Field Trip Guide
Hydrogeology of Sinking Valley
Pulaski County, Kentucky

Prepared for

American Institute of Professional Geologists, Kentucky Section

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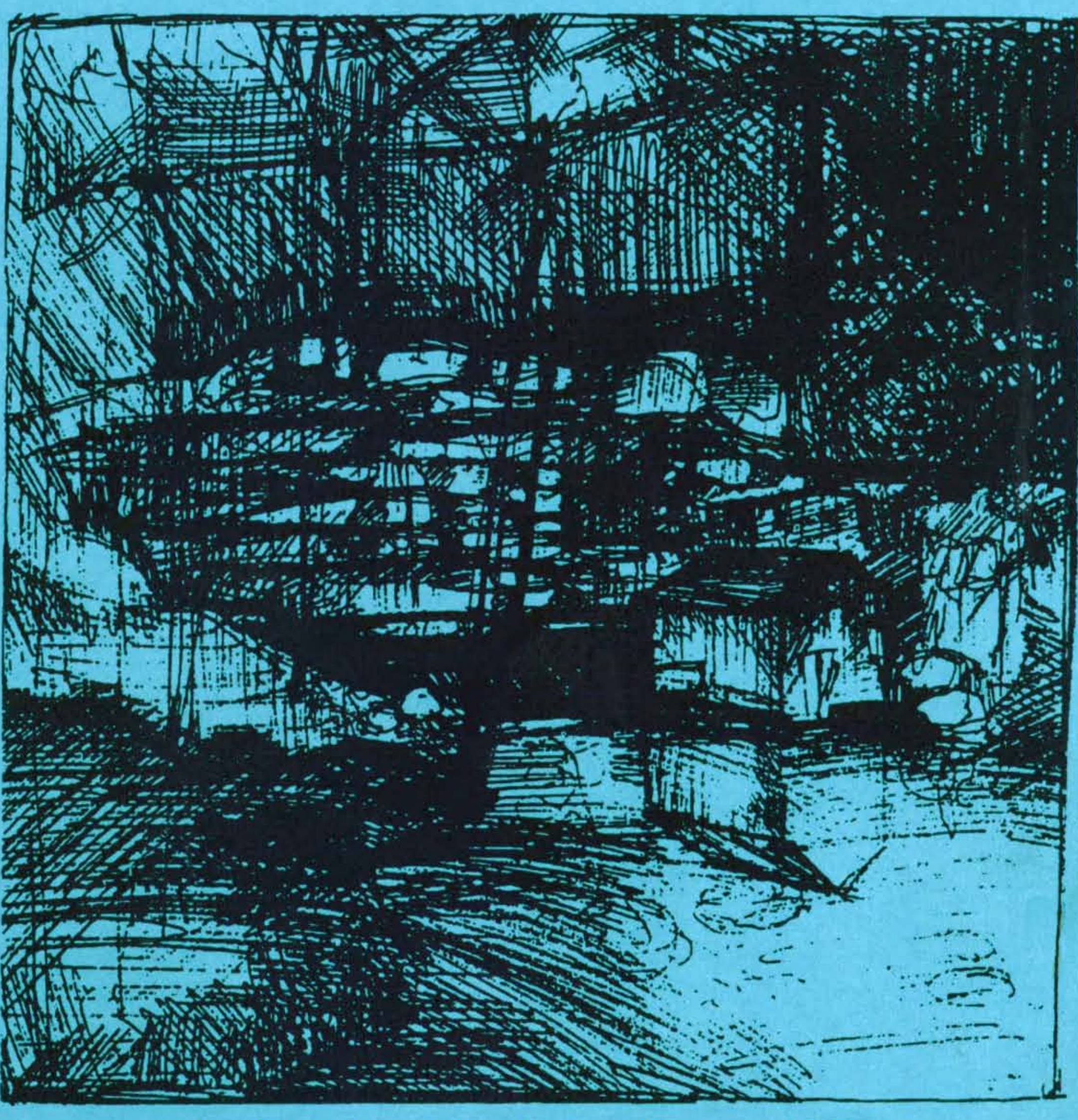


A mill at Short Creek, Stop#2, circa 1868.
Drawing by Miriam Ellen Ewers from a period photograph.

TABLE OF CONTENTS

IMPORTANT NOTICE

Most of the stops on this field trip are on private property. We have graciously been given access for our trip, but no permission has been given for future trips. For future trips, permission to enter or cross private land must be secured from the landowners. Failure to obtain this consent could jeopardize both research in progress and access for future trips. Always use (and close) gates. Do not climb fences. Do not use a rock hammer or collect samples without permission.

Acknowledgments

The authors wish to thank Norma and the late Elwood Taylor of Stab Kentucky for granting permission to use Short Creek and their help in preparation of this document. The Shopville-Stab Volunteer Fire Department provided facilities for the trip participants and the water for dye injection at Short Creek. The residents of Sinking Valley, especially Mr. Garry Price, permitted us to use their property during this field excursion and during the groundwater studies which are reported herein.

INTRODUCTION

This field trip is designed to show the geomorphic and hydrogeologic characteristics of a typical Cumberland Plateau margin karst and the tracer techniques employed in studying these and other karst terranes. Groundwater tracers will be introduced into this aquifer at several points. The trip will concentrate on a single groundwater basin, Sinking Valley, located primarily on the Shopville, Kentucky USGS (U.S. Geological Survey) 7.5 minute series topographic quadrangle map in Pulaski County. The geology of this area is depicted on the Shopville, Kentucky USGS 7.5 minute geologic quadrangle map (Hatch, 1964). A brief road log for our travel along Kentucky Route 461 is also included.

REGIONAL GEOLOGY

The Physiography–The field trip will be conducted within the Interior Low Plateaus physiographic province (Figs. 1 and 2). This province is bounded on the north by the limit of Pleistocene glaciation. This boundary corresponds very roughly to the course of the Ohio River. The eastern and southern boundaries are formed by the Appalachian Highlands locally known as the Cumberland Plateau. Resistant clastic rocks of Pennsylvanian age cap this plateau. The western boundary is formed by the coastal plain of the Mississippi Embayment.

The Bedrock Geology–The bedrock of the Mississippian plateau has undergone significant revision in recent years, particularly the upper units. These revisions are not yet incorporated into the USGS geologic quadrangle maps. The stratigraphy utilized in the USGS mapping program is depicted in Figures 3 and 4. Principal conduit (cavern) formers are the Kidder, Ste. Genevieve, and St. Louis members.

The Geologic Structure–The field trip route lies along the eastern flank of the broad anticlinorium of the Cincinnati Arch (Fig. 2). The rock units dip eastward along this trip route at about 50 feet per mile. This arch has two regions of accentuated uplift in the areas of Lexington and Nashville forming low structural

Figure 1

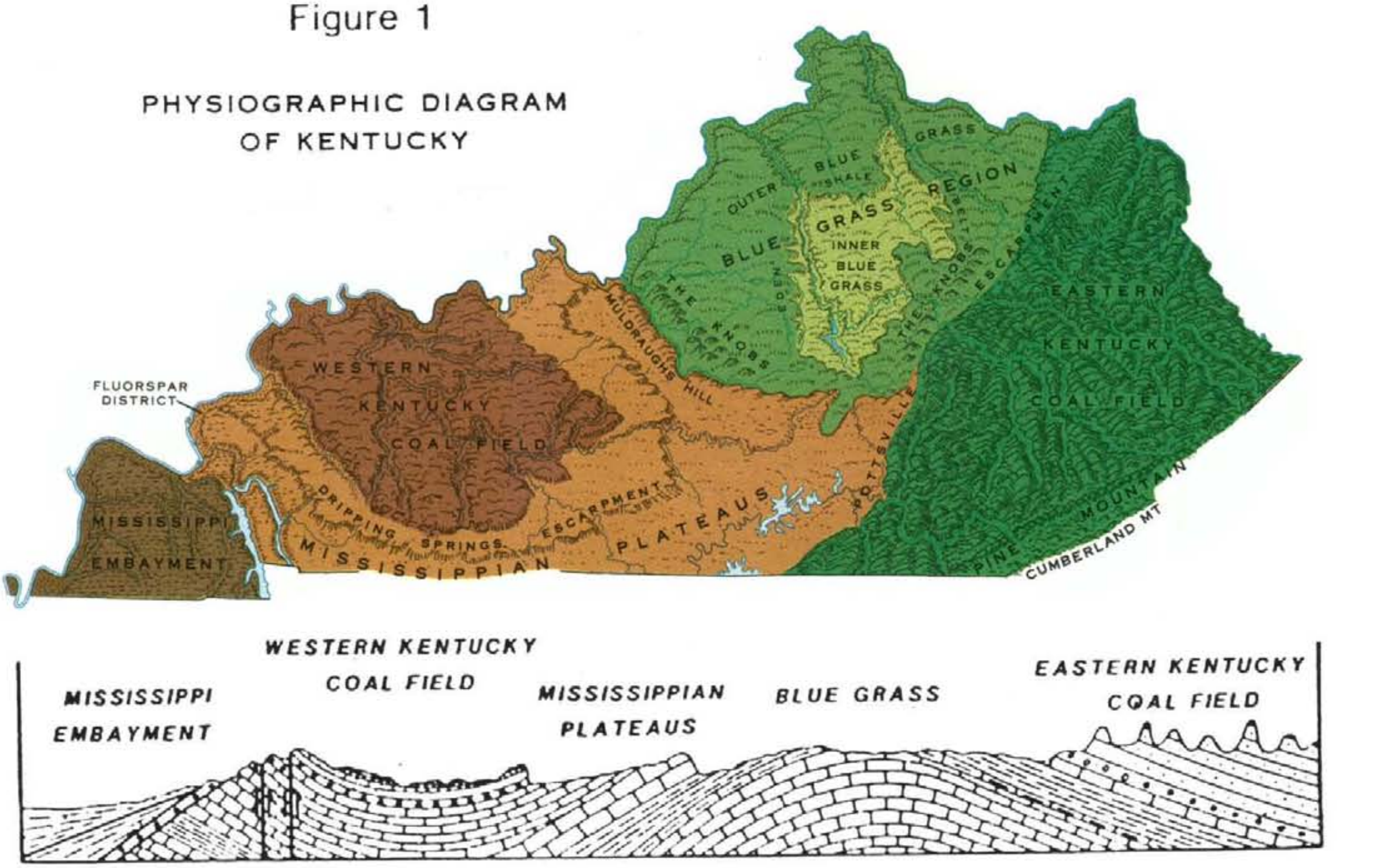
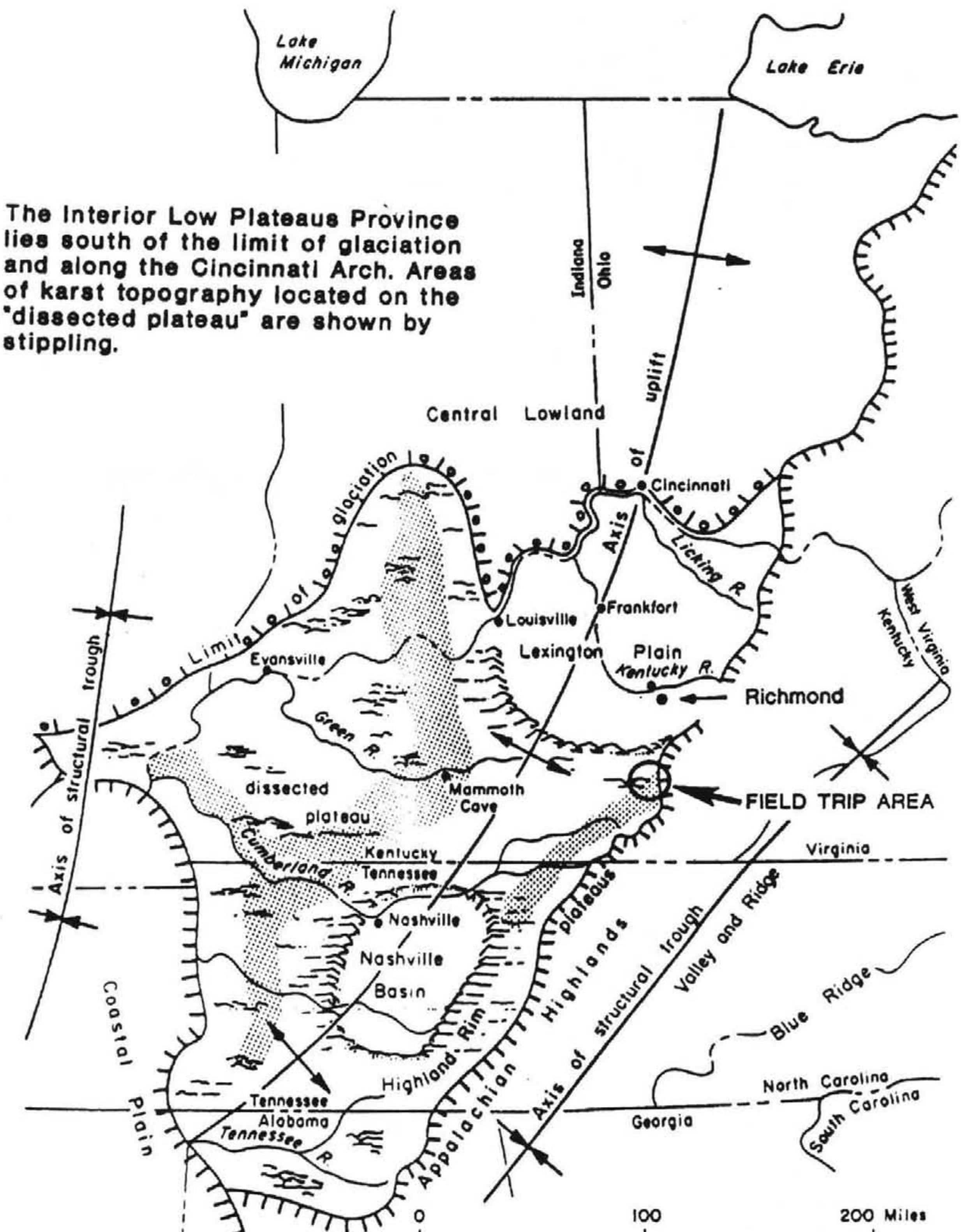
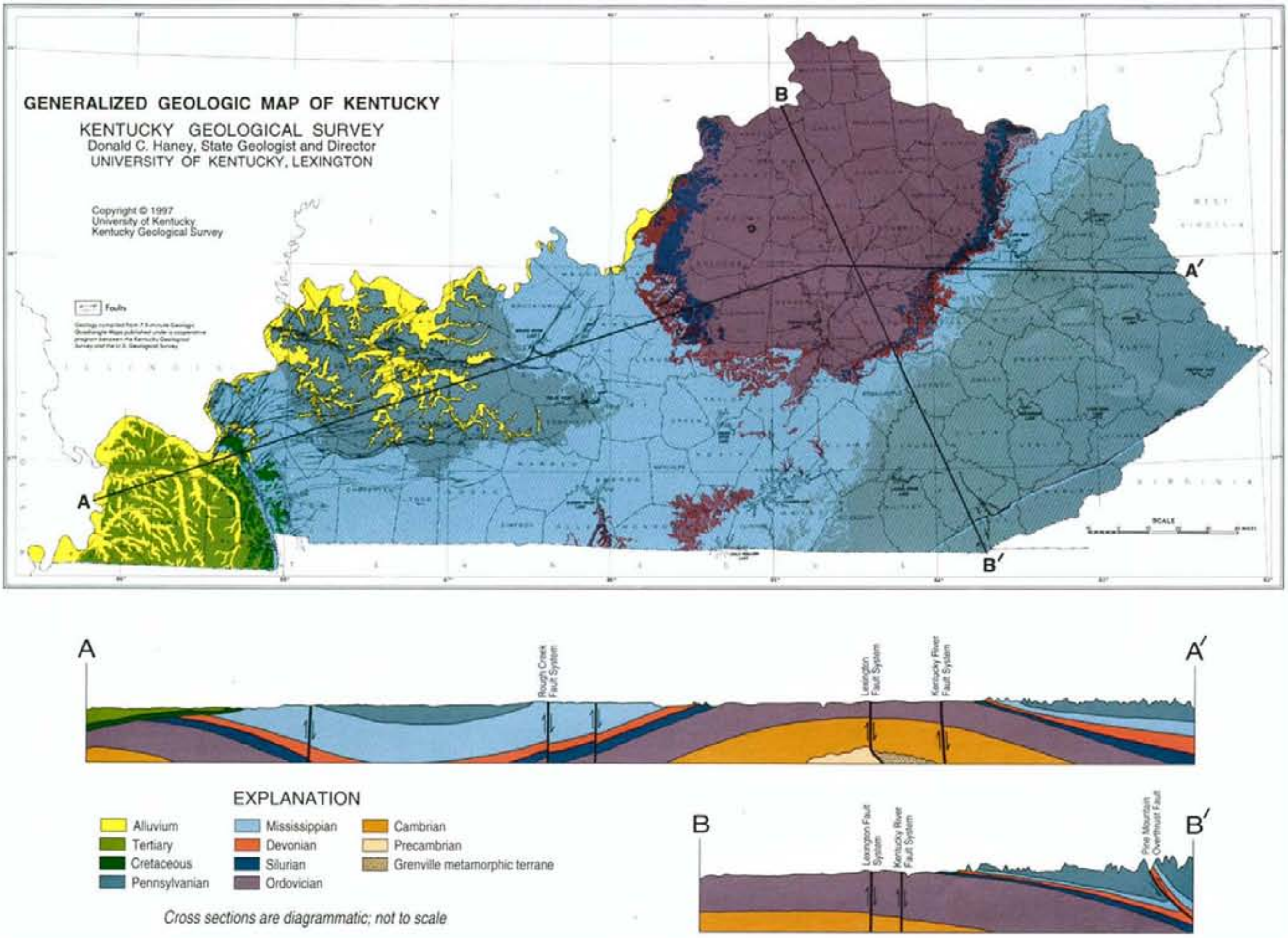


Figure 2
Interior Low Plateaus Physiographic Province



Modified From Hunt, Physiography of the U.S.

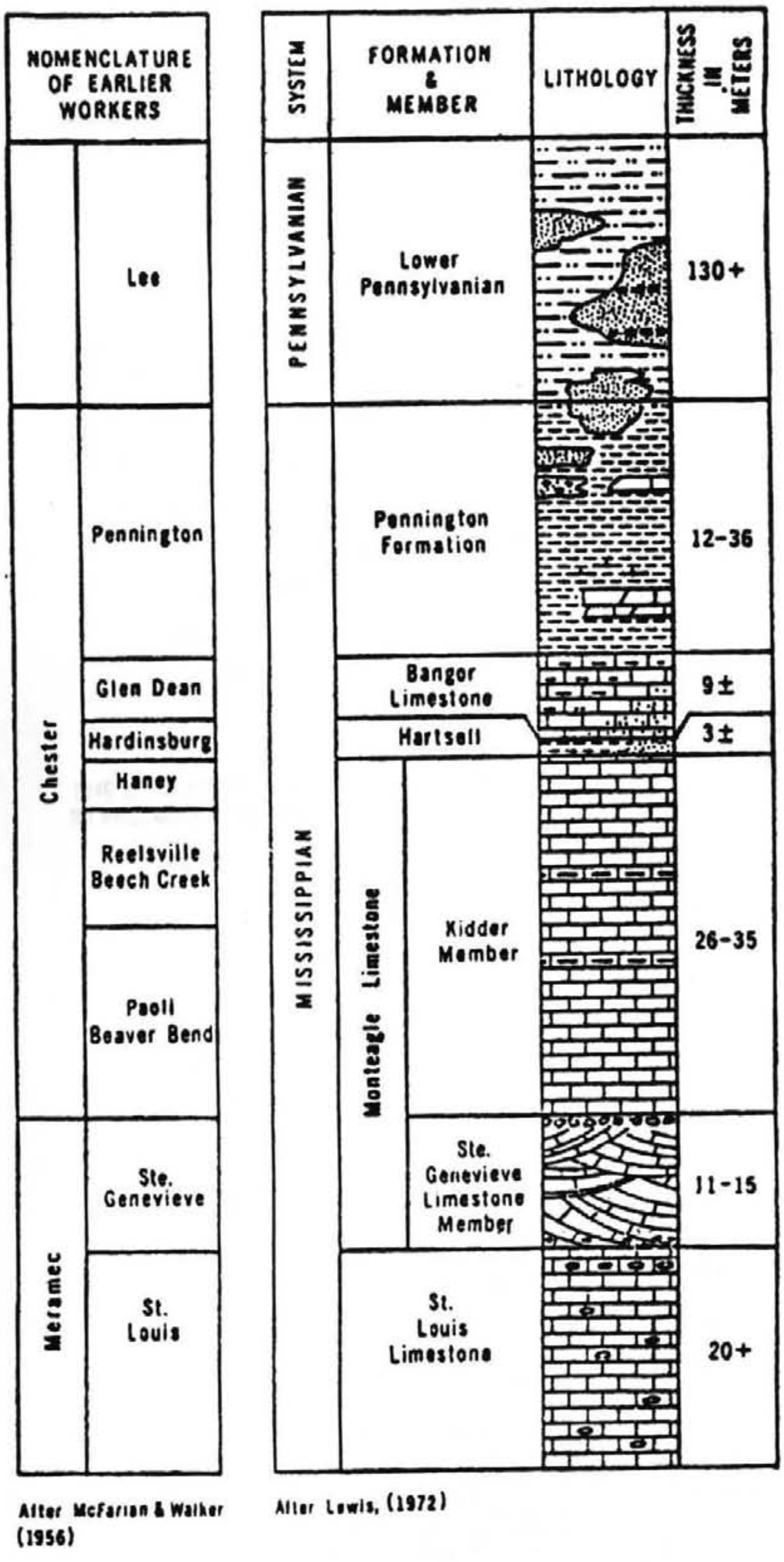


domes along the axis of folding. These domes are expressed topographically as basins–the Lexington Plain and the Nashville Basin.

Geomorphology–The Lexington Plain is formed upon Ordovician rocks, the oldest units found in Kentucky. The southern portion of the Lexington Plain and the entire Nashville Basin are rimmed by an escarpment and dissected plateau formed of Mississippian rocks referred to as the "Highland Rim" at Nashville and the "Highland Rim Equivalent" at Lexington (Fig. 2). The eastern rim of the Lexington Plain is formed by the escarpment of the Cumberland Plateau, without an intervening Mississippian escarpment. Karst topography is formed upon most of the Ordovician carbonate rocks of the Lexington Plain and virtually all of the Mississippian carbonates of the dissected plateau. Some units produce a more obvious karst topography than others but all contain conduits formed by dissolution and may be considered karst aquifers.

The field trip will be primarily within the eastern third of Pulaski County, Kentucky, which lies in the maturely dissected western margin of the Cumberland Plateau (Fig. 5). The hills in this area are capped with basal Pennsylvanian clastics of a highly variable nature. They range from cross-bedded conglomerates to siltstones, shales, and coals. The hilltops in the dissected plateau have an elevation of 1,300 ft. (400m). Maximum relief here is 720 ft. (200m) measured along the Rockcastle River. An area of Knobs occurs in a narrow strip normally three miles wide along the edge of the plateau. These detached plateau remnants have summit elevations from 1,100 to 1,300 ft. and rise about 325 feet above the intervening lowlands, which are at an elevation of 900 to 1,000 ft. These lowlands are developed on the lower Kidder and Ste. Genevieve limestones and are marked by numerous sinks and dry valleys.

Figure 4



After McFarlan & Walker (1956)

After Lewis, (1972)

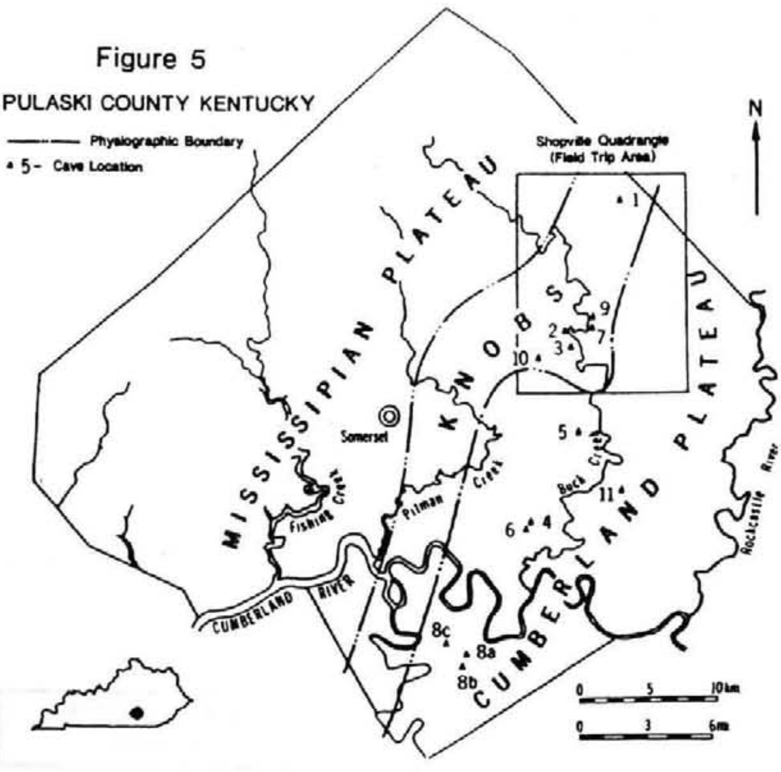
Surface streams originally flowing on the Cumberland escarpment have been lowered by erosion onto the soluble Mississippian limestones (Fig. 6). These surface streams have been gradually captured by evolving subsurface conduits. This leaves dry valleys where the streams formerly flowed. For the most part, the new subsurface streams parallel their ancestral surface courses. Autogenic waters, those originating as rain on the limestones, are captured by sinks. Allogenic waters, originating as rain upon the nearby clastic rocks of the Cumberland Escarpment, descend into swallets in sinkholes along the eastern portion of the dry valleys.

As erosion continued, the lower Mississippian limestones were exposed at the surface (Fig. 6). These deeper rocks were poorer cavern formers and the larger subsurface streams were gradually re-established as surface streams. Remnants of the subsurface tributaries of these conduit systems are preserved as caves in the Knobs.

Surface Drainage–The Cumberland River and the Kentucky River form the major surface drainage and base-level controls in the area. Both are tributary to the Ohio River. Four streams cross Pulaski County flowing from north to south, sub-parallel to the strike of the rocks–Fishing Creek, Pitman Creek, Buck Creek, and the Rockcastle River (Fig. 5). All of these streams flow on limestone. Their courses are primarily above ground at the present time. Limestone floored valleys tributary to Buck Creek and the Rockcastle River within the area of the Knobs and the dissected portion of the Cumberland Plateau are underdrained by subsurface streams along most of their courses.

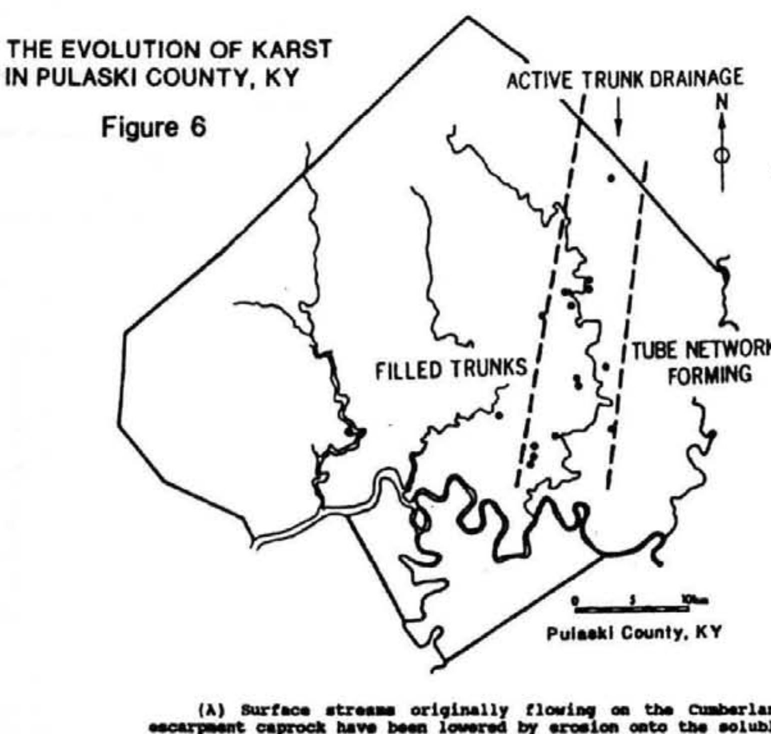
Figure 5

PULASKI COUNTY KENTUCKY



THE EVOLUTION OF KARST IN PULASKI COUNTY, KY

Figure 6



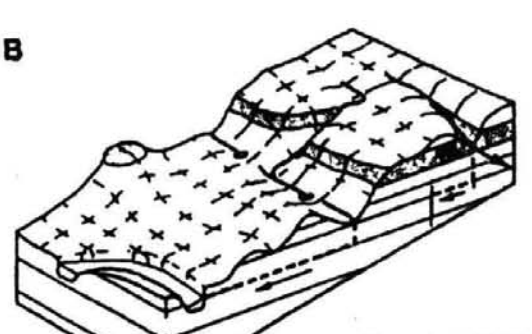
(A) Surface streams originally flowing on the Cumberland escarpment caprock have been lowered by erosion onto the soluble Mississippian limestones. (B) These surface streams have been gradually captured by evolving subsurface conduits, leaving dry valleys where these streams formerly flowed. For the most part, the new subsurface streams parallel their ancestral surface courses. (C) As erosion continued, the lower Mississippian limestones were exposed at the surface. These deeper rocks were poorer cavern formers and the larger subsurface streams were gradually re-established as surface streams.

Pulaski County can be divided into three evolutionary zones with respect to subsurface karst conduits. A zone in the east where tube networks are being established in the poorly dissected margin of the escarpment; a central zone of active trunk drainage; and a western zone where many major conduits are sediment filled or unroofed by erosion. The picture presented here has gradually evolved westward during the Holocene.

A

A surface stream breaches the clastic caprock and conduits begin to form along the valley axis and also up-dip toward the nearby surface stream.

B



The surface stream is captured by the subsurface conduits beneath the valley axis.

C

The subsurface stream returns to the surface when it encounters deeper less soluble limestone and erosion removes the cavern roof.

R. O. Ewers, 1995

KENTUCKY ROUTE 461 ROADLOG

This roadlog was partially obtained and modified from the 1990 annual field conference guidebook of the Geological Society of Kentucky (GSK) (Dever and others, 1990). It identifies the Mississippian rock units exposed along Kentucky Route 461. The mileages listed on the left are relative to the interchange at I-75 and increase as the trip proceeds southward. The mileage that is listed at the end of each description is the mileage that relates to the GSK roadlog.

Figure 7

System	South-Central Kentucky		East-Central Kentucky	
PENN.	Breathitt and Lee Formations		Breathitt and Lee Formations	
PENN.	Paragon Formation		Paragon Formation	
MISSISSIPPIAN	Bangor Limestone		Slade Formation	Poppin Rock Member
MISSISSIPPIAN	Hartselle Formation		Slade Formation	Maddox Branch Member
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Ramey Creek Member
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Tygarts Creek Member
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Armstrong Hill Member
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Cave Branch Bed
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Mill Knob Member
MISSISSIPPIAN	Monteagle Limestone	Kidder Limestone Member	Slade Formation	Warix Run Member
MISSISSIPPIAN	Monteagle Limestone / St. Louis Ls.	Ste. Genevieve Limestone Member	Slade Formation	Ste. Genevieve Member
MISSISSIPPIAN	St. Louis Ls.	Burnside member	Slade Formation	St. Louis Member
MISSISSIPPIAN	St. Louis Ls.	Bronston member	Slade Formation	Renfro Member
MISSISSIPPIAN	Salem and Warsaw Formations		Slade Formation	Renfro Member
MISSISSIPPIAN	Muldraugh Member of Borden Formation		Slade Formation	Renfro Member

Comparison of stratigraphic nomenclature for Mississippian rocks in south-central Kentucky (Friday trip) and east-central Kentucky (Saturday trip). South-central nomenclature from Lewis and others (1973), Ettensohn and others (1984), and Dever and Moody (in prep.). East-central nomenclature from Ettensohn and others (1984).

The stratigraphic nomenclature that is used for the roadlog along Kentucky Highway 461 is based on the work of Ettensohn and others (1984) and differs from that used in the USGS mapping program. Please refer to the correlation chart for a comparison of the names used to represent the different units (Fig. 7).

Roadcuts along Kentucky Route 461 expose numerous karst features. Time does not allow the trip to stop at more than one outcrop. As the trip proceeds to the south watch the soil bedrock interface and the irregularity of this surface in these cuts.

Mileage

- 0.0 Interchange of I-75 at Renfro Valley. (62.7)
- 0.7 U.S. Highway 25 south-bound goes left here. Proceed south on Highway 461. (62.0)
- 1.3 Roadcut through Tygarts Creek, Ramey Creek, Maddox Branch, and Poppin Rock Members of the Slade Formation along with the Paragon Formation. (61.4)
- 1.4 Asphalt plant on left side of road. (61.3)
- 2.1 Intersection with Kentucky Highway 1326. Northeast of the caution light the east-west-trending Mount Vernon Fault cuts the exposures, displacing the Ste. Genevieve limestones down to the north. The southwest end of the long roadcuts expose the upper Renfro, St. Louis, Ste. Genevieve, Warix Run, Mill Knob, Tygarts Creek, Ramey Creek, Maddox Branch, and Poppin Rock Members of the Slade Formation. (60.6)
- 3.0 Roadcuts through Warix Run (crossbedded calcarenite). (59.6)
- 3.2 Intersection with Highway 150. (59.5)
- 3.3 Warix Run and Mill Knob Members. Well-developed epikarst and other solution features in this cut. (59.4)
- 3.7 Mill Knob Member. (58.9)
- 4.0 Warix Run and Mill Knob Members. (highway mile 6.0) (58.6)
- **4.6 STOP #1–Typical Epikarst Features in Outcrop–(highway mile 5.5)**

The upper Renfro, St. Louis, Ste. Genevieve, and basal Warix Run Members of the Slade Formation are exposed here. There is an erosional remnant of the Lost River Chert Bed found in the northern end of this roadcut (Fig. 8). (57.8)

At this location excellent examples of solution features, typical of the epikarst, can be seen in cross-section. The irregular soil bedrock interface, klints, grikes, small shafts, and dissolution-widened fissures are present. Deeper karst features include anastomoses and bedding plane tubes with active groundwater discharge.

A tracer or a contaminant released at a point above this outcrop would likely flow along only one or two paths through the epikarst to the active conduit below. No true "plume" would form. Thus, a conventional monitoring well would be unlikely to detect the dye or contaminant in a convergent flow system of this nature. Monitoring in the conduit or at its spring discharge would be required (Fig 9).

Mileage

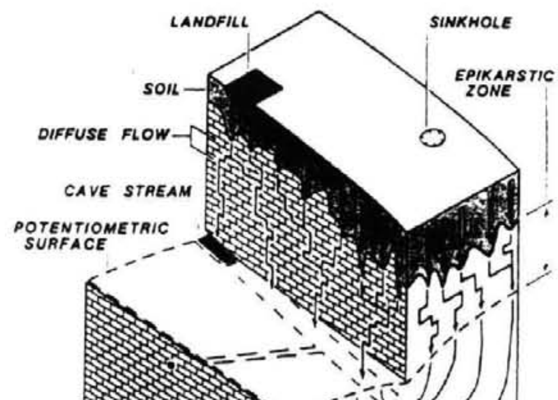
- 5.6 Renfro Member. (56.8)
- 6.0 Intersection with the road to Wabid, Route 1250. (56.7)
- 6.4 Jones Creek cut. Renfro, St. Louis, and Ste. Genevieve Members. (56.3)
- 7.0 Skeggs Creek cut. Renfro, St. Louis, and Ste. Genevieve Members. (highway mile 3) (55.5)
- 7.7 Brown Fork cut. Renfro, St. Louis, Ste. Genevieve, and Warix Run Members. (54.9)
- 8.1 Pinnacle Knob cut. Renfro, St. Louis, Ste. Genevieve, and Warix Run Members. (54.3)
- 8.8 Level Green School cut. Renfro, St. Louis, and Ste. Genevieve Members. Very well developed pinnacles, klints, and grikes are visible here. (53.8)
- 9.3 Level Green cut. Renfro Member. (53.4)
- 9.6 Junction with Kentucky Highway 1152. Renfro, St. Louis, and Ste. Genevieve Members. (53.0)
- 9.9 Renfro, St. Louis, and Ste. Genevieve Members are exposed. A fault striking N 71 E with a displacement of 1.5 meters down to the southeast cuts the outcrop. (52.8)
- 10.3 Pulaski-Rockcastle County line. (52.4)

Figure 8 Outcrop at stop 11 (highway mile 5.5) The northern end of the Wabid North roadcut (stop 11 of Dever, et al, 1990).

The Renfro Member of the Slade Formation is at the base of the outcrop to the left (south) of the photograph. The St. Louis and Ste. Genevieve members are shown. A remnant of the Lost River Chert Bed is exposed within the Ste. Genevieve together with associated paleosols. The basal Warix Run Member is exposed at the top, to the left of the photograph.

At this location excellent examples of solution features, typical of the epikarst, can be seen in cross-section. These include the irregular soil bedrock interface, klints, grikes, small shafts, and dissolution widened fissures. Deeper features include anastomoses and bedding plane tubes with active groundwater flow. The groundwater monitoring implications of these features are discussed in the text and in Figure 9.

Figure 9



Block diagram showing conduit flow and diffuse flow in a maturely karsted aquifer. The cave stream is fed by vertically percolating water which infiltrates through soil and through sinkholes, by tributary cave streams, and by seepage through conduit walls. Although flow lines beneath the potentiometric surface are shown as smooth curves, the actual flow routes are irregular, along bedding planes and other joints. No matter where the landfill is located, ground water flow will be convergent to a cave stream. Finding that stream is a prerequisite for reliable monitoring of the landfill. A hole randomly drilled down-gradient from the landfill is not likely to intercept that stream. A monitoring well in the unsaturated soil adjacent to the landfill might intercept leakage from it, but since most flow in the soil is nearly vertical, such interception would be fortuitous.

From Quinlan & Ewers, 1985

10.4 Junction with Kentucky Highway 934. (52.2)

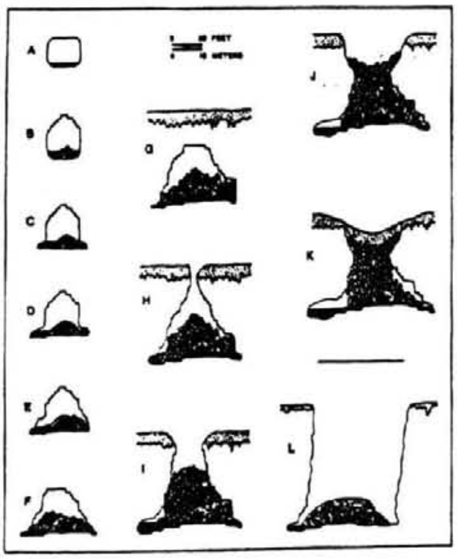
10.8 Mount Pleasant Church cut. Renfro, St. Louis, Ste. Genevieve, Warix Run, and basal Mill Knob Members. Bodies of dolomite are exposed in the St. Louis and Ste. Genevieve in this outcrop. These are similar to the dolomitic cave fillings that were studied by Furr (1985). These fillings are believed to have originated as lime muds that have been changed by mixed-water dolomitization. (51.6)

11.6 Junction with Plato-Vanhook road. Mill Knob and Tygarts Members. (50.9)

11.9 North end of Sunnyside Church Road. Warix Run and Mill Knob Members. (50.6)

12.6 Fanny Knob cut. Mill Knob Member, Cave Branch Bed, Tygarts Creek, Ramey Creek, Maddox Branch, and Poppin Rock Members. (49.8)

Figure 10



Cross section showing development of collapse sinkholes. Explanatory comments: A, initial stage; B, ceiling collapses, perhaps at the intersection between two passages; C, walls are undercut by stream on each side of pile of collapsed blocks; D, collapsed central core is covered by mud that settles out during flood stages and isolates the central core from corrosion by stream water; E, additional collapse; F, more undercutting of walls and consequent collapse of walls and ceiling; G, continuation of F; H, surface is breached, collapse and undercutting continues, frost riving may begin to substantially modify walls; I, diameter of sinkhole increases in response to collapse of walls, and undercutting continues; J, collapse continues; K, soil is washed into sink, soil-forming processes start to corrode the pile of collapsed blocks, and the sinkhole will widen and deepen and eventually will be difficult to distinguish from a sinkhole formed chiefly by solution; and L, an alternative end member following stage H or I, assuming the rock properties are different and assuming the rate of erosion, corrosion, and undercutting are able to keep pace with the rate of collapse and accumulation of debris. (Quinlan and Ewers, 1981)

13.3 South end of Sunnyside Church Road. Warix Run and Mill Knob Members. (49.4)

13.9 Leroys School cut. St. Louis and Ste. Genevieve Members. (48.7)

14.5 Renfro Member, with Science Hill Sandstone exposed at the south end. (48.2)

14.8 Bridge across Buck Creek. (48.0)

15.7 Renfro and St. Louis Members. (47.0)

16.2 Kentucky Highway 3268. (46.5)

16.6 Flat Lick Knob cut. Renfro, St. Louis, and Ste. Genevieve. (46.3)

17.1 Kentucky Highway 1677 on east side, Bobbitt Cemetery Road on west side. (45.9)

17.5 POINT OF INTEREST "A"–Alumitech Plant –Fluids released beneath the foundation slab of this building have precipitated collapse of soil arches over dissolution voids in the limestone. The collapse has compromised plumbing beneath the slab. As a result, contaminants have been released into the groundwater, appearing at several perched springs nearby.

17.3 Renfro Member. (45.6)

18.1 Renfro Member. (44.9)

18.2 Renfro Member. (44.7)

18.8 Junction with Kentucky Highway 80. (44.2)

END OF KENTUCKY ROUTE 461 ROADLOG

SINKING VALLEY FIELD TRIP GUIDE

The accompanying map shows the stops and points of interest covered in this roadlog.

Directions:

Turn left (east) on Kentucky Route 80 and proceed 3.25 miles to Stab Road and the junction with route 80. Turn right, and immediately left onto old Route 80. Proceed 0.1 miles to the bridge over Buck Creek at Stab, Kentucky.

POINT OF INTEREST "B"–Buck Creek

This stream receives the flow of Sinking Valley, a dry karst valley, with a drainage area of 33 square miles. The resurgence for these waters is at Short Creek Springs, 1,100 feet down-stream from this bridge. Buck Creek joins the Cumberland River 12 miles south of this location.

Directions:

Continue 0.35 miles on old Route 80 and turn right onto Short Creek Road. Continue 0.15 miles to Short Creek.

STOP #2–Short Creek

This feature is a "karst window," a collapse feature over a large groundwater conduit. It contains a spring resurgence and a sinking stream. The formation of these collapse features is shown diagrammatically in Figure 10. A dye detector will be exchanged at this site.

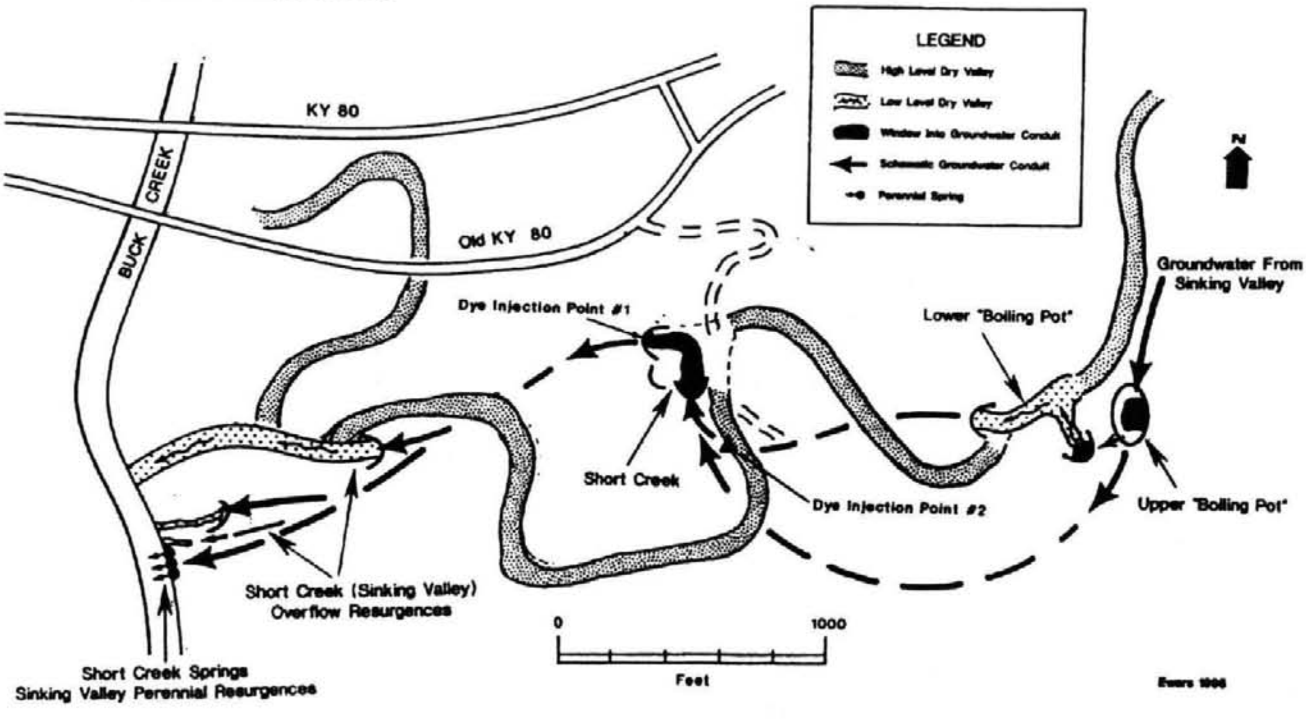
A mill was located here circa 1868, and the remains of a wooden bulkhead dam are visible at the point where the stream re-enters the subsurface. The frontispiece is one of three millhouses constructed at this site. The turbine used here is in the possession of the present landowners, Mr. and Mrs. Elwood Taylor of Stab, Kentucky.

Directions:

Continue on foot along the dry valley on the south side of the karst window to the overflow resurgence of Short Creek (Fig. 11). This valley is the former course of the surface stream that occupied Sinking Valley, one of several preserved

Figure 11

HYDROGEOLOGY AND GEOMORPHOLOGY OF THE SHORT CREEK AREA
Pulaski County, Kentucky



segments. Several sinks have formed along this section, some very recently. **USE CAUTION** as you proceed to avoid stepping into these features, a few are only a foot or less in diameter.

The large cavern opening is one of three overflow resurgences of Short Creek (Fig. 11). It carries water only after very heavy rains, perhaps six to ten times a year. During base flow periods it is possible to wade through the conduit, which connects this feature with Short Creek. A dye detector will be exchanged at this site.

Directions:
Continue westward along the low level dry valley to Buck Creek. A short walk southward, downstream, along the creek bank leads to two more overflow resurgences of Short Creek, and finally to a series of perennial springs, Short Creek Springs, located just above the base-flow level of the creek (Fig. 11). These are the base-flow discharge points for Short Creek and all of Sinking Valley to the north, except for its northernmost portion. Note the deep recesses containing some of these springs. This is the result of spring sapping. Dye detectors will be exchanged at this site.

Directions:
Return to Short Creek.

Located near the entrance to Short Creek Cave in the Ste. Genevieve Limestone are some dolomite bodies that have been studied by Furr (1985). The light yellow to tan color of the dolomite contrasts with the white or gray of the limestone. These features are believed to be Mississippian age conduits that have been filled with lime muds. The filling was later altered by mixed water dolomitization. Holocene cavern development has occurred along the edges of these dolomite bodies. Dolomitic bodies will also be seen at the upper end of the lower boiling pot.

Directions:
Proceed eastward on foot along the dry valley.

This route leads to a pair of karst windows locally known as the "boiling pots" (Fig. 11). The lower "boiling pot" has a long section of normally dry streambed between the spring resurgence and the sink-point. Flow occurs along this route somewhat more frequently than at the large short creek overflow. Note the large dune of Pennsylvanian sandstone gravel beyond the spring resurgence of the lower boiling pot. Note also the dolomitic bodies, like those at Short Creek, located above the spring.

Directions:
Ascend to the dry valley at the east end of the lower boiling pot.

This valley is an extension of the high level dry valleys on either side of Short Creek and can be traced northward through most of Sinking Valley. A short climb to the southeast from this point brings the upper "boiling pot" into view (Fig. 11). This karst window, like Short Creek, exhibits perennial flow. Dye traces conducted in Sinking Valley to the north appeared here and also appeared at Short Creek, indicating that both of these karst windows are located along the master conduit of Sinking Valley. A roughly northeast to southwest flow is continuous in this karst window. The rapid eddy motion occurring here during high flow is the source of the local term, "boiling pot." A dye detector will be exchanged at this site.

Directions:
Return to Short Creek along the same route.

LUNCH
Box lunches will be eaten here. Please be certain to deposit all lunch refuse in plastic bags provided in each vehicle. Rest room facilities are available at the Volunteer Fire House in Stab. Transportation will be provided.

DYE INJECTION #1
A fluorescent dye will be injected into Short Creek at the sink-point. Where natural water flow in a cave stream, karst window, or sinking stream can be used, dye injection is a relatively simple matter. We recommend that dye solutions be used whenever possible. They should be transported in carefully sealed and over packed containers, handled with gloves and other appropriate protective gear, and poured with care

to avoid splashing. Personnel involved with dye injections should not handle dye detectors until appropriate decontamination procedures have been followed. Dye in powdered form is an invitation to spurious tracer results. Personnel, clothing, and vehicles can become contaminated by powder carried by the slightest breeze.

DYE INJECTION #2

A fluorescent dye will be injected into a sinkhole in the high level dry valley south of Short Creek. Potable water will be provided courtesy of Mr. Elwood Taylor and the Volunteer fire department at Stab. Adequate pre-wetting of sinkholes and any sediment laden dry conduits leading from them with potable water helps to ensure that the tracer dye is not needlessly absorbed by the sediments. A "chaser" of potable water is normally used to ensure that the dye reaches the active groundwater conduits in the aquifer and is not held in pools above the active flow.

Directions:

Return to old Route 80 and proceed east 1 mile to the first bridge.

POINT OF INTEREST "C"–Dry Valley Bridge

The dry, grass-covered valley below is continuous with the high level dry valley at the boiling pots. After a large storm, surface flow occurs briefly here and along much of the normally dry "bottoms" of Sinking Valley. These high-flow events are referred to locally as "tides."

Directions:

Continue across the bridge and immediately turn left (north) on Price Valley Road. Turn left again at 0.7 miles, an unnamed gravel road.

POINT OF INTEREST "D"–Price Cave and Price Valley Sink

The sinkhole and swallet on the right at this location connect to a short section of cave conduit tributary to the master conduit beneath Sinking Valley. This conduit passes beneath the road and continues to the left where the master conduit is just west of the gravel road. Allogenic water from the Cumberland Plateau enters the karst groundwater system at this point.

Directions:

Continue across new Route 80 to the quarry entrance and park.

STOP #3–Greer Brothers Quarry Well and Collapse Sink

The site of this high yield well was located with the aid of a low frequency electromagnetic technique which will be demonstrated during our visit. At one time, it provided the water for the preparation of concrete and other quarry requirements.

DYE INJECTION #3

A method for injection of fluorescent dye into wells will be demonstrated at this location. Domestic and commercial water wells, monitoring wells, and wells drilled specifically for dye injection are commonly used for this purpose. Those demonstrating a good connection to the conduit porosity in the aquifer are best for this purpose. Wells sustaining high pumping rates with little drawdown, or wells which can accommodate large slugs of water with little effect on the water level, are assumed to have this desired connection.

Pre-wetting of the injection well is not normally required. However, an adequate "chaser" of potable water helps to ensure that the dye is delivered at an appropriate rate to the active groundwater conduits. Concentrated dye solutions may stain the well equipment, cause foaming during dye injection and injection of potable water, and remain trapped in the bottom of the well. We recommend injecting the dye and the initial water at a point below the standing water level and near the bottom of the well. It is also useful to monitor the water level in the well during the injection to avoid any possible overflow at the well. An injection device addressing these concerns will be demonstrated at this site.

Directions:

Continue north of the quarry entrance about 1000 feet to a large collapse sink.

A collapse sink formed here in 1998, directly into the master conduit draining Sinking Valley and connects with Short Creek. **Please use extreme caution in approaching the rim of**

this feature, collapse could occur without warning. The safest approach is along the southeast. This sink is in state "I" shown in Figure 10, but it apparently did not progress noticeably through the earlier stages depicted in this figure. There was no evidence of the sink before the collapse occurred, and a farm road crossed directly over this location. Sediment from the collapse has partly occluded the conduit downstream from this point, limiting access to the bottom of the quarry well. The constriction caused by the collapse debris has caused sediment to accumulate upstream from this location.

Directions:

Return to new Route 80 and proceed east (left) approximately 1.2 miles to Hawk Road and turn north (left). The road ascends to the Cumberland Plateau. The Plateau was formed by thick sandstone units that are visible from the road. Continue approximately 1.4 miles to the community of Public and turn left (west) onto "Public Road" (Route 1677) and continue approximately 1 mile.

POINT OF INTEREST "E"–Unnamed Sinking Streams

Two unnamed streams sink at a point 600 feet north of Kentucky Route 1677. Early tracing efforts in Sinking Valley by Ewers utilized this location among others. Water sinking here resurges at Short Creek.

Directions:

Continue west, on Route 1677 approximately 0.5 miles through the community of Sinking Valley to cross the central dry valley in this groundwater basin.

POINT OF INTEREST "F"–The Central Dry Valley

After exceptional storm events the subsurface conduits beneath Sinking Valley are unable to accommodate the runoff into sinkholes. When this occurs, surface flow is initiated along segments of the dry valley system. Water can be expected to flow on the surface at this point several times a year.

Directions:

Continue westward approximately 1.0 miles and pause.

POINT OF INTEREST "G"–Western Surface Drainage Divide

At this point the western surface drainage divide of Sinking Valley is crossed. Groundwater tracing from sinkholes just east of this divide by Romanik (1986) all go to Short Creek.

Directions:

Continue westward approximately 0.5 miles to the intersection of Dahl-Elrod Road in the community of Dahl and turn right. Turn right again at the next intersection onto Dahl-Vanhook Road and pause.

POINT OF INTEREST "H"–Leonard Price Sink

Two traces initiated from the sinkhole to the right by Romanik (1986) were not recovered. Another trace initiated by Michael Kelly (1988) showed that this sink drained to a small spring, which Romanik did not discover, 1.2 miles to the west on Buck Creek.

Directions:

Continue north-eastward. At 0.7 miles re-cross the western surface drainage divide into Sinking Valley. At 1.8 miles, park near the dip in the roadway.

STOP #4–Bullock Sink

Follow the streamway eastward from the road to Bullock Sink. Several times a year the roadway at this point is under several feet of water and the torrent fills the sink, carrying trees, road metal, silt, and clay into the subsurface. Locals describe a great whirlpool forming over the sink at these times. Until recently the debris in this sink blocked access to the conduits. Surface flow in the valley also blocks the roadway immediately north of the nearby house, leaving the Bullock and Randel families stranded for hours at a time.

Directions:

Continue northward 1.1 miles to the intersection of Plato-Vanhook Road. Turn left. Along this roadway are many broad solution subsidence sinks, some containing collapse features in their centers. Attempts to stop their evolution with fence wire, tires, automobiles, major appliances, and other refuse are usually futile. Travel 1.55 miles from the last intersection to the community of Plato and turn at an unmarked drive on the right. This area is the private property of Mr. James H. Purcell of Plato, who has given permission for this excursion and the research being conducted at this site. Continue through the gate to the bottom of the valley and turn left through the opening in the fence.

STOP #5 – Sinking Stream, The Pumped Monitoring Well Research Site, and Baker Cave

Karst–A term given to terrain that has been modified by the action of water, creating distinctive landforms and groundwater flow. The term karst has its origins with the word "kars," which means stony or barren ground. As the vehicles travel down the farm road observe the rocky terrain of the pasture. These rocks have not been removed from the field, as many farmers in other geologic settings do, because these exposed rocks are continuous with the underlying bedrock. The exposed bedrock highs are termed "klints" and the intervening lows are termed "grikes."

Sinking Stream–Small, fairly dependable surface streams exist at several locations within Sinking Valley. These streams derive their base flow from lateral seepage in the layered gravels, silts, and clays covering the valley floor. The clays and silts impede direct infiltration of these waters into the limestone. Additional input from small, perched springs and allogenic water from the caprock-covered areas may augment this baseflow. A spectacularly complex sink at this location conducts this water and the storm runoff into the subsurface. More than a dozen well-defined swallets operate here at various stages of the sinking stream.

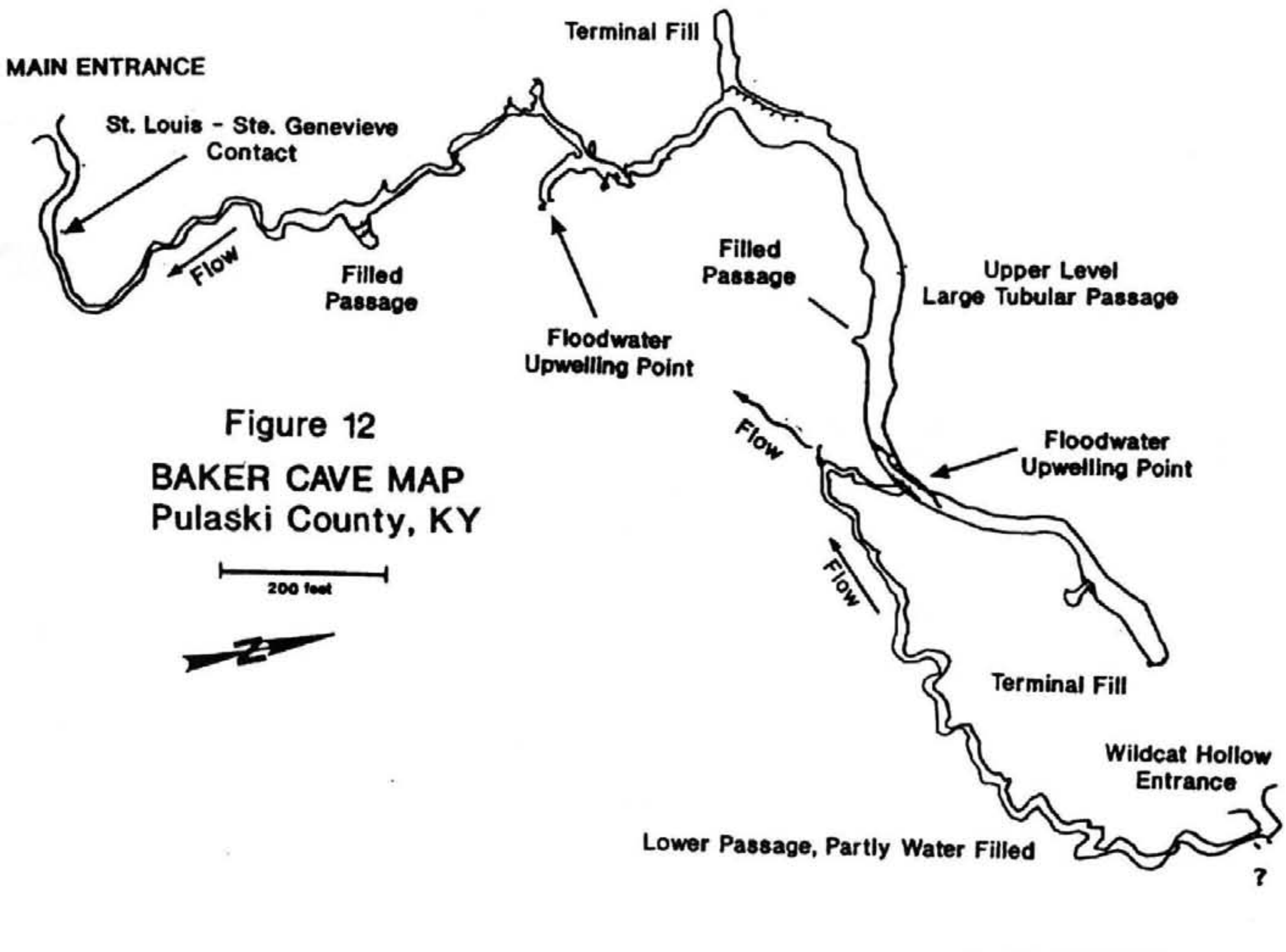


Figure 12
BAKER CAVE MAP
Pulaski County, KY

The Pumped Monitoring Well Research Site–This site is being used to evaluate the use of pumped wells to monitor for contaminants at a location the size of a typical underground storage tank site. Tracer dyes are being used as surrogates for the contaminants. The efficiency of monitoring wells in pumped mode is being contrasted with that achieved by simple purging.

Pumped monitoring wells should have greater efficiency than conventional monitoring wells and should have the following advantages over monitoring at a spring:

1. It should be more sensitive to contaminant release because the dilution of contaminants should be significantly reduced.

2. It should be more sensitive to contaminant release because the travel distance for the contaminant will be less and sorption and evaporation losses will be reduced.

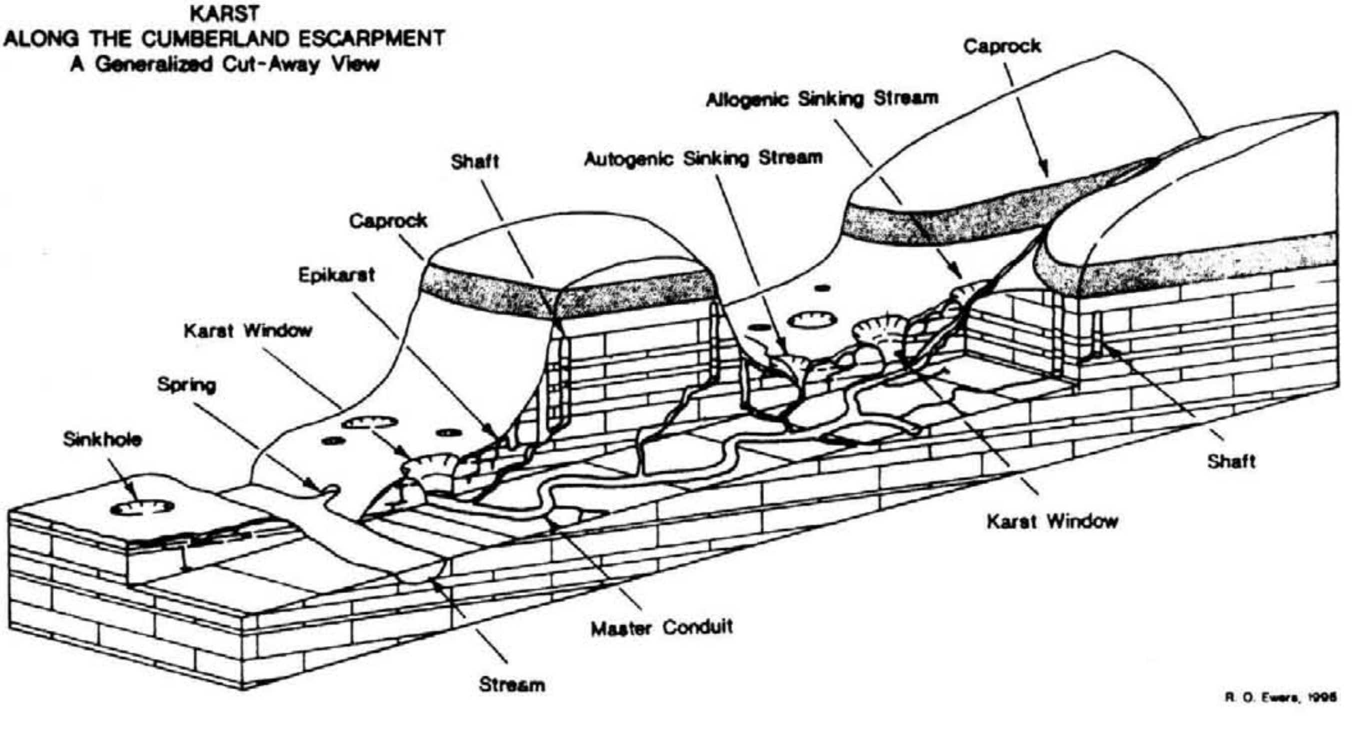
3. It is likely to be more specific to the site, because it does not involve most of the other potential contaminant sources in the area.

4. It accomplishes the same objective as a conventional three down-gradient monitoring well system.

5. The well located on-site has much better security than an off-site spring.

Baker Cave is a typical, partly relict, tributary conduit to Sinking Valley (Fig. 12). The central portion of the cave is a large, tubular passage following the bedding and is blocked by collapse at both ends. This tube is connected to the surface by a smaller conduit forming the cave entrance. A lower level conduit connects to Wildcat Hollow and carries groundwater to the main trunk conduit beneath Sinking Valley. During heavy rains water spills upward into the large tube and flows through the smaller conduit and out of the cave entrance. The point of the up-welling is marked by a large pit in the conduit floor. Occasionally, water ponded on the surface of the valley flows into the cave entrance to the deeper conduit and ultimately to Short Creek. The term, estavelle, is given to an intermittent reversing spring like the Baker Cave entrance. The St. Louis-Ste. Genevieve contact can be seen clearly just inside the cave.

Figure 13



KARST
ALONG THE CUMBERLAND ESCARPMENT
A Generalized Cut-Away View

Directions:

Return to the Plato-Vanhook Road and turn right (north) and proceed 0.85 miles. Turn right (east) on Smith-Broyles (gravel) Road and proceed 2.2 miles into Opossum Strut Hollow. This is the private property of Mr. Boyd Broyles, who has given permission for this excursion.

STOP #6–Opossum Strut Spring #2

A spring emerges here from the Pennsylvanian sandstone and Mississippian Pennington formation. The spring waters descend into a partly unroofed shaft in the Mississippian Monteagle, Kidder limestone. Groundwater flow from this point goes south eight miles to Short Creek. Shaft flows from the caprock are an important recharge component for the karst aquifer (Fig. 13). Figure 13 summarizes the different components of groundwater flow in Sinking Valley.

Directions:

Turn around and travel 0.7 miles on Smith-Broyles Road to the point where a stream flows under the road.

POINT OF INTEREST "I"–Dave Burton Sink

The stream flowing under the road at this point was traced by Romanik (1986) to Short Creek. This stream, like the stream at Stop 5, flows on clays, silts, and gravels over the limestones. The dye was introduced at Dave Burton Sink, which is along the side of the stream. Flow from the stream into the sink was always observed during the period of his study, and there was always flow continuing down the streambed. This clearly indicates a significant vertical gradient exists between the overburden and the karstified limestones below.

Directions:

Return to the Plato-Vanhook Road and turn right (north) and proceed to Kentucky 461. Turn north and proceed 2.1 miles, turn right on Route 1152. Proceed 1.4 miles and go right into the private driveway of Mr. Henry Owens.

STOP #7–Owens Sink

A trace initiated here by Romanik (1986) traveled outside of the surface basin of Sinking Valley and was recovered at a spring on Skeggs Creek. This is a prime example of how in a karst setting the surface basin and the groundwater basin may not be the same.

END OF SINKING VALLEY FIELD TRIP

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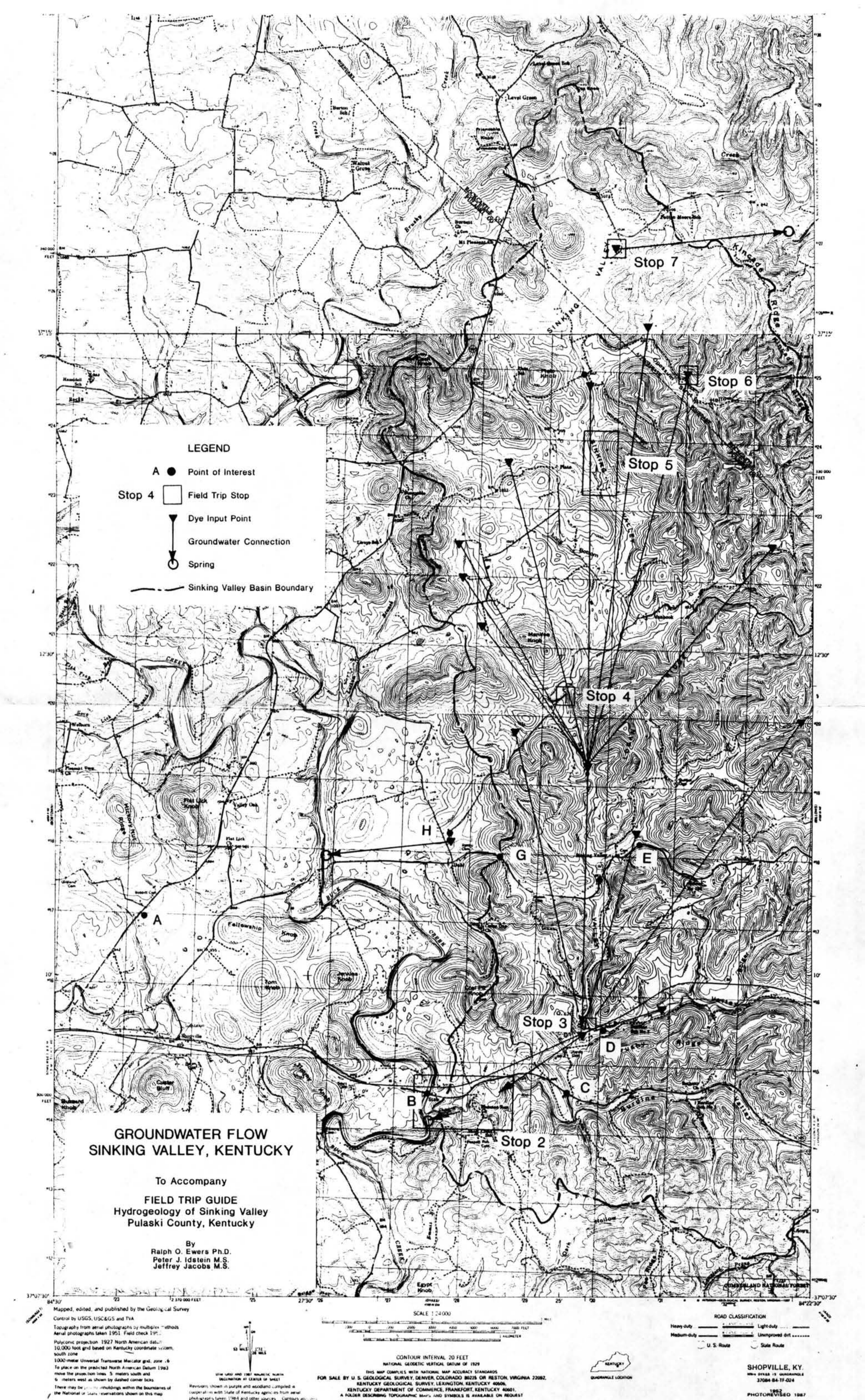

LEGEND
A ● Point of Interest
Stop 4 Field Trip Stop
Dye Input Point
Groundwater Connection
Spring
Sinking Valley Basin Boundary
Stop 7
Stop 6
Stop 5
Stop 4
Stop 3
Stop 2
A
B
C
D
E
G
H
SINKING VALLEY
Kincaid Ridge
Creek
Level Green
Walnut Grove
Brushy
Mt Pleasant
Fellowship Knob
Tom Knob
Flat Lick Knob
Flat Lick
Valley Oak
Egypt Knob
Hollow
GROUNDWATER FLOW
SINKING VALLEY, KENTUCKY
To Accompany
FIELD TRIP GUIDE
Hydrogeology of Sinking Valley
Pulaski County, Kentucky
By
Ralph O. Ewers Ph.D.
Peter J. Idstein M.S.
Jeffrey Jacobs M.S.
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37°07'30"
84°22'30"
Mapped, edited, and published by the Geological Survey
Control by USGS, USC&GS and TVA
SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route
KENTUCKY
QUADRANGLE LOCATION
SHOPVILLE, KY.
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