PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF KENTUCKY, UNIVERSITY OF KENTUCKY
KENTUCKY GEOLOGICAL SURVEY
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SYSTEM	SERIES	GROUP	FORMATION	SECTION	THICKNESS, IN FEET	LITHOLOGY	TOPOGRAPHY AND GEOLOGIC SETTING	HYDROLOGY
QUATERNARY	Pleistocene and Recent		Alluvium		0–105′	Brown to red gravel and sand and some clay under flood plain and in terraces along East Fork of Clarks River. Mostly silt and clay in small stream valleys.	Occurs along East Fork of Clarks River and along most small stream valleys.	Underlies availability area 1. Large-diameter wells in the valley of East Fork of Clarks River yield sufficient water for an adequate domestic supply. Water ranges from soft to hard, the pH ranges from 5.6 to 6.1, and the iron content ranges from 0.01 ppm to 0.78 ppm. An iron content of more than 0.3 ppm causes staining of clothes and utensils and imparts a disagreeable taste to water.
	Pleistocene		Loess		0–10′	Brown to tan unstratified silt and clay.	Mantles upland surfaces on both sides of East Fork of Clarks River. Missing along steep slopes and in eroded parts of uplands.	Not water bearing.
	Pleistocene / Pliocene(?)		Gravel and Sand[1]		0–115′	Brown to red round to angular chert pebbles in a matrix of quartz sand, angular chert fragments, and small amounts of mica. Upper part of deposit contains much sand along western border of quadrangle.	Underlies uplands, ridges, and their eroded edges. Overlies the eroded and truncated surfaces of Tertiary and Cretaceous formations. Thickness of deposit ranges from 30 to 45 feet under most uplands; reaches maximum of 115 feet in a fault zone near Hamlet Church.	Underlies availability area 2. Most large-diameter wells ranging in depth from 14 to 55 feet yield adequate quantities of water for domestic purposes. Water ranges from soft to very hard, the pH ranges from 5.8 to 8.2, and the iron content from 0.04 to 5.4 ppm. One well yields water containing 199 ppm of nitrate. Water containing more than 45 ppm of nitrate should not be used to prepare baby formulas because excessive nitrate may cause methemoglobinemia ("blue baby" disease), sometimes fatal.
TERTIARY	Paleocene	Midway	Porters Creek Clay		0–160′	Dark-gray massive slightly micaceous clay. Clay is jointed and breaks with conchoidal fracture. In some places clay is cut by sandstone dikes. Light- to dark-gray glauconitic clay and thin beds of glauconitic, micaceous sand at base.	Exposed in a narrow north-south belt west of East Fork of Clarks River. Most exposures are in gulleys of creeks which flow into East Fork of Clarks River.	Underlies availability area 3. Upper part of clay is not water bearing. Small amounts of water occur in colluvial gravel that mantles clay surface. Colluvial gravel is locally derived from Pliocene(?) deposits and water is similar in quality to that in availability area 2 (see above). Thin glauconitic sand beds at base of formation yield small amount of water to one well, but formation is not an aquifer in most places. Analysis of one sample shows the water is moderately hard, has a pH of 6.4, and contains 6.9 ppm of iron.
CRETACEOUS	Upper Cretaceous		McNairy Formation[2]		150–300′+	Light-gray very fine-grained micaceous sand interlaminated with dark-gray to black pyritic lignitic clay. Overlies light-gray fine- to medium-grained sand and thin beds of gray clay. Light-gray fine- to medium-grained micaceous sand containing small amounts of lignite in lower part of formation.	Exposed in stream valleys and on eroded edges of ridges east of East Fork of Clarks River. Exposed in stream valleys and on eroded edges of ridges between East Fork of Clarks River and highway between Benton and Hardin.	Shallow perched zones underlie availability area 4. Main zone of saturation underlies availability area 5. Large-diameter wells in zone of shallow perched water generally yield adequate quantities of water for domestic purposes. Both large-and small-diameter wells in main zone of saturation yield adequate quantities of water for domestic purposes. Water ranges from soft to moderately hard, the pH ranges from 4.8 to 7.0, and the iron content ranges from 0.13 ppm to 7.1 ppm.
			Tuscaloosa Formation		0–50′	Tan to dark-gray rounded chert pebbles, light-to dark-gray micaceous sand, and gray clay.	Not exposed in quadrangle. Penetrated by wells at Benton.	Not shown on availability map. Water-bearing character not known. Formation is an aquifer in adjacent quadrangles.
MISSISSIPPIAN			Mississippian limestones undifferentiated		0–150′	All rocks below the Cretaceous are of Paleozoic age and are the "bed-rock" of well drillers. Dark-gray to black fine-grained cherty limestone. Deeply weathered chert residuum in places.	Not exposed in quadrangle. Exposed in outcrops east of quadrangle.	Not shown on availability map. Water-bearing character not known. Cavernous limestone and chert residuum water bearing in quadrangles east and north.
DEVONIAN			Devonian rocks undifferentiated		0–400′	Dark-gray to black shale in upper part of Devonian System. Light- to dark-gray cherty dolomitic limestone in lower part.	Not exposed in quadrangle. Underlies the McNairy Formation west of East Fork of Clarks River. Penetrated by wells in adjacent quadrangles.	Not shown on availability map. Water-bearing character not known. Devonian limestone is an aquifer in adjacent quadrangles and probably is water bearing at some places in Hardin quadrangle.

[1]Age undetermined. Estimates of age range from Pliocene or older to Pleistocene
[2]May contain beds of Clayton age at the top

EXPLANATION

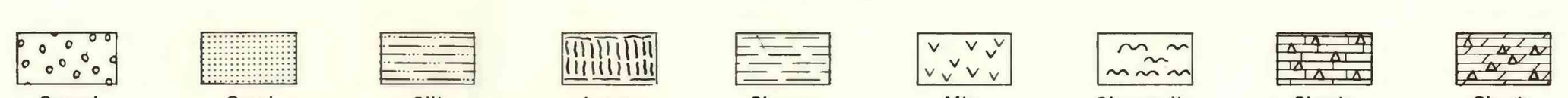


FIGURE 2—GENERALIZED COLUMNAR SECTION AND WATER-BEARING CHARACTER OF THE GEOLOGIC FORMATIONS

Base by Tennessee Valley Authority and U.S. Geological Survey, 1951

The Carter Coordinate System letters and numbers used to designate five-minute divisions of latitude and longitude are shown along the margins; tick marks indicate one-minute divisions

FIGURE 1—MAP SHOWING AVAILABILITY OF GROUND WATER, LOCATION OF WELLS AND A SPRING, AND QUALITY OF WATER

Hydrology by L. M. MacCary, 1961-62

APPROXIMATE MEAN DECLINATION, 1964

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

EXPLANATION

The water-availability areas on this map show the occurrence and availability of ground water in the shallowest aquifer that may yield adequate amounts of water for domestic use in each area. As considered in this report, an adequate domestic supply will deliver approximately 500 gallons per day from a well equipped with a power pump and pressure-distribution system. The shallowest aquifer is underlain by deeper aquifers whose water-bearing properties are described in the generalized columnar section, figure 2

Qal

AREA 1

Water in Quaternary alluvium

Large-diameter wells in the valley of East Fork of Clarks River yield sufficient water for an adequate domestic supply from the alluvium. Although the alluvium reaches a thickness of 75 feet at Benton and 105 feet at Hardin, wells tapping the alluvial aquifer are all less than 45 feet deep. With the exception of high terraces, most of the river valley is flooded during the winter and spring, and for this reason the area is sparsely settled. The alluvial deposits along the small stream valleys may be too thin or contain too much clay and silt for development of satisfactory domestic water supplies. If the alluvium is dry or yields only small amounts of water, wells may be deepened to obtain water from the underlying McNairy Formation

QTg

AREA 2

Water in gravel of Pliocene(?) age

Most large-diameter wells ranging in depth from 14 to 55 feet yield adequate quantities of water for domestic purposes. Wells that penetrate the full saturated thickness of the aquifer generally yield a perennial supply of water. Most wells that are reported inadequate or that are dry in late summer only partially penetrate the saturated gravel. If the Pliocene(?) deposits are dry or yield only small amounts of water, wells may be deepened to obtain water from the underlying McNairy Formation

Tpc

AREA 3

Water in Porters Creek Clay

The Porters Creek Clay generally is not water bearing. Small quantities of water occur in colluvial gravel that mantles the area. This shallow water generally is inadequate for a domestic supply. Large-diameter wells that are deepened into the underlying clay may provide sufficient storage for a small water supply. If the colluvium is dry or yields only small amounts of water, wells may be deepened to obtain water from the underlying McNairy Formation

Kmp

AREA 4

Perched water in McNairy Formation

Large-diameter wells less than 60 feet deep generally yield adequate quantities of water for domestic purposes. Water levels stand higher than in the underlying main zone of saturation and wells can be equipped with inexpensive pumps that operate at a relatively low cost. Perched water zones probably will yield no more than domestic supplies of water because the water-bearing sands are thin and the recharge areas are small. If only small amounts of water can be obtained from perched zones in the McNairy Formation, wells may be deepened to obtain water from the underlying main zone of saturation in the McNairy Formation

Km

AREA 5

Water in main zone of saturation of McNairy Formation

Furnishes sufficient water for an adequate domestic supply to many large- and small-diameter wells. Small-diameter wells are drilled below the water table until a sand of sufficient thickness, capable of being retained by a well screen, is reached. Small-diameter wells tapping this aquifer in other areas are as deep as 360 feet. Large-diameter wells are dug or bored below the water table for storage or below clay beds until a water-bearing sand is reached. These wells are as deep as 117 feet.

The maximum possible yield of wells tapping the main zone of saturation of the McNairy Formation is not known, but one city well at Benton has a yield of 450 gallons per minute. Many large- and small-diameter wells furnish enough water for gas stations and schools. Properly constructed small-diameter wells probably could yield 50 to 100 gallons per minute at most sites in the area and yields of several hundred gallons per minute are possible where beds of water-bearing sand are thick.

Neither the Tuscaloosa Formation nor the Paleozoic rocks of Mississippian and Devonian age are exposed in the quadrangle and no wells yield water from them. Both the Tuscaloosa Formation and the Paleozoic rocks are aquifers to the east and to the north of the quadrangle and it is likely that they will yield water to wells within the quadrangle. The potential yield of wells tapping these aquifers is not known

Area boundary

o 113

Test hole
Figure below line is depth of test hole

• D

Water well
D, *Drilled or jetted well, generally steel or plastic casing with well screen on lower end.*
B, *Bored or dug well, generally 24-inch concrete tile casing open at the bottom*

Spring

QTg – 28 (P) / 33
- Aquifer (see below)
- Water level in well, in feet below land surface
- Yield, in gallons per minute, or adequacy (see below)
- Depth of well, in feet below land surface

AQUIFER SYMBOLS

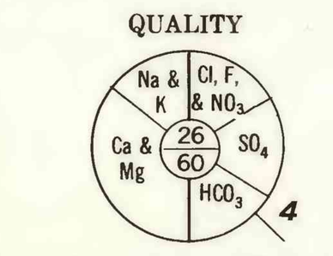
Qal .... Alluvium of Quaternary age
QTg .... Gravel and sand of Pliocene(?) age
Tpc .... Porters Creek Clay of Paleocene age
Km .... McNairy Formation of Cretaceous age
Kmp .... Perched water in McNairy Formation of Cretaceous age

YIELD OR ADEQUACY

(40) .... Gallons per minute where known
(P) .... Well reported adequate for power pump for domestic and/or stock supply
(H) .... Well reported adequate for hand pump or well bucket
(N) .... Well reported not adequate
(X) .... No yield data available
(D) .... Dry hole

—— 500 ——
Water level contour
Shows altitude of the water level in gravel of Pliocene age. Contour interval 10 feet; datum is mean sea level. Water level measurements taken in September 1961

QUALITY



Chemical composition of dissolved solids
Figure between circular diagram and well symbol refers to analysis number in table at end of text. Figure above line at center of circular diagram is carbonate hardness (calcium magnesium hardness, as ($CaCO_3$) in parts per million; figure below line is dissolved solids in parts per million. Hardness of water is classified by the U.S. Geological Survey as follows: 0-60 ppm, soft; 61-120 ppm, moderately hard; 121-180 ppm, hard; and 181 ppm or more, very hard. Dissolved solids in partial analysis are computed from specific conductances and are only approximate values. Areas of the segments of each circle are proportional to the mineral component in the dissolved solids in the water. Percentages are computed from equivalents per million of the anions and cations. Calcium and magnesium are shown as one segment in partial analyses. Nitrate shown separately if present in amounts greater than 45 ppm

AVAILABILITY OF GROUND WATER IN THE HARDIN QUADRANGLE, KENTUCKY

The purpose of this atlas is to present concise, nontechnical information about ground water to well drillers who operate in the Hardin quadrangle and to home owners who live in the area. The availability map (fig. 1) presents graphically the occurrence of ground water in the shallowest aquifer that may yield adequate amounts of water for domestic use. The ground-water conditions at a specific well site can be determined by the pattern on the map, which identifies the shallowest aquifer at the site, and by the map explanation which gives a brief summary of the characteristics of the aquifer. Additional hydrologic and geologic information about the aquifer can be found in the columnar section (fig. 2). Nearby wells within the same availability area will give the reader some idea of the probable depth of a well and the depth to water. If a neighboring well has been sampled for chemical analysis, the circular diagram can be examined to determine what the quality of water may be at the proposed well site. If the prospective water user requires more water than the shallowest aquifer at the well site is capable of yielding, he should consider drilling into one of the deeper aquifers described in the map explanation and the columnar section. The lower aquifers--McNairy Formation, Tuscaloosa Formation, Mississippian and Devonian rocks--are widespread and one or more of them underlie all the shallower aquifers. The generalized geologic section (fig. 3) is an aid to the understanding of the availability map because it shows the sequence of aquifers from the shallowest to the deepest and the typical water levels in several aquifers.

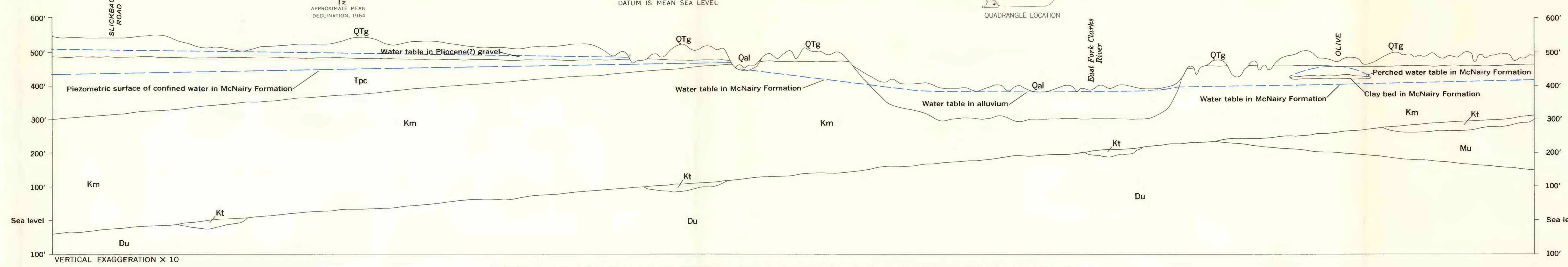
The McNairy Formation, which underlies the entire quadrangle, is capable of yielding more water than is now pumped from it. A pumping test at Benton indicates the aquifer has a coefficient of transmissibility of 32,000 gallons per day, which means that 32,000 gallons of water per day can move laterally through each vertical strip of the aquifer 1 foot wide and extending the full thickness of the aquifer. A pumping test of a well at Hardin indicates the well has a specific capacity of about 9 gallons per minute per foot. The static water level in this well stands 74 feet above the top of the well screen and the theoretical yield of the well is equal to the specific capacity times the number of feet of water above the screen, or about 660 gallons per minute. Actually, this amount of water could not be obtained from the well because of pipe friction and other losses, but the figure is an indication of the magnitude of the yield that can be expected from a well. Wells with yields as large as those at Benton and Hardin probably could be drilled in other parts of the quadrangle. The McNairy Formation contains the principal known ground-water reserves of the quadrangle and will supply much of the future water demands of people and industry.

The following table shows the iron content in parts per million and the hydrogen-ion concentration, expressed as pH, of the water analyses shown by circular diagrams on figure 1. A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. Corrosiveness of water generally increases with decreasing pH.

Analysis number	1	2	3	4	5	6	7	8	9	10
Iron content	0.40	0.56	0.01	0.10	0.35	0.18	0.41	0.04	0.57	0.18
pH	5.9	4.8	5.6	5.6	6.2	6.8	——	6.2	6.1	6.7

Analysis number	11	12	13	14	15	16	17	18	19	20
Iron content	0.14	0.25	0.17	6.9	0.56	7.1	0.16	0.13	0.78	5.4
pH	6.7	6.1	8.2	6.4	7.0	6.2	7.0	6.1	6.5	5.8

Analysis number	21	22
Iron content	0.12	0.33
pH	——	6.1



EXPLANATION

Qal .... Alluvium of Quaternary age
QTg .... Gravel of Pliocene(?) age
Tpc .... Porters Creek Clay of Paleocene age
Km .... McNairy Formation of Cretaceous age
Kt .... Tuscaloosa Formation of Cretaceous age
Mu .... Mississippian limestones, undifferentiated
Du .... Devonian rocks, undifferentiated

FIGURE 3—GENERALIZED GEOLOGIC SECTION ALONG A NORTHEAST-TRENDING LINE FROM SLICKBACK ROAD TO OLIVE

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1964

AVAILABILITY OF GROUND WATER IN THE HARDIN QUADRANGLE, KENTUCKY

By

L. M. MacCary

1964

For sale by U.S. Geological Survey, price 50 cents