Midwestern Regional Carbon Sequestration Partnership (MRCSP) Phase III (Development Phase)

Ordovician-Cambrian Units: Hierarchical Evaluation of Geologic Carbon Storage Resource Estimates

Prepared by:

Battelle
505 King Avenue
Columbus, Ohio 43201

Principal Investigator: Dr. Neeraj Gupta

Authors: Cristian R. Medina, John A. Rupp, and Kevin M. Ellett

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Program Manager: Andrea McNemar

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Principal Investigator: Neeraj Gupta (614-424-3820/ gupta@battelle.org)

Report Authors and Principal Technical Contributors – Cristian R. Medina, John A. Rupp, and Kevin M. Ellett (Indiana Geological and Water Survey)

ABSTRACT

The Indiana Geological and Water Survey (IGWS) led subtask 1.1 to assess the regional distribution and estimate the storage capacity of Ordovician-Cambrian stratigraphic units located within the partnership region. A comprehensive data set of wireline logs and petrophysical information was used to generate these interpretations. These data include core analysis for porosity and permeability, mercury injection capillary pressure (MICP), and existing well data including location and stratigraphic information.

This report includes storage resource estimates (SREs) for three potential storage reservoirs (limestone and dolostone from the Upper Ordovician Trenton Limestone/Black River Group and equivalent units, the Middle Ordovician St. Peter Sandstone, and primary target reservoir rocks of the Lower Ordovician and Upper Cambrian Knox Supergroup and equivalent units) calculated using six methodologies: (1) a fixed value of porosity of 10 percent in all units evaluated; (2) a unique average porosity (per well) from wireline-derived porosity (neutron, sonic, and/or density porosity for each unit); (3) porosity values from core analysis; (4) a depth-dependent porosity model (Knox Supergroup only); (5) porosity based on a model based on petrophysical facies; and (6) SREs using National Energy Technology Laboratory's CO2 Storage prospeCtive Resource Estimation Excel aNalysis (CO2-SCREEN beta V2). All methods used the same values for thickness for each unit. However, the areal extent of each assessment was limited by the data available for each method. Estimated volumes were calculated in 1-by-1 kilometer grid cells and summarized as county and total stratigraphic unit volumes.

The resultant SREs mass are displayed using boxplots, which allow for comparing data statistics (mean values and variability) between methods. Differences observed in SRE results from the six methods are mainly attributable to differences in the data and conceptual models used to interpret or estimate porosity in each method. Based on this systematic variability between methods, it is inferred that methods 1, 4, and 6 are best used for regional-scale reconnaissance estimates of storage capacity while methods 2, 3, and 5 are more appropriate for local scales where more data is required. All estimates are data-density dependent and different methods require different amounts of data for reasonable assessments. ArcMap 10.5.1 software was used to portray SREs to help visualize spatial variance of estimates for each methodology, and more importantly, to highlight those areas having the greatest total storage potential estimates.

Section 1. Introduction 1-1
Section 2. MICHIGAN BASIN, CINCINNATI ARCH, AND APPALACHIAN BASIN 2-1
2.1 CO_2 Point-Sources 2-3
2.2 Geology and Stratigraphy 2-3
2.3 Regional Geologic Structure and Stratigraphy 2-6
Section 3. Regional Characterization of Ordovician-Cambrian Systems 3-1
3.1 Purpose 3-1
3.2 Project Team 3-1
3.3 Overview of Major Tasks 3-1
3.3.1 Assessment of Storage for Ordovician-Cambrian Units 3-1
3.3.2 Ordovician-Cambrian Units Assessed 3-2
3.4 Methods of Investigation 3-2
3.4.1 Data Compilation Efforts 3-3
3.4.2 Digital Mapping 3-3
3.4.3 Storage Capacity Estimates for Saline Aquifers 3-3
3.4.4 Methodologies Explained 3-3
Section 4. Results and Discussion 4-1
4.1 Summary of Findings 4-5
4.1.1 Prospective Reservoirs 4-5
4.1.2 Storage Capacity Estimates 4-5
4.1.3 Challenges and Future Work 4-5
4.1.4 Opportunities 4-6
4.2 Recommendations 4-7
Section 5. References Cited 5-1
APPENDIX A Stratigraphic Nomenclature and Presence of Units Across the States in the MRCSP Region A-1
APPENDIX B PETROPHYSICAL DATA B-1
APPENDIX C STRUCTURE AND ISOPACH MAPS C-1
APPENDIX D SREs CALCULATED USING METHOD 1. VALUES ARE TOTAL SREs PER COUNTY (OR THE PORTION OF THE COUNTY DISPLAYED IN MAPS), IN MILLION TONS. D-1
APPENDIX E FORMULAE FOR ESTIMATING POROSITY FROM WIRELINE LOGS E-1
APPENDIX F TABULAR DATA FOR ALL WELLS USED IN THIS STUDY, FOR ALL METHODS. ONLY VALUES WHEN EFFICIENCY FACTOR WAS NOT APPLIED (E=1) ARE DISPLAYED, AND FOR EFFICIENCY FACTORS OF 1, 4, AND 10%, THESE VALUES SHOULD BE MULTIPLIED BY 0.01, 0.04, AND 0.1, RESPECTIVELY. .F-1

List of Tables

Page

Table 3-1. Regional efficiency factors for saline aquifers published by U.S. DOE NETL (2010). 3-4
Table 3-2. Number of wells used in each method. A graphic representation of this is available in Figure 3-2...3-7
Table 3-3. Summary statistics of main petrophysical data from MICP for four petrofacies. 3-13
Table 3-4. Scenario-based conceptual model for method 5: Case 1 represents the case when all unit is composed of petrofacies 1; Case 2 represents the case when all unit is composed of petrofacies 4 (tight reservoir); and Case 3 represents the case when all four petrofacies are present in equal parts (25% each)..3-13
Table 3-5. SREs summary for methodologies in this study. 3-15
Table 4-1. Statistical summary of data presented in Figure 4-1 and Figure 4-2......................................4-2

Table A- 1. Ordovician System in the MRCSP Region[a].. A-1

Table B- 1. Petrophysical dataa by state. B-3
Table B- 2. Petrophysical dataa by state (continued). B-5
Table B- 3. Petrophysical dataa by state (continued). B-6
Table E- 1. Interval transit times for different matrices used in the sonic porosity formula (after Schlumberger, 1972.) E-1
Table E- 2. Matrix densities of common lithologies used in the density porosity formula (after Schlumberger, 1972). E-2
Table F- 1. SRE Values, Unit 2, for Method 1 (E=1 or 100% of reservoir considered). F-1
Table F- 2. SRE Values, Unit 3, for Method 1 (E=1)...F-12
Table F- 3. SRE Values, Unit 4, for Method 1 (E=1) (continued). F-19
Table F- 4. SRE Values, Unit 2, for Method 6...F-27
Table F- 5. SRE Values, Unit 3, for Method 6...F-35
Table F- 6. SRE Values, Unit 4, for Method 6...F-38
Table F- 7. Average and Sum of SREs for Three Units Assessed Using Method 1 (Source data provided in Tables F.1, F.2, and F.3)..F-49

List of Figures

Page

Figure 2-1. Map showing the Midwest Regional Carbon Sequestration Partnership (MRCSP) area. 2-1
Figure 2-2. Map of the study area indicating the main structures in the region: Michigan, Illinois, and Appalachian basins. Modified from Gupta and Bair (1997) and Medina and Rupp (2012)..2-2
Figure 2-3. Stratigraphic correlation chart for the main units under assessment in the MRCSP region. 2-3
Figure 2-4. Map of CO_2 point-source emissions (Source: U.S. DOE NETL, 2018). 2-4
Figure 3-1. ArcGIS (ArcMap 10.5.1) workflow applied in this study to generate isopach, structure and SREs maps (Appendices C and D). 3-5
Figure 3-2. Dot plot chart illustrating number of data points for each method and unit. In this study, each county under assessment is considered a data point. When more than one well is available with porosity at any given county, we calculated the averaged values of porosity at such county. Method 4 and 5 was only applied to unit 4 (Knox Supergroup and equivalents)...3-6
Figure 3-3. Scatter plot and regression as an example of porosity reduction with depth in samples from the Mount Simon Sandstone (Medina et al., 2011). 3-9

Figure 3-4. Map of samples used for MICP (modified from Medina et al., 2017). 3-11
Figure 3-5. Photographs and charts of representative samples of 4 petrofacies. Entry pressure is indicated in right side of capillary curve. A scanned photo of the thin section is included in right hand side, with arrows indicating some of the larger pores. (A) Petrofacies 1 (Low values of entry pressure, P_0); (B) Petrofacies 2 (Low to intermediate values of P_0); (C) Petrofacies 3 (intermediate to high values of P_0); and (D) Petrofacies 4 (high values of P_0). Each horizontal line in histograms represents 5% frequency of total mercury saturation. 3-12
Figure 3-6. Map of wells used in method 6. For a complete list of results, refer to Table F- 6 in APPENDIX F. Each well represents one data point (n=117 for unit 2; n=42 for unit 3, and n=148 for unit 4)..........3-16
Figure 4-1. "Box-and-whisker" chart (sorted by units), illustrating SREs for all six methods using E=1 (100%). Instead of showing the mean and the standard error, the box-and-whisker plot shows the minimum, first quartile, median, third quartile, and maximum of a set of data. Statisticians refer to this set of statistics as a five-number summary (data in Table 3-5 and Table 4-1). 4-3
Figure 4-2. "Box-and-whisker" chart (sorted by method), illustrating SREs for three units using E=1 (100%). Note that Methods 4 and 5 are not presented as they were only applied to unit 4 in this study (data in Table 3-5 and Table 4-1). 4-4
Figure 4-3. Schematic representation of the reduction of values (and variability) of SREs as a function of the conceptual model chosen for porosity. 4-6
Figure C- 1. Isopach map (thickness) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-1
Figure C- 2. Measured depth (in feet) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 t are shown in gray.......... C-2
Figure C- 3. Structure map (in feet above sea level) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-3
Figure C- 4. Isopach map (thickness) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.......... C-4
Figure C- 5. Measured depth (in feet) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.......... C-5
Figure C- 6. Structure map (in feet above sea level) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-6
Figure C- 7. Isopach map (thickness) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-7
Figure C- 8. Measured depth (in feet) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-8
Figure C- 9. Structure map (in feet above sea level) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-9
Figure C- 10. Isopach map (thickness) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.......... C-10
Figure C- 11. Measured depth (in feet) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.......... C-11
Figure C- 12. Structure map (in feet above sea level) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. C-12

Figure D- 1. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-1
Figure D- 2. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-2
Figure D- 3. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-3
Figure D- 4. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-4
Figure D- 5. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-5
Figure D- 6. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-6
Figure D- 7. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-7
Figure D- 8. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-8
Figure D- 9. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-9
Figure D- 10. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-10
Figure D- 11. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-11
Figure D- 12. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray. D-12

Section 1. Introduction

The Midwest Regional Carbon Sequestration Partnership (MRCSP) has incorporated the work of geological research teams (Geoteams) in its regional characterization and project planning and carbon dioxide (CO_2) injection implementation work since the partnership was established by the U.S. Department of Energy (DOE) in 2003. Over this 14-year period, the cohort of Geoteams grew from five to ten states and has contributed to the characterization of geological sequestration opportunities, refined reservoir and seal data, and supported injection efforts through both predictive and post-injection assessments.

The regional characterization work conducted by the Geoteams during the MRCSP Phase III project period (2010–2017) focused on the following tasks: (1) refinement of geologic seals/reservoir systems; (2) assessment of Atlantic Coastal Plain and offshore opportunities; (3) expanded assessments of oil and gas fields, particularly as they relate to enhanced recovery opportunities; (4) regional support for implementation of carbon capture utilization and storage (CCUS) in the partnership area; and (5) communication and data sharing. The findings of this work are summarized in the final report entitled “Final Report of Geologic Carbon Capture Utilization and Storage Opportunities” in the form of a state-by-state presentation of CCUS opportunities for the MRCSP region.

In addition to the capstone deliverables mentioned above, the Geoteams also prepared a series of topical reports to elaborate on geologic horizons and/or geographic areas of study completed during the Phase III project period. Specifically, these topical reports address: (1) the Atlantic Coastal Plain and adjacent offshore; (2) Ordovician-Cambrian reservoirs/seals in the region; (3) enhanced oil and gas recovery opportunities in the Appalachian Basin; and (4) enhanced oil recovery (EOR) in the Michigan Basin. The remainder of this particular topical report presents our findings relative to the Ordovician-Cambrian reservoirs and seals in the region.

This report concerns the Ordovician-Cambrian reservoirs and seals and presents both the methodology and results of storage resource estimates (SREs) for the region. This is followed by a discussion of the potential of the Maquoketa Group and equivalent units as a seal and on the dual character (seal/reservoir) of the Trenton Limestone, Knox Supergroup, and their equivalent units in the MRCSP region.

Section 2. MICHIGAN BASIN, CINCINNATI ARCH, AND APPALACHIAN BASIN

The study area of Task 1.1 lies within a portion of the Midwest United States in the states of Kentucky, Indiana, Michigan, and Ohio (Figure 2-1). The subsurface geology of this region can be described as a thick sequence of relatively undeformed Paleozoic rocks lying unconformably on top of an impermeable Precambrian basement. The greatest thickness of the stratigraphic package occurs at the centers of the cratonic sedimentary basins, including the Appalachian, Illinois, and Michigan Basins, which are separated by relatively shallow terrain, defined as arches (Figure 2-2).

For simplicity, we have subdivided the stratigraphic sequence into four major sub-units to use in assessing the potential for geologic carbon sequestration in the region (Figure 2-3).

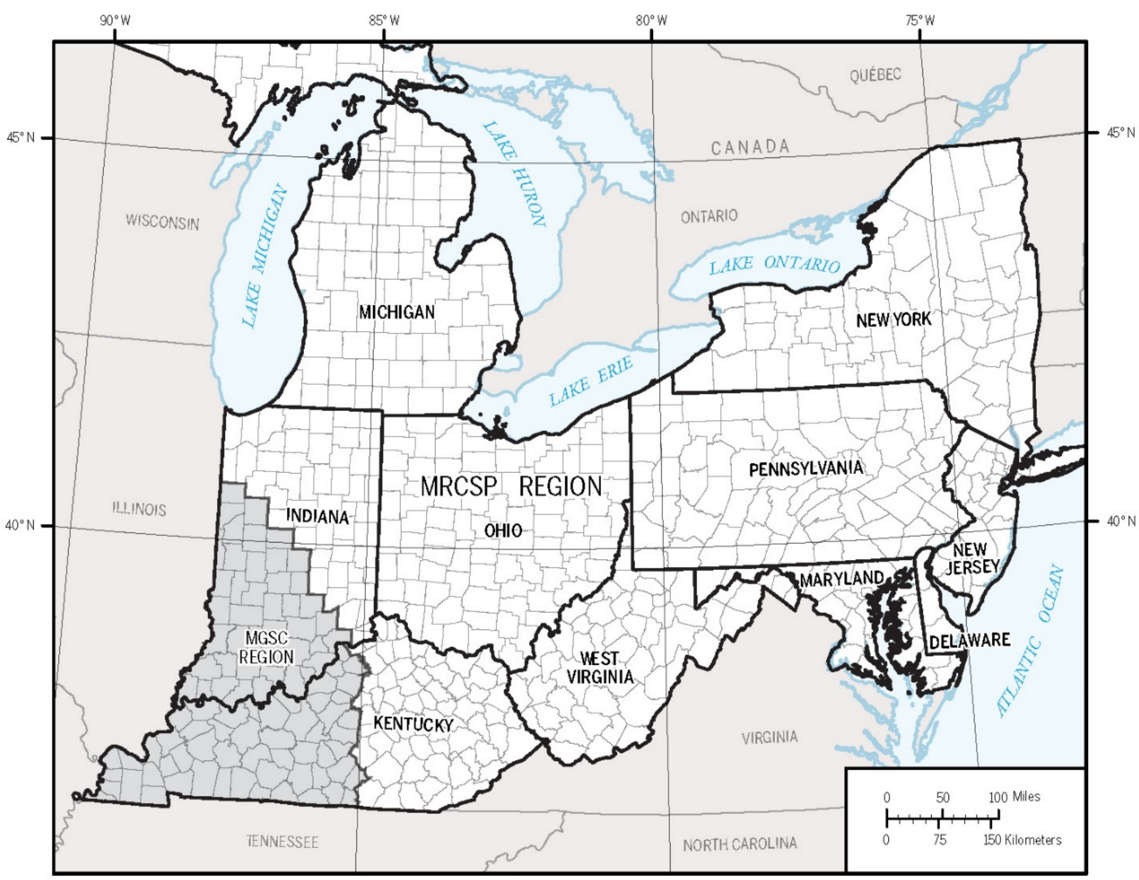

Figure 2-1. Map showing the Midwest Regional Carbon Sequestration Partnership (MRCSP) area.

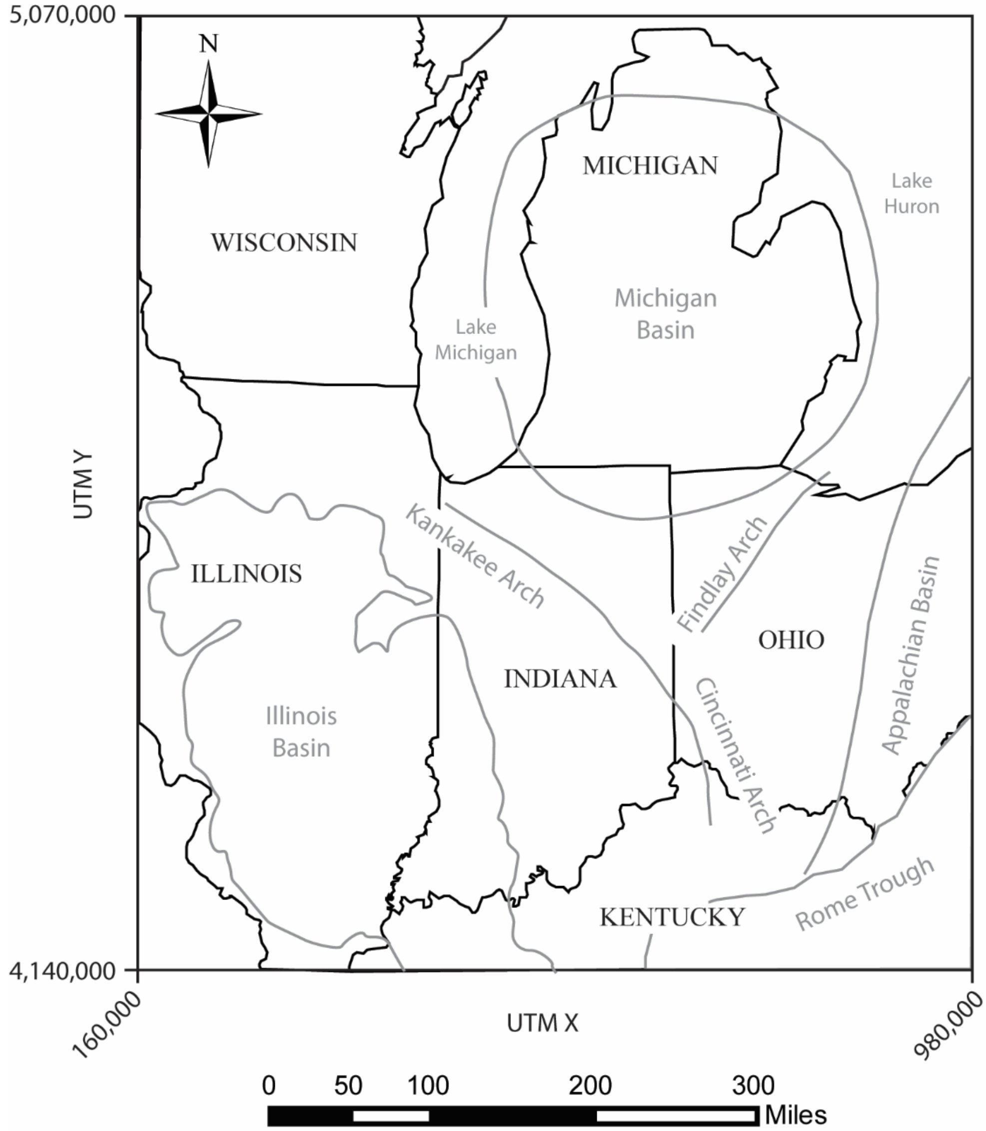

Figure 2-2. Map of the study area indicating the main structures in the region: Michigan, Illinois, and Appalachian basins. Modified from Gupta and Bair (1997) and Medina and Rupp (2012).

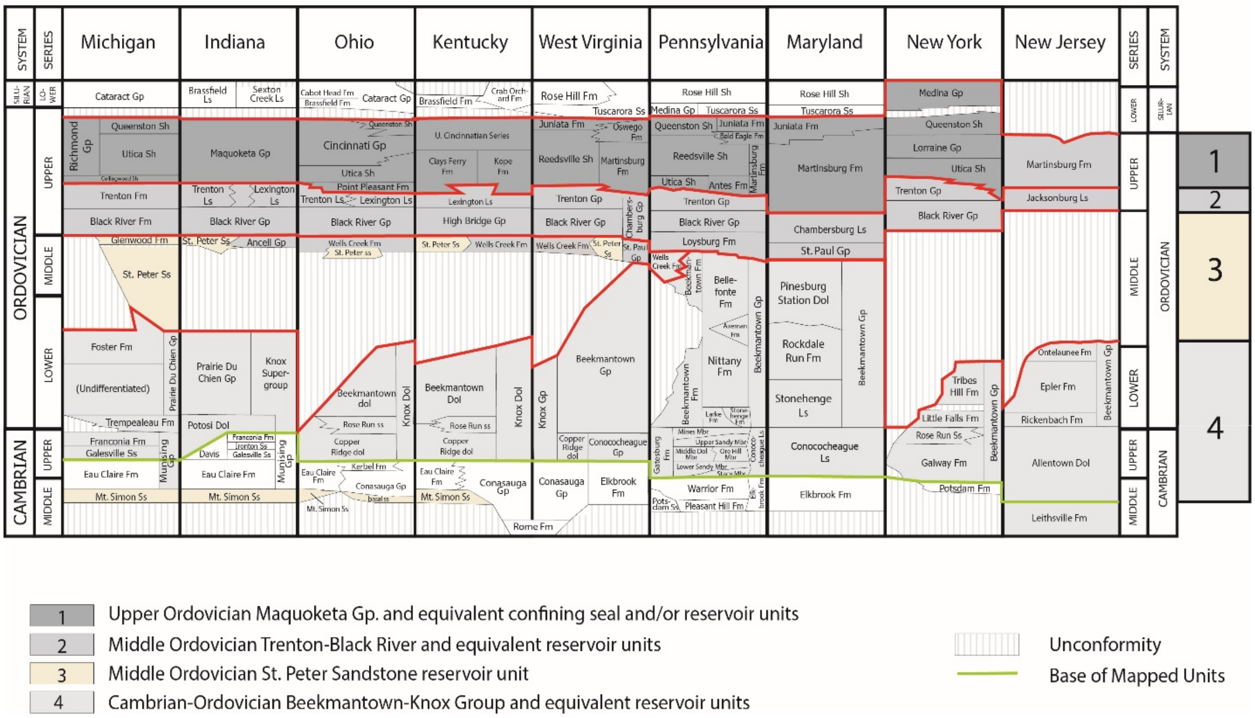

Figure 2-3. Stratigraphic correlation chart for the main units under assessment in the MRCSP region.

2.1 CO_2 Point-Sources

We provide a map with anthropogenic sources of CO2 resulting from human activity, including the burning of fossil fuels for electricity generation, cement production and other industrial processes, deforestation, agriculture, and changes in natural land usage. These data were obtained from the Department of Energy's National Energy Technology Laboratory (U.S. DOE NETL, 2018) webpage and was clipped to illustrate the distribution and magnitudes of such emissions within the MRCSP region (Figure 2-4). More information can be obtained from the U.S. DOE atlas (i.e., U.S. DOE NETL, 2010, 2015, 2018).

2.2 Geology and Stratigraphy

The U.S. DOE has identified several categories of geologic reservoirs for potential CO2 sequestration (U.S. DOE, 1999, 2004, 2005). Of these categories, four are considered important for the MRCSP region: (1) deep saline aquifers, (2) oil and gas fields, (3) unmineable coal beds, and (4) organic-rich (carbonaceous) shales.

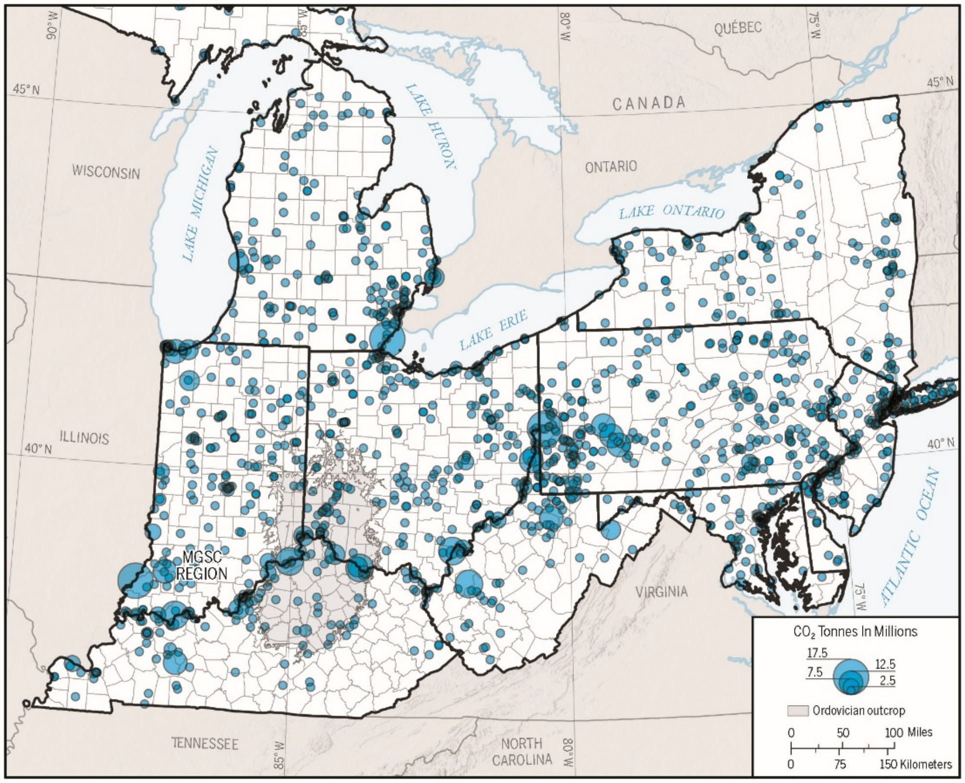

Figure 2-4. Map of CO_2 point-source emissions (Source: U.S. DOE NETL, 2018).

The saline aquifers are natural salt-water-bearing intervals of porous and permeable sedimentary rocks that occur beneath the level of potable groundwater. Currently, a number of the saline aquifers in the MRCSP region are used for waste-fluid disposal (especially in Indiana, Michigan, and Ohio); thus, a long history of technological and regulatory factors exist that could be applied to CO2 injection/disposal. Saline aquifers are widespread, close to many large CO2 sources, and are thought to have large pore volumes available for injection and storage (U.S. DOE NETL, 2004, 2005). To maintain the injected CO2 in a supercritical phase (i.e., liquid), the geologic unit must be at a depth of approximately 2,500 feet (ft) or greater. Maintaining the CO2 in a liquid phase is desirable because, as a liquid, it occupies less volume than when in the gaseous phase. One metric ton of CO2 at surface temperature and pressure (in gaseous phase) occupies approximately 18,000 cubic ft. The same amount of CO2, when injected to approximately 2,600 ft in depth, will occupy only 50 cubic ft. Deep sequestration depths also help ensure there is an adequate interval of rocks (confining layers) above the potential injection zones to act as a geologic seal. In this type of reservoir, CO2 is injected under pressure down a specially constructed well where it displaces (hydrodynamic trapping) and mixes (solubility trapping) with saline water and fills the pore spaces between the mineral grains of the rocks in the reservoir and is trapped within minerals (mineral trapping) in the rock matrix. For the purposes of the MRCSP Phase III project, we did not consider the potential use of shallow saline aquifers for CO2 storage.

Depth, permeability, injectivity, reservoir pressure and temperature, caprock integrity, reservoir architecture, flow regimes, and in-situ water chemistry are some of the variables that control the sequestration potential in deep saline aquifers (Bachu and Adams, 2003). In addition to favorable properties of the injection zone in the reservoir, an overlying seal unit (confining layers) is necessary. The injected CO2 has a lower specific gravity, and thus, is more buoyant than the natural formation fluids and will rise to the top of the porous zones. Hence, all cap-rock units must be relatively impermeable and sufficiently thick to arrest any appreciable vertical movement of the CO2 within the sequestration interval, thereby trapping it in the deep subsurface. As part of the Phase III study, the MRCSP Geoteams collected data and mapped several intervals that would act as satisfactory cap rock.

Similar to hydrocarbon resources, storage of CO2 in porous and permeable reservoirs can be facilitated by the presence of an overlying impermeable, caprock to prevent the vertical migration of CO2, and the presence of structural and/or stratigraphic traps to prevent the lateral migration of CO2. CO2 storage can also occur outside of structural/stratigraphic traps, and the boundaries of the reservoir volume/flow regime are then defined by the extent of the caprock, and discontinuities in reservoir facies and flow regimes. In subsurface traps, the more buoyant CO2 will occupy the highest portion of any structural (e.g., anticline) or stratigraphic (e.g., pinch-out) feature. This same mechanism of trapping is found in many of the natural gas and oil reservoirs (i.e., traps) that occur in the MRCSP region, with the exception that the size of the resource is well-defined a finite accumulation of fluids within a pore volume. In CO2 storage reservoirs, structural and stratigraphic traps only define a portion of the pore volume available for storage in the reservoir and the thickness and lateral extent of the connected (permeable) pore volume limits the volume of CO2 that can be injected/stored. In some units, the CO2 is injected in regional aquifers located in rocks without specific structural closures or stratigraphic traps. Once injected, a portion of the CO2 will migrate to the highest portion of the saline formation where it accumulates against the cap rock, which prevents further vertical movement (Bentham and Kirby, 2005). At that point, the injected CO2 then will migrate laterally, following the normal hydrodynamic flow regime of the region (usually towards shallower areas). In CO2 storage operations occurring outside of structural/stratigraphic traps, and the boundaries of the reservoir volume/flow regime are then defined by the extent of the caprock, and discontinuities in reservoir facies and flow regimes. However, it must be emphasized that flow velocities in deep geologic systems occur at rates measured in feet per hundreds or thousands of years.

Commercial sequestration in saline aquifers has been successful in the Sleipner field of Norway, and the U.S. DOE is involved in a small-scale demonstration project in the Oligocene Frio Formation of Texas (Hovorka et al., 2001). Several testing and pilot studies took place in the United States during Phase II of the Regional Carbon Sequestration Partnerships (U.S. DOE, 2004, 2005).

The study area includes the states of the MRCSP and includes Indiana, Kentucky, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, and West Virginia. However, the wells included in this particular study are from Indiana, Kentucky, Ohio, Michigan, Pennsylvania, and West Virginia. The regional stratigraphy includes the Ordovician-Cambrian units that are present across the states. These sedimentary rocks overly a late Proterozoic sequence of mixed intrusive igneous and metasedimentary rocks that comprise the Precambrian basement complex. The overall tectonic context is that of the stable interior of the craton, while the regional structural setting is that of a north-south trending antiform, the Cincinnati Arch, which gently dips to the east into the Appalachian Basin and to the west into the Illinois Basin. The Paleozoic sedimentary column of interest is dominated by carbonate rocks (predominately shallower limestone units and deeper dolostone units (Trenton/Black River and Knox, respectively) and subordinate amounts of shales, sandstones, and siltstones.

The evaluation of the Paleozoic stratigraphy in this study focused on three intervals as reservoirs: (1) limestone and dolostone from the Trenton/Black River Group (Upper Ordovician), (2) the Middle Ordovician St. Peter Sandstone, and (3) primary target reservoir rocks of the Upper Cambrian and Lower Ordovician Knox Supergroup and equivalent units (Figure 2-3). The Upper Ordovician Maquoketa Group (and equivalent units) was also evaluated as the main caprock and maps for its spatial distribution are provided (isopach of measured depth (in ft) and structure maps in Figure C- 1, Figure C- 2, and Figure C- 3).

The subsurface data were interpreted to portray the general structural and thickness configurations of these three rock sequences. Thickness and structure maps were constructed for the following horizons (in descending stratigraphic order): Trenton/Black River equivalents (Figure C- 4, Figure C- 5, and Figure C- 6), St. Peter Sandstone (Figure C- 7, Figure C- 8, and Figure C- 9), and Knox Supergroup and equivalent units (Figure C- 10, Figure C- 11, and Figure C- 12).

2.3 Regional Geologic Structure and Stratigraphy

A regional stratigraphic correlation chart and accompanying schematic subsurface geologic cross sections for CCUS considerations in the MRCSP region are provided by Greb (2018). Although we did not use this information in our SRE calculations per se, they serve as a means to easily visualize the depth and lateral distribution of key storage units, confining intervals, and location of regional faults, which can be used for educational and regional planning purposes.

Section 3. Regional Characterization of Ordovician-Cambrian Systems

3.1 Purpose

The purpose of Task 1.1 is to provide a regional assessment of the potential for geologic carbon sequestration in the Ordovician-Cambrian stratigraphic units located within the Midwest Region (Figure 2-1). This assessment consists of the calculation of SREs using a series of methodologies. This assessment contributes to the general knowledge of these geologic units by providing information pertaining to their petrophysical properties (porosity and permeability). Results are presented through a series of georeferenced maps, which are based on data from wireline logs, core analyses, mercury porosimetry, image analysis from thin sections, and stratigraphic tops, depending on methodology.

The present work focuses on the SREs of saline aquifers, and will add to the existing literature of storage resource estimation performed in other saline aquifers (Ellet et al., 2013; Greb et al., 2012; Goodman et al., 2011, 2016; Sanguinito et al., 2017), depleted gas reservoirs or EOR (i.e., Clarke et al., 2017; Hawkins et al., 2017), shales and unconventional reservoirs (Levine et al., 2016). Specifically, this investigation builds upon preliminary studies of the storage resource potential in the Ordovician-Cambrian carbonate rocks of the MRCSP region, as well as of the Illinois Basin (Wickstrom et al., 2005; Greb et al., 2012; Harris et al., 2014; Barnes et al., 2017).

3.2 Project Team

The team that completed Task 1.1 (Assessment of Storage for Ordovician-Cambrian Units) was led by geologists from the Indiana Geological and Water Survey (IGWS). This task had the support from the Kentucky Geological Survey, Western Michigan University, the Ohio Division of Geological Survey (ODGS), and the Pennsylvania Geological Survey (PAGS). Team members include but are not limited to John Rupp, Cristian Medina, Kevin Ellett, Stephen Greb, William Harrison, and Brian Dunst.

3.3 Overview of Major Tasks

3.3.1 Assessment of Storage for Ordovician-Cambrian Units

SREs were calculated for three broad units or intervals of Ordovician-Cambrian age. This assessment includes the use of different sources of porosity information to arrive at different values of SRE (i.e., Goodman et al., 2013, 2016). The differences, along with data robustness and standard deviation, provide information about the advantages and disadvantages of each method (explained in detail in following sections). The analysis is well-site-based (i.e., SREs are estimated at each well), and maps with interpolated values of SREs among wells are also provided. This analysis and assessment provide a preliminary evaluation of sites and regions with higher potential for geologic carbon sequestration. We provide these maps so managers, policy makers, and/or operators can have a preliminary idea of the storage resources available in different areas across the MRCSP region before more detailed reservoir characterization takes place.

3.3.2 Ordovician-Cambrian Units Assessed

Four units representing broad combinations of rock units are defined for regional assessment. Detailed unit descriptions can be seen in reports from Phase I and Phase II. Units were picked based on common characteristics and general stratigraphic position.

Unit 1 are Upper Ordovician shales, termed Maquoketa Group in Illinois Basin, Cincinnati Group or varied unit names on Cincinnati Arch and eastward into Appalachian Basin. This unit is considered a regional confining interval for underlying intervals, so is not assessed for storage potential.

Unit 2 are Upper Ordovician carbonates of the Trenton Limestone and Black River Group. This interval is dominated by regionally extensive limestone. In some areas, the interval is confining, but in others, may have local reservoirs.

Unit 3 are Upper to Middle Ordovician strata beneath unit 2 and above the regional Knox Supergroup unconformity surface. It is the thinnest of the three units across the region. Unit 3 includes a variety of rock types with varying porosity. Many of the rock units in this interval are confining strata, but the St. Peter Sandstone is a potential CO2 storage reservoir with good porosity in some areas. Much of the reservoir data from this interval is from the St. Peter Sandstone portion of the unit.

Unit 4 includes all Lower Ordovician through Upper Cambrian rocks in the region beneath the Knox unconformity surface to the top of the Cambrian clastics. It is the thickest of the four intervals assessed. Dolostones of the Knox Supergroup and equivalents are regionally extensive and have storage reservoir potential. This unit is underlain by shales, siltstones, sandstones, and minor carbonates of various Cambrian units.

3.4 Methods of Investigation

The standard DOE methodology for calculation of SREs is initially utilized to calculate the mass of CO2 that can be stored in the three reservoirs (Figure 2-3). This method uses a simple multiplication of the area, thickness, porosity and an efficiency factor to generate a volumetric value (e.g., Goodman et al., 2011). Although this method provides reasonable values of static SREs, other methods have also been developed for SRE calculations. For this assessment, we decided to use multiple methods and compare the results of those methods. In addition to the standard method, a hierarchical set of other methods is used in an effort to evaluate resource variability and possible identify sources of uncertainty and therefore improve the accuracy of the volumetric-based estimates. All methods use the extent, thickness, and porosity of the aquifer. How porosity is calculated for each method, however, varies. In many cases where SREs are calculated, the area of interest or the projected area to which the assessed unit extends is required to estimate storage resources (U.S. DOE NETL, 2015). However, in this study, we report SREs in units of mass per areal unit (i.e., million tonnes per square kilometer [MMTons/km2]). This approach eliminates the uncertainty associated with the lateral distribution and presence of any given unit, but allows the users to utilize information from other published studies concerning lateral displacement and plume distribution from modeling and flooding experiments.

Structure depth and isopach maps of the four units analyzed (APPENDIX C) were generated using data managed in Petra® Geological Interpretation Software and interpolation capabilities available in ArcMap (v. 10.5.1). Porosity data from geophysical well logs, core analyses, and mercury porosimetry have been collected from multiple states from the MRCSP region. This information is essential for different methods used to calculate SREs.

3.4.1 Data Compilation Efforts

Stratigraphic tops, porosity data, Shapefiles, and geophysical logs that represent the four stratigraphic units (one confining interval and three underlying potential reservoir-bearing intervals) were compiled from multiple states within the MRCSP region. These data were input into Petra® software for further processing and analysis. The challenges associated with data compilation from multiple sources are (1) data quality, in particular, of those older vintage wireline logs, and (2) correlation. To properly estimate porosity from wireline logs such as neutron (NPHI), sonic (DT), or density (RHOB), an extensive effort of quality assurance and quality control (QA/QC) was undertaken. Those wells with anomalous behavior, or with evident poor quality, were not included in the analysis. Stratigraphic tops were carefully checked to ensure consistency throughout the region. In some cases, stratigraphic units (formations or groups) are named differently across the region, and the studied intervals comprise multiple geologic units (see Figure 2-3 and APPENDIX A for nomenclature and presence of stratigraphic units per state).

3.4.2 Digital Mapping

Stratigraphic tops and porosity data were processed and compiled to interpolate relevant information using ArcMap GIS v. 10.5.1. The maps generated include: measured depth, structure (ft above sea level), and SRE maps for all methods that meet the minimum requirements, such as spatial well density.

For mapping purposes, SREs are calculated and displayed only for units at depths between 2,500 ft. and 10,000 ft, which is the depth interval previously determined to be potentially suitable for carbon storage in the region in Phase I and Phase II studies (e.g., Wickstrom et al., 2005). This provides a quick visualization of those areas that, if reservoir conditions permit, are suitable for geologic carbon sequestration.

All maps are presented in APPENDIX C and were generated at the facilities of the IGWS using data from multiple states of the MRCSP region, consisting of stratigraphic tops, geodatabases with structure and isopach maps of the units at different states, geophysical logs for calculation of SREs, and tabulated data for porosity and permeability.

3.4.3 Storage Capacity Estimates for Saline Aquifers

Six methods were employed to generate the SREs presented in this report. The rationale for using multiple methods is that differences in data availability and density provide opportunities for different types of estimates. If methods are sequentially attempted based on available data, then a hierarchy of results can be estimated, and assessed for statistical accuracy and robustness. Different methods may be more accurate for different types of data and units.

3.4.4 Methodologies Explained

The volumetric calculations used throughout this study are based on the DOE NETL method described by Goodman et al. (2011), which is considered the standard method for storage resource calculations in the U.S. by DOE, with nation-wide results reported on a biennial basis in the Carbon Utilization and Storage Atlas (U.S. DOE NETL, 2015). The SRE following the standard method uses the general expression:

$$SRE_{CO_2} = Area * Thickness * Porosity * Density_{CO_2} * E_{saline} \qquad [1]$$

where Esaline is the efficiency factor applied to the theoretical maximum volume in an effort to determine what fraction of the pore space can effectively store CO2 (U.S. DOE NETL, 2015).

Appendix B in The Carbon Sequestration Atlas of the United States and Canada introduced a discussion of these storage efficiency factors and their use in making regional storage resource calculations and suggests that a range of values between 0.4%-5.5% (Table 3-1).

$$SRE = \rho_{CO_2} * \emptyset_{ave} * h_n * E_{saline} * 0.3048 * 10^6 * 10^{-9} \qquad [2]$$

where SRE = CO2 storage resource in metric tons per unit of area [MM Tons/km2]; ρCO2 = CO2 density [kg/m3]; øave = average porosity [-]; hn = net thickness [ft]; and E = storage efficiency factor [-]. In order to obtain a value of SRE in metric units, we use the conversion factors 0.3048 [m/ft.]; 106 [m2/km2]; and 10-9 [MM Tons/kg]. The resulting value is a unit of mass per unit area [MM Tons/km2]. To estimate the total SRE for any given county, we simply calculate the values of SREs explained above by the total area of the county, which is done using the toolsets provided by GIS via ArcMap (v. 10.5.1) software. A workflow illustrating the methodology applied to represent the results from SREs estimates is displayed in Figure 3-1.

If using a constant value for the density of CO2 in a supercritical state under reservoir conditions (69.85 oC; 9 MPa (=1305 psi)) of 737 kg/m3 (41.8 lbs/ft3) (Tamulonis et al., 2011), equation [1] can be written as:

$$SRE = 0.2246 * \emptyset_{ave} * h_n * E_{saline} \qquad [3]$$

This deterministic methodology was previously applied in the MRCSP region during Phase II to estimate storage capacity in 13 deep saline aquifers, and in particular in the deep saline Upper Cambrian Mount Simon Sandstone (U.S. DOE NETL, 2010; Medina et al., 2011; Medina and Rupp, 2012).

Table 3-1. Regional efficiency factors for saline aquifers published by U.S. DOE NETL (2010).

Lithology	P_{10}	P_{50}	P_{90}
Clastics	0.51%	2.00%	5.40%
Dolomite	0.64%	2.20%	5.50%
Limestone	0.40%	1.50%	4.10%

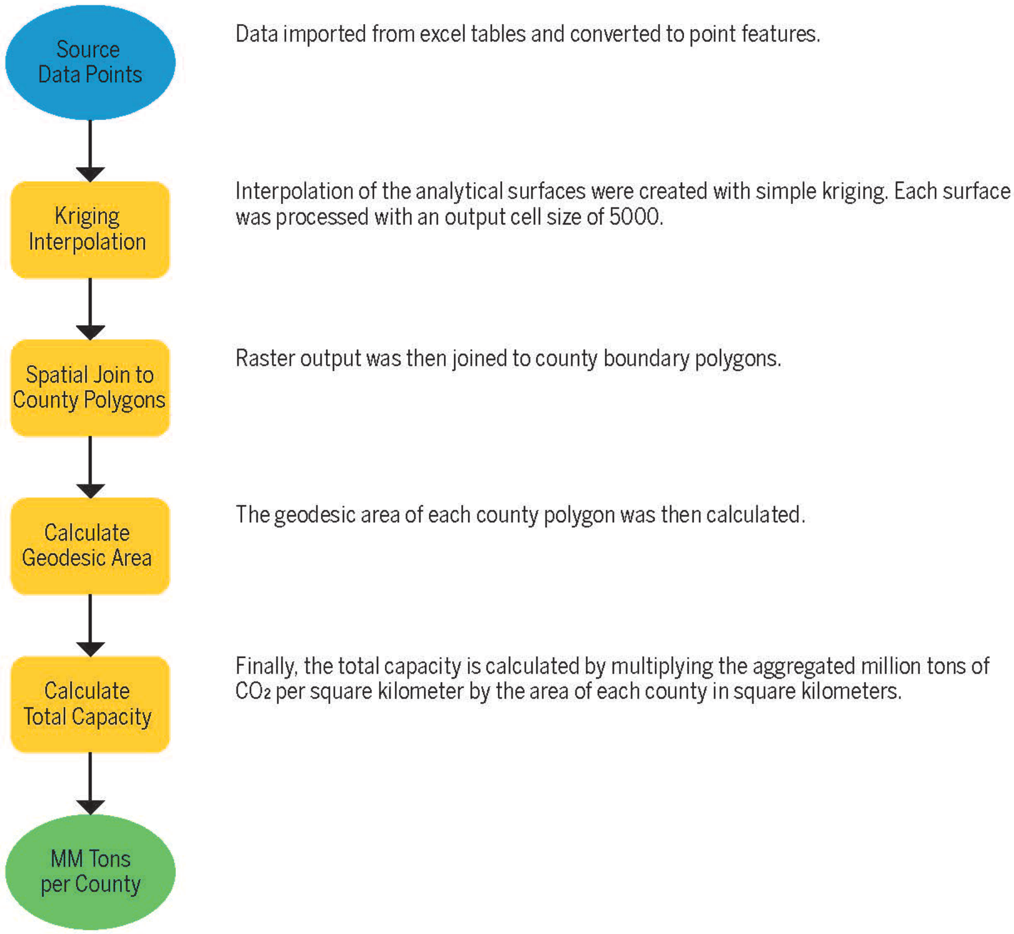

Figure 3-1. ArcGIS (ArcMap 10.5.1) workflow applied in this study to generate isopach, structure and SREs maps (Appendices C and D).

The number of data points varies from method to method, and, in general, tends to decrease with depth and older stratigraphic intervals (Figure 3-2). For example, in Method 1, the number of data points containing stratigraphic picks decreases with depth (n2=2048 for unit 2; n3=770 for unit 3; and n4=765 for unit 4,Table 3-2).

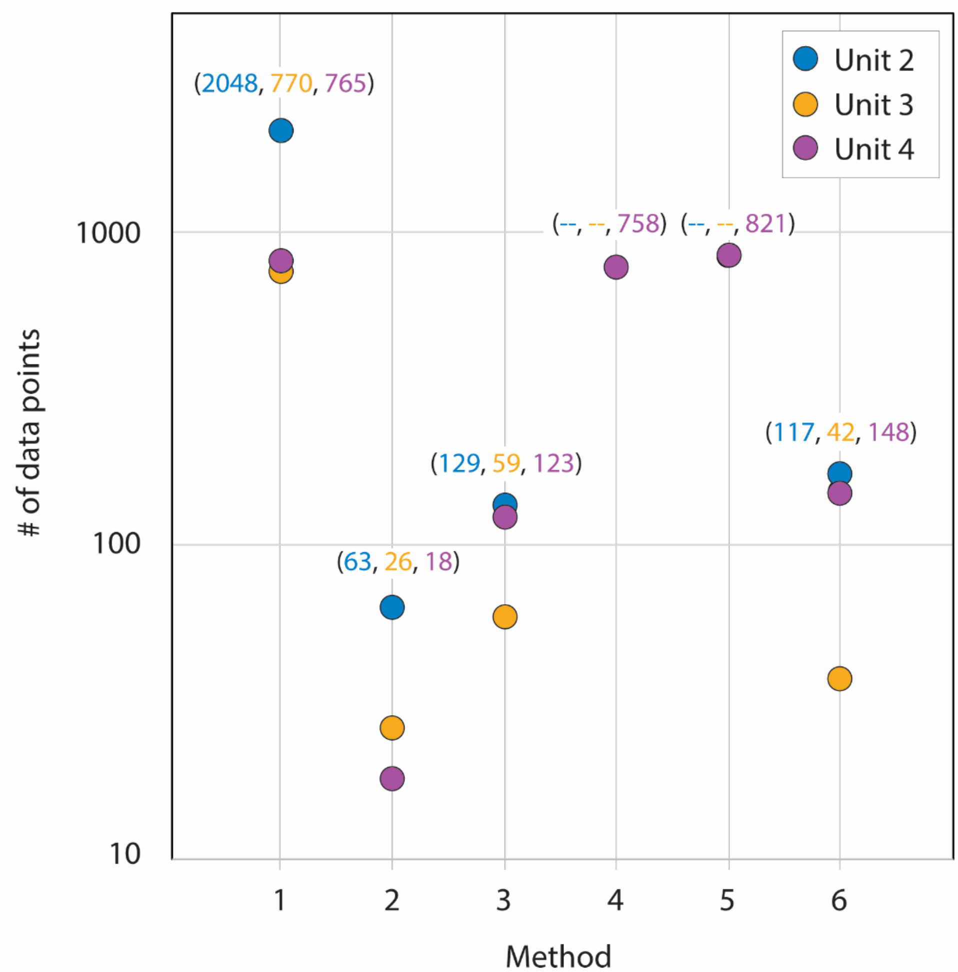

Figure 3-2. Dot plot chart illustrating number of data points for each method and unit. In this study, each county under assessment is considered a data point. When more than one well is available with porosity at any given county, we calculated the averaged values of porosity at such county. Method 4 and 5 was only applied to unit 4 (Knox Supergroup and equivalents).

Table 3-2. Number of wells used in each method. A graphic representation of this is available in Figure 3-2.

Method	# of Wells		
	Unit 2	Unit 3	Unit 4
Method I	2,048	770	765
Method II	63	26	18
Method III	129	59	123
Method IV	--	--	758
Method V	--	--	821
Method VI	117	42	148

Method 1: SREs assuming a constant value of porosity (standard DOE method)

This method is equivalent to the earlier, conventional method used by DOE and published in all five editions of the Atlas (U.S. DOE NETL, 2007, 2008, 2010, 2012, 2015), as described in the previous paragraphs. It is the simplest of the methods used. SREs are based on the assumption of a constant (average) value of porosity throughout all the units (□=10%). For well data, the thickness of a unit is used to calculate SREs for that unit using efficiency factors of 1% and 4%, respectively.

Replacing the porosity values (□=0.1) in equation [3], we can estimate SREs for efficiency factors of 1%, 4%, and 10% as follows:

$$SRE_I = 0.0002246 * h_n \qquad \text{(E=1\%)} \qquad [4]$$

$$SRE_I = 0.0008984 * h_n \qquad \text{(E=4\%)} \qquad [5]$$

$$SRE_I = 0.002246 * h_n \qquad \text{(E=10\%)} \qquad [6]$$

This method is equivalent to the method used by DOE and published in all five editions of the Atlas (U.S. DOE NETL, 2007, 2008, 2010, 2012, 2015).

The following section (method 2) takes into account porosity variations observed from core data analysis results in overall more accurate values of SREs.

Method 2: SREs using porosity from core analysis

Storage resource using averaged values of porosity from core analysis for each unit of interest is estimated by using Equation [7]. This method is potentially a more accurate approach than the method presented by the standard U.S. DOE methodology outlined in the Carbon Sequestration Atlas (U.S. DOE NETL, 2007, 2008, 2010, 2012, 2015) in cases where porosity data is available. The standard approach (Method 1) uses the gross thickness and only a single value for porosity because porosity values are not commonly available across a region. Method 2 uses measured values of porosity, generally performed using helium porosimetry, which should provide a more realistic quantification of the reservoir porosity at different depth and locations where data is available. Because of the limited availability of analytically measured porosity data (Figure 3-2), however, this method is the least robust in terms of the number of data points for the region.

$$SRE_{II} = 0.2246 * \emptyset_{core} * h_n * E_{saline} \qquad [7]$$

where ϕcore is the average value of core analysis for the interval under evaluation, *hn* is the thickness of the unit, and *E*saline is the efficiency factor.

This assessment was only performed for units in counties in which data are available, and therefore offer a less robust analysis in terms of spatial data coverage. The following section (Method 3) uses the most comprehensive data set that uses wireline logs for porosity, resulting in the most robust method of all.

Method 3: SREs using wireline-derived porosity

This method uses the average wireline-derived porosity (neutron, sonic, or density logs) in Petra® Software to estimate SREs. In the MRCSP region, there are many more wireline logs from which porosity can be derived for Method 3 than there are porosity analyses from core used in Method 2. When more than of one type of geophysical log provides porosity for an individual well, the best log type was selected based on close inspection of data distribution and porosities of similar intervals from wells in the vicinity for use in calculations. When available, analytically-derived porosity data from cores were used to check porosity derived from wireline tools in the same or nearby wells.

Values of porosity were estimated from wireline logs using the set of equations included in APPENDIX E.

$$SRE_{III} = 0.2246 * \emptyset_{LOG} * h_n * E_{saline} \qquad [8]$$

The value 0.2246 is a conversion factor that takes into account density of CO2, and unit conversion from imperial to metric (See Equation [3] for detailed explanation).

Method 4: Depth-dependent porosity

Diagenetic compaction is a process that reduces porosity. Studies of porosity from core data and wireline logs in the MRCSP and neighboring regions suggest that diagenetic compaction results in a decrease in porosity with increasing depth within unit 4 of the current study (Figure 2-2). However, data of from this study show more significant scatter when compared to previously published data for the Mount Simon Sandstone (Figure 3-3) (Brown, 1997; Hoholick et al., 1984, Medina et al., 2011). Method 4 incorporates a depth-dependent porosity model for SREs assessment for unit 4, assuming that diagenetic compaction took place and reduced porosity with increasing depth (i.e., Bloch, 1991; Brown, 1997; Ehrenberg and Nadeau, 2005; Ehrenberg et al., 2008, 2009; Medina et al., 2011). The depth of the units is widely available data across the region, so this methodology uses regional isopach and depth maps based on thousands of wells for calculations. While depth-dependent porosity reduction is common and moderately predictable in quartzose sandstones like the Mount Simon Sandstone (e.g., Hoholick et al., 1984), it can be more variable and complex in carbonate rocks. Available porosity data from cores from the Ordovician-Cambrian section in the MRCSP region indicate a wide range of porosity values (R2=0.00014). When porosity and depth are plotted, we observe a logarithmic trend similar to that observed by Hoholick et al. (1984). This depth-porosity relationship is the basis for our Method 4. A total of 5,701 porosity values from core analyses for all units from 333 wells were plotted and the exponential curve resulting from the regression in Petra® is:

$$\emptyset(z) = 0.1497 * e^{-0.000233*depth[ft]} \quad R^2=0.00014 \qquad [9]$$

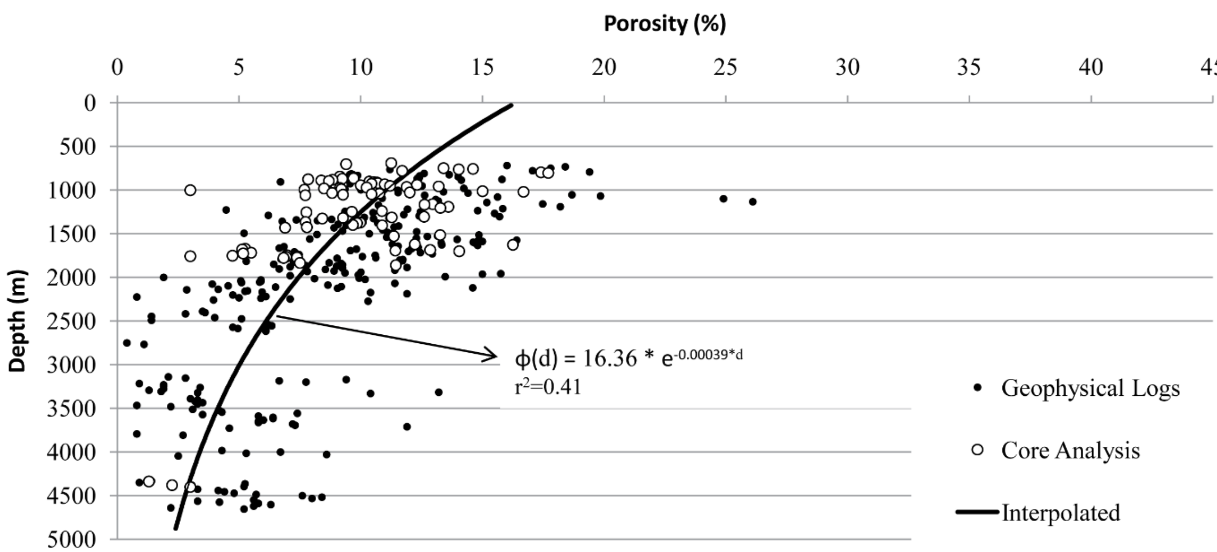

Figure 3-3. Scatter plot and regression as an example of porosity reduction with depth in samples from the Mount Simon Sandstone (Medina et al., 2011).

This equation allows the calculation of net porosity by integrating the values of porosity in the depth interval for each well under study that has information on top and bottom for each unit.

$$SRE_{IV} = 0.2246 * \int_{z_{top}}^{z_{bottom}} \emptyset(z)dz * E_{saline} \quad [10]$$

where Ztop and Zbottom are the measured depths (ft) of the top and bottom of unit 4, respectively. Replacing [9] into [10]:

$$SRE_{IV} = 0.2246 * (\int_{z_{top}}^{z_{bottom}} 0.1497 * e^{-0.00023*z} dz) * E_{saline} \quad [11]$$

Solving the integral, we obtain:

$$SRE_{IV} = 146.18 * (e^{-0.00023*z_{top}} - e^{-0.00023*z_{bottom}}) * E_{saline} \quad [12]$$

It is important to mention that we are using this method for the purpose of comparing the SREs results from several methods in unit 4. Although an exponential decrease in porosity with depth due to diagenesis has been widely reported for sandstones, a similar relationship for carbonates is unresolved, in part, because of more complex pore systems and cementation histories in carbonates.

Method 5: Petrophysical model from MICP data

Mercury injection capillary pressure (MICP) data can be collected from core samples to determine aspects of pressures needed to inject fluids and gases into the available porosity of the rock and aspects of porosimetry including pore sizes, pore volumes, and the distribution of sizes and volumes for use in reservoir analyses. This data is significantly more expensive than standard core-derived porosity measurements, so fewer data are available for regional analyses. Sixty-six MICP samples were collected from Ordovician-Cambrian samples in the Midwestern United States (Figure 3-4). The samples included in this study are from Indiana (30 samples), Ohio (10), Kentucky (24), and Pennsylvania (2). Of the 66 samples, 59 are from carbonates from the Knox Supergroup and equivalent units (part of unit 4 in this study, Figure 2-2). The other seven samples are from Upper Ordovician shales in unit 1 (4 samples) and Middle-Upper Cambrian shales in unit 4 (three samples) (APPENDIX B). Similar to Method 2, this methodology is limited by data availability.

From the available MICP entry-pressure data, we defined four petrofacies (Figure 3-5), ranging from low capillary entry pressure (high injectivity, petrofacies 1) to high capillary entry pressure (low injectivity, petrofacies 4). We estimated SREs using the average porosity from core analyses in each lithofacies (Table 3-3) and included three scenarios concerning the distribution of such petrofacies along each well site. This scenario-based conceptual model assumes different amounts of a given “petrophysical facies” present at each well location (Table 3-4).

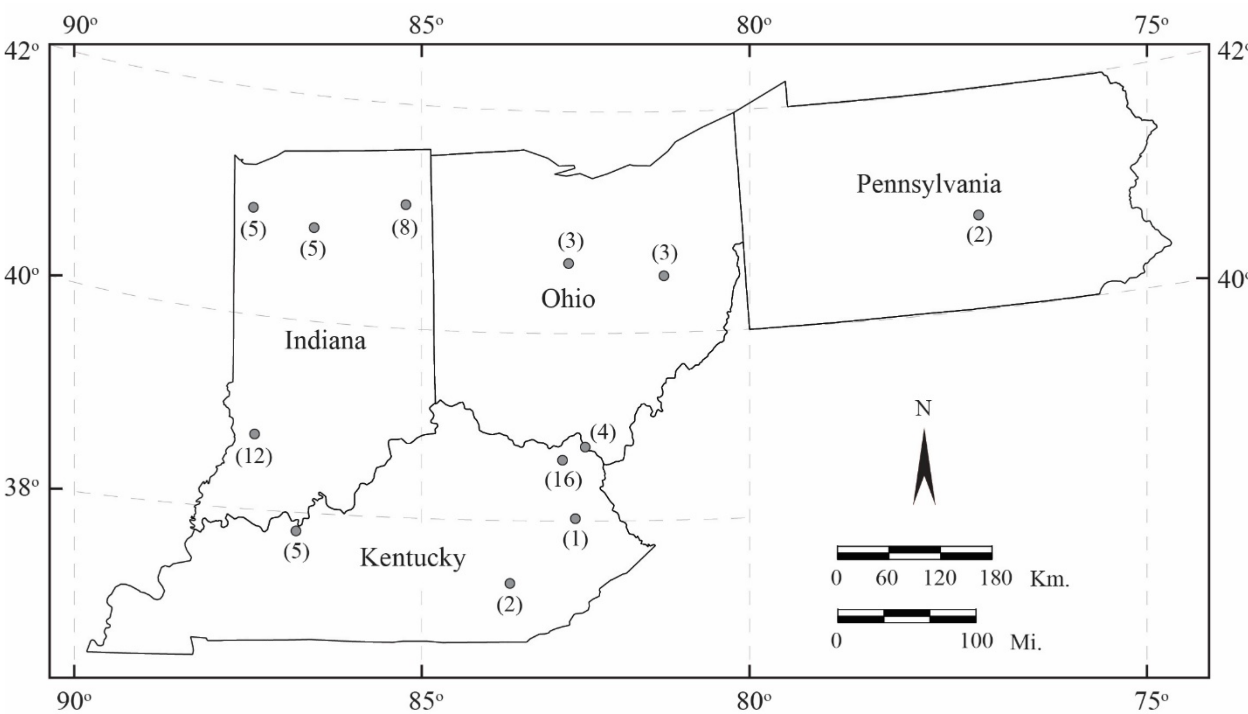

Figure 3-4. Map of samples used for MICP (modified from Medina et al., 2017).

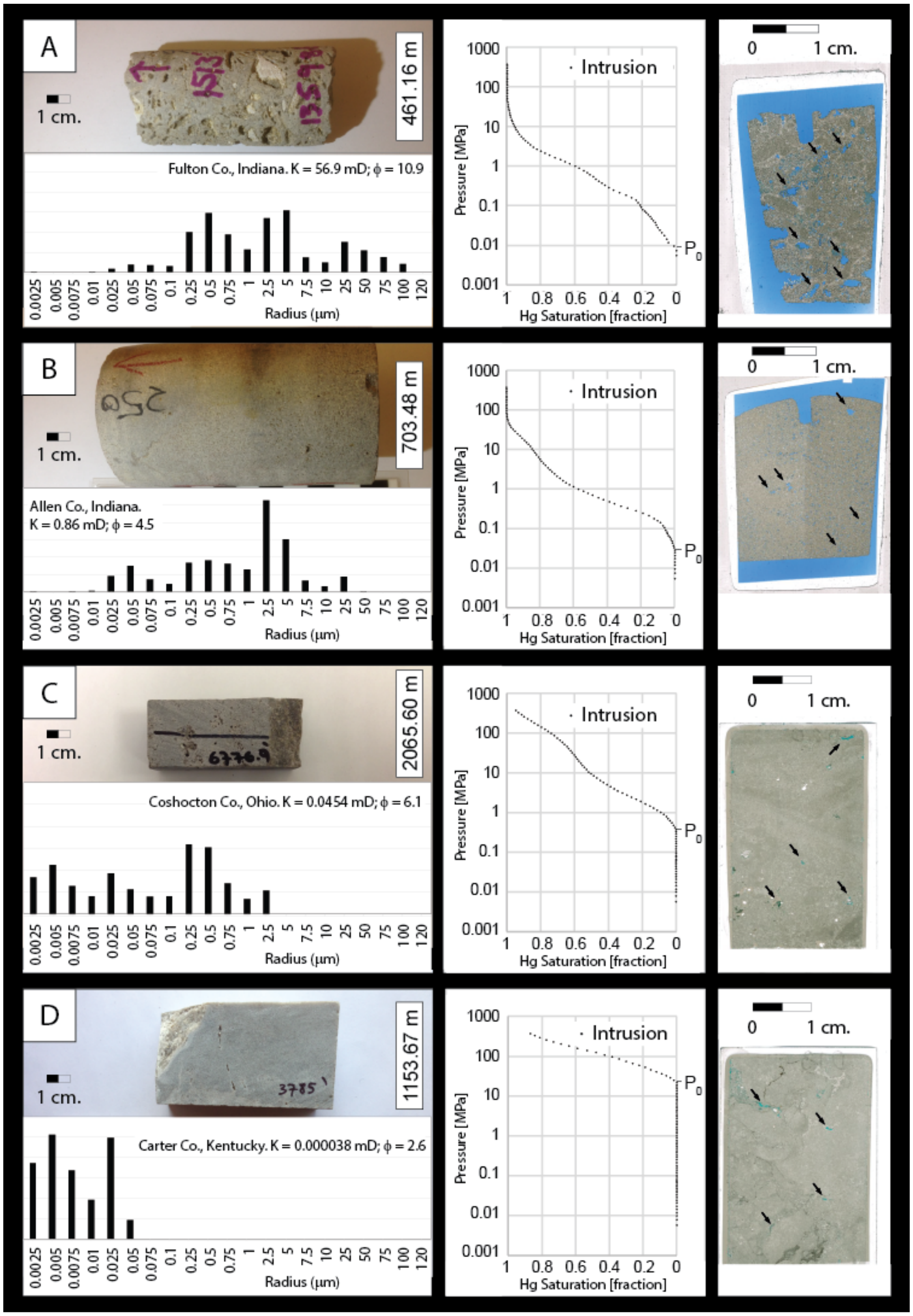

Figure 3-5. Photographs and charts of representative samples of 4 petrofacies. Entry pressure is indicated in right side of capillary curve. A scanned photo of the thin section is included in right hand side, with arrows indicating some of the larger pores. (A) Petrofacies 1 (Low values of entry pressure, P_0); (B) Petrofacies 2 (Low to intermediate values of P_0); (C) Petrofacies 3 (intermediate to high values of P_0); and (D) Petrofacies 4 (high values of P_0). Each horizontal line in histograms represents 5% frequency of total mercury saturation.

Table 3-3. Summary statistics of main petrophysical data from MICP for four petrofacies.

		Entry Pressure						Permeability			Porosity	
Petro-facies	n	Ave. Po (MPa)	GeoMean (MPa)	SD	Ave. P20 (Mpa)	Ave. P80 (Mpa)	GeoAve P (sqrt[P20*P80])	ArithAve (mD)	GeoMean (mD)	SD	Ave. Φ (%)	SD
1	17	0.0263	0.0185	0.0260	0.0913	22.6711	1.4385	74.4235	24.9483	121.9543	9.0059	6.2708
2	13	0.1702	0.1233	0.1336	0.7297	16.1969	3.4378	0.3730	0.1249	0.3886	4.5917	3.2595
3	22	2.1875	1.4088	2.1130	7.8588	85.7894	25.9653	0.0112	0.0040	0.0151	4.1609	2.2382
4	15	26.6027	21.0164	19.3108	72.3029	254.3242	135.6037	0.0002	0.0001	0.0003	3.5667	1.4064

Table 3-4. Scenario-based conceptual model for method 5: Case 1 represents the case when all unit is composed of petrofacies 1; Case 2 represents the case when all unit is composed of petrofacies 4 (tight reservoir); and Case 3 represents the case when all four petrofacies are present in equal parts (25% each).

Case	Petrofacies 1 (Φ=9.0%)	Petrofacies 2 (Φ=4.5%)	Petrofacies 3 (Φ=4.1%)	Petrofacies 4 (Φ=3.5%)
Case 1 (M5a)				
Case 2 (M5b)				
Case 3 (M5c)				
Note: Each square represents 25% of the unit.				

The equation used to estimate SREs for unit 4 using method 5 is:

$$SRE = 0.2246 * \sum_i \emptyset\ (petrofacies)_i * h_i * E_{saline} \qquad [13]$$

where $\emptyset(petrofacies)_i$ is the averaged porosity of each petrofacies as indicated in Table 3-4; $h_{ni}[ft]$ is thickness of petrofacies i, in feet; and E_{saline} is the efficiency factor (1%, 4%, and 10%).

The value 0.2246 is a conversion factor that takes into account density of CO2, and unit conversion from imperial to metric (Equation [3]).

Method 6: CO2 Storage prospeCtive Resource Estimation Excel aNalysis (SCREEN)

Method 6 is NETL's CO2 Storage prospeCtive Resource Estimation Excel aNalysis (CO2-SCREEN) (Goodman et al., 2016). CO2-SCREEN is a tool developed by the U.S. DOE NETL and is intended to aid users with SRE estimation in saline aquifers. CO2-SCREEN is a user-friendly Excel spreadsheet that can be completed with basic reservoir information (input), and linked to a GoldSim Player model that generates ten thousand realizations of SREs via Monte Carlo simulations. The methodology is currently in development at DOE NETL, but we were granted permission to use it for this assessment (Sanguinito et al., 2017).

The tool allows for a maximum of 300 data points, each one consisting of thickness, mean porosity, mean pressure and mean temperature, and their associated standard deviations. In addition, a lithology and depositional environment can be input to allow more characteristic efficiency factors for specific types and grouping of rock strata.

We used wells where units 2, 3, and 4 are at or deeper than 2,500 ft of measured depth. A total of 210 wells were used (*n*2 = 117; *n*3= 42; *n*4= 148) for this method (Figure 3-2 and Figure 3-6). Results are summarized in Table 3-5. For a complete list of results from this methodology, by unit, see APPENDIX F (Table F- 4, Table F- 5, and Table F- 6, respectively). For simplicity, we presented an averaged value for SREs using the three values of SREs estimated for each well using CO2-SCREEN. The equation used to estimate the average SRE is:

$$Average\ SRE\ (E = 100\%) = \frac{100}{3}\left(\frac{SRE_{P10}}{E_{10}} + \frac{SRE_{P50}}{E_{50}} + \frac{SRE_{P90}}{E_{90}}\right) \quad [14]$$

Where SREP10, SREP50, and SREP90 are the storage resources estimated calculated by CO2-SCREEN for efficiency factors associated with P10, P50, and P90 percentiles (E10, E50, and E90, respectively). Because this methodology is still in development, it should be used for reference only. Results from this method, however, can be compared to the results from the other methods for a more robust assessment of SREs for the MRCSP region. More details of this methodology are provided at the NETL's Energy Data Exchange (EDX) at https://edx.netl.doe.gov/dataset/co2-screen-users-manual.

Table 3-5. SREs summary for methodologies in this study.

Method	Description of method used for calculating SREs	Average SRE values ($MMTons\ CO_2/km^2$)[a] Unit 1	Unit 2	Unit 3	Unit 4
1	Assumes a constant value of porosity (10%)	This is a seal unit, and was not assessed for SREs.	17.68	4.76	18.41
2	SRE calculated using porosity from core analyses		5.37	1.24	9.15
3	SRE calculated using porosity from wireline logs		6.39	1.46	11.25
4	SRE calculated assuming a diagenetic reduction of porosity with depth[a]		na	na	14.28
5a	SRE calculated assuming different scenarios of petrofacies defined from MICP. a: 100% petrofacies 1 (Φ =9.0059) b: 100% petrofacies 4 (Φ = 3.5667) c: 25% of each petrofacies (ave Φ = 5.3313)		na	na	17.78
5b			na	na	6.60
5c			na	na	9.90
6[a]	SRE calculated using NETL's CO_2 Storage prospeCtive Resource Estimation Excel aNalysis (SCREEN)		5.37	1.41	5.04

[a]To convert to MMTons CO_2 / acre, multiply by 247.1. These values represent an efficiency factor of 100% (E=1).

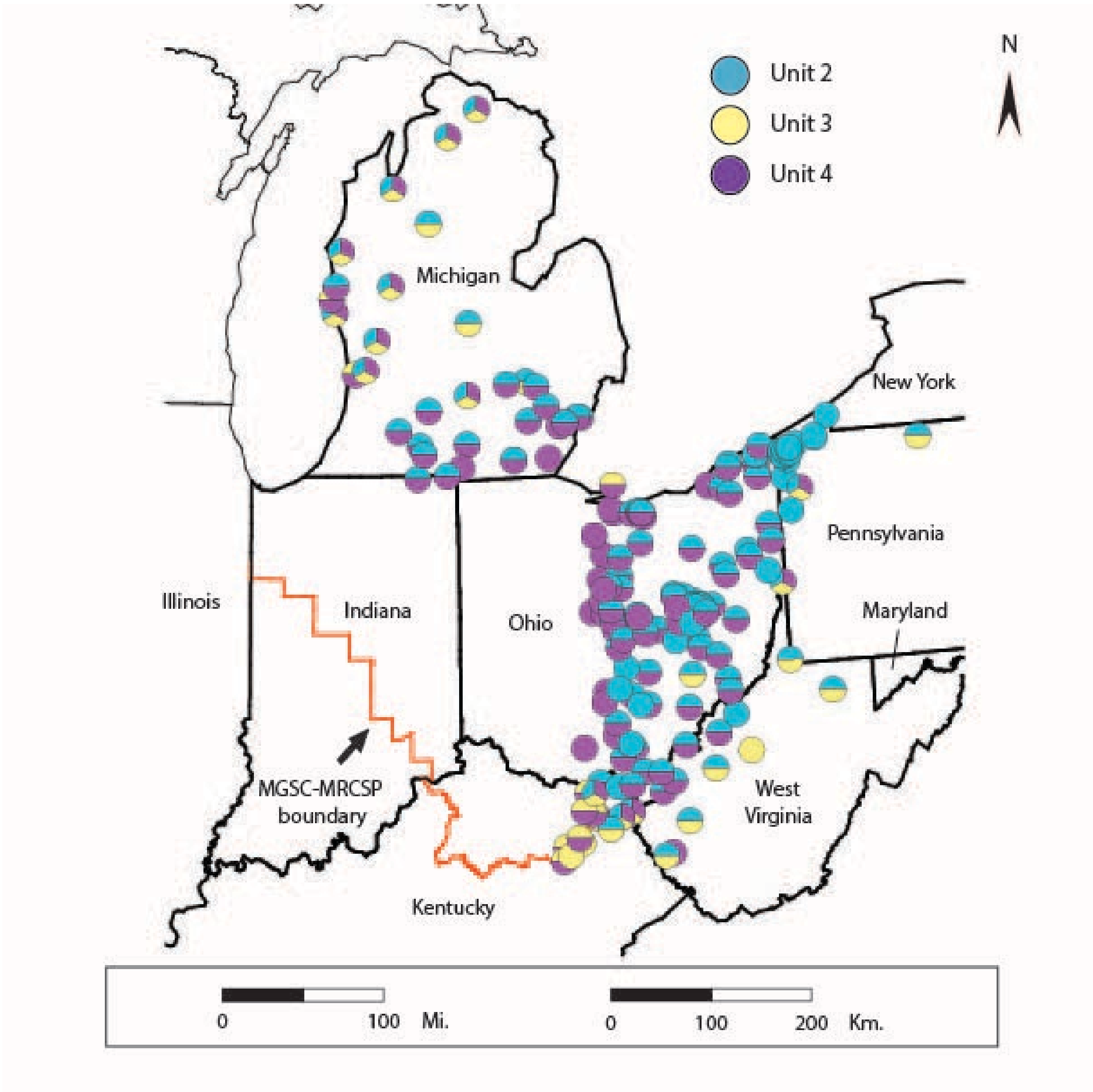

Figure 3-6. Map of wells used in method 6. For a complete list of results, refer to Table F- 6 in APPENDIX F. Each well represents one data point (n=117 for unit 2; n=42 for unit 3, and n=148 for unit 4).

Section 4. Results and Discussion

In the present study (Phase III, MRCSP), application of a six-part hierarchical approach generated a suite of SREs. Figure 4-1 and Figure 4-2 compare the resulting SREs for each unit using each method.

The evaluation of the Paleozoic stratigraphy in this study focused on three intervals as reservoirs: (1) limestone and dolomite from the Trenton/Black River Group (Upper Ordovician), (2) the Middle Ordovician St. Peter Sandstone, and (3) primary target reservoir rocks of the upper Cambrian and Lower Ordovician Knox Supergroup and equivalent units (Figure 2-2).

A statistical summary of the SREs results by method and unit for the three reservoir-bearing units is shown in Table 4-1. Values from the table are used in the box-and-whisker plot (Figures 4.1 and 4.2), which shows the minimum, first quartile, median, third quartile, and maximum results from the different methods. Statisticians refer to this type of statistics as a five-number summary, and it consists of representing each five-number summary as a box with “whiskers.” The box is bounded on the top by the third quartile and on the bottom by the first quartile. The median divides the box. The whiskers are error bars: One extends upward from the third quartile to the maximum, and the other extends downward from the first quartile to the minimum (Figure 4-1 and Figure 4-2).

Resultant values of SREs are presented in these boxplots using an efficiency factor of 100 percent (i.e., E=1) for each method. Results are plotted next to each other for comparison. To better understand the storage resources available across the partnership region, we report the SREs in MMTons CO2/Km2. In addition to these charts, results are shown in a series of georeferenced maps in which total SREs are shown per county (due to the number of maps, we are including those results from method 1 only, using E=0.01, 0.04, 0.1, and 1 for three units assessed, for a total of twelve maps for SREs).

Table 4-1. Statistical summary of data presented in Figure 4-1 and Figure 4-2.

	Unit 2			Unit 3			Unit 4			
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M4
Mean	17.68	5.37	6.39	4.76	1.24	1.46	18.41	9.15	11.25	14.28
n	2,048	63	129	770	26	59	765	18	123	758
Min	0.74	1.18	0.41	0.02	0.08	0.01	0.56	1.32	0.95	0.08
Q1	13.90	3.78	3.56	0.63	0.73	0.40	8.35	3.30	6.09	3.73
Med	16.22	5.27	5.82	1.43	1.00	0.71	12.98	7.38	9.24	9.86
Q3	21.05	6.92	8.25	3.54	1.57	1.99	23.02	10.33	15.34	19.58
Max	79.49	10.73	18.42	50.38	3.77	8.09	125.84	38.49	40.02	92.34
	Unit 2			Unit 3			Unit 4			
	M4	M5	M6	M4	M5	M6	M5a	M5b	M5c	M6
Mean	--	--	5.37	--	--	1.41	17.78	6.60	9.90	5.04
n	--	--	117	--	--	42	821	821	821	148
Min	--	--	0.27	--	--	0.12	0.54	0.20	0.30	0.02
Q1	--	--	1.99	--	--	0.29	8.28	3.07	4.61	2.46
Med	--	--	3.42	--	--	0.66	12.98	4.82	7.23	4.30
Q3	--	--	6.50	--	--	1.70	21.98	8.16	12.24	6.53
Max	--	--	29.48	--	--	7.03	111.17	41.26	61.89	22.19

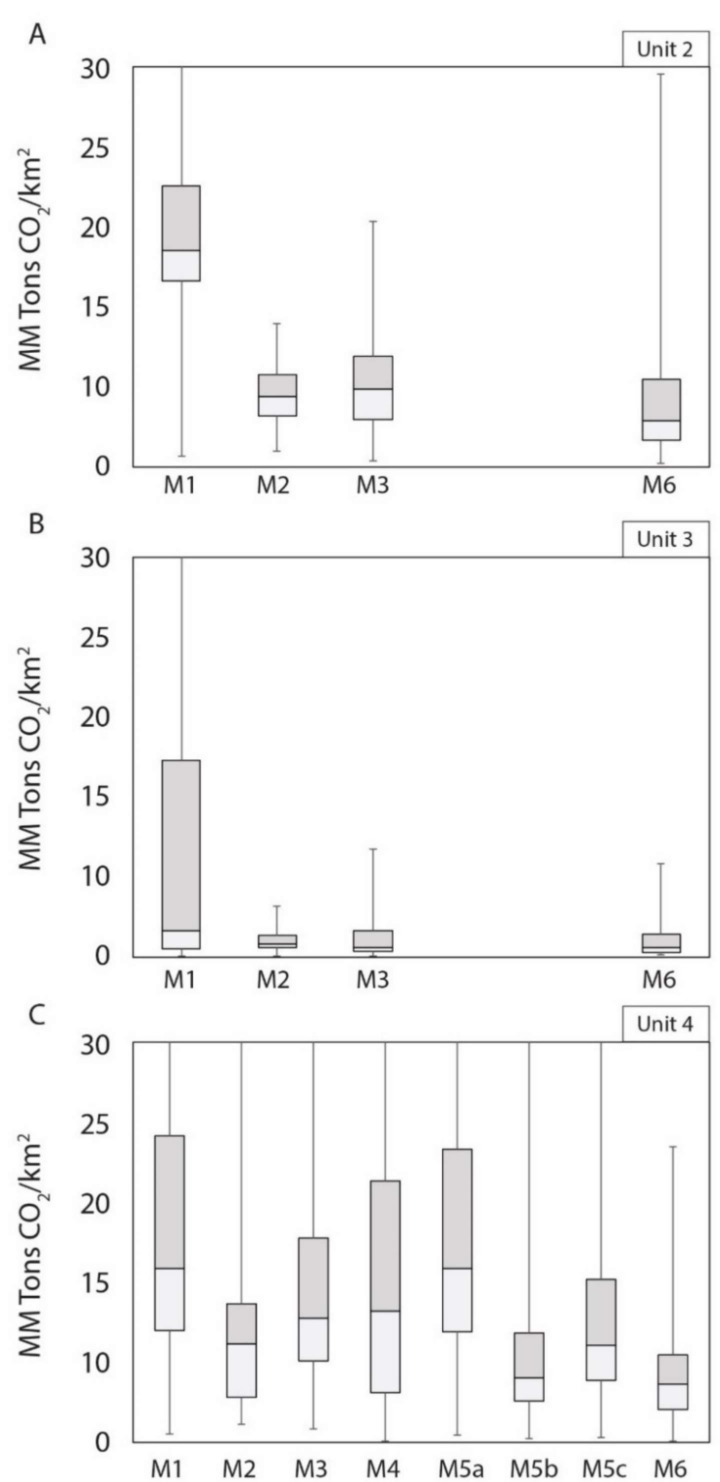

Figure 4-1. "Box-and-whisker" chart (sorted by units), illustrating SREs for all six methods using E=1 (100%). Instead of showing the mean and the standard error, the box-and-whisker plot shows the minimum, first quartile, median, third quartile, and maximum of a set of data. Statisticians refer to this set of statistics as a five-number summary (data in Table 3-5 and Table 4-1).

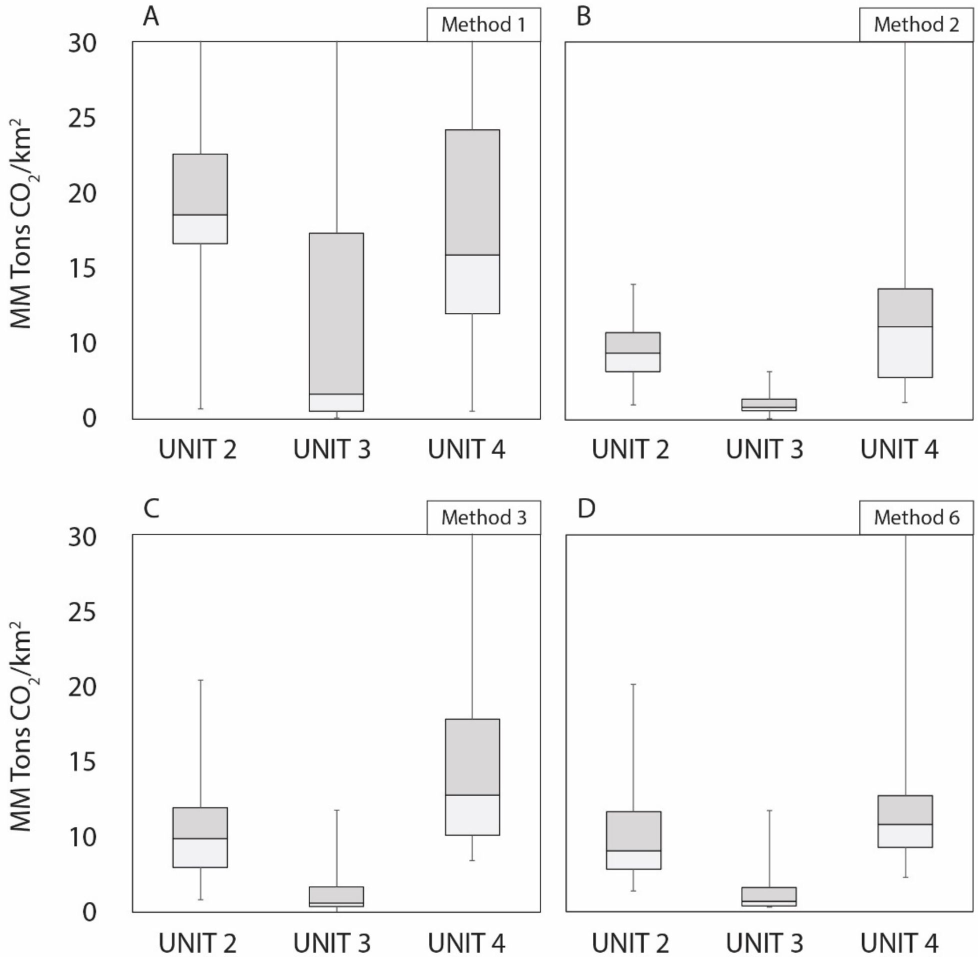

Figure 4-2. "Box-and-whisker" chart (sorted by method), illustrating SREs for three units using E=1 (100%). Note that Methods 4 and 5 are not presented as they were only applied to unit 4 in this study (data in Table 3-5 and Table 4-1).

4.1 Summary of Findings

4.1.1 Prospective Reservoirs

SREs in the MRCSP region suggest that there is sufficient storage capacity in the carbonate reservoirs of the Ordovician-Cambrian to deploy CCUS in the Midwest Region. Considering SREs estimated in this study and the CO2 emissions from stationary sources in the region result in 100+ years of storage.

4.1.2 Storage Capacity Estimates

These methodologies suggest that using a single value for the porosity of 10% (Method 1) or average porosity from wireline logs (Method 3) results in an overestimation of SREs.

For a complete list of SREs for Method 1, see APPENDIX F (Table F- 1, Table F- 2, and Table F- 3). Method 1-derived SREs assume a porosity of 10%, for a unit at a well, which resulted in higher values compared with the other methods, which use well-specific porosity data where available. Therefore, the hierarchical approach presented in this report can be used to apply the correct factor to the results in this table. For example, from Table F-5, we can see that resultant SREs when applying Method 3 result in values that are 36, 30, and 61% lower than same results from Method 1 for unit 2, 3, and 4, respectively. SREs calculated by different methods, not surprisingly result in different values. For regional planning purposes, results from Methods 1, 4, and 6 are perhaps best. Resulting SREs from the three methods should be viewed as representing estimates based on different types of data and data distribution. Methods 2, 3, and 5 are more appropriate for more local evaluations where the data needed for these methods are readily available. Regional scale SREs could possibly benefit from the use of efficiency factors that incorporate regional or basin-specific data for reservoir area, thickness, and porosity. These “intermediate” efficiency factors will generally increase in value and decrease in range to reflect the decrease in uncertainty (e.g., Ellett et al., 2013; Gorecki et al., 2009a, b; Goodman et al., 2013, 2016; Peck et al., 2014).

These estimates do not include local factors that should be included in the site-scale analysis (i.e., details of the local geology). Future work should incorporate dynamic aspects of reservoir performance during and after injection (Figure 4-3). This study is exploratory in nature and does not intend to determine which method is “better” or “worse than”, but rather, sets the stage for future consideration of integration of different methods based on robustness and availability. This is a good time, for example, to start considering stochastic SREs using formation-specific and site-scale data (e.g. Goodman et al., 2016) and the Variable Grid Method (VGM) introduced by NETL (Bauer and Rose, 2015).

4.1.3 Challenges and Future Work

To provide a more rigorous assessment of resource uncertainty, we will attempt to use other more advanced methods to further refine SREs, such as the rendering of a three-dimensional conceptual model of porosity using Petrel Software and/or a dynamic 3-D geological model that incorporates the changes in porosity as a function of CO2 saturation. However, these methods need a more comprehensive set of data and will only be applied in more restricted areas of the MRCSP region that have the required data (e.g., Michigan Basin). This work element is another important step in addressing the key programmatic goal of demonstrating reduced uncertainty in storage resource estimates.

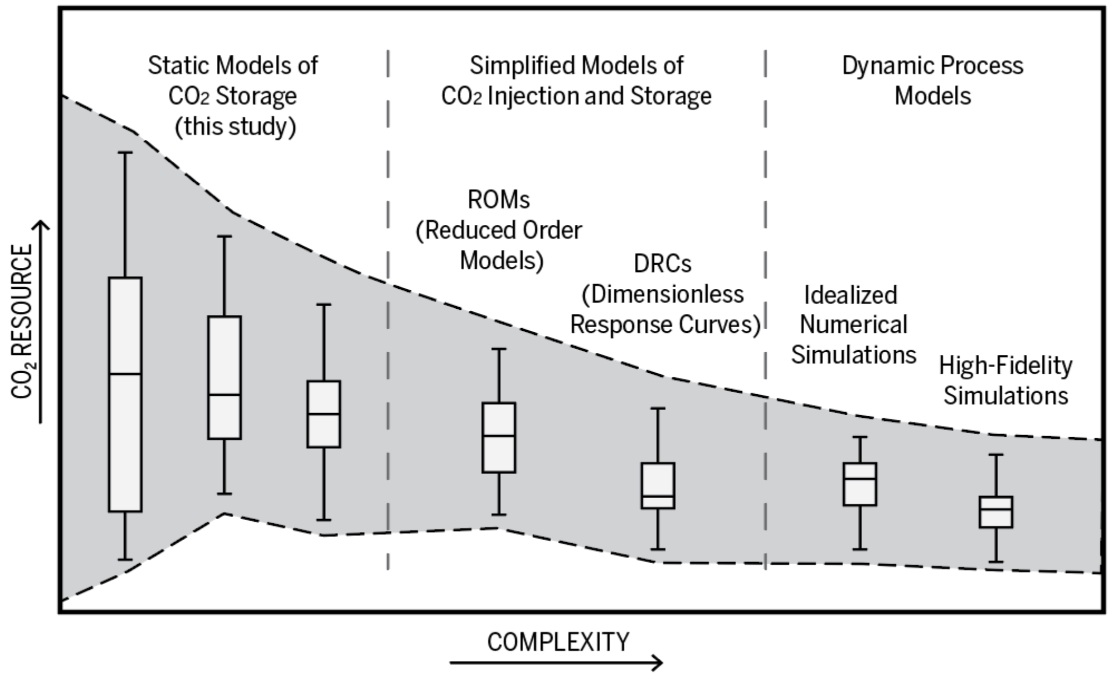

Figure 4-3. Schematic representation of the reduction of values (and variability) of SREs as a function of the conceptual model chosen for porosity.

4.1.4 Opportunities

We acknowledge that the drilling of a test well with an injection of supercritical CO_2 will provide more site-scale information that will decrease the level of uncertainties associated with the regional-scale assessments presented in this report. For example, the CarbonSAFE program is a possible activity that could help this preliminary assessment move towards implementation of CCUS practices in the reservoirs in this region.

A feasible way of portraying storage opportunities in the region is by means of regional-scale maps displaying the quantification of SREs, along with maps of depth and thickness of the units at any given county of the area assessed (APPENDIX C and APPENDIX D). Generally speaking, these maps and the results from this study suggest that the SRE potential is higher in those areas where the assessed potential reservoir-units occur at depths of 2,500-8,000 ft measured depth. These areas include the rim of the Michigan Basin in Michigan (units are often too deep in the center of the state), and parts of the Appalachian Basin, especially in parts of Ohio, eastern Kentucky, Pennsylvania, New York, and West Virginia. Although some areas in eastern West Virginia display some potential as indicated in Figure D- 1 through Figure D- 4 and Figure D- 9 through Figure D- 12, we did not assess the units in detail due to the complexities of the units associated with the Appalachian Basin. Because of the significant variability in depth and complexity of reservoir characteristics in the Rome Trough and the eastern portion of the Appalachian Basin, regional scale maps portraying storage capacities may be suspect. In these areas, we recommend site-scale assessments.

4.2 Recommendations

Future drilling provides opportunities to incorporate data from new tests to be used to carefully quantify the absolute storage effectiveness in a reservoir and how that highly accurate (dynamically derived) assessment be compared with the other types of estimates.

Based on the variability observed in the six methods applied in this work, we recommend that Methods 1, 4, and 6 can be best utilized for regional scale reconnaissance estimates of storage capacity while Methods 2, 3, and 5 are more appropriate for more local scales where more data is required. However, at site-scale evaluations, multiple factors should be considered, mostly related to data quantity and quality. For further reading on how the scale of investigations affects the resulting SREs and associated uncertainties, and to ensure that efforts on geologic characterization follow the best practices recommended for site screening and selection, we recommend the work of Goodman et al. (2016) and U.S. DOE NETL (2017).

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APPENDIX A Stratigraphic Nomenclature and Presence of Units Across the States in the MRCSP Region

Table A- 1. Ordovician System in the MRCSP Region[a]

Name	Indiana	Ohio	Michigan	Kentucky	West Virginia	Pennsylvania	Maryland	New York	New Jersey	System/Series	Unit Number
QUEENSTONE Formation		X	X			X		X		Upper Ordovician	
MAQUOKETA Group	X									Upper Ordovician	
RICHMOND Group			X							Upper Ordovician	
CINCINNATI Group		X								Upper Ordovician	
DRAKES Formation				X						Upper Ordovician	
BULL FORK Formation				X						Upper Ordovician	
JUNIATA Formation					X	X	X			Upper Ordovician	1
OSWEGO Formation					X					Upper Ordovician	
REEDSVILLE Shale					X	X				Upper Ordovician	
MARTINSBURG Formation					X	X	X		X	Upper Ordovician	
UTICA Shale			X			X		X		Upper Ordovician	
ANTES Formation						X				Upper Ordovician	
POINT PLEASANT Formation		X								Upper Ordovician	
COLLINGWOOD Shale			X							Upper Ordovician	
LEXINGTON Limestone	X	X		X						Upper Ordovician	
CHAMBERSBURG Group/Limestone					X		X			Upper Ordovician	
TRENTON Limestone	X	X	X		X	X		X		Upper Ordovician	
BLACK RIVER Group	X	X	X		X	X		X		Upper Ordovician	2
GLENWOOD Formation			X							Upper Ordovician	
PLATTIN Formation	X									Upper Ordovician	
PECATONICA Formation	X									Upper Ordovician	
HIGH BRIDGE Group				X						Upper Ordovician	

Name	Indiana	Ohio	Michigan	Kentucky	West Virginia	Pennsylvania	Maryland	New York	New Jersey	System/Series	Unit Number
LOYSBURG Formation						X				Upper Ordovician	
ANCELL Group	X									Upper Ordovician	
WELLS CREEK Dolomite		X		X	X	X				Middle Ordovician	
ST PAUL Group					X		X			Middle Ordovician	
ST PETER Sandstone	X	X	X	X	X					Middle Ordovician	
JOACHIM Dolomite	X									Middle Ordovician	3
DUTCHTOWN Formation	X									Middle Ordovician	
BEEKMANTOWN Dolomite		X		X	X	X	X	X	X	Middle Ordovician	
BELLEFONTE Formation						X				Middle Ordovician	
AXEMANN Formation						X				Middle Ordovician	
NITTANY Formation					X	X				Lower Ordovician	
STONEHENGE Formation					X	X	X		X	Lower Ordovician	
LARKE Formation						X				Lower Ordovician	
KNOX Supergroup	X	X		X	X			X		Lower Ordovician	4
PRAIRIE DU CHIEN Group	X		X							Lower Ordovician	
FOSTER Formation			X							Lower Ordovician	
SHAKOPEE Dolomite	X									Lower Ordovician	
ONEOTA Dolomite	X									Lower Ordovician	
PINESBURG STATION Dolomite					X		X			Lower Ordovician	
ROCKDALE RUN Formation					X		X			Lower Ordovician	
TOP OF: Eau Claire/Davis/Conasauga Gp./Elbrook Fm./Warrior Fm											5

a. Delaware not included.

APPENDIX B PETROPHYSICAL DATA

Petrophysical data* by state.

Sample #	Well ID	County	State	Lithology	Core Plug Depth		Core ϕ	ImageJ Porosity	Core Permeability
					[ft]	[m]	[%]	[%]	[mD]
11	162029	Jasper	Indiana	Carbonate	1369.00	417.27	2.80	13.5	47.4
12	162029	Jasper		Carbonate	1382.00	421.23	1.80	1.40	5.58
13	135986	Jasper		Carbonate	1451.00	442.26	3.30	4.20	0.0312
14	162029	Jasper		Carbonate	1646.00	501.70	1.40	0.10	3.59
15	162029	Jasper		Carbonate	1898.00	578.51	4.30	2.60	72.7
16	162029	Jasper		Carbonate	1454.00	443.18	5.70	6.00	0.00328
17	135986	Fulton		Carbonate	1513.00	461.16	10.90	11.80	56.9
18	135986	Fulton		Carbonate	1765.50	538.12	5.00	2.80	6.72
19	135986	Fulton		Carbonate	1995.00	608.08	5.40	5.50	24.6
20	135986	Fulton		Carbonate	2042.00	622.40	3.10	0.30	0.5
21	133708	Allen		Carbonate	2115.00	644.65	3.00	1.30	0.00614
22	133708	Allen		Carbonate	2115.50	644.80	2.80	2.80	0.0018
23	133708	Allen		Carbonate	2289.50	697.84	2.80	2.10	6.71
24	133708	Allen		Carbonate	2308.00	703.48	4.50	4.50	0.866
25	133708	Allen		Carbonate	2456.50	748.74	10.90	6.50	470
26	133708	Allen		Carbonate	2611.00	795.83	2.60	0.40	0.000949
27	133708	Allen		Carbonate	2648.00	807.11	22.30	8.70	93.8
28	133708	Allen		Carbonate	2687.50	819.15	6.60	5.20	0.351
29	164778	Knox		Carbonate	4414.00	1345.39	11.10	9.40	104
30	164778	Knox		Carbonate	4431.40	1350.69	1.00	3.40	0.00991
31	164778	Knox		Carbonate	4447.10	1355.48	2.90	0.10	0.000847
32	164778	Knox		Carbonate	4447.50	1355.60	2.70	0.30	0.000175
33	164778	Knox		Carbonate	5271.10	1606.63	3.20	13.10	5.96
34	164778	Knox		Carbonate	5284.70	1610.78	4.00	13.10	0.544
35	164778	Knox		Carbonate	5286.30	1611.26	1.00	0.74	0.000336
36	164778	Knox		Carbonate	5287.10	1611.51	8.80	7.30	1.23
37	164778	Knox		Carbonate	5654.80	1723.58	2.50	2.20	0.000692
38	164778	Knox		Carbonate	5659.40	1724.99	2.70	0.80	0.00168
39	164778	Knox		Carbonate	5665.50	1726.84	0.30	-	0.00651
40	164778	Knox		Carbonate	5671.80	1728.76	0.60	-	0.0402

*Carbonate lithology corresponds to samples from the Knox Supergroup and equivalent units (unit 4 in this study); Shale corresponds to the Maquoketa Shale (unit 1 in this study).

Petrophysical data* by state (continued).

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core ϕ [%]	ImageJ Porosity [%]	Core Permeability [mD]
41	16043001050000	Carter	Kentucky	Shale	2081.50	634.44	3.30	-	0.000037
42	16043001050000	Carter		Shale	2116.30	645.05	4.10	-	0.00004
43	16043001050000	Carter		Shale	2120.05	646.19	4.50	-	0.00006
44	16043001050000	Carter		Shale	2137.95	651.65	4.80	-	0.000058
45	16043001050000	Carter		Carbonate	3311.40	1009.31	18.70	11.00	275
46	16043001050000	Carter		Carbonate	3321.29	1012.33	3.60	0.70	0.000441
47	16043001050000	Carter		Carbonate	3325.19	1013.52	2.20	-	0.000051
48	16043001050000	Carter		Carbonate	3327.60	1014.25	9.60	-	0.0473
49	16043001050000	Carter		Carbonate	3331.00	1015.29	5.80	-	0.0084
50	16043001050000	Carter		Carbonate	3345.00	1019.56	8.20	0.50	0.0139
51	16043001050000	Carter		Carbonate	3349.50	1020.93	5.60	-	0.0115
52	16051012430000	Clay		Carbonate	3510.00	1069.85	8.70	1.14	0.419
53	16051012430000	Clay		Carbonate	3513.20	1070.82	7.70	-	0.0082
54	16043001050000	Carter		Carbonate	3785.00	1153.67	2.60	1.20	0.000038
55	16043001050000	Carter		Carbonate	3798.30	1157.72	6.70	2.10	2.5
56	16091013960000	Hancock		Carbonate	3845.30	1172.05	4.20	-	0.003
57	16091013960000	Hancock		Carbonate	3863.30	1177.53	6.30	-	0.0009
58	16091013960000	Hancock		Carbonate	3872.00	1180.19	4.40	-	0.031
59	16091013960000	Hancock		Carbonate	3873.45	1180.63	6.30	-	0.469
60	16043001050000	Carter		Shale	4261.85	1299.01	2.40	-	0.00009
61	16043001050000	Carter		Shale	4313.80	1314.85	1.70	-	0.000008
62	16043001050000	Carter		Shale	4615.95	1406.94	1.40	-	0.000004
63	16115461790000	Johnson		Carbonate	4852.00	1478.89	2.30	-	0.000315
64	16091013960000	Hancock		Carbonate	5098.05	1553.89	1.90	-	0.009

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core ϕ [%]	ImageJ Porosity [%]	Core Permeability [mD]
1	34031259620000	Coshocton	Ohio	Carbonate	6776.90	2065.60	6.10	0.55	0.0454
2	34031259620000	Coshocton		Carbonate	6777.50	2065.78	2.50	0.41	0.0034
3	34031259620000	Coshocton		Carbonate	6791.90	2070.17	4.80	0.28	0.0157
4	34117235520000	Morrow		Carbonate	2909.30	886.75	18.40	4.54	22.2
5	34117235520000	Morrow		Carbonate	2912.70	887.79	11.30	3.11	62.6
6	34117235520000	Morrow		Carbonate	2917.00	889.10	7.50	2.88	4.94
7	34145601410000	Scioto		Carbonate	4660.90	1420.64	3.10	0.02	0.00258
8	34145601410000	Scioto		Carbonate	4680.90	1426.74	4.80	1.11	0.000157
9	34145601410000	Scioto		Carbonate	4718.50	1438.20	4.90	1.03	0.000042
10	34145601410000	Scioto		Carbonate	4767.80	1453.23	4.40	0.77	0.000045

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core ϕ [%]	ImageJ Porosity [%]	Core Permeability [mD]
65	3706720001	Juniata	Pennsylvania	Carbonate	10027.00	3056.2296	2.16	-	0.038
66	3706720001	Juniata		Carbonate	10028.70	3056.7478	2.78	-	0.002

*Carbonate lithology corresponds to samples from the Knox Supergroup and equivalent units (unit 4 in this study); Shale corresponds to the Maquoketa Shale (unit 1 in this study).

Table B- 1. Petrophysical data[a] by state.

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core Φ [%]	ImageJ Porosity [%]	Core Permeability [mD]
1	162029	Jasper	Indiana	Carbonate	1369.00	417.27	2.80	13.5	47.4
2	162029	Jasper		Carbonate	1382.00	421.23	1.80	1.40	5.58
3	135986	Jasper		Carbonate	1451.00	442.26	3.30	4.20	0.0312
4	162029	Jasper		Carbonate	1646.00	501.70	1.40	0.10	3.59
5	162029	Jasper		Carbonate	1898.00	578.51	4.30	2.60	72.7
6	162029	Jasper		Carbonate	1454.00	443.18	5.70	6.00	0.00328
7	135986	Fulton		Carbonate	1513.00	461.16	10.90	11.80	56.9
8	135986	Fulton		Carbonate	1765.50	538.12	5.00	2.80	6.72
9	135986	Fulton		Carbonate	1995.00	608.08	5.40	5.50	24.6
10	135986	Fulton		Carbonate	2042.00	622.40	3.10	0.30	0.5
11	133708	Allen		Carbonate	2115.00	644.65	3.00	1.30	0.00614
12	133708	Allen		Carbonate	2115.50	644.80	2.80	2.80	0.0018
13	133708	Allen		Carbonate	2289.50	697.84	2.80	2.10	6.71
14	133708	Allen		Carbonate	2308.00	703.48	4.50	4.50	0.866
15	133708	Allen		Carbonate	2456.50	748.74	10.90	6.50	470
16	133708	Allen		Carbonate	2611.00	795.83	2.60	0.40	0.000949
17	133708	Allen		Carbonate	2648.00	807.11	22.30	8.70	93.8
18	133708	Allen		Carbonate	2687.50	819.15	6.60	5.20	0.351
19	164778	Knox		Carbonate	4414.00	1345.39	11.10	9.40	104
20	164778	Knox		Carbonate	4431.40	1350.69	1.00	3.40	0.00991
21	164778	Knox		Carbonate	4447.10	1355.48	2.90	0.10	0.000847
22	164778	Knox		Carbonate	4447.50	1355.60	2.70	0.30	0.000175
23	164778	Knox		Carbonate	5271.10	1606.63	3.20	13.10	5.96
24	164778	Knox		Carbonate	5284.70	1610.78	4.00	13.10	0.544
25	164778	Knox		Carbonate	5286.30	1611.26	1.00	0.74	0.000336

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core Φ [%]	ImageJ Porosity [%]	Core Permeability [mD]
26	164778	Knox		Carbonate	5287.10	1611.51	8.80	7.30	1.23
27	164778	Knox		Carbonate	5654.80	1723.58	2.50	2.20	0.000692
28	164778	Knox		Carbonate	5659.40	1724.99	2.70	0.80	0.00168
29	164778	Knox		Carbonate	5665.50	1726.84	0.30	-	0.00651
30	164778	Knox		Carbonate	5671.80	1728.76	0.60	-	0.0402

a. Carbonate lithology corresponds to samples from the Knox Supergroup and equivalent units (unit 4 in this study); shale corresponds to the Maquoketa Shale (unit 1 in this study).

Table B- 2. Petrophysical data[a] by state (continued).

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core Φ [%]	ImageJ Porosity [%]	Core Permeability [mD]
31	160430	Carter	Kentucky	Shale	2081.50	634.44	3.30	-	0.000037
32	160430	Carter		Shale	2116.30	645.05	4.10	-	0.00004
33	160430	Carter		Shale	2120.05	646.19	4.50	-	0.00006
34	160430	Carter		Shale	2137.95	651.65	4.80	-	0.000058
35	160430	Carter		Carbonate	3311.40	1009.31	18.70	11.00	275
36	160430	Carter		Carbonate	3321.29	1012.33	3.60	0.70	0.000441
37	160430	Carter		Carbonate	3325.19	1013.52	2.20	-	0.000051
38	160430	Carter		Carbonate	3327.60	1014.25	9.60	-	0.0473
39	160430	Carter		Carbonate	3331.00	1015.29	5.80	-	0.0084
40	160430	Carter		Carbonate	3345.00	1019.56	8.20	0.50	0.0139
41	160430	Carter		Carbonate	3349.50	1020.93	5.60	-	0.0115
42	160510	Clay		Carbonate	3510.00	1069.85	8.70	1.14	0.419
43	160510	Clay		Carbonate	3513.20	1070.82	7.70	-	0.0082
44	160430	Carter		Carbonate	3785.00	1153.67	2.60	1.20	0.000038
45	160430	Carter		Carbonate	3798.30	1157.72	6.70	2.10	2.5
46	160910	Hancock		Carbonate	3845.30	1172.05	4.20	-	0.003
47	160910	Hancock		Carbonate	3863.30	1177.53	6.30	-	0.0009
48	160910	Hancock		Carbonate	3872.00	1180.19	4.40	-	0.031
49	160910	Hancock		Carbonate	3873.45	1180.63	6.30	-	0.469
50	160430	Carter		Shale	4261.85	1299.01	2.40	-	0.00009
51	160430	Carter		Shale	4313.80	1314.85	1.70	-	0.000008
52	160430	Carter		Shale	4615.95	1406.94	1.40	-	0.000004
53	1611546	Johnson		Carbonate	4852.00	1478.89	2.30	-	0.000315
54	1609101	Hancock		Carbonate	5098.05	1553.89	1.90	-	0.009

a. Carbonate lithology corresponds to samples from the Knox Supergroup and equivalent units (unit 4 in this study); shale corresponds to the Maquoketa Shale (unit 1 in this study).

Table B- 3. Petrophysical data[a] by state (continued).

Sample #	Well ID	County	State	Lithology	Core Plug Depth [ft]	Core Plug Depth [m]	Core Φ [%]	ImageJ Porosity [%]	Core Permeability [mD]
55	340312	Coshocton	Ohio	Carbonate	6776.90	2065.60	6.10	0.55	0.0454
56	340312	Coshocton		Carbonate	6777.50	2065.78	2.50	0.41	0.0034
57	340312	Coshocton		Carbonate	6791.90	2070.17	4.80	0.28	0.0157
58	341172	Morrow		Carbonate	2909.30	886.75	18.40	4.54	22.2
59	341172	Morrow		Carbonate	2912.70	887.79	11.30	3.11	62.6
60	341172	Morrow		Carbonate	2917.00	889.10	7.50	2.88	4.94
61	341456	Scioto		Carbonate	4660.90	1420.64	3.10	0.02	0.00258
62	341456	Scioto		Carbonate	4680.90	1426.74	4.80	1.11	0.000157
63	341456	Scioto		Carbonate	4718.50	1438.20	4.90	1.03	0.000042
64	341456	Scioto		Carbonate	4767.80	1453.23	4.40	0.77	0.000045
Sample #	**Well ID**	**County**	**State**	**Lithology**	**Core Plug Depth [ft]**	**Core Plug Depth [m]**	**Core Φ [%]**	**ImageJ Porosity [%]**	**Core Permeability [mD]**
65	370672	Juniata	Pennsylvania	Carbonate	10027.00	3056.23	2.16	-	0.038
66	370672	Juniata		Carbonate	10028.70	3056.748	2.78	-	0.002

a. Carbonate lithology corresponds to samples from the Knox Supergroup and equivalent units (unit 4 in this study); shale corresponds to the Maquoketa Shale (unit 1 in this study).

APPENDIX C STRUCTURE AND ISOPACH MAPS

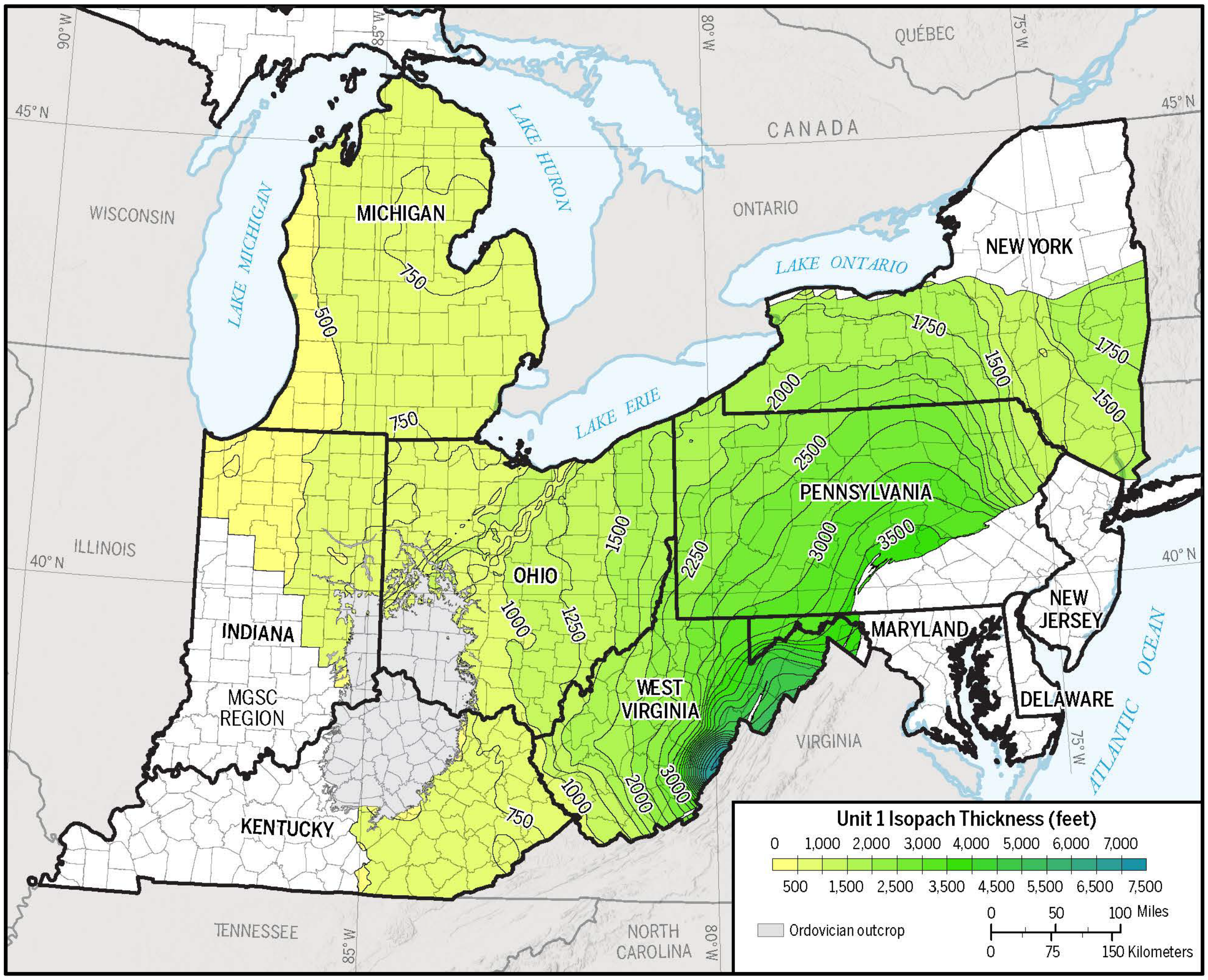

Figure C- 1. Isopach map (thickness) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

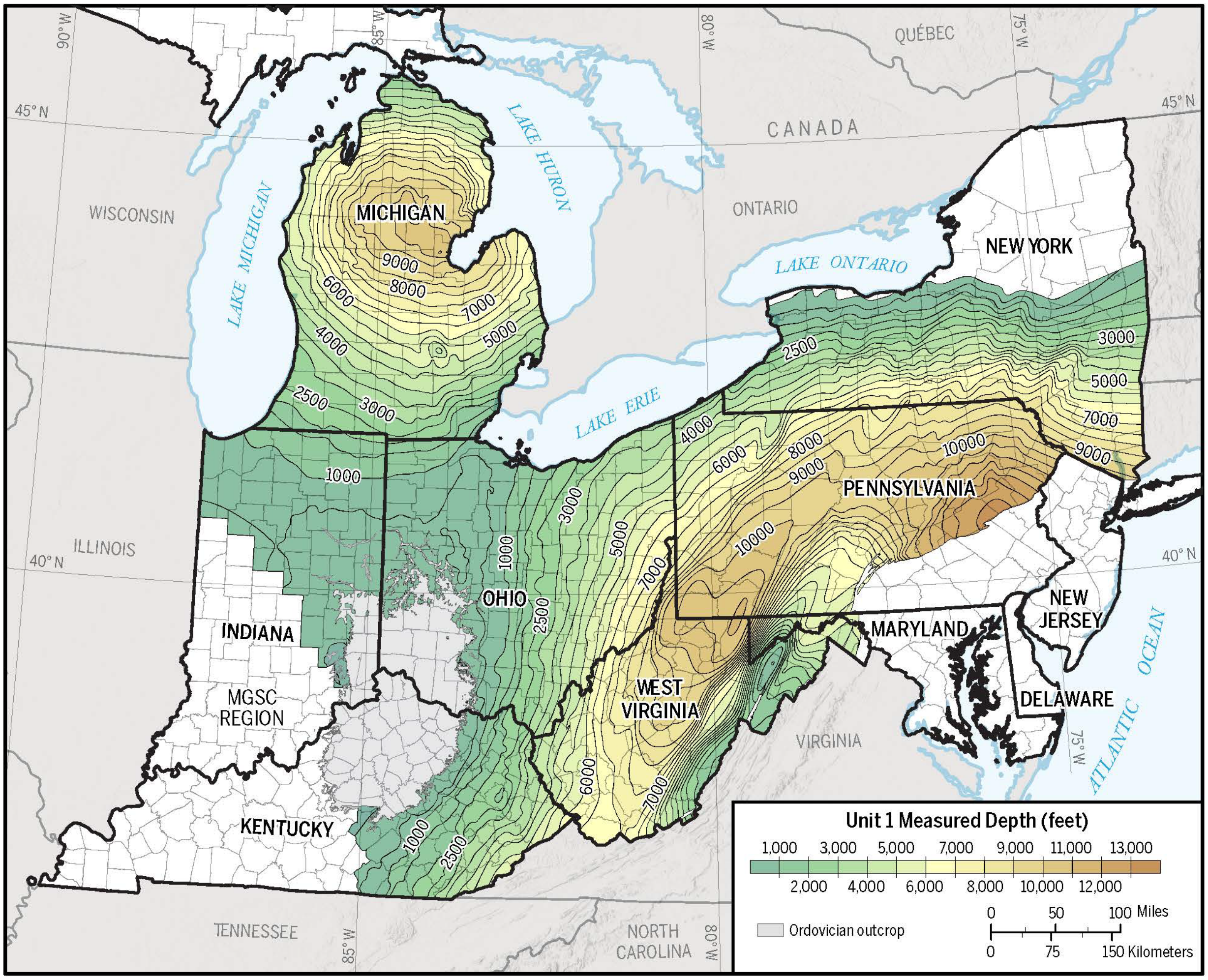

Figure C- 2. Measured depth (in feet) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 t are shown in gray.

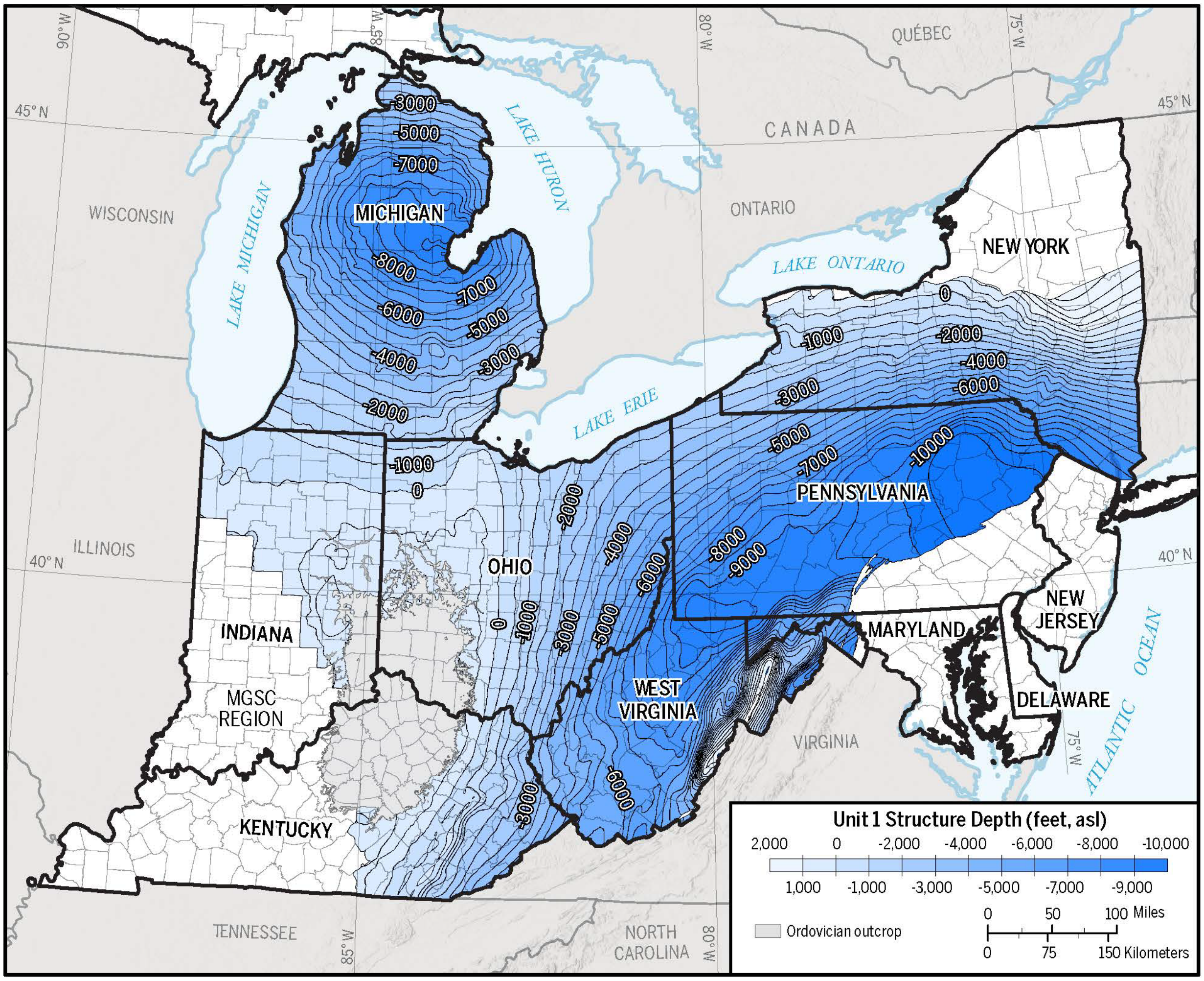

Figure C- 3. Structure map (in feet above sea level) of the Maquoketa Group and equivalent units (unit 1). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

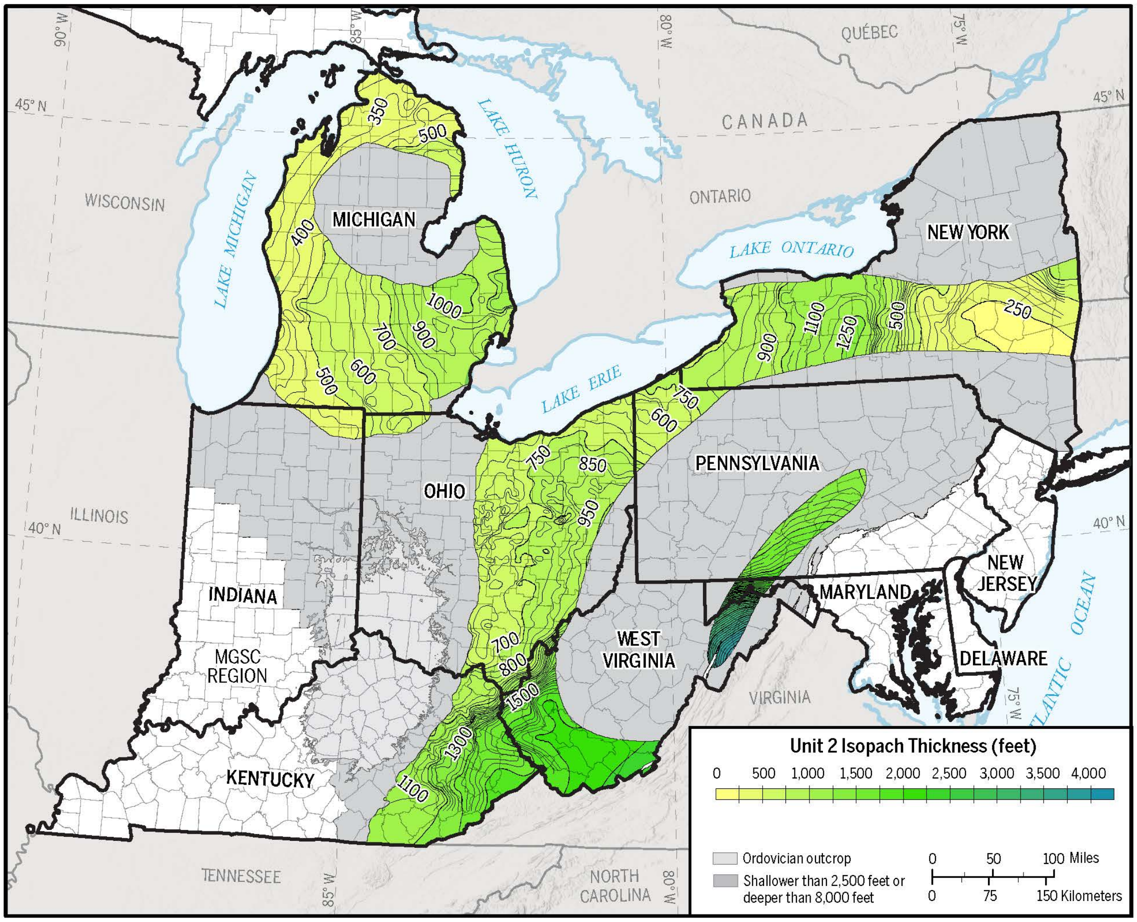

Figure C- 4. Isopach map (thickness) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

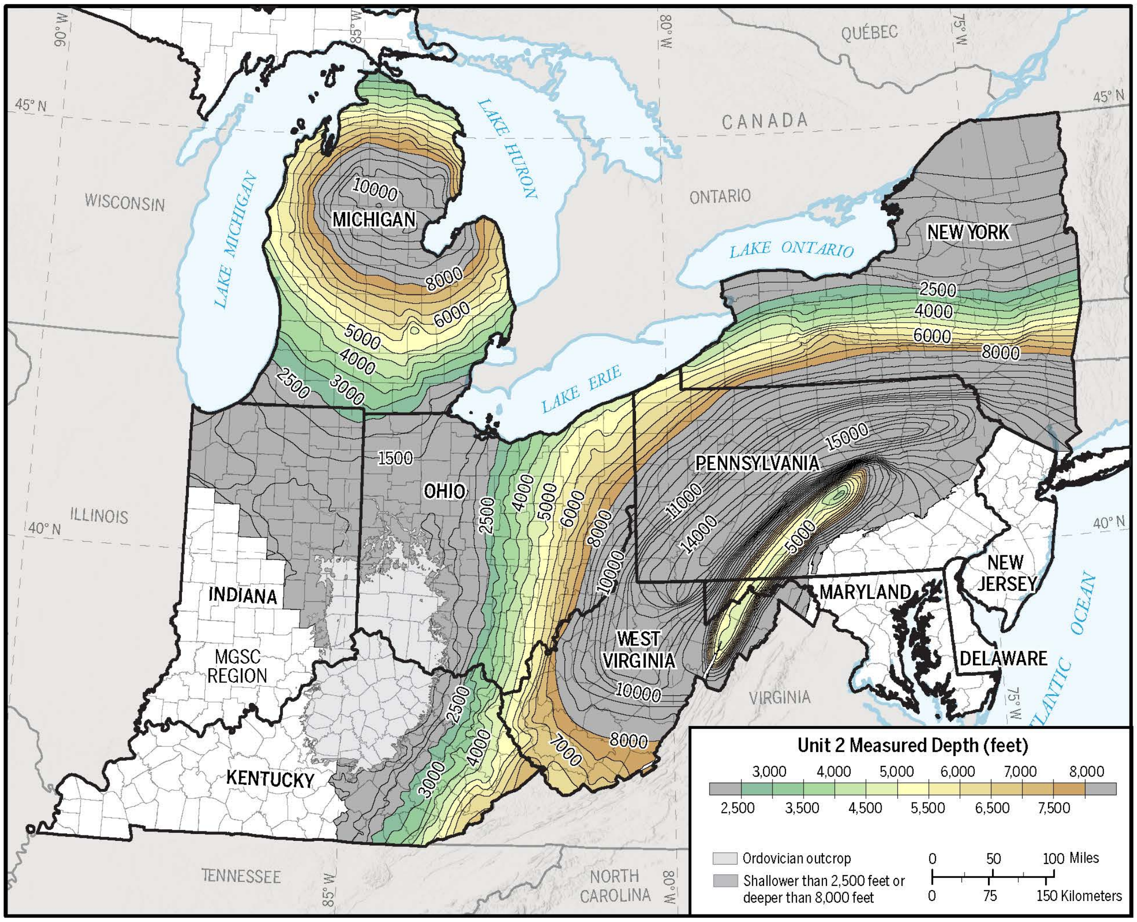

Figure C- 5. Measured depth (in feet) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

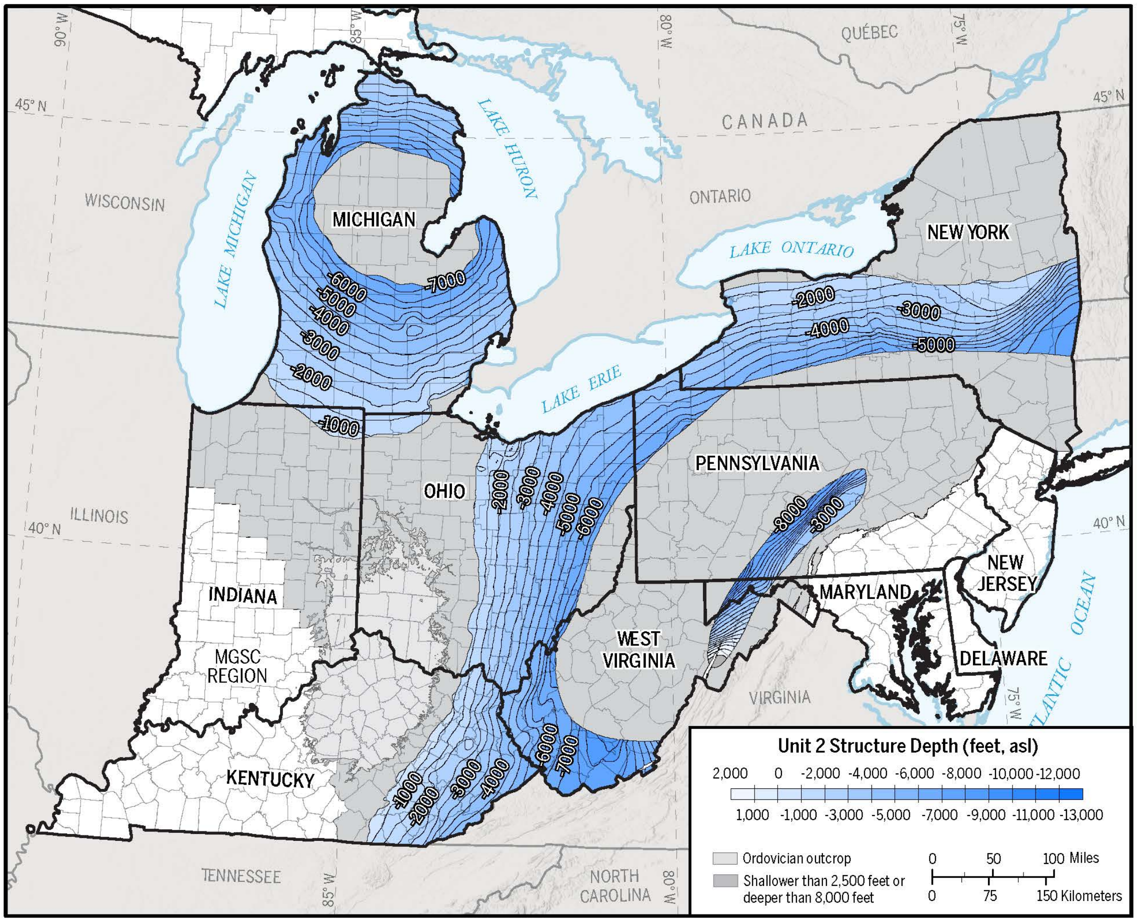

Figure C- 6. Structure map (in feet above sea level) of the Trenton/Black River Group and equivalent units (unit 2). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

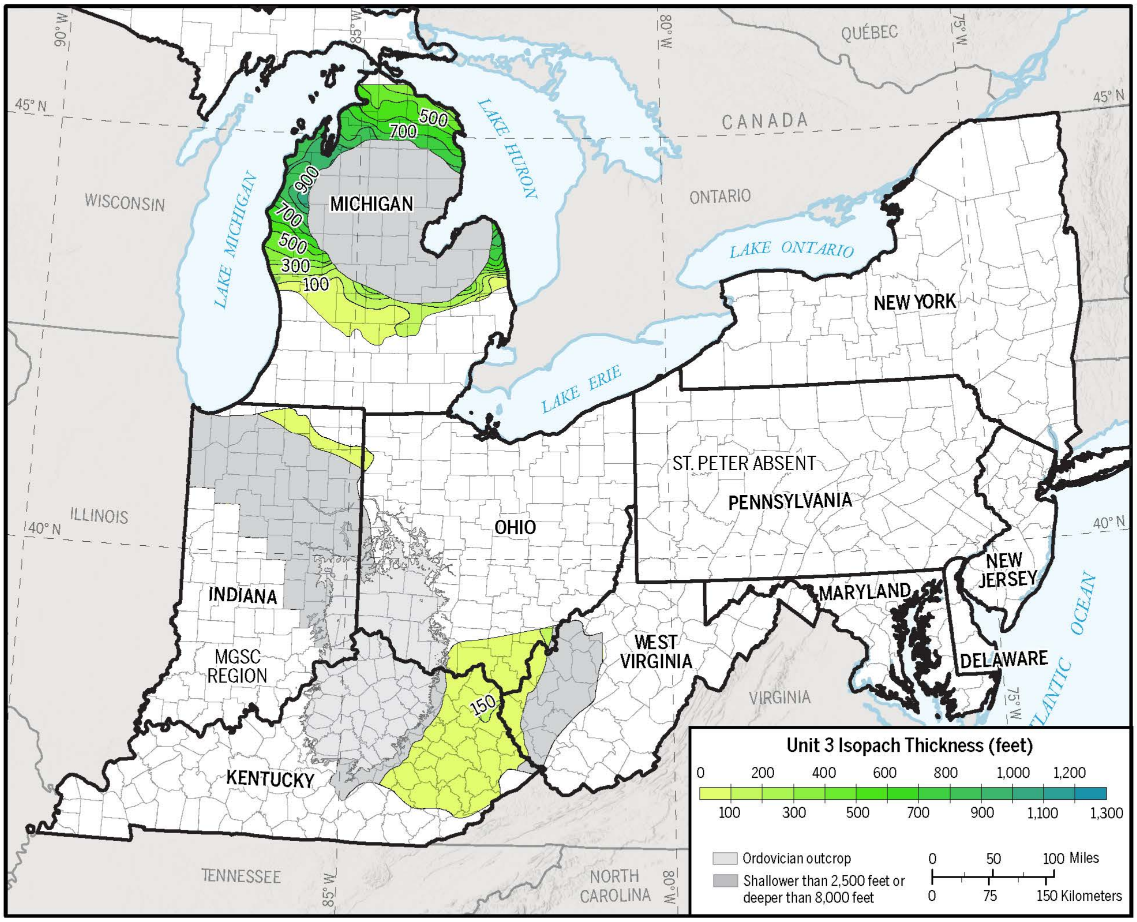

Figure C- 7. Isopach map (thickness) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

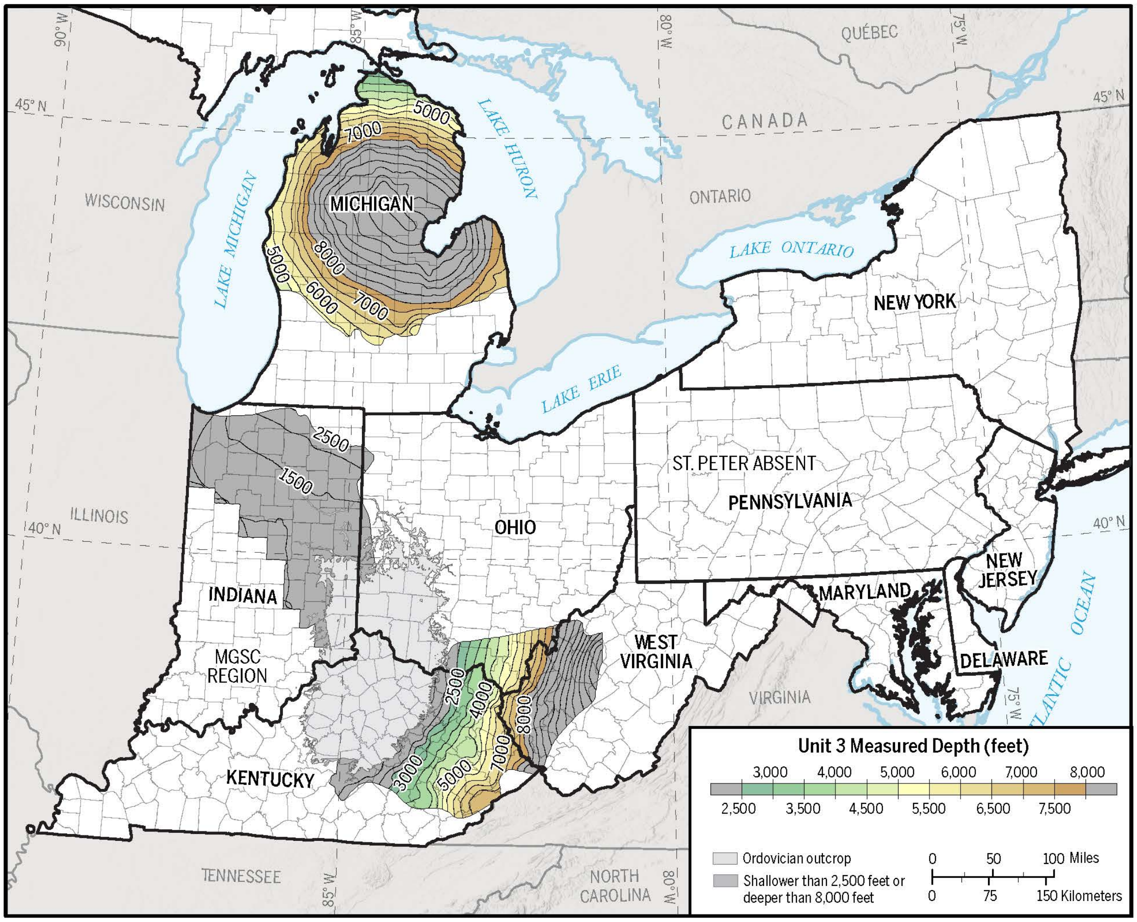

Figure C- 8. Measured depth (in feet) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

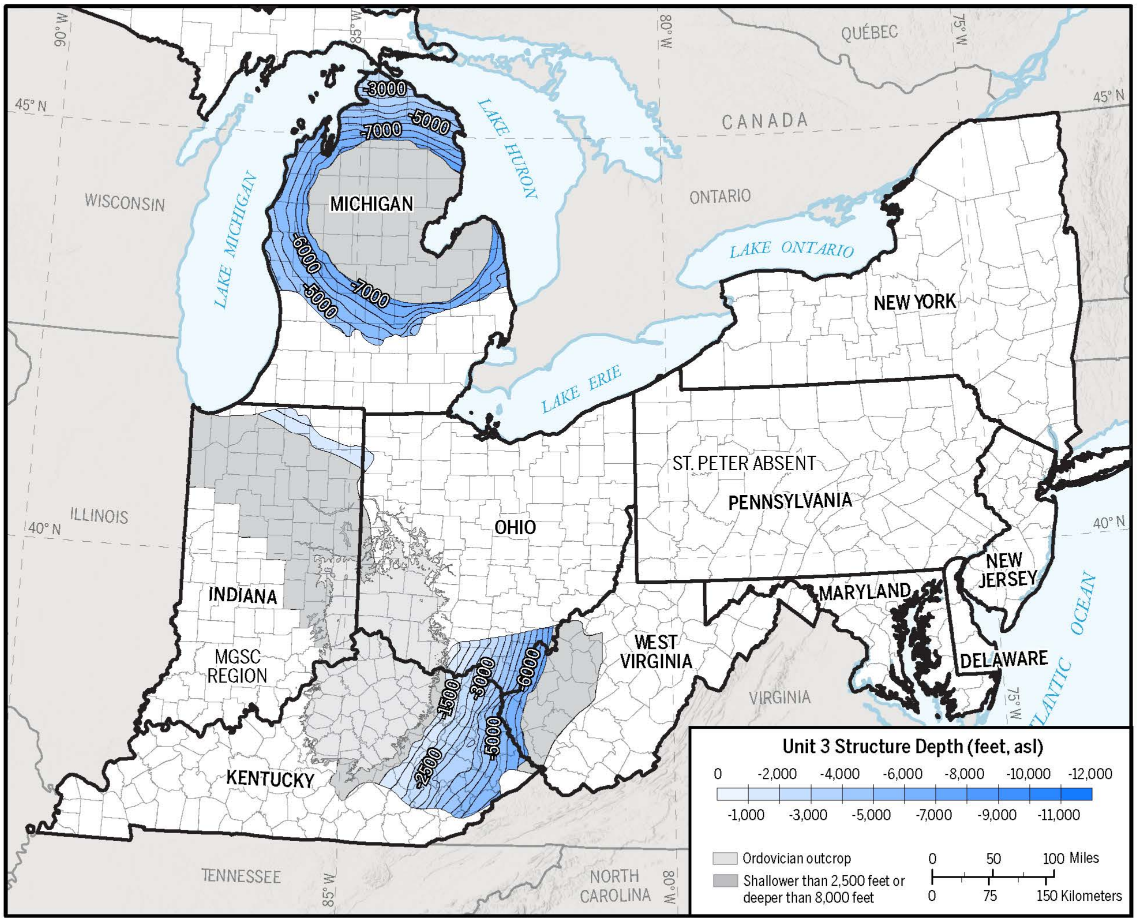

Figure C- 9. Structure map (in feet above sea level) of the St. Peter Sandstone (unit 3). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

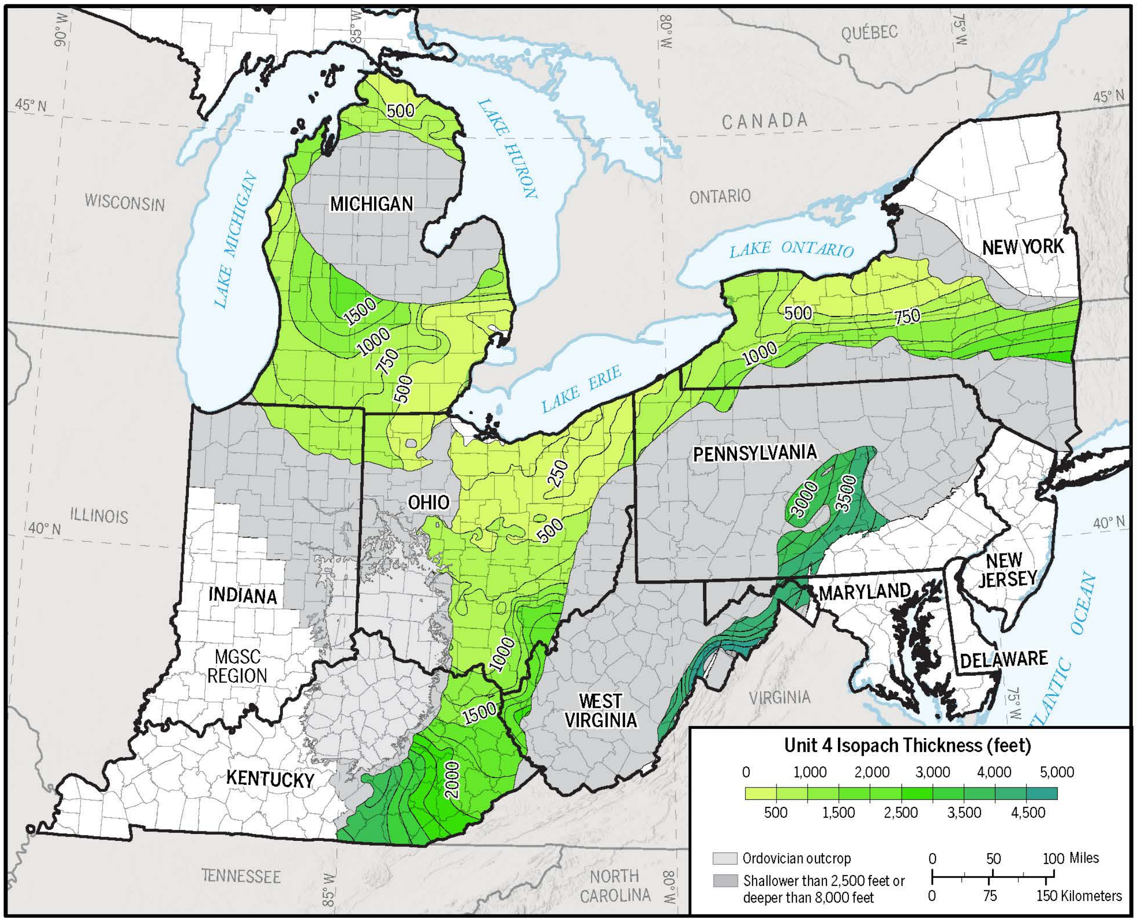

Figure C- 10. Isopach map (thickness) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

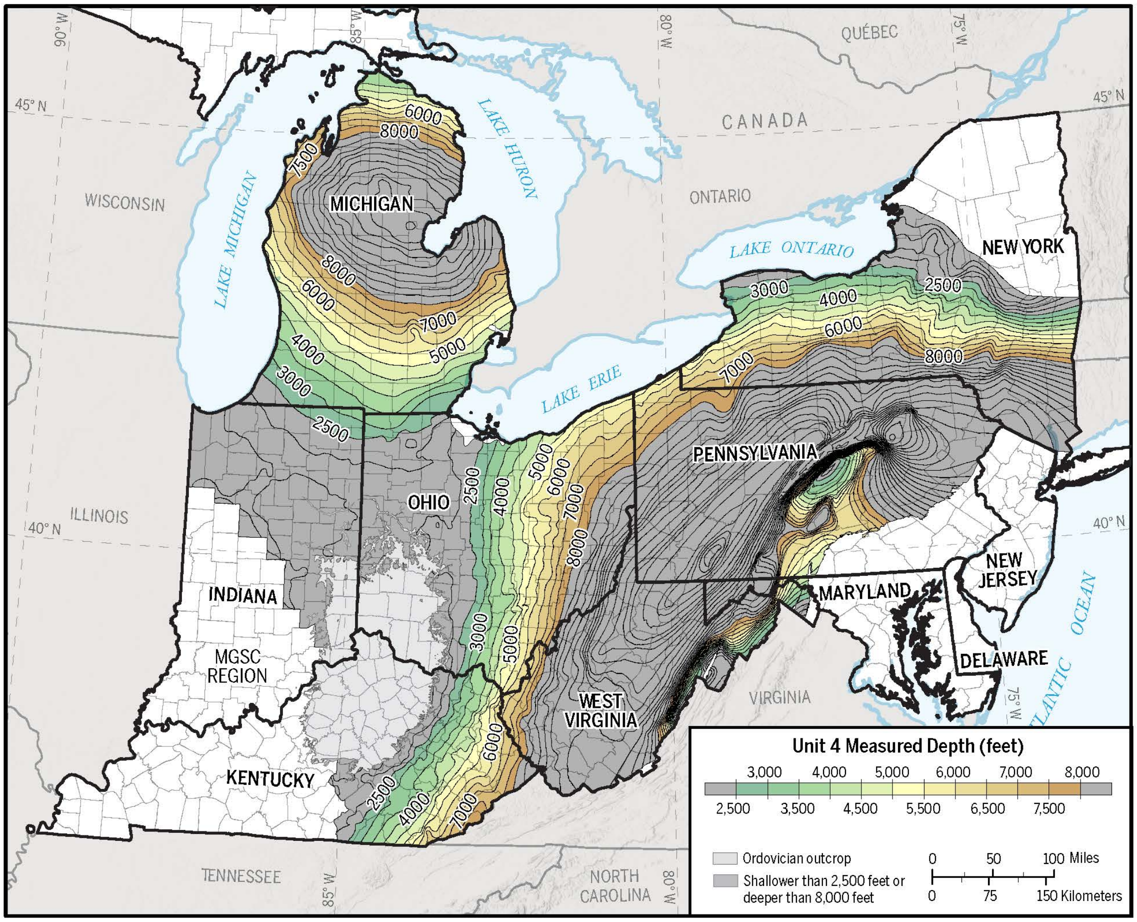

Figure C- 11. Measured depth (in feet) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

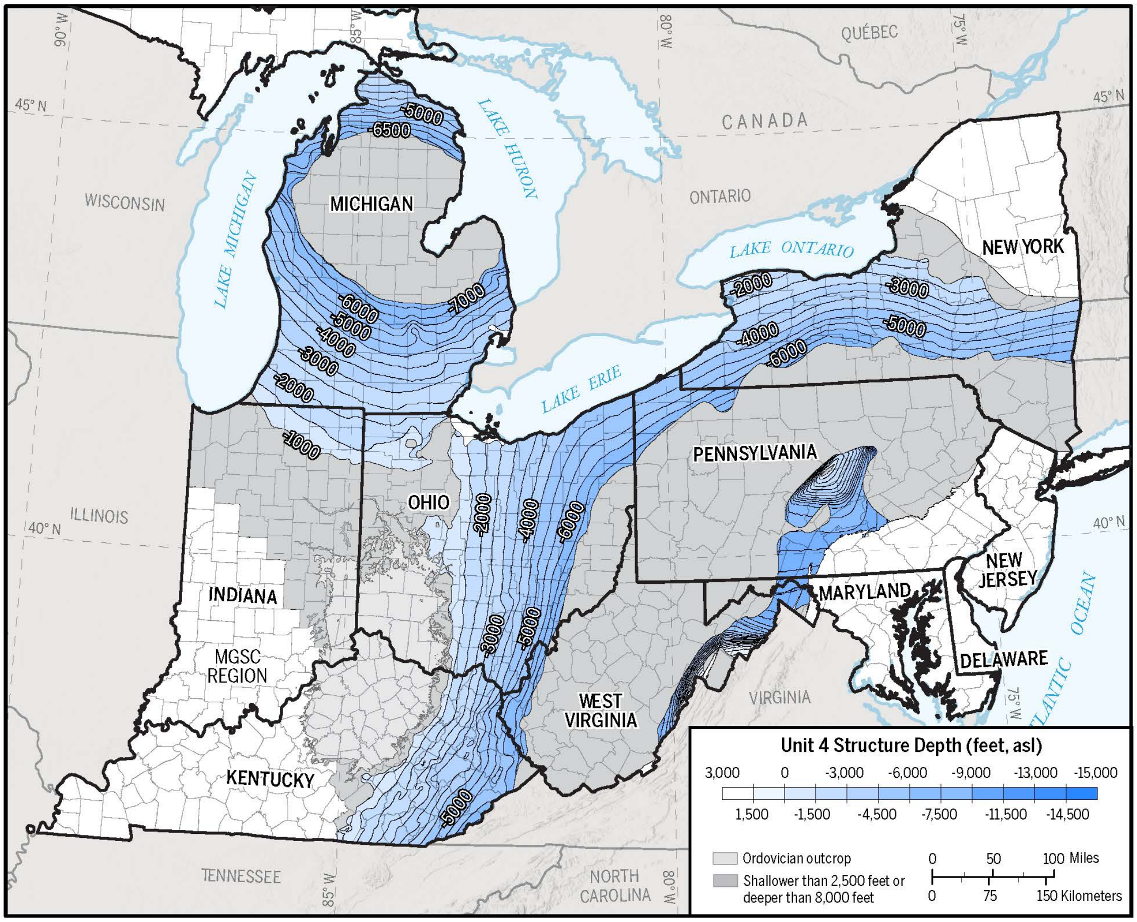

Figure C- 12. Structure map (in feet above sea level) of the Knox Supergroup and equivalent units (unit 4). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

APPENDIX D SREs CALCULATED USING METHOD 1. VALUES ARE TOTAL SREs PER COUNTY (OR THE PORTION OF THE COUNTY DISPLAYED IN MAPS), IN MILLION TONS.

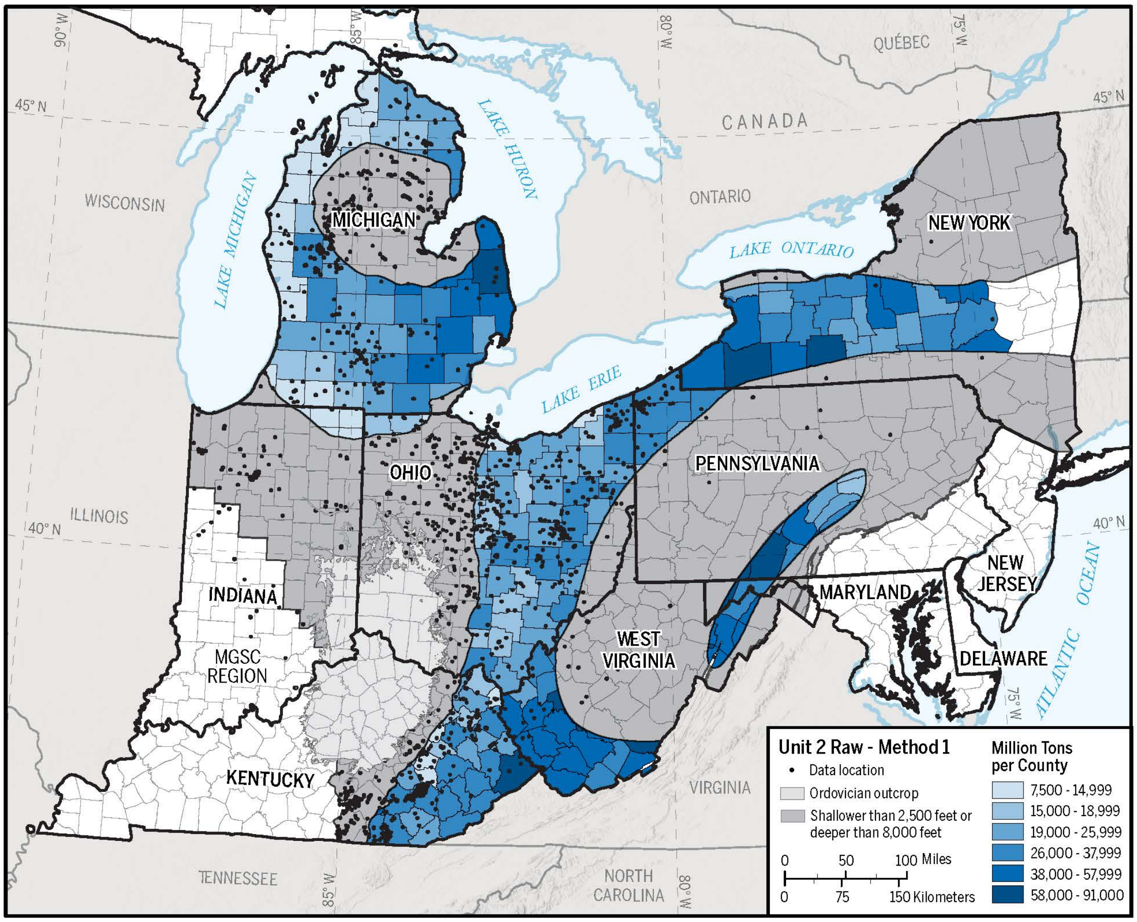

Figure D- 1. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

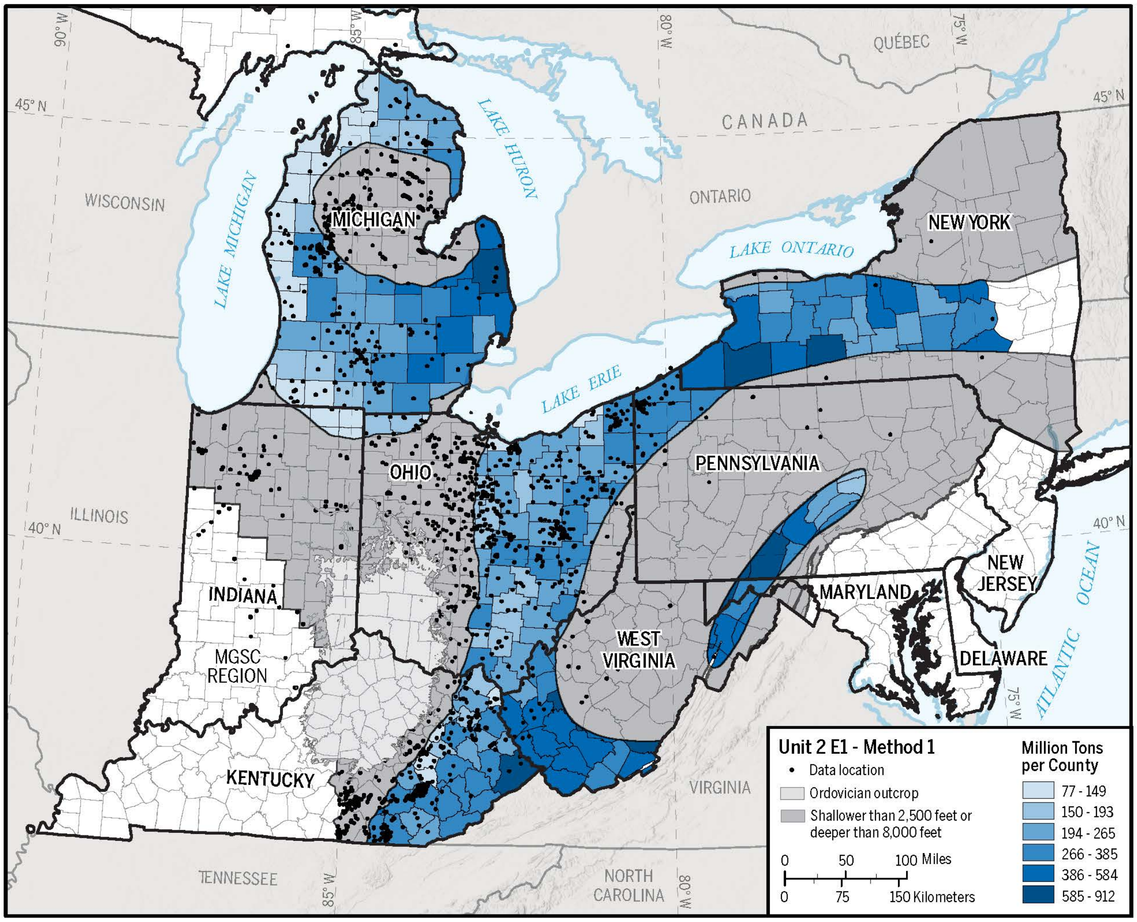

Figure D- 2. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

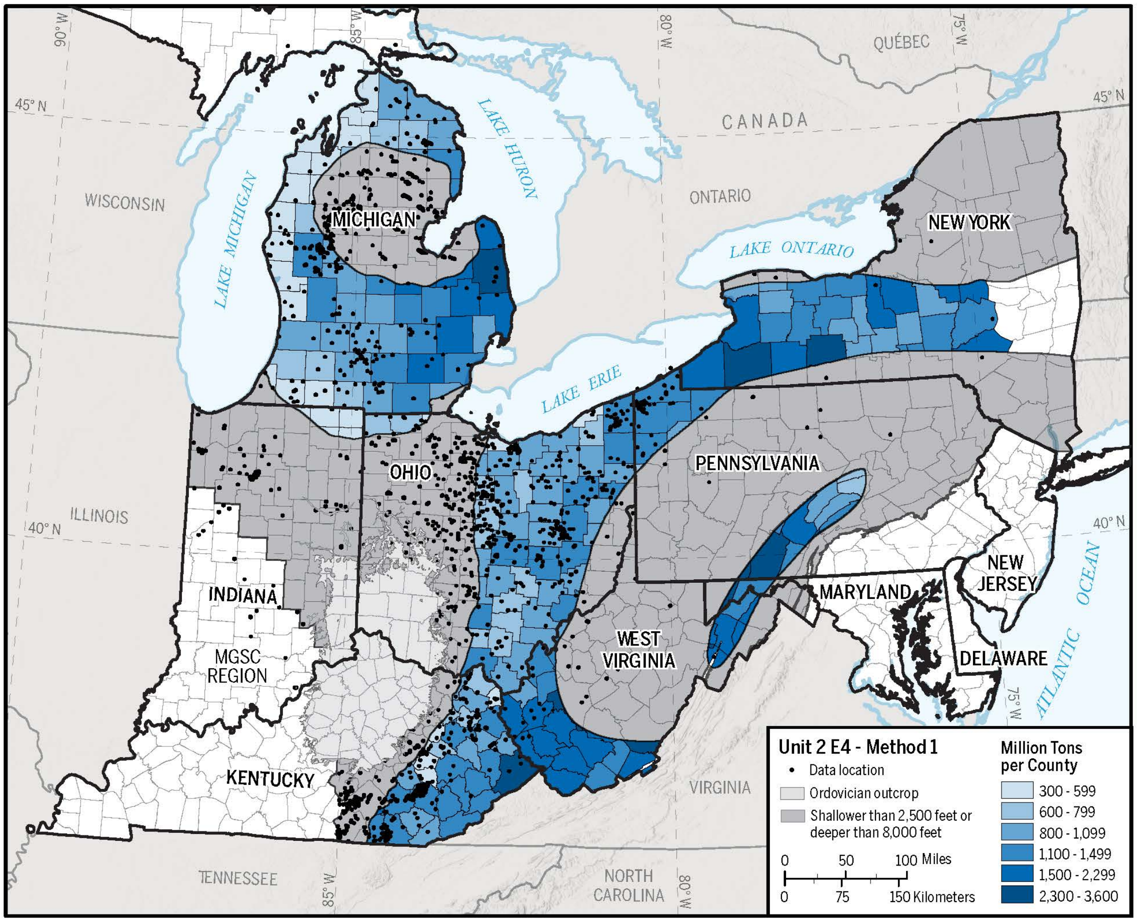

Figure D- 3. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

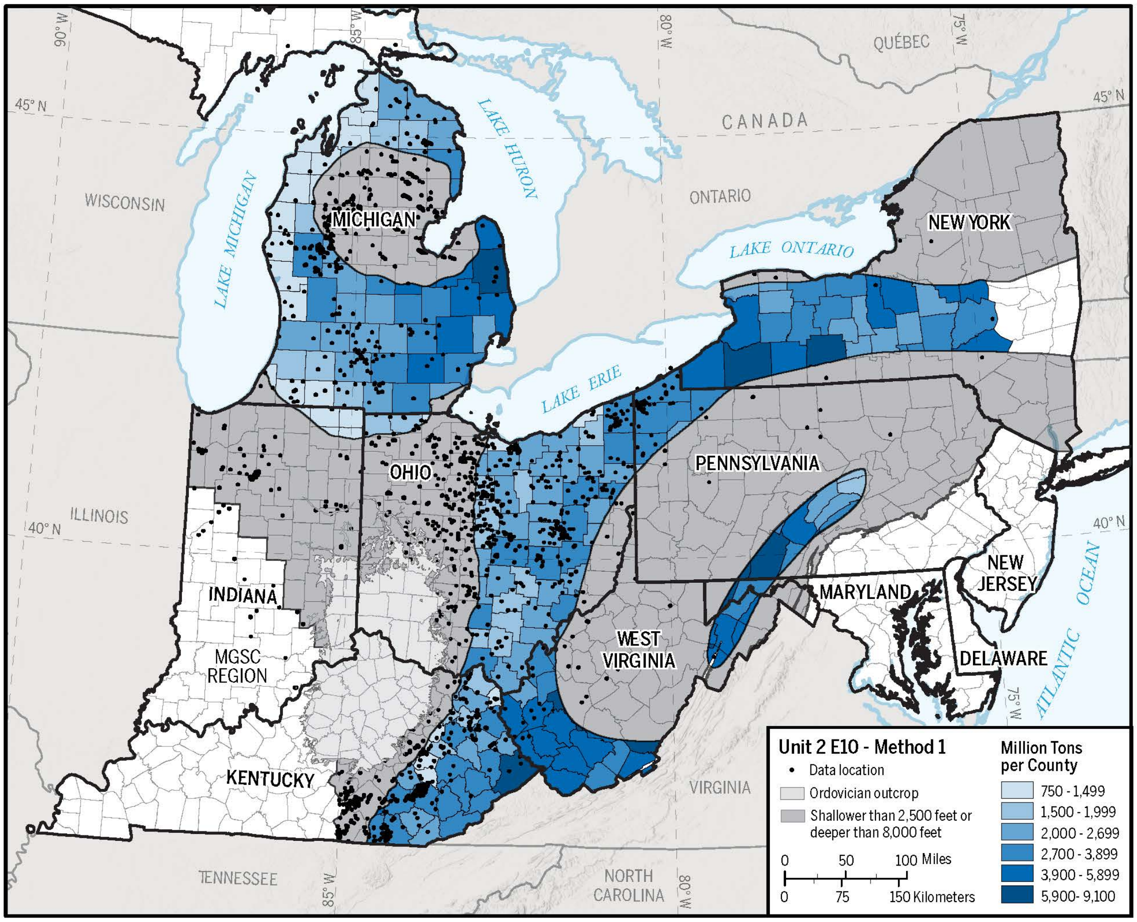

Figure D- 4. Storage resource estimates (SREs) for the Trenton/Black River Group and equivalent units (unit 2). This map represents results from Method 1 with efficiency factor =0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

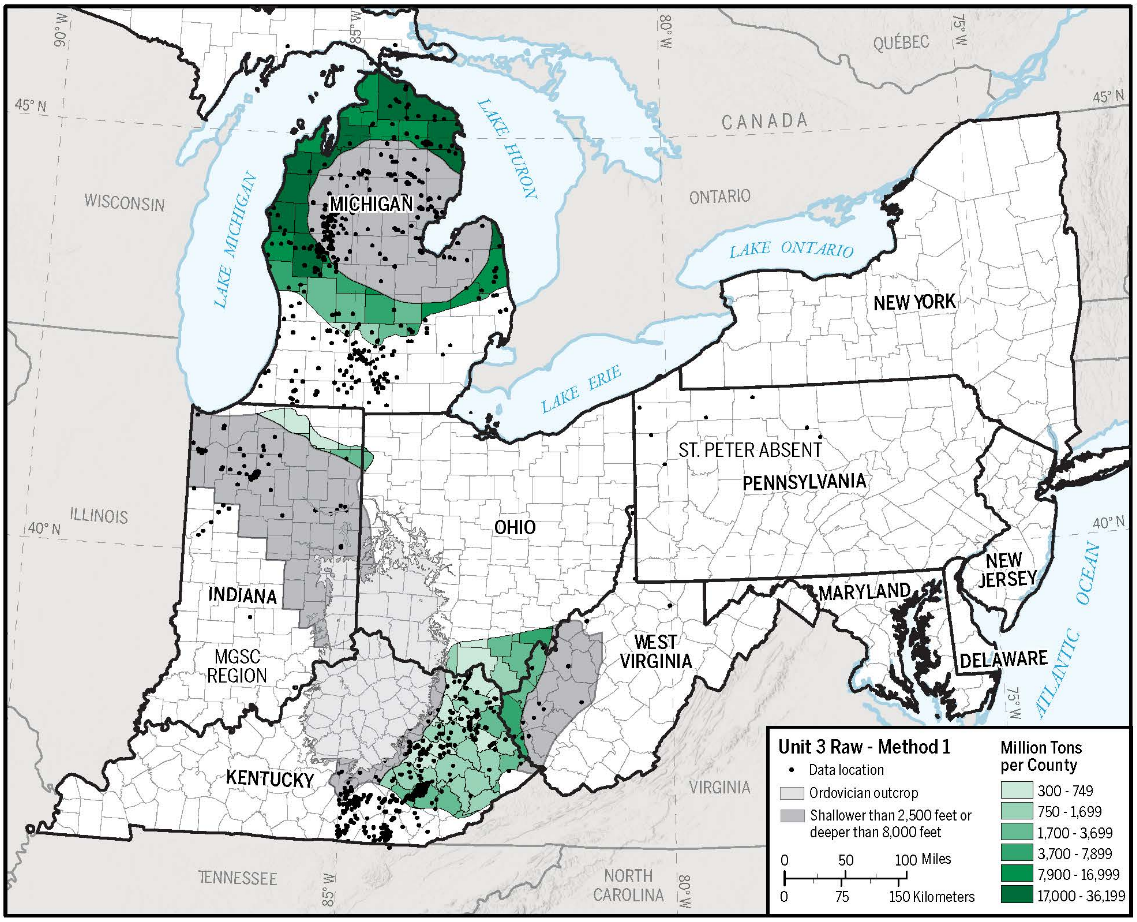

Figure D- 5. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

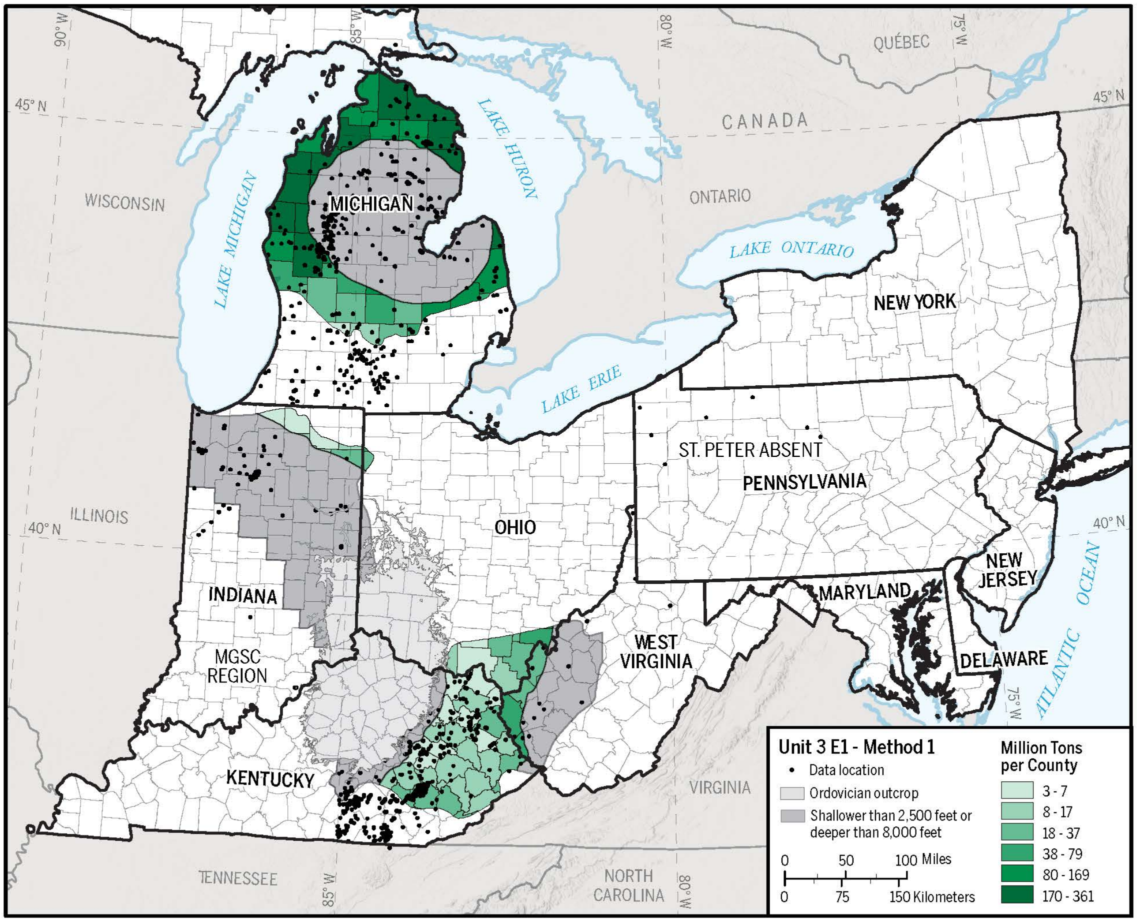

Figure D- 6. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

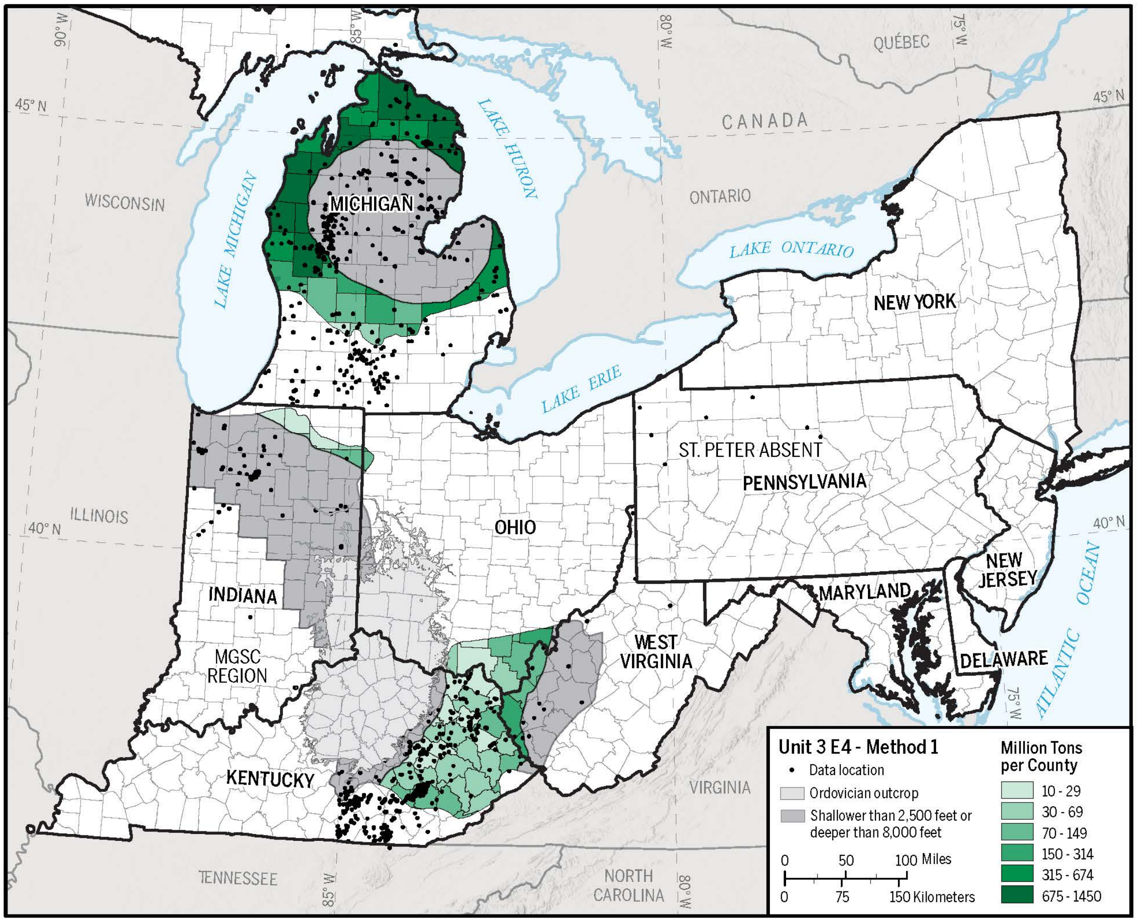

Figure D- 7. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

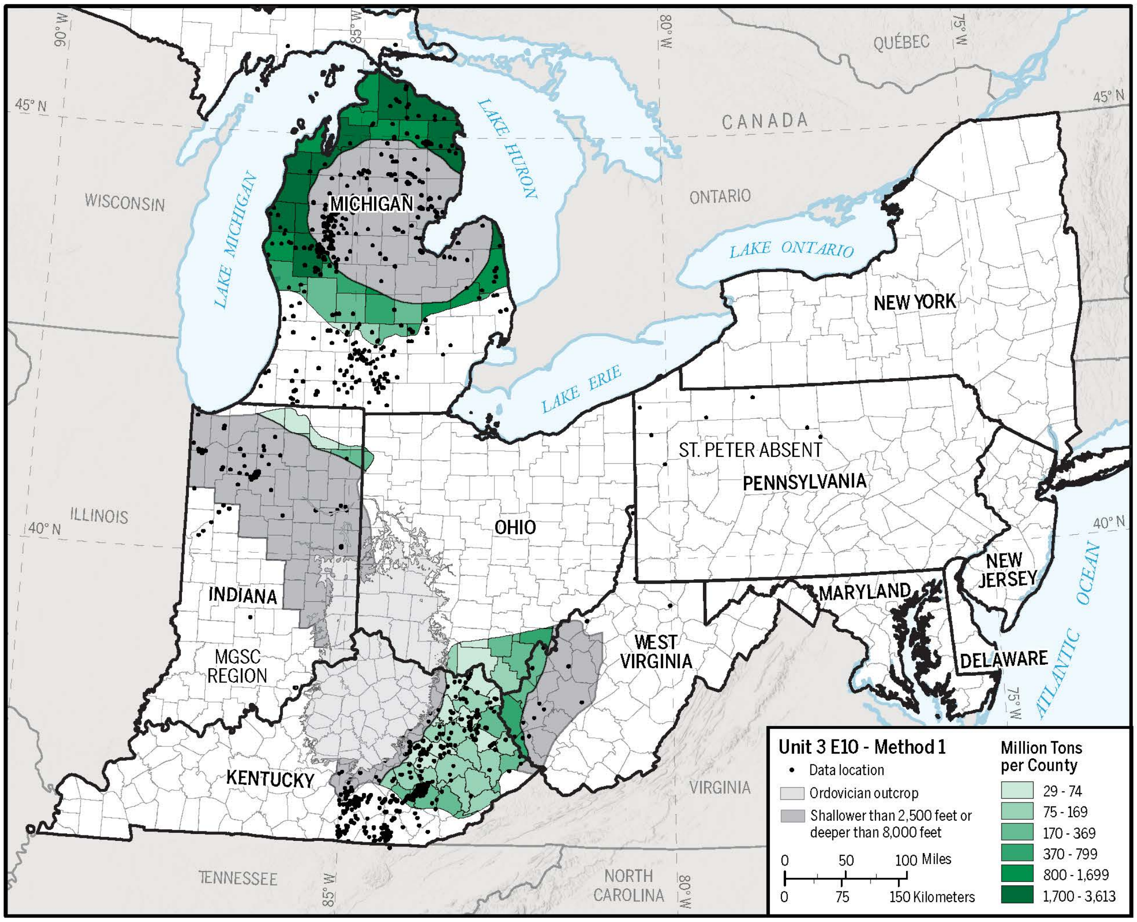

Figure D- 8. Storage resource estimates (SREs) for the St. Peter Sandstone (unit 3). This map represents results from Method 1 with efficiency factor = 0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

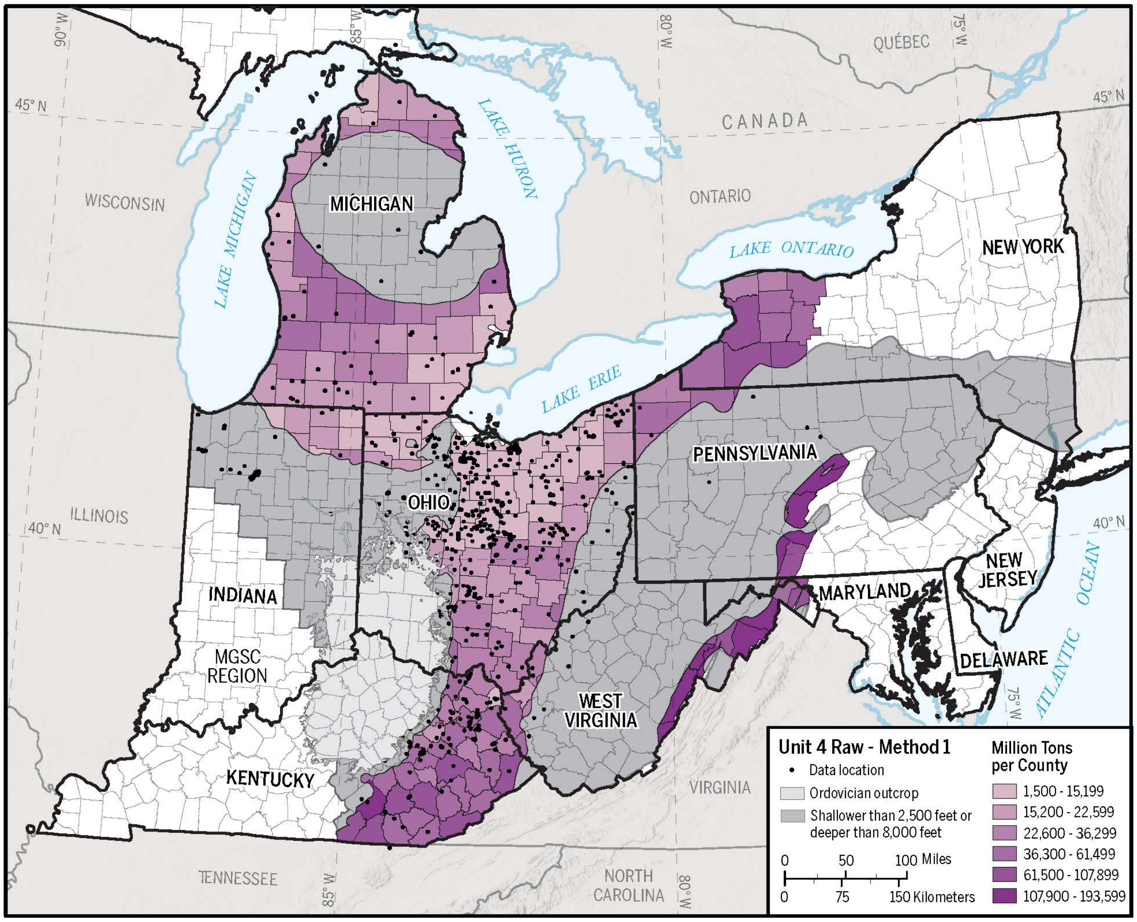

Figure D- 9. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 1 (100% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

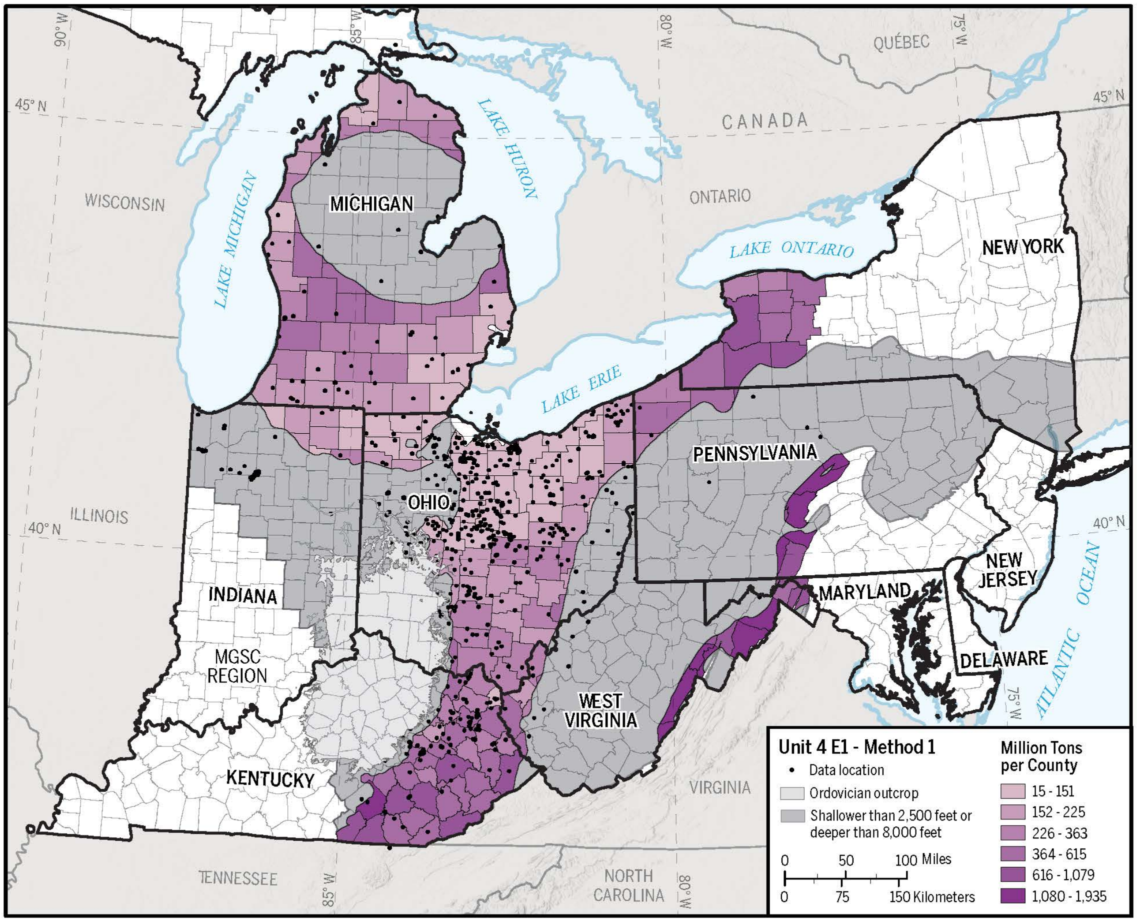

Figure D- 10. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.01 (1% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

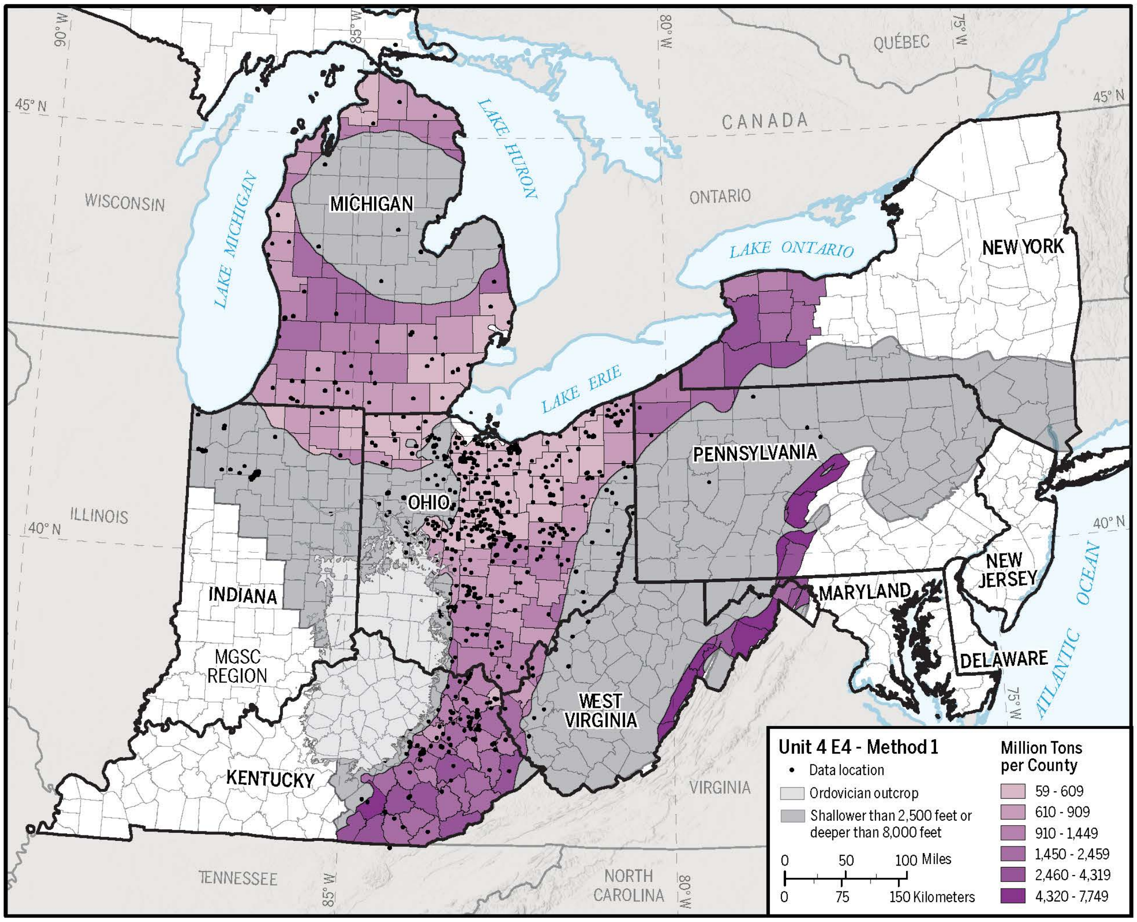

Figure D- 11. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.04 (4% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

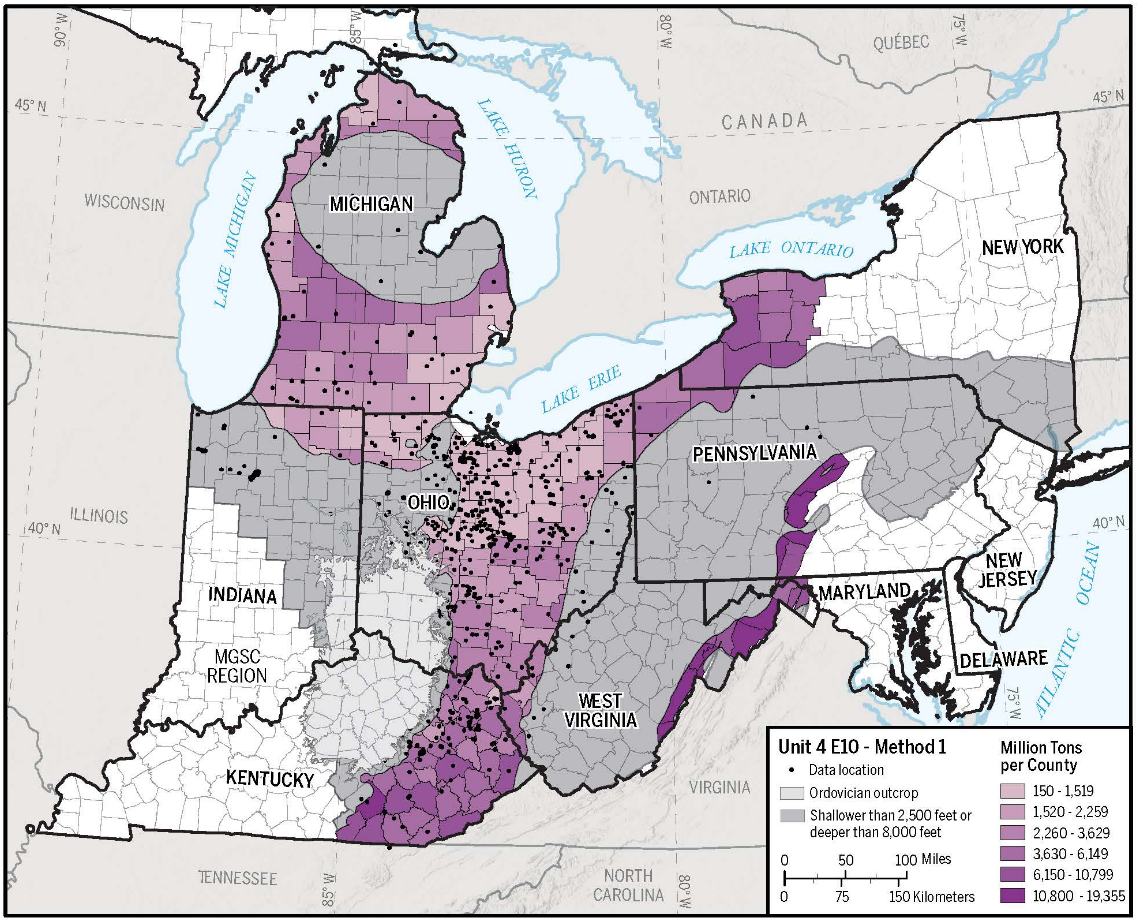

Figure D- 12. Storage resource estimates (SREs) for the Knox Supergroup (unit 4). This map represents results from Method 1 with efficiency factor = 0.1 (10% of the unit is considered). Areas where the top of the unit is shallower than 2,500 ft or deeper than 8,000 ft are shown in gray.

APPENDIX E FORMULAE FOR ESTIMATING POROSITY FROM WIRELINE LOGS

Equations

To calculate porosity using wireline logs, we applied the following equations (Asquith and Gibson, 1982)

E.1. Sonic Log (Wyllie et al., 1956).

$$\emptyset_{sonic} = \frac{\Delta t_{log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}$$

where: $\emptyset_{sonic} = \text{sonic derived porosity}$; $\Delta t_{ma} = \text{interval transit time of the matrix}$ (Table E- 1); $\Delta t_{log} = \text{ interval transit time of formation}$; and $\Delta t_f =$ $\text{interval transit time of the fluid in the well bore (in fresh mud} = 189)$

Table E- 1. Interval transit times for different matrices used in the sonic porosity formula (after Schlumberger, 1972.)

Matrix	Δt_{ma} (µsec/ft)
Sandstone	55.5-51.0
Limestone	47.6
Dolomite	43.5
Anhydrite	50
Salt	67

E.2. Density Log.

$$\emptyset_{den} = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$$

where ρ_{den} = density derived porosity; ρ_{ma} = matrix density (Table E- 2); ρ_b = formation bulk density; and ρ_f = fluid density (1.0 for fresh mud).

Table E- 2. Matrix densities of common lithologies used in the density porosity formula (after Schlumberger, 1972).

Matrix	ρ_{ma} (gm/cc)
Sandstone	2.648
Limestone	2.71
Dolomite	2.876
Anhydrite	2.977
Salt	2.032

APPENDIX F TABULAR DATA FOR ALL WELLS USED IN THIS STUDY, FOR ALL METHODS. ONLY VALUES WHEN EFFICIENCY FACTOR WAS NOT APPLIED (E=1) ARE DISPLAYED, AND FOR EFFICIENCY FACTORS OF 1, 4, AND 10%, THESE VALUES SHOULD BE MULTIPLIED BY 0.01, 0.04, AND 0.1, RESPECTIVELY.

Table F- 1. SRE Values, Unit 2, for Method 1 (E=1 or 100% of reservoir considered).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Dekalb	Indiana	11.19	943.95	10564.77
Elkhart	Indiana	9.77	1211.99	11846.90
Lagrange	Indiana	10.74	1001.86	10764.55
Noble	Indiana	10.27	1080.68	11096.16
Steuben	Indiana	12.42	836.43	10387.76
Bath	Kentucky	19.12	735.21	14055.25
Bell	Kentucky	28.32	934.11	26454.81
Boyd	Kentucky	23.31	419.93	9789.81
Breathitt	Kentucky	29.25	1281.52	37488.92
Carter	Kentucky	21.41	1068.47	22872.89
Clay	Kentucky	24.05	1220.64	29356.46
Elliott	Kentucky	26.74	609.12	16288.11
Estill	Kentucky	22.60	662.24	14968.85
Floyd	Kentucky	36.77	1024.29	37661.83
Greenup	Kentucky	18.62	917.93	17094.30
Harlan	Kentucky	30.27	1213.00	36715.69
Jackson	Kentucky	23.99	897.22	21522.46
Johnson	Kentucky	35.89	683.75	24538.15

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Knott	Kentucky	34.59	914.45	31631.36
Knox	Kentucky	26.39	1004.42	26501.66
Laurel	Kentucky	23.10	1149.40	26552.15
Lawrence	Kentucky	31.12	1086.79	33825.80
Lee	Kentucky	25.97	547.89	14230.21
Leslie	Kentucky	28.77	1047.19	30127.19
Letcher	Kentucky	32.88	878.20	28879.04
Lewis	Kentucky	18.31	1282.96	23487.04
Magoffin	Kentucky	31.78	801.51	25472.27
Martin	Kentucky	38.72	596.99	23114.47
Mccreary	Kentucky	23.89	1116.17	26665.91
Menifee	Kentucky	23.84	533.37	12715.26
Morgan	Kentucky	27.76	994.43	27601.80
Owsley	Kentucky	25.17	513.76	12930.41
Perry	Kentucky	30.50	886.92	27053.06
Pike	Kentucky	36.88	2041.80	75300.56
Powell	Kentucky	22.75	465.91	10598.70
Pulaski	Kentucky	22.10	1753.87	38755.84
Rockcastle	Kentucky	21.32	823.98	17571.02
Rowan	Kentucky	21.74	741.63	16122.43
Whitley	Kentucky	26.60	1152.81	30659.05
Wolfe	Kentucky	27.34	577.22	15781.37
Allegany	Maryland	29.86	1112.08	33207.64
Garrett	Maryland	34.64	1697.20	58785.12

Table F.1. SRE Values, Unit 2, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Alcona	Michigan	15.23	1798.95	27399.07
Allegan	Michigan	10.76	2182.12	23475.79
Alpena	Michigan	13.12	1536.83	20163.05
Antrim	Michigan	10.00	1359.77	13596.53
Barry	Michigan	14.68	1494.54	21939.21
Benzie	Michigan	8.52	900.53	7671.91
Berrien	Michigan	9.08	1502.96	13648.27
Branch	Michigan	12.29	1345.80	16534.94
Calhoun	Michigan	13.58	1860.63	25270.19
Cass	Michigan	9.65	1316.28	12699.35
Charlevoix	Michigan	8.99	1173.59	10554.50
Cheboygan	Michigan	10.82	2061.94	22303.54
Clinton	Michigan	17.20	1488.24	25593.47
Crawford	Michigan	13.68	1459.01	19965.88
Eaton	Michigan	14.58	1500.66	21879.33
Emmet	Michigan	9.37	1254.00	11743.72
Genesee	Michigan	22.61	1682.43	38046.55
Grand Traverse	Michigan	9.75	1269.84	12382.06
Gratiot	Michigan	18.55	1480.55	27467.10
Hillsdale	Michigan	14.38	1572.03	22603.93
Huron	Michigan	23.62	2170.86	51272.34
Ingham	Michigan	17.54	1452.20	25469.31
Ionia	Michigan	14.54	1502.31	21842.20
Iosco	Michigan	21.67	1466.80	31787.69
Jackson	Michigan	14.93	1873.75	27972.36
Kalamazoo	Michigan	11.47	1503.10	17242.55

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Kalkaska	Michigan	12.56	1477.66	18564.17
Kent	Michigan	13.17	2258.43	29751.20
Lake	Michigan	11.49	1487.24	17090.23
Lapeer	Michigan	23.47	1716.76	40291.87
Leelanau	Michigan	8.60	973.64	8376.67
Lenawee	Michigan	17.38	1972.59	34281.21
Livingston	Michigan	21.43	1516.38	32490.32
Macomb	Michigan	20.30	1253.42	25440.06
Manistee	Michigan	7.75	1444.53	11194.73
Mason	Michigan	7.74	1321.01	10229.89
Mecosta	Michigan	14.40	1479.56	21309.98
Monroe	Michigan	18.32	1445.64	26477.01
Montcalm	Michigan	13.66	1866.80	25496.40
Montmorency	Michigan	12.22	1457.28	17811.32
Muskegon	Michigan	10.02	1366.31	13694.58
Newaygo	Michigan	12.17	2232.05	27167.94
Oakland	Michigan	20.35	2349.75	47806.80
Oceana	Michigan	8.88	1414.55	12559.19

Table F.1. SRE Values, Unit 2, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Oscoda	Michigan	15.31	1480.37	22659.48
Otsego	Michigan	13.32	1362.78	18157.06
Ottawa	Michigan	9.71	1494.53	14516.62
Presque Isle	Michigan	13.27	1774.35	23542.83
Saginaw	Michigan	21.07	2113.26	44536.21
Sanilac	Michigan	23.83	2497.38	59514.14
Shiawassee	Michigan	20.36	1400.89	28528.05
St. Clair	Michigan	21.48	1898.03	40771.70
St. Joseph	Michigan	10.33	1349.26	13942.12
Tuscola	Michigan	23.74	2108.53	50049.69
Van Buren	Michigan	10.00	1613.92	16138.70
Washtenaw	Michigan	20.94	1871.00	39184.23
Wayne	Michigan	18.82	1665.27	31344.32
Wexford	Michigan	9.72	1490.40	14491.31
Allegany	New York	21.62	2679.14	57929.69
Broome	New York	16.92	1853.35	31364.70
Cattaraugus	New York	19.08	3423.67	65337.71
Cayuga	New York	20.41	1899.84	38776.85
Chautauqua	New York	15.80	2810.47	44410.16
Chenango	New York	15.01	2327.66	34936.12
Cortland	New York	18.04	1298.07	23412.53
Delaware	New York	11.36	3803.31	43190.17
Erie	New York	18.42	2728.70	50262.09
Genesee	New York	19.64	1282.75	25191.52
Herkimer	New York	12.30	3777.52	46452.41
Livingston	New York	21.32	1659.49	35372.03

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Madison	New York	15.28	1713.75	26193.94
Monroe	New York	20.29	1726.65	35027.30
Niagara	New York	18.06	1379.36	24912.15
Oneida	New York	14.22	3254.57	46287.21
Onondaga	New York	18.65	2087.28	38921.75
Ontario	New York	21.81	1719.35	37505.97
Orleans	New York	19.04	1016.92	19358.06
Oswego	New York	18.20	2637.12	47986.89
Otsego	New York	10.58	2628.15	27815.71
Schuyler	New York	22.48	885.02	19898.00
Seneca	New York	21.18	1006.16	21313.23
Steuben	New York	24.00	3636.97	87282.10
Tioga	New York	19.83	1353.27	26840.40
Tompkins	New York	20.32	1273.23	25866.94
Wayne	New York	20.65	1577.05	32571.01
Wyoming	New York	20.24	1544.43	31262.69
Yates	New York	22.64	972.86	22023.58

Table F.1. SRE Values, Unit 2, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Ashland	Ohio	16.94	1105.06	18722.14
Ashtabula	Ohio	14.90	1836.38	27367.13
Athens	Ohio	18.05	1317.49	23786.18
Belmont	Ohio	24.33	1403.43	34140.49
Carroll	Ohio	21.35	1033.37	22063.34
Columbiana	Ohio	21.74	1384.23	30099.77
Coshocton	Ohio	17.66	1469.34	25946.93
Crawford	Ohio	15.04	1043.08	15691.81
Cuyahoga	Ohio	17.69	1188.04	21018.65
Defiance	Ohio	13.38	1071.66	14333.52
Delaware	Ohio	15.54	1184.92	18410.52
Erie	Ohio	14.36	658.59	9459.19
Fairfield	Ohio	15.99	1317.05	21060.62
Franklin	Ohio	15.01	1408.75	21143.13
Fulton	Ohio	14.46	1054.32	15240.89
Gallia	Ohio	19.18	1221.66	23435.15
Geauga	Ohio	16.27	1057.95	17212.20
Guernsey	Ohio	19.41	1368.51	26560.05
Harrison	Ohio	21.72	1064.10	23108.65
Henry	Ohio	14.48	1087.13	15736.90
Hocking	Ohio	15.67	1097.13	17186.70
Holmes	Ohio	17.80	1098.30	19544.55
Huron	Ohio	15.27	1284.58	19619.65
Jackson	Ohio	15.70	1091.44	17139.26
Knox	Ohio	16.38	1371.68	22466.25
Lake	Ohio	15.28	599.62	9164.86

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Lawrence	Ohio	21.55	1183.91	25512.18
Licking	Ohio	16.29	1780.36	29004.29
Lorain	Ohio	15.44	1278.62	19743.90
Lucas	Ohio	16.45	896.83	14751.16
Mahoning	Ohio	19.73	1099.78	21703.74
Marion	Ohio	14.71	1046.73	15393.46
Medina	Ohio	18.06	1095.41	19780.73
Meigs	Ohio	19.65	1117.69	21959.41
Monroe	Ohio	24.28	1184.76	28770.18
Morgan	Ohio	18.75	1092.47	20485.54
Morrow	Ohio	15.07	1054.42	15891.11
Muskingum	Ohio	17.95	1741.87	31271.09
Noble	Ohio	20.39	1047.94	21363.03
Ottawa	Ohio	17.04	688.47	11734.05
Perry	Ohio	16.77	1068.29	17918.23
Pickaway	Ohio	14.84	1311.35	19455.27
Pike	Ohio	16.43	1150.00	18893.34
Portage	Ohio	19.87	1305.61	25937.93
Richland	Ohio	15.66	1295.32	20287.52
Ross	Ohio	15.69	1794.91	28170.78
Sandusky	Ohio	16.73	1069.74	17899.61
Scioto	Ohio	17.36	1595.52	27692.19
Seneca	Ohio	14.05	1432.10	20125.63
Stark	Ohio	20.68	1502.87	31086.50
Summit	Ohio	19.06	1087.76	20729.75
Trumbull	Ohio	17.15	1645.11	28221.66
Tuscarawas	Ohio	18.40	1480.26	27242.91

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Vinton	Ohio	15.35	1075.05	16501.93
Washington	Ohio	19.66	1656.63	32574.20
Wayne	Ohio	18.19	1442.65	26247.45
Williams	Ohio	13.74	1093.82	15023.89

Table F.1. SRE Values, Unit 2, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Bedford	Pennsylvania	27.72	2631.80	72950.03
Blair	Pennsylvania	20.28	1366.33	27707.05
Centre	Pennsylvania	21.70	2887.29	62661.04
Crawford	Pennsylvania	14.24	2690.34	38321.40
Erie	Pennsylvania	16.25	2079.42	33781.67
Franklin	Pennsylvania	27.10	2001.10	54222.91
Fulton	Pennsylvania	27.63	1134.93	31362.72
Huntingdon	Pennsylvania	20.90	2303.53	48149.87
Juniata	Pennsylvania	22.14	1018.56	22555.34
Lawrence	Pennsylvania	17.13	940.75	16118.76
Mercer	Pennsylvania	15.14	1768.10	26762.89
Mifflin	Pennsylvania	21.84	1071.98	23411.71
Perry	Pennsylvania	22.21	1445.02	32100.46
Snyder	Pennsylvania	21.91	861.02	18860.72
Somerset	Pennsylvania	29.64	2800.66	83020.97
Union	Pennsylvania	22.38	826.76	18501.58
Venango	Pennsylvania	14.48	1769.27	25620.90
Warren	Pennsylvania	16.08	2327.70	37428.74
Boone	West Virginia	36.62	1304.42	47761.79
Cabell	West Virginia	29.83	746.12	22253.42
Fayette	West Virginia	32.68	1732.11	56608.43
Grant	West Virginia	34.35	1245.26	42775.53
Greenbrier	West Virginia	29.64	2661.81	78896.83
Hampshire	West Virginia	30.02	1669.82	50123.83
Hardy	West Virginia	30.35	1511.06	45856.03
Jackson	West Virginia	25.05	1222.84	30633.98

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Kanawha	West Virginia	30.81	2354.70	72543.67
Lincoln	West Virginia	36.85	1137.84	41927.48
Logan	West Virginia	40.51	1180.10	47809.46
Mason	West Virginia	24.07	1154.09	27780.25
Mcdowell	West Virginia	39.75	1386.99	55126.69
Mercer	West Virginia	34.33	1089.99	37419.68
Mineral	West Virginia	31.82	852.56	27125.16
Mingo	West Virginia	38.55	1097.55	42308.78
Monroe	West Virginia	35.36	1223.81	43269.92
Pendleton	West Virginia	30.25	1806.77	54657.53
Putnam	West Virginia	31.88	907.02	28917.08
Raleigh	West Virginia	34.65	1583.06	54859.90
Randolph	West Virginia	33.82	2695.92	91182.31
Summers	West Virginia	33.08	957.85	31682.86
Tucker	West Virginia	36.32	1095.54	39788.11
Wayne	West Virginia	29.55	1327.07	39217.46
Wood	West Virginia	21.09	978.44	20639.07
Wyoming	West Virginia	38.09	1296.30	49376.84

Table F- 2. SRE Values, Unit 3, for Method 1 (E=1).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Allen	Indiana	1.07	1711.32	1833.67
Dekalb	Indiana	1.61	943.95	1517.82
Elkhart	Indiana	0.60	1211.99	730.76
Kosciusko	Indiana	0.68	1435.94	980.88
Lagrange	Indiana	0.58	1001.86	577.05
Laporte	Indiana	0.61	1565.41	953.04
Noble	Indiana	0.63	1080.68	676.30
St Joseph	Indiana	0.51	1195.11	609.07
Whitley	Indiana	0.95	875.35	830.68
Bath	Kentucky	0.67	735.21	492.86
Boyd	Kentucky	1.44	419.93	604.24
Breathitt	Kentucky	1.19	1281.52	1523.29
Carter	Kentucky	1.35	1068.47	1440.27
Clay	Kentucky	2.37	1220.64	2893.28
Elliott	Kentucky	1.15	609.12	702.22
Estill	Kentucky	0.70	662.24	461.73
Fleming	Kentucky	0.66	909.90	602.46
Floyd	Kentucky	1.32	1024.29	1355.20
Greenup	Kentucky	0.53	917.93	490.52
Harlan	Kentucky	2.55	1213.00	3096.09
Jackson	Kentucky	1.11	897.22	992.10
Johnson	Kentucky	1.05	683.75	716.06
Knott	Kentucky	1.20	914.45	1093.86
Knox	Kentucky	2.84	1004.42	2855.33
Laurel	Kentucky	2.06	1149.40	2370.89
Lawrence	Kentucky	2.67	1086.79	2904.90

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Lee	Kentucky	0.54	547.89	293.83
Leslie	Kentucky	2.67	1047.19	2793.97
Letcher	Kentucky	1.72	878.20	1509.27
Lewis	Kentucky	0.52	1282.96	668.81
Magoffin	Kentucky	1.58	801.51	1264.99
Martin	Kentucky	1.24	596.99	739.61
Menifee	Kentucky	1.41	533.37	750.16
Morgan	Kentucky	0.84	994.43	830.75
Owsley	Kentucky	1.47	513.76	757.11
Perry	Kentucky	1.74	886.92	1543.47
Pike	Kentucky	1.54	2041.80	3146.66
Powell	Kentucky	0.94	465.91	439.06
Rockcastle	Kentucky	1.23	823.98	1011.38
Rowan	Kentucky	0.47	741.63	345.57
Wolfe	Kentucky	0.95	577.22	549.94

Table F.2. SRE Values, Unit 3, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Alcona	Michigan	12.60	1798.95	22661.20
Alpena	Michigan	11.55	1536.83	17747.15
Antrim	Michigan	15.99	1359.77	21743.37
Barry	Michigan	0.36	1494.54	531.67
Benzie	Michigan	19.75	900.53	17785.68
Charlevoix	Michigan	9.97	1173.59	11704.40
Cheboygan	Michigan	9.07	2061.94	18692.53
Clinton	Michigan	2.75	1488.24	4093.16
Eaton	Michigan	0.56	1500.66	837.32
Emmet	Michigan	8.39	1254.00	10518.99
Genesee	Michigan	5.00	1682.43	8408.82
Grand Traverse	Michigan	21.47	1269.84	27260.11
Gratiot	Michigan	8.03	1480.55	11894.28
Huron	Michigan	12.94	2170.86	28086.33
Ingham	Michigan	1.69	1452.20	2454.62
Ionia	Michigan	1.45	1502.31	2180.09
Kalkaska	Michigan	23.36	1477.66	34513.91
Kent	Michigan	1.46	2258.43	3295.27
Lake	Michigan	22.76	1487.24	33847.04
Lapeer	Michigan	7.21	1716.76	12380.04
Leelanau	Michigan	16.53	973.64	16092.69
Livingston	Michigan	2.64	1516.38	3999.28
Manistee	Michigan	20.81	1444.53	30056.63
Mason	Michigan	14.33	1321.01	18934.31
Mecosta	Michigan	10.16	1479.56	15036.90
Montcalm	Michigan	3.84	1866.80	7171.99

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Montmorency	Michigan	11.58	1457.28	16877.81
Muskegon	Michigan	4.09	1366.31	5583.28
Newaygo	Michigan	8.56	2232.05	19111.15
Oceana	Michigan	8.31	1414.55	11755.13
Otsego	Michigan	12.07	1362.78	16452.22
Ottawa	Michigan	1.34	1494.53	2006.43
Presque Isle	Michigan	9.85	1774.35	17469.58
Sanilac	Michigan	4.72	2497.38	11799.52
Shiawassee	Michigan	2.11	1400.89	2958.57
St. Clair	Michigan	2.03	1898.03	3858.20
Wexford	Michigan	24.24	1490.40	36129.32
Adams	Ohio	0.70	1518.48	1056.31
Athens	Ohio	8.49	1317.49	11181.22
Defiance	Ohio	4.01	1071.66	4293.14
Gallia	Ohio	2.36	1221.66	2888.91
Jackson	Ohio	2.19	1091.44	2389.75
Lawrence	Ohio	0.97	1183.91	1147.46
Meigs	Ohio	6.27	1117.69	7009.81
Paulding	Ohio	3.17	1083.60	3436.53
Pike	Ohio	0.61	1150.00	704.57
Scioto	Ohio	0.44	1595.52	709.13
Vinton	Ohio	2.74	1075.05	2943.74
Cabell	West Virginia	2.53	746.12	1889.13
Jackson	West Virginia	5.40	1222.84	6604.40
Lincoln	West Virginia	6.16	1137.84	7014.75
Mason	West Virginia	2.83	1154.09	3269.13
Mingo	West Virginia	3.63	1097.55	3980.87

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Putnam	West Virginia	2.86	907.02	2595.07
Wayne	West Virginia	4.54	1327.07	6020.15

Table F.3. SRE Values, Unit 4, for Method 1 (E=1).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Allen	Indiana	14.83	1711.32	25380.28
Dekalb	Indiana	13.51	943.95	12756.69
Elkhart	Indiana	12.66	1211.99	15344.26
Kosciusko	Indiana	15.37	1435.94	22075.22
Lagrange	Indiana	16.58	1001.86	16608.89
Marshall	Indiana	12.93	1164.40	15060.60
Noble	Indiana	14.85	1080.68	16045.75
St Joseph	Indiana	10.55	1195.11	12610.06
Steuben	Indiana	15.44	836.43	12917.95
Whitley	Indiana	15.17	875.35	13282.93
Bath	Kentucky	36.64	735.21	26934.58
Bell	Kentucky	60.14	934.11	56181.44
Boyd	Kentucky	23.56	419.93	9894.12
Breathitt	Kentucky	49.86	1281.52	63895.81
Carter	Kentucky	22.12	1068.47	23630.20
Clay	Kentucky	53.89	1220.64	65781.93
Clinton	Kentucky	70.30	531.25	37345.67
Elliott	Kentucky	65.19	609.12	39706.60
Estill	Kentucky	57.20	662.24	37878.42
Fleming	Kentucky	33.45	909.90	30439.94
Floyd	Kentucky	39.10	1024.29	40054.30
Greenup	Kentucky	33.85	917.93	31067.73
Harlan	Kentucky	52.00	1213.00	63070.18
Jackson	Kentucky	63.88	897.22	57311.59
Johnson	Kentucky	38.00	683.75	25981.67
Knott	Kentucky	42.53	914.45	38894.73

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Knox	Kentucky	45.04	1004.42	45235.92
Laurel	Kentucky	58.90	1149.40	67704.32
Lawrence	Kentucky	36.83	1086.79	40030.10
Lee	Kentucky	80.78	547.89	44256.39
Leslie	Kentucky	48.73	1047.19	51030.11
Letcher	Kentucky	43.17	878.20	37909.09
Lewis	Kentucky	29.41	1282.96	37727.99
Lincoln	Kentucky	58.81	871.88	51273.32
Magoffin	Kentucky	41.19	801.51	33017.99
Martin	Kentucky	41.15	596.99	24568.82
Mccreary	Kentucky	65.10	1116.17	72663.02
Menifee	Kentucky	39.68	533.37	21164.52
Montgomery	Kentucky	39.79	515.44	20510.95
Morgan	Kentucky	40.20	994.43	39972.17
Owsley	Kentucky	63.57	513.76	32660.84
Perry	Kentucky	42.90	886.92	38049.33
Pike	Kentucky	41.62	2041.80	84988.98
Powell	Kentucky	53.20	465.91	24787.86

Table F- 3. SRE Values, Unit 4, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Pulaski	Kentucky	72.18	1753.87	126595.14
Rockcastle	Kentucky	66.56	823.98	54845.16
Rowan	Kentucky	39.25	741.63	29109.90
Wayne	Kentucky	70.18	1254.61	88043.86
Whitley	Kentucky	41.24	1152.81	47538.44
Wolfe	Kentucky	62.91	577.22	36313.68
Allegany	Maryland	78.60	1112.08	87412.14
Washington	Maryland	82.44	1210.55	99798.08
Alcona	Michigan	26.64	1798.95	47916.80
Allegan	Michigan	17.80	2182.12	38837.47
Alpena	Michigan	18.15	1536.83	27900.39
Antrim	Michigan	20.81	1359.77	28294.80
Barry	Michigan	20.81	1494.54	31104.36
Benzie	Michigan	19.85	900.53	17871.64
Berrien	Michigan	10.22	1502.96	15352.99
Branch	Michigan	15.21	1345.80	20465.39
Calhoun	Michigan	15.31	1860.63	28487.54
Cass	Michigan	12.66	1316.28	16668.05
Charlevoix	Michigan	12.74	1173.59	14947.17
Cheboygan	Michigan	8.03	2061.94	16550.73
Clinton	Michigan	24.44	1488.24	36372.84
Eaton	Michigan	15.72	1500.66	23590.73
Emmet	Michigan	8.55	1254.00	10724.43
Genesee	Michigan	18.25	1682.43	30702.91
Grand Traverse	Michigan	27.07	1269.84	34377.41
Gratiot	Michigan	33.61	1480.55	49763.77

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Hillsdale	Michigan	12.99	1572.03	20426.90
Huron	Michigan	21.59	2170.86	46868.55
Ingham	Michigan	13.06	1452.20	18959.65
Ionia	Michigan	27.37	1502.31	41123.10
Jackson	Michigan	12.55	1873.75	23522.43
Kalamazoo	Michigan	14.90	1503.10	22395.92
Kent	Michigan	23.76	2258.43	53664.86
Lake	Michigan	22.11	1487.24	32879.26
Lapeer	Michigan	13.57	1716.76	23295.05
Leelanau	Michigan	18.53	973.64	18040.15
Lenawee	Michigan	8.78	1972.59	17323.76
Livingston	Michigan	11.56	1516.38	17535.14
Macomb	Michigan	4.57	1253.42	5734.04
Manistee	Michigan	18.58	1444.53	26832.75
Mason	Michigan	10.74	1321.01	14186.88
Mecosta	Michigan	29.37	1479.56	43461.25
Monroe	Michigan	8.18	1445.64	11825.15
Montcalm	Michigan	29.51	1866.80	55089.41

Table F.3. SRE Values, Unit 4, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Montmorency	Michigan	19.51	1457.28	28432.41
Muskegon	Michigan	16.40	1366.31	22414.21
Newaygo	Michigan	21.80	2232.05	48656.83
Oakland	Michigan	9.37	2349.75	22014.83
Oceana	Michigan	13.94	1414.55	19715.28
Otsego	Michigan	19.04	1362.78	25944.57
Ottawa	Michigan	18.66	1494.53	27894.05
Presque Isle	Michigan	11.74	1774.35	20831.14
Sanilac	Michigan	15.71	2497.38	39235.41
Shiawassee	Michigan	20.79	1400.89	29122.88
St. Clair	Michigan	4.31	1898.03	8178.74
St. Joseph	Michigan	13.86	1349.26	18701.09
Van Buren	Michigan	16.72	1613.92	26983.24
Washtenaw	Michigan	5.53	1871.00	10343.30
Wayne	Michigan	4.50	1665.27	7501.30
Allegany	New York	35.20	2679.14	94306.19
Cattaraugus	New York	23.41	3423.67	80161.71
Chautauqua	New York	18.77	2810.47	52742.82
Erie	New York	24.56	2728.70	67025.61
Genesee	New York	31.03	1282.75	39805.43
Livingston	New York	34.88	1659.49	57890.23
Monroe	New York	33.72	1726.65	58227.48
Niagara	New York	24.91	1379.36	34365.27
Orleans	New York	30.25	1016.92	30764.76
Wyoming	New York	29.46	1544.43	45497.26
Adams	Ohio	24.93	1518.48	37856.30

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Ashland	Ohio	8.92	1105.06	9855.00
Ashtabula	Ohio	9.60	1836.38	17625.22
Athens	Ohio	20.36	1317.49	26824.22
Carroll	Ohio	12.03	1033.37	12433.29
Champaign	Ohio	15.28	1113.69	17014.76
Clark	Ohio	16.52	1039.82	17175.83
Columbiana	Ohio	16.20	1384.23	22429.33
Coshocton	Ohio	14.12	1469.34	20745.31
Crawford	Ohio	6.68	1043.08	6970.46
Cuyahoga	Ohio	5.91	1188.04	7018.41
Defiance	Ohio	11.81	1071.66	12659.99
Delaware	Ohio	10.45	1184.92	12380.93
Erie	Ohio	2.36	658.59	1556.76
Fairfield	Ohio	14.76	1317.05	19438.69
Fayette	Ohio	19.37	1054.55	20423.54
Franklin	Ohio	15.01	1408.75	21139.54
Fulton	Ohio	9.69	1054.32	10217.30

Table F.3. SRE Values, Unit 4, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Gallia	Ohio	21.42	1221.66	26168.36
Geauga	Ohio	5.64	1057.95	5964.68
Guernsey	Ohio	17.55	1368.51	24012.99
Hancock	Ohio	8.21	1382.42	11350.69
Harrison	Ohio	8.72	1064.10	9283.09
Henry	Ohio	11.35	1087.13	12336.65
Highland	Ohio	22.94	1444.50	33143.44
Hocking	Ohio	17.82	1097.13	19546.27
Holmes	Ohio	10.69	1098.30	11737.49
Huron	Ohio	4.82	1284.58	6198.03
Jackson	Ohio	21.93	1091.44	23932.45
Knox	Ohio	10.17	1371.68	13949.61
Lake	Ohio	7.16	599.62	4291.83
Lawrence	Ohio	25.05	1183.91	29662.76
Licking	Ohio	12.70	1780.36	22608.68
Logan	Ohio	12.38	1208.78	14961.48
Lorain	Ohio	4.66	1278.62	5958.93
Lucas	Ohio	7.72	896.83	6919.80
Madison	Ohio	15.11	1210.62	18287.51
Mahoning	Ohio	15.55	1099.78	17106.73
Marion	Ohio	8.50	1046.73	8893.53
Medina	Ohio	6.99	1095.41	7651.77
Meigs	Ohio	17.17	1117.69	19194.40
Morgan	Ohio	19.52	1092.47	21320.88
Morrow	Ohio	8.62	1054.42	9089.83
Muskingum	Ohio	14.70	1741.87	25602.57

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Noble	Ohio	14.93	1047.94	15643.99
Ottawa	Ohio	2.16	688.47	1485.54
Paulding	Ohio	14.14	1083.60	15321.89
Perry	Ohio	15.28	1068.29	16325.04
Pickaway	Ohio	15.33	1311.35	20104.23
Pike	Ohio	19.63	1150.00	22576.91
Portage	Ohio	8.52	1305.61	11122.60
Putnam	Ohio	13.20	1254.05	16547.30
Richland	Ohio	8.52	1295.32	11030.62
Ross	Ohio	18.45	1794.91	33109.46
Sandusky	Ohio	2.66	1069.74	2840.42
Scioto	Ohio	19.71	1595.52	31444.54
Seneca	Ohio	3.54	1432.10	5075.98
Stark	Ohio	11.24	1502.87	16897.49
Summit	Ohio	8.33	1087.76	9059.67
Trumbull	Ohio	12.91	1645.11	21243.01
Tuscarawas	Ohio	14.94	1480.26	22121.16
Union	Ohio	12.00	1131.20	13570.68
Vinton	Ohio	19.93	1075.05	21424.31

Table F.3. SRE Values, Unit 4, for Method 1 (E=1) (continued).

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Washington	Ohio	27.79	1656.63	46039.78
Wayne	Ohio	8.64	1442.65	12458.20
Williams	Ohio	12.02	1093.82	13152.16
Wood	Ohio	5.72	1607.62	9190.77
Wyandot	Ohio	7.06	1055.44	7451.86
Bedford	Pennsylvania	73.54	2631.80	193548.72
Blair	Pennsylvania	66.04	1366.33	90236.75
Centre	Pennsylvania	66.77	2887.29	192793.84
Clinton	Pennsylvania	65.00	2314.09	150413.61
Crawford	Pennsylvania	13.73	2690.34	36938.59
Erie	Pennsylvania	12.35	2079.42	25683.45
Fulton	Pennsylvania	77.69	1134.93	88170.43
Huntingdon	Pennsylvania	71.26	2303.53	164152.14
Mckean	Pennsylvania	27.54	2551.64	70273.18
Mercer	Pennsylvania	16.59	1768.10	29333.91
Warren	Pennsylvania	22.21	2327.70	51693.10
Berkeley	West Virginia	83.05	832.39	69133.89
Cabell	West Virginia	28.93	746.12	21586.03
Grant	West Virginia	72.63	1245.26	90438.52
Greenbrier	West Virginia	59.03	2661.81	157131.05
Hampshire	West Virginia	81.14	1669.82	135484.46
Hardy	West Virginia	77.96	1511.06	117804.61
Jefferson	West Virginia	83.70	547.19	45798.74
Lincoln	West Virginia	29.63	1137.84	33710.31
Mason	West Virginia	29.73	1154.09	34309.53
Mineral	West Virginia	75.68	852.56	64526.00

County	State	Average SRE [MMTons CO_2/km^2]	Area [km^2]	Total Capacity [MMTons CO_2]
Mingo	West Virginia	45.42	1097.55	49855.62
Morgan	West Virginia	81.94	595.32	48779.99
Pendleton	West Virginia	74.36	1806.77	134351.40
Pocahontas	West Virginia	62.48	2440.19	152471.69
Putnam	West Virginia	43.96	907.02	39869.63
Randolph	West Virginia	66.02	2695.92	177980.69
Tucker	West Virginia	67.59	1095.54	74046.85
Wayne	West Virginia	37.89	1327.07	50288.69

Table F- 4. SRE Values, Unit 2, for Method 6.

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
159232	640340.0	4621183.0	Lagrange	Indiana	2719	0.43	1.50	3.87	0.0058	0.0278	0.1022	1.95
146918	673204.0	4624060.0	Steuben	Indiana	3097	0.42	1.51	3.97	0.0084	0.0394	0.1545	2.84
1604316235	840109.7	4245513.3	Carter	Kentucky	3024	0.42	1.50	3.92	0.0200	0.0819	0.2695	5.71
1608921256	843699.1	4284166.4	Greenup	Kentucky	3067	0.42	1.49	3.99	0.0444	0.1854	0.5922	12.63
1613521132	837304.5	4272399.0	Lewis	Kentucky	2938	0.41	1.50	4.00	0.0317	0.1512	0.5949	10.87
1601927870	879206.8	4252232.5	Boyd	Kentucky	4793	0.41	1.51	3.97	0.0174	0.0798	0.3204	5.88
1604322935	867365.8	4246344.2	Carter	Kentucky	4253	0.41	1.50	3.90	0.0081	0.0458	0.2234	3.58
1601921652	876829.2	4253089.5	Boyd	Kentucky	4458	0.42	1.51	3.93	0.0000	0.0007	0.0116	0.12
21163001847000	817228.7	4690328.4	Wayne	Michigan	3418	0.42	1.50	3.94	0.0027	0.0179	0.1074	1.52
21163004537000	803879.0	4683407.1	Wayne	Michigan	3401	0.42	1.49	3.95	0.0268	0.1058	0.3452	7.39
21127582490000	549736.5	4834792.2	Oceana	Michigan	5205	0.41	1.52	3.92	0.0084	0.0402	0.1631	2.95
21057297390000	696420.2	4793985.5	Gratiot	Michigan	8194	0.42	1.50	3.94	0.0036	0.0233	0.1362	1.95
21059404140000	695216.2	4659521.4	Hillsdale	Michigan	3960	0.43	1.49	3.93	0.0196	0.0751	0.2192	5.07
21077003277000	619468.3	4673788.3	Kalamazoo	Michigan	3355	0.41	1.49	3.96	0.0163	0.0635	0.1853	4.29
21093279860000	760156.8	4729474.7	Livingston	Michigan	5750	0.42	1.50	4.01	0.0179	0.1076	0.5629	8.48
21093404380000	740599.9	4729475.3	Livingston	Michigan	5129	0.42	1.51	3.94	0.0531	0.2020	0.5735	13.49
21093437270000	738510.7	4726418.8	Livingston	Michigan	5838	0.42	1.51	3.92	0.0050	0.0301	0.1706	2.51
21093540210000	771657.7	4723819.4	Livingston	Michigan	5832	0.42	1.51	3.96	0.0529	0.2057	0.6180	13.96
21105399840100	555149.5	4873149.1	Mason	Michigan	5678	0.43	1.50	3.94	0.0028	0.0152	0.0683	1.13

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
21113343760000	652323.3	4904513.3	Missaukee	Michigan	10315	0.42	1.50	3.97	0.0069	0.0366	0.1706	2.79
21121000027000	548278.8	4805117.4	Muskegon	Michigan	4444	0.41	1.50	3.95	0.0160	0.0646	0.2100	4.49
21123398560100	610344.8	4834837.5	Newaygo	Michigan	7636	0.42	1.50	3.98	0.0033	0.0166	0.0712	1.23
21139004707000	582352.5	4741509.9	Ottawa	Michigan	3949	0.42	1.49	3.94	0.0068	0.0328	0.1307	2.38
21055342920000	612645.0	4943580.3	Grand Traverse	Michigan	7480	0.42	1.50	3.90	0.0010	0.0072	0.0500	0.66
21161003287000	763078.5	4685428.5	Washtenaw	Michigan	4299	0.43	1.50	3.87	0.0075	0.0433	0.2194	3.44
21161416710000	783262.9	4701999.9	Washtenaw	Michigan	4359	0.42	1.52	3.94	0.0035	0.0167	0.0670	1.22
21163001557000	821049.0	4689532.6	Wayne	Michigan	3561	0.41	1.50	4.00	0.0117	0.0442	0.1328	3.03
21139348850000	594642.7	4774434.4	Ottawa	Michigan	5377	0.41	1.50	3.88	0.0016	0.0100	0.0577	0.85
21031306820000	705480.8	5031766.7	Cheboygan	Michigan	4395	0.42	1.49	3.96	0.0090	0.0419	0.1722	3.09
21045291170000	695749.4	4713740.0	Eaton	Michigan	5415	0.42	1.52	3.94	0.0008	0.0069	0.0577	0.70
21091004207000	747310.2	4642261.9	Lenawee	Michigan	3396	0.42	1.50	3.96	0.0093	0.0461	0.1888	3.35
21025404170000	652601.9	4696743.5	Calhoun	Michigan	4396	0.43	1.49	4.01	0.0007	0.0037	0.0161	0.27
21029348240000	673381.2	5000896.3	Charlevoix	Michigan	6496	0.43	1.49	3.99	0.0111	0.0479	0.1778	3.43
21023375690000	647818.0	4648131.2	Branch	Michigan	3170	0.41	1.49	4.06	0.0021	0.0137	0.0830	1.16
21023299690000	643012.7	4657490.1	Branch	Michigan	3298	0.42	1.50	3.93	0.0008	0.0068	0.0565	0.69
3400722038	1017739.2	4624441.7	Ashtabula	Ohio	5815	0.42	1.49	3.99	0.0078	0.0374	0.1575	2.78
3400721847	1018133.2	4625547.8	Ashtabula	Ohio	5806	0.42	1.49	3.92	0.0059	0.0276	0.1057	1.99
3400523938	887496.6	4550436.9	Ashland	Ohio	3878	0.43	1.49	3.95	0.0042	0.0287	0.1608	2.33

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3400720213	1016000.0	4636991.2	Ashtabula	Ohio	5521	0.43	1.50	3.90	0.0057	0.0283	0.1198	2.10
3403125889	955121.7	4482315.1	Coshocton	Ohio	6305	0.41	1.50	3.96	0.0187	0.0747	0.2417	5.19
3403123377	942012.7	4471393.2	Coshocton	Ohio	5919	0.42	1.50	3.96	0.0033	0.0190	0.0967	1.50
3404120314	859907.0	4453622.8	Delaware	Ohio	3211	0.43	1.50	3.95	0.0578	0.2156	0.6521	14.82

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F.4. SRE Values, Unit 2, for Method 6 (continued).

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3404120354	859732.0	4465400.7	Delaware	Ohio	3221	0.42	1.50	3.91	0.0059	0.0306	0.1395	2.34
3404120358	856978.8	4463274.5	Delaware	Ohio	3042	0.42	1.50	3.99	0.0051	0.0314	0.1793	2.60
3404320156	878171.6	4583462.8	Erie	Ohio	3306	0.43	1.49	3.94	0.0028	0.0156	0.0784	1.23
3404320157	886256.7	4583455.0	Erie	Ohio	3504	0.42	1.50	3.96	0.0255	0.0961	0.2744	6.45
3405320985	911362.7	4296076.9	Gallia	Ohio	5689	0.42	1.50	3.91	0.0194	0.0962	0.4198	7.23
3405520339	977643.7	4610967.3	Geauga	Ohio	5746	0.42	1.49	3.97	0.0033	0.0205	0.1153	1.69
3407524527	924384.2	4493601.2	Holmes	Ohio	5030	0.43	1.50	4.02	0.0063	0.0351	0.1629	2.62
3407525231	926064.2	4491002.4	Holmes	Ohio	5057	0.42	1.49	3.93	0.0050	0.0321	0.1815	2.65
3407525275	925628.0	4490980.1	Holmes	Ohio	5019	0.42	1.50	3.93	0.0086	0.0426	0.1892	3.23
3408323931	883798.7	4469782.5	Knox	Ohio	3816	0.43	1.49	3.92	0.0063	0.0296	0.1219	2.19
3408324064	884618.1	4470574.5	Knox	Ohio	3851	0.42	1.52	3.93	0.0032	0.0201	0.1142	1.66
3408520142	985903.6	4638620.5	Lake	Ohio	5045	0.41	1.51	3.94	0.0105	0.0444	0.1524	3.12
3408720219	879454.8	4282037.3	Lawrence	Ohio	4404	0.42	1.50	3.89	0.0217	0.0986	0.3369	6.79
3408921826	898523.6	4455630.6	Licking	Ohio	4462	0.42	1.51	3.96	0.0069	0.0369	0.1699	2.79
3408922252	863861.6	4434009.2	Licking	Ohio	3261	0.43	1.50	3.96	0.0091	0.0493	0.2397	3.82
3408924792	907756.2	4454214.6	Licking	Ohio	4578	0.43	1.49	3.93	0.0298	0.1106	0.3232	7.55
3408925413	868866.8	4442816.4	Licking	Ohio	3559	0.41	1.50	3.96	0.0125	0.0637	0.2918	4.87
3408925435	893647.3	4450037.9	Licking	Ohio	4221	0.42	1.48	4.00	0.0357	0.1577	0.5566	11.03
3409321038	890592.1	4579731.0	Lorain	Ohio	3582	0.41	1.51	3.98	0.0263	0.1013	0.2965	6.84

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3411720047	864950.7	4513378.2	Morrow	Ohio	3550	0.42	1.50	3.94	0.0114	0.0569	0.2426	4.21
3411721388	854803.4	4475727.3	Morrow	Ohio	3035	0.42	1.50	3.93	0.0105	0.0570	0.2443	4.18
3411723737	865432.8	4499990.1	Morrow	Ohio	3576	0.42	1.51	3.92	0.0071	0.0390	0.1831	2.98
3411723850	853179.6	4501411.8	Morrow	Ohio	3032	0.41	1.51	3.97	0.0033	0.0234	0.1548	2.08
3413920678	864677.6	4533819.3	Richland	Ohio	3306	0.42	1.50	3.94	0.0091	0.0504	0.2297	3.79
3415121999	978817.7	4525727.0	Stark	Ohio	6967	0.43	1.51	3.92	0.0680	0.2513	0.7053	16.79
3415723715	949642.5	4482525.7	Tuscarawas	Ohio	6454	0.42	1.48	3.97	0.0346	0.1333	0.4010	9.12
3416728666	987875.9	4386491.0	Washington	Ohio	9016	0.42	1.50	3.93	0.1077	0.3945	1.1016	26.63
3416920071	944426.3	4544633.8	Wayne	Ohio	5505	0.42	1.50	3.92	0.0099	0.0585	0.2927	4.57
3417120046	699613.5	4617205.9	Williams	Ohio	2886	0.42	1.49	4.02	0.0009	0.0064	0.0390	0.54
3408521278	984467.0	4634461.1	Lake	Ohio	5252	0.42	1.50	3.94	0.0042	0.0226	0.1120	1.78
3414120007	862290.6	4349880.7	Ross	Ohio	2964	0.42	1.50	3.91	0.0137	0.0752	0.3521	5.77
3415725334	967909.5	4481624.0	Tuscarawas	Ohio	6804	0.42	1.50	3.94	0.0028	0.0228	0.1741	2.20
3405924067	955161.1	4434852.4	Guernsey	Ohio	6906	0.42	1.50	3.91	0.0169	0.0860	0.3842	6.54
3400724113	1015649.4	4648076.2	Ashtabula	Ohio	5154	0.43	1.49	3.94	0.0034	0.0198	0.1043	1.59
3400760010	1019946.3	4658578.4	Ashtabula	Ohio	4870	0.42	1.49	3.93	0.0048	0.0229	0.0902	1.66
3400923210	942477.5	4368545.7	Athens	Ohio	6668	0.42	1.51	3.91	0.0679	0.2525	0.6680	16.66
3402920620	1008947.7	4536047.7	Columbiana	Ohio	7953	0.43	1.50	3.97	0.0825	0.2967	0.8182	19.93
3403123753	941208.5	4481108.9	Coshocton	Ohio	5855	0.41	1.50	3.89	0.0582	0.2144	0.5740	14.38

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3406720737	994078.2	4465616.8	Harrison	Ohio	8308	0.42	1.50	3.97	0.0547	0.2174	0.6626	14.72
3407321222	897085.8	4371164.5	Hocking	Ohio	4665	0.42	1.50	3.96	0.0108	0.0572	0.2551	4.28
3407323421	878969.6	4381329.7	Hocking	Ohio	3832	0.42	1.50	3.94	0.0183	0.0826	0.2947	5.80
3407920076	881929.9	4322237.3	Jackson	Ohio	4235	0.43	1.48	3.91	0.0088	0.0479	0.2239	3.67

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F.4. SRE Values, Unit 2, for Method 6 (continued).

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3407920078	869286.8	4311568.6	Jackson	Ohio	3589	0.42	1.50	3.97	0.0372	0.1390	0.3918	9.36
3407920102	877704.6	4326810.9	Jackson	Ohio	3969	0.43	1.49	3.91	0.0026	0.0187	0.1285	1.71
3408720174	892629.1	4296657.0	Lawrence	Ohio	4707	0.42	1.50	3.94	0.0156	0.0771	0.3337	5.77
3411927076	929901.6	4453405.0	Muskingum	Ohio	5599	0.41	1.49	3.95	0.0150	0.0726	0.3030	5.39
3412121278	985385.2	4399882.3	Noble	Ohio	8875	0.42	1.49	3.90	0.0311	0.1254	0.3931	8.62
3405521327	986679.8	4605377.8	Geauga	Ohio	6024	0.42	1.51	3.96	0.0022	0.0153	0.0940	1.31
3409923127	1030448.9	4571365.4	Mahoning	Ohio	7254	0.42	1.48	3.92	0.0046	0.0288	0.1572	2.34
3409923158	1033368.6	4554004.9	Mahoning	Ohio	8074	0.43	1.49	3.93	0.0106	0.0553	0.2537	4.20
3415725465	960241.3	4473540.5	Tuscarawas	Ohio	6810	0.42	1.50	3.96	0.0044	0.0263	0.1500	2.20
3403126379	955090.9	4477634.9	Coshocton	Ohio	6297	0.42	1.49	3.98	0.0045	0.0286	0.1615	2.35
3404320025	885888.6	4585908.7	Erie	Ohio	3534	0.42	1.49	3.96	0.0285	0.1029	0.2879	6.99
3404320027	887782.8	4585781.7	Erie	Ohio	3469	0.42	1.49	3.95	0.0039	0.0185	0.0743	1.35
3404320079	888571.3	4584099.6	Erie	Ohio	3471	0.43	1.50	3.93	0.0499	0.1797	0.4764	11.87
3401922045	982536.9	4515283.7	Carroll	Ohio	7104	0.42	1.48	3.94	0.0100	0.0543	0.2584	4.20
3405920782	950541.5	4445220.3	Guernsey	Ohio	6534	0.42	1.51	3.97	0.0158	0.0764	0.3001	5.47
3403126397	945814.5	4486230.0	Coshocton	Ohio	6174	0.42	1.48	3.95	0.0416	0.1641	0.5507	11.62
3404521136	896690.0	4406842.3	Fairfield	Ohio	4268	0.41	1.50	4.02	0.0036	0.0220	0.1147	1.73
3412124072	974579.9	4426230.3	Noble	Ohio	7805	0.41	1.51	3.98	0.0056	0.0351	0.1883	2.81
3703923539	1047641.5	4647461.9	Crawford	Pennsylvania	5812	0.42	1.51	3.96	0.0062	0.0321	0.1395	2.37

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3708331744	1195805.6	4669655.1	Mc Kean	Pennsylvania	9513	0.42	1.49	4.00	0.0298	0.1209	0.4051	8.45
3708520116	1064832.3	4612146.6	Mercer	Pennsylvania	7415	0.42	1.48	3.96	0.0025	0.0177	0.1164	1.57
3703920907	1047554.5	4647516.6	Crawford	Pennsylvania	5841	0.42	1.51	3.96	0.0197	0.0801	0.2575	5.51
4710700756	975152.9	4340107.3	Wood	West Virginia	9204	0.42	1.49	3.92	0.0995	0.3838	1.2367	26.96
4705300423	938608.4	4326338.7	Mason	West Virginia	7065	0.43	1.49	3.96	0.0288	0.1393	0.5647	10.11
4705300069	924631.1	4296368.5	Mason	West Virginia	6098	0.43	1.49	3.96	0.0096	0.0541	0.2728	4.26
4705300297	925862.9	4286373.5	Mason	West Virginia	6841	0.42	1.49	4.02	0.0789	0.3198	1.0168	21.84
4705900879	916746.6	4203505.1	Mingo	West Virginia	6653	0.42	1.51	4.01	0.0244	0.1056	0.3765	7.41
4705100539	1054417.8	4421397.2	Marshall	West Virginia	13595	0.42	1.49	3.95	0.0490	0.1789	0.4894	12.05
4701100537	913028.0	4274594.7	Cabell	West Virginia	6037	0.42	1.50	3.90	0.0067	0.0451	0.2718	3.86
4702900080	1045889.2	4507676.8	Hancock	West Virginia	9450	0.42	1.51	3.91	0.0190	0.0958	0.4107	7.13
4703501366	971935.2	4300800.1	Jackson	West Virginia	9605	0.42	1.49	4.01	0.0434	0.2163	0.8887	15.68
4704900244	1101681.9	4388106.0	Marion	West Virginia	14518	0.41	1.50	4.00	0.0788	0.3343	1.1992	23.77
4704301469	943137.3	4242035.8	Lincoln	West Virginia	8186	0.41	1.51	4.01	0.0664	0.2529	0.7438	17.13

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F- 5. SRE Values, Unit 3, for Method 6.

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
1601921652	876829.2	4253089.5	Boyd	Kentucky	4947	0.64	2.72	8.06	0.0010	0.0030	0.0110	0.13
1601927870	879206.8	4252232.5	Boyd	Kentucky	5357	0.68	2.72	8.05	0.0050	0.0210	0.0650	0.77
1604300000	838996.1	4249296	Carter	Kentucky	3370	0.67	2.66	8.14	0.0060	0.0260	0.0900	0.99
1604316235	840109.7	4245513.3	Carter	Kentucky	3490	0.67	2.71	8.26	0.0020	0.0100	0.0350	0.36
1604322935	867365.8	4246344.2	Carter	Kentucky	4754	0.66	2.71	8.22	0.0030	0.0130	0.0400	0.47
1604325730	855083.2	4232862.9	Carter	Kentucky	4843	0.66	2.71	8.23	0.0030	0.0140	0.0450	0.51
1604326995	835882.4	4249913.7	Carter	Kentucky	3354	0.66	2.71	8.14	0.0040	0.0180	0.0610	0.67
1613500000	829808.2	4273079	Lewis	Kentucky	2532	0.66	2.74	8.14	0.0010	0.0060	0.0210	0.21
1613502579	825686.3	4252759.1	Lewis	Kentucky	2847	0.67	2.71	8.10	0.0000	0.0000	0.0010	0.00
1613521132	837304.5	4272399	Lewis	Kentucky	3362	0.65	2.73	8.12	0.0010	0.0040	0.0150	0.16
1616518101	806153.7	4212612.7	Menifee	Kentucky	2738	0.67	2.71	8.07	0.0010	0.0040	0.0170	0.17
1616529846	803343.8	4197391.6	Menifee	Kentucky	3149	0.68	2.67	8.01	0.0030	0.0110	0.0380	0.44
1617521871	824129.7	4217187.3	Morgan	Kentucky	3082	0.67	2.71	8.24	0.0020	0.0070	0.0270	0.29
1617527544	811266.9	4203097.1	Morgan	Kentucky	3129	0.67	2.67	8.20	0.0020	0.0090	0.0300	0.33
1620525356	820315.8	4222948.2	Rowan	Kentucky	3163	0.68	2.68	8.10	0.0010	0.0060	0.0190	0.20
21055342920000	612645	4943580.3	Grand Traverse	Michigan	8139	0.67	2.72	8.24	0.0140	0.0880	0.4450	3.58
21113343760000	652323.3	4904513.3	Missaukee	Michigan	11174	0.68	2.65	8.19	0.0230	0.1260	0.6110	5.20
21139348850000	594642.7	4774434.4	Ottawa	Michigan	5645	0.65	2.71	8.06	0.0040	0.0180	0.0570	0.66
21045291170000	695749.4	4713740	Eaton	Michigan	5772	0.66	2.72	8.15	0.0010	0.0050	0.0160	0.18

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km²]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
21093279860000	760156.8	4729474.7	Livingston	Michigan	6290	0.68	2.70	8.04	0.0100	0.0450	0.1580	1.70
21121000027000	548278.8	4805117.4	Muskegon	Michigan	4767	0.67	2.73	8.16	0.0240	0.1110	0.3990	4.18
21123398560100	610344.8	4834837.5	Newaygo	Michigan	8160	0.67	2.69	8.24	0.0120	0.0610	0.2720	2.45
21127331340000	544767.9	4820322	Oceana	Michigan	4863	0.68	2.71	8.20	0.0360	0.1600	0.5480	5.96
21139000537000	571176.3	4737157.1	Ottawa	Michigan	3806	0.66	2.71	8.15	0.0000	0.0030	0.0220	0.13
21139004707000	582352.5	4741509.9	Ottawa	Michigan	4185	0.67	2.70	8.23	0.0070	0.0320	0.1220	1.24
21031306820000	705480.8	5031766.7	Cheboygan	Michigan	4831	0.66	2.70	8.27	0.0190	0.0920	0.3600	3.55
21029348240000	673381.2	5000896.3	Charlevoix	Michigan	6984	0.65	2.69	8.16	0.0390	0.1850	0.6690	7.03
21057297390000	696420.2	4793985.5	Gratiot	Michigan	8818	0.65	2.69	8.22	0.0060	0.0340	0.1590	1.37
21105399840100	555149.5	4873149.1	Mason	Michigan	6148	0.66	2.72	8.10	0.0090	0.0530	0.2590	2.17
21093404380000	740599.9	4729475.3	Livingston	Michigan	5687	0.68	2.72	8.10	0.0120	0.0580	0.2450	2.31
3411523703	945714.2	4404461	Morgan	Ohio	6988	0.66	2.69	8.05	0.0000	0.0000	0.0010	0.00
3404320171	856543.7	4614929.2	Erie	Ohio	2920	0.66	2.70	8.26	0.0050	0.0230	0.0740	0.84
3708520116	1064832.3	4612146.6	Mercer	Pennsylvania	7742	0.68	2.69	8.14	0.0020	0.0100	0.0370	0.37
3708331744	1195805.6	4669655.1	Mc Kean	Pennsylvania	9990	0.68	2.72	8.21	0.0020	0.0170	0.0990	0.71
4705300069	924631.1	4296368.5	Mason	West Virginia	6664	0.67	2.71	8.17	0.0000	0.0010	0.0060	0.04
4705900879	916746.6	4203505.1	Mingo	West Virginia	7599	0.68	2.68	8.07	0.0050	0.0310	0.1840	1.39
4703501366	971935.2	4300800.1	Jackson	West Virginia	10511	0.66	2.68	8.21	0.0010	0.0060	0.0240	0.22
4704900244	1101681.9	4388106	Marion	West Virginia	15996	0.67	2.73	7.94	0.0030	0.0130	0.0410	0.48

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
4702900080	1045889.2	4507676.8	Hancock	West Virginia	9945	0.67	2.70	8.12	0.0010	0.0030	0.0090	0.12
4704301469	943137.3	4242035.8	Lincoln	West Virginia	9270	0.65	2.72	8.06	0.0010	0.0040	0.0160	0.17
4701302503	1011741.8	4320371.3	Calhoun	West Virginia	13534	0.67	2.69	8.26	0.0000	0.0030	0.0250	0.14
4705100539	1054417.8	4421397.2	Marshall	West Virginia	14431	0.67	2.67	8.13	0.0030	0.0160	0.0660	0.62

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F- 6. SRE Values, Unit 4, for Method 6.

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km²]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
146918	673204	4624060	Steuben	Indiana	3675	0.66	2.21	5.31	0.0270	0.1260	0.4640	6.18
159232	640340	4621183	Lagrange	Indiana	3284	0.65	2.23	5.33	0.0300	0.1420	0.5910	7.36
146918	673204	4624060	Steuben	Indiana	3675	0.65	2.22	5.28	0.0280	0.1300	0.4730	6.37
1601920459	870649	4247292	Boyd	Kentucky	5814	0.66	2.21	5.33	0.0390	0.1840	0.7830	9.64
1604316235	840110	4245513	Carter	Kentucky	4137	0.66	2.21	5.28	0.1520	0.5790	1.7200	27.27
1604322935	867366	4246344	Carter	Kentucky	5422	0.67	2.19	5.24	0.0310	0.1530	0.6230	7.83
1604326995	835882	4249914	Carter	Kentucky	3958	0.65	2.22	5.33	0.0110	0.0800	0.5360	5.12
1608921256	843699	4284166	Greenup	Kentucky	4026	0.67	2.2	5.29	0.0050	0.0440	0.3690	3.24
1613500000	829808	4273079	Lewis	Kentucky	3082	0.67	2.22	5.35	0.0360	0.1590	0.6000	7.92
1604300000	838996	4249296	Carter	Kentucky	3976	0.67	2.21	5.24	0.0980	0.3300	0.8520	15.27
1613521132	837305	4272399	Lewis	Kentucky	3916	0.67	2.21	5.35	0.0160	0.1260	0.8020	7.69
1616518101	806154	4212613	Menifee	Kentucky	3585	0.66	2.22	5.27	0.1040	0.4330	1.4930	21.20
1616529846	803344	4197392	Menifee	Kentucky	4045	0.66	2.2	5.33	0.0880	0.4050	1.5280	20.14
1620525356	820316	4222948	Rowan	Kentucky	3851	0.66	2.19	5.31	0.0570	0.2900	1.2580	15.19
1601927870	879207	4252233	Boyd	Kentucky	6042	0.64	2.22	5.32	0.0510	0.2370	0.9200	11.98
1613502579	825686	4252759	Lewis	Kentucky	3464	0.67	2.2	5.26	0.0390	0.1330	0.3410	6.12
1601921652	876829	4253090	Boyd	Kentucky	5591	0.67	2.2	5.28	0.0650	0.2190	0.5400	9.96
21093404380000	740600	4729475	Livingston	Michigan	6084	0.65	2.18	5.28	0.0130	0.0720	0.3290	3.84
21059532680000	689749	4632977	Hillsdale	Michigan	3873	0.66	2.18	5.37	0.0340	0.1530	0.6060	7.82

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
21105399840100	555150	4873149	Mason	Michigan	6678	0.66	2.21	5.31	0.0570	0.1960	0.5010	8.98
21115359480000	785984	4644637	Monroe	Michigan	2916	0.68	2.2	5.31	0.0180	0.0920	0.3990	4.78
21121000027000	548279	4805117	Muskegon	Michigan	5205	0.67	2.18	5.3	0.0230	0.1050	0.4080	5.32
21123398560100	610345	4834838	Newaygo	Michigan	8927	0.65	2.22	5.3	0.0560	0.2130	0.6180	9.96
21127331340000	544768	4820322	Oceana	Michigan	5286	0.65	2.2	5.37	0.0360	0.1390	0.4380	6.67
21139000537000	571176	4737157	Ottawa	Michigan	4242	0.66	2.21	5.25	0.0100	0.0720	0.4650	4.54
21139004707000	582353	4741510	Ottawa	Michigan	4660	0.66	2.2	5.34	0.0020	0.0280	0.3240	2.55
21139348850000	594643	4774434	Ottawa	Michigan	6111	0.66	2.19	5.28	0.0520	0.2030	0.6650	9.91
21161003287000	763079	4685429	Washtenaw	Michigan	4991	0.66	2.2	5.26	0.0070	0.0370	0.1660	1.97
21161416710000	783263	4702000	Washtenaw	Michigan	4926	0.65	2.21	5.36	0.0060	0.0360	0.1740	1.93
21163001557000	821049	4689533	Wayne	Michigan	3926	0.67	2.19	5.37	0.0060	0.0390	0.2450	2.41
21163001847000	817229	4690328	Wayne	Michigan	3958	0.68	2.17	5.27	0.0000	0.0010	0.0250	0.17
21163003767000	797708	4679669	Wayne	Michigan	3815	0.65	2.21	5.23	0.0070	0.0430	0.2460	2.58
21077003277000	619468	4673788	Kalamazoo	Michigan	3927	0.66	2.2	5.3	0.0350	0.1730	0.7280	8.97
21163556620000	804307	4684064	Wayne	Michigan	3932	0.68	2.21	5.27	0.0020	0.0180	0.1530	1.34
21091004207000	747310	4642262	Lenawee	Michigan	4040	0.68	2.2	5.23	0.0020	0.0210	0.1800	1.56
21127582490000	549737	4834792	Oceana	Michigan	6022	0.65	2.22	5.3	0.0060	0.0390	0.2280	2.33
21163004537000	803879	4683407	Wayne	Michigan	3982	0.66	2.19	5.34	0.0080	0.0530	0.3240	3.23
21059404140000	695216	4659521	Hillsdale	Michigan	4681	0.66	2.19	5.27	0.0610	0.2790	1.0570	14.01

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
21055342920000	612645	4943580	Grand Traverse	Michigan	9231	0.66	2.19	5.37	0.0030	0.0240	0.2090	1.81
21029348240000	673381	5000896	Charlevoix	Michigan	7602	0.65	2.2	5.28	0.0330	0.1330	0.4480	6.54
21093437270000	738511	4726419	Livingston	Michigan	6645	0.67	2.22	5.34	0.0030	0.0170	0.1090	1.08
21093540210000	771658	4723819	Livingston	Michigan	6584	0.65	2.19	5.39	0.0160	0.0850	0.4270	4.75

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F.6. SRE Values, Unit 4, for Method 6 (continued).

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
21045291170000	695749	4713740	Eaton	Michigan	6053	0.66	2.2	5.34	0.0100	0.0450	0.1790	2.30
21025404170000	652602	4696744	Calhoun	Michigan	5068	0.66	2.2	5.32	0.0060	0.0450	0.2880	2.79
21023299690000	643013	4657490	Branch	Michigan	3914	0.67	2.17	5.33	0.0500	0.2150	0.7740	10.63
21023375690000	647818	4648131	Branch	Michigan	3780	0.66	2.19	5.27	0.0150	0.0910	0.4710	5.12
21031306820000	705481	5031767	Cheboygan	Michigan	5230	0.65	2.2	5.34	0.0190	0.0730	0.2320	3.53
3405924067	955161	4434852	Guernsey	Ohio	7736	0.67	2.19	5.35	0.0340	0.1600	0.6490	8.17
3400720213	1016000	4636991	Ashtabula	Ohio	6075	0.66	2.2	5.34	0.0230	0.0860	0.2670	4.13
3415725334	967910	4481624	Tuscarawas	Ohio	7592	0.67	2.21	5.32	0.0200	0.0950	0.3760	4.78
3403125889	955122	4482315	Coshocton	Ohio	7036	0.68	2.16	5.34	0.0170	0.0890	0.3940	4.67
3403126379	955091	4477635	Coshocton	Ohio	6903	0.67	2.2	5.35	0.0200	0.0830	0.3010	4.13
3403320050	846725	4536930	Crawford	Ohio	3120	0.66	2.21	5.4	0.0150	0.0740	0.3010	3.73
3400523938	887497	4550437	Ashland	Ohio	4390	0.67	2.21	5.24	0.0150	0.0750	0.3040	3.81
3404120314	859907	4453623	Delaware	Ohio	3775	0.66	2.2	5.3	0.0030	0.0240	0.1920	1.72
3404120329	834666	4473304	Delaware	Ohio	2843	0.66	2.21	5.21	0.0150	0.0880	0.4630	5.05
3404120354	859732	4465401	Delaware	Ohio	3747	0.66	2.21	5.31	0.0380	0.1580	0.5380	7.68
3404120356	847029	4472160	Delaware	Ohio	3187	0.67	2.19	5.24	0.0300	0.1020	0.2680	4.75
3404120358	856979	4463275	Delaware	Ohio	3569	0.67	2.19	5.28	0.0000	0.0010	0.0200	0.14
3404320111	857433	4583633	Erie	Ohio	3042	0.66	2.21	5.34	0.0150	0.0560	0.1600	2.60
3404320154	854581	4587692	Erie	Ohio	2921	0.65	2.21	5.29	0.0000	0.0010	0.0150	0.11

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3404320156	878172	4583463	Erie	Ohio	3675	0.66	2.2	5.3	0.0020	0.0150	0.0940	0.92
3404320157	886257	4583455	Erie	Ohio	3904	0.66	2.21	5.26	0.0020	0.0140	0.1000	0.95
3404320171	856544	4614929	Erie	Ohio	2972	0.66	2.21	5.31	0.0000	0.0020	0.0250	0.19
3405320985	911363	4296077	Gallia	Ohio	6569	0.66	2.22	5.33	0.0000	0.0000	0.0030	0.02
3405520339	977644	4610967	Geauga	Ohio	6248	0.66	2.17	5.32	0.0020	0.0120	0.0770	0.77
3407524527	924384	4493601	Holmes	Ohio	5667	0.67	2.17	5.32	0.0360	0.1180	0.3020	5.50
3407525231	926064	4491002	Holmes	Ohio	5727	0.65	2.2	5.35	0.0170	0.0960	0.4920	5.39
3407525275	925628	4490980	Holmes	Ohio	5668	0.66	2.18	5.37	0.0130	0.0750	0.3980	4.27
3408323931	883799	4469783	Knox	Ohio	4389	0.67	2.19	5.37	0.0280	0.1100	0.3490	5.23
3408324064	884618	4470575	Knox	Ohio	4472	0.66	2.19	5.27	0.0310	0.1300	0.4470	6.37
3408520142	985904	4638621	Lake	Ohio	5546	0.65	2.22	5.36	0.0100	0.0570	0.2810	3.12
3408720219	879455	4282037	Lawrence	Ohio	5393	0.67	2.19	5.35	0.0850	0.3170	0.9700	15.10
3408921826	898524	4455631	Licking	Ohio	5101	0.67	2.2	5.29	0.0380	0.1520	0.4960	7.32
3408922252	863862	4434009	Licking	Ohio	3901	0.67	2.18	5.37	0.0900	0.3160	0.8310	14.47
3408924792	907756	4454215	Licking	Ohio	5236	0.65	2.2	5.3	0.0220	0.1000	0.3910	5.10
3408925413	868867	4442816	Licking	Ohio	4190	0.66	2.2	5.29	0.0240	0.1130	0.4660	5.86
3408925435	893647	4450038	Licking	Ohio	4872	0.65	2.21	5.27	0.0020	0.0240	0.2170	1.84
3409321038	890592	4579731	Lorain	Ohio	4019	0.65	2.21	5.34	0.0130	0.0600	0.2220	2.96
3410120009	843090	4509311	Marion	Ohio	3052	0.67	2.21	5.29	0.0290	0.1340	0.5240	6.77

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3411720033	845742	4484201	Morrow	Ohio	3123	0.66	2.18	5.3	0.0460	0.1620	0.4360	7.54
3411720047	864951	4513378	Morrow	Ohio	4086	0.66	2.19	5.32	0.0470	0.1600	0.4180	7.43
3411721388	854803	4475727	Morrow	Ohio	3604	0.66	2.19	5.29	0.0570	0.1880	0.4670	8.68
3411723737	865433	4499990	Morrow	Ohio	4132	0.65	2.21	5.32	0.0240	0.1230	0.5560	6.57

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F.6. SRE Values, Unit 4, for Method 6 (continued).

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3411723850	853180	4501412	Morrow	Ohio	3558	0.65	2.22	5.3	0.0210	0.1020	0.4120	5.20
3413920678	864678	4533819	Richland	Ohio	3796	0.67	2.19	5.35	0.0070	0.0310	0.1270	1.61
3414720312	836393	4558669	Seneca	Ohio	2696	0.67	2.2	5.31	0.0070	0.0370	0.1780	2.03
3415121999	978818	4525727	Stark	Ohio	7743	0.65	2.2	5.35	0.0090	0.0540	0.2930	3.11
3415723715	949643	4482526	Tuscarawas	Ohio	7179	0.66	2.19	5.31	0.0290	0.1430	0.5540	7.12
3416728666	987876	4386491	Washington	Ohio	10166	0.66	2.21	5.29	0.0620	0.2640	0.9480	13.09
3416920071	944426	4544634	Wayne	Ohio	6130	0.65	2.19	5.37	0.0180	0.0650	0.1790	3.02
3417120046	699614	4617206	Williams	Ohio	3460	0.65	2.19	5.3	0.0150	0.0660	0.2530	3.36
3408521278	984467	4634461	Lake	Ohio	5760	0.67	2.18	5.35	0.0390	0.1500	0.4800	7.22
3409923127	1030449	4571365	Mahoning	Ohio	8027	0.65	2.19	5.32	0.0370	0.1820	0.7670	9.47
3409923158	1033369	4554005	Mahoning	Ohio	8920	0.66	2.2	5.29	0.0470	0.1920	0.6490	9.37
3400721847	1018133	4625548	Ashtabula	Ohio	6398	0.66	2.2	5.25	0.0330	0.1420	0.4750	6.83
3400722038	1017739	4624442	Ashtabula	Ohio	6403	0.65	2.2	5.4	0.0080	0.0500	0.2830	2.91
3400724113	1015649	4648076	Ashtabula	Ohio	5684	0.65	2.21	5.34	0.0240	0.1080	0.4010	5.36
3400760010	1019946	4658578	Ashtabula	Ohio	5430	0.67	2.19	5.29	0.0590	0.2000	0.5090	9.19
3400923210	942478	4368546	Athens	Ohio	7596	0.67	2.2	5.24	0.0530	0.2240	0.7990	11.11
3402920620	1008948	4536048	Columbiana	Ohio	8785	0.67	2.2	5.33	0.0040	0.0290	0.1790	1.76
3403123753	941209	4481109	Coshocton	Ohio	6513	0.66	2.2	5.31	0.0150	0.0900	0.4730	5.09
3403123377	942013	4471393	Coshocton	Ohio	6638	0.66	2.19	5.32	0.0530	0.2060	0.6440	9.85

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3403124118	938724	4481591	Coshocton	Ohio	6324	0.67	2.19	5.34	0.0140	0.0680	0.3080	3.65
3403126006	955383	4468747	Coshocton	Ohio	7419	0.66	2.18	5.36	0.0470	0.1900	0.6250	9.17
3403126397	945815	4486230	Coshocton	Ohio	6839	0.65	2.19	5.34	0.0160	0.0910	0.4860	5.24
3404521136	896690	4406842	Fairfield	Ohio	4976	0.66	2.21	5.28	0.0180	0.0890	0.4200	4.90
3405920782	950542	4445220	Guernsey	Ohio	7307	0.67	2.19	5.28	0.0320	0.1410	0.5490	7.20
3406720737	994078	4465617	Harrison	Ohio	9275	0.65	2.21	5.27	0.0470	0.1890	0.5910	9.00
3407321222	897086	4371165	Hocking	Ohio	5435	0.66	2.19	5.33	0.0280	0.1350	0.5740	7.06
3407323421	878970	4381330	Hocking	Ohio	4573	0.66	2.21	5.34	0.0690	0.2940	1.1020	14.80
3407920076	881930	4322237	Jackson	Ohio	5097	0.64	2.19	5.31	0.0420	0.1990	0.7650	10.02
3407920078	869287	4311569	Jackson	Ohio	4464	0.66	2.19	5.31	0.0230	0.1220	0.5010	6.16
3407920102	877705	4326811	Jackson	Ohio	4808	0.66	2.2	5.33	0.0110	0.0790	0.5030	4.90
3408720174	892629	4296657	Lawrence	Ohio	5707	0.66	2.2	5.34	0.0100	0.0740	0.5040	4.77
3411927076	929902	4453405	Muskingum	Ohio	6302	0.67	2.21	5.27	0.0010	0.0150	0.1420	1.17
3412121278	985385	4399882	Noble	Ohio	10000	0.67	2.2	5.29	0.0390	0.1570	0.4940	7.43
3412920024	850264	4384806	Pickaway	Ohio	3176	0.64	2.21	5.28	0.0070	0.0600	0.4570	4.15
3413120036	861304	4336612	Pike	Ohio	4176	0.66	2.19	5.32	0.0390	0.1950	0.8280	10.13
3414120007	862291	4349881	Ross	Ohio	3738	0.65	2.19	5.41	0.0500	0.2490	1.0690	12.94
3403521625	962818	4614438	Cuyahoga	Ohio	5847	0.66	2.2	5.27	0.0080	0.0500	0.2890	2.99
3414520257	825896	4322263	Scioto	Ohio	3185	0.66	2.19	5.3	0.0150	0.0800	0.3880	4.42

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3404320027	887783	4585782	Erie	Ohio	3843	0.66	2.22	5.4	0.0010	0.0080	0.0700	0.60
3415725465	960241	4473541	Tuscarawas	Ohio	7558	0.66	2.2	5.3	0.0400	0.1570	0.4740	7.38
3414120008	848356	4373153	Ross	Ohio	3181	0.65	2.2	5.34	0.0010	0.0100	0.1560	1.18
3401922045	982537	4515284	Carroll	Ohio	7853	0.65	2.19	5.33	0.0830	0.3060	0.8970	14.52

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F.6. SRE Values, Unit 4, for Method 6 (continued).

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km^2]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
3405521327	986680	4605378	Geauga	Ohio	6450	0.66	2.22	5.25	0.0030	0.0140	0.0630	0.76
3404320063	889586	4583353	Erie	Ohio	3915	0.65	2.2	5.27	0.0010	0.0120	0.0860	0.78
3411724190	847257	4498585	Morrow	Ohio	3245	0.67	2.2	5.3	0.0260	0.1270	0.5170	6.47
3408324000	886040	4467786	Knox	Ohio	4537	0.66	2.2	5.29	0.0930	0.3260	0.8460	14.97
3412124072	974580	4426230	Noble	Ohio	8476	0.65	2.21	5.3	0.0340	0.1240	0.3410	5.76
3403122653	944133	4476270	Coshocton	Ohio	6868	0.67	2.19	5.32	0.0210	0.1170	0.5400	6.21
3403125531	951889	4479295	Coshocton	Ohio	7071	0.67	2.21	5.26	0.0130	0.0780	0.4280	4.54
3403125988	957161	4477868	Coshocton	Ohio	7417	0.67	2.21	5.3	0.0100	0.0680	0.4260	4.20
3404320025	885889	4585909	Erie	Ohio	3887	0.66	2.2	5.35	0.0030	0.0170	0.0860	0.94
3403126284	931119	4462523	Coshocton	Ohio	6400	0.65	2.22	5.39	0.0110	0.0690	0.4120	4.15
3403126294	928478	4478739	Coshocton	Ohio	5916	0.66	2.21	5.26	0.0120	0.0710	0.3600	3.96
3404320079	888571	4584100	Erie	Ohio	3835	0.66	2.22	5.3	0.0050	0.0290	0.1540	1.66
3703920907	1047555	4647517	Crawford	Pennsylvania	6400	0.65	2.2	5.31	0.0110	0.0680	0.3890	4.04
3708520116	1064832	4612147	Mercer	Pennsylvania	8112	0.65	2.2	5.38	0.0570	0.2130	0.6420	10.13
3703923539	1047642	4647462	Crawford	Pennsylvania	6368	0.67	2.19	5.34	0.0160	0.0670	0.2340	3.28
4705900805	924799	4206229	Mingo	West Virginia	9575	0.66	2.18	5.38	0.0380	0.1760	0.7040	8.97
4705300423	938608	4326339	Mason	West Virginia	8123	0.67	2.19	5.26	0.0900	0.3120	0.8460	14.59
4705300297	925863	4286374	Mason	West Virginia	8199	0.66	2.2	5.3	0.0000	0.0050	0.0790	0.57
4710700756	975153	4340107	Wood	West Virginia	10659	0.66	2.19	5.26	0.0110	0.0900	0.6910	6.30

Well ID	Surf X (UTM)	Surf Y (UTM)	County	State	Depth[a] (ft)	Efficiency Factors			SRE			Average SRE (E=100%)[b] [MMTons CO_2/km²]
						P_{10} (%)	P_{50} (%)	P_{90} (%)	P_{10} (Mt)	P_{50} (Mt)	P_{90} (Mt)	
4701100537	913028	4274595	Cabell	West Virginia	7382	0.66	2.19	5.28	0.1080	0.3570	0.8800	16.44
4702900080	1045889	4507677	Hancock	West Virginia	10174	0.67	2.21	5.32	0.0020	0.0150	0.1310	1.15
4705300069	924631	4296369	Mason	West Virginia	7359	0.65	2.2	5.27	0.0120	0.0650	0.3180	3.61

a. The depth listed corresponds to the middle point within the formation/unit evaluated.
b. To estimate the average SREs we used the relationship indicated in equation [14] in Section 3.4.3.

Table F- 7. Average and Sum of SREs for Three Units Assessed Using Method 1 (Source data provided in Table F- 1, Table F- 2 and Table F- 3).

Unit	Number of Counties	Average SRE [MMTons / km^2]				Total SRE (All Counties in MRCSP States) [billion ton, Gt]			
		RAW*	E=1 %	E=4%	E=10%	RAW*	E=1%	E=4%	E=10%
2	230	20.27	0.20	0.81	2.03	6581.79	65.82	263.27	658.18
3	96	4.84	0.05	0.19	0.48	645.01	6.45	25.80	64.50
4	210	27.97	0.28	1.12	2.80	7736.19	77.36	309.45	773.62

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