

GSA 2002
Implementing Geoinformatics for
Knowledge Integration and Decision Management

The MIDCARB Carbon
Sequestration Project:
Midcontinent Interactive Digital
Carbon Atlas and Relational
DataBase

Kansas Open-file Report 2002-45



<http://www.midcarb.org>

October 28, 2002

Abstract

MIDCONTINENT INTERACTIVE DIGITAL CARBON ATLAS AND RELATIONAL DATABASE (MIDCARB)

CARR, Timothy R.¹, BARTLEY, Jeremy D.², NELSON, Kenneth A.², ADKINS-HELJESON, Dana¹, WEISENFLUH, Gerald A.³, EATON, Nathan⁴, KOROSE, Christopher P.⁵, and WELLS, Joseph G.⁶,

(1) Kansas Geological Survey, Univ of Kansas, 1930 Constant Ave, Lawrence, KS 66047-3726, tcarr@kgs.ku.edu

(2) Kansas Geological Survey, Univ of Kansas, 1930 Constant Avenue, Lawrence, KS 66047-3726

(3) Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506-0107

(4) Indiana Geol Survey, 611 North Walnut Grove, Bloomington, IN 47405-2208

(5) Illinois State Geol Survey, 615 E. Peabody Dr, Champaign, IL 61820

(6) Ohio Div of Geol Survey, 4383 Fountain Square Dr, Columbus, OH 43224-1362

The **Midcontinent Interactive Digital Carbon Atlas and Relational Database (MIDCARB)** is a cooperative project that assembles a consortium of five states (Indiana, Illinois, Kansas, Kentucky and Ohio) to construct an online distributed Relational Database Management System (RDBMS) and Geographic Information System (GIS) covering aspects of carbon dioxide geologic sequestration (<http://www.midcarb.org>). Geologic sequestration may be one way to safely store carbon over long periods of time, if the proper tools to analyze the geological feasibility as well as the associated costs can be developed. The MIDCARB server provides users the ability to analyze the amount of CO₂ available for sequestration in relation to a source, the geologic security and safety of a sequestration site, the long-term effects on a reservoir, and the cost of compression and transport of CO₂ between source and sequestration site. The system links the five states of the consortium into a coordinated regional database system consisting of datasets useful to industry, regulators and the public. The project provides advanced distributed computing solutions that dynamically link database servers across the five states so that data can be maintained at the local level but accessed through a single web portal. All data is available to the user and can be queried, assembled, analyzed and displayed. Each individual state has strengths in data gathering, data manipulation and data display, including GIS mapping, custom application development, web development, and database design. Sharing of expertise provides the critical mass of technical expertise to improve CO₂ databases and data access in all states. This project improves the flow of data across servers in the five states and increases the amount and quality of available digital data. The MIDCARB project has developed custom online tools to provide real-time display and analyze CO₂ sequestration data. Using spatial data engines, Internet map servers and RDBMS operating through a common web-based application links together data from sources, sinks and transportation within a spatial context. Display of both the tabular and spatial information through an online client can assist decision makers by providing flexible access to common sets of high quality data.



<http://www.midcarb.org>

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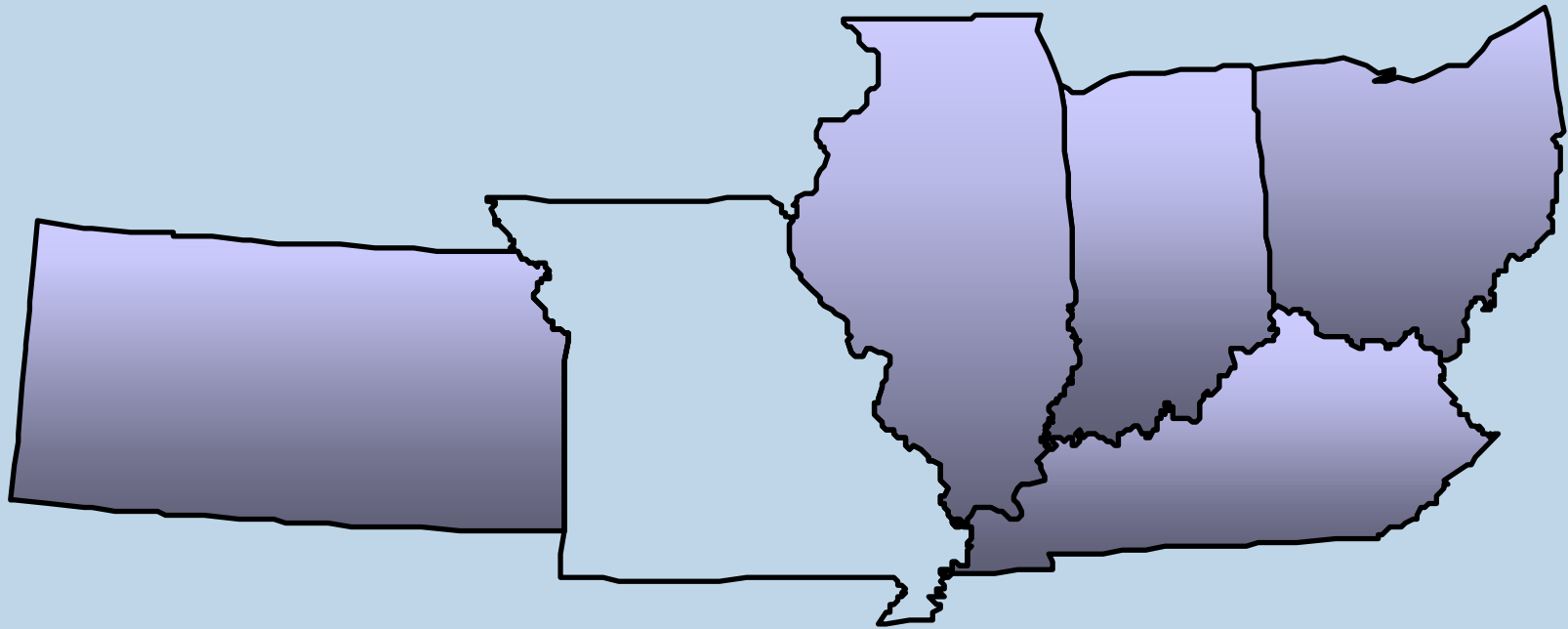
Relevance: Geoinformatics

- To serve data and analysis that satisfies the user
- To have an immediate, significant and direct bearing on the matter at hand
- To provide information that is opportune
- To maintain high quality and current information



<http://www.midcarb.org>

MIDCARB Consortium



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MIDCARB Project Goals:

- Characterize Major CO₂ Sources
 - Quantity, Quality, Location
- Characterize Potential Sequestration Sites
 - Geology and Reservoir Characteristics
- Develop Relational/Spatial Databases
 - Local and Regional Reporting Levels
- Supply Data to the Public
 - For use as tools in cost/feasibility analyses, etc.



Data Connectivity Options:

- Store and serve all data layers from one central server
 - Maintenance issues
- Create database views to join tables remotely
 - Difficult with different RDBMS software packages
- Join remote tables and layers via a Internet Map Server and other web application tools to build dynamic web pages.
 - Easy, flexible, and it works!

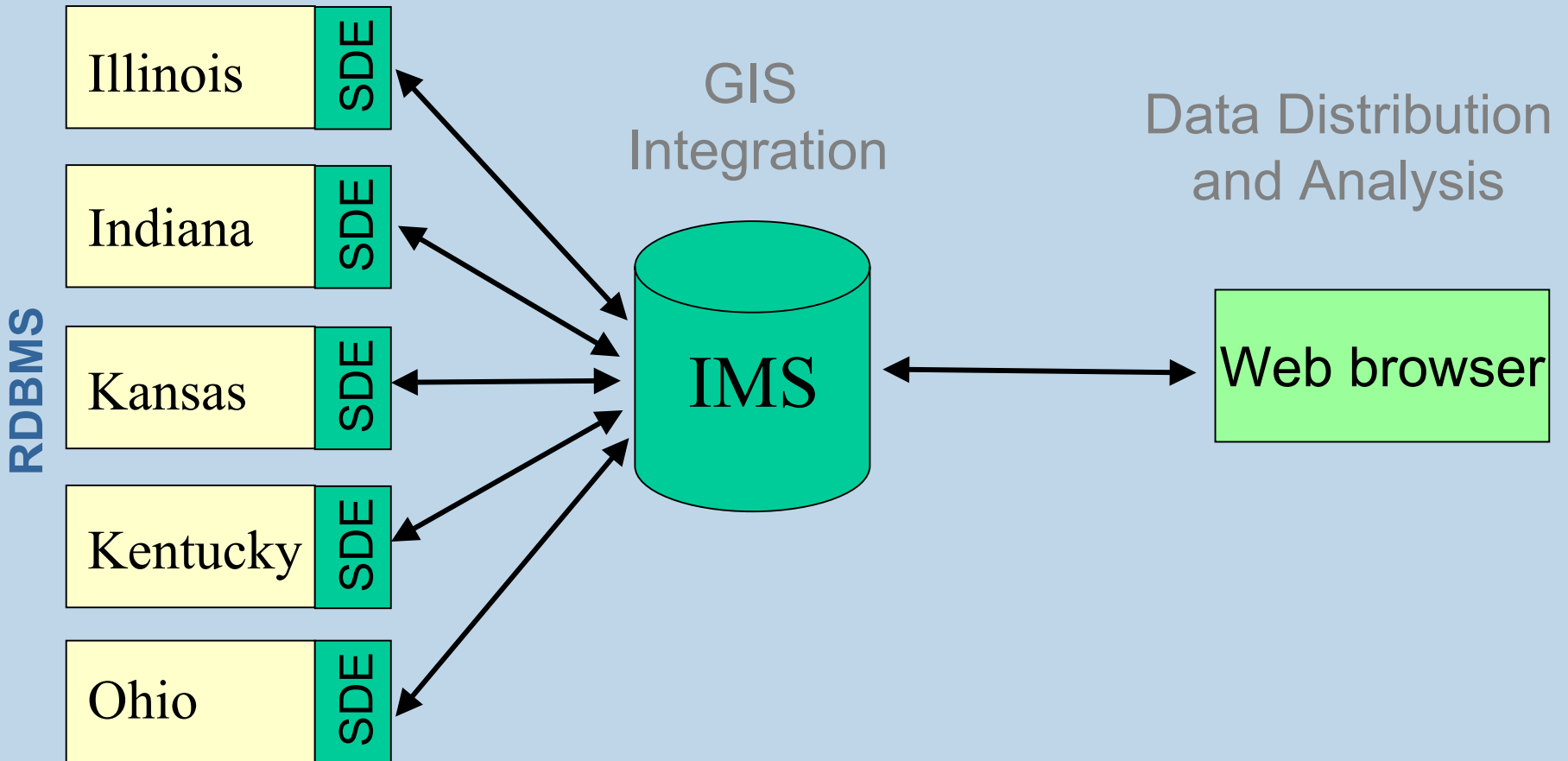


Database Structure:

- Each organization maintains their own data layers according to their own database design and formats.
- A MIDCARB structure for database themes is under continuous construction to define what data elements are necessary and how the information will be presented to the user
- Implement database views rather than alter the table structure to adhere to centralized database standards



Spatial Database Connections



MIDCARB - Map Server Deployment



The Midcontinent Interactive Digital Carbon Atlas and Relational DataBase (MIDCARB) is a joint project between the Geological Survey's of Illinois, Indiana, Kansas, Kentucky, and Ohio, with funding from the Department of Energy National Energy Technology Laboratory. The purpose of MIDCARB is to enable the evaluation of carbon sequestration potential in these states. When completed, the digital spatial database will allow users to estimate the amount of carbon dioxide (CO₂) emitted by source supplies (such as power plants, refineries and other fossil fuel consuming industries) in relation to geologic reservoirs that can provide safe and secure sequestration over geologic periods of time.

Click the map to access the graphical interface to the data:

The long-term effects on a reservoir will be provided and the user will be able to calculate the cost to compress and transport CO₂ between source and sequestration sites. MIDCARB will organize and enhance the critical information about CO₂ sources and develop the technology needed to access, query, model, analyze, display, and distribute natural-resource data related to carbon management.



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MIDCARB Client Evolution Stage 3 :

Legend/Layer Controls

Tool mode: Zoom In
Active layer: IL - Power Plants

Home
Downloads

Map Layers

Select Active Layer
IL - Power Plants

- CO2 Sources
- Infrastructure
- Base
- Petroleum
- Coal
- Geology

Map Coordinates: -94890 meters (East), 4313780 meters (North) [UTM Zone 16 NAD83]

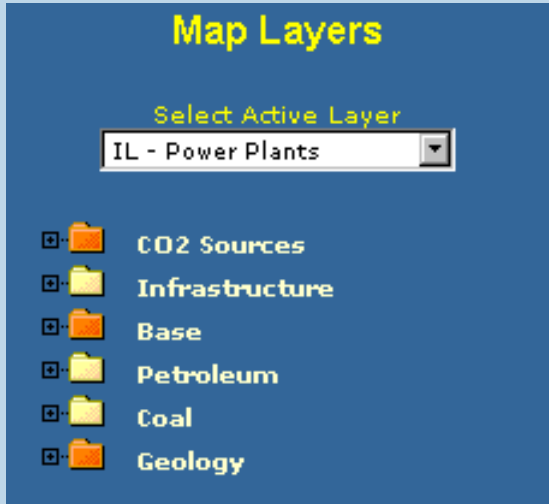
Toolbar



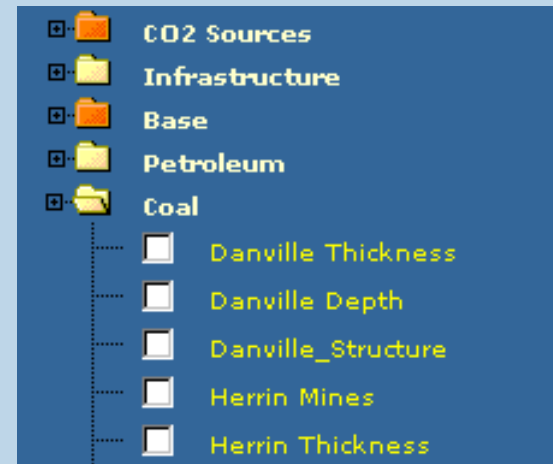
<http://www.midcarb.org>

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MIDCARB IMS Client – Legend Customization



*Expandable database folders
organize layers into thematic
categories*



Tabular Data A

MIDCARB MAPS • A FIVE-STATE GIS C

Current Tool: Identify

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IL - Power Plants											
Rec	Facility ID	Calendar Quarter	Year	Plant Name	EPA Facility ID	EPA AIRS ID	State Facility ID	State	County Code	Latitude	Longitude
1	55204	3	2001	KINMUNDY POWER	000093980741	1712100093	121803AAA	IL	121	38.74778	-89.0

MIDCARB--Generating Facility Emissions - Microsoft Internet Explorer

Illinois
PINCKNEYVILLE POWER

Also available is a [summary of total Illinois emissions](#)

Unit: CT01; Turbine: Combustion turbine

Rated Capacity (MWe): 49
Plant Operation Start: Jun 4, 2000

Most Recent Data			
Data Type	Quarterly totals Apr 9, 2002	Cumulative for 2002	
CO2 (Tons)	207.30	207.30	Make Chart
SO2 (Tons)	0.00	0.00	Not enough data to chart.
NOX (Tons)	.11	.11	Make Chart
Heat Input (mmBtu)	3,487.00	3,487.00	Make Chart

MIDCARB--Illinois--Emissions Charts - Microsoft Internet Explorer

Illinois
PINCKNEYVILLE POWER

Unit: CT01; Turbine: Combustion turbine

Rated Capacity (MWe): 49
Plant Operation Start: Jun 4, 2000
Most Recent Data: 1-2001

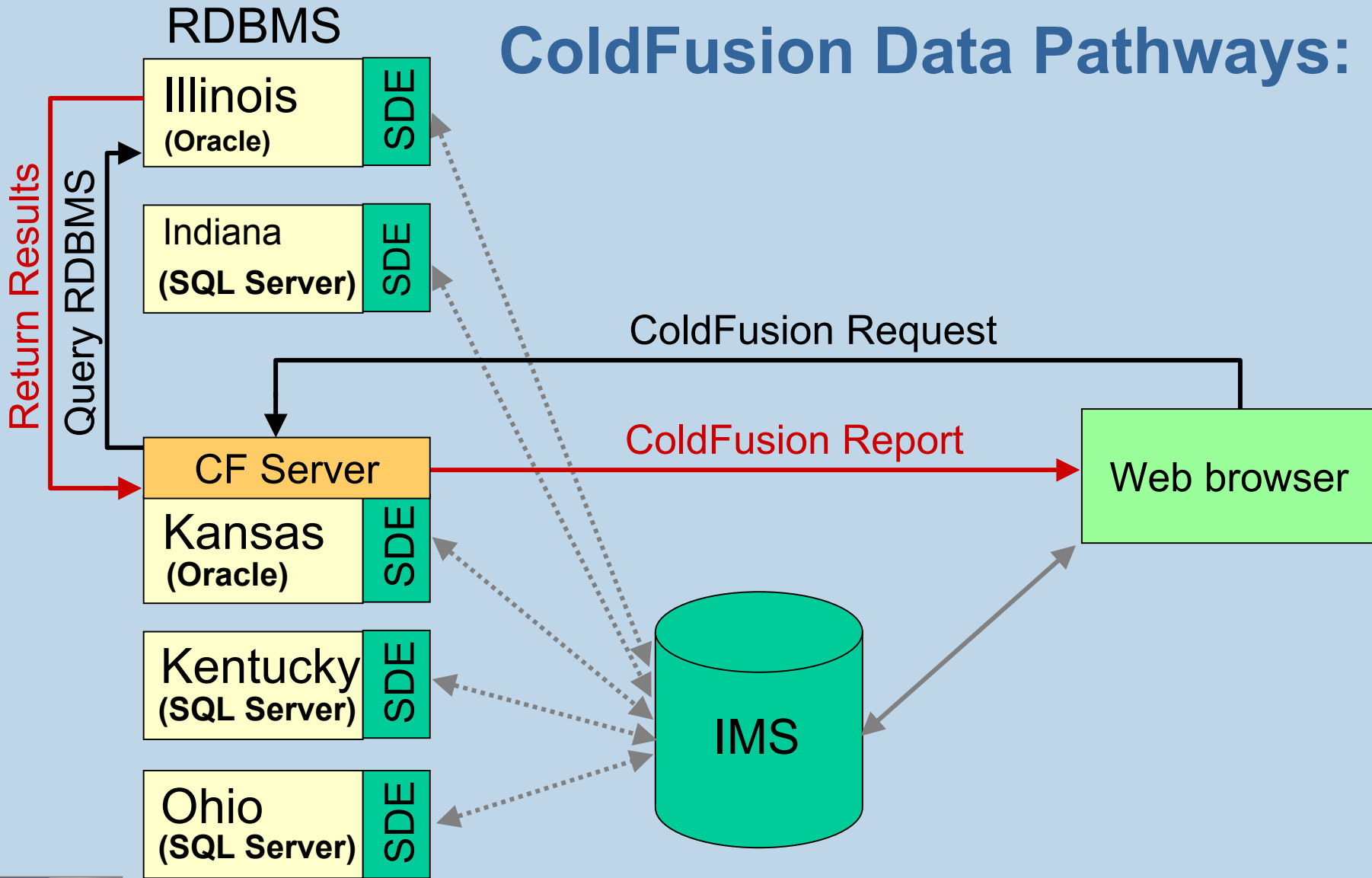
CO2 Tons Quarterly

Quarter	CO2 Tons
Nov 2000	~100
Mar 2001	~100
Apr 2001	~100
Aug 2001	~1000
Oct 2001	9839.80
Jan 2002	~100

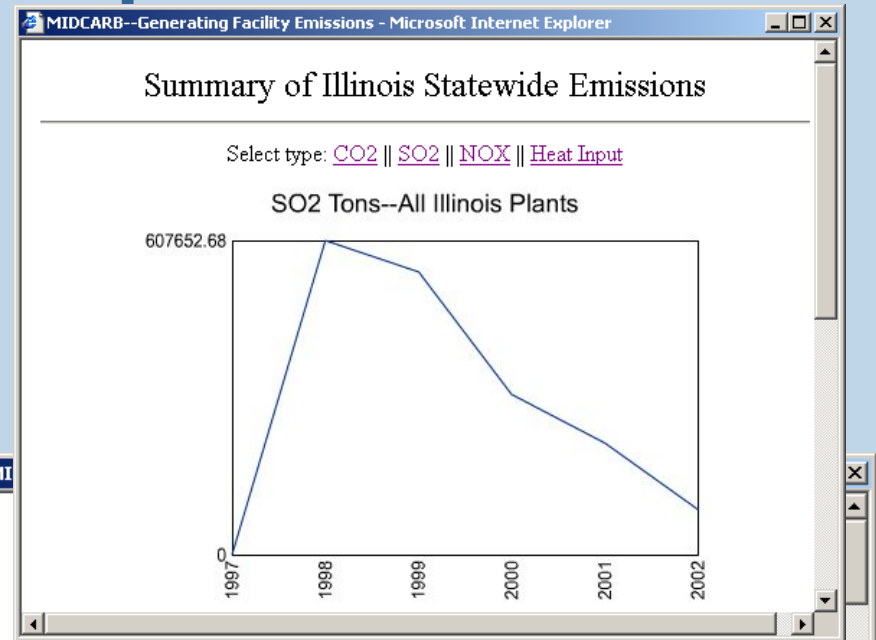
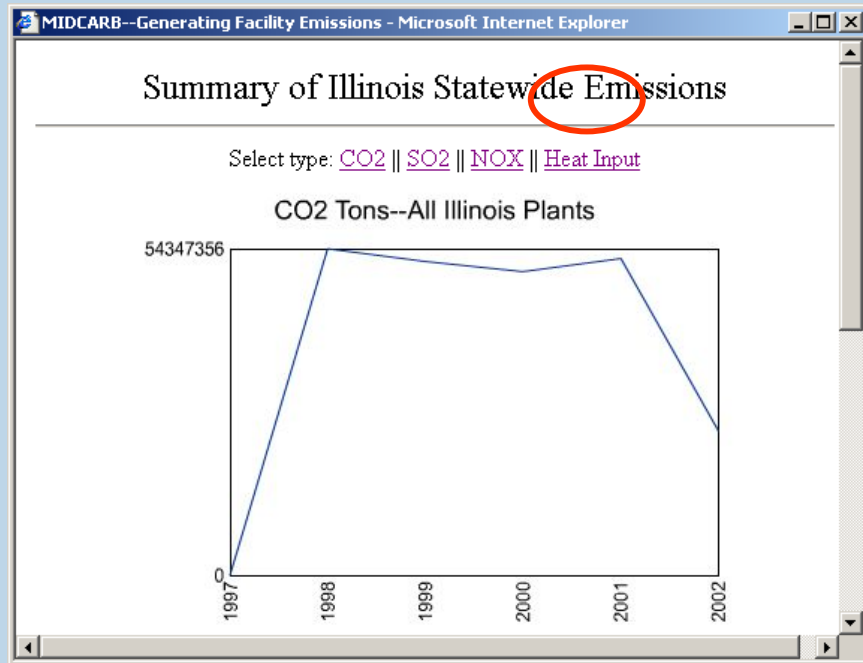


<http://www.midcarb.org>

ColdFusion Data Pathways:



Tabular Data Computation:



Unit: CT01; Turbine: Combustion turbine

Rated Capacity (MWe): 49

Plant Operation Start: Jun 4, 2000

Most Recent Data		
Data Type	Quarterly totals Apr 9, 2002	Cumulative for 2002
CO2 (Tons)	207.30	207.30
SO2 (Tons)	0.00	0.00
NOX (Tons)	.11	.11
Heat Input (mmBtu)	3,487.00	3,487.00



<http://www.midcarb.org>

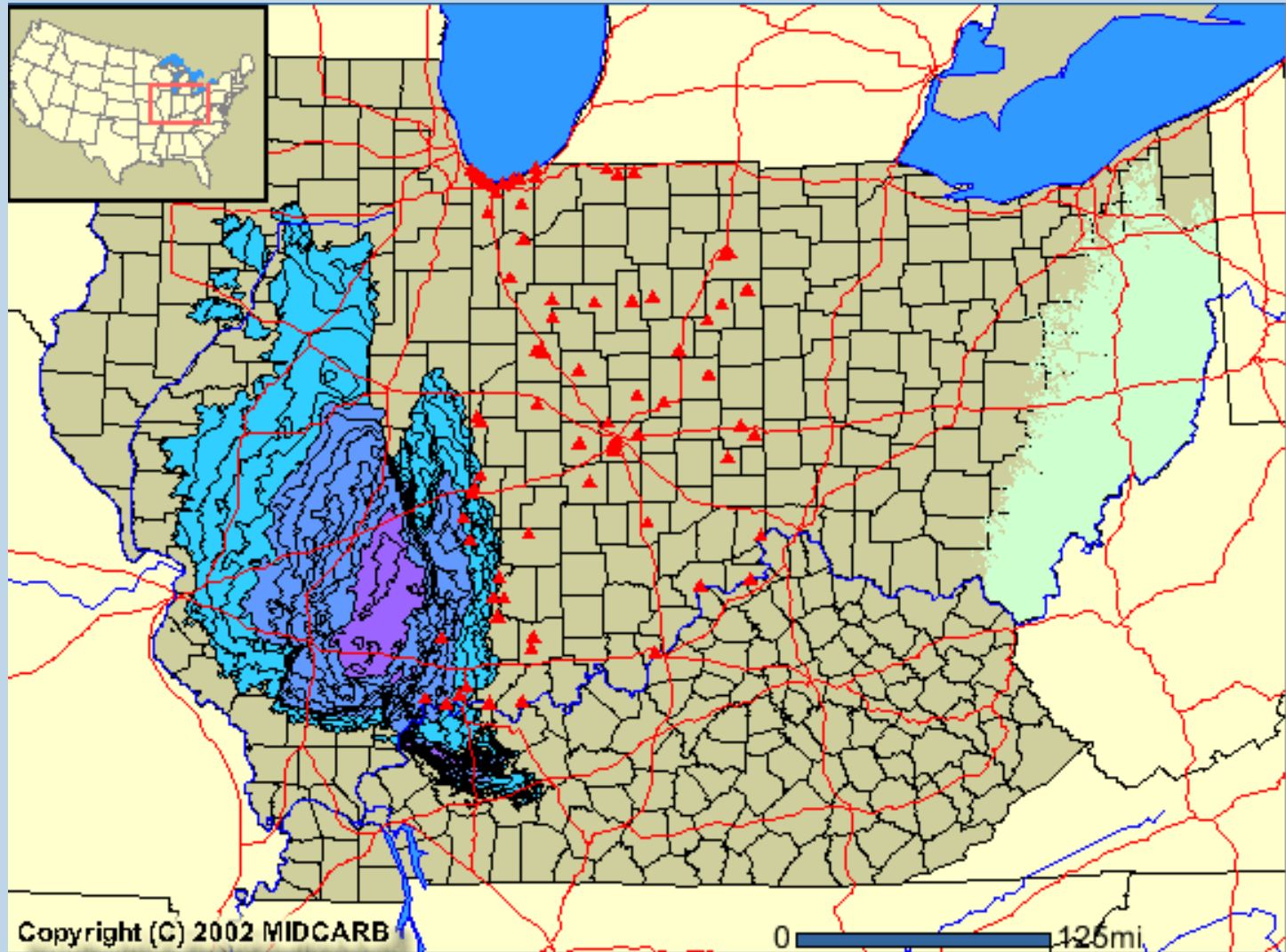
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MIDCARB Databases

- Major CO₂ Sources
 - Quantity, Quality, Location
- Transportation Infrastructure
 - Pipelines, Electric Lines
- Base
 - Roads, Rivers, Political Boundaries, DOOQ's, etc.
- Potential Petroleum Sequestration Sites
 - Reservoir Characteristics, Production, Wells
- Potential Coal Sequestration Sites
 - Structure, Thickness,
- Potential Aquifer Sequestration Sites
 - Structure, Thickness, Geochemistry
- General Geology



Distributed Coal Themes:



<http://www.midcarb.org>

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MIDCARB Browser - Tools

The screenshot shows the MIDCARB MAPS browser interface. The title bar reads "MIDCARB MAPS | Interactive Map Page - Microsoft Internet Explorer". The main header says "MIDCARB MAPS • A FIVE-STATE GIS COMPILATION". Below the header is a toolbar with various GIS tools. The current tool is "Pan". The map displays a large circular buffer around a yellow point, with a red circle labeled "1" on the buffer's edge and another red circle labeled "3" on the map. A red circle labeled "2" points to the "IN - Petroleum Fields" data table at the bottom. The legend on the right is circled in red and includes items like "Selected Features", "theBuffer", "theBufferTarget", and various CO2 sources and infrastructure. The data table at the bottom is titled "IN - Petroleum Fields" and contains the following data:

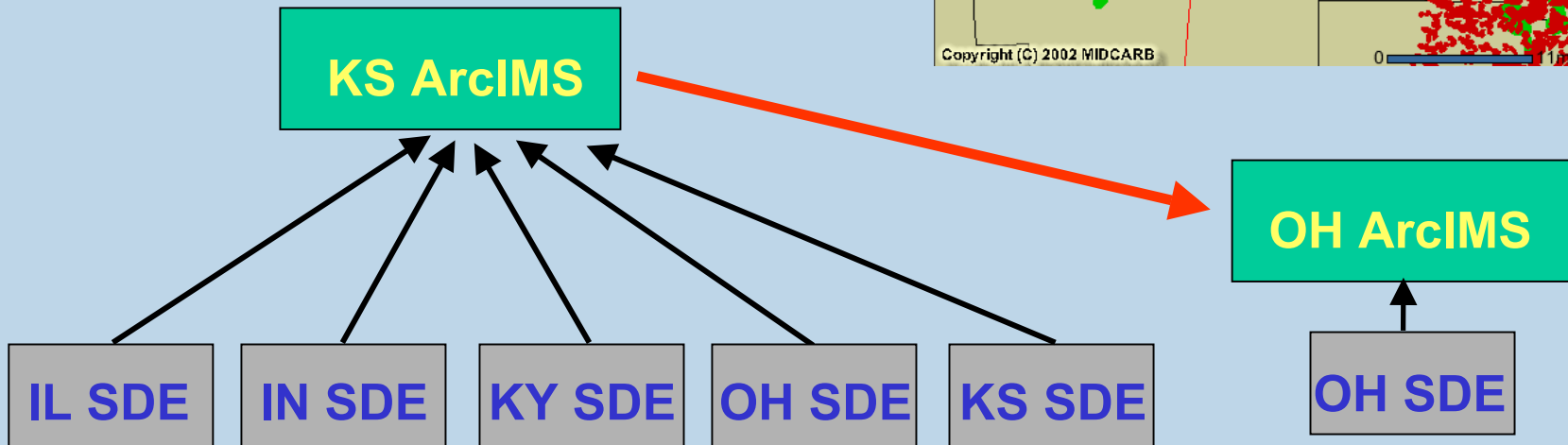
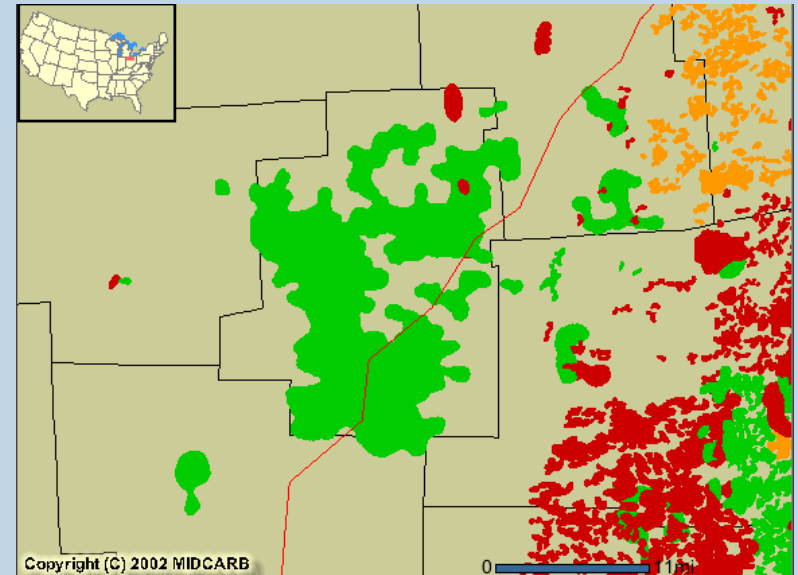
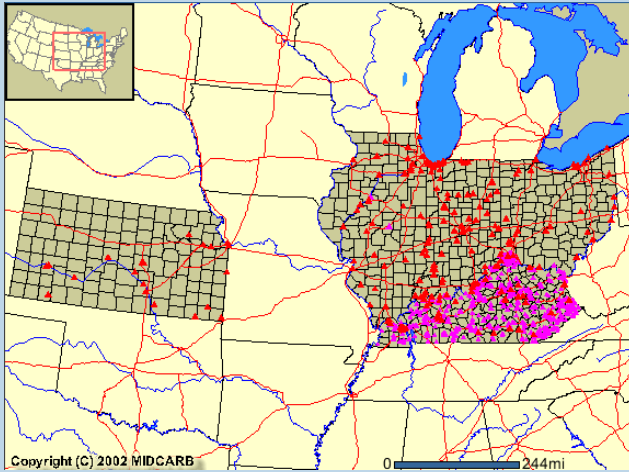
Rec	MIDCARB_GIS.MIDCARB_DATA.PETROLEUM_FIELDS.AREA	MIDCARB_GIS.MIDCARB_DATA.PETROLEUM_F
1	4900819.5	8653.021
2	6581115.5	10193.448
3	3036988	7740.482



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MIDCARB Browser - Level of Detail:



<http://www.midcarb.org>

MIDCARB Browser – Local Computations:

The screenshot displays the ArcView GIS 3.2 interface. The main map window, titled "Demo 5 - CO2 Sequestration", shows a geographic area with a grid overlay. The map is color-coded: green for Oil, red for Gas, and yellow for Storage. A legend on the left side of the map window lists the layers: Township Boundary, County Boundary, State Boundary, and Clnn_co2_sps83. The Clnn_co2_sps83 layer is further detailed with a legend: Oil (Green), Gas (Red), and Storage (Yellow). Below the map, the "Attributes of Clnn_co2_sps83.shp" table is visible, showing columns for Area, Field Name, Thickness, Porosity, and CO2. The table contains 11 rows of data, all with "CANTON CONS." as the Field Name.

Area	Field Name	Thickness	Porosity	CO2
2850301313.737	CANTON CONS.	15.00000	7.00000	51626082545.061
4285518.030	CANTON CONS.	15.00000	7.00000	77621445.318
194849825.051	CANTON CONS.	15.00000	7.00000	3529217456.236
6205116.892	CANTON CONS.	15.00000	7.00000	112390179.706
2606997.778	CANTON CONS.	0.00000	0.00000	0.000
5864018.234	CANTON CONS.	15.00000	7.00000	106212030.263
506368349.835	CANTON CONS.	15.00000	7.00000	9171596736.386
5626921.239	CANTON CONS.	15.00000	7.00000	101917610.941
6335351.338	CANTON CONS.	15.00000	7.00000	114749051.110
4620734.257	CANTON CONS.	0.00000	0.00000	0.000
3444833782.952	CANTON CONS.	15.00000	7.00000	62394551893.718

OH ArcIMS

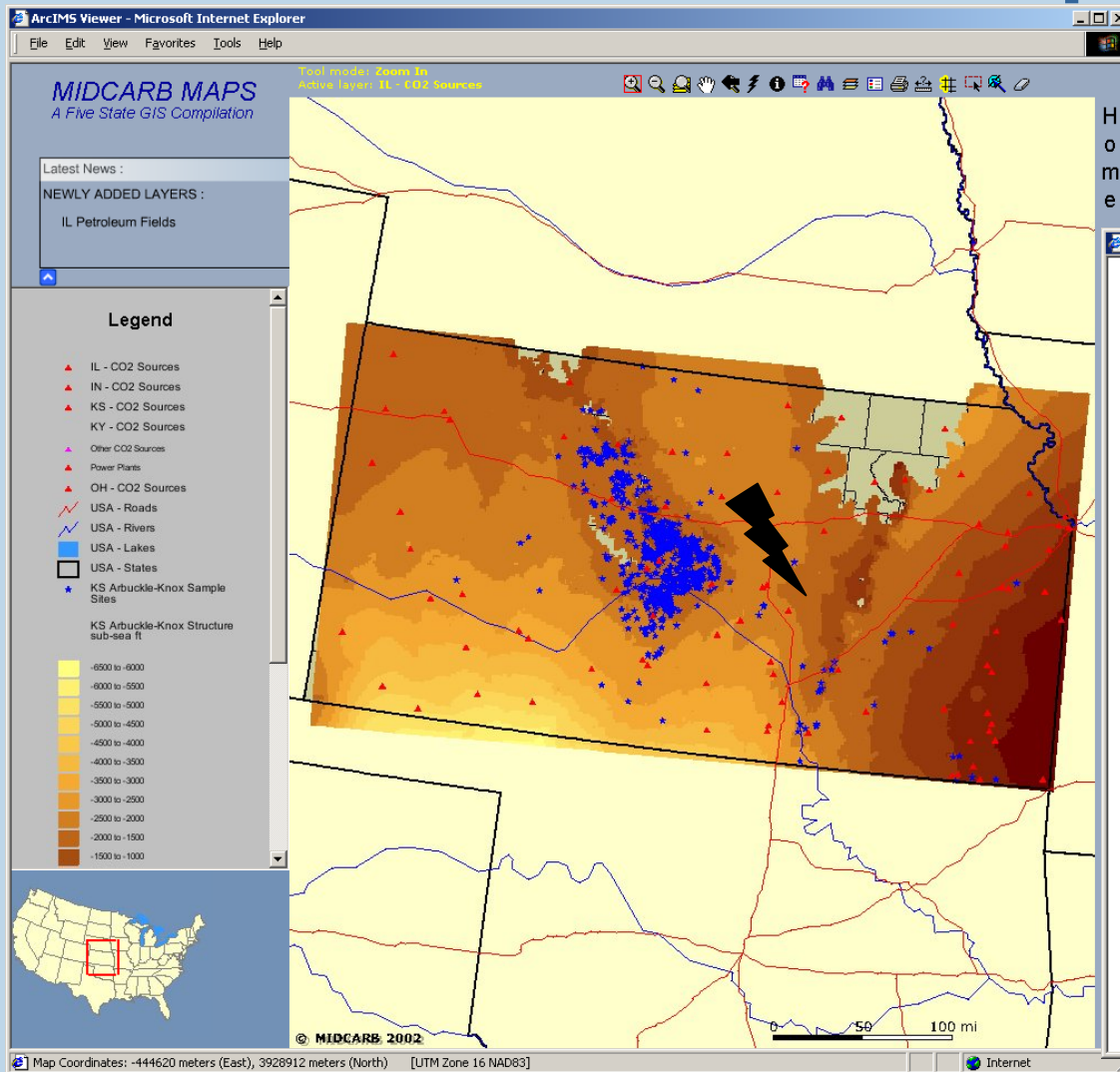
OH SDE



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MIDCARB Browser - Aquifers



Kansas Geological Survey

Oil and Gas

Brine Analyses

Kansas Brine Analyses

Location Info

County: Ness	Location: T17S, R25W, Sec. 33
Formation: Arbuckle Gp	Depth:
Data Source: Halliburton Company	Sample Date: Aug-06-1958

General Analyses

PH: 7	Temperature: °F
Specific Gravity: 1.014	Resistivity:
Total Dissolved Solids: 21600 mg/L	

Individual Chemical Analyses

Sodium/Potassium: mg/L	Sodium: mg/L
Calcium: 572 mg/L	Magnesium: 369 mg/L
Iron: mg/L	Chlorine: 11000 mg/L
Sulfate: 3750 mg/L	Bicarbonate: mg/L
Carbonate: mg/L	Bromine: mg/L
Iodine: mg/L	Hydrogen Sulfide: 0 mg/L

Kansas Geological Survey
Comments to webadmin@kgs.ku.edu
URL=<http://www.kgs.ku.edu/Magellan/Brine/index.html>
Display Program Updated March 12, 1999
Data from K.G.S Files



<http://www.midcarb.org>

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MIDCARB Browser - Oil & Gas



<http://www.midcarb.org>

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Metadata Access:

MIDCARB MAPS • METADATA/DATA DOWNLOAD

Datasets download

Follow the links in the table below to access metadata and download GIS datasets. GIS datasets are provided as zipped ESRI shapefiles. Refer to the metadata to determine layer projection and datum. The blue column indicates the source location of each dataset.

Warning

The recipient of the data assumes all responsibility for assuring the fitness of the data for the intended purpose. The data are provided electronically as a courtesy. Please contact the owners of the data for comment; the sources for the datasets may be found in the metadata.

CO₂ Sources	Infrastructure	Base Layers
Petroleum	Coal	Geology

CO ₂ Sources			
IL - Sources	IL SDE	EPA_FAC_IL	shapefile (10 KB)
IL - Ethanol Plants	IL SDE	IL_ETHANOL_PLANTS	not available
IN - Sources	IN SDE	IN_CO2_SOURCES	shapefile (7 KB)
KS - Sources	KS SDE	KS_CO2_SOURCES	not available



Application Management Tools: (Under Construction)

- ColdFusion based application that stores the ArcXML (AXL) file in RDBMS -- **Completed**
- Password protected site that allows the user to make modifications to the MIDCARB XML file(s) and refresh the map service(s) -- **Completed**
- Automated procedure that pings the MIDCARB map services to see if they are alive, alerts system administrators if there is problem, and dynamically routes traffic to the backup map server if necessary



Distributed Application Management Utilities:

The screenshot shows a web browser window with the following content:

Browser title: `Opera - [http://hercules.kgs.ukans.edu/website/midcarb/midcarb_manage/load_midcarb_axl.cfm]`

Navigation buttons: Back, Forward, Reload, Home, Hotlist, Print

Search bars: Super search, Amazon.com search, Find in page

featureclass	IN - CO2 Sources	true	2	CO2 Sources	Details
featureclass	IL - Ethanol Plants	true	1	CO2 Sources	View Layer Details
featureclass	IL - Power Plants	true	0	CO2 Sources	View Layer Details

ADD MIDCARB MAPLAYER

Layer Name	<input type="text"/>
Layer Type	<input type="text" value="featureclass"/>
Image not supported	
Layer Visible	<input checked="" type="checkbox" value="true"/>
Layer Max Scale	<input type="text"/>
(Leave blank if none, otherwise like "1:1000000")	
Layer Min Scale	<input type="text"/>
(Leave blank if none, otherwise like "1:1000000")	
Layer Group	<input type="text" value="CO2 Sources"/>
Dataset Name	<input type="text"/>
Dataset Workspace	<input type="text" value="Indiana"/>
Dataset Type	<input type="text" value="point"/>
<input type="button" value="Add New Layer"/>	

Allows user to define the properties of a map service and store the property definition in an RDBMS table



<http://www.midcarb.org>

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Distributed Application Management Utilities:

http://hercules.kgs.ukans.edu/website/midcarb/midcarb_manage/layer_info.cfm?layer_begin=6197&layer_count=1394&maps...

Details of layer OH - NET COAL THICKNESS from the MIDCARB_NEW MapService on HERCULES

Layer Name	OH - Net Coal Thickness
Feature Type	featureclass
Layer Visible	false
Layer ID	40
Layer Group	Coal

```
<LAYER type="featureclass" name="OH - Net Coal Thickness" visible="false" id="40">
  <DATASET name="MIDCARB.OH_NET_COAL" type="polygon" workspace="sde_ws-87" />
  <COORDSYS id="4269" />
  <VALUEMAPRENDERER lookupfield="COAL_INCH">
    <RANGE lower="24.0" upper="81.6" label="Less than 81.6">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="0,0,255" boundarycaptype="round" boundarycolor="0,0,255" />
    </RANGE>
    <RANGE lower="81.6" upper="139.2" label="81.6 - 139.2">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="51,0,204" boundarycaptype="round" boundarycolor="51,0,204" />
    </RANGE>
    <RANGE lower="139.2" upper="196.8" label="139.2 - 196.8">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="102,0,153" boundarycaptype="round" boundarycolor="102,0,153" />
    </RANGE>
    <RANGE lower="196.8" upper="254.4" label="196.8 - 254.4">
      <SIMPLEPOLYGONSYMBOL boundarytransparency="1.0" filltransparency="1.0"
fillcolor="153,0,102" boundarycaptype="round" boundarycolor="153,0,102" />
    </RANGE>
  </VALUEMAPRENDERER>
</LAYER>
```

Refresh Mapservice Layer

Allows user to modify properties of layer running on an IMS server



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Future System Work

- Pre-IMS layer selection tool to simplify the TOC/Legend
- Implement new metadata server (ArcIMS 4.0)
- Design advanced query tools to analyze the spatial relationship between CO2 sources and sinks
- Complete application management tools
- Explore XML client options (OpenGIS)
- Add additional organizations



Future Content Work

- More Isopach, Depth and Structure Maps
 - Covering Major Oil & Gas Reservoirs, Coals, Aquifers, Shales
- Reservoir Volumetric Parameters
 - MMP, Coal Adsorption, Perm, Porosity
- Detailed Field and Well Data
- Improved Coverage on CO2 Sources
 - Ethanol, Refineries, Cement, Other Industrial Sources

