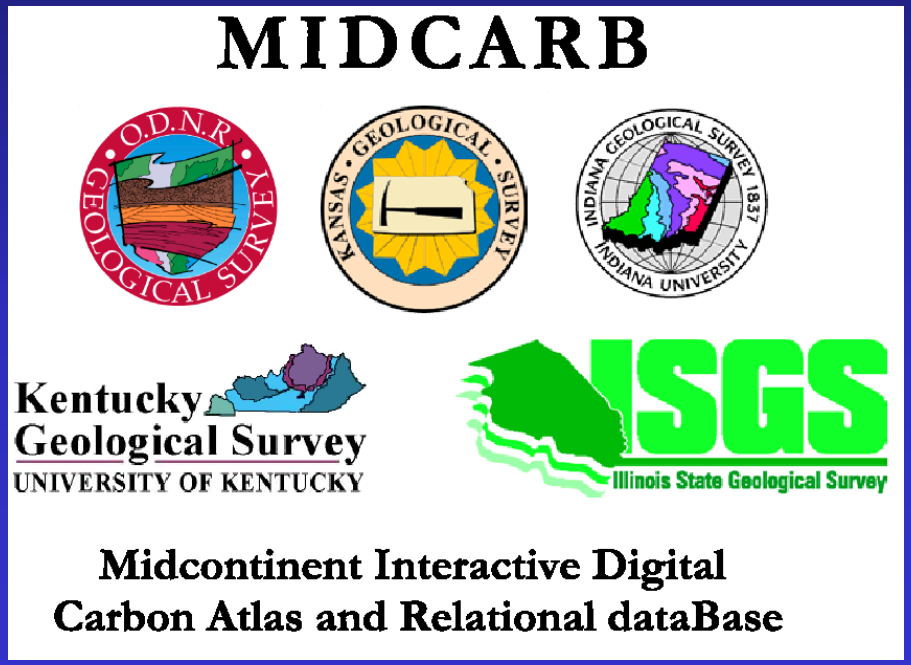
Online Tools to Evaluate Oil and Gas Fields for CO2 Sequestration

Larry Wickstrom, James McDonald, Ronald A. Riley, Timothy R. Carr, Brandon Nuttall, John A. Rupp, Wilfrido Solano-Acosta, Charles W. Zuppann, and Beverly Seyler

Midcontinent Interactive Digital Carbon Atlas and Relational DataBase



What is MIDCARB?

- It is a research consortium composed of the State Geological Survey's of Illinois, Indiana, Kansas, Kentucky, and Ohio, with funding from the US Department of Energy through the National Energy Technology Laboratory.
- The main objective is to evaluate the potential capacity for geologic sequestration of Carbon Dioxide in the member states.
- Obtaining realistic estimates of the potential amounts of carbon that can be stored in geologic reservoirs, and the locations of these reservoirs, is of vital importance to establishing this technology.

The MIDCARB Website

- To share the results of this research MIDCARB has constructed an online distributed Database Management and Geographic Information System for analyzing the spatial relationships and technical characteristics of large point sources of CO_2 and geologic sequestration options.
- The data presented on the MIDCARB web site actually reside on the local computers at each state geological survey.
- The MIDCARB system is the first DISTRIBUTED system of natural resource data focused on CO_2 sources and potential geologic sequestration sites.

MIDCARB

Primary Geologic Sequestration Target Reservoirs

- Oil and Gas Pools / Fields
- Coal Beds
- Deep Saline Aquifers
- Unconventional Reservoirs - tight gas sands; organic shales; solution salt cavities, etc.

MIDCARB Home Page - Microsoft Internet Explorer

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Back Search Favorites History Links

Address http://www.midcarb.org/ Go

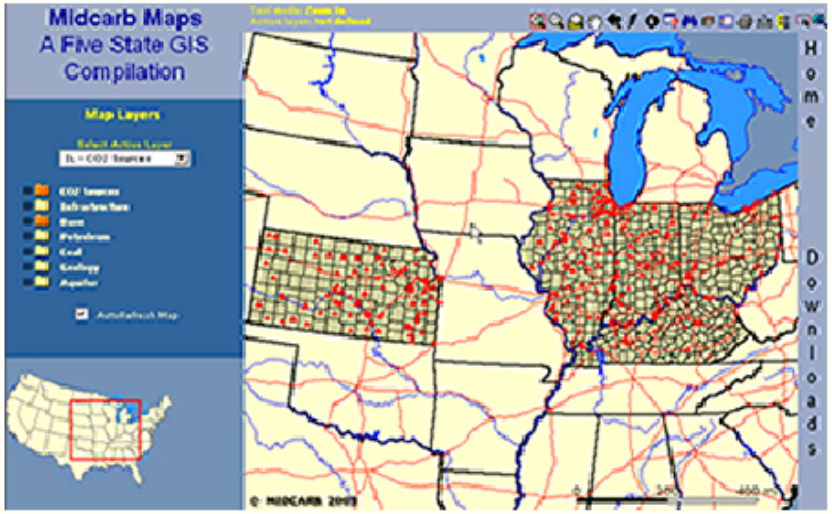
MIDCARB

Midcontinent Interactive Digital Carbon Atlas and Relational dataBase

Home | Map Interface | Table Interface | Calculators | Reports | Contacts

Click on the map below to access the graphical interface to the data

To view the maps: Use Internet Explorer 5 or Netscape 7 or above



What is MIDCARB?

What is Carbon Sequestration?

Why Sequester CO2?

Geologic Sequestration Reservoirs

Run a Guided Tour of the Map Interface

Internet

Address http://abyss.kgs.ku.edu/pls/abyss/midcarb.co2_calc.aquifer Go

MIDCARB Calculators

Solubility of CO2 and Volumetrics

Click on **any** "Update" button to refresh all of the calculations.

Step 1--Modify Aquifer Temperature, Pressure, and Salinity as required.

Aquifer Temperature	90	Degrees F
Aquifer Pressure	1100	psia
Salinity NaCl concentration	200,000	ppm
	Update	

CO2 Solubility	SCF/bbl Water	lbs/bbl Water	scf/cu-ft	lbs/cu-ft	lbs/acre-ft	tonnes/acre-ft	mcf/acre-ft
	165	19.2	29.4	3.4	148,593	67.5	1280.1
(with salinty correction)	71	8.2	12.6	1.5	63,895	29.0	550.5

Step 2--Reservoir Volumetrics. Enter aquifer parameters to determine CO2 sequestration volumetrics.

Reservoir Thickness	20	feet
Reservoir Area	12800	acres
Porosity	6	%
Sequestration Volume	84,546	MMCF CO2
	4,462	tonnes * 1000
	Update	

Done Internet

Data on CO2 properties from: Practical Aspects of CO2 Flooding, SPE Monograph Vol. 22

Step 1--Modify Reservoir Temperature and Pressure as required.

Reservoir Temperature	100	Degrees F
Reservoir Pressure	1200	psia
	Update	

Step 2--Reservoir Volumetrics.
Enter reservoir parameters or skip to step 2a.

Reservoir Thickness	10	feet
Reservoir Area	640	acres
Porosity	10	%
Sequestration Volume	293,737	metric tonnes
	Update	

Step 2a--Replacement of Produced Fluid (Oil).
Enter produced fluid.

Barrels Produced	1000	MBO
CO2 Sequestered	59.0	tonnes*1000
	1.0	MMCF
	Update	

Step 3--Volume of Reservoir Needed to Sequester a Given Volume of CO2

Volume of CO2	70	Million Metric Tonnes
Reservoir Volume Required	152,517	acre-ft

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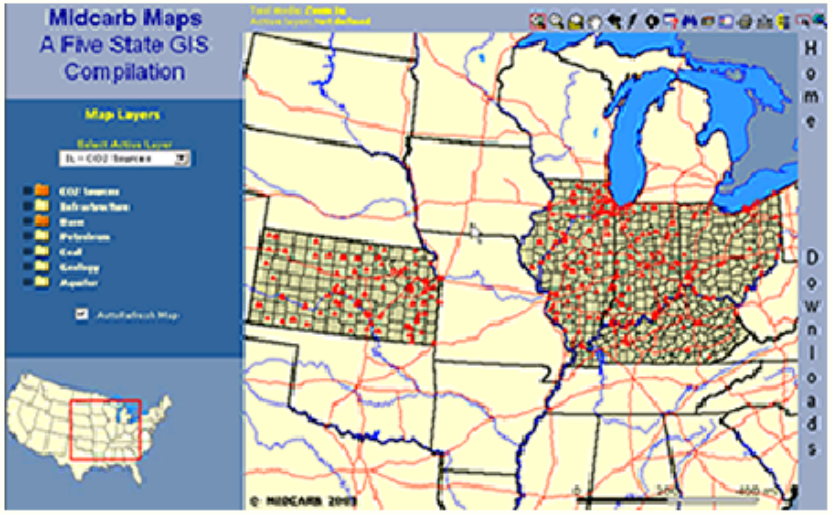

What is MIDCARB?

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Geologic Sequestration Reservoirs

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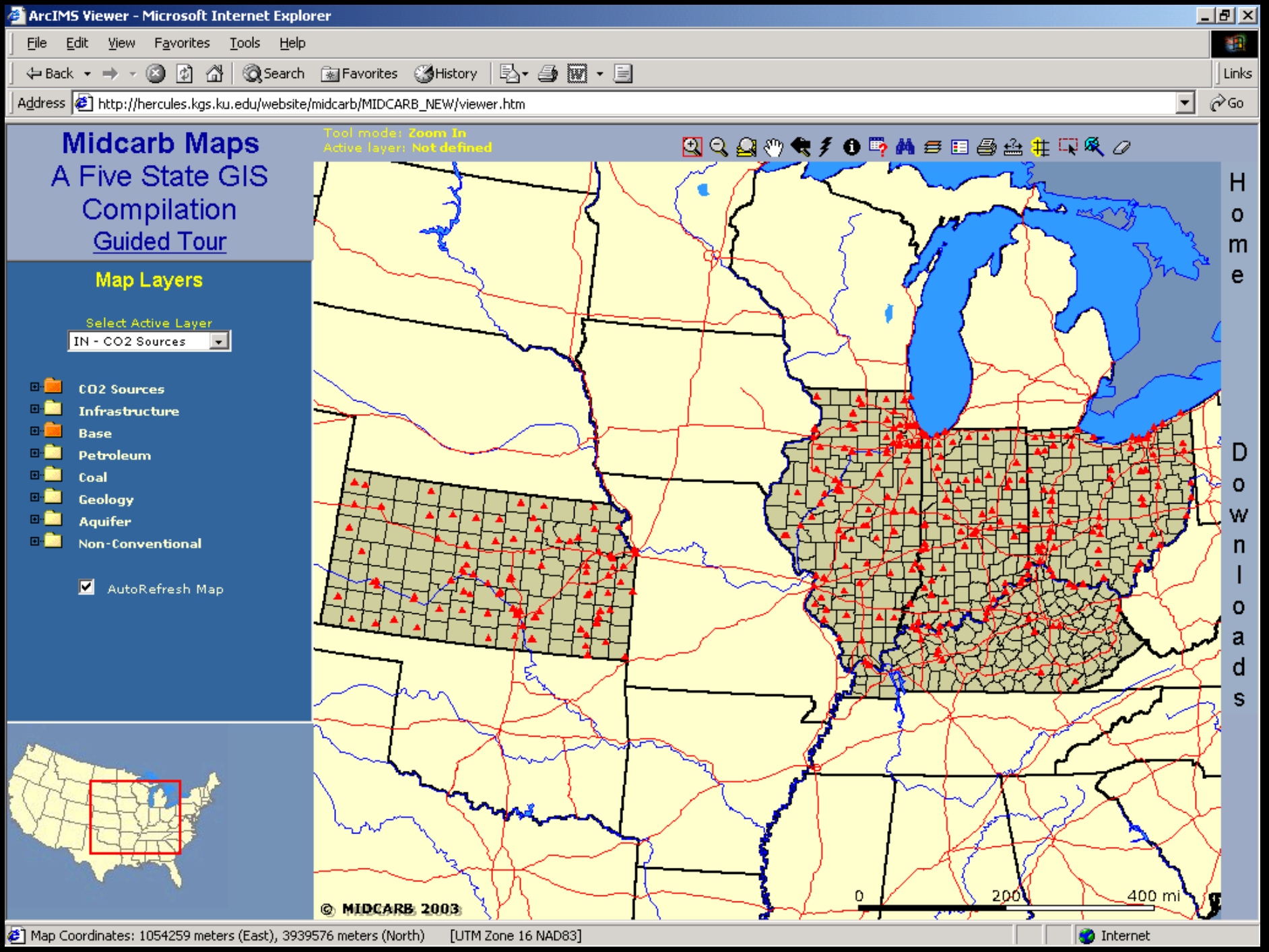
ArcIMS Viewer - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History Links
Address http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm
Go
Midcarb Maps
A Five State GIS Compilation
Guided Tour
Tool mode: Zoom In
Active layer: Not defined
Map Layers
Select Active Layer
IN - CO2 Sources
CO2 Sources
Infrastructure
Base
Petroleum
Coal
Geology
Aquifer
Non-Conventional
AutoRefresh Map
Home
Downloads
© MIDCARB 2003
0
200
400 mi
Map Coordinates: 1054259 meters (East), 3939576 meters (North) [UTM Zone 16 NAD83]
Internet

ArcIMS Viewer - Microsoft Internet Explorer

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Back Search Favorites History

Address http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

Midcarb Maps

Tool mode: Hyperlink
Active layer: IL - CO2 Sources

MIDCARB--Illinois--Facility Emissions - Microsoft Internet Explorer

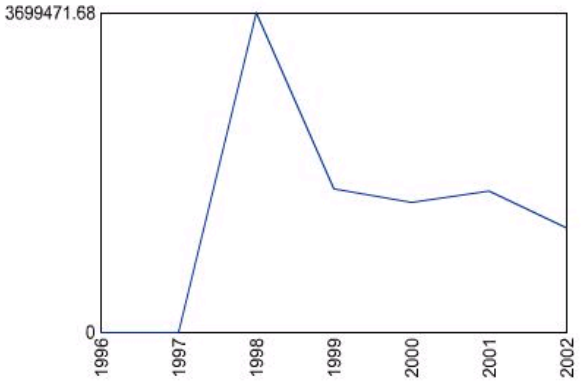
Illinois

MARION

Facility is a UTILITY owned by Southern Illinois Power Coop
Also available is a summary of total Illinois emissions

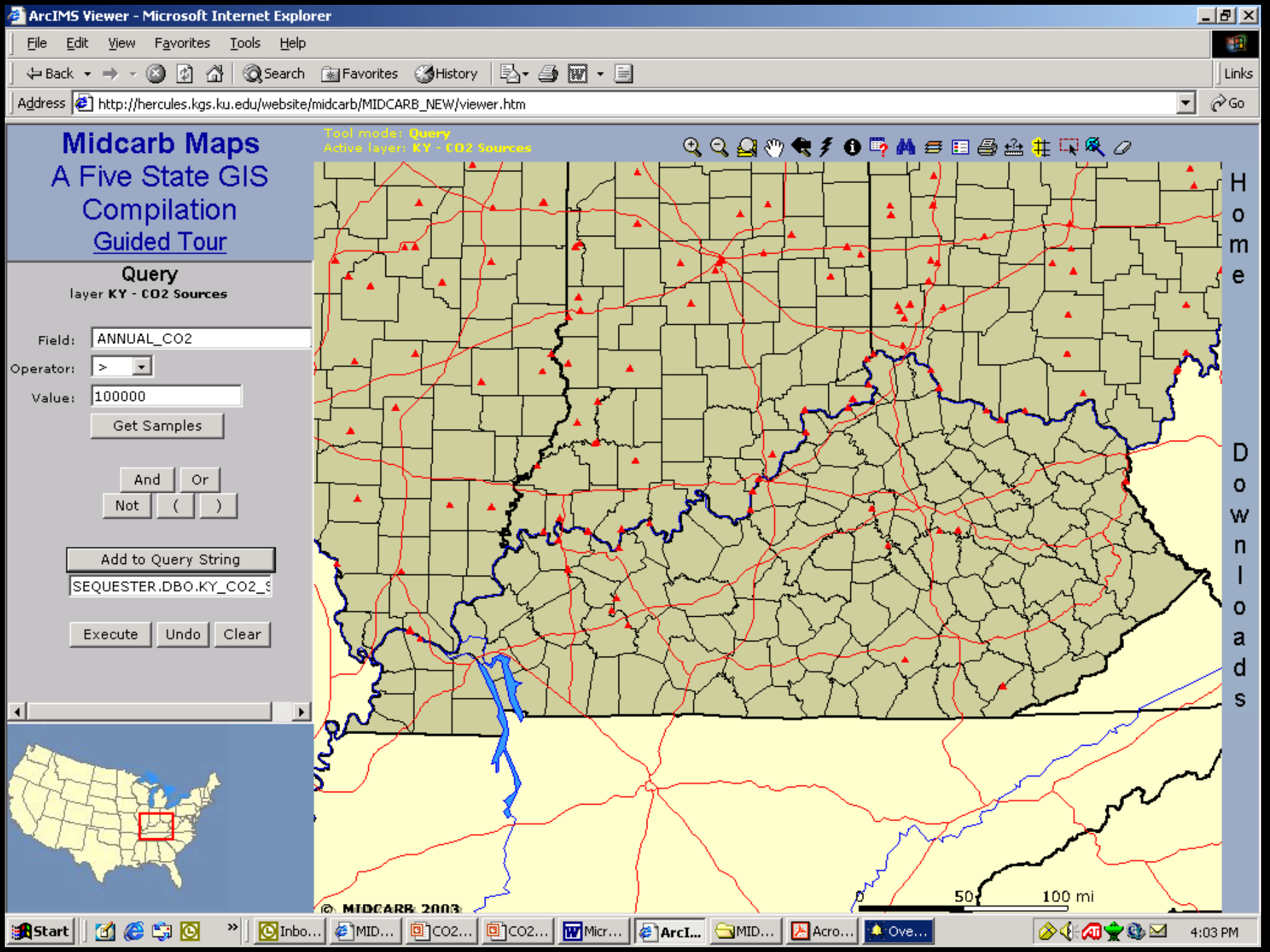
Select chart desired: CO2 || SO2 || NOX || Mercury

CO2 Tons



Data Type	Last year reported: 2002
CO2 (Tons)	1,207,463.20
SO2 (Tons)	4,172.90
NOX (Tons)	5.94
Mercury (lbs)	0.00

Start Inbo... MID... CO2... CO2... Micr... ArcI... MID... Acro... Ove... 4:00 PM


ArcIMS Viewer - Microsoft Internet Explorer
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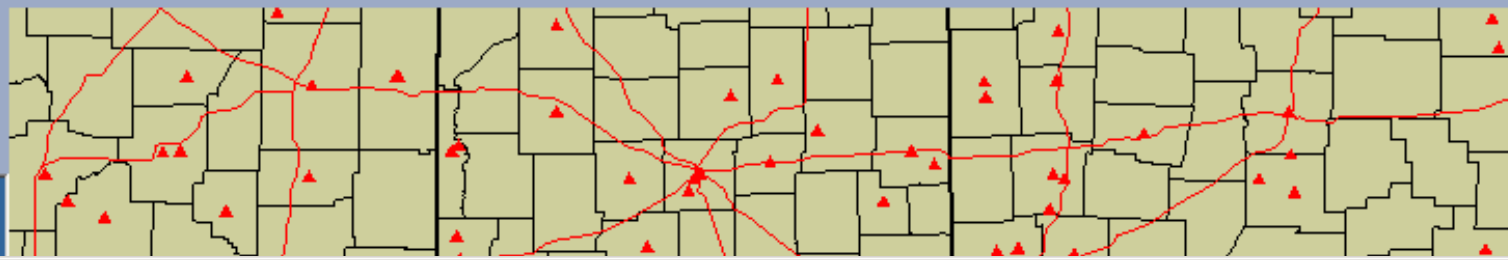
Address http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm
Go
Links
Midcarb Maps
A Five State GIS Compilation
Guided Tour
Query
layer KY - CO2 Sources
Field: ANNUAL_CO2
Operator: >
Value: 100000
Get Samples
And Or
Not ( )
Add to Query String
SEQUESTER.DBO.KY_CO2_S
Execute Undo Clear
Tool mode: Query
Active layer: KY - CO2 Sources
Home
Downloads
© MIDCARB 2003
0 50 100 mi
Start
4:03 PM

Midcarb Maps
A Five State GIS Compilation

Guided Tour

Map Layers

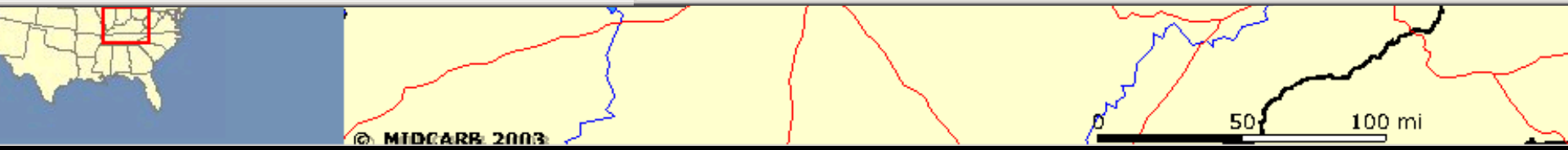
Tool mode: **Query**
Active layer: **KY - CO2 Sources**



Query/Selection Results - Microsoft Internet Explorer

20 feature(s) have been identified in layer **KY - CO2 Sources**

Rec	ID	PLANT	COMPANY_NAME	EPA_EDR	MIDCARB_ID	ANNUAL_CO2	ANNUAL_CO	ANNUAL_NOX	ANNUAL_SO2	PERCENT_COAL	PERCENT_OIL	PERCENT_GAS	TYPE
1	2	Big Sandy	Kentucky Power Co	1353	KY1353	7570210	0	0	0	99.7524	0.2476	0	Electric Powe
2	3	Cane Run	Louisville Gas & Electric Co	1363	KY1363	3594857.407	0	0	0	98.4184	0.0032	1.5784	Electric Powe
3	4	Cooper	East Kentucky Power Coop Inc	1384	KY1384	1825466	0	0	0	99.8743	0.1257	0	Electric Powe
4	5	D B Wilson	Big Rivers Electric Corp	6823	KY6823	3084165	0	0	0	99.9972	0.0028	0	Electric Powe
5	6	Dale	East Kentucky Power Coop Inc	1385	KY1385	1240120.041	0	0	0	99.7429	0.2571	0	Electric Powe
6	8	E W Brown	Kentucky Utilities Co	1355	KY1355	3784251.377	0	0	0	98.8113	0.2317	0.957	Electric Powe
7	9	East Bend	Cincinnati Gas & Electric Co	6018	KY6018	5196246	0	0	0	99.7878	0.2122	0	Electric Powe
8	10	Elmer Smith	Owensboro City of	1374	KY1374	3398229	0	0	0	99.8949	0.1051	0	Electric Powe
9	11	Ghent	Kentucky Utilities Co	1356	KY1356	13309771	0	0	0	99.9379	0.0621	0	Electric Powe
10	12	Green River	Kentucky Utilities Co	1357	KY1357	863625	0	0	0	99.8026	0.1974	0	Electric Powe
11	13	H L Spurlock	East Kentucky Power Coop Inc	6041	KY6041	6853526	0	0	0	99.9443	0.0557	0	Electric Powe
12	16	HMP&L Station 2	Big Rivers Electric Corp	1382	KY1382	2490685	0	0	0	99.8118	0.1882	0	Electric Powe
13	18	K C Coleman	Big Rivers Electric Corp	1381	KY1381	3511592	0	0	0	99.8476	0	0.1524	Electric Powe
14	22	Mill Creek	Louisville Gas & Electric Co	1364	KY1364	9078842	0	0	0	99.4622	0.3949	0.1429	Electric Powe
15	25	Paradise	Tennessee Valley Authority	1378	KY1378	17134052	0	0	0	99.9847	0.0153	0	Electric Powe
16	28	R A Reid	Big Rivers Electric Corp	1383	KY1383	291683.463	0	0	0	98.8172	1.1828	0	Electric Powe
17	29	R D Green	Big Rivers Electric Corp	6639	KY6639	3447715	0	0	0	99.8855	0.1145	0	Electric Powe
18	30	Shawnee	Tennessee Valley Authority	1379	KY1379	10435320	0	0	0	99.8476	0.1524	0	Electric Powe
19	31	Trimble County	Louisville Gas & Electric Co	6071	KY6071	3920505	0	0	0	99.901	0.099	0	Electric Powe
20	32	Tyrone	Kentucky Utilities Co	1361	KY1361	174074	0	0	0	100	0	0	Electric Powe



http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

Midcarb Maps

A Five State GIS Compilation

Guided Tour

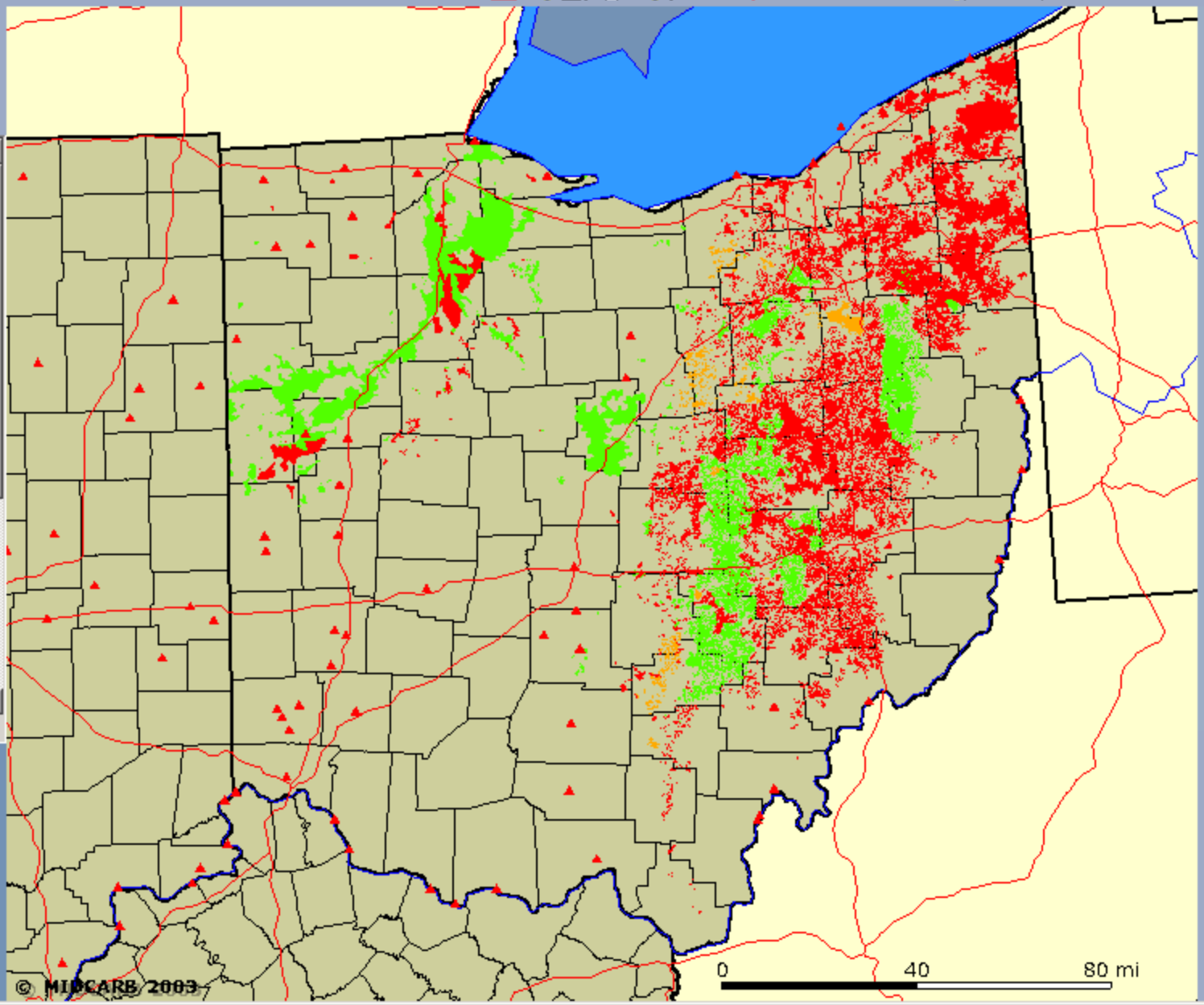
Tool mode: **Zoom In**
Active layer: **OH - Oil and Gas Fields**

Map Layers

Select Active Layer

OH - Oil and Gas Fie...

- CO2 Sources
- Infrastructure
- Base
- Petroleum
  - IN - Petroleum Wells
  - IN - Oil and Gas Fields
  - KY - Petroleum Wells
  - KY - Petroleum Fields
  - IL - Oil and Gas Fields
  - OH - Oil and Gas Fields
    - Gas
    - Gas Storage
    - Oil
  - KS - Oil and Gas Wells



p Coordinates: 591325 meters (East), 4268872 meters (North) [UTM Zone 16 NAD83]

Internet

CALCULATION FOR CO_2 SEQUESTRATION VOLUMES IN OHIO OIL AND GAS FIELDS

$$Q = \rho co_2 \times h \times a \times \phi \times (1 - Sw)/2200$$

Q = Sequestration volume (metric tonnes)

ρco_2 = CO_2 density (lbs/acre-ft)

h = Net thickness (feet)

a = Area (acres)

ϕ = Porosity (percent)

Sw = Water saturation (percent)

2200 (lbs) = 1 metric tonne

A	B	C	D	E	F	G	H	I	J	K	L	M
ATITUDE	LONGITUDE	FACILITY_ID	FACILITY_ID_EGRID	FACILITY_ID_EPA	FACILITY_NAME	FACILITY_TYPE	FACILITY_OWNER_NAME	LAT_LONG_SOURCE	POWER_CAPACITY_MW	FUEL_TYPE_COMBUSTED	LATEST_YEAR	CO2_
38.69028	-83.48028	6031	0	OHD000724310	KILLEN STATION	UT	DAYTON POWER & LIGHT COMPANY	EPA	666.45	Coal	2002	37
40.25222	-80.64861	2828	0	9021264	CARDINAL	UT	BUCKEYE POWER, INC	EPA	1880.46	Coal	2002	82
40.53083	-80.63111	2866	0	OHD041076266	W. H. SAMMIS	UT	OHIO EDISON COMPANY	EPA	2468.15	Coal	2002	1
39.59083	-81.67973	2872	0	9020970	MUSKINGUM RIVER	UT	OHIO POWER COMPANY	EPA	1529.61	Coal	2002	29
41.6925	-83.4375	2878	0	OHD000821389	BAY SHORE	UT	TOLEDO EDISON COMPANY	EPA	2760	Coal	2002	10
38.86889	-84.22861	6019	0	OHD000816595	WH ZIMMER	UT	CINCINNATI GAS & ELECTRIC CO	EPA	1425.62	Diesel Oil	2002	
38.93472	-82.11584	8102	0	OHD000676775	GAVIN	UT	OHIO POWER COMPANY	EPA	2600	Coal	2002	1
38.99166	-84.29806	2830	0	OHD000724237	WALTER C BECKJORD	UT	CINCINNATI GAS & ELECTRIC CO	EPA	1432.9	Diesel Oil	2002	66
39.11306	-84.80305	2832	0	OHD000724245	MIAMI FORT STATION	UT	CINCINNATI GAS & ELECTRIC CO	EPA	1557.25	Diesel Oil	2002	5
41.90833	-80.76667	2835	0	OHD000772764	ASHTABULA	UT	CLEVELAND ELECTRIC ILLUM CO	EPA	2580	Coal	2002	14
41.50417	-82.05	2836	0	2836	AVON LAKE	UT	CLEVELAND ELECTRIC ILLUM CO	EPA	884	Coal	2002	4
41.67083	-81.47916	2837	0	OHD094511607	EASTLAKE	UT	CLEVELAND ELECTRIC ILLUM CO	EPA	1289	Coal	2002	64
40.18417	-81.88111	2840	0	OHD000816686	CONESVILLE PLANT	UT	COLUMBUS SOUTHERN POWER CO	EPA	2174.9	Coal	2002	
38.63611	-83.69389	2850	0	OHD000721407	J.M. STUART	UT	CINCINNATI GAS & ELECTRIC CO	EPA	2440.8	Coal	2002	150
												96,23

http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

Midcarb Maps

A Five State GIS Compilation

Guided Tour

Buffer

Highlight features from

H - Oil and Gas Fields

within a distance of

15 MILES

around the selected features of

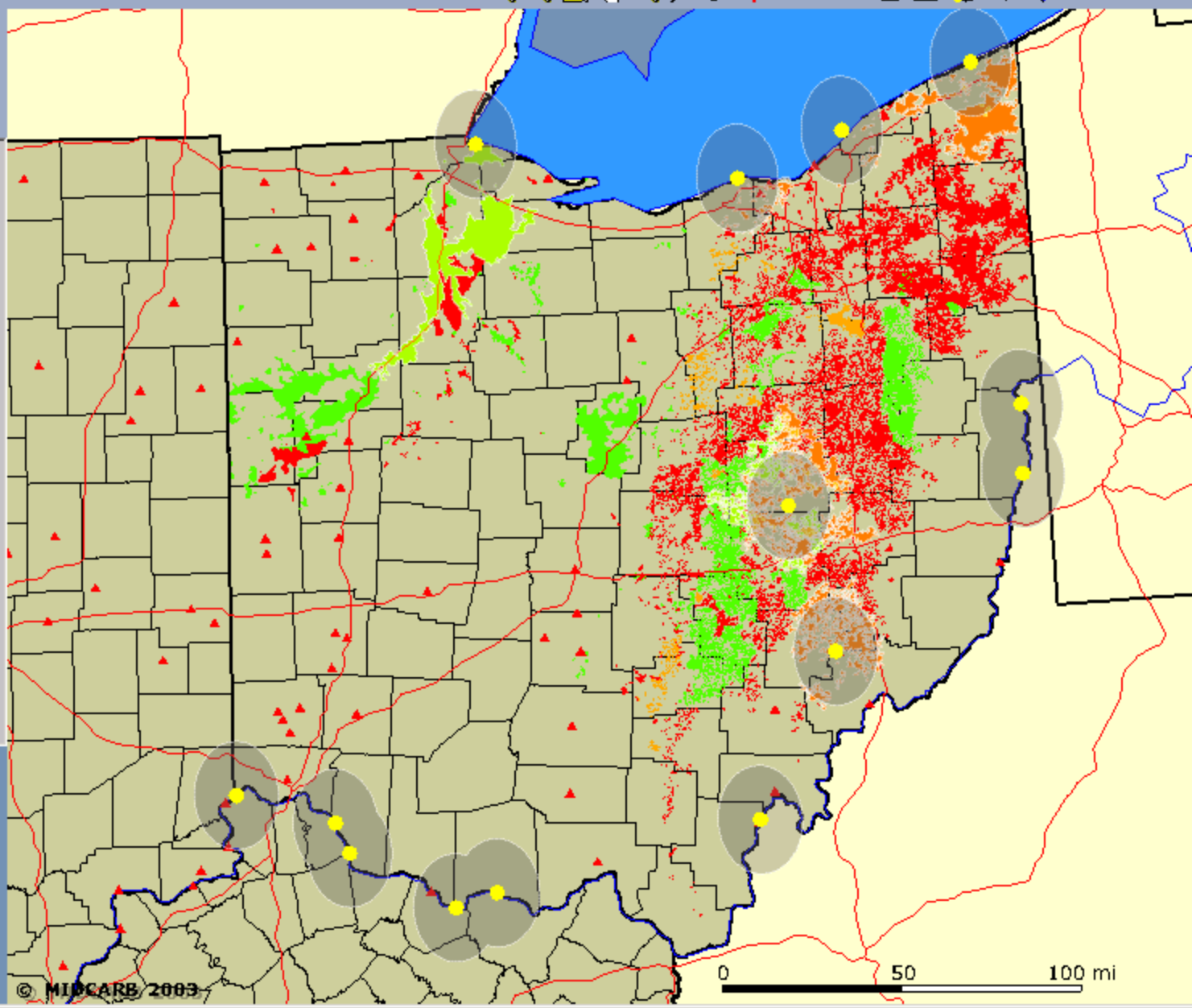
OH - CO2 Sources

Create Buffer

Display Attributes

Tool mode: **Buffer**

Active layer: **OH - CO2 Sources**



Map Coordinates: 595629 meters (East), 4443196 meters (North) [UTM Zone 16 NAD83]

Internet

File Edit View Insert Format Tools Data Window Help

P33 =

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
FIELDID	FMTN	FIELD_NAME	DEPTH	NETTHICK	TEMP	PRESSURE	POROSITY	YEAR	SW	No. Wells	ACRES	No. Pools	CO2_DENSITY	CO2_SEQ_VOLUME
160	CLNN	LAFAYETTE, WEST	3304	18	90	1300	0.08	0	50	73	8335	3	1931886	5,643,186
161	CLNN	MORGAN RUN	4017	25	100	1200	0.08	1972	27	53	3720	8	1003720.8	2,432,725
348	RSRN	BALTIC	6390	40	130	2500	0.098	1965	20	549	100505	12	1938855.6	277,770,747
967	BKMN	BAKERSVILLE	7050	10	130	2200	0.15	1980	20	103	19977	3	1805997.6	19,679,135

214,932,078 **OIL ONLY**

Metric Tonnes

onesville 2002 CO2 output= 5019733

43 YEARS of Sequestration potenti

In oil reservoirs alone

1004	CLNN	MONROE-COSHOCTON CON	3338	12	100	1600	0.055	1917	40	3444	117511	33	1939231.2	41,013,643
1019	CLNN	GRATIOT-NEWCASTLE	3000	18	90	1000	0.1	1924	30	7043	177216	30	622036.8	63,134,518
1036	CLNN	PHILO CONSOLIDATED	4650	18	100	1400	0.065	1928	30	1863	164960	47	1763308.8	108,284,986
														1,042,929,135

Midcarb Maps

A Five State GIS Compilation

Guided Tour

Tool mode: **Query**
Active layer: **OH - Oil and Gas Fields**

Query

layer **OH - Oil and Gas Fields**

Field: SEQUESTRATION_VOLUME

rator: >=

alue: 100000

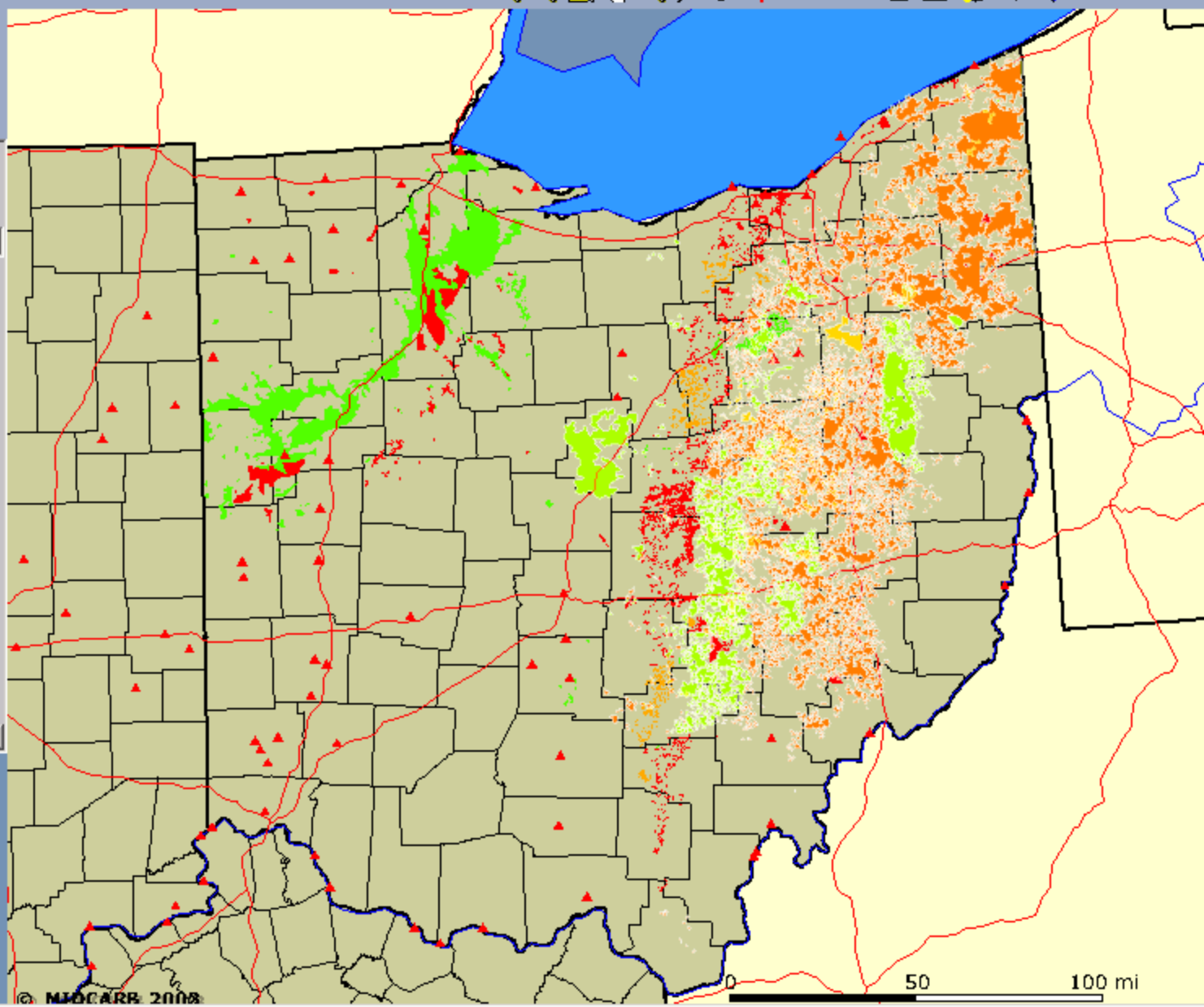
Get Samples

And | Or
Not | (|)

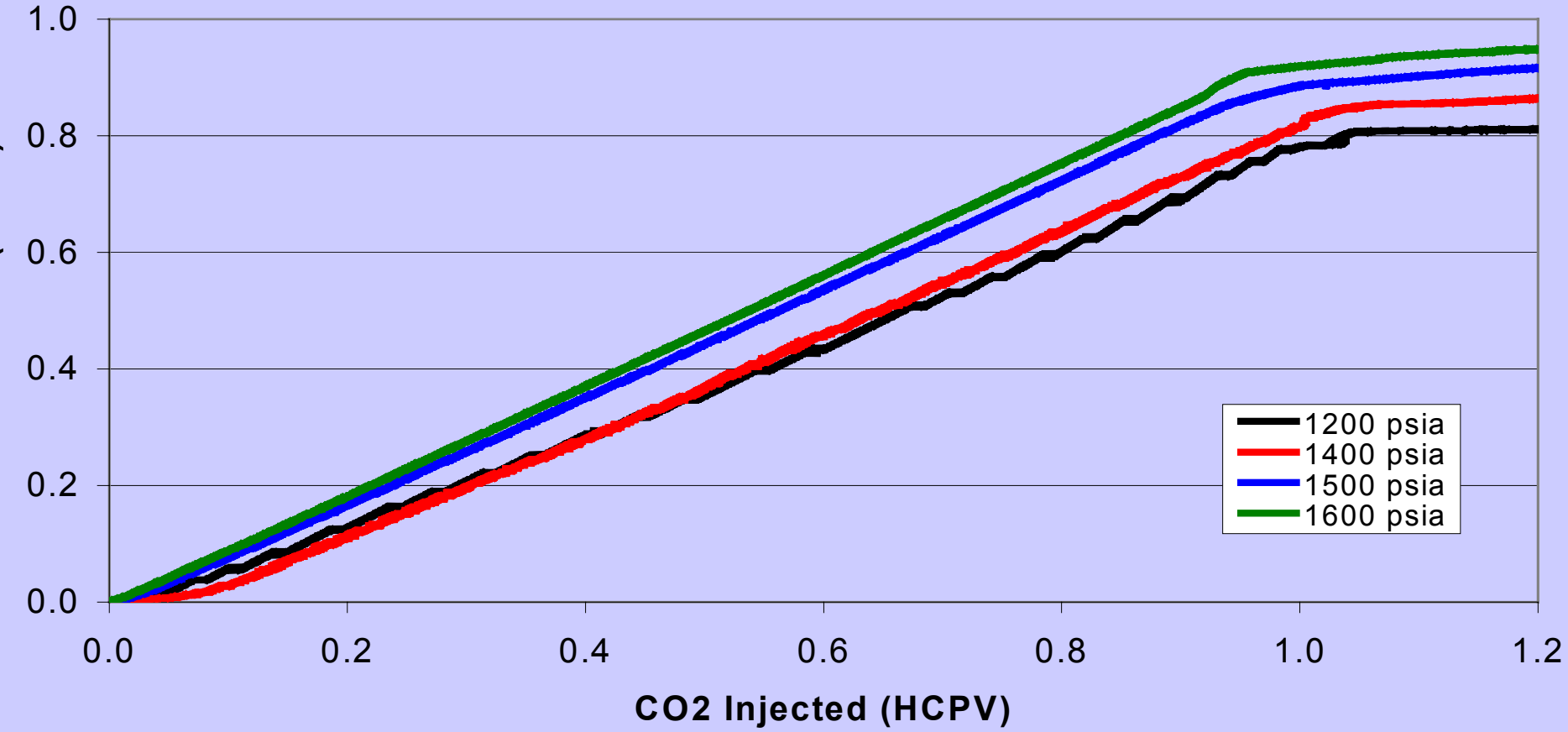
Add to Query String

)S.AVGPRODEPT >= 3000

Execute | Undo | Clear



OIL RECOVERY RESULTS IN SLIM-TUBE EXPERIMENT WITH $C0_2$ DISPLACING COPPER RIDGE SS OIL SAMPLE, APINO 3416925035, AT 107^0 F



MMP is about 1500 psia, based on the trend line and the definition of hing 90% recovery at 1.2 HCPV of CO_2 injection.

http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

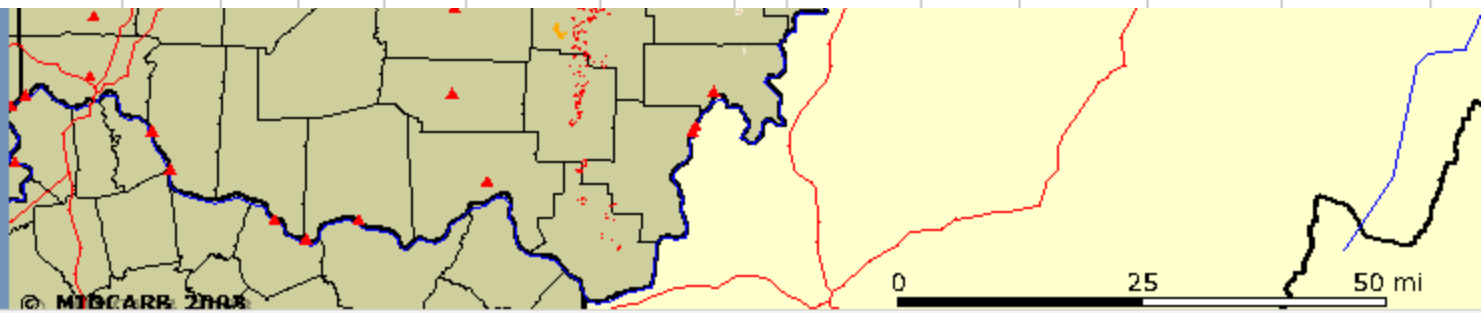
Midcarb Maps

Tool mode: Query
Active layer: OH - Oil and Gas Fields

osoft Excel - Book1

Edit View Insert Format Tools Data Window Help

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
IELDID	PLAY	FMTN_CODE	FIELD_NAME	DEPTH	Thick	TEMP	PRES	POROSITY	DISCOVERY_YEAR	SW	NUMBER_OF_WELLS	ACRES	No. Pools	CO2_DENSITY	SEQUESTRATION_VOLUME
1369	KNOX	BKMN	BRANNONS FORK	7469	10	110	2600	0.15	1983	50	3	501	1	2172337.2	371025.3195
1392	KNOX	BKMN	PLEASANT GROVE	6040	10	100	2100	0.15	1994	50	6	967	1	2144458.8	706940.3385
1397	KNOX	RSRN	ROCKBRIDGE	4334	35	90	1500	0.08	1993	50	37	4747	6	2056467.6	6212214.716
1401	KNOX	RSRN	COLFAX	4219	35	90	1500	0.08	1995	50	15	1615	1	2056467.6	2113487.838
1359	KNOX	RSRN	LAKE OTTO	4962.5	35	100	1700	0.08	1997	50	18	2890	3	1995048	3669074.64
1393	KNOX	RSRN	RUSH CREEK	5327	35	100	1800	0.08	1988	50	115	13307	12	2040786	17281561.37
1390	KNOX	RSRN	FRAZEYBURG	5825	30	100	2000	0.08	1989	30	133	16901	6	2113966.8	27283316.75
1378	KNOX	RSRN	DORSET	6011	35	100	2100	0.08	1990	50	10	1687	2	2144458.8	2302173.997
1374	KNOX	RSRN	GRIGGS CORNERS	5808	35	100	2000	0.08	1995	50	3	403	1	2113966.8	542136.3948
1377	KNOX	RSRN	MUNSON HILL	5494	35	100	1900	0.08	1999	50	12	1613	1	2079554.4	2134568.066
											TOTAL POOLS		34		62,616,499
															CO2 SEQ Pote



Start | Inbox - ... | Microso... | Overdu... | Kansas ... | ArcIMS... | pages - ... | Overdu... | Query/... | 10:24

Midcarb Maps

A Five State GIS Compilation

Guided Tour

Tool mode: Zoom In
Active layer: KS - CO2 Sources

OH - Oil and Gas Fields
KS - Oil and Gas Wells
KS OIL-GAS FIELD BOUNDA

KS OIL-GAS FIELD BOUNDARIES

- 0OIL & 1GAS
- 0OIL & 2GAS
- 0OIL & 3GAS
- 1OIL & 0GAS
- 1OIL & 1GAS
- 1OIL & 2GAS
- 1OIL & 3GAS
- 2OIL & 0GAS
- 2OIL & 1GAS
- 2OIL & 2GAS
- 2OIL & 3GAS
- 2OIL & 4GAS

KS Cumulative Oil Product
KS Cumulative Gas Produc

0 50 100 mi

Map Coordinates: -120404 meters (East), 4028519 meters (North) [UTM Zone 16 NAD83]

Internet

http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

Midcarb Maps

A Five State GIS Compilation

Guided Tour

KS - Oil and Gas We

GAS

OIL

KS OIL-GAS FIELD BOUNDA

KS OIL-GAS FIELD BOUNDARIES

0OIL & 1GAS
0OIL & 2GAS
0OIL & 3GAS
1OIL & 0GAS
1OIL & 1GAS
1OIL & 2GAS
1OIL & 3GAS
2OIL & 0GAS
2OIL & 1GAS
2OIL & 2GAS
2OIL & 3GAS
2OIL & 4GAS

Tool n
Active

KGS--Oil and Gas Wells--Specific Well--15-145-00788 - Microsoft Internet Explorer

KGS

Oil and Gas Well Database

Oil & Gas

Specific Well--15-145-00788

All Well Data

API: 15-145-00788 **Operator:** SUNRAY OIL CO INC **Field:** Larned **Lease:** HANSHEW **Well** 1	**Location:** T21S R16W, Sec. 34, C SW NW NW 4290 North, 4950 West, from SE corner **Longitude:** -99.07576 **Latitude:** 38.1862 **County:** Pawnee	**Spud Date:** 21-APR-1953 **Completion Date:** **Plugging Date:** **Status:** OIL	**Total Depth:** 3852 **Elevation:** 1996 KB **Formation:**

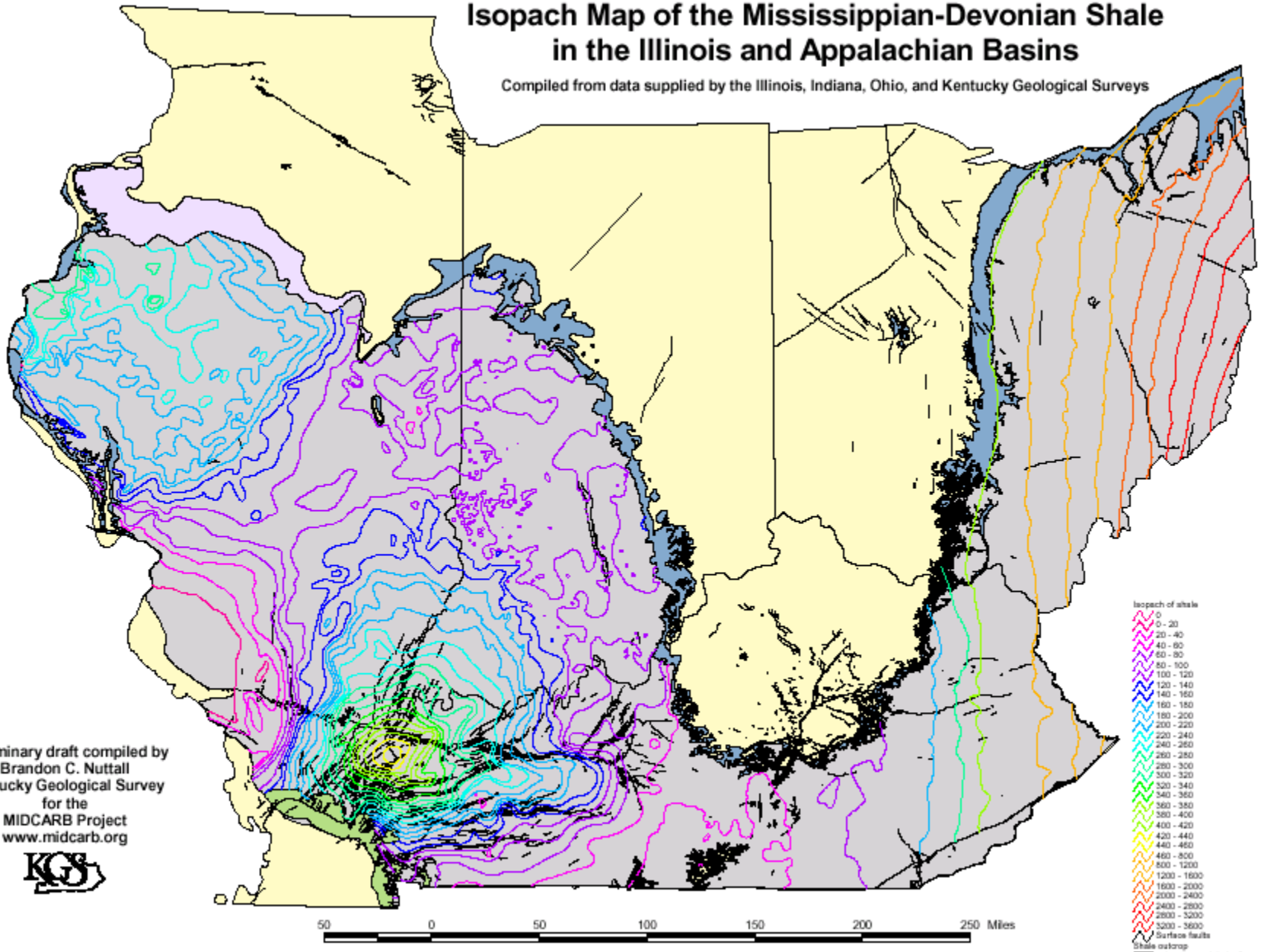
Tops Data

Form.	Top	Base	Source	Updated
HEEBNER SHALE	3389			15-APR-1999
TORONTO LIMESTONE	3410			15-APR-1999
LANSING GROUP	3500			15-APR-1999
KANSAS CITY GROUP	3734			15-APR-1999
SIMPSON GROUP	3811			15-APR-1999
ARBUCKLE	3842			15-APR-1999

Kansas Geological Survey, Oil and Gas Well Database
Comments to webadmin@kgs.ku.edu
URL=http://www.kgs.ku.edu/Magellan/Qualified/index.html
Well Display Programs Updated June 10, 2002. Data added continuously.

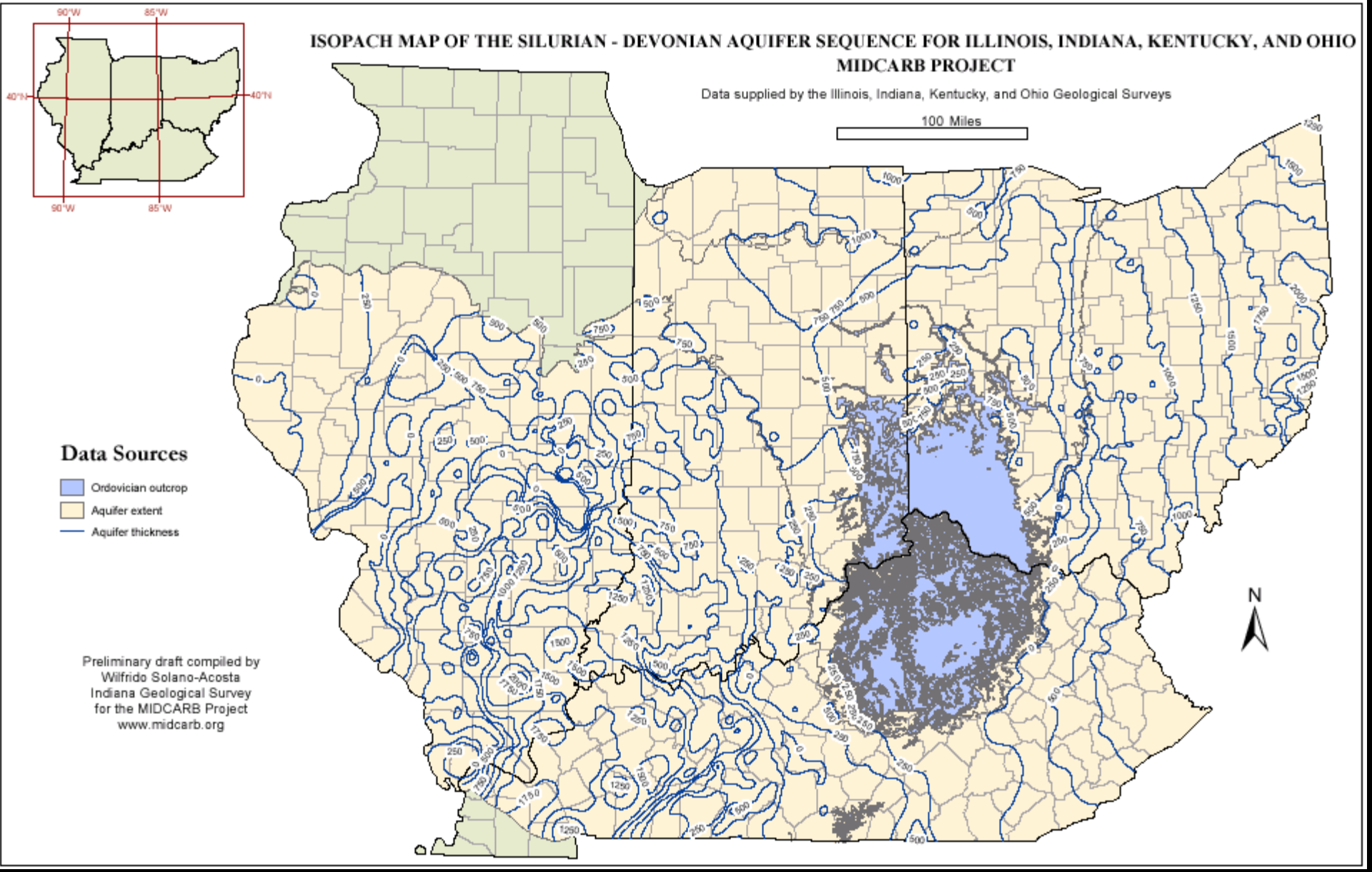
Isopach Map of the Mississippian-Devonian Shale in the Illinois and Appalachian Basins

Compiled from data supplied by the Illinois, Indiana, Ohio, and Kentucky Geological Surveys

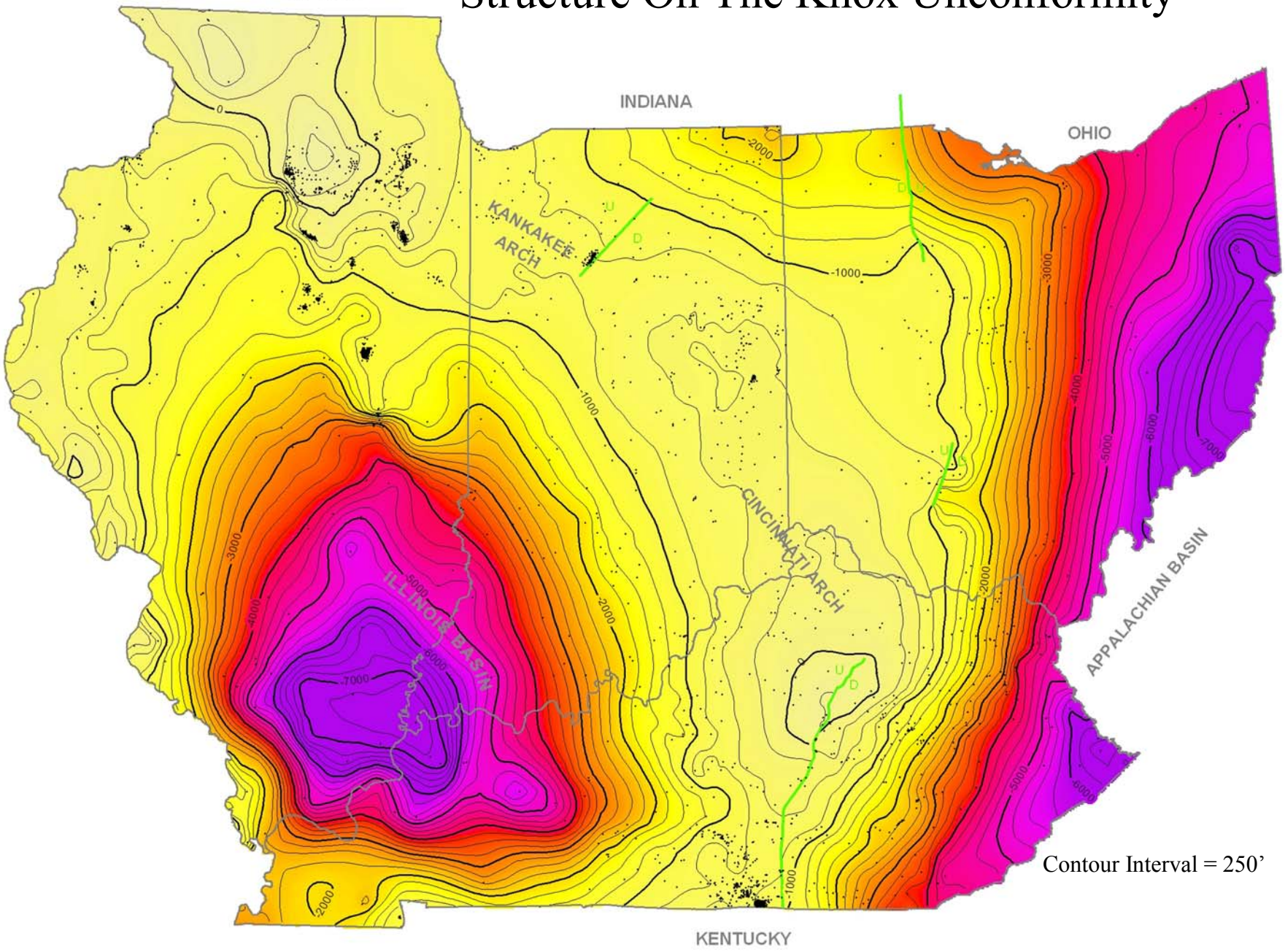


Preliminary draft compiled by
Brandon C. Nuttall
Kentucky Geological Survey
for the
MIDCARB Project
www.midcarb.org

The Midcontinent Interactive Digital Carbon Atlas and Relational Database (MIDCARB) Project is funded by the DOE National Energy Technology Laboratory under cooperative agreement number DE-FC26-00NT40936


90°W
85°W
40°N
ISOPACH MAP OF THE SILURIAN - DEVONIAN AQUIFER SEQUENCE FOR ILLINOIS, INDIANA, KENTUCKY, AND OHIO
MIDCARB PROJECT
Data supplied by the Illinois, Indiana, Kentucky, and Ohio Geological Surveys
100 Miles
Data Sources
Ordovician outcrop
Aquifer extent
Aquifer thickness
Preliminary draft compiled by
Wilfrido Solano-Acosta
Indiana Geological Survey
for the MIDCARB Project
www.midcarb.org
N

Structure On The Knox Unconformity



Contour Interval = 250’

http://hercules.kgs.ku.edu/website/midcarb/MIDCARB_NEW/viewer.htm

Midcarb Maps

A Five State GIS Compilation

Guided Tour

Query

ver **Hunton Aquifer Top Contour**

Field: VALUE

erator: <=

Value: -3000

Get Samples

And Or

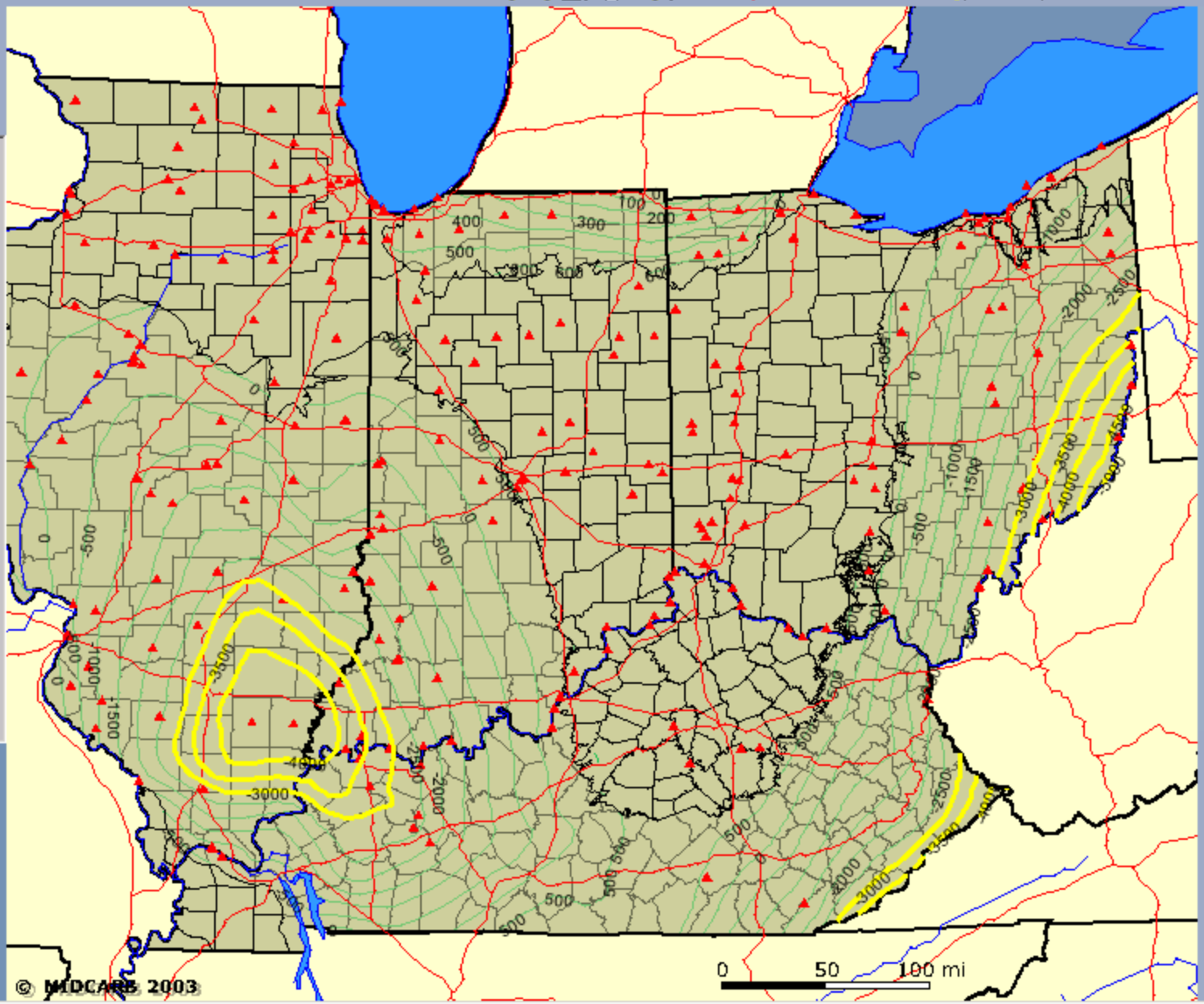
Not ( )

Add to Query String

MIDCARB_GIS.MIDCARB_D

Execute Undo Clear

Tool mode: **Query**
Active layer: **Hunton Aquifer Top Contour**



p Coordinates: 249620 meters (East), 4015206 meters (North) [UTM Zone 16 NAD83]

Internet

Future of MIDCARB

- Improve Data and Coverages; Temp, salinity, MMIP, etc.
- Improved Distributed Management Tools
  - Multiple Servers (Hand-Off to Local Server)
- Modify the current MIDCARB Internet Map Server to support additional states.
- Educate decision makers and public on how to use the site.
  - Feasibility studies
  - Site planning
  - Regional assessments

Future of MIDCARB?