as well as to demonstrate that the reported reductions represent an actual net decrease in entity-wide emissions, as calculated by one or more of the methods allowed by the General Guidelines. Meanwhile, smaller entities, i.e. those with average annual emissions of less than 10,000 tons of CO_2e, would be eligible to register emission reductions associated with specific activities without completing an entity-wide inventory or reduction assessment.[20]

As certification and verification standards of the 1605(b) program could impact SECARB accounting frameworks, the certification and verification recommendations for the new General Guidelines merit examination. Under the proposed new General Guidelines, an agency head, CEO, or other responsible official is required to certify that the reporting entity accurately follows the revised guidelines for determining emissions, emission reductions, and sequestration achievements with sufficient records maintained for at least three years to enable independent verification. In addition, entities are encouraged to obtain independent verification of the accuracy of their reports and compliance with DOE Guidelines. It is also important to note that the required reports sent to EIA should be sufficiently detailed to enable EIA to review and confirm the final emission reduction calculations for each method and output measure utilized, and to review and confirm the rates of conversion used for each category of GHG covered and for electricity-related use or emissions avoidance, by region.[21]

With reference to reporting and registering emissions reductions, including those achieved via carbon sequestration, there are a number of significant points to consider, including legal rights and ownership, as well as emissions intensity metrics. Notably, as legal rights to sequestration opportunities or other emissions management activities may be in question given current laws, the proposed new General Guidelines state that the owner of the facility, land or vehicle that generated the emission reductions or sequestration is the entity presumed to have the right to report and register any

[20] USDOE, USDOE 1650(b) Program Enhancements Website, Proposed Guidelines, General Guidelines at *www.pi.energy.gov/enhancingGHGregistry/proposedguidelines/generalguidelines.html*

[21] USDOE, USDOE 1650(b) Program Enhancements Website, Proposed Guidelines, General Guidelines at *www.pi.energy.gov/enhancingGHGregistry/proposedguidelines/generalguidelines.html*

emission reductions or sequestration. Also, entities are required to coordinate with other entities that share ownership of particular operations to ensure no double counting occurs and this no double counting must be certified. With reference to emissions intensity metrics, the proposed General Guidelines recommend the use of emission intensity indicators as the basis for determining emission reductions. However, the DOE Technical Guidelines will set procedures to calculate emission reductions, including lists of possible output indicators, calculation methods for determining reductions associated with terrestrial and geologic sequestration, methods and emission factors for calculating avoided emissions, and project-based methods. Also, it is important to note that, entities could report reduction in emissions intensity, absolute reductions in emissions, increased carbon storage, avoided emissions, and project emission reductions.[22]

State-Based Accounting

While the 1605(b) program has been in operation for a sufficient period to allow for the thoughtful consideration of enhancements and revisions, state voluntary reporting programs are only beginning to appear. While a number of states are moving forward to initiate and adopt voluntary GHG registries, including Georgia in the SECARB region, a smaller number (California, New Hampshire, and New Jersey) have active state voluntary GHG registries, which include opportunities for reporting and registering emissions reductions achievements, including those produced via carbon sequestration projects, both terrestrial and geologic. In the SECARB region, however, less activity has occurred and most existing state enactments tend to deal only with the technology and approaches presently enjoying expansion – terrestrial sequestration. For instance, the State of Georgia, under its recently enacted Senate Bill 356, established the Georgia Carbon Sequestration Registry Act, which supported the use of terrestrial sequestration, but is seemingly silent on geologic sequestration opportunities. The launch date for the Georgia Registry has not been established at this time.

Private Sector Initiatives

In addition to analysis on federal and state reporting and registry mechanisms that could impact the SECARB accounting framework action plans, Augusta Systems also examined the requirements of reporting, registering, and accounting under the Chicago Climate Exchange, as well as the World Business Council for Sustainable Development and World Resources Institute (WBCSD/WRI) Greenhouse Gas Protocol. For reference, the WBCSD/WRI Greenhouse Gas Protocol may provide the most comprehensive method and process for GHG and carbon sequestration accounting activities produced to-date, and as such will serve as a vital resource for accounting framework developments by SECARB. In general, the most significant issues regarding carbon sequestration accounting for private sector initiatives tend to key on the same points as public sector initiatives – baselines, minimum legal requirements, additionality, measurement, monitoring, and verification.

[22] USDOE, USDOE 1650(b) Program Enhancements Website, Proposed Guidelines, General Guidelines at www.pi.energy.gov/enhancingGHGregistry/proposedguidelines/generalguidelines.html

Thus, it appears that while all existing reporting, registering, and accounting methodologies are still developing, there is some level of commonality among the existing accounting framework standards. Year two of SECARB efforts will focus on developing an action plan with accounting frameworks that meets the needs of stakeholders and duly defers to the existing and emerging federal, state, and private sector practices.

<u>Ecosystem Impacts</u>

The states of the Southeast Regional Carbon Sequestration Partnership encompass many types of open and undeveloped land and developed single and multi-use land. For the purposes of examining the effects of CO_2 on the environment, a non-exhaustive list designates land as original ecoregions and current-day agricultural, industrial, mining, ranching, recreational and urban areas.

An ecoregion is a relatively large unit of land "containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use".[23] Fifteen terrestrial ecoregions within the area covered by the states of the SECARB have been described by the National Geographic Society[24] and the World Wildlife Fund[25], as shown in Table 5. Within patches of the original ecoregions, endemic species are found, which are a major focus for conservation of threatened and endangered species.

An ecosystem is "a community of plants, animals, and microorganisms that are linked by energy and nutrient flows and that interact with each other and with the physical environment. Rain forests, deserts, coral reefs, grasslands, and a rotting log are all examples of ecosystems."[26] Thus, an ecosystem can be a large unit or a small unit and can include or exclude humans.

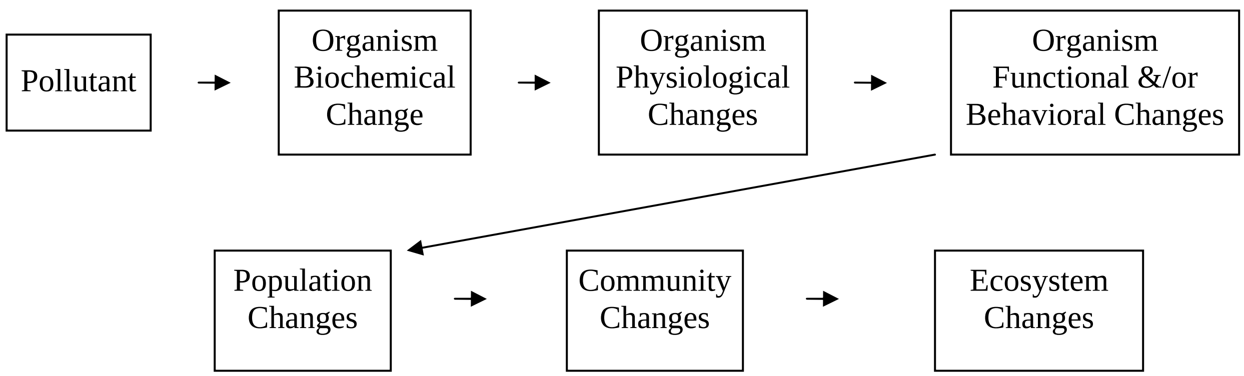
In general terms, an ecosystem may consist of algae, bacteria, fungi, viruses, plants, and animals (invertebrates [e.g., arthropods including insects, helminths, mollusks, protozoa,] and vertebrates). Each type of organism comprises a separate population, which exists in a larger community.[27] Changes in one ecosystem can, in turn, affect other ecosystems, and so on.

Each ecoregion has species that are endemic to that area. That is, certain species occur naturally only in that one area or region. The southern states are home to

[23] Olson et al., Bioscience 51:993-938, 2001. An ecoregion is a geographically distinct area of land that is characterized by a distinctive climate, ecological features, and plant and animal communities.
[24] The National Geographic Society (http://www.nationalgeographic.com/wildworld/terrestrial.html).
[25] The relationship of World Wildlife Fund delineation of ecoregion to those of others is described by the World Wildlife Fund at http://worldwildlife.org/science/ecoregions/nearctic.cfm.
[26] World Wildlife Fund (http://worldwildlife.org).
[27] A community is a characteristic group of plants and animals living and interacting with one another in a specific region under similar environmental conditions (World Wildlife Fund, 2001, http://www.nationalgeographic.com/wildworld)

hundreds of endangered endemic species. Most are endangered because of loss of natural habitat. Additional pressure exists in the form of air, water, and soil pollution from numerous sources. The inadvertent release of captured, transported, or stored carbon dioxide is one potential additional source of chemical pollution. CO_2 and other toxic chemicals, or pollutants, exert effects on the ecosystem according to the scheme shown in Figure 37.

Figure 37. Progression of Pollutant-Induced Changes Influencing an Ecosystem.



CO_2 can enter an ecosystem via the air, water, or soil. Most living organisms can be adversely affected by exposure to high concentrations of CO_2. The time to effect is species dependent. CO_2 causes toxicity by both direct and indirect actions. It exerts direct at the cellular level and indirect effects via cellular acidification and/or displacement of oxygen. Each organism has its own characteristic response to CO_2 that is dependent on the concentration of CO_2, route and duration of exposure, life stage at exposure, environmental conditions (e.g., oxygen concentration, temperature, humidity), and other factors. Additionally, effects of CO_2 on one type of organism may affect an entire ecosystem by disruption of the normal interdependence among organisms within an ecosystem.

The relatively low-dose, non-toxic effects of CO_2 are most apparent in mammals where increased ventilation (due primarily to an increased depth of breathing) can be observed. Mammals can be severely injured or killed by exposure to CO_2 for minutes to hours at or above 8% in air, while insects and plants exhibit no lasting, if any, effects. Food-producing animals of significance for these states are beef cattle, milk cows, laying and broiler chickens, and hogs and pigs. Honey bees are also an important domesticated insect.

Plants benefit from elevated CO_2 levels up to about a 2% concentration in air. The primary agricultural crops in these states are corn, cotton, peanuts, wheat, sorghum, soybeans, and tobacco. Although leaves of plants produce oxygen (O_2) from CO_2 during photosynthesis, an increase in the soil content of CO_2 can be deleterious because roots need to absorb O_2 and nutrients directly. The gas content of the soil normally contains 1% CO_2 or less. The large areas of tree kill at Mammoth Mountain are an example of high soil CO_2 concentrations (~20 to 95%) denying tree roots O_2 and by interfering with nutrient uptake.

CO_2 also affects water-breathing animals, such as fish. The transport of gases from the water to the blood is generally difficult because most gases have low water solubility and water has a high density. CO_2 is the exception because it is very soluble in water. At 25° C, CO_2 is 25-times more soluble in water than O_2. Its high water solubility minimizes its partial pressure in water. Thus, if equal volumes of CO_2 and O_2 are exchanged in a fixed volume of water, the PO_2 would decrease markedly but the PCO_2 would only slightly increase. Many natural water habitats have little dissolved CO_2, and others have higher concentrations of CO_2 to which native fish are adapted. The blood of water breathers has very little CO_2 compared to air breathers. High concentrations in the water would impede CO_2 excretion.

Table 5 presents examples of the effects of CO_2 over a wide range of concentrations in several types of organisms. In general, sensitivity increases from unicellular organisms, such as bacteria, which are relatively resistant, to mammals, which can be very sensitive to the effects of CO_2.

Evaluation of environmental risk from CO_2 is inherently dependent on the specific composition and characteristics of an ecosystem. Risk in the vicinity of a specific agricultural crop (a relatively uniform area with a limited number species) would be much easier to assess than risk in a forest area.

Table 5. Terrestrial Ecoregions within the Area of the Southeast Regional Partnership.

Ecoregion Name & Map Designation[28]	Biome	Total mi[29]	Boundary of Ecoregion within Southern States Partnership States[30]	% of Ecoregion Converted[31]
South Florida Rocklands NT0164	Tropical & subtropical moist broadleaf forests	800	Southern Florida	98% to agriculture & urban development
Florida sand pine scrub NA0513	Temperate coniferous forests	1,500	Southeastern coast Florida	85-90% to citrus groves, & urban development
Everglades NT0904	Flooded grasslands & savannas	7,800	Southern tip of Florida	~70% to sugar cane, truck crops, & urban development
Southeastern conifer NA0529	Temperate coniferous forests	91,400	Florida panhandle; southeastern Louisiana, southern Mississippi & Alabama, central & southern Georgia	>50% to agriculture, pine plantations, & urban development
Southeastern mixed forests NA0413	Temperate broadleaf & mixed forests	134,300	Western Virginia, central North Carolina, eastern South Carolina, central Georgia, Alabama, Mississippi & small area in Louisiana	99% to agriculture & other
Middle atlantic coastal forests NA0517	Temperate coniferous forests	51,600	Southeastern Virginia, eastern North & South Carolina to just south of Georgia/So. Carolina border	~88% to agriculture, pine plantations, urbanization, & coastal development (including resorts)
Appalachian-Blue Ridge forests NA403	Temperate broadleaf & mixed forests	~61,500	Northeastern Alabama & Georgia, eastern Tennessee, western North Carolina & Virginia	~83% to agriculture, urban & recreational development, logging, & coal & mineral mining
Appalachian mixed mesophytic NA0402	Temperate broadleaf & mixed forests	74,200	AL, northeast to southwest Mississippi, E central Tennessee	>95% to agriculture, coal, copper, ore mining, logging, & other
Central US hardwood forests NA0404	Temperate broadleaf & mixed forests	114,300	Western Tennessee, north central Mississippi	99% to agriculture, grazing, urban development, & tree plantations,
Mississippi lowland forests NA0409	Temperate broadleaf & mixed forests	43,400	Flood plain of the Mississippi river including Louisiana, Mississippi, Arkansas, Tennessee	91-95% to agriculture & levee construction
Ozark Mountain forests NA0412	Temperate broadleaf & mixed forests	23,900	Western and central Arkansas	97% to logging & recreational development
Piney Woods forests NA0523	Temperate coniferous forests	54,400	Eastern Texas, northwestern Louisiana, southwestern Arkansas	97% to urban development, logging, & pine plantation
Western Gulf coastal grasslands NA0701	Tropical/subtropical grasslands, savannas, & shrublands	30,000	Gulf coast wetland of Louisiana & Texas	To agriculture, grazing, urbanization around areas such as Houston

[28] Map designations on websites of the World Wildlife Fund (http://worldwildlife.org/science/ecoregions/nearctic.cfm) and the National Geographic Society (http://www.nationalgeographic.com/wildworld/terrestrial.html).
[29] The total area of the ecoregion may not lie within the boundary of the Southern States Partnership.
[30] Only the Texas Gulf Coast and other ecoregions that extend into Partnership States beyond Texas are included.
[31] The original reason for conversion may no longer be operational, although the land has been converted from its original ecosystem. The list is non-exhaustive.

Table 6. Effects of CO_2 on Various Types of Organisms.

Organism Type	Medium	Effects of CO_2		
		Maximum Beneficial or Non-Toxic	Immobilized or Toxic	Lethal
Bacterial spore	air	1% CO_2: increased spore germination		
Mold spore	liquid		1% CO_2: increased heat sensitivity	
Mold spore			4-5% CO_2 in air above liquid: decreased respiration and sugar uptake	
Amoeba (soil), cyst	water	0.8-2.0% CO_2 in air above liquid: increased excystment		
Amoeba (soil), cyst	on agar	0.33-2.0% CO_2 in air above agar: increased excystment		
Insect larvae	air		50% CO_2: cardiac arrest and immobilization	
Insect larvae	water		100% CO_2 above water: decreased movement and exsheathment	
Insect larvae	water	25% CO_2 bubbled through water: not immobilized >9 days	100% CO_2 bubbled through water: immobilized in 1-2 min; acidified blood; not lethal >9 days	
Insect larvae	water		100% CO_2 bubbled through water: immobilized in 1-2 min	100% CO_2: ~5 days
Mosquito	air	~10% CO_2 intermittently		
Cockroach, adult	air		~100% CO_2: convulsions & paralysis; no lethality at 60 min	
Cockroach, instar	air		70% CO_2: immobilized; after recovery increased instars to maturity, growth retardation	
Crustacea, freshwater	water		25% CO_2 bubbled through water: slightly less active after several hr	
Crustacea, freshwater	water		100% CO_2 bubbled through water: immobilized 1-2 min	100% CO_2 bubbled through water: ~ 5 hr
Leech	water		20-40% "soda water": immobilized	100% "soda water"
Trees	soil	1-2% CO_2 chronically		20-95% CO_2
Salmon	water		5-9 mmHg PCO_2 chronically: nephrocalcinosis	
Trout	water		7-13 mmHg PCO_2 chronically: nephrocalcinosis	
Chicken	air	2.25% CO_2: increased ventilation in 10 min		
Mouse	air			32.5% CO_2 with 20% O_2: mean time 87 min
Mouse	air			40% CO_2 with 20% O_2: mean time 63 min
Mouse	air			40% CO_2 with 4.5% O_2: mean time 1.8 min

Measurement, Monitoring and Verification

During the semiannual reporting period, the SECARB project team has completed an initial survey of measurement, monitoring and verification technologies. In addition, the team has identified emerging technologies that may play an important role in MMV within five years, and MMV needs that are either unfulfilled, or where there are significant opportunities for improvement.

Goals for MMV technology

DOE has clearly stated its goals for MMV technologies:

- By 2006, DOE will apply promising MMV technologies in several field tests or commercial applications.
- By 2008, MMV protocols will enable 95% of CO_2 uptake in a terrestrial ecosystem to be credited, and represent no more than 10% of the total sequestration cost.
- By 2012, MMV protocols will enable 95% of CO_2 injected into a geological reservoir to be credited, and represent no more than 10% of the total sequestration cost.

Thus, it is important to evaluate MMV technologies in terms of their ability to contribute to meeting those goals. Further, MMV must also be evaluated in terms of their effectiveness in achieving certain specific aims:

- Measurement of the amount of CO_2 stored at a specific sequestration site.
- Monitoring of the site for leaks/deterioration over time, i.e., storage stability, and potential harm to the ecosystem.
- Alarming, to notify of CO_2 leakage and possible ecological damage.

Categories of MMV

MMV technologies can be classified into three broad application categories: subsurface, surface, and above-surface. Subsurface MMV involves tracking the fate of the CO_2 within the geologic formations underlying the earth and its possible migration to the surface. This area also encompasses developments to mitigate CO_2 leakage, should it occur. Surface MMV involves tracking carbon uptake and storage in the first several feet of topsoil as well as tracking potential leakage pathways into the atmosphere from the underlying geologic formation. This area is especially challenging due to the difficulty of detecting small changes in concentration above the background emissions (~370 ppm) that already exist in the atmosphere. Above-surface MMV is specific to terrestrial sequestration and involves quantification of the above-surface carbon stored in vegetation. DOE's MMV research and development (R&D) is aimed at developing site-deployable instrumentation, comprehensive computer models, and advanced protocols for each of these areas.

MMV technologies

The following are listings based on initial examination of the existing literature. In particular, it does not include the instrumentation that has been used at the Frio experiment in Texas. Information from that experiment, and others currently not yet completed, will be included in an update to these tables.

Geological sequestration	Subsurface-measure movement of CO_2 plume	*Seismic*	Surface based: 3D & 4D seismic imaging
		Fluid movement monitoring	Borehole: Vertical Seismic Profile (VSP)
			Cross-Well Tomography
			Borehole and wellhead pressure sensors
		Near surface	Horizontal and vertical flow meters
			Streaming potential sensors
			Soil gas monitoring (LIBS, INS)
	Surface – verification that CO_2 stays sequestered	*Atmospheric*	Near IR Diode Laser Absorption Spectroscopy
			Standing Acoustic Wave Gas Chromatography
			Thermal conductivity sensors
			Gas Chromatography
			Chemical reaction/visual indication Draeger tubes
			Satellite measurements (imaging and remote sensing)
			Airborne measurements (trace compounds)

Terrestrial Sequestration	Modeling	*Correlation of in-soil and above- ground carbon*	
		Ecosystem and landscape scale models	
		Global models/ predictions of changes in size of terrestrial sinks over next century	
	Measurements	*Regional Monitoring*	IR imaging
			Ameriflux network (and others)
		Soil measurements	LIBS and INS
			LIBS/Raman technology
			Isotopic measurements
			Microbial indicators
			Regional maps/estimates
			Traditional, dry combustion
		Above-surface carbon measurements	Forest inventories/ accounting
			Employing growth and yield models
			Aerial/satellite measurements (Winrock method)
			Forest management techniques
			Traditional field measurement techniques

Oceanic Sequestration			Gravitational measurements
			Seawater chemistry
			Diffraction
			Nuclear Magnetic Resonance Spectroscopy
			Raman Spectroscopy

Important technology needs

There are two major development needs relating to MMV technologies. The most important is cost reduction. While reliable estimates of overall costs are not available, recent experience suggests that the costs of MMV for geologic sequestration far exceed DOE's 10% goal cited earlier. It appears that the best way to achieve this goal is with a combination of less expensive instrumentation and modeling. We intend to use the experience gained during the Frio experiment to test this. Similarly, for terrestrial sequestration, soil carbon measurements are still highly expensive because of the lack of a readily deployed field technique. While Los Alamos National Laboratory's Lazer Induced Breakdown Spectroscopy (LIBS) probe has shown some potential, it is still rather expensive and not proven as a general tool. This indicates the need for an approach such as that taken by Winrock for carbon in vegetation. In this approach, algorithms relating more expensive "standard" measurements and less expensive remote sensing measurements have been developed.

In terms of instrumentation, the most important need is for inexpensive and readily deployable downhole techniques for geologic sequestration. Direct CO_2 monitoring in a reservoir to monitor system status is obviously desirable, but status indicators for such important variables as the pressure and temperature suitable for routine downhole deployment are lacking. It appears that techniques such as the ringdown spectroscopy being developed by Mississippi State University's Diagnostic Instrumentation Analysis Laboratory can provide the less expensive techniques needed for applications downhole. In the longer term, nano-scale devices may also have great promise, assuming greatly reduced costs and increased ruggedness.

MMV is defined as the capability to MEASURE the amount of CO_2 stored at a specific sequestration site, MONITOR the site for leaks or other deterioration of storage integrity over time, and VERIFY that the CO_2 is stored properly and not being harmful to the host ecosystem.

MMV is needed in order to account for inventories of greenhouse gas emissions reductions for credits and emissions trading, as currently envisioned in voluntary GHG reduction programs. It will be needed to address regulatory issues associated with carbon sequestration in the environment. Finally, public acceptance of carbon sequestration initiatives will require that the public know that projects are safe and that investors know that projects are effective.

Monitoring and surveillance will be needed to determine the extent of plumes as it relates to containment and subsurface ownership. Any out of zone leakage will need to be detected. Potable water will need to be monitored to ensure that displaced saline brine, metals or organics liberated by reactive brine or dissolution in CO_2 will not have adverse impacts. Leaks to the atmosphere will need to be monitored to determine health, safety and environmental risk, and to determine rates of escape for accounting purposes.

Atmospheric monitoring devices are available for CO_2 measurement. Detection of sequestered CO_2 is complicated because of high ambient concentrations that exist from atmosphere, soil and vegetation. It is therefore difficult to isolate small fluxes from the subsurface.

Soil Gas Monitoring is a relatively low cost detection technique that can integrate seepage over a period of time. The escaped CO_2 is likely to be concentrated in the vadose zone. Like air, detection in soil is complicated because of high ambient levels in the soil.

Groundwater monitoring is an accepted and standard technique for detecting constituents at contaminated sites. This historic application provides a good back drop for monitoring CO_2 migration into groundwater. However, natural carbonate balances in water may result in chemical changes that would mask leakage. Since the signal of leakage may be complex, the use of natural or introduced tracers could increase the confidence level of data. Introduced materials, such as Nobel gasses, that travel with CO_2 can uniquely fingerprint migration. Carbon isotopes and impurities also may be used to fingerprint the geochemical uniqueness of sequestered CO_2.

In addition, TX BEG has determined that tools used in surface geophysics can be applied to sequestration projects. Interferometry/tilt can be used to monitor injection sites. Surface seismic imaging (2D, 3D, 4D) can be used for characterization and monitoring. Alternative methods, such as electrical contrast, gravity and passive seismic, can be applied. Traditional reservoir management techniques, such as wire-line well logs and subsurface fluid sampling also can be applied to sequestration sites.

The Texas Bureau of Economic Geology has utilized its Frio Brine Project, located within the SECARB region, to address MMV concerns relating to atmospheric, soils, and groundwater monitoring.

The Frio Brine Pilot Site, located in the SECARB region, provides an exceptional field laboratory for investigating Most Promising Opportunities for MMV of CO_2 sequestration. TX BEG is working in cooperation with SECARB and others to leverage its ability to provide pilot-level information during upcoming CO_2 events. Initial injections of CO_2 begin in October 2004 and results will be available during the second year of investigation by SECARB. These finding will provide the basis for TX BEG and SECARB to prepare action plans for implementation and technology validation activities for MMV.

Task 4: Public Involvement

As a federal-state energy compact, the SSEB hosts a number of activities for SSEB members during the course of a calendar year, including an SSEB Annual Meeting, an SSEB Chairman's Forum, and a meeting at the Southern Legislative Conference (SLC). As a significant benefit to SECARB, these meetings, as proposed in the SECARB proposal to NETL, have been utilized to facilitate early engagement of partners and stakeholders alike in SECARB, which will need to be involved in the final development of the SECARB regulatory, permitting, safety, and accounting frameworks and action plans.

During year one of SECARB Phase I, the SECARB team utilized the SSEB as a vehicle for engaging and informing opinion leaders and stakeholders in the Southeast on SECARB and its goals. Information about SECARB was disseminated through various SSEB communications and events, including the SSEB Chairman's Forum, the SSEB Annual Meeting, the SLC Annual Meeting, meetings of the SECARB Technical Team and Technology Coalition and the Carbon Sequestration Programmatic Environmental Impact Statement (PEIS) public scoping meeting held in the SECARB region, among others.

The initial meeting of the SECARB Technical Team and Technology Coalition occurred in January 2004 in Atlanta, Georgia. The meeting served to report on the status of subcontracts for SECARB, the work effort accomplished following the NETL RCSP Kick-off Meeting in November 2003, and to solicit input from Technology Coalition stakeholders for the coming months of the activity. A copy of the agenda from the event is attached as Appendix A.

As a result of the decision of SSEB 2004 Chairman, West Virginia Governor Bob Wise, to host an SSEB Chairman's Forum focused on carbon management, entitled "Regional Meeting on Defining Priority Actions for Voluntary Carbon Management Activities in the South," SECARB had another opportunity to present to stakeholders the plans and initial efforts of SECARB. Speakers at the SSEB Chairman's Forum included representatives from DOE, NETL, EPA, the U.S. Department of State, state governments, Natural Resources Defense Council, Southern Company and other private industry, the SECARB Technology Coalition and the SECARB Technical Team. A copy of the agenda from the SSEB Chairman's Forum is attached as Appendix B. Notably, this event featured an update on regulatory and accounting research activities for the Technical Team and Technology Coalition, which serves as a de-facto partnership advisory board for SECARB.

In August 2004, Augusta Systems and the SSEB, on behalf of SECARB, provided remarks to a meeting of the Southern Legislative Conference regarding the carbon sequestration issues of potential interest to legislators in SECARB and other southern states. A copy of a briefing document distributed along with a Power Point presentation delivered by Augusta Systems is attached as Appendix C. For reference, the oral presentation and Power Point Presentation included features on carbon management overview, SECARB regulatory and accounting research activities, voluntary and regulatory efforts at carbon management by states, and SECARB plans for action plan development and implementation, and a mechanism for feedback from SECARB and SSEB state legislative representatives.

In addition, the SSEB and SECARB provided comments during the NETL Carbon Sequestration PEIS public scoping meeting. A copy of these comments is provided for reference as Appendix D.

<u>Outreach</u>

In addition to the Technical Team, the SECARB Technology Coalition, a joint membership of stakeholders from the public and private sector, will advise, guide and provide input related to advancing carbon sequestration technology deployment in the Southeast. The Technology Coalition is integral for identifying viable potential SECARB Phase II pilot projects. Furthermore, these participants are integral to achieving and leveraging the technical information transfer, outreach and public perception activities of the Partnership. Initially, the Coalition will be represented by public sector officials from SSEB member states involved in SECARB and the Interstate Oil and Gas Compact Commission. The initial private sector members of the SECARB Technology Coalition include: Southern Company; TVA; Duke Power; Tampa Electric Company; Progress Energy; SCANA; Center for Energy and Economic Development (CEED); North American Coal Corporation; and Clean Energy Systems, Inc, among others.

As part of its mission, SECARB has a goal to develop public involvement and education mechanisms and plans to raise public awareness of sequestration opportunities in the region and provide interested stakeholders with information about technology deployment efforts. Through the efforts of the SECARB team, SECARB has worked to advance this goal and the overall mission during the first year of the RCSP initiative. As a result of the unique structure of the SSEB, the SECARB is well positioned to obtain input from a broad cross-section of stakeholders and develop public involvement and education mechanisms and associated multi-year action plans to assist in the wide-scale deployment of carbon sequestration technologies and approaches.

To meet the public outreach and education goals of SECARB, year one efforts focused on conducting a preliminary assessment of public perception regarding the SECARB effort and developing a follow-on plan focused on undertaking in-depth research that would serve to assist in the development of the formal action plans for public outreach and education.

Based upon communication efforts to ascertain knowledge of and interest in carbon sequestration, as well as follow-on discussions with SECARB and SSEB stakeholders, the team concluded that a thorough planning effort was necessary to facilitate and structure on-going education and outreach efforts. Therefore, a planning effort was developed that could assist in creating positive public perceptions of SECARB. It was determined that this plan would consist of efforts to further effective message development for SECARB outreach activities, as well efforts to gauge the unique environmental histories of the states in the SECARB region.

Specifically, this plan called for survey research methods, to be conducted by RMS Strategies and The Phillips Group, with the assistance of Augusta Systems and SSEB, to determine the opinions of industry and environmental organizations for the purposes of outreach message development and an in-depth series of interviews with state government representatives from states in the SECARB region. These methods allowed for an understanding of the unique environmental history of each state in such areas as project permitting and historical public reaction to project development, for instance. Implementation of the plan began during the quarter with a focus group discussion featuring industry representatives. A final report summarizing the findings of the focus group discussion is under development with a planned completion in October 2004. This process will continue with similar engagement of environmental nongovernmental organization stakeholders in the first quarter of year two of this Phase I effort. Additionally, the processes for both a survey of environmental organizations and for the in-depth interviews with state representatives are under development. These efforts will be concluded during the next quarter.

Baseline Research and Training Activities

Initial outreach activities of SECARB focused on two key areas – engagement in the NETL RCSP outreach working group and an examination of possible worst case comparables for carbon sequestration, i.e. historic issues that could be raised as analogs to geologic carbon sequestration despite the misapplication of this status. Activities in both areas are discussed below.

In an effort to ensure that all RCSPs, including SECARB, engaged in outreach and education activities with an appropriate base of background knowledge about carbon sequestration and outreach activities, NETL coordinated and managed RCSP outreach working group meetings, including risk communication workshops, and were assisted in this process by The Keystone Group, the AJW Group, and other private consultants.

As a result of these monthly meetings, calls, and workshops, SECARB and the other partnerships are working to ensure that common outreach messages are being conveyed throughout the RCSPs. Notably, the RCSP outreach working group has completed a question and answer briefing paper for utilization as questions and concerns may be presented to the RCSPs by stakeholders.

To supplement this NETL-provided training and education, Augusta Systems undertook baseline analysis of potential negative analogs for geologic carbon sequestration, which is generally considered to involve more public risk concerns than terrestrial sequestration. Research efforts were focused on the garnering of data related to recent environmental disasters, both anthropogenic and naturally occurring, which could arise during discussions of geologic carbon sequestration. This investigation focused on four environmental scenarios, located in: Longview, Texas; Lake Nyos, Cameroon; Hutchinson, Kansas; and the Western Pennsylvania region.

The Longview, Texas scenario involved an incident related to the oil extraction process under which a resident discovered crude oil spilling out from all plumbing receptacles within the home. This incident appeared to be the result of the household plumbing being connected to a saltwater disposal line, which oil companies operated in their extraction process, instead of the sewage line. So, when the saltwater line experienced blockage, it forced oil up through the homeowners existing plumbing. Thus, there appears to be no correlation of this potential analog to geologic carbon sequestration, and any attempt to suggest that similar results could occur with geologic carbon sequestration would be easily countered.

The Lake Nyos, Cameroon scenario involved naturally occurring CO_2 migration from a volcanic overlying lake, which caused a catastrophic natural disaster that claimed the lives of 1800 people, livestock, and animal life as far as 25 km away. Scientists agree that the CO_2 was produced from the volcano, and, was substantially similar to a previous gas eruption from neighboring Lake Monoun that caused the death of 37 people two years before the Lake Nyos eruption. This scenario is not an analog to geologic sequestration as it would be unlikely as geologic sequestration activities would ever be permitted to occur in areas of such seismic instability as this Lake Nyos region.

The Hutchinson, Kansas scenario concerns natural gas migration, stemming from a gas storage facility casing leak, causing numerous explosions and surface venting. In this area, progression of natural gas explosions and geysers were observed around the city, some jetting up to 30 feet. The explosions destroyed numerous structures and resulted in the deaths of two people when their mobile home exploded. The source of the natural gas leak was a Kansas Gas Service-owned Yaggy salt cavern storage facility, seven miles northwest of Hutchinson, of approximately 143 million cubic feet. The natural gas, which escaped through a leaky casing pipe, migrated from the subsurface, emerging via uncapped brine wells, and by pressure, was forced through preexisting fractures throughout the geologic strata. While some parties could attempt to draw a relationship between these natural gas storage field issues and geologic carbon sequestration, the overall lack of structure surrounding the natural gas storage field activities likely would eliminate any true ability for these situations to be analogs.

The western Pennsylvania scenario, which involves elevated levels of CO_2 in home basements and drinking water source contamination, is, perhaps, the most probable analog for geologic carbon sequestration of the scenarios investigated. Numerous homes in western Pennsylvania have chronicled elevated amounts of CO_2, which can be extremely hazardous and pose lethal implications, making several residences uninhabitable. These elevated CO_2 levels were believed to have originated from anthropogenic sources, including spoil from reclaimed or abandoned surface coal mines; functioning surface mines; deserted underground mines; oil and natural gas wells; and reactions of abandoned mine drainage with bedrock containing carbonate. While this potential analog has the highest likely correlation to geologic carbon sequestration, clear differences exist that make it unreasonable as an analog. Principal differences focus on the lack of stringent permitting and safety measures associated with these activities believed to have produced the dangerous levels of CO_2, which would be present in the case of geologic carbon sequestration.

While these four above-referenced potential analogs fail to qualify as true analogs, these scenarios are useful for purposes of developing outreach and education mechanisms as these scenarios demonstrate the type of historical incidents that could be employed by parties disinclined to support geologic carbon sequestration.

With this baseline of knowledge from the NETL RCSP outreach working groups and initial potential comparable risk activities, the SECARB outreach team will work to ensure that early stage meetings and briefings would include low-risk outreach activities and that the SECARB integrated outreach strategy would be well-positioned to facilitate outreach successes for SECARB, NETL and DOE.

SECARB Integrated Outreach Strategy

As a result of the outreach training and research activities and discussions from the early stage meetings and briefings, SECARB developed an integrated outreach strategy, which served as an initial action plan for the Phase I effort. Based upon the potential issues and concerns identified in the early activities of SECARB, Augusta Systems developed the SECARB Integrated Outreach Strategy prior to the implementation of the in-depth survey research activities.

The objective of the SECARB Integrated Outreach Strategy is to implement an outreach and education program that connects the value of carbon sequestration technologies among multiple constituencies. The program will incorporate both internal, which includes SECARB Technical Team and Technology Coalition partners, and external components with strategies targeted to respective audiences and their needs. It will create awareness and comprehension of the purpose of the SECARB as outlined by the objectives of DOE and NETL. It will advance RCSPs through the distribution of ongoing analysis and findings relative to the activities of SECARB initiatives. As a result, the application of carbon sequestration technologies will be accepted as an economically and environmentally sound energy technology and approach.

This SECARB Integrated Outreach Strategy, which consists of four key elements – determination of stakeholders and needs; establishment of outreach goals, and determination of outreach strategies, and initiation of outreach activities and on-going evaluation, is further detailed below.

Determination of Stakeholders and Needs

To initiate the outreach program, the SECARB outreach team defined the SECARB partners and other stakeholders and is moving forward to determine the needs of these stakeholders with reference to education and outreach. The SECARB partners included, among others, the SECARB Technical Team Members, the SECARB Technology Coalition Members, DOE, and others as defined by the SECARB leadership. In addition, the other SECARB stakeholders included SECARB regional organizations from industry, environmental nongovernmental organizations, the public, other special interest groups, academic and research institutions, government agencies, and others including stakeholders from beyond the SECARB region.

The determination of stakeholder outreach and education needs element of the effort is being conducted currently. Additional details follow in Section E of this report below.

Establishment of Outreach Goals

Following the determination of outreach needs of these internal SECARB stakeholders, the SECARB outreach team would set outreach goals focused on both SECARB partners and external SECARB stakeholders. These goals would support the objectives of DOE, NETL, and SECARB in generating understanding and support for carbon sequestration technologies among stakeholders through the communication and validation of SECARB demonstrations and findings. These goals would be based upon four factors, as follows:

- Background research and survey research activity analysis;
- Existing environmental history that could drive awareness, education, and attitude needs of audience;
- Technology validation needs; and,
- Potential barriers to acceptance of carbon sequestration technologies and approaches.

Determination of Outreach Strategies

Following the formal establishment of outreach goals, which will be based in large measure on the outcomes of the first element – determination of stakeholder outreach needs – and subsequent analysis efforts under element two – establishment of outreach goals, SECARB will move forward to determine outreach strategies. The outreach strategies will develop the infrastructure, mechanisms and implementation methodologies aligned with DOE, NETL, and SECARB in terms of overall objectives and objectives of the Integrated Outreach Strategy. The outreach strategies, which will be targeted at both SECARB partners and other SECARB stakeholders following input from NETL, will include focuses on:

- Stakeholder Prioritization;
- Message Development;
- Identity Development;
- Technology and Approach Concept Training;
- Outreach Infrastructure Development (possibilities include SECARB Web page, e-mail lists, newsletter, letters, resource book, forums, brochures, fact sheets, maps, charts, background papers, SECARB fact sheets, background papers, maps, etc.); and
- Outreach Timeline Development (for outreach on findings, announcements, achievements, ongoing activities, results, etc.).

Under this element, SECARB will develop the Action Plan for Public Involvement, Education, and Acceptance called for by Subtask 6.5 of the SECARB proposal. As part of this overall plan, SECARB has embraced utilization of the NETL-supported Carbon Offset Opportunity Program (COOP) as a tool to assist in facilitating collaborative carbon sequestration activities in the SECARB region.

Formal Initiation of Outreach and On-going Evaluation

This initiation of outreach and on-going evaluation will center on the roll-out, implementation and refinement of the Action Plan for Public Involvement, Education, and Acceptance.

Stakeholder Needs Analysis: In-Depth Survey Research Activities

As noted, the determination of stakeholder outreach and education needs element of the effort is being conducted currently. These activities have focused, to-date, on two areas: (1) SECARB Regional Perceptions of Carbon Sequestration; and (2) SECARB Region Environmental History Research. Details on these areas follow.

SECARB Regional Perceptions of Carbon Sequestration

The objective of the SECARB regional perceptions of carbon sequestration research effort is to determine and evaluate the attitudes and perceptions of key opinion leaders

– including most notably leaders of industry and environmental non-government organizations – regarding carbon sequestration issues. The primary goals of the study will be to assess the awareness and understanding of carbon sequestration; identify any barriers to the carbon sequestration effort; and determine effective messages among the stakeholders. Thus, the results of this research can direct the initial outreach and education efforts for SECARB.

The SSEB Annual Meeting in September 2004 provided a suitable platform for an industry focus group session in Richmond, Virginia. A facilitator from the project team led the focus group activities and conducted the planning and structuring of these activities. The focus group discussion covered a host of question areas, including:

- General environmental perceptions;
- Climate change perceptions;
- Overall awareness of carbon sequestration efforts; and,
- Messaging.

A copy of the email invitation letter sent to SECARB industry focus group participants is attached as Appendix E, while a copy of the SECARB industry focus group agenda is included as Appendix F. Further, copies of the SECARB industry focus group discussion guide and worksheet are included as Appendix G and H, respectively.

Documentation and analysis of this initial SECARB stakeholder perception survey research activity will be completed during October 2004. Also, to further ascertain perceptions from other SECARB constituencies, including national and regional environmental nongovernmental organizations, a list of similar questions will be posed to a select group of identified SECARB stakeholders by RMS Strategies, with assistance from Augusta Systems and SSEB, through a telephone-based in-depth interview process.

<u>SECARB Region Environmental History Research</u>

Clearly, the paths that have been tread before play an important role in determining what courses may be taken in the future. To support efforts to ascertain the appropriate outreach strategies and mechanisms that should be employed to assist with wide-scale carbon sequestration deployment in the SECARB region, the project team has undertaken a research effort to determine the environmental history of each state within the SECARB region. This research – taking the form of a telephone interview with state energy and environmental officials – is meant to assist the partnership with its outreach efforts. Through this survey, SECARB will gain knowledge of the environmental issues unique to each state in the SECARB region to better understand how these issues may relate to regional and national carbon sequestration efforts.

At present, a draft letter to be emailed to each identified contact in the eleven SECARB states has been prepared, as has the draft list of questions for the thirty minute telephone interview session. A copy of the draft letter follows as Appendix I, while the draft telephone survey question list is attached as Appendix J. These efforts will be initiated in October 2004.

SSEB created and is operating a dedicated web site for the Southeast Carbon Sequestration Partnership. The web site is a work in progress and is intended to play an integral role as a general outreach tool. The web site address is www.secarbon.org.

SECARB technical team members participated in the various inter-regional working groups that addressed specific issues related to regulatory and compliance issues; public education and outreach; capture and separation technologies; geologic sink characterization and infrastructure requirements; and terrestrial sink characterization and infrastructure requirements. Working groups were established as a result of the breakout sessions and SECARB technical members participate with other regional partnership representatives on a regular basis to enhance communication.

Meetings and Presentations

SECARB project team members participated in the following during this semiannual reporting period:

- North Carolina State Mercury/ CO_2 workshop April 19-21, 2004
- Third Carbon Sequestration Partnership meeting, May 2-5, 2004
- NETL Workshop, May 6, 2004
- Second Technical Team/Technology Coalition quarterly meeting in conjunction with the SSEB Chairman's Forum on Carbon Management, May 19-21, 2004
- Regional Environmental Impact Statement public meeting sponsored by NETL in Norcross, Georgia, June 2, 2004
- CO_2 conference at the University of Georgia, June 10-11, 2004
- COOP Meeting, Charleston, West Virginia, on July 13, 2004
- Southern States Energy Board Briefing to Legislative Members, Little Rock, Arkansas, on August 14, 2004
- Southern States Energy Board Associate Members and Utility Advisory Committee Meeting, Richmond, Virginia, on September 11, 2004
- Southern States Energy Board 44th Annual Meeting, Richmond, Virginia, on September 13, 2004
- SECARB Focus Group Meeting, Richmond, Virginia, on September 13, 2004

In addition, TX BEG conducted paper and booth presentations were made at the Seventh International Conference on Greenhouse Gas Control Technologies (GHGT-7) in Vancouver, Canada (September 5-9, 2004) and attended the SSEB Annual Meeting in Richmond, Virginia (September 11-13, 2004), where geological characterization efforts and MMV for the Southeast regional carbon partnership was discussed.

Tasks 5 and 6: Identify Most Promising Capture Sequestration and Transportation Options and Prepare Action Plans for Implementation

Tasks 5 and 6 will be implemented beginning October 1, 2004. Under Task 5, Identify the Most Promising Capture, Sequestration, and Transport Options, SSEB and Hill will evaluate findings from work performed during the first year, and shifting the focus of the SECARB team from region-wide mapping and characterization to a more detailed screening approach designed to identify the most promising opportunities. Under Task 6, Prepare Action Plans for Implementation and Technology Validation Activity, SSEB and Hill will guide the SECARB team in developing an integrated approach to implementing the most promising opportunities and in setting up measurement, monitoring and verification programs for the most promising opportunities.

Conclusion

The coordination and integration of regional-wide mapping and characterization data for capture, sequestration and transport options is progressing. The outreach and education process is underway and several forums have been held during the semiannual period. During the next quarter Texas and Virginia information will be fully integrated with the other nine states. During the next year the focus of the SECARB team will shift from region-wide mapping and characterization to a more detailed screening approach designed to identify the most promising opportunities.

Data collection for source characterization is proceeding well for power plants but information on other industries continues to be limited and additional efforts are ongoing to develop the information needed for the project. No issues have been identified for transport. For terrestrial, significant information is available for the states where work is being done under EPRI by Winrock and work in Georgia is underway. Early efforts to develop an economic evaluatIon of regional options is underway.

SECARB characterized the southeast region geologically using a step-wise approach, first at the macro level and then refining the characterization to begin focusing on areas within the region having higher sequestration potential. Three primary data sets were developed from public data: saline formations, coal seams, and oil & gas reservoirs.

The initial, minimum dataset included geographical parameters that would aid in locating the potential sinks. State and county names were usually, but not always available. Well location coordinates were sometimes available as were field and formation names. The smallest geographical entity most frequently available for locating a data point was the county name, so initial maps were developed on a county basis.

Priority technical parameters included formation depth, thickness, and porosity. Depth was commonly available, or at least a range of depths. Both thickness and porosity values were infrequently available, thus average values were sought for different formations, fields, etc. Where available, additional data were collected simultaneously on permeability, fluid saturations, pressures, productive areas, and area geology, but these data were even less readily available. Even though many data gaps were apparent across the large region, information should be sufficient for identifying areas with significant potential for sequestration.

The SECARB region is a very large region to characterize on the whole at the same precision necessary for selection of specific sequestration targets. The stepwise approach to narrow the focus to areas warranting further investigation is a more practical approach. The next step will allow SECARB to identify the areas of opportunity for effective sequestration activities.

Virginia Tech's terrestrial characterization of carbon sequestration sinks is on schedule. Model runs of the modified Winrock method and Tier 1 land management options are currently proceeding while model runs for Tiers 2 and 3 will be the next step.

Virginia Tech and Marshall Miller and Associates are completing the characterization phase of a GIS coal seam database for southwestern Virginia. Development of the transportation infrastructure database is continuing. Characterizing conventional natural gas reservoirs, saline aquifers, valley coalfields and Richmond basin coalfieds is work in progress and should be completed during the next quarter.

The potential for enhanced coalbed methane recovery has been investigated by Anderson, John et al. Figure 38 is a map of U.S. basins containing coalbed methane reserves. Figure 39 contains information on U.S. production and number of producing wells.

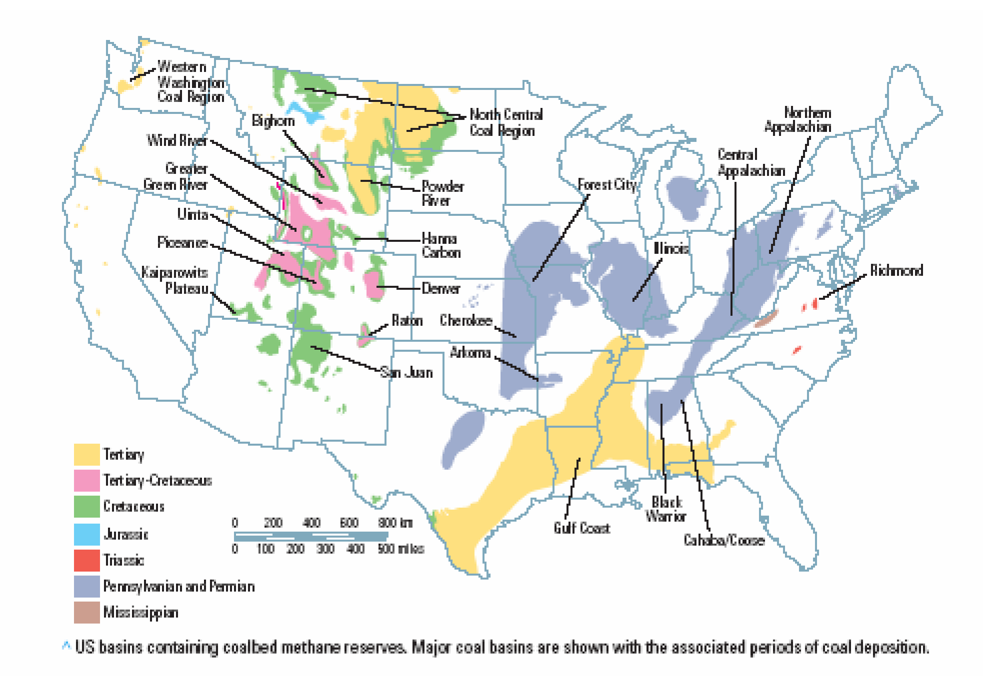


Figure 38. U.S. Basins Containing Coalbed Methane Reserves.
Source: Anderson, John et al, 2003. Oilfield Review, v.15, no.3, p.10

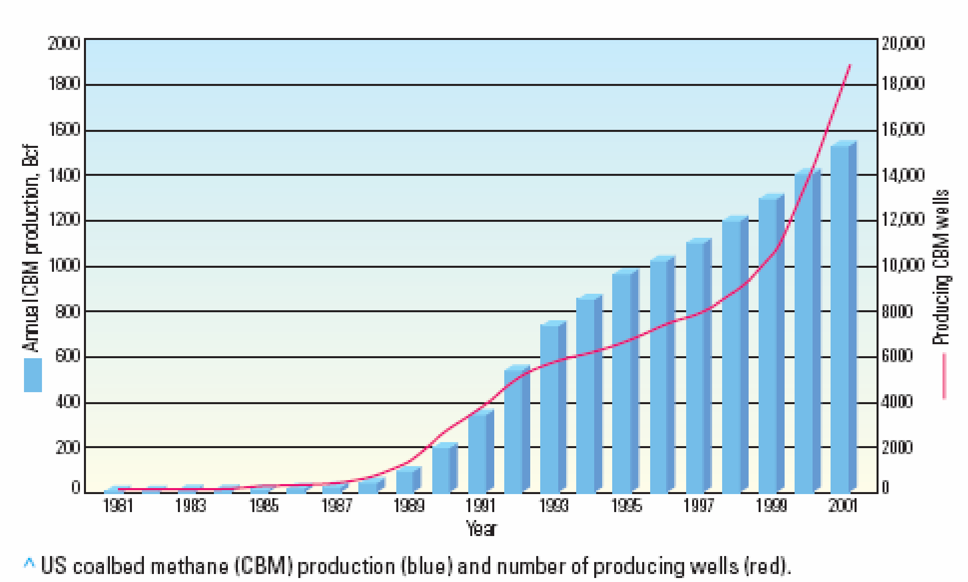


Figure 39. U.S. Coalbed Methane Production (blue) and Number of Producing Wells (red).
Source: Anderson, John et al, 2003. Oilfield Review, v.15, no.3, p.10

Preliminary conclusions of the SECARB work indicate that coalbeds in southwest Virginia have significant potential for carbon sequestration, particularly in Buchanan, Dickenson and Wise counties. Regional mapping also suggests carbon sequestration potential in adjoining West Virginia and Kentucky counties. The target area for Most Promising Options is indicated in Figure 40.

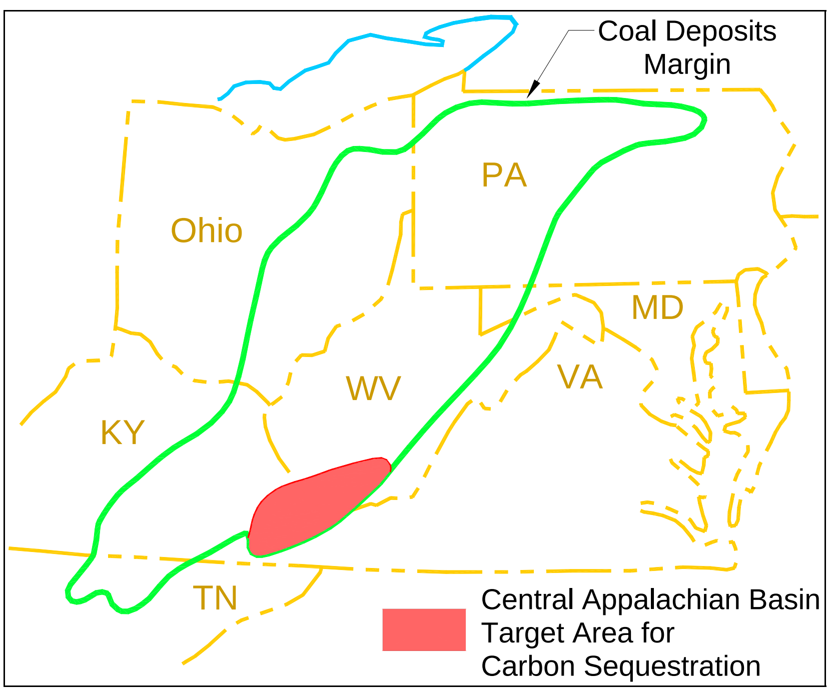


Figure 40. Central Appalachian Basin Target Area for Carbon Sequestration.

Major completed efforts during this quarter have been the geological characterization of Texas oil and gas reservoirs. These have been created as GIS data layers to add to the previously created brine formation data layers. Continued progress is expected in the next quarter in terms of finalizing the subcontracts to LGS and MMRI to initiate geological characterization of Louisiana and Mississippi oil and gas reservoirs. Terrestrial sequestration potential will also be examined in the next quarter. Continued efforts to participate in regional carbon sequestration partnership activities such as meetings and national CO_2 sequestration forums will be made in the next quarter.

Based upon initial applications of screening criteria, TX BEG has determined that opportunities exist for expanding CO_2 – EOR into east central and southeast Texas. Based upon the characteristics of reservoirs in the area designated by Denbury as "Eastern Gulf Coast," SECARB has designated this area as having <u>Most Promising Opportunities</u> for expanding the use of anthropogenic CO_2 for enhance oil recovery.

The first year of the SECARB regulatory, permitting, safety, and accounting framework activity efforts have focused on conducting a thorough analysis of the existing environment that could impact the carbon sequestration regulatory, permitting, safety, and accounting frameworks in the SECARB region. As the carbon sequestration arena is a rapidly developing field, multiple, complimentary efforts are underway that will ultimately affect the SECARB Action Plan for the Regulatory, Permitting, Safety, and Accounting Frameworks. These include:

- The Carbon Sequestration Leadership Forum Legal, Regulatory, and Financial Issues Task Force;
- The Interstate Oil and Gas Compact Commission Task Force on Geologic Carbon Sequestration;
- The DOE 1605(b) Program Enhancements, especially the revised Technical Guidelines; and,
- The emerging GHG emissions trading markets, both nationally and globally, including the Chicago Climate Exchange.

While none of the above-referenced efforts will deliver methods and processes that must be adhered to by SECARB or any RCSP, these high-profile efforts and their outcomes must be incorporated into the above-referenced Action Plan to assist SECARB stakeholders and regional entities by providing frameworks that would allow for participation in the national and international GHG emissions management and carbon sequestration activities. Year two efforts will continue to monitor the progress in these areas as first Draft Action Plans, which will be reviewed by the SECARB partners, and then Final Action Plans are produced.

Key questions that must be integrated into the final Action Plan are as follows:

- Will CO_2 be defined as a commodity, waste, or pollutant under federal, state, or federal and state laws and regulations, including UIC regulations?
- What federal and/or state standards should be devised for measurement of CO_2 concentration at the point of capture to ascertain and verify the quality and purity of the CO_2?
- Will the federal and state entities with existing CO_2 pipelines continue business-as-usual with regulating, permitting, and enforcing safety as CO_2 pipelines enjoy greater proliferation under wide-scale sequestration endeavors?
- Will geologic carbon sequestration injection and storage activities be wholly subject to existing UIC regulations?
- Will new UIC classes or definitions emerge to facilitate geologic sequestration injection and storage activities?
- Will long-term geologic sequestration projects without enhanced hydrocarbon recovery components be subject to UIC at all?
- How will the existing federal and state land management and restoration, timber management, and farm management legislation be augmented to include comprehensive plans to encourage terrestrial sequestration?
- How will the 1605(b) guideline enhancements, state registry activities, and private sector standards develop and allow for reconciliation to create reliable accounting frameworks?
- How quickly can effective measurement, monitoring, and verification technologies be developed that will provide reliable data to advance regulatory and accounting activities, both for terrestrial and geologic carbon sequestration activities?

Thus, the Year two SECARB activities for the regulatory, permitting, safety, and accounting framework activity efforts will focus on developing frameworks that will incorporate available information to forge a flexible Action Plan that would allow for the integration of new findings and pronouncements during the course of a potential SECARB Phase II. The year one regulatory, permitting, safety, and accounting framework activity efforts of SECARB Phase I have produced a platform for successes to be built upon in year two of SECARB Phase I. In year two, SECARB will work with DOE to obtain the requisite guidance for the content and context of the development of the Action Plan for Regulatory, Permitting, Safety, and Accounting Frameworks.

The year one outreach activity efforts of SECARB Phase I have produced a platform for successes to be built upon in year two of SECARB Phase I. In year two, SECARB will complete the activities of its integrated outreach strategy, which served as an initial action plan for the Phase I effort, including the in-depth survey research activities focused on determination of stakeholder education and outreach needs, as well as the establishment of outreach goals, outreach strategies, and initiation of outreach activities and on-going evaluation. The result will be the development of an Action Plan for Public Involvement, Education, and Acceptance.

Problems Encountered

No unforeseen problems were encountered. The publicly available data was somewhat less comprehensive than had been anticipated, particularly with respect to the identification of the important parameters such as formation thickness, permeability, and their lateral distributions. Even so, the region could be characterized generally with respect to the clear availability of geological formations across large parts of the region for potential sequestration sites.

Significant Accomplishments

SECARB achieved a number of significant milestones including the development of a logical strategy for obtaining the information needed to identify potential regional geologic sequestration sites for field testing and evaluation; the assimilation of public geological information on coal, oil & gas, and saline formations with potential for use in sequestration; and GIS maps showing the potential for developing sequestration options across large parts of the region in oil and gas producing areas. The potential coal and saline formations are expected to provide similar opportunities.

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List of Acronyms and Abbreviations

CBM	Coalbed Methane
CO_2	Carbon Dioxide
COOP	Carbon Offset Opportunity Program
DEM	Digital Elevation Model
Department	United States Department of Energy
DIAL	Diagnostic Instrumentation and Analysis Laboratory
DOE	United States Department of Energy
DOT	United States Department of Transportation
ECBM	Enhanced Coalbed Methane
EGR	Enhanced Gas Recovery
EOR	Enhanced Oil Recovery
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute
GHG	Greenhouse Gas
GIS	Geographical Information System
GNIS	Geographic Names Information System
GSWG	Geologic Sequestration Working Group
IOGCC	Interstate Oil and Gas Compact Commission
LIBS	Lazer Induced Breakdown Spectroscopy
LGS	Louisiana Geological Survey

MIT	Massachusetts Institute of Technology
MMA	Marshall Miller and Associates
MMRI	Mississippi Mineral Resource Institute
MMV	Monitoring, Measurement and Verification
MSU	Mississippi State University
NARSAL	Natural Resources Spatial Analysis Laboratory
NATCARB	National Carbon Database
NETL	National Energy Technology Laboratory
NLCD	National Land Cover Dataset
NOAA	National Oceanic & Atmospheric Administration
O_2	Oxygen (pure)
OPS	Office of Pipeline Safety
Partnership	Southeast Regional Carbon Sequestration Partnership
PEIS	Programmatic Environmental Impact Statement
PSI	Pounds Per Square Inch
RCSP	Regional Carbon Sequestration Partnership
R&D	Research and Development
SDWA	Safe Drinking Water Act
SECARB	Southeast Regional Carbon Sequestration Partnership
SLC	Southern Legislative Conference
SSEB	Southern States Energy Board
STATSGO	State Soil Geographic
TVA	Tennessee Valley Authority
TX BEG	Texas Bureau of Economic Geology
U.S. DOE	United States Department of Energy
U.S.	United States
UIC	Underground Injection Control
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USDOE	United States Department of Energy
USDOT	United States Department of Transportation
USDW	Underground Sources of Drinking Water
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UT-BEG	University of Texas Bureau of Economic Geology
VRGGP	Voluntary Reporting of Greenhouse Gases Program
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Appendices

APPENDIX A – JANUARY SECARB MEETING

Southeast Regional Carbon Sequestration Partnership Technical Team and Technology Coalition Meetings

Grand Hyatt Atlanta – In Buckhead

Atlanta, Georgia

January 14-15, 2004

AGENDA

Wednesday, January 14, 2004

"Administrative and Project Management Meeting for Lead Technical Team Members"

9:00 a.m. Welcome and Introductions
Mr. Kenneth J. Nemeth, Executive Director
Southern States Energy Board

Task 1, 2 & 3 Progress Reports and Crosscutting Activity Reports

- *Regulatory Compliance and Liability Issues*
- *Public Outreach and Education*
  Mr. Patrick R. Esposito, II, Chief Operating Officer
  Augusta Systems, Incorporated

- *Capture and Separation Technologies*
  Dr. M. John Plodinec, Director, Diagnostic Instrumentation Analysis Laboratory
  Mississippi State University

- *Geologic Sink Characterization and Infrastructure Requirements*
  Dr. Patrick R. Esposito, Sr., Chief Executive Officer
  Augusta Systems, Incorporated

- *Terrestrial Sink Characterization and Infrastructure Requirements*
  Mr. John Kadyszewski
  Winrock International

- *GIS/Database Development*
  Mr. Richard Rhudy, Project Manager
  Electric Power Research Institute

Review of ***Work Responsibility Matrix*** with Key Team Leaders (some via phone)

Southeast Regional Carbon Sequestration Partnership Website, www.secarbon.org

Goals for January 15th Presentation to Coalition Members

Governor's Forum Discussion

12:30 p.m. Lunch on Your Own

"Technical Team Working Session"

2:00 p.m. Welcome and Introductions
Mr. Kenneth J. Nemeth, Executive Director
Southern States Energy Board

Introduction of Lead Technical Team
Dr. Gerald R. Hill, Senior Technical Advisor
Southern States Energy Board

Goals for January 15th Meeting
Dr. Patrick R. Esposito, Sr., Chief Executive Officer
Augusta Systems, Incorporated

3:45 p.m. Task 1, 2 & 3 Input Requirements

Breakout Sessions for Working Groups

Action Items for Technical Team

5:30 p.m. Adjourn

6:00-7:00 p.m. Networking Session for SERCSP Technical Team and Technology Coalition Members
Location: Buckhead Ballroom 2

Thursday, January 15, 2004

"Technology Coalition Briefing and Working Session"

8:00 a.m. Welcome
Mr. Kenneth J. Nemeth, Executive Director
Southern States Energy Board

Introduction of Coalition Members and Team Leaders
Dr. M. John Plodinec, Director, Diagnostic Instrumentation Analysis Laboratory
Mississippi State University

Project Overview
Dr. Patrick R. Esposito, Sr., Chief Executive Officer
Augusta Systems, Incorporated

Task 1, 2 & 3 Status Report and Crosscutting Activity Reports

- *Regulatory Compliance and Liability Issues*
- *Public Outreach and Education*
  Mr. Patrick R. Esposito, II, Chief Operating Officer
  Augusta Systems, Incorporated

- *Capture and Separation Technologies*
  Dr. M. John Plodinec, Director, Diagnostic Instrumentation Analysis Laboratory
  Mississippi State University

- *Geologic Sink Characterization and Infrastructure Requirements*
  Dr. Patrick R. Esposito, Sr., Chief Executive Officer
  Augusta Systems, Incorporated

- *Terrestrial Sink Characterization and Infrastructure Requirements*
  Mr. John Kadyszewski
  Winrock International

- *GIS/Database Development*
  Mr. Richard Rhudy, Project Manager
  Electric Power Research Institute

U.S. Department of Energy Report
Dr. Karen Cohen, DOE Project Manager
U.S. Department of Energy

- *Regional Partnership Working Groups*
- *Carbon Sequestration Atlas*

GIS Overviews

- *Terrestrial*
  Mr. John Kadyszewski
  Winrock International

- *Geological*
  Mr. Howard Herzog
  Massachusetts Institute of Technology

12:00 p.m. Lunch on Your Own

1:30 p.m. Roundtable Discussion: Perspectives for Phase II Carbon Sequestration
Mr. Richard Rhudy, Project Manager
Electric Power Research Institute

Panel Discussion of Coalition Representatives

Action Items for Project Team

Announcement of April 2004 Chairman's Forum on
Carbon Management in the Southern States
Dr. Patrick R. Esposito, Sr., Chief Executive Officer
Augusta Systems, Incorporated

3:00 p.m. Adjourn

APPENDIX B – SSEB CHAIRMAN'S FORUM MEETING

Southern States Energy Board

2004 Chairman's Forum on Carbon Management in the Southern States

"Regional Meeting on Defining Priority Actions for Voluntary Carbon Management Activities in the South"

Washington Plaza
Washington, DC
Thursday, May 20, 2004

8:00 am **Continental Breakfast and Registration**

8:30 am **Welcome and Introductions**

Presiding: The Honorable Jimmy Skipper
House of Representatives, State of Georgia
Vice Chairman, Southern States Energy Board

Dr. Patrick R. Esposito
Chairman, Governor's Energy Task Force, State of West Virginia
Governor's Alternate, Southern States Energy Board

The Honorable Brian C. Griffin
Federal Representative, Southern States Energy Board

8:45 am **Overview of Carbon Management**

Mr. Mark Maddox
Acting Assistant Secretary for Fossil Energy
United States Department of Energy

Mr. Jeffrey R. Holmstead
Assistant Administrator for Air and Radiation
United States Environmental Protection Agency

Mr. John F. Turner
Assistant Secretary, Bureau of Oceans and International Environmental Scientific Affairs
United States Department of State

10:00 am **Break**

10:15 am **Perspectives on Carbon Management**

Presiding: Dr. M. John Plodinec, Director
Diagnostic Instrumentation and Laboratory, Mississippi State University

- Federal Government Perspective
  Dr. Robert Wright
  Power Systems Portfolio Manager, Office of Fossil Energy
  United States Department of Energy

- Historical Perspective
  Mr. Roger Ballentine
  President
  Green Strategies, Inc.

- Industry Perspective
  Mr. Dwight H. Evans
  Executive Vice President
  Southern Company

- Public Perspective
  Mr. David Hawkins
  Director, Climate Center
  Natural Resources Defense Council

12:00 pm **Luncheon**

Keynote Presentation: "The Road to Sensible Carbon Sequestration: An Insurance Policy for the Future"

Mr. Ben Yamagata
Executive Director
Coal Utilization Research Council

1:30 pm **Carbon Management in the South: Technologies and Approaches**

Presiding: The Honorable Tommy Robertson
Senate, State of Mississippi

- Terrestrial Sequestration Approaches
  <u>*Mississippi River Valley Activities*</u>
  Mr. Lawrence A. Selzer
  President and Chief Executive Officer
  The Conservation Fund

- Accounting and Monitoring Approaches
  <u>*Ecolytics – A GHG Emissions System*</u>
  Mr. Patrick R. Esposito II
  Chief Operating Officer
  Augusta Systems, Inc.

- Methane Management Approaches
  Mr. Richard Winschel
  Director, Coal Utilization
  CONSOL Energy, Inc.

- Geologic Sequestration Approaches
  CO_2 Test Center Project
  Mr. Richard G. Rhudy
  Project Manager
  Electric Power Research Institute

3:00 pm **Break**

3:15 pm **Carbon Management in the South: Technologies and Approaches** (*continued)*

Presiding: The Honorable Jerry Paul
House of Representatives, State of Florida
Executive Member, Southern States Energy Board

- Biobased Approaches
  Mr. Steve Segrest
  The Common Purpose Institute

- Nuclear Power Contributions
  Dr. Tim Valentine
  Legislative Fellow
  United States Senator Lamar Alexander's Office, State of Tennessee

- Distributed Generation Approaches
  Mr. Dave Walls
  Director, New Business and Technology
  Navigant Consulting, Inc.

- Combustion Approaches/Cleaner Fossil Fuel Systems
  Mr. Brian C. Griffin
  President
  Clean Energy Systems, Inc.

4:30 pm **Break**

4:45 pm **Determining Priority Actions for Voluntary Carbon Management in the South**
A discussion hosted by:
The Honorable Bob Wise
Governor, State of West Virginia
Chairman, Southern States Energy Board

5:30 pm **Closing Remarks**
Mr. Kenneth J. Nemeth

6:00 pm **Adjournment to Networking Reception**

APPENDIX C – SOUTHERN LEGISLATIVE CONFERENCE BRIEFING

Southern Legislative Conference Briefing:
Considerations for Legislators Interested in Voluntary Carbon Management

Introduction

State legislators have an important role to play in encouraging voluntary greenhouse gas (GHG) and carbon management activities in the Southern States region. With the region accounting for roughly 44% of the United States (U.S.) GHG emissions and a current Federal government position that focuses on voluntary GHG and carbon management approaches and encourages state action to facilitate the achievement of Federal goals, it is clear that the Southern States must play a leading role in the facilitation of activities that allow voluntary carbon management initiatives to take hold. The Southern States Energy Board (SSEB) is assisting the U.S. Department of Energy (USDOE) by leading the Southeast Regional Carbon Sequestration Partnership (SECARB), which is working to foster the development of potential model state legislation on carbon sequestration, a leading field of carbon management approaches, and GHG emissions management on a region-wide basis. As this effort and others move forward, there are proactive steps that state legislators can take on this matter today.

What's Happening in States?

Throughout the United States, state legislators have taken the lead in drafting and advancing legislation to assist in facilitating voluntary GHG and carbon management activities in their states. Notable types of legislation, as well as the states in which these concepts have been adopted, include:

- Development of studies and creation of advisory bodies on carbon management (various states including Idaho and South Dakota);
- Adoption of voluntary GHG and carbon emissions registries (examples include California, Georgia, and New Hampshire); and,
- Passage of legislation to encourage terrestrial sequestration activities (Oklahoma and others).

Conclusions

As GHG and carbon emissions management will be a significant issue in the coming years, state legislators have a unique opportunity to impact the arena of carbon management. With the Federal government supporting development of innovative approaches and technologies, including those focused on carbon sequestration, state legislators can work to assist their resident businesses and individuals with adopting and implementing voluntary carbon management activities and programs. The SSEB and its partners in SECARB are ready to assist legislators in the Southern States in efforts to adopt cost-effective approaches to GHG and carbon emissions management. Leading options include:

- Authorizing and funding state studies on GHG and carbon emissions management approaches;
- Implementing legislation to establish voluntary GHG emissions management registries;
- Implementing legislation encouraging, or even providing incentives for, investments in voluntary GHG or carbon emissions reduction or offset projects that can be facilitated by initiatives like the Carbon Offset Opportunity Program (www.offsetopportunity.com) and others, or traded through programs like the Chicago Climate Exchange (www.chicagoclimatex.com) and others;
- Working with national and regional efforts, such as those related to SECARB, to ensure that terrestrial sequestration projects, including those activities which include aspects of mine land reclamation, no till farming, soil conservation, brownfield restoration, among others, are legally permissible and economically feasible in states; and,
- Working with national and regional efforts, such as those related to SECARB and the parallel efforts of the Interstate Oil and Gas Compact Commission, to ensure that geologic sequestration activities, including those related to the capture, separation, transportation, injection, and storage phases, are legally permissible and economically feasible in states.

For more information

For more information on options and approaches to allow state legislators to proactively assist with voluntary carbon management activities, please contact Kenneth Nemeth, of the Southern States Energy Board, by email at nemeth@sseb.org or telephone at 770.242.7712, or Patrick Esposito, of Augusta Systems, by email at pesposito@augustasystems.com or by telephone at 304.599.3200.

APPENDIX D – SECARB COMMENTS AT USDOE PEIS MEETING

(Please note: This document features the comments of Dr. Gerald R. Hill, of SECARB and the SSEB, at the USDOE Programmatic Environmental Impact Statement Public Scoping Meeting in Atlanta, Georgia on June 2, 2004.)

Comments of
DR. GERALD R. HILL
Public Scoping Meeting
NORCROSS, GA – JUNE 2, 2004
U.S. Department of Energy
Programmatic Environmental Impact Statement
Carbon Sequestration Program

INTRODUCTION

My name is Dr. Gerald Hill. I am Senior Technical Advisor to the Southern States Energy Board. The Southern States Energy Board, or "SSEB", is located at 6325 Amherst Court, Norcross, Georgia 30092.

I am speaking on behalf of SSEB, and in support of Carbon Sequestration Programs. We believe that the potential environmental benefits of carbon sequestration are significant and, therefore, the demonstration and deployment of enabling technologies to implement the Program should proceed.

SSEB is a non-profit interstate compact organization created in 1960 and established under Public Law 87-563 and 92-400 of the United States Congress. The Board's mission is to enhance economic development and the quality of life in the South through innovations in energy and environmental programs and technologies.

Sixteen southern states and two territories comprise the membership of SSEB. Each jurisdiction is represented by the governor and a legislator from the House and Senate. A Federal Representative is appointed by the President of the United States.

SSEB is chaired by a Governor who is instrumental in setting priorities for the Board's activities.

In September 2002, West Virginia Governor Bob Wise became SSEB Chairman and declared carbon management to be a priority. On May 20, 2004 Governor Wise convened a Chairman's Forum on Carbon Management in the Southern States.

SSEB's carbon management forum was attended by over 100 people. Presentations were made by government officials, private sector experts, and public interest advocates. A highlight of the two-day forum was a May 21st meeting of the Technology Coalition of the Southeast Regional Carbon Sequestration Partnership, or "SECARB".

In DOE's announcement of tonight's carbon sequestration meeting it was stated that:

> "*Major initiatives to demonstrate the key elements of the Program may require collaboration with Federal agencies, state and regional governments, and private sector partnerships."*

I am please to note that the groundwork for future collaboration on demonstration projects has been initiated.

SECARB is one of seven regional partnerships that work with the National Energy Technology Laboratory to assess issues related to the capture, transport and storage of carbon dioxide emissions from fossil fuel sources. Nine months of work by SECARB, and discussions with the SECARB Technology Coalition, provide the basis for specific comments I will make this evening.

CAPTURE, TRANSPORT AND STORAGE

I would like to discuss each of the three points noted here (carbon dioxide capture, transport and storage) in the context of current industry experience and potential environmental impacts.

(1) Carbon dioxide capture (or separation) is an accepted and historic practice world-wide. Both food grade and industrial grade CO_2 are produced and consumed within world economies. The DOE program of demonstration and deployment will simply expand the available sources of CO_2 to include fossil fuel emissions. Expanding potential sources to include fossil fuel emissions has the environmental benefit of offsetting others production processes.

(2) Carbon dioxide transport is an accepted and historic practice world-wide. Food grade and industrial grade CO_2 are transported via pipeline, tanker truck and rail on a regular basis. The CO_2 that originates from fossil fuel emissions can be transported in the same manner. The specifications will be the same, primarily relating to moisture content and oxygen content (to prevent corrosion of pipes or vessel surfaces) and the presence of other trace constituents (depending on whether the CO_2 is intended for food-grade applications or various industrial applications). Transporting CO_2 that is captured from fossil fuel emissions sources will not introduce new or unknown environmental impacts to the pipeline, tanker truck or rail industries.

(3) Carbon dioxide storage occurs naturally in terrestrial and geologic systems.

(a) Terrestrial systems are being evaluated as potential sinks for sequestering CO_2 emissions as stored carbon. Building up soil carbon content or increasing the inventory of stored carbon in croplands and forest lands is viewed as a viable and immediate opportunity for reducing greenhouse gas (GHG) intensity. The US Department of Agriculture has noted that the south central and southeast regions of the United States have the highest potential for carbon storage in terrestrial systems. Utilizing terrestrial systems as sinks for carbon will have a positive environmental benefit upon the reduction in greenhouse gas intensity.

(b) Geologic systems are being evaluated as potential sinks for storing CO_2 emissions. Injecting CO_2 into underground formations has been occurring for the past twenty years. Specifically, CO_2 from natural underground formations or from commercially available separation units is injected into oil/gas wells in order to increase the output of the wells. This practice is called enhanced oil recovery, or "EOR". The potential market for CO_2 used in enhanced oil recovery is large. The Texas Bureau of Economic Geology has evaluated over 3300 wells and determined that about 1800 are suitable for EOR, with CO_2 injection being a candidate technology for many of these wells. The use of CO_2 that is captured from fossil fuel emission sources will not introduce new or unknown environmental impacts to the EOR industry. In fact, it will have the added environmental benefit of removing large volumes of CO_2 from the atmospheric inventory and also will reduce the amount of CO_2 that is being extracted from natural formations or produce by commercial separation units.

In addition, CO_2 injection can be used for recovering coalbed methane. In this practice CO_2 is pumped into coal seams and methane is liberated from the seams. The southeast region has many thin seams of coal that could store CO_2 and produce methane. Recovering methane by utilizing CO_2 emissions from fossil fuel facilities can provide positive economic benefits to the southeastern region, while increasing the supply of pipeline-grade natural gas. Additional work is needed in order to fully understand the mechanisms of coalbed methane recovery using CO_2. The potential economic benefits of methane production and the potential environmental benefits of CO_2 sequestration in coal seams are both very high. Therefore, work should continue in the demonstration and deployment of these technologies, including the evaluation of environmental impacts.

A third category of geologic storage is the sequestration of CO_2 in deep saline formations. Unlike enhanced oil recovery or coalbed methane production, this category of storage has no economic drivers within the region. It is, however, a viable option for storing huge volumes of CO_2 emissions from fossil fuel facilities. The oil industry and industries that extract materials from salt brine have practiced underground injection for decades. The activity is regulated by the US Environmental Protection Agency and state agencies within the Underground Injection Control, or "UIC", program. The potential environmental benefits of CO_2 sequestration in deep saline formations are very high. Therefore, work should continue in the demonstration and deployment of these technologies, including the evaluation of environmental impacts.

REGULATORY, PERMITTING AND SAFETY FRAMEWORK

Clearly, at its inception, the Underground Injection Control program could not have anticipated the injection of fossil fuel CO_2 emissions. Consequently, there exists the potential for regulatory uncertainty. It is essential that the regulatory, permitting and safety framework for CO_2 injection evolve on its own merit.

The framework must not be inappropriately or inaccurately constrained by UIC programs designed for unrelated activities. We are asking DOE, as part of the Programmatic Environmental Impact Statement process, to call attention to potential regulatory barriers to the demonstration and deployment of CO_2 sequestration options and related technologies.

SSEB further requests that the US Environmental Protection Agency consider proactive steps, including but not limited to, the creation a new regulatory framework (or perhaps a new UIC category) for CO_2 injection and storage.

The federal and state regulatory frameworks should facilitate, not block, the demonstration and deployment of technologies that can increase our ability to produce domestic oil and gas (including coalbed methane gas). We have an opportunity to generate positive economic activity in the region, while reducing our dependence on foreign sources of oil and gas. At the same time we can facilitate the development of a regulatory structure that will provide clear guidance for storing CO_2 from fossil fuel emissions.

MEASUREMENT, MONITORING AND VERIFICATION

The ability to measure, monitor and verify performance of carbon sequestration technologies is an essential component of any demonstration or deployment program. Existing tools need to be modified for CO_2 sequestration applications. New tools will be needed for deployment efforts. Measurement and verification systems will be needed to support voluntary reporting programs such as the US DOE 1605(b) initiative. Future trading platforms and regulatory programs will require measurement and verification. Also, monitoring systems will be needed to assess real-time performance of equipment as well as long-term performance of storage options.

Analytical tools and methods must be demonstrated under conditions that reasonably represent actual field conditions for carbon sequestration. The potential environmental benefits of demonstrating analytical systems and methods are great and, under carefully controlled field conditions, the environmental risks can be very low. Therefore, DOE should move forward in an aggressive fashion to ensure that the proper measurement, monitoring and verification tools are made available as soon as possible.

BREAKTHROUGH CONCEPTS

A major objective of the carbon sequestration program is to demonstrate and deploy technologies that can achieve environmental benefits and remain economically viable. For this reason, the carbon sequestration program must maintain a level of flexibility that allows breakthrough concepts to be tested and verified. The potential environmental benefit of a quantum leap breakthrough in carbon sequestration solutions is enormous. Therefore, the programmatic EIS must incorporate sufficient flexibility to test and verify breakthrough concepts in order to realize potential environmental benefits.

SUMMARY

In summary, please allow me to recap key points that SSEB would ask the Department to consider as it develops a Programmatic Environmental Impact Statement:

Capture:

- Expanding potential sources to include fossil fuel emissions has the environmental benefit of offsetting others production processes.

Transport:

- Transporting CO_2 that is captured from fossil fuel emissions sources will not introduce new or unknown environmental impacts to the pipeline, tanker truck or rail industries.

Storage:

- The use of CO_2 that is captured from fossil fuel emissions sources will not introduce new or unknown environmental impacts to the EOR industry.

- The potential economic benefits of methane production and the potential environmental benefits of CO_2 sequestration in coal seams are both very high. Therefore, work should continue in the demonstration and deployment of these technologies, including the evaluation of environmental impacts.

- The potential environmental benefits of CO_2 sequestration in deep saline formations are very high. Therefore, work should continue in the demonstration and deployment of these technologies, including the evaluation of environmental impacts.

Measurement, monitoring and verification:

- The potential environmental benefits of demonstrating analytical systems and methods are great and, under carefully controlled field conditions, the environmental risks can be very low.

Regulatory, permitting and safety framework:

- Federal and state regulatory frameworks should facilitate, not block, the demonstration and deployment of technologies.

Breakthrough concepts:

- The programmatic EIS must incorporate sufficient flexibility to test and verify breakthrough concepts in order to realize potential environmental benefits.

FURTHER INFORMATION

Thank you for the opportunity to speak this evening. For those who would more information about SSEB and SECARB, log on to www.sseb.org and click on the Southeast Regional Carbon Sequestration Partnership.

APPENDIX E – SECARB INDUSTRY FOCUS GROUP DISCUSSION LETTER

(Please note: This letter was utilized to invite participants to the SECARB Industry Focus Group conducted on September 12, 2004 in Richmond, Virginia).

Dear SSEB Associate Member:

During the upcoming Southern States Energy Board 44th Annual Meeting in Richmond, Va., the SSEB will host a focus group to gauge industry views on carbon sequestration, an emerging technology that could assist with common-sense solutions to carbon management and climate change in the south and beyond.

As you may be aware, the SSEB is the leading entity in SECARB, the Southeast Regional Carbon Sequestration Partnership, a U.S. Department of Energy-funded and industry-supported effort to study the possibilities for carbon sequestration in the southeast. The focus group is a part of this effort, providing industry with a valuable opportunity to shape the debate on carbon sequestration and common-sense solutions to climate change.

As an energy leader in the southern region, your input in this process would be of great value. As the focus group will help to shape the issues, prior knowledge of the topic is not required. Please consider participating in the focus group, to be held in conjunction with our annual meeting, from 10:30 am to 12:30 p.m., September 12, 2004, at the Omni Hotel Richmond hotel in Richmond. Focus group attendees will be compensated for their participation. Refreshments will be provided.

To R.S.V.P., or for more information, please contact Mark Blankenship of RMS Strategies, who will assist SSEB with this effort, at (304) 343-7655 or mblankenship@rmsstrategies.com.

Thank you for consideration.

Best regards,
Ken Nemeth

APPENDIX F – SECARB INDUSTRY FOCUS GROUP AGENDA

(Please note: This agenda was utilized for the SECARB Industry Focus Group conducted on September 12, 2004 in Richmond, Virginia).

Southern States Energy Board
Southeast Regional Carbon Sequestration Partnership (SECARB)

"Focus Group on Industry Perceptions of the Value of Carbon Sequestration Research"

Omni Hotel Richmond
Richmond, Virginia
Sunday, September 12, 2004
10:30 a.m. to 12:30 p.m.
Boardroom, 2nd Floor

This Focus Group discussion will be moderated by Mr. Mark Blankenship, Senior Account Executive for RMS Strategies. RMS Strategies, a full-service custom survey research and consulting firm with locations throughout the southern region, provides expertise in the research of stakeholder perceptions and design of industry, government and public outreach communications strategies. RMS has performed services for energy businesses and industry interest groups throughout the southern region. RMS will perform a limited survey research activity for the ***Southeast Regional Carbon Sequestration Partnership*** to ascertain industry perceptions of the value of carbon sequestration research.

A G E N D A

10:30 a.m. **Welcome and Introductions**
Mr. Mark Blankenship, Moderator
Senior Account Executive, RMS Strategies
Technical Team Member, Southeast Regional Carbon Sequestration Partnership
- **General Background Overview**
- **Discussion Guidelines**

10:45 a.m. **Industry Perceptions of the Value of Carbon Sequestration**
All Participants
Closing Remarks and Final Thoughts

Mr. Mark Blankenship

12:30 p.m. **Adjourn**

APPENDIX G – SECARB INDUSTRY FOCUS GROUP DISCUSSION GUIDE

(Please note: This focus group discussion guide was utilized as the main element of the SECARB Industry Focus Group conducted on September 12, 2004 in Richmond, Virginia).

Introduction (:5 minutes)

Hello, my name is ______________ and I'll be your moderator for the next 2 hours during our group discussion. First of all, I would like to thank you all for coming and taking time out of your busy schedules. We'll be talking about national and state organizations and associations and the issues and programs they support. Before we get into our discussion, I would like to share a few things about myself and the room set-up.

I'm an independent research person and am not trying to sell you anything today. I work for a research company based in Charleston, West Virginia, with offices in Arlington, Virginia and Cincinnati, Ohio.

I'll be writing a report based on what you tell me, and in order to make sure that I'm accurately reflecting your views and opinions – without quoting anyone by name – I'm making a video and audio tape recording of our discussion.

I have a few members of my research team with me who are also working on this project, but rather than have them be part of our discussion, I've asked them to sit in the next room.

During our discussion please help yourself – one at a time – to the refreshments on the table. The restrooms are down the corridor. If there's anything I can do to make you more comfortable, please let me know.

I do have a few favors to ask of you. For the sake of my tape recording, please speak one at a time in a voice as loud as mine. I also want to encourage you to speak directly to each other. There is no need to direct every comment to me – as long as you don't have private side conversations.

Finally, there are no right or wrong answers. I want to hear as many different opinions as possible. We often learn new and important things from people who do not agree with the majority. So, if you have a different opinion, I'd encourage you to tell me and the others exactly how you feel.

Let's get to know each other a little bit before we begin. I would like each of you to introduce yourself to the group: tell us your first name, who you work for, where you live and one or two personal interests outside work.

Warm-Up and General Environmental Issues (:10 minutes)

1. Tell me a little about the business environment your company faces today? Is it better than it was five years ago, worse? Why?

2. What are some of the major issues and challenges your company or organization will face during the next five years? How are you preparing to deal with these issues and challenges?

3. When thinking about the environment, would you say environmental quality has improved, gotten worse or stayed about the same during the past few years? Why do you say that?

(DISTRIBUTE HAND OUT 1) I am going to give you a simple worksheet to complete. You will see a number of different environmental issues and/or attributes. Please tell me how important each of these issues is to your company or organization. If it is an issue which is "very important" you will want to assign a rating of 9. If the issue is "not at all important" you will want to assign a rating of 1. You can use any number between 1 and 9 and you can use any number more than once. Please let me know if you have any questions.

4. Who sets your company or organization's environmental "agenda?" What are some of the issues or characteristics which are considered when setting this agenda?

5. What are the most important environmental issues within your company, in other words, what issues are prioritized by the management and leadership, shareholders, et cetera? Do you believe these issues are consistent with the concerns of the environmental community and general public? Why or why not?

6. What are some of the most likely environmental challenges your company or organization will face during the next few years? What kinds of things is your company or organization doing to prepare for these issues and challenges?

7. How would you describe your company's or organization's "attitude" regarding environmental issues? How would others describe your company's attitude regarding environmental issues? Do you believe your company or organization has a good environmental image? How could it be improved?

8. How would you describe your company's or organization's working relationship with environmental groups? Is there room for improvement? Describe to me some of the ways in which you believe it could be improved.

Climate Change Issues (:10 minutes)

9. How important are climate change issues to your company's or organizational leadership? Why is it so/not so important from an internal perspective?

10. Does your company or organization participate in any climate change strategies or projects? If so, what are some of the projects? How effective are these strategies and projects in your opinion?

11. Who within your organization determines what, if any, climate change issues and projects you will participate in? Describe for me how those decisions are made. **(Probe what issues are important to determine usefulness of said strategies/projects such as cost, environmental impact, public perceptions, etc.)**

12. When your company or organization works in a climate change strategy or project, do you handle the work with internal staff or do you generally use outside consultants? Is one more effective than the other in your opinion?

13. How useful or effective are these climate change projects and strategies perceived **within** your company or organization? How could these perceptions be improved?

14. How useful or effective are these climate change projects and strategies perceived **outside** your organization (by government officials, environmental groups, general public)? How could those external perceptions be improved?

15. What would be/are the primary benefits to your organization with regard to participation in climate change strategies/projects? **(Probe long-term cost, compliance, public perception, community outreach, etc.)**

Carbon Sequestration – Awareness and Image (:20 minutes)

16. Can you explain to me, generally, what carbon sequestration is **(PROBE terrestrial/geological)**? Do you believe you have a deep understanding of carbon sequestration? Why or why not?

17. How attainable or feasible do you believe carbon sequestration is? What leads you to believe that?

18. How effective do you believe carbon sequestration efforts are currently? What leads you to believe that? How effective do you believe carbon sequestration efforts will be in, say, the next five years? Why do you say that?

19. What are some of the major barriers you see to long-term, sustained carbon sequestration efforts? How likely is it that these barriers will be addressed?

20. Who are some of the "thought leaders" or experts in carbon sequestration? Who is managing this effort? Who should be leading these efforts? Why?

21. Are there any groups outside the industry who are participating in carbon sequestration efforts? Who?

22. How much support exists in your company's or organizational leadership for carbon sequestration efforts? Should it be more of a priority or less of a priority? Why?

23. Thinking about your industry, how much support exists for carbon sequestration? Do you believe more support can be garnered? If so, how?

24. How much support do you believe exists in the environmental community for carbon sequestration efforts? Can it be improved?

25. In your opinion, what are the primary benefits or advantages of carbon sequestration? Are they the same for terrestrial carbon sequestration and geologic carbon sequestration?

26. What are some of your concerns regarding carbon sequestration efforts? How should those concerns be addressed? Are there risks **(probe economic and environmental risks)** associated with carbon sequestration? How do you believe those risks should be addressed?

27. Do you believe carbon sequestration efforts could be an effective component of climate change strategy? Why or why not?

28. How much support do you believe your company or organization would lend to carbon sequestration efforts as a component of an overall climate change strategy?

29. Are there any major environmental concerns you believe need to be addressed? What are they? How much of a barrier do you believe environmental groups and the general public will be to major carbon sequestration initiatives?

Messaging (:5 minutes)

30. What would you describe as the most effective way to communicate the overall message of carbon sequestration to your company or organization? In other words, who should hear the message and what should that message be in order to increase support?

31. How would you communicate or "sell" the general public in your area on carbon sequestration efforts? What would you say to them? What benefits would you want to promote? Why?

32. What advice would you give to those leading the carbon sequestration efforts regarding working with environmental groups or interests during this process? What messages would you deliver? What concerns would you address?

33. From your perspective, what is a better way to describe this issue – carbon sequestration or carbon capture and storage? Why? Is there another way you would describe it?

34. Those are all the questions I have for you this evening. I appreciate your time and participation. Is there anything else you would like to add to our discussion which I may not have covered or you did not get a chance to discuss? Thank you.

The focus group activity concludes following question 34 above.

APPENDIX H – SECARB INDUSTRY FOCUS GROUP WORKSHEET

(Please note: This focus group worksheet was utilized in the course of the SECARB Industry Focus Group conducted on September 12, 2004 in Richmond, Virginia).

Name: ______________________

Listed below are some specific issues. Please tell me how important each issue is to your company or organization. If it is an issue which is "very important" you will want to assign a rating of 9. If the issue is "not at all important" you will want to assign a rating of 1. You can use any number between 1 and 9 and you can use any number more than once.

	Not at All Important								**Very Important**
Greenhouse Gas Emissions Management	1	2	3	4	5	6	7	8	9
Air Quality (NOx, SOx and mercury emissions)	1	2	3	4	5	6	7	8	9
Legacy Issues (including post-operations land use)	1	2	3	4	5	6	7	8	9
Carbon Sequestration (Geologic and terrestrial)	1	2	3	4	5	6	7	8	9
Hydrogen technology research and development	1	2	3	4	5	6	7	8	9
Energy security and assurance	1	2	3	4	5	6	7	8	9
Renewable energy investments (biomass, wind and solar)	1	2	3	4	5	6	7	8	9
Clean coal technology and development	1	2	3	4	5	6	7	8	9
Climate change planning and development	1	2	3	4	5	6	7	8	9

APPENDIX I – DRAFT ENVIRONMENTAL HISTORY RESEARCH LETTER

(Please note: This draft letter was prepared for utilization to invite SECARB state government stakeholders to participate in the SECARB Environmental History research activities to be conducted during October and November 2004 via telephone.)

Dear _______________:

The Southern States Energy Board is conducting a telephone survey on environmental issues in the Southeast. As a state energy leader in the southern region, we would be honored if you could assist us by participating in this effort.

As you may be aware, the Board is the managing entity for SECARB, the Southeast Regional Carbon Sequestration Partnership, a U.S. Department of Energy-funded and industry-supported effort to study the potential for capture, storage and sequestration of carbon dioxide in the Southeast. This project seeks to research common sense solutions to greenhouse gas emissions reduction and climate change issues.

An important part of this effort is public outreach. Through this survey, we hope to gain knowledge of the environmental issues unique to each state in the SECARB region to better understand how these issues may relate to our carbon sequestration effort.

The survey, in the form of a telephone interview, would take no more than 30 minutes of your time. A representative from The Phillips Group, which is assisting the SSEB with this effort, will be in contact to schedule a convenient time for the interview.

As your input in this process would be of great value to our effort to research new environmental solutions for the Southeast, I ask that you please consider participating.

Thank you in advance for your assistance.

Sincerely,

Ken Nemeth
Executive Director, SSEB
Project Manager, SECARB

APPENDIX J – DRAFT ENVIRONMENTAL HISTORY INTERVIEW QUESTIONNAIRE

(Please note: This draft environmental history interview questionnaire was prepared for utilization with the SECARB state government stakeholders during the SECARB Environmental History research activities to be conducted during October and November 2004 via telephone.)

Hello, my name is __________ and I am conducting this interview on behalf of the Southern States Energy Board-led Southeast Regional Carbon Sequestration Partnership, known as SECARB.

Thank you once again for participating in this research effort. As you may be aware, the Southern States Energy Board is the managing entity for SECARB, which is a U.S. Department of Energy-funded and industry-supported effort to study the potential for capture, storage and sequestration of carbon dioxide in the Southeast. This project seeks to research common sense solutions to greenhouse gas emissions reduction and climate change issues.

An important part of this project is public outreach. Therefore, it is important for us to understand the environmental lay-of-the-land, so to speak, in your state. Efforts to capture, store and sequester carbon dioxide gas may be new to the Southeast and to your state, but the techniques and topics are similar to energy and environmental issues for which your state may be familiar.

With this discussion, we hope to learn the unique energy generation and environmental protection circumstance in your state, and to analyze how these circumstances may relate to our research into carbon sequestration. Once again, thank you for your participation. I'll now begin with my set of questions.

<u>Questions</u>

1. Please provide me with a brief overview of your office's responsibilities.
2. How would you characterize your state's efforts to balance energy production with environmental protection and economic growth? Is there room for improvement? Are there specific examples of successes?
3. How does industry view your state's permitting process for energy projects, such as natural resources extraction projects, energy generation projects, etc.? That is, does industry view the process as fair or overly burdensome?
4. How do citizen and environmental groups view the permitting process?
5. Generally, how are current natural resource extraction and energy generation projects viewed within your state by the general public and by citizen and environmental groups? Are there past or on-going environmental protection issues with these projects that have generated negative feelings on the part of the general public and/or citizen and environmental groups? Are there any noteworthy examples?
6. Generally, how are new natural resource extraction and energy generation projects viewed by the general public and by citizen and environmental groups?
7. In the above cases where there have been or are negative reactions, is the opposition locally based (i.e., from local NIMBY factions) or state based (i.e., from active statewide or regional environmental groups)?
8. What are the biggest hurdles to energy generation in your state?
9. What are the biggest hurdles to environmental protection in your state?
10. Specifically, how is coal-fired power generation viewed within your state by the general public and by citizen and environmental groups?

11. Specifically, how is carbon dioxide injection for enhanced oil and gas recovery viewed within your state by the general public and by citizen and environmental groups?
12. Specifically, how important are climate change issues within your state?
13. How receptive is the general public and citizen and environmental groups to new energy and environmental research initiatives involving fossil fuels?
14. What is the most contentious energy generation or environmental protection issue in your state right now?
15. What is the most contentious issue in your state right now, outside of energy generation or environmental protection?
16. Thank you very much for your time. Your responses will help the SSEB to move forward on its research efforts. Please don't hesitate to contact me with any further questions or follow-up thoughts.

APPENDIX K – A COST MODEL FOR CARBON DIOXIDE PIPELINE TRANSPORTATION

The algorithm used to estimate the CO_2 transportation cost is summarized below. The algorithm is based on the CO_2 transportation model developed by Heddle, Herzog, and Klett (2003)[32]. The memo consists of three sections: (1) pipeline diameter calculation; (2) least-cost route selection; (3) cost estimation.

(1) Pipeline Diameter Calculation

By assuming an inlet CO_2 pressure of 152 bar and an outlet CO_2 pressure of 103 bar, Heddle *et al.* gives the correlation between pipeline diameter and CO_2 mass flow rate for a 100 km pipeline (see Figure K1).

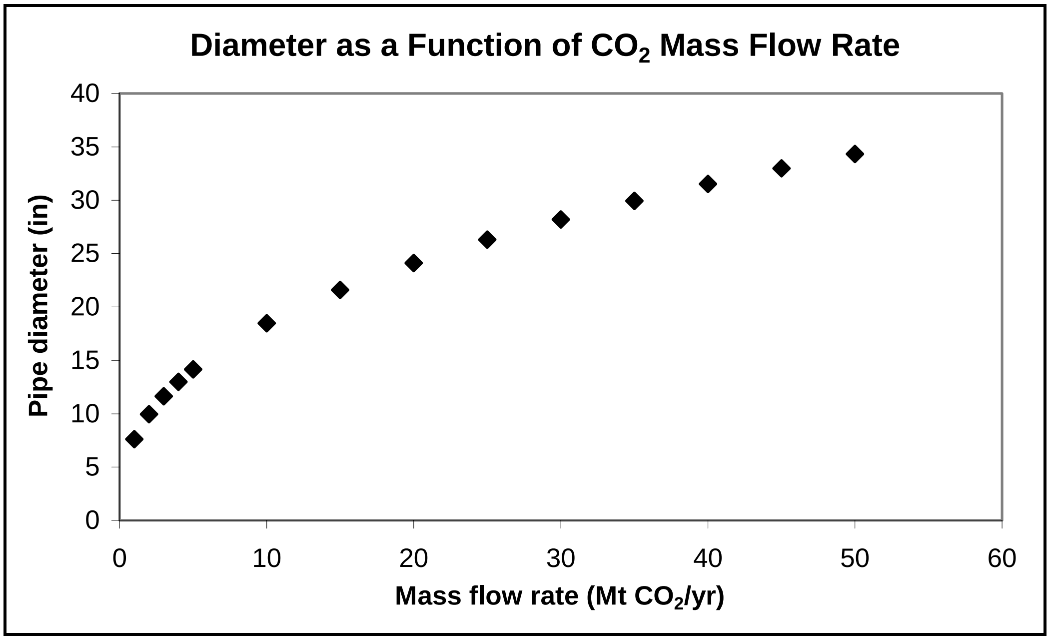

Figure K1. Calculated pipe diameter for 100 km pipeline as a function of CO_2 mass flow rate.

The algorithm assumes that standard pipelines in the gas industry will be used in CO_2 transportation. The pipeline diameter starts at 8 inches and increases for every 4 inches. Based on the result in Figure K1, Table K1 gives the breakdown of CO_2 flow rate for each pipeline diameter within the range 8 to 32 inches.

[32] Heddle, G., H. Herzog and M. Klett, "The Economics of CO2 Storage," MIT LFEE 2003-003 RP, August (2003). Available: http://sequestration.mit.edu/pdf/lfee_2003-003_rp.pdf

Table K1 Pipleline Diameter and CO_2 Flow Rate

Pipeline Diameter (inch)	**CO_2 Flow Rate (Mt/yr)**	
	lower bound	upper bound
8	-	1.0
12	1.0	3.3
16	3.3	6.6
20	6.6	11.8
24	11.8	18.9
28	18.9	27.7
32	27.7	40.2

(2) Least-cost Route Selection

The obstacle layers used in the transportation analysis consists of polygon features and line features. For environmental concerns, the pipeline should avoid passing through populated places, wetlands, and national and state parks, all are polygon features in the GIS system. Three line features—waterways, railroads, and highways—will impose additional construction cost if the pipeline crosses those features.

To build up the transportation cost contour, all the polygon and line features are rasterized into 1km by 1km cells. The base case is that no transportation obstacles listed above exists in the cell. By assuming the relative transportation cost to pass one cell in the base case is “1”, appropriate weights are assigned to each obstacle in Table K2.

The relative weighted transportation cost for passing each cell would then be the sum of the cost factors for the base case and all the obstacles exist in that cell. For example, the relative cost to cross a river in the national park would be 41: 1 (base case) + 30 (national park) + 10 (river crossing). Using the weighted cost layer calculated above, the spatial analysis function in ArcGIS would be able to decide the pipeline route with the lowest relative accumulative cost to collecting a source point and a sink point.

Table K2 Estimated Relative Construction Cost Factor

Construction Condition	Cost Factor
Base Case	1
Protected Area	
Populated Place*	15
Wetland	15
National Park	30
State Park	15
Crossing	
Wateway Crossing	10
Railroad Crossing	3
Highway Crossing	3

*The relative weights are calculated as the ratios of the additional construction costs to cross those obstacles and the base case construction cost for an 8 inch pipeline.

(3) Cost Estimation

The model decomposes the pipeline construction cost into two components: the base case construction cost and the additional obstacle crossing cost. The base case pipeline construction cost is estimated to be $12,000/in/km.[33] The obstacle crossing cost is calculated as the product of the relative weight assigned in Table A2 and the base case construction cost for an 8 inch pipeline, but is assumed to be the same for pipelines of any diameter (see Table A3)[34]. The O&M cost is estimated to be $3,100/km per year, independent of pipeline diameter[35].

[33] Heddle et al. (2003, p. 21) estimate that the average pipeline construction cost (including obstacle crossing cost) is $20,989/in/km. While Fox (1999) reports the average pipeline construction cost as $12,400/in/km for sparsely populated areas.

[34] For a 100km 8 inch pipeline with 6 waterway crossings, 1 railroad crossing, 1 highway crossing, and pass 1 km wetland. The estimated construction cost is $12,000*8*100 (base case construction) + $960,000*6 (waterway crossing) + $288,000 (railroad crossing) + $288,000 (highway crossing) + $1,440,000 (wetland crossing) = $17,376,000, which is quite similar to what we can get by using the average number provided by Heddle: $20,989*8*100=$16,791,200.

[35] Heddle et al. (2003), p. 22.

Table K3 Estimated Pipeline Construction Cost

Construction Condition	Construction Cost
Base Case	$12,000/in/km
Protected Area	
Populated Place	$1,440,000/km
Wetland	$1,440,000/km
National Park	$2,880,000/km
State Park	$1,440,000/km
Crossing	
Wateway Crossing	$960,000/per crossing
Railroad Crossing	$288,000/per crossing
Road Crossing	$288,000/per crossing