# National Assessment of Geologic Carbon Dioxide Storage Resources—Summary

The U.S. Geological Survey (USGS) recently completed an evaluation of the technically accessible storage resource ($TA_{SR}$) for carbon dioxide ($CO_2$) for 36 sedimentary basins in the onshore areas and State waters of the United States (fig. 1). The $TA_{SR}$ is an estimate of the geologic storage resource that may be available for $CO_2$ injection and storage and is based on current geologic and hydrologic knowledge of the subsurface and current engineering practices. By using a geology-based probabilistic assessment methodology, the USGS assessment team members obtained a mean estimate of approximately 3,000 metric gigatons (Gt) of subsurface $CO_2$ storage capacity that is technically accessible below onshore areas and State waters; this amount is more than 500 times the 2011 annual U.S. energy-related $CO_2$ emissions of 5.5 Gt (U.S. Energy Information Administration, 2012).

In 2007, the Energy Independence and Security Act (Public Law 110–140) directed the U.S. Geological Survey to conduct a national assessment of geologic storage resources for $CO_2$ in consultation with the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and State

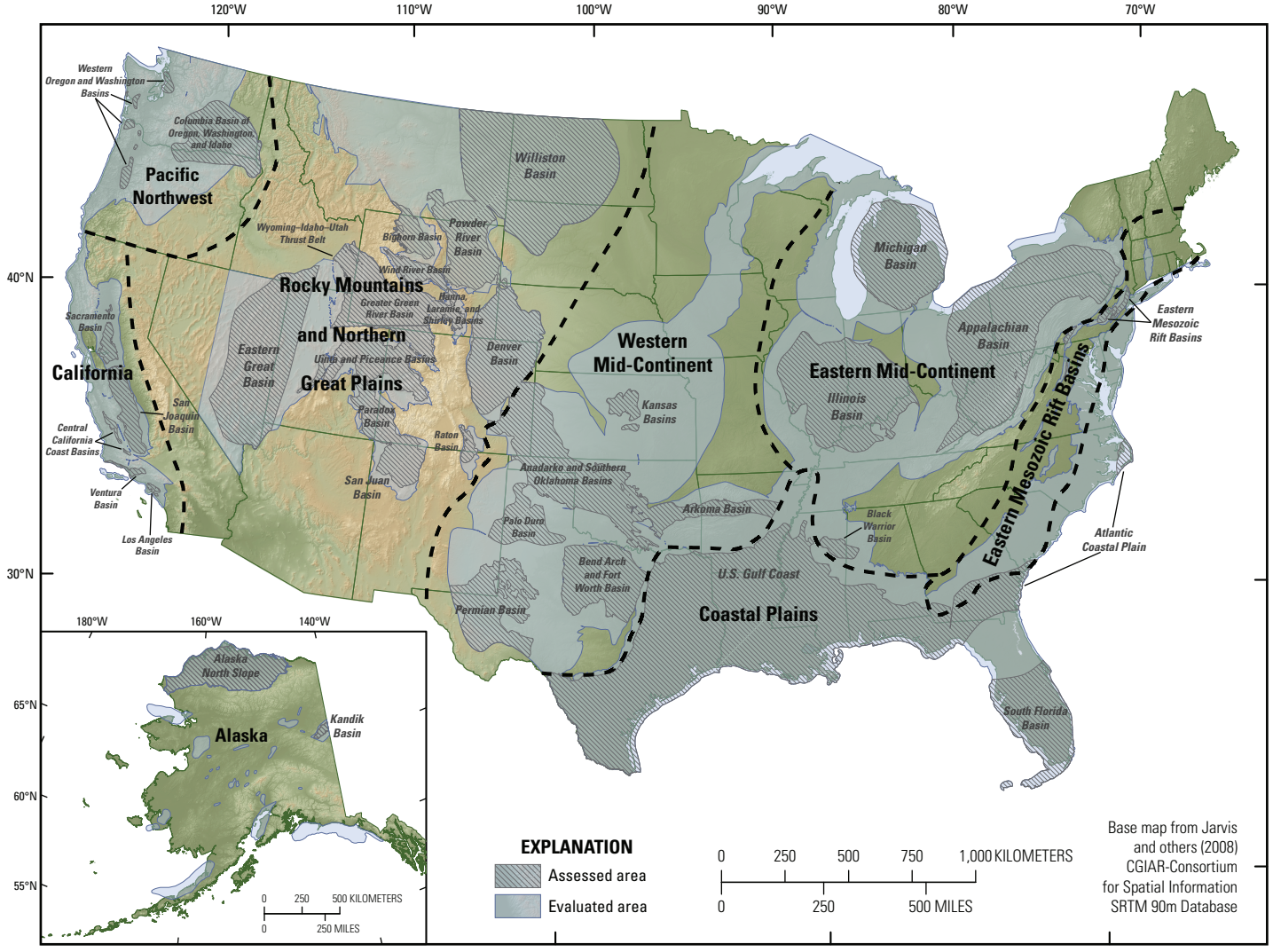


**Figure 1.** Map of the conterminous United States and Alaska showing 8 regions (separated by bold dashed lines), evaluated areas (bluish gray) that were not assessed, and 36 areas (pattern) that were assessed by the U.S. Geological Survey for carbon dioxide ($CO_2$) storage. Resources in federally owned offshore areas were not assessed, and Hawaii was considered unlikely to have significant storage resources. Regions and study areas are plotted over a shaded-relief image showing higher elevations in brown and tan and lower elevations in green.

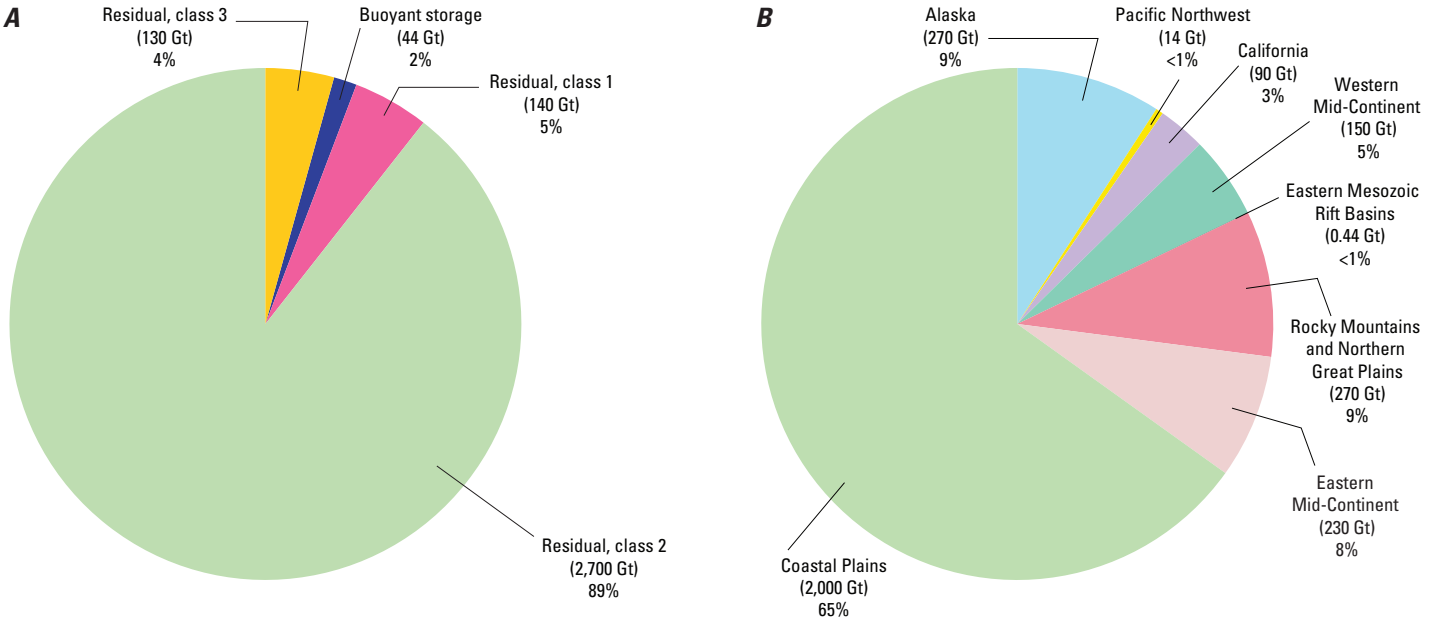


**Figure 2.** Pie charts showing mean estimates by the U.S. Geological Survey in 2012 of technically accessible storage resources ($TA_{SR}$) for carbon dioxide ($CO_2$) in the United States by (*A*) type and class and (*B*) region. Resources were estimated for eight geographic regions shown in figure 1. A mean total of 3,000 metric gigatons (Gt) of storage resources was estimated to exist in buoyant and residual storage types. The known recovery replacement storage resource ($KRR_{SR}$) is not shown in part *A* but is included in the buoyant storage type. Resources in federally owned offshore areas were not assessed. Mean values sum to totals but are reported to only two significant figures. Percentages were calculated from unrounded resource estimates.

**Table 1.** Estimates by the U.S. Geological Survey in 2012 of national totals for technically accessible storage resources ($TA_{SR}$) for carbon dioxide ($CO_2$) in the United States by resource type and class.

[Estimates are in billions of metric tons (gigatons, Gt). $P_5$, $P_{50}$, and $P_{95}$ are probability percentiles and represent the 5-, 50-, and 95-percent probabilities, respectively, that the true storage resource is less than the value shown. The terminology used in this report differs from that used by the petroleum industry and follows standard statistical practice (for example, Everitt and Skrondal, 2010), where percentiles, or fractiles, represent the value of a variable below which a certain proportion of observations falls. The percentiles were calculated by using the aggregation method described in U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team (2013b) and in Blondes, Schuenemeyer, and others (2013). Percentile values do not sum to totals because the aggregation procedure used partial dependencies between storage assessment units. The $P_{50}$ (median) values are generally less than mean values because most output distributions are right skewed. The known recovery replacement storage resource ($KRR_{SR}$) is listed separately as determined from petroleum production volumes; the same type of resource is also included in the buoyant storage type estimated from a geologic model. Mean values sum to totals but are reported to only two significant figures]

| $CO_2$ storage resource type and class | | $P_5$ | $P_{50}$ | $P_{95}$ | Mean |
|---|---|---|---|---|---|
| Symbol | Name | | | | |
| Storage resource estimated from geologic models | | | | | |
| $B_{SR}$ | Buoyant trapping storage resource | 19 | 31 | 110 | 44 |
| $R1_{SR}$ | Residual trapping class 1 storage resource | 97 | 140 | 200 | 140 |
| $R2_{SR}$ | Residual trapping class 2 storage resource | 2,100 | 2,600 | 3,300 | 2,700 |
| $R3_{SR}$ | Residual trapping class 3 storage resource | 58 | 120 | 230 | 130 |
| $TA_{SR}$ (total) | Technically accessible storage resource | 2,400 | 3,000 | 3,700 | 3,000 |
| Storage resource estimated from petroleum production volumes | | | | | |
| $KRR_{SR}$ | Known recovery replacement storage resource | 11 | 13 | 15 | 13 |

geological surveys. The USGS developed a methodology to estimate storage resource potential in geologic formations in the United States (Burruss and others, 2009; Brennan and others, 2010; Blondes, Brennan, and others, 2013). In 2012, the USGS completed the assessment, and the results are summarized in this Fact Sheet (fig. 2*A*,*B*; tables 1, 2) and are provided in more detail in companion reports (U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team, 2013a,b).

The goal of this project was to conduct an initial assessment of storage capacity on a regional basis, and results are not intended for use in the evaluation of specific sites for potential $CO_2$ storage. The national assessment was a geology-based examination of all sedimentary basins in the onshore and State waters area of the United States that contain storage assessment units (SAUs) that could be defined according to geologic and hydrologic characteristics. Although geologic storage of $CO_2$

**Table 2.** Estimates by the U.S. Geological Survey in 2012 of basin and regional totals for technically accessible storage resources ($TA_{SR}$) for carbon dioxide ($CO_2$) in the United States.

[Estimates are in millions of metric tons (megatons, Mt). $P_5$, $P_{50}$, and $P_{95}$ are probability percentiles; see table 1. Mean values sum to totals but are reported to only two significant figures if the value is greater than 1 Mt and are rounded to the nearest 0.1 Mt if the value is less than 1 Mt. Regions are listed from northwest to east, and basins are listed alphabetically]

| Basin name | $KRR_{SR}$ Known recovery replacement storage resource | | | | $B_{SR}$ Buoyant trapping storage resource | | | | $R1_{SR}$ Residual trapping class 1 storage resource | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_5$ | $P_{50}$ | $P_{95}$ | Mean | $P_5$ | $P_{50}$ | $P_{95}$ | Mean | $P_5$ | $P_{50}$ | $P_{95}$ | Mean |
| **Alaska Region** | | | | | | | | | | | | |
| Alaska North Slope | 700 | 910 | 1,100 | 910 | 2,400 | 8,600 | 62,000 | 18,000 | 510 | 770 | 1,100 | 790 |
| Kandik Basin | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 13 | 150 | 38 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Aggregated totals** | **700** | **910** | **1,100** | **910** | **2,400** | **8,600** | **62,000** | **18,000** | **510** | **770** | **1,100** | **790** |
| **Pacific Northwest Region** | | | | | | | | | | | | |
| Western Oregon and Washington Basins | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.5 | 35 | 8.2 | 860 | 1,600 | 2,700 | 1,700 |
| **Aggregated totals** | **0.0** | **0.0** | **0.0** | **0.0** | **0.1** | **1.5** | **35** | **8.2** | **860** | **1,600** | **2,700** | **1,700** |
| **California Region** | | | | | | | | | | | | |
| Los Angeles Basin | 10 | 13 | 16 | 13 | 43 | 75 | 140 | 81 | 66 | 130 | 230 | 130 |
| Sacramento Basin | 34 | 48 | 67 | 49 | 42 | 57 | 180 | 80 | 460 | 740 | 1,100 | 760 |
| San Joaquin Basin | 18 | 24 | 32 | 25 | 31 | 98 | 980 | 270 | 1,600 | 2,400 | 3,400 | 2,500 |
| Ventura Basin | 23 | 32 | 43 | 32 | 29 | 52 | 290 | 93 | 76 | 160 | 300 | 170 |
| **Aggregated totals** | **94** | **120** | **150** | **120** | **180** | **320** | **1,500** | **520** | **2,500** | **3,500** | **4,700** | **3,500** |
| **Rocky Mountains and Northern Great Plains Region** | | | | | | | | | | | | |
| Bighorn Basin | 75 | 93 | 110 | 93 | 89 | 120 | 290 | 150 | 0.0 | 0.0 | 0.0 | 0.0 |
| Denver Basin | 76 | 100 | 130 | 100 | 110 | 170 | 850 | 300 | 35 | 100 | 250 | 120 |
| Eastern Great Basin | 0.9 | 1.2 | 1.6 | 1.2 | 1.2 | 2.2 | 23 | 6.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Greater Green River Basin | 380 | 500 | 650 | 500 | 440 | 580 | 1,500 | 740 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hanna, Laramie, and Shirley Basins | 0.9 | 1.1 | 1.4 | 1.1 | 17 | 74 | 370 | 120 | 5.2 | 12.0 | 23 | 12 |
| Paradox Basin | 36 | 51 | 71 | 52 | 45 | 63 | 160 | 78 | 0.0 | 0.0 | 0.0 | 0.0 |
| Powder River Basin | 96 | 120 | 150 | 120 | 120 | 180 | 710 | 280 | 0.3 | 1.8 | 4.1 | 2.0 |
| San Juan Basin | 9.4 | 12 | 16 | 12 | 11 | 15 | 37 | 19 | 3.8 | 8.4 | 17 | 9.1 |
| Uinta and Piceance Basins | 46 | 58 | 75 | 59 | 47 | 73 | 280 | 110 | 0.0 | 0.0 | 0.0 | 0.0 |
| Williston Basin | 150 | 180 | 230 | 180 | 340 | 710 | 2,000 | 880 | 1,600 | 2,700 | 4,400 | 2,800 |
| Wind River Basin | 52 | 66 | 81 | 66 | 63 | 86 | 280 | 130 | 0.6 | 1.4 | 3.3 | 1.6 |
| Wyoming-Idaho-Utah Thrust Belt | 240 | 310 | 390 | 310 | 290 | 370 | 600 | 400 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Aggregated totals** | **1,300** | **1,500** | **1,800** | **1,500** | **1,800** | **2,700** | **6,300** | **3,200** | **1,700** | **2,900** | **4,600** | **3,000** |
| **Western Mid-Continent Region** | | | | | | | | | | | | |
| Anadarko and Southern Oklahoma Basins | 220 | 300 | 420 | 310 | 1,000 | 1,400 | 3,300 | 1,700 | 450 | 920 | 1,700 | 990 |
| Arkoma Basin | 3.7 | 5.2 | 7.3 | 5.3 | 14 | 25 | 66 | 31 | 0.0 | 0.0 | 0.0 | 0.0 |
| Bend Arch and Fort Worth Basin | 210 | 290 | 370 | 290 | 230 | 310 | 500 | 340 | 330 | 660 | 1,100 | 680 |
| Kansas Basins | 4.5 | 5.6 | 6.9 | 5.7 | 4.8 | 6.1 | 9.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Palo Duro Basin | 120 | 150 | 190 | 150 | 1.6 | 4.1 | 32 | 9.3 | 72 | 110 | 170 | 120 |
| Permian Basin | 1,000 | 1,300 | 1,700 | 1,300 | 1,600 | 2,000 | 4,000 | 2,400 | 2,200 | 3,900 | 6,700 | 4,100 |
| **Aggregated totals** | **1,700** | **2,100** | **2,500** | **2,100** | **3,100** | **3,800** | **7,800** | **4,500** | **3,600** | **5,700** | **8,900** | **5,900** |
| **Eastern Mid-Continent Region** | | | | | | | | | | | | |
| Appalachian Basin | 21 | 28 | 37 | 28 | 38 | 79 | 370 | 130 | 160 | 270 | 440 | 280 |
| Black Warrior Basin | 14 | 23 | 32 | 23 | 13 | 17 | 30 | 19 | 0.0 | 0.0 | 0.0 | 0.0 |
| Illinois Basin | 69 | 85 | 100 | 85 | 94 | 290 | 1,300 | 440 | 900 | 1,400 | 2,300 | 1,500 |
| Michigan Basin | 140 | 180 | 220 | 180 | 190 | 280 | 790 | 360 | 2,800 | 4,500 | 6,800 | 4,600 |
| **Aggregated totals** | **260** | **310** | **370** | **320** | **380** | **740** | **2,200** | **940** | **4,100** | **6,300** | **9,100** | **6,400** |
| **Coastal Plains Region** | | | | | | | | | | | | |
| Atlantic Coastal Plain | 0.0 | 0.0 | 0.0 | 0.0 | 39 | 100 | 270 | 120 | 2,000 | 3,100 | 4,700 | 3,200 |
| South Florida Basin | 6.7 | 8.5 | 10 | 8.5 | 21 | 97 | 900 | 240 | 0.0 | 0.0 | 0.0 | 0.0 |
| U.S. Gulf Coast | 6,400 | 8,000 | 9,800 | 8,000 | 7,800 | 11,000 | 39,000 | 16,000 | 75,000 | 120,000 | 170,000 | 120,000 |
| **Aggregated totals** | **6,400** | **8,000** | **9,800** | **8,000** | **8,000** | **11,000** | **40,000** | **17,000** | **78,000** | **120,000** | **180,000** | **120,000** |
| **Eastern Mesozoic Rift Basins Region** | | | | | | | | | | | | |
| Eastern Mesozoic Rift Basins | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 2.0 | 19 | 5.9 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Aggregated totals** | **0.0** | **0.0** | **0.0** | **0.0** | **1.3** | **2.0** | **19** | **5.9** | **0.0** | **0.0** | **0.0** | **0.0** |

**Table 2.** Estimates by the U.S. Geological Survey in 2012 of basin and regional totals for technically accessible storage resources ($TA_{SR}$) for carbon dioxide ($CO_2$) in the United States.—Continued

| $R2_{SR}$ Residual trapping class 2 storage resource | | | | $R3_{SR}$ Residual trapping class 3 storage resource | | | | $TA_{SR}$ Technically accessible storage resource | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_5$ | $P_{50}$ | $P_{95}$ | Mean | $P_5$ | $P_{50}$ | $P_{95}$ | Mean | $P_5$ | $P_{50}$ | $P_{95}$ | Mean |
| Alaska Region—Continued | | | | | | | | | | | |
| 150,000 | 200,000 | 280,000 | 210,000 | 7,600 | 38,000 | 110,000 | 45,000 | 170,000 | 260,000 | 400,000 | 270,000 |
| 480 | 1,100 | 2,200 | 1,200 | 22 | 170 | 630 | 230 | 570 | 1,400 | 2,700 | 1,500 |
| **150,000** | **200,000** | **280,000** | **210,000** | **7,700** | **39,000** | **110,000** | **45,000** | **180,000** | **260,000** | **410,000** | **270,000** |
| Pacific Northwest Region—Continued | | | | | | | | | | | |
| 6,600 | 12,000 | 20,000 | 12,000 | 0.6 | 10 | 43 | 14 | 7,500 | 14,000 | 22,000 | 14,000 |
| **6,600** | **12,000** | **20,000** | **12,000** | **0.6** | **10** | **43** | **14** | **7,500** | **14,000** | **22,000** | **14,000** |
| California Region—Continued | | | | | | | | | | | |
| 2,000 | 3,300 | 5,600 | 3,500 | 0.1 | 1.6 | 6.2 | 2.2 | 2,200 | 3,500 | 5,800 | 3,700 |
| 19,000 | 28,000 | 39,000 | 29,000 | 0.0 | 2.3 | 10 | 3.2 | 20,000 | 29,000 | 40,000 | 29,000 |
| 33,000 | 48,000 | 65,000 | 48,000 | 25 | 120 | 300 | 130 | 36,000 | 51,000 | 69,000 | 51,000 |
| 3,100 | 5,500 | 9,200 | 5,700 | 0.5 | 9.0 | 35 | 12 | 3,200 | 5,700 | 9,600 | 6,000 |
| **63,000** | **85,000** | **110,000** | **86,000** | **35** | **130** | **320** | **150** | **67,000** | **90,000** | **120,000** | **90,000** |
| Rocky Mountains and Northern Great Plains Region—Continued | | | | | | | | | | | |
| 890 | 1,500 | 2,400 | 1,500 | 21 | 86 | 230 | 100 | 1,100 | 1,700 | 2,800 | 1,800 |
| 1,000 | 2,700 | 5,900 | 3,000 | 37 | 210 | 830 | 300 | 1,400 | 3,300 | 7,200 | 3,700 |
| 80 | 170 | 360 | 190 | 1.9 | 24 | 97 | 34 | 98 | 210 | 430 | 230 |
| 21,000 | 30,000 | 43,000 | 31,000 | 1,700 | 6,200 | 17,000 | 7,400 | 26,000 | 38,000 | 57,000 | 39,000 |
| 1,100 | 2,000 | 3,200 | 2,100 | 25 | 91 | 240 | 110 | 1,300 | 2,200 | 3,600 | 2,300 |
| 1,000 | 2,500 | 5,300 | 2,800 | 28 | 380 | 1,600 | 530 | 1,300 | 3,100 | 6,300 | 3,400 |
| 11,000 | 17,000 | 25,000 | 18,000 | 39 | 170 | 510 | 210 | 11,000 | 18,000 | 26,000 | 18,000 |
| 380 | 640 | 1,100 | 670 | 5.2 | 30 | 94 | 37 | 430 | 710 | 1,200 | 740 |
| 1,300 | 2,200 | 3,300 | 2,200 | 290 | 1,200 | 3,300 | 1,400 | 2,000 | 3,500 | 6,300 | 3,800 |
| 99,000 | 140,000 | 180,000 | 140,000 | 1,100 | 5,200 | 14,000 | 6,000 | 110,000 | 140,000 | 190,000 | 150,000 |
| 4,100 | 7,100 | 11,000 | 7,300 | 150 | 580 | 1,500 | 670 | 4,600 | 7,800 | 12,000 | 8,100 |
| 26,000 | 39,000 | 55,000 | 39,000 | 780 | 3,800 | 12,000 | 4,700 | 28,000 | 43,000 | 63,000 | 44,000 |
| **180,000** | **240,000** | **310,000** | **240,000** | **7,300** | **19,000** | **43,000** | **22,000** | **200,000** | **270,000** | **350,000** | **270,000** |
| Western Mid-Continent Region—Continued | | | | | | | | | | | |
| 34,000 | 55,000 | 88,000 | 57,000 | 670 | 2,500 | 6,100 | 2,800 | 38,000 | 60,000 | 96,000 | 62,000 |
| 3,500 | 7,000 | 13,000 | 7,400 | 39 | 360 | 1,300 | 480 | 3,800 | 7,500 | 13,000 | 7,900 |
| 7,000 | 13,000 | 20,000 | 13,000 | 170 | 1,100 | 3,800 | 1,400 | 8,600 | 15,000 | 24,000 | 15,000 |
| 160 | 280 | 480 | 300 | 1.5 | 12 | 48 | 17 | 180 | 300 | 510 | 320 |
| 4,900 | 6,900 | 9,400 | 7,000 | 9.0 | 56 | 170 | 67 | 5,100 | 7,100 | 9,600 | 7,200 |
| 31,000 | 48,000 | 75,000 | 50,000 | 460 | 2,200 | 6,400 | 2,600 | 37,000 | 57,000 | 89,000 | 59,000 |
| **93,000** | **130,000** | **190,000** | **130,000** | **2,600** | **6,800** | **15,000** | **7,500** | **110,000** | **150,000** | **210,000** | **150,000** |
| Eastern Mid-Continent Region—Continued | | | | | | | | | | | |
| 13,000 | 18,000 | 27,000 | 19,000 | 180 | 840 | 2,500 | 1,000 | 14,000 | 20,000 | 29,000 | 20,000 |
| 170 | 280 | 450 | 290 | 0.2 | 2.1 | 7.2 | 2.7 | 180 | 300 | 480 | 310 |
| 110,000 | 140,000 | 200,000 | 150,000 | 1,000 | 5,100 | 14,000 | 6,100 | 110,000 | 150,000 | 210,000 | 150,000 |
| 33,000 | 47,000 | 66,000 | 48,000 | 560 | 3,400 | 11,000 | 4,200 | 40,000 | 56,000 | 78,000 | 57,000 |
| **160,000** | **210,000** | **280,000** | **210,000** | **2,700** | **9,900** | **25,000** | **11,000** | **170,000** | **230,000** | **300,000** | **230,000** |
| Coastal Plains Region—Continued | | | | | | | | | | | |
| 6,900 | 11,000 | 16,000 | 11,000 | 0.0 | 0.1 | 4.7 | 1.1 | 9,200 | 14,000 | 20,000 | 14,000 |
| 120,000 | 160,000 | 200,000 | 160,000 | 1,400 | 7,600 | 21,000 | 9,000 | 120,000 | 160,000 | 210,000 | 170,000 |
| 1,100,000 | 1,600,000 | 2,200,000 | 1,600,000 | 6,300 | 29,000 | 82,000 | 34,000 | 1,300,000 | 1,700,000 | 2,400,000 | 1,800,000 |
| **1,300,000** | **1,700,000** | **2,400,000** | **1,800,000** | **11,000** | **38,000** | **95,000** | **43,000** | **1,400,000** | **1,900,000** | **2,600,000** | **2,000,000** |
| Eastern Mesozoic Rift Basins Region—Continued | | | | | | | | | | | |
| 130 | 280 | 510 | 290 | 7.6 | 100 | 410 | 140 | 180 | 400 | 830 | 440 |
| **130** | **280** | **510** | **290** | **7.6** | **100** | **410** | **140** | **180** | **400** | **830** | **440** |

may be possible in some areas not assessed by the USGS, the SAUs identified in this assessment represent those areas within sedimentary basins that met the assessment criteria. A geologic description of each SAU was prepared; descriptions for SAUs in several basins are in Warwick and Corum (2012).

The resources were estimated without consideration either of accessibility due to land-management or regulatory restrictions or of economic viability. Thus, if storage of $CO_2$ within a formation is feasible with current technology, it was considered for this report. Because the legislation that mandated this assessment (Public Law 110–140) required that the assessment incorporate EPA regulations about underground sources of drinking water, a substantial percentage of potential storage formations containing water with less than 10,000 milligrams per liter (mg/L) of total dissolved solids (TDS) (considered freshwater for the purpose of this assessment) was disqualified as a protected underground source of potential drinking water.

The SAU is a mappable volume of rock that consists of a porous reservoir and a bounding regional sealing formation. The upper vertical limit chosen for this assessment was 3,000 feet (914 meters) because $CO_2$ at this depth is typically subjected to temperatures and pressures that maintain the $CO_2$ in a supercritical state and maximize the storage resource per unit volume. The lower vertical limit for the SAU of 13,000 ft (3,962 m) is based on the potential $CO_2$ injection depth at pipeline pressures without additional compression at the surface. *Standard SAUs* are between depths of 3,000 ft (914 m) and 13,000 ft (3,962 m). If reservoir rock properties suggested that a viable storage resource is present at depths below 13,000 ft (3,962 m), the assessment geologist may have added an additional *deep SAU* for this deeper reservoir.

Sedimentary rocks of deep saline formations and of existing oil and gas fields were evaluated. Specifically, 33 sedimentary basins, or combined basin areas, within 8 regions of the United States were assessed (table 2). Numerous other basins (study areas shown in bluish gray in fig. 1) were evaluated but not assessed because existing geologic conditions and available data indicated that the areas failed to meet the minimum requirements for $CO_2$ storage as outlined in Brennan and others (2010). Within the assessed basins, 202 SAUs were identified as having good storage potential because of the presence of a robust regional seal, adequate reservoir rock, and sufficient areas containing saline formation waters. Ten of the SAUs did not have sufficient data to build a robust geologic model to accurately estimate the storage resource and were designated as nonquantitative SAUs; no storage resources were estimated for the 10 nonquantitative SAUs. Three basins (Central California Coast Basins; Columbia Basin of Oregon, Washington, and Idaho; and Raton Basin) contain only nonquantitative SAUs, bringing the total number of basins shown in figure 1 to 36. For nonquantitative SAUs, surficial geographic boundaries were defined and a geologic description was prepared.

Two general storage types, buoyant and residual, were defined in the methodology used in this assessment. Buoyantly trapped $CO_2$ can be held in place in porous formations by top and lateral seals. Residually trapped $CO_2$ can be held in porous formations as individual droplets within pores by capillary forces. The residual storage resource consists of three injectivity classes based on reservoir permeability: residual trapping class 1 ($R1_{SR}$) represents storage in rocks with permeability greater than 1 darcy (D); residual trapping class 2 ($R2_{SR}$) represents storage in rocks with moderate permeability, defined as permeability between 1 millidarcy (mD) and 1 D; and residual trapping class 3 ($R3_{SR}$) represents storage in rocks with low permeability, defined as permeability less than 1 mD.

The known recovery replacement storage resource ($KRR_{SR}$) is the mass of $CO_2$ that can be stored in existing hydrocarbon reservoirs. The $KRR_{SR}$ is a minimum range of values that represent the amount of $CO_2$ at subsurface conditions that could replace the volume of known hydrocarbons in petroleum reservoirs. $KRR_{SR}$ is determined from production volumes rather than the geologic model of buoyant and residual resources that make up the $TA_{SR}$. The same type of resource is also included in the buoyant storage type estimated from a geologic model.

Regions with the largest technically accessible storage resources ($TA_{SR}$) are the Coastal Plains Region (mean estimate of 2,000 Gt, of which about 1,800 Gt, or 91 percent, is in the U.S. Gulf Coast) and the Alaska Region (mean estimate of 270 Gt), where the resource is almost entirely in the Alaska North Slope. Most (89 percent) of the $TA_{SR}$ is in the residual trapping class 2 storage resource category (mean estimate of 2,700 Gt; fig. 2*A*). Residual trapping classes 1 and 3 account for 5 and 4 percent of the $TA_{SR}$, respectively. The USGS team obtained a mean estimate of 44 Gt for storage in buoyant traps, $B_{SR}$. The mean estimate for $KRR_{SR}$ storage resources available in petroleum reservoirs within the assessed areas is 13 Gt (table 1).

The 44 Gt (mean estimate) of buoyant trapping storage resources includes non-hydrocarbon-bearing reservoir formations, but most of the resources are well defined by hydrocarbon exploration data. Existing oil in hydrocarbon reservoirs may be produced in the near future by using enhanced-oil-recovery technology that utilizes anthropogenic $CO_2$ (fig. 3), and then the reservoirs could be used for $CO_2$ storage. Because of the depth of knowledge about the hydrocarbon reservoirs, buoyant trapping storage resources in these reservoirs may be more attractive for storage of $CO_2$ than residual trapping storage resources.

**Figure 3.** $CO_2$ injection well at the Pump Canyon test site in New Mexico. The well was drilled by the Southwest Regional Partnership on Carbon Sequestration (sponsored by the U.S. Department of Energy) to test the effectiveness of storing $CO_2$ in deep, unminable coal seams (Koperna and others, 2009). Similar wells could inject $CO_2$ for storage in depleted oil and gas reservoirs. Photograph by Eelco Kruizinga; used with permission.

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## By U.S. Geological Survey Geologic Carbon Dioxide Storage Resources Assessment Team[1]

Peter D. Warwick, Project Chief

Madalyn S. Blondes
Sean T. Brennan
Marc L. Buursink
Steven M. Cahan
James L. Coleman
Troy A. Cook
Margo D. Corum
Jacob A. Covault
William H. Craddock
Christina A. DeVera
Colin Doolan
Ronald M. Drake II
Lawrence J. Drew
Joseph A. East
Philip A. Freeman
Christopher P. Garrity
Kevin J. Gooley
Mayur A. Gosai
Hossein Jahediesfanjani[2]
Celeste D. Lohr
John C. Mars
Matthew D. Merrill
Ricardo A. Olea
Tina L. Roberts-Ashby
William A. Rouse
Paul G. Schruben
John H. Schuenemeyer[2]
Ernie R. Slucher
Brian A. Varela
Mahendra K. Verma

[1] All members are or were with the U.S. Geological Survey unless otherwise indicated.

[2] Contractor.

## For information, please contact:

Peter D. Warwick
U.S. Geological Survey
Mail Stop 956
12201 Sunrise Valley Drive
Reston, VA 20192

Telephone: (703) 648–6469
E-mail: pwarwick@usgs.gov
http://energy.usgs.gov/GeneralInfo/ScienceCenters/Eastern.aspx

Or

Director, Eastern Energy Resources Science Center
U.S. Geological Survey
Mail Stop 956
12201 Sunrise Valley Drive
Reston, VA 20192
http://energy.usgs.gov/