

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

Daniel I. Carey

Acknowledgments

Geology adapted from Murphy (2000), Sullivan (2000), Morris (2005a-c), Murphy and Lambert (2005), Nelson (2005a, b), Sparks (2005), and Sullivan and Lambert (2005). Mapped sinkhole data from Poyser and others (2004). Thanks to Kim and Kent Amess, Kentucky Division of Geographic Information, for base-map data.

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Powell County, an area of 180 square miles in the Knobs and Eastern Kentucky Coal Field Regions, was formed in 1852. The terrain is characterized by sandstone ridges, steep valley walls, and wide alluvium typical of valleys cut from shale. Knobby hills rim the valleys. Eastern Powell County is famous for its natural sandstone arches and the scenic Red River Gorge. The highest elevation, 1,452 feet, is on Pilot Knob. The lowest elevation, 580 feet, is where the Red River leaves the county. The 2005 population of 13,460 was 1.7 percent greater than that of 2000. Photo by Dan Carey, Kentucky Geological Survey.



Looking west from Pilot Knob. Photo by Dan Carey, Kentucky Geological Survey.



The shales and dolomites of unit 6 are exposed along this roadcut on Ky. 1028. 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.

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.

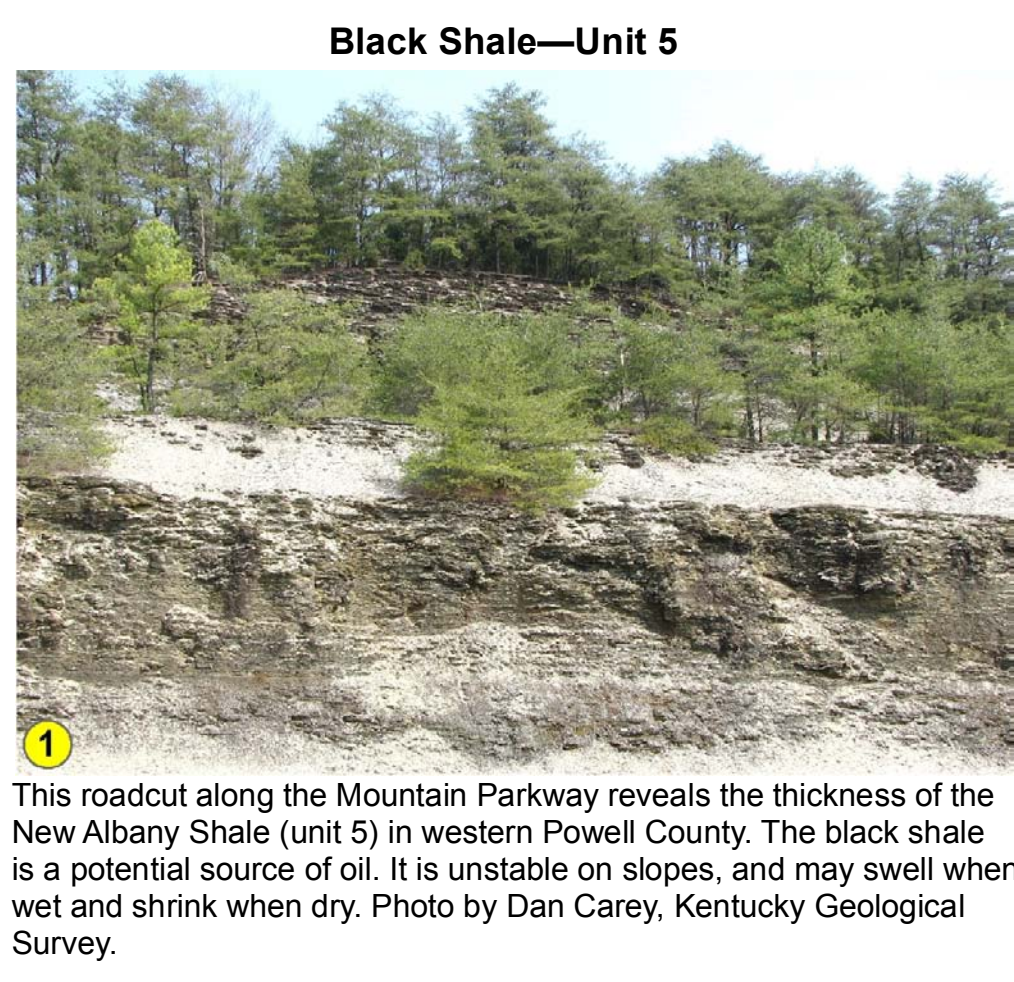
Flood information is available from the Kentucky Division of Water, Flood Plain Management Branch, www.water.ky.gov/floods/.

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 (Hayes, 1993).	Severe limitations. Low permeability. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe limitations. Seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).	Refer to soil report (Hayes, 1993).	Refer to soil report (Hayes, 1993).	Permeous material. Seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).	Fair stability. Fair compaction characteristics. Piping hazards. Refer to soil report (Hayes, 1993).	Slight limitations. In general, except for seasonal high water table. Subject to flooding. Refer to soil report (Hayes, 1993).
2. Shale and siltstone**	Siltstone, fair to good foundation material; difficult to excavate. Shale, fair to poor; easy to moderately difficult to excavate.	Severe limitations. Low permeability. Subject to flooding. Refer to soil report (Hayes, 1993).	Moderate to severe limitations. Rock excavation may be required. Local drainage problems on shale.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems on shale.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems on shale.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems on shale.	Moderate to slight limitations, depending on activity and topography.	Moderate to slight limitations, depending on activity and topography.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Siltstone; rock excavation. Shale; poor strength, weeps.
3. Sandstone	Good to excellent foundation material; difficult to excavate.	Severe limitations.	Severe to moderate limitations. Rock excavation may be required.	Severe to moderate limitations. Rock excavation may be required.	Severe to moderate limitations. Rock excavation may be required.	Severe to moderate limitations. Rock excavation may be required.	Severe to moderate limitations. Rock excavation may be required.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Moderate to severe limitations. Reservoir may leak where rocks are fractured.	Moderate to severe limitations. Rock excavation.
4. Limestone, dolomite, and shale	Good to excellent foundation material; difficult to excavate.	Moderate to severe limitations. Impermeable rock. Locally fast drainage through fractures and sinks. Danger of groundwater contamination.	Severe to moderate limitations. Rock excavation may be required. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems.	Severe limitations. Leaky rock.	Severe limitations. Leaky rock.	Severe limitations. Rock excavation.
5. Black shale*	Poor foundation material; extremely difficult to excavate. Low strength and stability. May contain peat deposits.	Severe limitations. Low permeability. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe limitations. Low strength, slumping, and seepage problems.	Severe limitations. Low strength, slumping, and seepage problems.	Severe limitations. Low strength, slumping, and seepage problems.	Severe limitations. Low strength, slumping, and seepage problems.	Moderate to severe limitations. Low strength, slumping, and seepage problems.	Slight to severe limitations. Low strength, slumping, and seepage problems. Slight limitations for forest or nature preserve.	Slight limitations for small ponds.	Severe limitations. Poor strength and stability.	Moderate limitations. Poor strength. Weeps.
6. Shale and dolomite	Fair to good foundation material; easy to excavate. Shales when wet. Avoid steep slopes.	Slight to severe limitations. Low permeability. Subject to flooding. Refer to soil report (Hayes, 1993).	Severe to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Severe to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Severe to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Severe to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Slight to severe limitations. Low strength, slumping, and seepage problems. Slight limitations for forest or nature preserve.	Slight to moderate limitations. Rock excavation may be required. Slumps when wet. Avoid steep slopes.	Moderate to slight limitations. Reservoir may leak where rocks are fractured.	Slight to moderate limitations. Reservoir may leak where rocks are fractured.	Moderate to severe limitations. Possible rock excavation.
7. Shale, siltstone, sandstone, coal, and sand	Good to excellent foundation material; difficult to excavate.	Severe limitations. Impermeable rock.	Moderate limitations. Rock excavation. Local drainage problems.	Moderate limitations. Rock excavation. Local drainage problems.	Moderate limitations. Rock excavation. Local drainage problems.	Moderate to severe limitations. Rock excavation. Local drainage problems.	Moderate to severe limitations. Rock excavation. Local drainage problems.	Slight to moderate limitations. Rock excavation may be required. Local drainage problems. Slight limitations for forest or nature preserve.	Moderate to severe limitations. Reservoir may leak where rocks are fractured.	Moderate to severe limitations. Reservoir may leak where rocks are fractured.	Moderate to severe limitations. Possible rock excavation.
8. Silt, clay, sand, and gravel (terrace deposits)	Fair foundation material; easy to excavate.	Slight to severe limitations, depending on soil cover.	Slight to moderate limitations, depending on slope.	Slight limitations.	Slight limitations, depending on slope.	Slight limitations, depending on slope.	Slight to moderate limitations, depending on activity and topography.	Slight to moderate limitations, depending on activity and topography.	Not recommended. Permeous material.	Fair stability. Previous material subject to piping.	Slight limitations.

*Shales and clays in these units may shrink during dry periods and swell during wet periods, and cause cracking of foundations. On hillsides, especially where seeps and springs are present, they can also be susceptible to landslides.

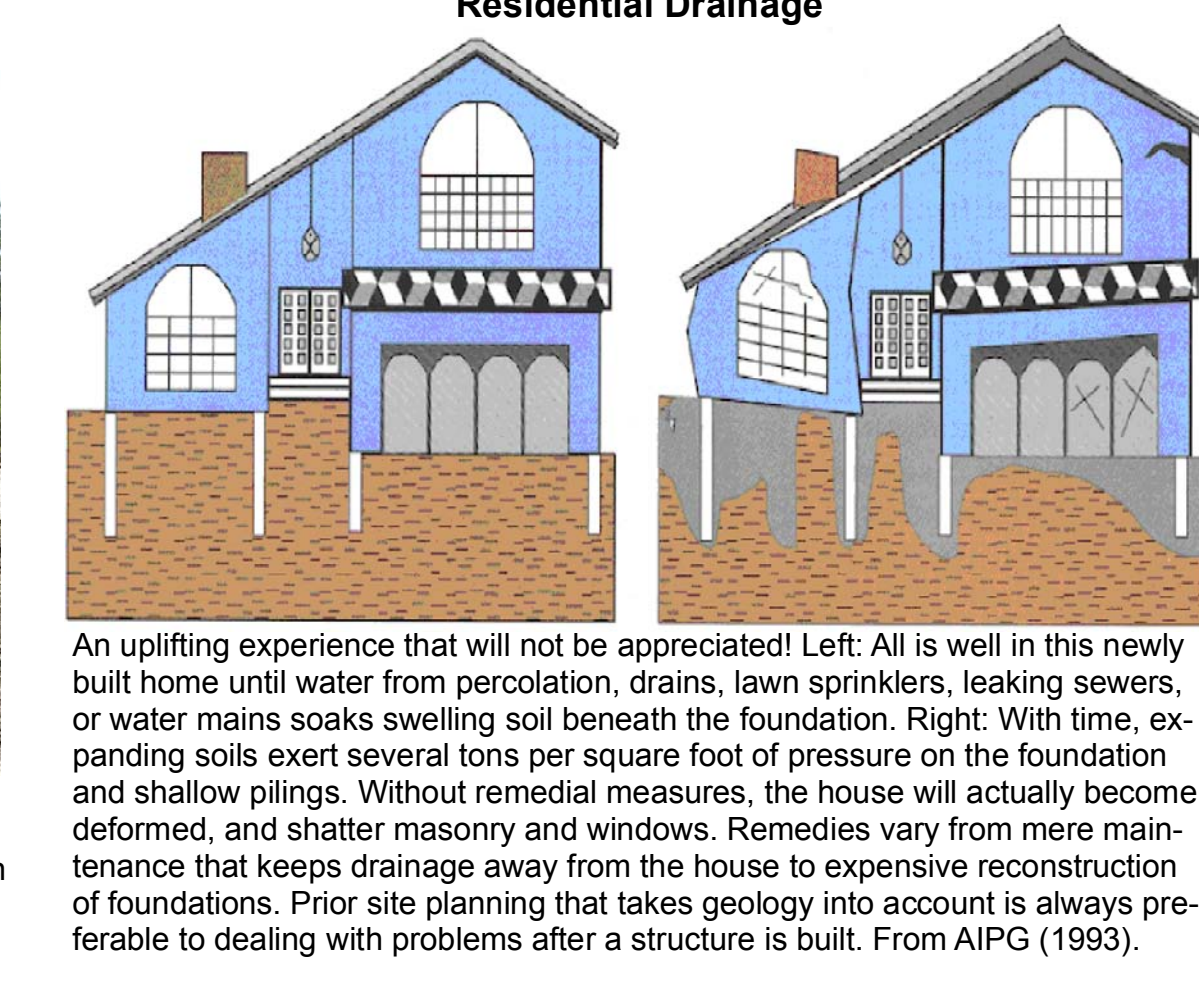
**Siltstone usually occurs in cliffs or steep hillsides, with shale above and below.



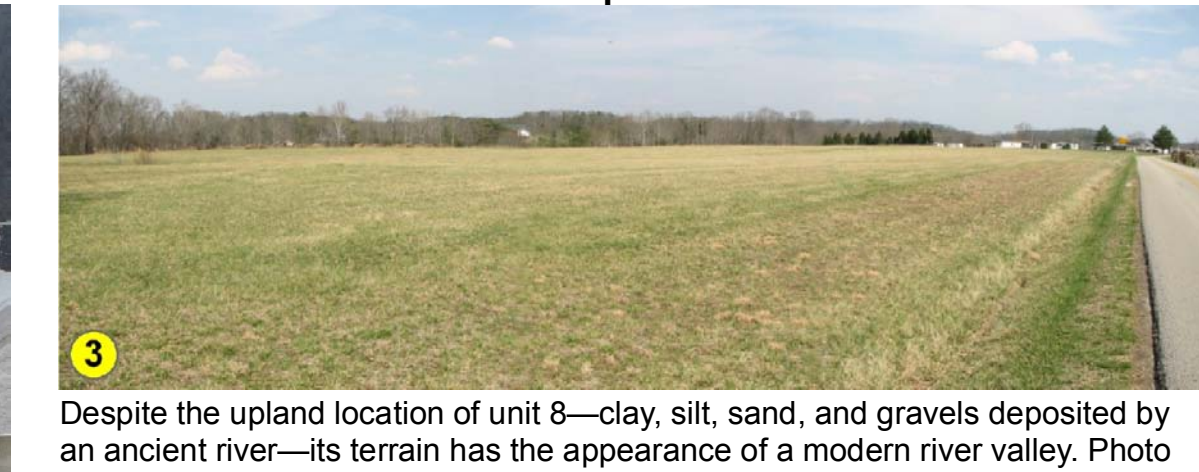
This roadcut along the Mountain Parkway reveals the thickness of the New Albany Shale (unit 5) in western Powell County. The black shale is a potential source of oil. It is unstable on slopes, and may swell when wet and shrink when dry. Photo by Dan Carey, Kentucky Geological Survey.



Hinkle Contracting Corporation excavates limestone aggregate from the Stale Formation (unit 4) near Cow Creek Road. Photo by Dan Carey, Kentucky Geological Survey.

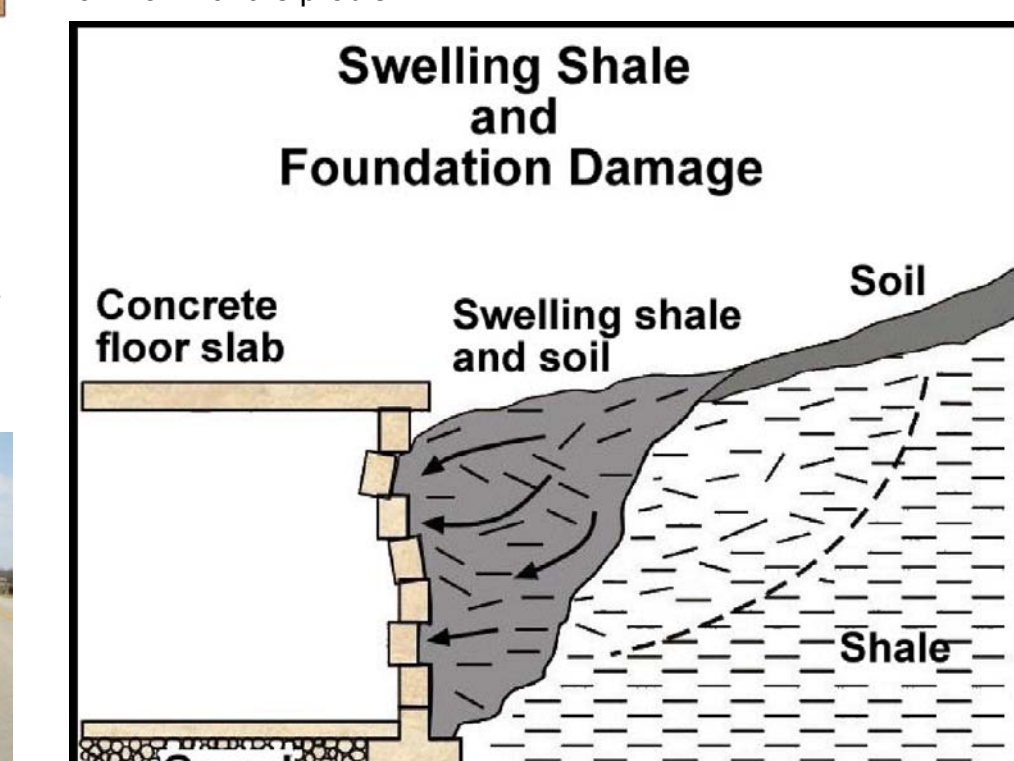


An uplifting experience that will not be appreciated! Left: All is well in this newly built home until water from percolation, drains, lawn sprinklers, leaking sewers, or water mains soaks swelling soil beneath the foundation. Right: With time, expanding soils exert several tons per square foot of pressure on the foundation and shallow pilings. Without remedial measures, the house will actually become deformed, and shatter masonry and windows. Remedies vary from mere maintenance that keeps drainage away from the house to expensive reconstruction of foundations. Prior site planning that takes geology into account is always preferable to dealing with problems after a structure is built. From AIPG (1993).

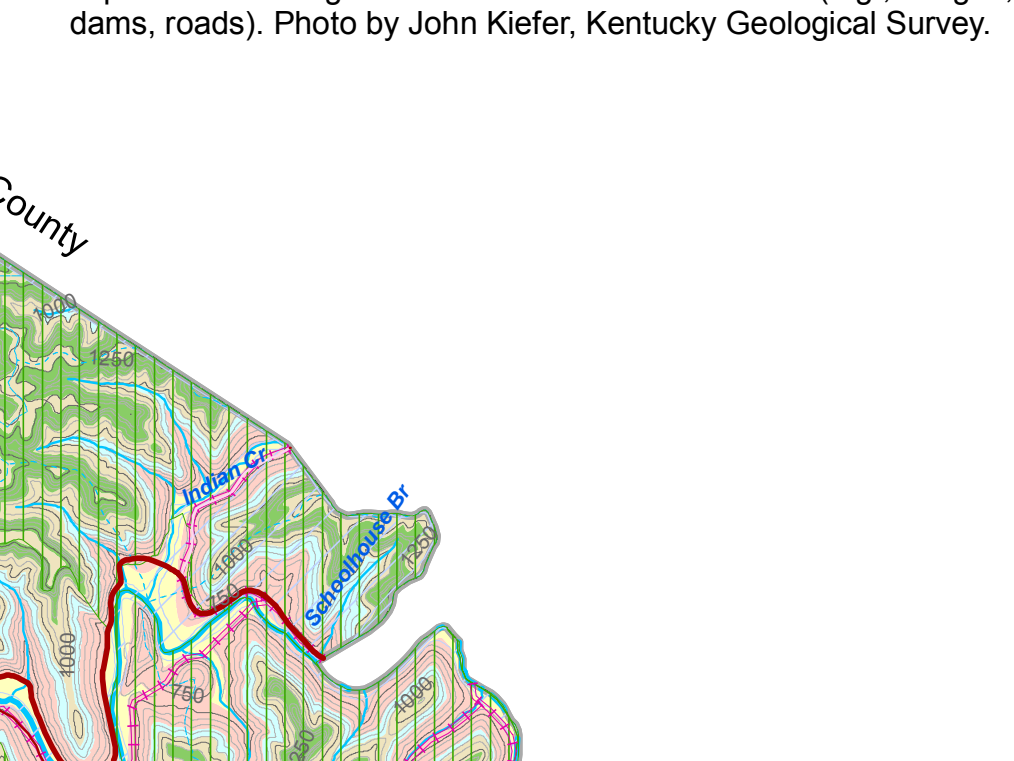


Despite the upland location of unit 8—silt, sand, and gravels deposited by an ancient river—its terrain has the appearance of a modern river valley. Photo by Dan Carey, Kentucky Geological Survey.

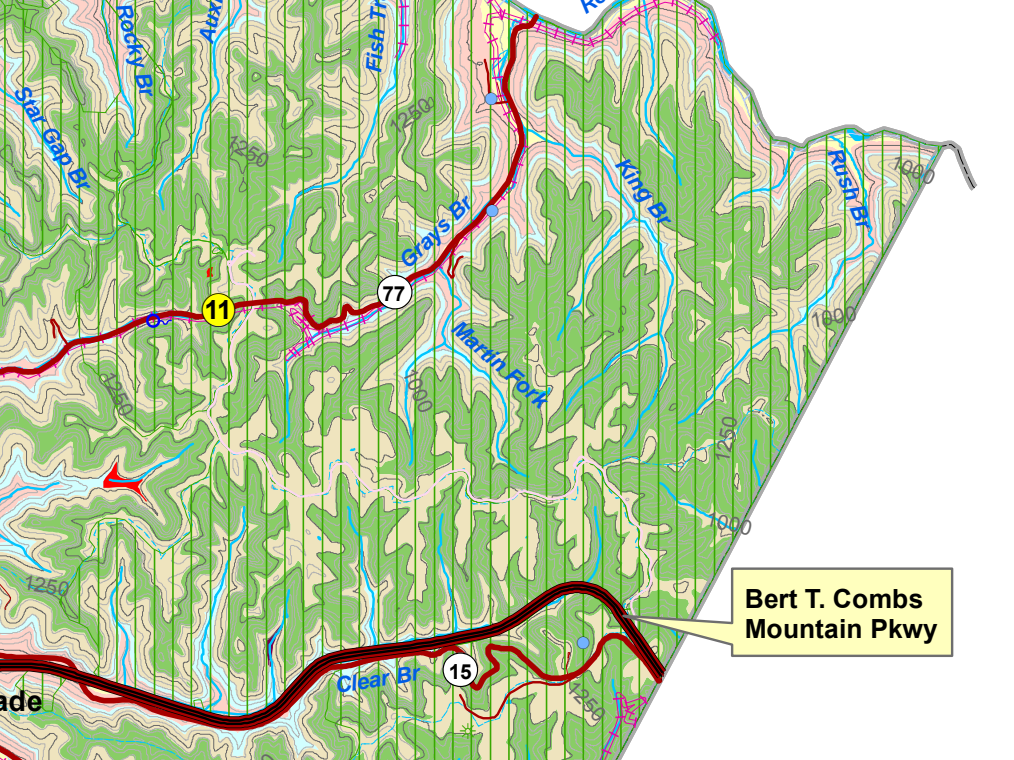
Swelling and Shrinking Shales
A problem of some concern in this area is the swelling of some of the clays and shales. Expanding shale can cause backfill to swell and concrete to crack and crumble. It can heave the foundation, the slab, and interior partitions resting on it, and damage upper floors and interior partitions. This phenomenon has been responsible for extensive damage to schools, homes, and businesses in Kentucky. During times of drought, these same shales may shrink, causing foundations to drop. Anyone planning construction on these shales should seek professional advice from a geologist or engineer familiar with the problem.



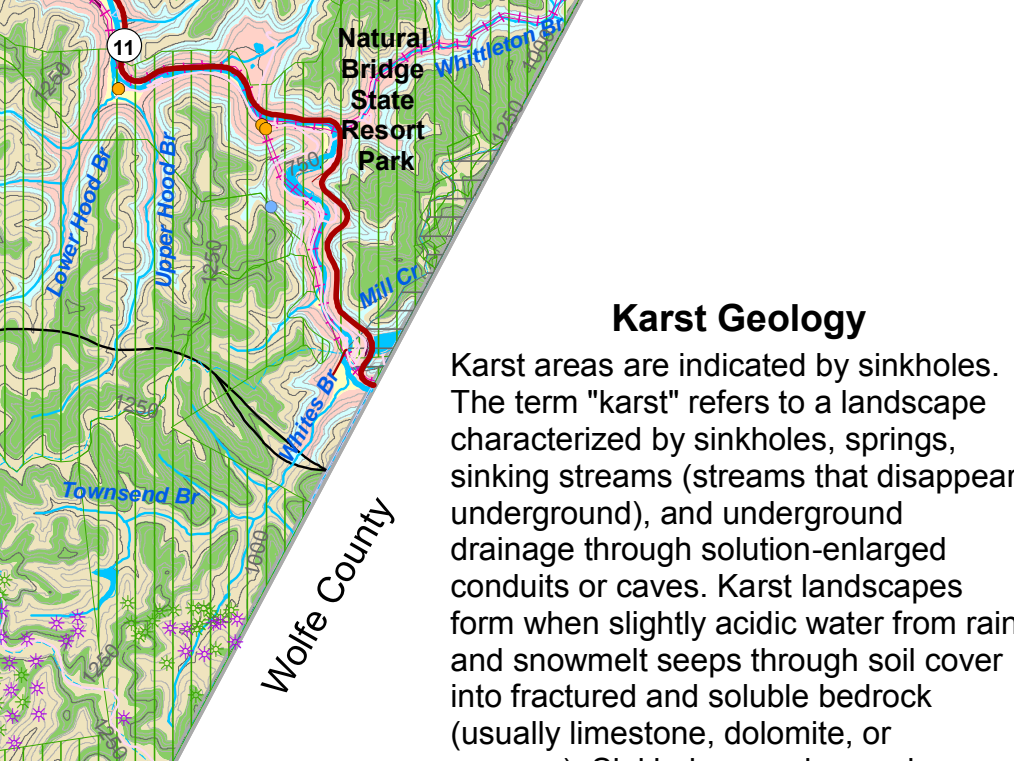
Some shales and the soils derived from them swell when exposed to water or air. These swelling shales and soils can have severe impacts on building foundations and other structures (e.g., bridges, dams, roads). Photo by John Kiefer, Kentucky Geological Survey.



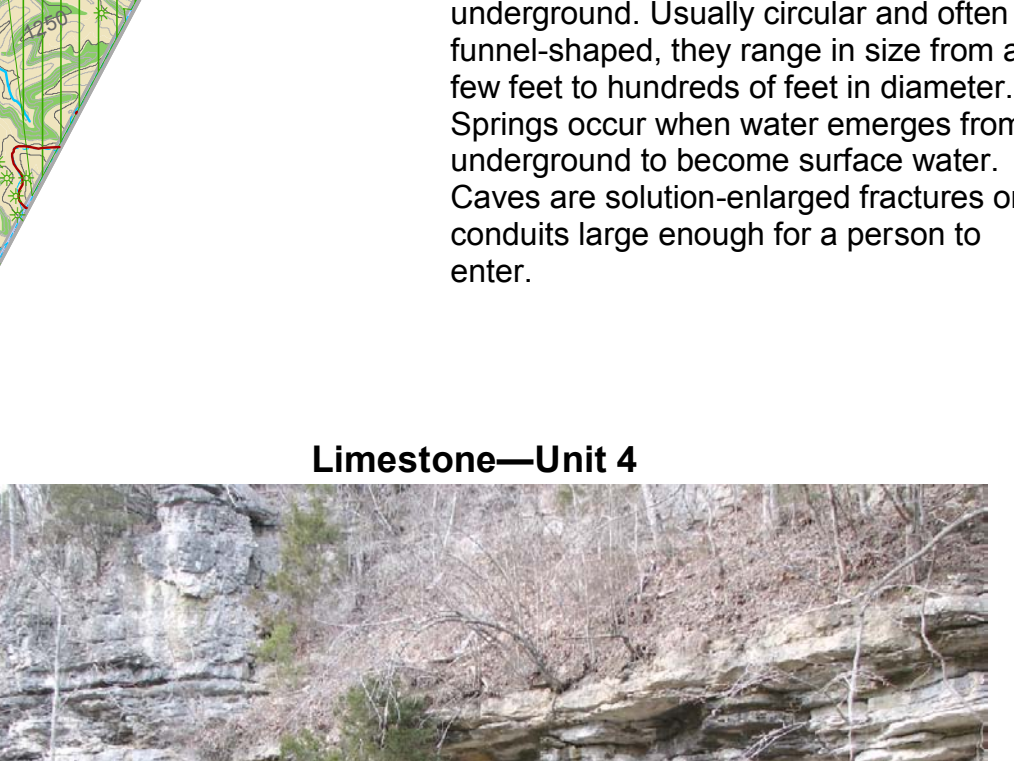
The steep, hilly terrain of unit 2 results from the combination of erosion-resistant siltstone and highly erodible shale. Photo by Dan Carey, Kentucky Geological Survey.



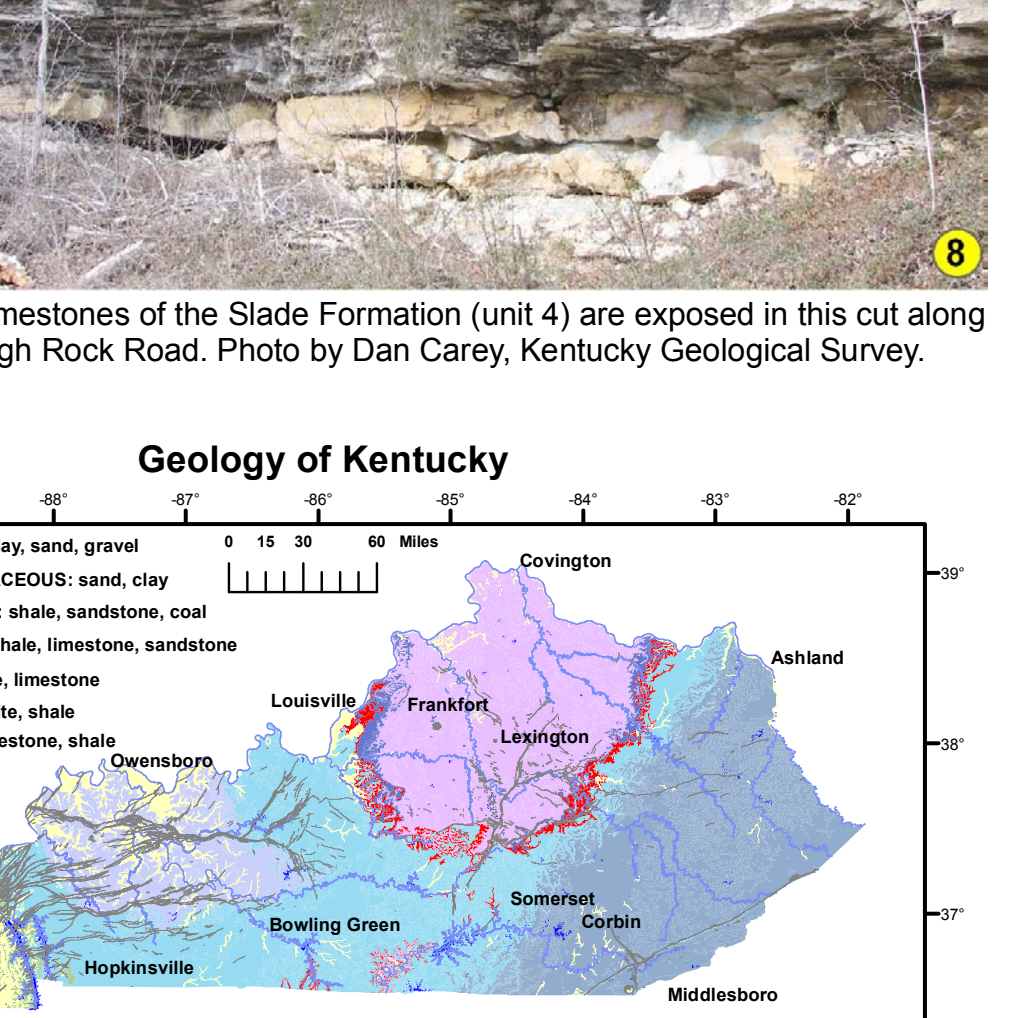
Unit 4 limestones form hillside oases with soils for agriculture. Oil wells in southeastern Powell County penetrate the dolomitic rocks (unit 6) beneath the black shale. Photo by Dan Carey, Kentucky Geological Survey.



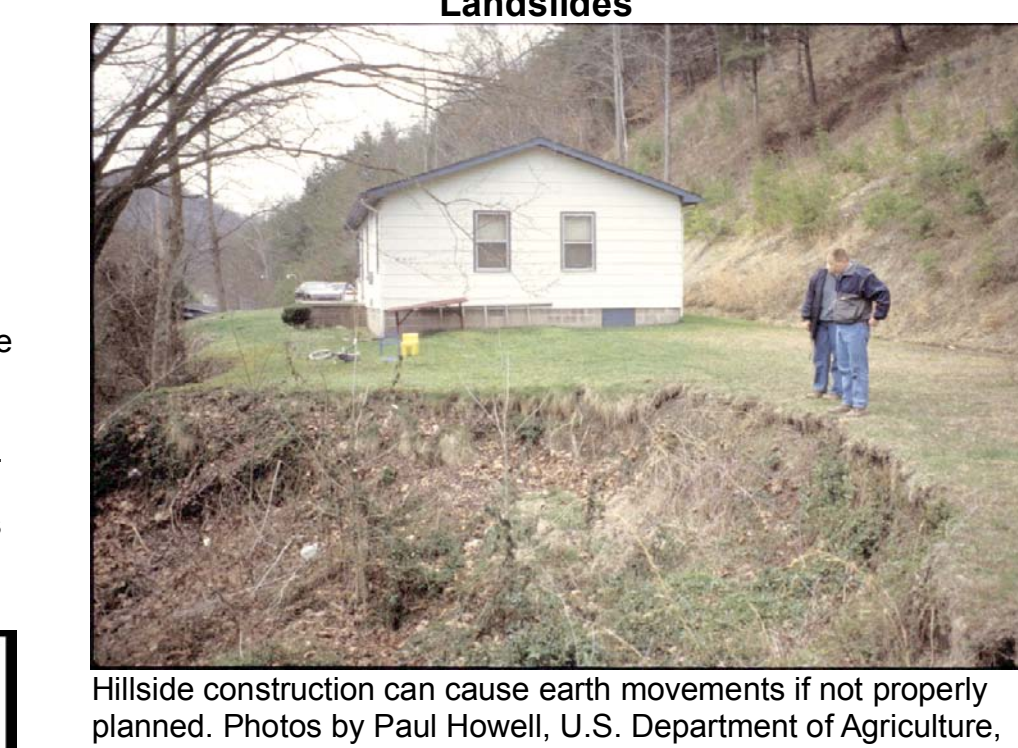
The 800-foot-long Nada Tunnel on Ky. 77 was carved through the Corbin Member of the Lee Sandstone (unit 3) in 1910-11 by the railroad. This sandstone provides natural arches, spectacular cliffs, and the enchantment of the Red River Gorge in eastern Powell County. Photos by Dan Carey, Kentucky Geological Survey.



Limestones of the Stale Formation (unit 4) are exposed in this cut along High Rock Road. Photo by Dan Carey, Kentucky Geological Survey.



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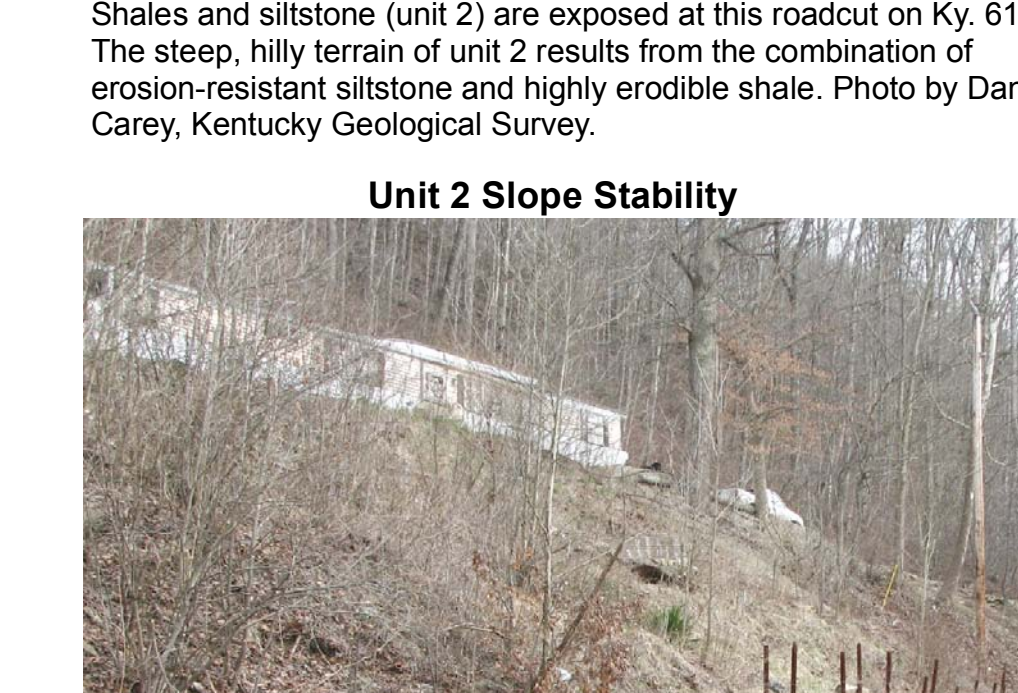
Hillside construction can cause earth movements if not properly planned. Photos by Paul Howell, U.S. Department of Agriculture, Natural Resources Conservation Service.



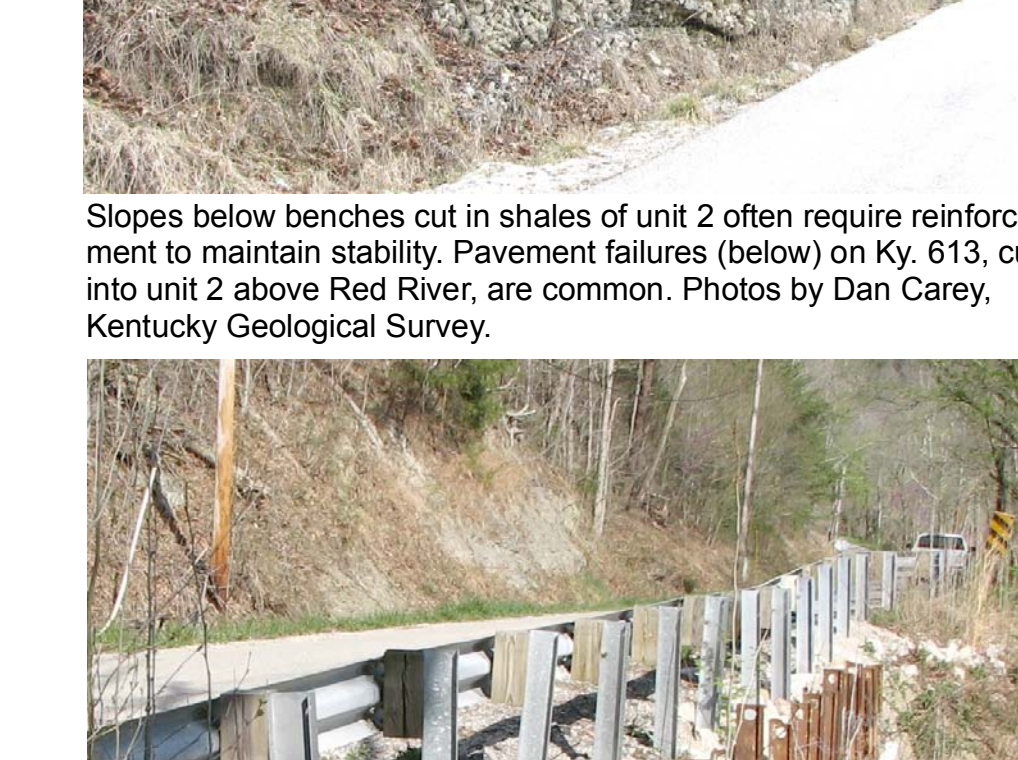
Gravity is the main driving force, but water nearly always plays a critical role by adding weight and lubricating the shale. Caution in overloading a slope with structures and fill can also be major contributory factors.



Roof runoff may seep into the soil and cause settlement.



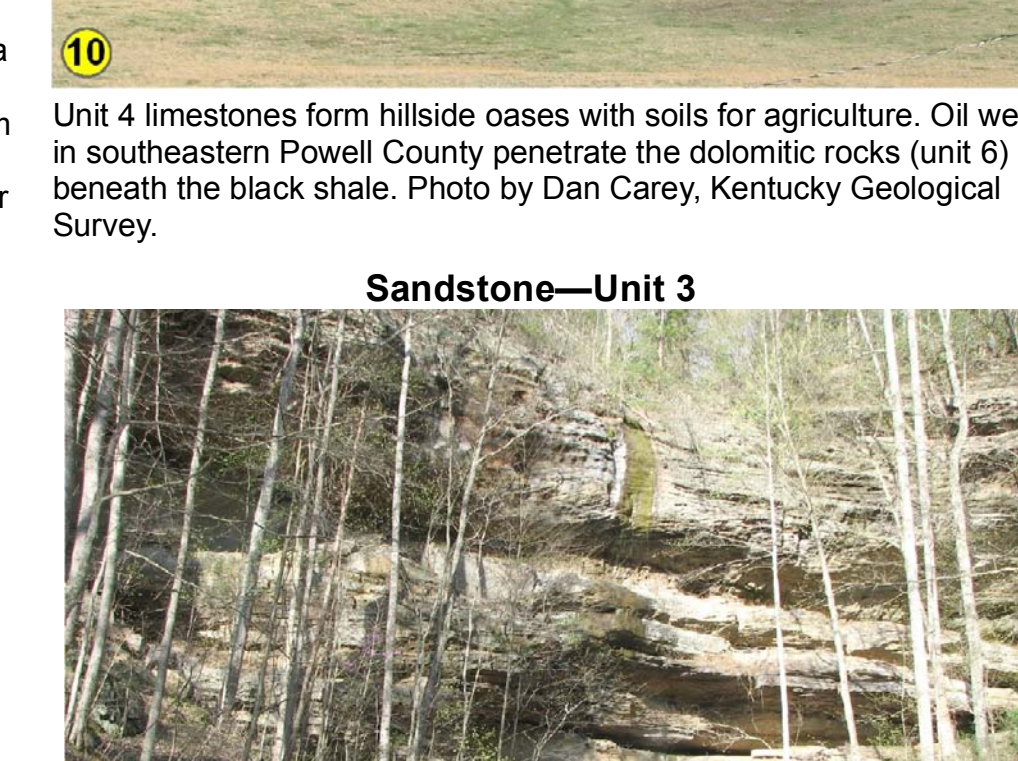
Shales and siltstone (unit 2) are exposed at this roadcut on Ky. 613. The steep, hilly terrain of unit 2 results from the combination of erosion-resistant siltstone and highly erodible shale. Photo by Dan Carey, Kentucky Geological Survey.



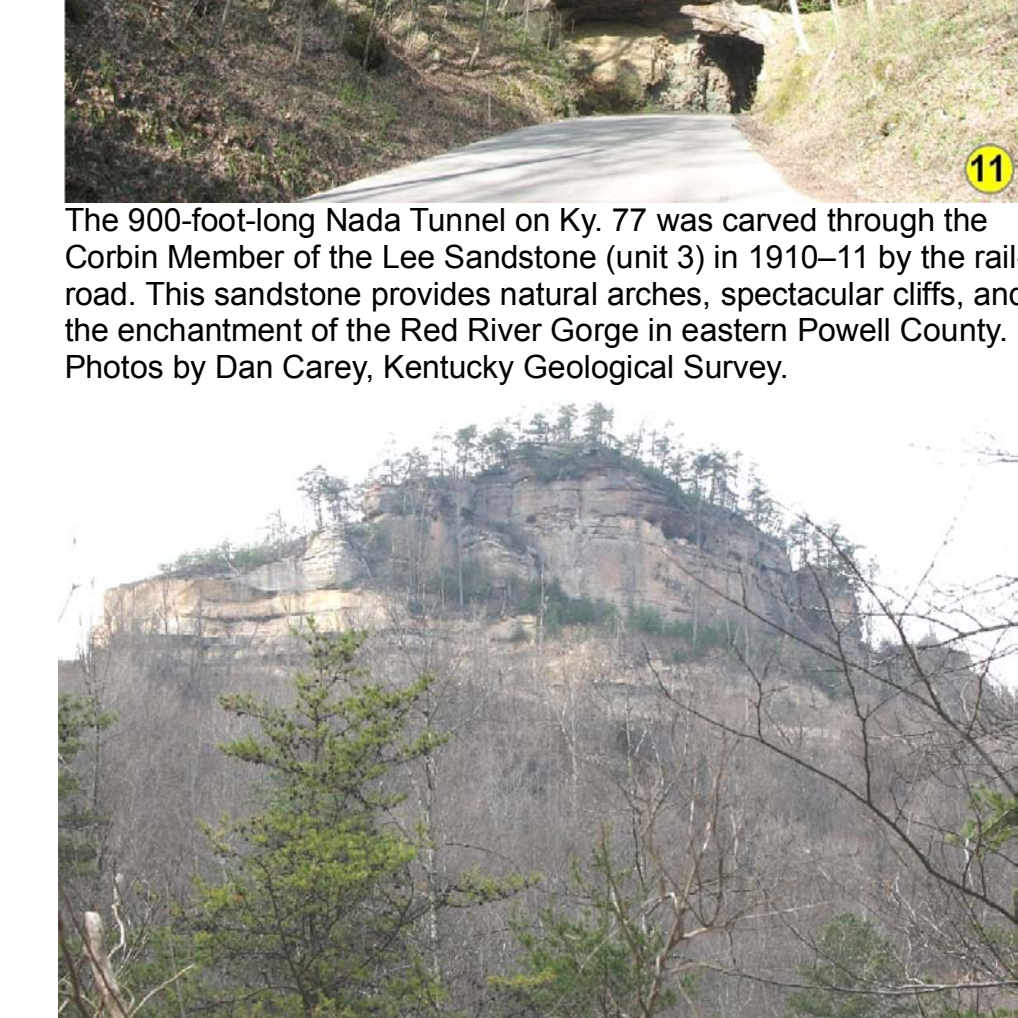
Unit 4 limestones form hillside oases with soils for agriculture. Oil wells in southeastern Powell County penetrate the dolomitic rocks (unit 6) beneath the black shale. Photo by Dan Carey, Kentucky Geological Survey.



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Limestones of the Stale Formation (unit 4) are exposed in this cut along High Rock Road. Photo by Dan Carey, Kentucky Geological Survey.



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Slope Failure
Mass movements or landslides of surficial materials are 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. Shales will break down and weather rapidly when exposed to air and water. Many shaly units tend to swell considerably when exposed to water. For this reason, plumbing trenches under walls and foundations should be prevented from accumulating water.

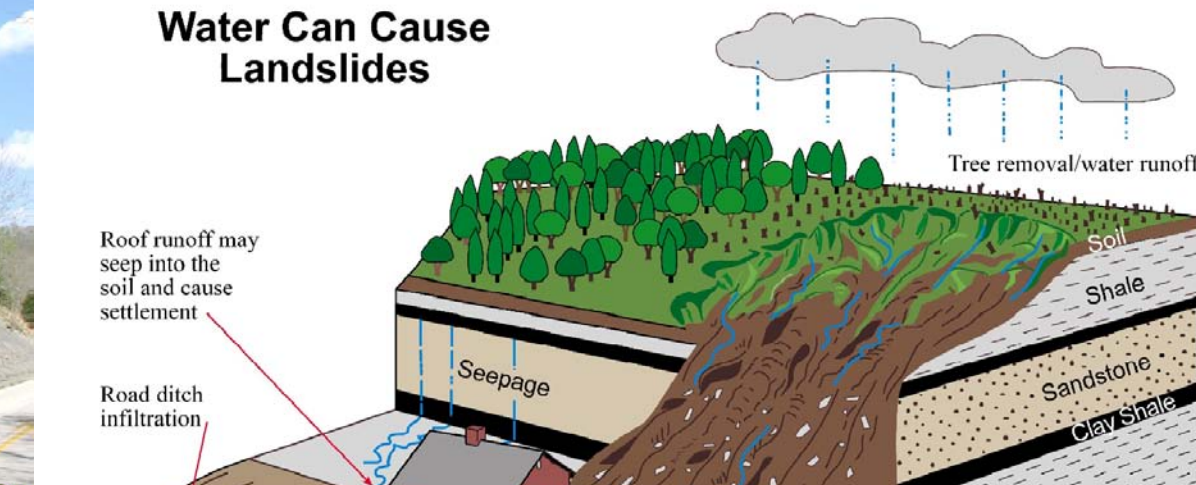
Gravity is the main driving force, but water nearly always plays a critical role by adding weight and lubricating the shale. Caution in overloading a slope with structures and fill can also be major contributory factors. Precautions include taking care of air surface water runoff by making certain that 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.

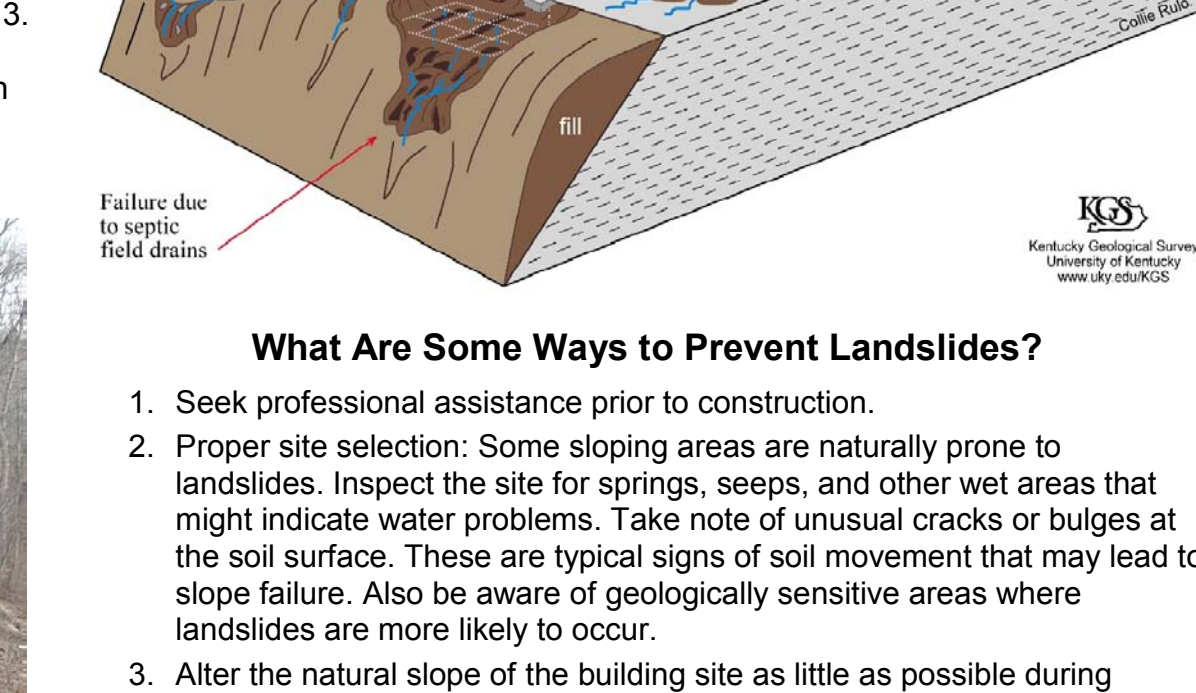
What Are the Factors That Cause Landslides?

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.

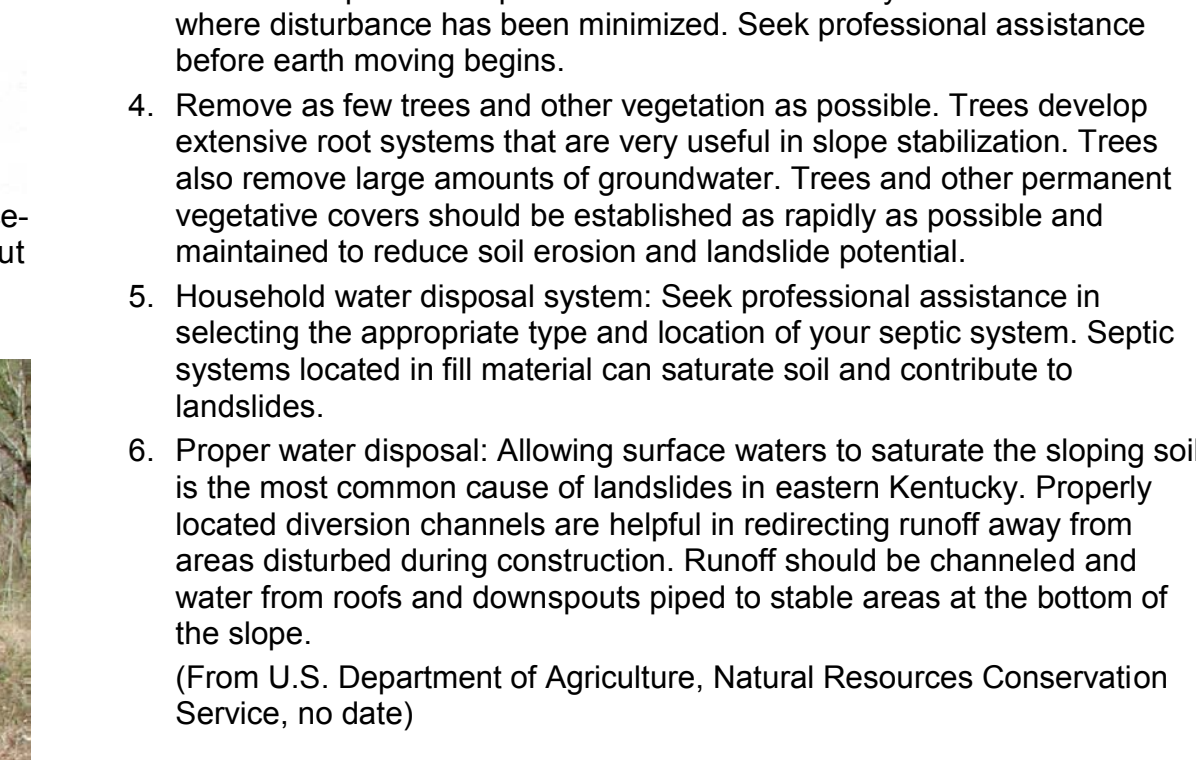
Water Can Cause Landslides



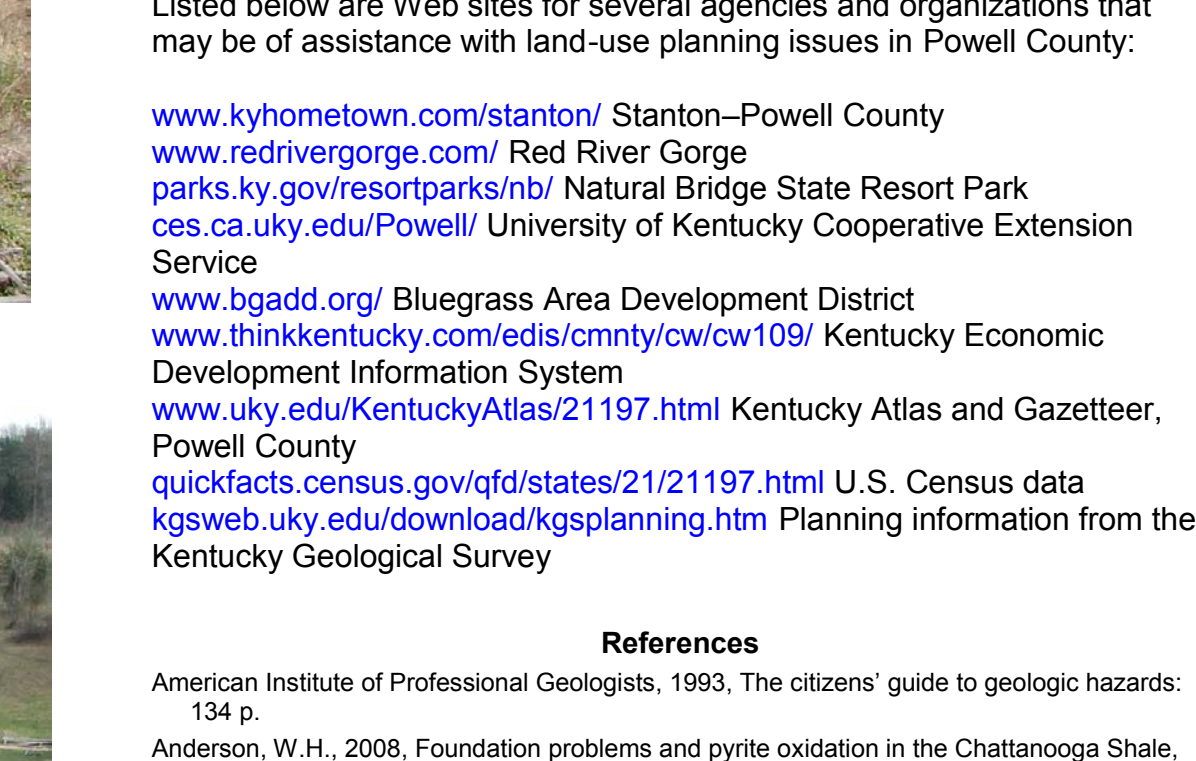
Shales and siltstone (unit 2) are exposed at this roadcut on Ky. 613. The steep, hilly terrain of unit 2 results from the combination of erosion-resistant siltstone and highly erodible shale. Photo by Dan Carey, Kentucky Geological Survey.



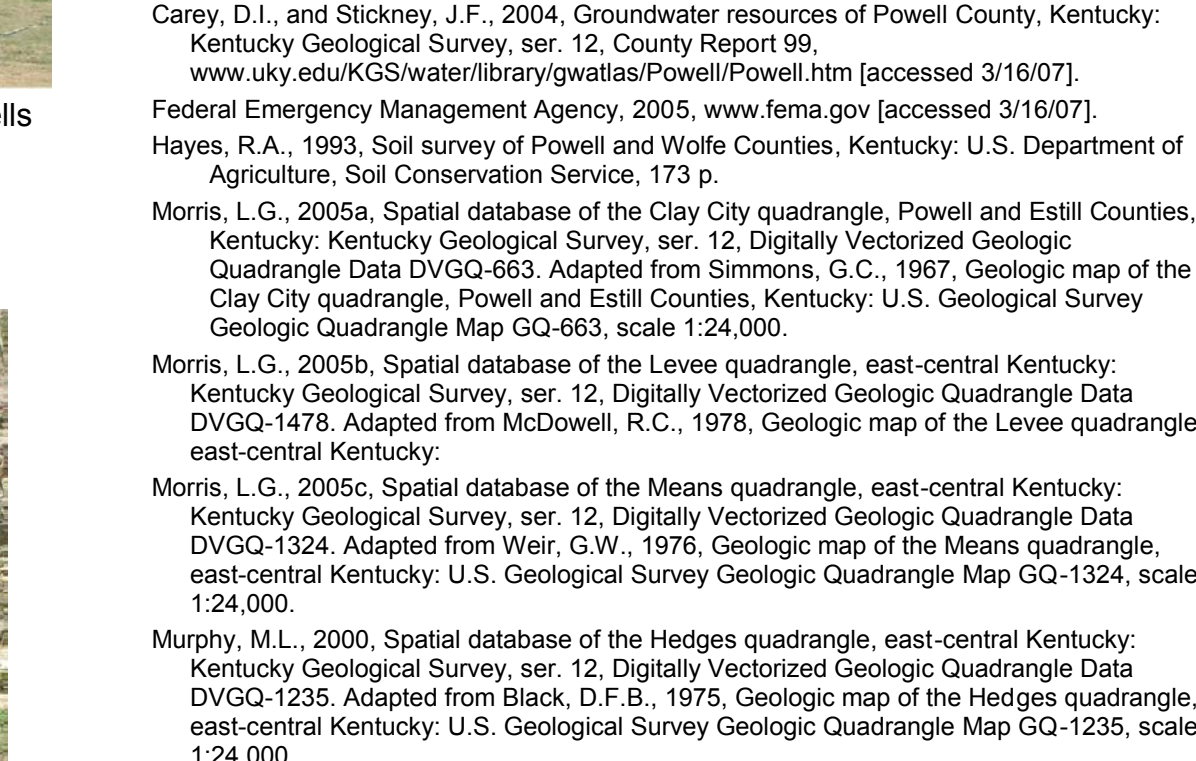
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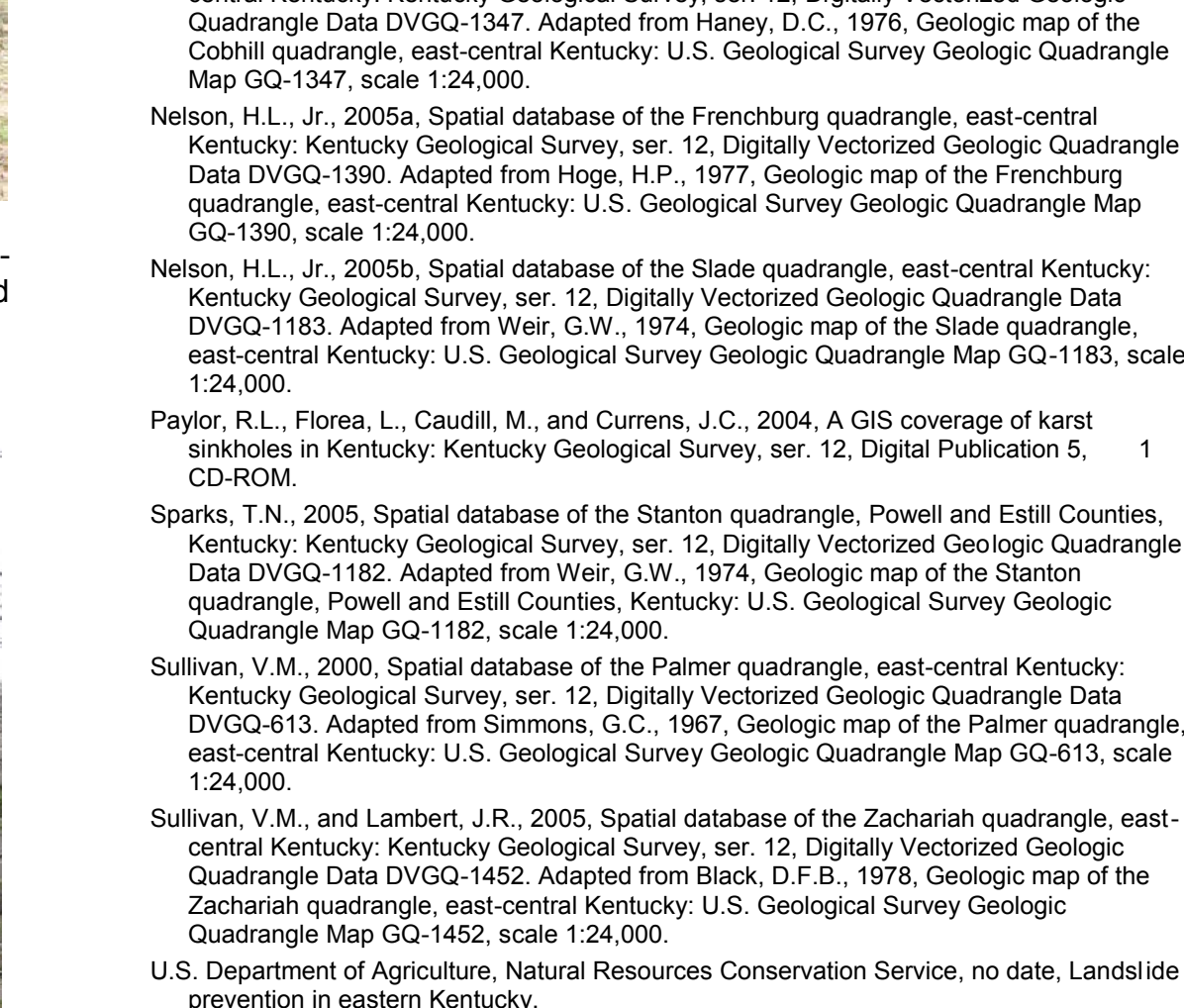
Unit 4 limestones form hillside oases with soils for agriculture. Oil wells in southeastern Powell County penetrate the dolomitic rocks (unit 6) beneath the black shale. Photo by Dan Carey, Kentucky Geological Survey.



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Limestones of the Stale Formation (unit 4) are exposed in this cut along High Rock Road. Photo by Dan Carey, Kentucky Geological Survey.

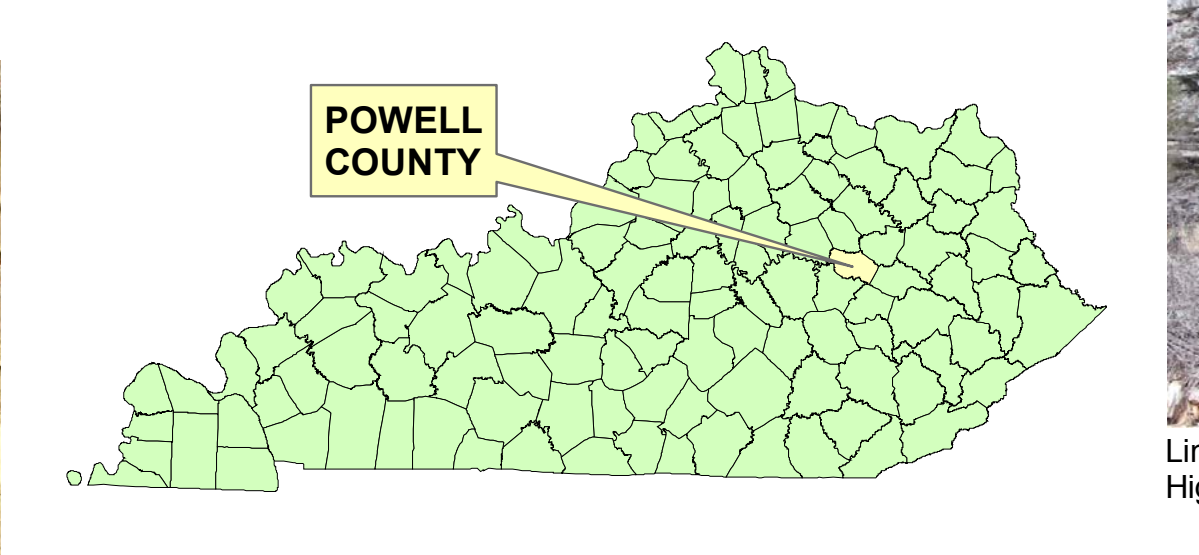


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Groundwater

About 3,200 residents of Powell County rely on private domestic water supplies: 1,400 use wells and 1,800 use other sources. In the main stem of the Red River Valley in central Powell County, most drilled wells will produce enough water for a domestic supply at depths of less than 100 feet. In the larger creek valleys throughout the county, some wells will produce enough water for a domestic supply except during dry weather. In upland areas of Powell County (60 percent of the county), most drilled wells will not produce enough water for a dependable domestic supply unless they are drilled along drainage lines, in which case they may produce enough water except during dry weather. Throughout the county groundwater is hard or very hard and may contain salt or hydrogen sulfide, especially at depths greater than 100 feet. A few springs supply enough water for domestic use.

For more information on groundwater in the county, see Carey and Stickney (2004).



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.

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Groundwater emerges from limestone (unit 4) at this spring along High Rock Road. Photo by Dan Carey, Kentucky Geological Survey.