Kentucky Geological Survey
James C. Cobb, State Geologist and Director
UNIVERSITY OF KENTUCKY, LEXINGTON

Generalized Geologic Map for Land-Use Planning: Magoffin County, Kentucky

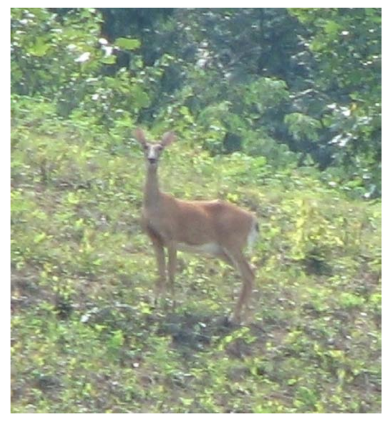
Daniel I. Carey

MAP AND CHART 175
Series XII, 2007

Acknowledgments

Geology adapted from Murphy (2004, 2005a-c), Ciszak and Lambert (2005), Ciszak and others (2005a-c), Sparks and Lambert (2005), Sparks and others (2005a-c), Sullivan and others (2005), and Zhang and others (2005). Thanks to Bart Davidson, Kentucky Geological Survey, for photo assistance. Thanks to Meg Smath, Kentucky Geological Survey, for editorial improvements. Thanks to Kim and Kent Anness, Kentucky Division of Geographic Information, for base-map data.

Lost Treasures of Salyersville

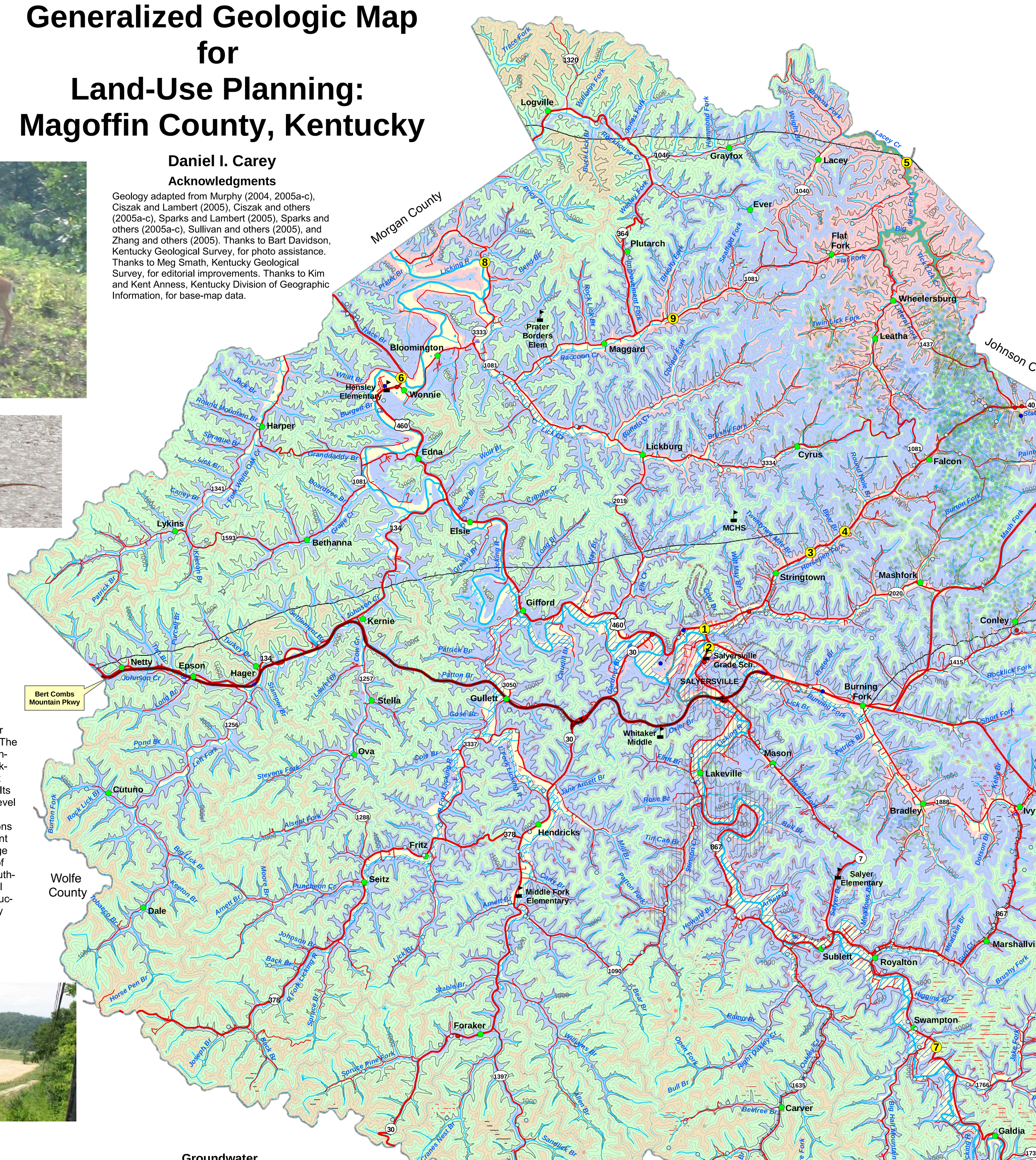

Adults, students, and artist Debra Burchett collaborated to produce this beautiful mural near the Justice Center that depicts historic Salyersville. Magoffin County, 309 square miles in the Eastern Kentucky Coal Field, was formed in 1860. The terrain is generally rugged, except in stream valleys, with ridgetops higher in the south. The highest elevation, 1,640 feet, is on the Floyd County line near the southeastern tip of the county. The lowest elevation, 785 feet, is where the Licking River leaves the county in the northwest. The 2006 population of 13,478 was 1 percent greater than that of 2000. There are also many deer and a few lizards. Photos by Dan Carey, Kentucky Geological Survey.

Oil and Gas

Oil and gas have contributed to the local economy. From 1980 through 2005, Magoffin County produced 3.4 million barrels of oil and 15.8 billion cubic feet of natural gas. Photo by Dan Carey, Kentucky Geological Survey.

Licking River


Construction of a new bridge on U.S. 460 over the Licking River (left). The river is born in the southeast and forms the backbone of the county as it flows to the northwest. Its broad valley provides level land for agriculture and communities. Precautions must be taken to prevent flood damages, drainage problems, or pollution of the water. The new Southside Elementary School (below) is under construction in a meander valley south of Swampton. Photos by Dan Carey, Kentucky Geological Survey.



Shale, Sandstone, Siltstone, Coal (Units 2 and 5)

Sandstone, siltstone, and coal lie above the dark shale of unit 2 at the intersection of U.S. 460 and Ky. 7. Photo by Dan Carey, Kentucky Geological Survey.

Hillside Construction

Construction on hillsides where shale is present, particularly cutting a driveway, often requires slope support. Photo by Dan Carey, Kentucky Geological Survey.

EXPLANATION

- School
- Water wells
  - Mining or industrial
  - Domestic
  - Monitoring
  - Public
- Severely eroded area
- Wet area
- Gas well
- Oil well
- Enhanced recovery well
- Railroad
- County line
- Watershed boundary
- Geologic fault
- Concealed geologic fault
- Designated flood zone* (FEMA, 2005)
- Source-water protection area, zone 1
- Wetlands > 1 acre (U.S. Fish and Wildlife Service, 2003)
- Incorporated city boundaries
- Surface, auger, or unknown type mined area
- Underground-mined area
- 100-foot contour interval
- 4 Photo location

*Flood information is available from the Kentucky Division of Water, Flood Plain Management Branch, www.water.ky.gov/floods/.

Source-Water Protection Areas

Source-water protection areas are those in which activities are likely to affect the quality of the drinking-water source. For more information, see kgsweb.uky.edu/download/water/swapp/swapp.htm.

Sandstone, Siltstone, Shale, and Coal (Unit 5)

Sandstone and siltstone overlie shale of unit 5 along Ky. 3333. The roadbed support is typical of that used to prevent pavement failure for roads built on shale. Photo by Dan Carey, Kentucky Geological Survey.

Sandstone (Unit 6)

Sandstone of unit 6 supports Jellico Road. Photo by Dan Carey, Kentucky Geological Survey.

Landslides


Hillside construction can cause earth movements if not properly planned. Photos by Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service.

Slope Failure

Mass movements or landslides of surficial materials are frequent and costly geologic hazards in eastern Kentucky. The failure of the slope may be rapid, but more commonly is a slow, almost imperceptible movement, called creep, of a few inches per year. Whether rapid or slow, the end results and damage are similar and costly: broken plumbing, cracked walls and foundations, cracked streets and sidewalks, and commonly, total loss of the structures.

Virtually all units containing shale on slopes are subject to landslides.

Gravity is the main driving force, but water nearly always plays a critical role by adding weight and lubricating the particles in the weathered shale. Cutting into or overloading a slope with structures and fill can also be major contributing factors.

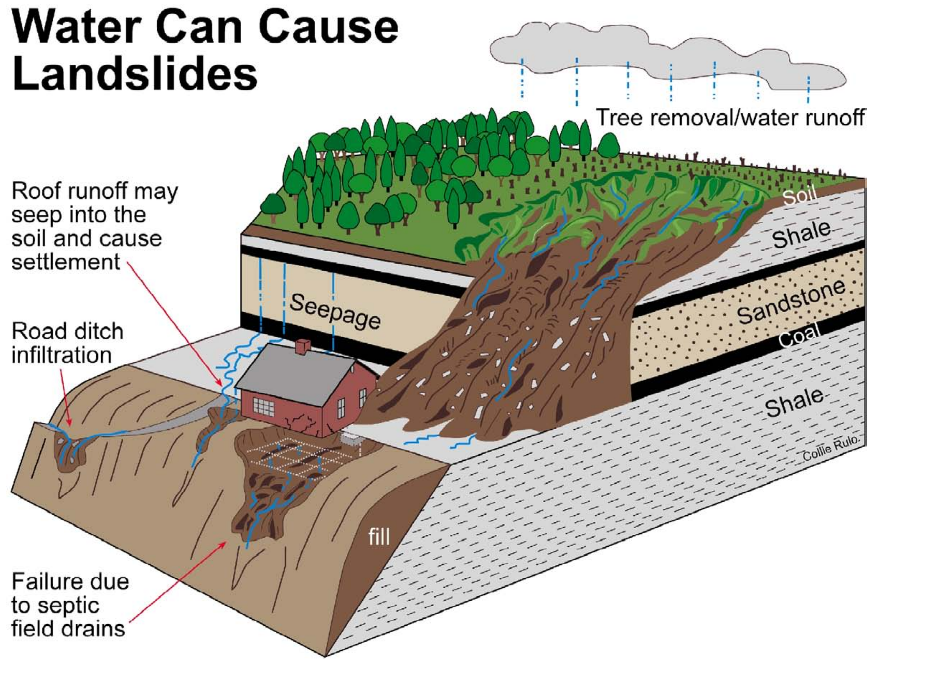
Precautions include taking care of all surface-water runoff by making certain that all runoff from roofs, gutters, patios, sidewalks, and driveways is carried well away from and not toward the house; diverting drainage from areas sloping toward the house; cutting into natural slopes as little as possible and avoiding the use of fill; and trying to place the foundation of the structure on undisturbed bedrock.

When in doubt, consult an engineering geologist or a geotechnical engineer. Relict landslides can also be easily reactivated. Look for unusual bulges or cracks in the slope, tilted or curved trees, springs coming out onto the hillside, and tilted and cracked sidewalks, streets, and retaining walls.

What Are the Factors That Cause Landslides?

Many factors contribute to landslides. The most common in eastern Kentucky are listed below:

1. Steep slopes: Avoid when choosing a building site.
2. Water: Slope stability decreases as water moves into the soil. Springs, seeps, roof runoff, gutter downspouts, septic systems, and site grading that cause ponding or runoff are sources of water that often contribute to landslides.
3. Changing the natural slope by creating a level area where none previously existed.
4. Poor site selection for roads and driveways.
5. Improper placement of fill material.
6. Removal of trees and other vegetation: Site construction often results in the elimination of trees and other vegetation. Plants, especially trees, help remove water and stabilize the soil with their extensive root systems.



What Are Some Ways to Prevent Landslides?

1. Seek professional assistance prior to construction.
2. Proper site selection: Some sloping areas are naturally prone to landslides. Inspect the site for springs, seeps, and other wet areas that might indicate water problems. Take note of unusual cracks or bulges at the soil surface. These are typical signs of soil movement that may lead to slope failure. Also be aware of geologically sensitive areas where landslides are more likely to occur.
3. Alter the natural slope of the building site as little as possible during construction. Never remove soil from the toe or bottom of the slope or add soil to the top of the slope. Landslides are less likely to occur on sites where disturbance has been minimized. Seek professional assistance before earth moving begins.
4. Remove as few trees and other vegetation as possible. Trees develop extensive root systems that are very useful in slope stabilization. Trees also remove large amounts of groundwater. Trees and other permanent vegetative covers should be established as rapidly as possible and maintained to reduce soil erosion and landslide potential.
5. Household water disposal system: Seek professional assistance in selecting the appropriate type and location of your septic system. Septic systems located in fill material can saturate soil and contribute to landslides.
6. Proper water disposal: Allowing surface waters to saturate the sloping soil is the most common cause of landslides in eastern Kentucky. Properly located diversion channels are helpful in redirecting runoff away from areas disturbed during construction. Runoff should be channeled and water from roofs and downspouts piped to stable areas at the bottom of the slope.

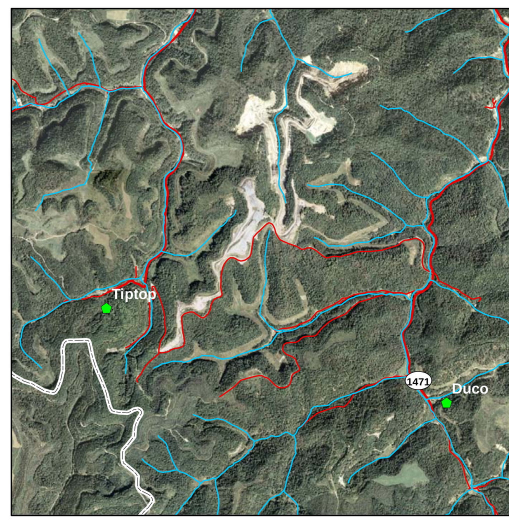
(From U.S. Department of Agriculture, Natural Resources Conservation Service, no date)

Mapped Surface Faults

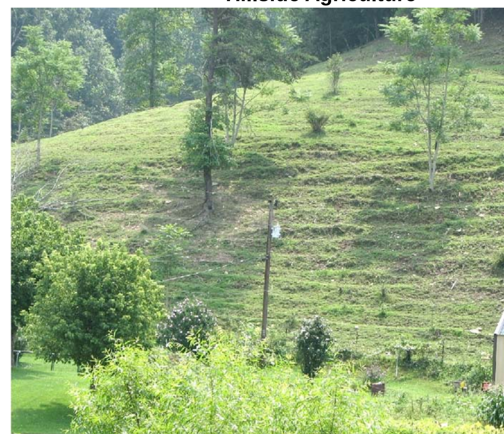
Faults are common geologic structures across Kentucky, and have been mapped in many of the commonwealth's counties. The faults shown on this map represent seismic activity that occurred several million years ago at the latest. There has been no activity along these faults in recorded history. Seismic risk associated with these faults is very low. Faults may be associated with increased fracturing of bedrock in the immediately adjacent area. This fracturing may influence slope stability and groundwater flow in these limited areas.

Coal

From 1889 to 2004, Magoffin County produced 56.4 million tons of coal: 46.9 million tons from surface mining and 9.4 million tons from deep mining. Peak production was in 1981, 4.2 million tons. Production in 2004 was 851,299 tons from surface mines. Ongoing and previous mountaintop mining near Tiptop and Duco (unit 3) is seen in the aerial photo (right, U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program, 2004).



Hillside Agriculture



Soils on a hillside stripped of trees ripple slowly downhill under the forces of cattle, moisture, freezing, and thawing. Photo by Dan Carey, Kentucky Geological Survey.

Radon

Radon gas can be a local problem, in some areas exceeding the U.S. Environmental Protection Agency's maximum recommended limit of 4 picocuries per liter. The shales of unit 5 and limestones of units 2, in particular, may contain high levels of uranium or radium, parent materials for radon gas. The U.S. Environmental Protection Agency recommends that all homes be tested for radon, but the homeowner should keep in mind that the threat to health results from relatively high levels of exposure over long periods, and the remedy may simply be additional ventilation of the home.

Radon Risk If You've Never Smoked (U.S. Environmental Protection Agency, 2005)

Radon Level	If 1,000 people who never smoked were exposed to this level over a lifetime*...	The risk of cancer from radon exposure compares to**...	WHAT TO DO:
20 pCi/L	About 36 people could get lung cancer	35 times the risk of drowning	Fix your home
10 pCi/L	About 18 people could get lung cancer	20 times the risk of dying in a home fire	Fix your home
8 pCi/L	About 15 people could get lung cancer	4 times the risk of dying in a fall	Fix your home
4 pCi/L	About 7 people could get lung cancer	The risk of dying in a car crash	Fix your home
2 pCi/L	About 4 people could get lung cancer	The risk of dying from poison	Consider fixing between 2 and 4 pCi/L
1.3 pCi/L	About 2 people could get lung cancer	(Average indoor radon level)	(Reducing radon levels below 2 pCi/L is difficult.)
0.4 pCi/L		(Average outdoor radon level)	

Note: If you are a former smoker, your risk may be higher.
* Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003).
** Comparison data calculated using the Centers for Disease Control and Prevention's 1999-2001 National Center for Injury Prevention and Control Reports.

Radon Ventilation

Ventilation system removes radon from the basement area of this home on unit 5. Photo by Dan Carey, Kentucky Geological Survey.

LAND-USE PLANNING TABLE DEFINITIONS

FOUNDATION AND EXCAVATION

The terms "earth" and "rock" excavation are used in the engineering sense; earth can be excavated by hand tools, whereas rock requires heavy equipment or blasting to remove.

LIMITATIONS

Slight—A slight limitation is one that commonly requires some corrective measure but can be overcome without a great deal of difficulty or expense.

Moderate—A moderate limitation is one that can normally be overcome but the difficulty and expense are great enough that completing the project is commonly a question of feasibility.

Severe—A severe limitation is one that is difficult to overcome and commonly is not feasible because of the expense involved.

LAND USES

Septic tank disposal system—A septic tank disposal system consists of a septic tank and a filter field. The filter field is a subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the soil.

Residences—Ratings are made for residences with basements because the degree of limitation is dependent upon ease and required depth of excavation. For example, excavation in limestone has greater limitation than excavation in shale for a house with a basement.

Highways and streets—Refers to paved roads in which cuts and fills are made in hilly topography, and considerable work is done preparing subgrades and bases before the surface is applied.

Access roads—These are low-cost roads, driveways, etc., usually surfaced with crushed stone or a thin layer of blacktop. A minimum of cuts and fills are made, little work is done preparing a subgrade, and generally only a thin base is used. The degree of limitation is based on year-around use and would be less severe if not used during the winter and early spring. Some types of recreation areas would not be used during these seasons.

Light industry and malls—Ratings are based on developments having structures or equivalent load limit requirements of three stories or less, and large paved areas for parking lots. Structures with greater load limit requirements would normally need footings in solid rock, and the rock would need to be core drilled to determine the presence of caverns, cracks, etc.

Intensive recreation—Athletic fields, stadiums, etc.

Extensive recreation—Camp sites, picnic areas, parks, etc.

Reservoir areas—The floor of the area where the water is impounded. Ratings are based on the permeability of the rock.

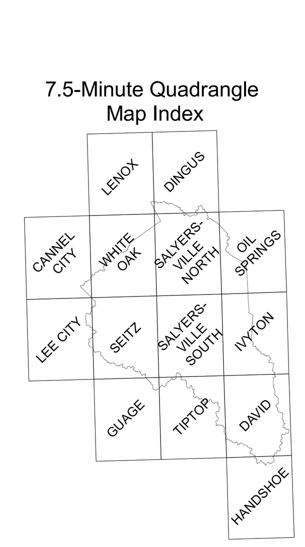
Reservoir embankments—The rocks are rated on limitations for embankment material.

Underground utilities—Included in this group are sanitary sewers, storm sewers, water mains, and other pipes that require fairly deep trenches.

Groundwater

About 4,900 people, 35 percent of Magoffin County, rely on private domestic water supplies: 4,700 use wells and 200 use hauled water, cisterns, and other sources. Most wells drilled in valley bottoms are adequate for domestic use. Fewer than half the wells drilled on hillsides are adequate for domestic supply, and even fewer wells on hilltops and ridges produce enough water for a domestic supply. Wells in the southern third of the county generally produce slightly more water, perhaps enough for small municipal or industrial supplies, in wells below 200 feet. Most of the water obtained from drilled wells is extremely hard and contains noticeable amounts of iron. Salty water may be found from 50 to several hundred feet below the level of the principal valley bottoms. Groundwater quality is slightly better in the southern third of the county, with moderately hard water and salty water found occasionally from 100 feet and deeper. A few springs supply enough water for domestic use. Almost all springs yield less than 5 gallons per minute. For more information on groundwater in the county, see Carey and Stickney (2004).

7.5-Minute Quadrangle Map Index



N

Scale = 1:63,360

1 inch = 1 mile

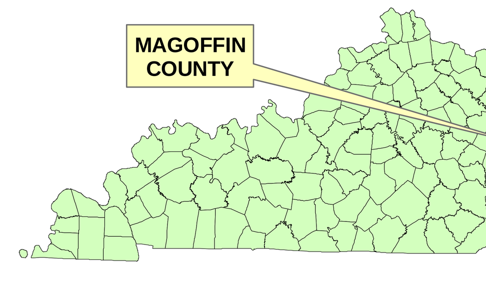
0 0.5 1 2 3 4 Miles

For information on obtaining copies of this map and other Kentucky Geological Survey maps and publications call our Public Information Center at 859.257.3896 or 877.778.7827 (toll free).

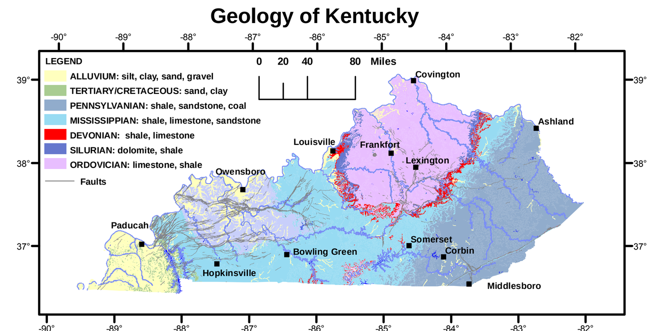
Visit the KGS World Wide Web site at: www.uky.edu/kgs

For Planning Use Only

This map is not intended to be used for selecting individual sites. Its purpose is to inform land-use planners, government officials, and the public in a general way about geologic bedrock conditions that affect the selection of sites for various purposes. The properties of thick soils may supersede those of the underlying bedrock and should be considered on a site-to-site basis. At any site, it is important to understand the characteristics of both the soils and the underlying rock. For further assistance, contact the Kentucky Geological Survey, 859.257.5500. For more information, visit the KGS Community Development Planning Web Site at kgsweb.uky.edu/download/kgsplanning.htm.



Geology of Kentucky



Learn more about Kentucky geology at www.uky.edu/KGS/geoky/

Planning Guidance by Rock Unit Type

Rock Unit	Foundation and Excavation	Septic System	Residence with Basement	Highways and Streets	Access Roads	Light Industry and Malls	Intensive Recreation	Extensive Recreation	Reservoir Areas	Reservoir Embankments	Underground Utilities
1. Clay, silt, sand, and gravel (alluvium)	Fair foundation material; easy to excavate. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Slight to severe limitations, depending on type of activity and topography. Subject to flooding. Refer to soil report (McIntosh, 2002).	Slight to severe limitations, depending on type of activity and topography. Subject to flooding. Refer to soil report (McIntosh, 2002).	Pervious material. Seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).	Fair stability. Fair compaction characteristics. Piping hazard. Refer to soil report (McIntosh, 2002).	Slight limitations, in general, except for seasonal high water table. Subject to flooding. Refer to soil report (McIntosh, 2002).
2. Shale, siltstone, sandstone, and thin coal	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, sparse coals, and underclays.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Possible rock excavation.
3. Sandstone, siltstone, shale, coal, and underclay	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, sparse coals, and underclays. Possibility of underground coal-mine voids.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Possible rock excavation.
4. Sandstone, siltstone, shale, limestone, coal, and underclay	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, sparse coals, and underclays. Possibility of underground coal-mine voids.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Possible rock excavation.
5. Sandstone, siltstone, shale, and thin coal	Fair to good foundation material; difficult to excavate. Possible low strength associated with shales, sparse coals, and underclays.	Severe limitations. Thin soils and impermeable rock associated with shales.	Severe to moderate limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required. Possible steep slopes.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography. Possible steep wooded slopes. Slight limitations for forest or nature preserve.	Slight limitations. Reservoir may leak where rocks, including coal, are jointed or fractured.	Severe limitations. Reservoir may leak where rocks are fractured.	Severe to moderate limitations. Thin soils. Possible rock excavation.
6. Sandstone and shale	Good to excellent foundation material; difficult to excavate.	Severe limitations.	Severe to moderate limitations. Rock excavation may be required. Possible radon occurrence in shale.	Severe to moderate limitations. Rock excavation may be required.	Moderate to severe limitations. Rock excavation may be required.	Moderate to severe limitations. Rock excavation may be required.	Slight to severe limitations, depending on activity and topography.	Slight to severe limitations, depending on activity and topography. Slight limitations for forest or nature preserve.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Severe limitations. Rock excavation.

Additional Resources

Listed below are Web sites for several agencies and organizations that may be of assistance with land-use planning issues in Magoffin County:

www.kyhometown.com/salyersville/ Salyersville
ces.ca.uky.edu/Magoffin/ University of Kentucky Cooperative Extension Service
www.bigsandy.org/ Big Sandy Area Development District
www.thinkkentucky.com/edis/cmnty/index.aspx?cw=120 Kentucky Economic Development Information System
www.uky.edu/KentuckyAtlas/21153.html Kentucky Atlas and Gazetteer, Magoffin County
quickfacts.census.gov/qfd/states/21/21153.html U.S. Census data
kgsweb.uky.edu/download/kgsplanning.htm Planning information from the Kentucky Geological Survey

References Cited

Carey, D.I., and Stickney, J.F., 2004, Groundwater resources of Magoffin County, Kentucky: Kentucky Geological Survey, ser. 12, County Report 74, www.uky.edu/KGS/water/library/gwatlas/Magoffin/Magoffin.htm [accessed 7/31/07].

Ciszak, E.A., and Lambert, J.R., 2005, Spatial database of the Lenox quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-181. Adapted from Johnston, J.E., 1962, Geology of the Lenox quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-181, scale 1:24,000.

Ciszak, E.A., Hesley, J., and Lambert, J.R., 2005a, Spatial database of the Salyersville North quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-276. Adapted from Adkison, W.L., and Johnston, J.E., 1964, Geology of the Salyersville North quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-276, scale 1:24,000.

Ciszak, E.A., Hesley, J., and Lambert, J.R., 2005b, Spatial database of the Salyersville South quadrangle, Magoffin and Breathitt Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1373. Adapted from Spengler, R.W., 1977, Geologic map of the Salyersville South quadrangle, Magoffin and Breathitt Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1373, scale 1:24,000.

Ciszak, E.A., Hesley, J., and Lambert, J.R., 2005c, Spatial database of the White Oak quadrangle, Magoffin and Morgan Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1480. Adapted from Sable, E.G., 1978, Geologic map of the White Oak quadrangle, Magoffin and Morgan Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1480, scale 1:24,000.

Federal Emergency Management Agency, 2005: www.fema.gov [accessed 11/20/06].

McIntosh, J.D., 2002, Soil survey of Magoffin and Morgan Counties, Kentucky: U.S. Department of Agriculture, Natural Resources Conservation Service, 228 p.

Murphy, M.L., 2004, Spatial database of the Handshoe quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1372. Adapted from Danilchik, W., 1977, Geologic map of the Handshoe quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1372, scale 1:24,000.

Murphy, M.L., 2005a, Spatial database of the David quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-720. Adapted from Outerbridge, W.F., 1968, Geologic map of the David quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-720, scale 1:24,000.

Murphy, M.L., 2005b, Spatial database of the Ivyton quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-801. Adapted from Rice, C.L., 1969, Geologic map of the Ivyton quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-801, scale 1:24,000.

Murphy, M.L., 2005c, Spatial database of the Oil Springs quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-586. Adapted from Outerbridge, W.F., 1967, Geologic map of the Oil Springs quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-586, scale 1:24,000.

Sparks, T.N., and Lambert, J.R., 2005, Spatial database of the Cannel City quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1498. Adapted from Sable, E.G., 1978, Geologic map of the Cannel City quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1498, scale 1:24,000.

Sparks, T.N., Hesley, J., and Lambert, J.R., 2005a, Spatial database of the Guage quadrangle, Breathitt and Magoffin Counties, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1416. Adapted from Lee, K.Y., Danilchik, W., and Rice, C.L., 1977, Geologic map of the Guage quadrangle, Breathitt and Magoffin Counties, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1416, scale 1:24,000.

Sparks, T.N., Hesley, J., and Lambert, J.R., 2005b, Spatial database of the Seitz quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1435. Adapted from Spengler, R.W., 1978, Geologic map of the Seitz quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1435, scale 1:24,000.

Sparks, T.N., Hesley, J., and Lambert, J.R., 2005c, Spatial database of the Tiptop quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1410. Adapted from Danilchik, W., 1977, Geologic map of the Tiptop quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1410, scale 1:24,000.

Sullivan, V.M., Lambert, J.R., and Sparks, T.N., 2005, Spatial database of the Lee City quadrangle, Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-198. Adapted from Post, E.V., and Johnston, J.E., 1963, Geology of the Lee City quadrangle, Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-198, scale 1:24,000.

U.S. Department of Agriculture, Natural Resources Conservation Service, no date, Landslide prevention in eastern Kentucky.

U.S. Environmental Protection Agency, 2005, A citizen's guide to radon: The guide to protecting yourself and your family from radon: www.epa.gov/radon/pubs/citguide.html [accessed 7/12/07].

U.S. Fish and Wildlife Service, 2003, National Wetlands Inventory: www.nwi.fws.gov [accessed 11/24/06].

Zhang, Q., Lambert, J.R., and Sparks, T.N., 2005, Spatial database of the Dingus quadrangle, eastern Kentucky: Kentucky Geological Survey, ser. 12, Digitally Vectorized Geologic Quadrangle Data DVGQ-1463. Adapted from Outerbridge, W.F., 1978, Geologic map of the Dingus quadrangle, eastern Kentucky: U.S. Geological Survey Geologic Quadrangle Map GQ-1463, scale 1:24,000.