## Supplemental Information

## Nitrate in groundwater of the United States, 1991-2003

*Karen R. Burow*, Bernard T. Nolan, Michael G. Rupert, and Neil M. Dubrovsky*

This document is 12 pages and contains three figures (Figures S1, S2, and S3) and two tables (Table S1, S2) that provide supplemental information in support of the subject article.

The soil characteristic depth to seasonally high water table (Figure S3) was determined from soil variables in the State Soil Geographic (STATSGO) database (33) and was compiled in a 1:250 000 scale GIS map. The variable was determined by averaging the low and high values for the range in depth to seasonally high water table. A GIS was used to compile the values within 500-m buffers around each sampled site. These values are measured only to a depth of 6 feet in most states.

## Supplemental Figure Captions

FIGURE S1. Map of land use and major aquifer networks sampled by the NAWQA program during 1991-2003.

FIGURE S2. Graph of relation between median nitrate concentration and total nitrogen input for agricultural and urban land-use study networks sampled by the NAWQA program during 1991-2003.

FIGURE S3. Map of redox condition for sampled wells and depth to seasonally high water table soil variable.

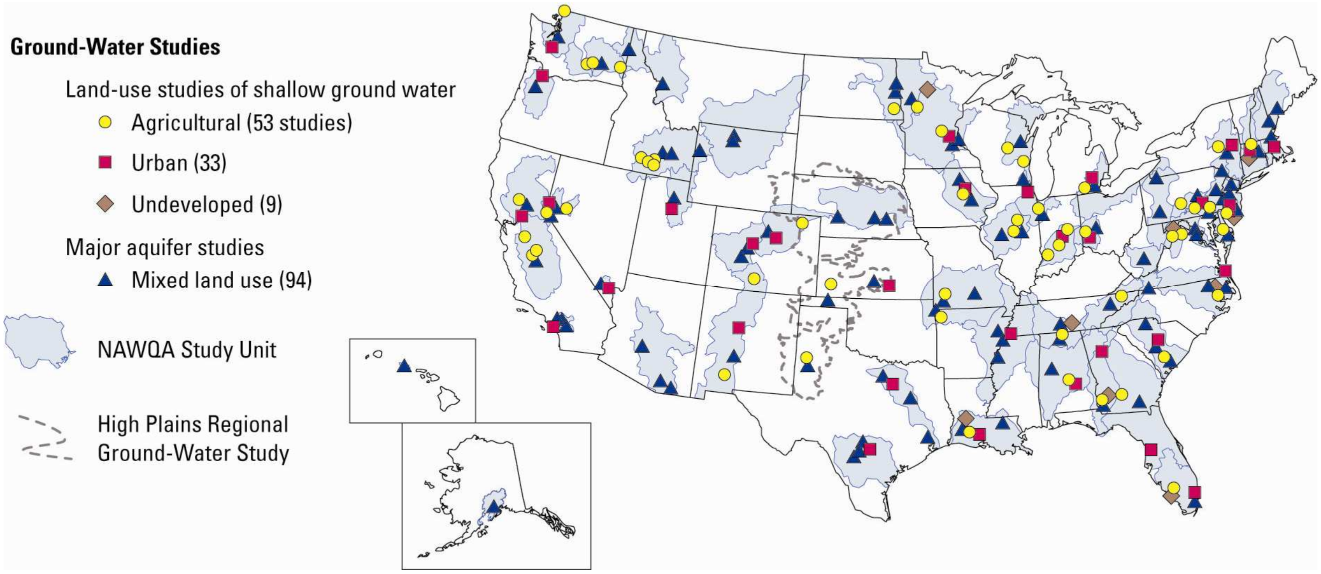


Figure S1.

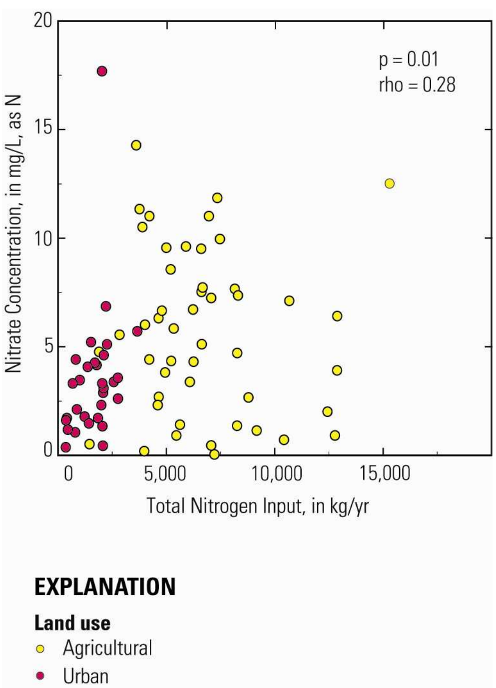


Figure S2.

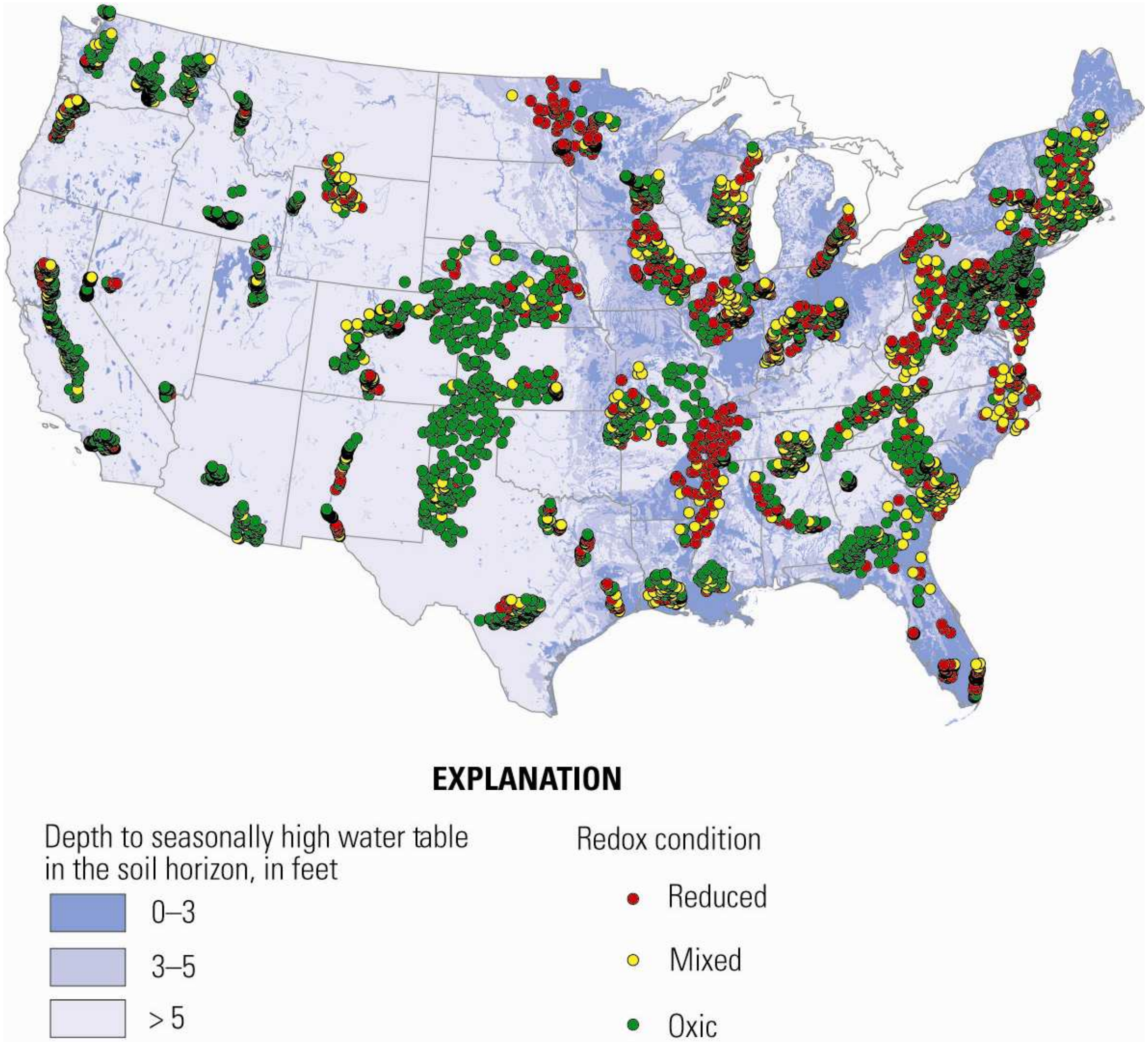
EXPLANATION
Depth to seasonally high water table in the soil horizon, in feet
0–3
3–5
> 5
Redox condition
Reduced
Mixed
Oxic

Figure S3

**Table S1. Study areas and networks sampled as part of the National-Water Quality Assessment Program**

[AG LUS, agricultural land-use study; URB LUS, urban land-use study; MAJOR AQ, major aquifer study; mg/L, milligrams per liter; ft, feet below land surface]

| Study unit abbreviation | Study unit name | Network type | Number of wells sampled | Median nitrate concentration, in mg/L | Median well depth below water level, in ft |
|---|---|---|---|---|---|
| ACAD | Acadian-Pontchartrain Drainages | MAJOR AQ | 30 | <0.05 | 103 |
| | | MAJOR AQ | 30 | 0.05 | 65 |
| | | AG LUS | 27 | <0.05 | 17 |
| | | URB LUS | 28 | 0.14 | 15 |
| | | FORESTED | 2 | 0.07 | 8 |
| ACFB | Apalachicola-Chattahoochee-Flint River Basin | MAJOR AQ | 25 | 1.8 | 110 |
| | | AG LUS | 19 | 1.4 | 17 |
| | | URB LUS | 21 | 1.6 | 9 |
| | | FORESTED | 4 | 0.57 | 11 |
| ALBE | Albemarle-Pamlico Drainage Basin | MAJOR AQ | 10 | 0.37 | 15 |
| | | MAJOR AQ | 15 | <0.05 | 16 |
| | | AG LUS | 17 | <0.05 | 8 |
| | | URB LUS | 15 | <0.05 | 55 |
| | | FORESTED | 1 | <0.05 | 4 |
| ALMN | Allegheny and Monongahela River Basins | MAJOR AQ | 30 | 0.09 | 74 |
| | | MAJOR AQ | 30 | 0.17 | 52 |
| CAZB | Central Arizona Basins | MAJOR AQ | 35 | 2.7 | 186 |
| | | MAJOR AQ | 29 | 1.4 | 109 |
| | | MAJOR AQ | 18 | 1.0 | 117 |
| | | MAJOR AQ | 43 | 1.0 | 137 |
| CCPT | Central Columbia Plateau | AG LUS | 29 | 5.3 | 50 |
| | | AG LUS | 49 | 6.7 | 34 |
| | | AG LUS | 40 | 6.0 | 21 |
| CNBR | Central Nebraska Basins | MAJOR AQ | 27 | 2.8 | 34 |
| CONN | Connecticut, Housatonic and Thames River Basins | MAJOR AQ | 30 | 0.12 | 228 |
| | | AG LUS | 40 | 3.7 | 10 |
| | | FORESTED | 6 | 0.18 | 8 |
| | | URB LUS | 40 | 1.1 | 11 |
| COOK | Cook Inlet Basin | MAJOR AQ | 29 | 0.12 | 33 |
| DELR | Delaware River Basin | MAJOR AQ | 29 | 2.9 | 136 |
| | | MAJOR AQ | 30 | 0.62 | 155 |
| | | MAJOR AQ | 16 | 0.49 | 76 |
| DLMV | Delmarva Peninsula | MAJOR AQ | 29 | 5.5 | 35 |
| | | AG LUS | 29 | 5.4 | 13 |

| | | | | | |
|---|---|---|---|---|---|
| EIWA | Eastern Iowa Basins | MAJOR AQ | 33 | <0.05 | 174 |
| | | MAJOR AQ | 32 | 0.07 | 41 |
| | | AG LUS | 31 | 5.1 | 11 |
| | | URB LUS | 30 | 1.8 | 12 |
| GAFL | Georgia-Florida Coastal Plain | MAJOR AQ | 36 | 1.1 | 17 |
| | | AG LUS | 23 | 6.7 | 18 |
| | | URB LUS | 16 | 0.95 | 11 |
| GRSL | Great Salt Lake Basins | MAJOR AQ | 55 | 2.0 | 147 |
| | | URB LUS | 30 | 6.8 | 18 |
| HDSN | Hudson River Basin | MAJOR AQ | 48 | <0.05 | 116 |
| | | AG LUS | 14 | 2.2 | 12 |
| | | URB LUS | 27 | 0.39 | 17 |
| HPGW | High Plains Regional Ground Water Study | MAJOR AQ | 74 | 2.3 | 104 |
| | | MAJOR AQ | 49 | 3.0 | 61 |
| | | MAJOR AQ | 104 | 2.1 | 118 |
| | | MAJOR AQ | 20 | 6.2 | 51 |
| | | MAJOR AQ | 27 | 2.1 | 88 |
| | | AG LUS | 29 | 6.6 | 17 |
| | | AG LUS | 29 | 4.1 | 20 |
| | | URB LUS | 30 | 2.2 | 11 |
| KANA | Kanawha-New River Basins | MAJOR AQ | 30 | <0.05 | 71 |
| | | MAJOR AQ | 30 | 0.42 | 180 |
| LERI | Lake Erie-Lake Sant Clair Drainages | MAJOR AQ | 28 | <0.05 | 58 |
| | | AG LUS | 30 | 0.17 | 7 |
| | | URB LUS | 30 | 0.74 | 10 |
| LINJ | Long Island-New Jersey Coastal Drainages | MAJOR AQ | 30 | 0.86 | 170 |
| | | MAJOR AQ | 30 | 0.33 | 80 |
| | | MAJOR AQ | 22 | 1.5 | 143 |
| | | AG LUS | 15 | 13 | 12 |
| | | FORESTED | 6 | 0.12 | 10 |
| | | URB LUS | 30 | 2.6 | 11 |
| | | URB LUS | 20 | 2.7 | 11 |
| LIRB | Lower Illinois River Basin | MAJOR AQ | 30 | <0.05 | 164 |
| | | MAJOR AQ | 30 | 1.3 | 44 |
| | | AG LUS | 28 | 0.07 | 11 |
| | | AG LUS | 29 | 0.37 | 10 |
| LSUS | Lower Susquehanna River Basin | MAJOR AQ | 29 | 0.13 | 124 |
| | | MAJOR AQ | 29 | 6.6 | 106 |
| | | AG LUS | 30 | 11 | 130 |
| | | AG LUS | 30 | 9.1 | 83 |
| | | AG LUS | 30 | 8.6 | 87 |
| | | URB LUS | 20 | 3.5 | 81 |
| LTEN | Lower Tennessee River Basin | MAJOR AQ | 32 | 1.4 | 52 |
| | | MAJOR AQ | 31 | 0.18 | 91 |
| | | AG LUS | 32 | 0.94 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| | | FORESTED | 1 | 0.07 | 26 |
| MIAM | Miami River Basin | MAJOR AQ | 30 | 0.35 | 29 |
| | | AG LUS | 26 | 5.9 | 9 |
| | | URB LUS | 25 | 2.8 | 14 |
| MISE | | MAJOR AQ | 29 | <0.05 | 96 |
| | Mississippi Embayment | MAJOR AQ | 30 | 0.05 | 573 |
| | | MAJOR AQ | 25 | <0.05 | 87 |
| | | URB LUS | 32 | 0.33 | 22 |
| MOBL | Mobile River Basin | MAJOR AQ | 31 | 0.07 | 94 |
| | | AG LUS | 29 | 3.0 | 17 |
| | | URB LUS | 30 | 1.5 | 17 |
| NECB | New England Coastal Basins | MAJOR AQ | 28 | <0.05 | 172 |
| | | MAJOR AQ | 30 | <0.05 | 282 |
| | | MAJOR AQ | 30 | 0.73 | 33 |
| | | URB LUS | 29 | 1.1 | 12 |
| NROK | Northern Rockies Intermontane Basins | MAJOR AQ | 31 | 0.26 | 51 |
| | | MAJOR AQ | 30 | 0.40 | 39 |
| NVBR | Nevada Basin and Range | MAJOR AQ | 22 | 0.65 | 608 |
| | | MAJOR AQ | 18 | 0.89 | 339 |
| | | MAJOR AQ | 17 | 1.1 | 114 |
| | | AG LUS | 20 | 0.16 | 14 |
| | | AG LUS | 10 | 1.0 | 10 |
| | | URB LUS | 29 | 4.8 | 14 |
| | | URB LUS | 27 | 1.9 | 13 |
| OAHU | Island of Oahu | MAJOR AQ | 30 | 0.92 | 219 |
| OZRK | Ozark Plateaus | MAJOR AQ | 20 | <0.05 | 1197 |
| | | MAJOR AQ | 33 | 0.5 | 142 |
| | | MAJOR AQ | 16 | 0.66 | 77 |
| | | AG LUS | 20 | 1.2 | 147 |
| | | AG LUS | 20 | 1.3 | 175 |
| POTO | Potomac River Basin | MAJOR AQ | 25 | 1.4 | 104 |
| | | MAJOR AQ | 23 | 0.86 | 133 |
| | | AG LUS | 28 | 4.6 | 101 |
| | | AG LUS | 24 | <0.05 | 98 |
| | | FORESTED | 3 | 0.05 | 123 |
| PUGT | Puget Sound Basin | MAJOR AQ | 30 | 0.98 | 27 |
| | | AG LUS | 22 | 13 | 17 |
| | | URB LUS | 27 | 4.2 | 16 |
| REDN | Red River of the North Basin | MAJOR AQ | 20 | <0.05 | 42 |
| | | MAJOR AQ | 23 | <0.05 | 43 |
| | | MAJOR AQ | 16 | <0.05 | 120 |
| | | AG LUS | 28 | 6.1 | 8 |
| | | AG LUS | 29 | <0.05 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| RIOG | Rio Grande Valley | MAJOR AQ | 30 | <0.05 | 153 |
| | | AG LUS | 30 | 0.48 | 10 |
| | | AG LUS | 35 | 2.7 | 11 |
| | | URB LUS | 24 | <0.05 | 11 |
| SACR | Sacramento River Basin | MAJOR AQ | 31 | 1.3 | 99 |
| | | AG LUS | 28 | 0.59 | 33 |
| | | URB LUS | 19 | 2.4 | 32 |
| SANA | Santa Ana Basin | MAJOR AQ | 29 | 6.1 | 374 |
| | | MAJOR AQ | 20 | 1.5 | 906 |
| | | MAJOR AQ | 22 | 3.4 | 535 |
| | | URB LUS | 24 | <0.05 | 15 |
| SANJ | San Joaquin-Tulare Basins | MAJOR AQ | 30 | 4.6 | 96 |
| | | AG LUS | 18 | 6.3 | 102 |
| | | AG LUS | 20 | 4.7 | 95 |
| | | AG LUS | 20 | 10 | 106 |
| SANT | Santee River Basin and Coastal Drainages | MAJOR AQ | 29 | 0.42 | 142 |
| | | MAJOR AQ | 30 | <0.05 | 148 |
| | | MAJOR AQ | 30 | 0.70 | 170 |
| | | AG LUS | 30 | 5.5 | 8 |
| | | URB LUS | 30 | 0.69 | 6 |
| SCTX | South-Central Texas | MAJOR AQ | 28 | 1.1 | 82 |
| | | MAJOR AQ | 31 | 0.12 | 188 |
| | | MAJOR AQ | 30 | 1.7 | 1075 |
| | | URB LUS | 30 | 1.5 | 57 |
| SOFL | Southern Florida | MAJOR AQ | 30 | 0.05 | 90 |
| | | AG LUS | 29 | <0.05 | 9 |
| | | URB LUS | 30 | <0.05 | 10 |
| | | FORESTED | 5 | <0.05 | 7 |
| SPLT | South Platte River Basin | MAJOR AQ | 26 | 0.48 | 196 |
| | | AG LUS | 30 | 9.4 | 9 |
| | | URB LUS | 30 | 2.1 | 15 |
| TRIN | Trinity River Basin | MAJOR AQ | 24 | 1.1 | 129 |
| | | MAJOR AQ | 22 | 0.05 | 128 |
| | | MAJOR AQ | 23 | <0.05 | 101 |
| | | URB LUS | 20 | 0.05 | 18 |
| UCOL | Upper Colorado River Basin | MAJOR AQ | 29 | 0.25 | 40 |
| | | MAJOR AQ | 14 | 0.22 | 20 |
| | | URB LUS | 25 | 0.56 | 13 |
| UIRB | Upper Illinois River Basin | MAJOR AQ | 27 | 0.05 | 44 |
| | | MAJOR AQ | 23 | <0.05 | 33 |
| | | AG LUS | 29 | 2.4 | 9 |
| | | URB LUS | 26 | 0.36 | 13 |
| UMIS | Upper Mississippi River Basin | MAJOR AQ | 25 | 0.64 | 110 |
| | | MAJOR AQ | 24 | 0.09 | 130 |

| | | | | | |
|---|---|---|---|---|---|
| | | URB LUS | 30 | 1.5 | 7 |
| | | FORESTED | 6 | 0.06 | 8 |
| USNK | Upper Snake River Basin | MAJOR AQ | 43 | 1.4 | 84 |
| | | MAJOR AQ | 38 | 0.60 | 99 |
| | | MAJOR AQ | 20 | 0.18 | 64 |
| | | AG LUS | 29 | 7.1 | 23 |
| | | AG LUS | 31 | 3.9 | 39 |
| | | AG LUS | 30 | 0.90 | 44 |
| | | AG LUS | 15 | 2.0 | 54 |
| UTEN | Upper Tennessee River Basin | MAJOR AQ | 30 | 0.59 | 135 |
| | | AG LUS | 30 | 0.68 | 11 |
| WHIT | White River Basin | AG LUS | 23 | <0.05 | 17 |
| | | AG LUS | 22 | 0.27 | 17 |
| | | AG LUS | 24 | 5.1 | 12 |
| | | URB LUS | 25 | 2.6 | 9 |
| WILL | Willamette Basin | MAJOR AQ | 70 | 0.40 | 38 |
| | | URB LUS | 12 | 5.4 | 25 |
| WMIC | Western Lake Michigan Drainages | MAJOR AQ | 29 | <0.05 | 122 |
| | | AG LUS | 26 | 0.05 | 17 |
| | | AG LUS | 30 | 6.8 | 18 |
| YELL | Yellowstone River Basin | MAJOR AQ | 25 | <0.05 | 11 |
| | | MAJOR AQ | 29 | 0.08 | 110 |

## Table S2. Nitrate concentrations and well depth below water level within principal aquifers of the United States

[AG LUS, agricultural land-use study; URB LUS, urban land-use study; MAJOR AQ, major aquifer study; mg/L, milligrams per liter; ft, feet below land surface]

| Principal aquifer lithology | Principal aquifers represented | Network type | Number of wells sampled | Median nitrate concentration, in mg/L | Median well depth below water level, in ft |
|---|---|---|---|---|---|
| Western volcanics | Columbia Plateau basalt<br>Hawaiian volcanic<br>Snake River Plain basalt | MAJOR AQ | 107 | 1.0 | 154 |
| | Columbia Plateau basalt<br>Snake River Plain basalt | AG LUS | 119 | 2.5 | 53 |
| Carbonate rocks | Biscayne<br>Floridan<br>Ordovician<br>Ozark Plateaus<br>Silurian-Devonian<br>Valley and Ridge carbonate | MAJOR AQ | 249 | 0.11 | 130 |
| | Floridan<br>Ozark Plateaus<br>Piedmont and Blue Ridge carbonate<br>Valley and Ridge carbonate | AG LUS | 181 | 6.4 | 102 |
| | Biscayne<br>Valley and Ridge carbonate | URB LUS | 50 | 0.13 | 14 |
| Igneous and metamorphic | New England crystalline<br>Piedmont and Blue Ridge crystalline<br>Rocky Mountain Front Range | MAJOR AQ | 256 | 0.38 | 172 |
| | Piedmont and Blue Ridge crystalline | URB LUS | 21 | 1.6 | 9 |
| Sandstone | Cambrian-Ordovician<br>Early Mesozoic<br>Lower Tertiary<br>Pennsylvanian<br>Upper or Lower Cretaceous<br>Valley and Ridge sandstone | MAJOR AQ | 309 | 0.15 | 110 |
| | Pennsylvanian<br>Valley and Ridge sandstone | AG LUS | 35 | <0.05 | 56 |
| | Woodbine | URB LUS | 20 | 0.05 | 18 |
| Semiconsolidated sand | Coastal lowlands | MAJOR | 279 | 0.06 | 84 |

| | | | | | |
|---|---|---|---|---|---|
| | | AQ | | | |
| | Mississippi Embayment<br>North Atlantic Coastal Plain<br>Southeastern Coastal Plain<br>Texas coastal uplands | | | | |
| | Coastal lowlands<br>North Atlantic Coastal Plain<br>Southeastern Coastal Plain | AG LUS | 117 | 1.1 | 14 |
| | Coastal lowlands<br>Mississippi Embayment<br>North Atlantic Coastal Plain<br>Southeastern Coastal Plain | URB LUS | 161 | 0.70 | 12 |
| Sandstone/carbonate | Edwards-Trinity<br>Mississippian | MAJOR AQ | 160 | 0.99 | 123 |
| | Mississippian | AG LUS | 32 | 0.94 | 9 |
| | Edwards-Trinity | URB LUS | 30 | 1.5 | 57 |
| Sand and gravel | Basin and Range<br>California Coastal Basins<br>Central Valley<br>Columbia Plateau<br>High Plains<br>Mississippi River Valley<br>Northern Rocky Mountains Intermontane Basins<br>Rio Grande<br>Snake River Plain<br>Stream-valley alluvial<br>Surficial<br>Willamette Lowland | MAJOR AQ | 1,004 | 1.4 | 84 |
| | Basin and Range<br>Central Valley<br>Columbia Plateau<br>High Plains<br>Rio Grande<br>Snake River Plain<br>Stream-valley alluvial<br>Surficial | AG LUS | 470 | 4.0 | 15.605 |
| | Basin and Range<br>California Coastal Basins<br>Central Valley<br>High Plains<br>Rio Grande<br>Stream-valley alluvial<br>Surficial<br>Willamette Lowland | URB LUS | 290 | 1.9 | 14.105 |

| | | | | | |
|---|---|---|---|---|---|
| Glacial sand and gravel | Glacial<br>Unconsolidated-deposits - Alaska | MAJOR AQ | 390 | 0.07 | 42.035 |
| | Glacial | AG LUS | 458 | 2.0 | 10.855 |
| | Glacial | URB LUS | 289 | 1.5 | 11.38 |