Kentucky Geological Survey
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Generalized Geologic Map for Land-Use Planning: Warren County, Kentucky

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Warren County Courthouse at Bowling Green

Warren County, 545 square miles in the Pennyrile and Western Kentucky Coal Field, was formed in 1797. The slightly rolling karst sinkhole plain in the south has few surface streams and hundreds of sinkholes. Sandstone-capped hills lie to the northwest. The two areas are separated by the Dripping Springs Escarpment, which rises 200 feet above the karst plain, traversing the county from northeast to southwest. The highest point in the county, 955 feet, is Pilot Knob, 2 miles southeast of Smiths Grove. The lowest elevation, 395 feet, is at the confluence of the Barren and Green Rivers. The 2006 population of 99,525, was 7.6 percent greater than that of 2000. Photo by Dan Carey, Kentucky Geological Survey.

Karst Plain

Seen from the sandstone-capped hills of the Dripping Springs Escarpment, the fertile farmland of the limestone (unit 2) karst plain stretches to the south. Photo by Dan Carey, Kentucky Geological Survey.

Oil and Gas

Oil and gas have contributed to the local economy. From 1980 through 2005, 3.4 million barrels of oil and 1.7 billion cubic feet of gas were produced. Photo by Dan Carey, Kentucky Geological Survey.

Mineral Resources

Rinker Materials produces construction aggregate and agricultural lime from the St. Genevieve limestone at this quarry (left) on Barren River Road and another quarry south of Girkin. Aerial photo (2004) by the U.S. Department of Agriculture, Farm Services Administration, National Agricultural Imagery Program.

Water Resources

Warren County is blessed with an abundance of water. The Barren River (left) is one of many streams that provide fishing, boating, and swimming. Photo by Dan Carey, Kentucky Geological Survey.

Groundwater

In karst areas such as Warren County, stormwater runoff can flow underground through large solution channels. This groundwater flow does not follow the topography of the surface, and water from one watershed may flow underground and reappear in an adjacent watershed. A knowledge of the groundwater flow, gained through dye-trace studies, is required to manage storm water and to protect water quality and drinking-water sources. For more information about dye tracing in the area, see Ray and Currens (1998, 2000).

In the upland regions of Warren County more than three-quarters of the drilled wells are adequate for a domestic supply. Yields as high as 50 gallons per minute have been reported from wells penetrating large solution channels. In the northwest corner of the county and in low-lying areas near the Barren River and its main tributaries most wells are inadequate for domestic use, unless the well intercepts a major solution opening in the limestone; in this case, the yield could be very large. Springs with flows ranging from a few gallons per minute to 2,000 gallons per minute are found in the county. Minimum flows generally occur in early fall, maximum flows in late winter.

For more about the groundwater resources of the county, see Carey and Stickney (2004).

Tar-Sands in Western Kentucky

Investigations by the Kentucky Geological Survey have confirmed that major tar-sand resources are present in western Kentucky (Noger, 1999). In-place resources are calculated to be in excess of 3 billion barrels. The principal formations that contain tar-sand deposits (also referred to as asphaltic sandstones, heavy-oil deposits, or bitumen-impregnated sandstones) are the Kyrock, Bee Springs, Tar Springs, Hardinsburg, and Big Clifty Sandstones. Some of these may occur in Logan, Warren, Butler, Edmonson, Hart, Grayson, Breckinridge, and Hardin counties. In Warren County, tar-sands may be present in unit 4. Photo by Randy Bruner.

For more information information on tar-sands, go to kgsweb.uky.edu/PubsSearching/PubsSimpleSearch.asp, keyword= tar sands.

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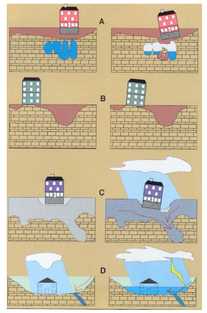
Sandstone (Unit 4) and Shale (Unit 6)

Sandstone (unit 4) overlying shale (unit 6) is exposed along the Natchez Parkway near Butler County. The erosion-resistant sandstone caps the hills (below) north of the Dripping Springs Escarpment. Photos by Dan Carey, Kentucky Geological Survey.

Construction on Karst



Limestone terrain can be subject to subsidence hazards, which usually can be overcome by prior planning and site evaluation. "A" shows construction above an open cavern, which later collapses. This is one of the most difficult situations to detect, and the possibility of this situation beneath a structure warrants insurance protection for homes built on karst terrain. In "B," a heavy structure presumed to lie above solid bedrock actually is partially supported on soft, residual clay soils that subside gradually, resulting in damage to the structure. This occurs where inadequate site evaluation can be traced to lack of geophysical studies and inadequate core sampling. "C" and "D" show the close relationship between hydrology and subsidence hazards in limestone terrain. In "C," the house is situated on porous fill (light shading) at a site where surface- and groundwater drainage move supporting soil (darker shading) into voids in limestone (blocks) below. The natural process is then accelerated by infiltration through fill around the home. "D" shows a karst site where normal rainfall is absorbed by subsurface conduits, but water from infrequent heavy storms cannot be carried away quickly enough to prevent flooding of low-lying areas. Adapted from AIPG (1993).

Limestone (Unit 3)

White, and gray bands of limestone in the 340-million-year-old Mississippian Age Girkin Formation can be seen (right) along the Natcher Parkway. This rock is difficult to excavate. Photo by Dan Carey, Kentucky Geological Survey.

Karst Geology

Karst areas (unit 2) are indicated by sinkholes. The term "karst" refers to a landscape characterized by sinkholes, springs, sinking streams (streams that disappear underground), and underground drainage through solution-enlarged conduits or caves. Karst landscapes form when slightly acidic water from rain and snowmelt seeps through soil cover into fractured and soluble bedrock (usually limestone, dolomite, or gypsum). Sinkholes are depressions on the land surface into which water drains underground. Usually circular and often funnel-shaped, they range in size from a few feet to hundreds of feet in diameter. Springs occur when water emerges from underground to become surface water. Caves are solution-enlarged fractures or conduits large enough for a person to enter.

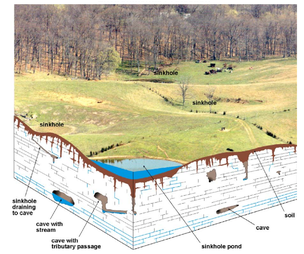
Limestone (Unit 2)

Limestone (unit 2) is exposed along the Natcher Parkway. Water seeps into cracks and crevices, dissolving the limestone and creating underground flow paths, sinkholes, and caves. Photo by Dan Carey, Kentucky Geological Survey.

Major Construction

Following geologist's recommendations can help prevent costly construction failures. (Photos above and below courtesy of Richard McGehee, Inspector, Field Operations Branch, Kentucky Division of Water.)

Environmental Protection



- Never use sinkholes as dumps. All waste, but especially pesticides, paints, household chemicals, automobile batteries, and used motor oil, should be taken to an appropriate recycling center or landfill.
- Make sure runoff from parking lots, streets, and other urban areas is routed through a detention basin and sediment trap to filter it before it flows into a sinkhole.
- Make sure your home septic system is working properly and that it's not discharging sewage into a crevice or sinkhole.
- Keep cattle and other livestock out of sinkholes and sinking streams. There are other methods of providing water to livestock.
- See to it that sinkholes near or in crop fields are bordered with trees, shrubs, or grass buffer strips. This will filter runoff flowing into sinkholes and also keep tilled areas away from sinkholes.
- Construct waste-holding lagoons in karst areas carefully, to prevent the bottom of the lagoon from collapsing, which would result in a catastrophic emptying of waste into the groundwater.
- If required, develop a groundwater protection plan (410KAR5:037) or an agricultural water-quality plan (KRS224.71) for your land use.

(From Currens, 2001)

Pond Construction

Successful pond construction must prevent water from seeping through structured soils into limestone solution channels below. A compacted clay liner (left) or artificial liner may prevent pond failure. Getting the basin filled with water as soon as possible after construction prevents drying and cracking, and possible leakage, of the clayey soil liner. Ponds constructed in dry weather are more apt to leak than ponds constructed in wet weather. A geotechnical engineer or geologist should be consulted regarding the requirements of a specific site. Other leakage prevention measures include synthetic liners, bentonite, and asphaltic emulsions. The U.S. Department of Agriculture–Natural Resources Conservation Service can provide guidance on the application of these liners to new construction, and for treatment of existing leaking ponds. Dams should be constructed of compacted clayey soils at slopes flatter than 3 units horizontal to 1 unit vertical. Ponds with dam heights exceeding 25 feet, or pond volumes exceeding 50 acre-feet, require permits. Contact the Kentucky Division of Water, 14 Reilly Rd., Frankfort, KY 40601, telephone: 502.564.3410. Illustration by Paul Howell, U.S.Department of Agriculture–Natural Resources Conservation Service.

Radon

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

Radon gas can be a local problem, although it is not widely distributed in Kentucky in amounts above the U.S. Environmental Protection Agency's maximum recommended limit of 4 picocuries per liter. Some areas of Unit 2 may contain high levels of uranium or radium, parent materials for radon gas. Several limestones in the state contain apatite, a phosphate mineral. Uranium is sometimes part of the apatite crystal structure, and when the limestone weathers away the phosphates containing uranium can become concentrated in the soil and ultimately give rise to high levels of radon. A few areas of moderately high radon concentrations are known in the Warren County sinkhole plain. About 60 percent of measured radon values in Unit 2 exceeded EPA limits, ranging from 4 to less than 32 picocuries per liter. Homes in these areas should 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 of time, and the remedy may simply be additional ventilation of the home.

Radon Risk If You've Never Smoked

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.

The EPA recommends action be taken if indoor levels exceed 4 picocuries per liter, which is 10 times the average outdoor level. Some EPA representatives believe the action level should be lowered to 2 picocuries per liter; other scientists dissent and claim the risks estimated in this chart are already much too high for low levels of radon. The action level in European countries is set at 10 picocuries per liter. Note that this chart is only one estimate; it is not based upon any scientific result from a study of a large population meeting the listed criteria. (From the U.S. Environmental Protection Agency.)

Radon Ventilation

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

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.

Acknowledgments

Bedrock mapping was adapted from Davidson (2002), Mullins (2002a-f), Thompson (2002a-h), and Toth (2002a-c). Sinkhole data from Paylor and others (2004). Thanks to Richard McGehee, Inspector, Field Operations Branch, Kentucky Division of Water; Paul Howell, U.S. Department of Agriculture-Natural Resources Conservation Service; and Jim Currens, Kentucky Geological Survey, for photographs and illustrations. Thanks to Richard Sergeant, Kentucky Geological Survey, for photo assistance.

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.	Severe limitations. Failed septic systems can contaminate groundwater. Refer to soil report (Barton and others, 1981).	Severe limitations. Water in alluvium may be in direct contact with basement. Refer to soil report (Barton and others, 1981).	Moderate to severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Barton and others, 1981).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Barton and others, 1981).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Barton and others, 1981).	Subject to flooding. Poor drainage. Refer to soil report (Barton and others, 1981).	Subject to flooding. Refer to soil report (Barton and others, 1981).	Pervious material. Seasonal high water table. Subject to flooding. Refer to soil report (Barton and others, 1981).	Fair stability. Fair compaction characteristics. Piping hazard. Refer to soil report (Barton and others, 1981).	Moderate to severe limitations. Wetness, flooding. Refer to soil report (Barton and others, 1981).
2. Limestone	Excellent foundation material; difficult to excavate.	Severe limitations. Impermeable rock. Locally fast drainage through fractures and danger of groundwater contamination.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Sinks possible; drainage required.	Slight to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Sinks possible; drainage required.	Slight limitations. Local drainage problems from seeps or springs; sinks possible.	Slight to moderate limitations, depending on topography. Rock excavation; locally, upper few feet may be rippable. Sinks possible; local drainage problems.	Severe to slight limitations, depending on activity and topography. Steep slopes.	Slight to moderate limitations, depending on activity and topography.	Severe limitations. Leaky reservoir; locally, conditions may be favorable. Sinks possible.	Severe limitations.	Severe limitations. Rock excavation.
3. Limestone, shale, sandstone, and siltstone	Fair to good foundation material; difficult to excavate.	Severe limitations. Impermeable rock. Thin soils.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Severe limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Moderate limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Severe to slight limitations, depending on activity and topography. Steep slopes.	Slight to moderate limitations, depending on activity and topography.	Slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations.	Moderate limitations. Highly variable amount of rock and earth excavation.
4. Sandstone	Fair to good foundation material; difficult to excavate.	Severe limitations. Thin soils.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable; steep slopes.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable; steep slopes.	Moderate limitations. Rock excavation. Steep slopes.	Moderate limitations. Rock excavation. Steep slopes.	Severe limitations. Steep slopes.	Slight to moderate limitations, depending on activity and topography.	Moderate limitations; permeable rock.	Severe limitations.	Moderate limitations. Highly variable amount of rock and earth excavation. Steep slopes.
5. Shale, siltstone, limestone, coal, underclay, and conglomerate	Fair to good foundation material; difficult to excavate.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable; steep slopes.	Severe limitations. Rock excavation; locally, upper few feet may be rippable; steep slopes.	Severe limitations. Rock excavation; locally, upper few feet may be rippable; steep slopes.	Moderate limitations. Rock excavation. Steep slopes.	Severe limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Severe limitations. Steep slopes.	Moderate to slight limitations, depending on activity and topography.	Slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations.	Moderate limitations. Highly variable amount of rock and earth excavation.
6. Sandstone, siltstone, thin limestone, and shale	Fair to good foundation material; difficult to excavate.	Severe limitations. Thin soils and low permeability.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Moderate limitations. Rock excavation. Steep slopes.	Severe to moderate limitations. Rock excavation; locally, upper few feet may be rippable. Steep slopes.	Severe limitations. Steep slopes.	Slight to moderate limitations, depending on activity and topography.	Slight limitations. Reservoir may leak where rocks are fractured.	Severe limitations.	Moderate limitations. Highly variable amount of rock and earth excavation.
7. Rock fragments mixed with clay	Severe limitations. Unstable materials.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Severe limitations.	Moderate limitations. Unstable materials. Sparks when struck by heavy equipment; explosion hazard if natural gas present.

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.

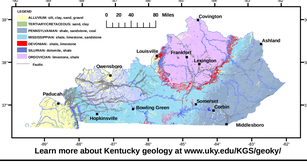
Reservoir areas—The floor of the area where the water is impounded. Ratings are based on the permeability of the rock.

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.

7.5-Minute Quadrangle Map Index

Geology of Kentucky



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

Additional Resources

Listed below are Web sites for several agencies and organizations that may be of assistance with landuse planning issues in Warren County:

www.warrencountyky.com/—Warren County
www.bgky.org/—City of Bowling Green
ces.ca.uky.edu/warren/—University of Kentucky Cooperative Extension Service
www.bradd.org/—Barren River Area Development District
www.thinkkentucky.com/EDIS/cmnty/index.aspx?cw=067—Kentucky Economic Development Information System
www.uky.edu/KGS/gis/atlas/21227.html—Kentucky Atlas and Gazetteer
quickfacts.census.gov/qfd/states/21/21227.html—U.S. Census data
kgsweb.uky.edu/download/kgsplanning.htm—Planning information from the Kentucky Geological Survey

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 are part of the Pennyrile Fault System, which is not considered to be active. Earthquake damage in Warren County is still a possibility, however. Soil creep, slumps, and landslides along steep slopes may occur from erosion or ground motion associated with a strong earthquake. Areas associated with alluvium (Unit 1) are subject to liquefaction during a strong earthquake. Faults may be associated with increased fracturing of bedrock in the immediately adjacent area. This fracturing may influence slope stability and ground-water flow in these limited areas.

EXPLANATION

- School
- Gas well
- Oil well
- Enhanced recovery well

Water wells
- Domestic
- Monitoring
- Public
- Industrial
- Agricultural

- Sinkhole
- Rock outcrop
- Severely eroded area
- Wet area
- Spring
- County line
- Watershed boundary
- Railroad
- Geologic fault
- Concealed geologic fault
- Public lands
- Designated flood zone* (FEMA, 2005)
- Wetlands > 1 acre (U.S. Fish and Wildlife Service, 2003)
- Incorporated city boundaries
- Source-water protection area, zone 1
- Wildlife management area
- Mapped sinkhole
- Quarry
- 40-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/.