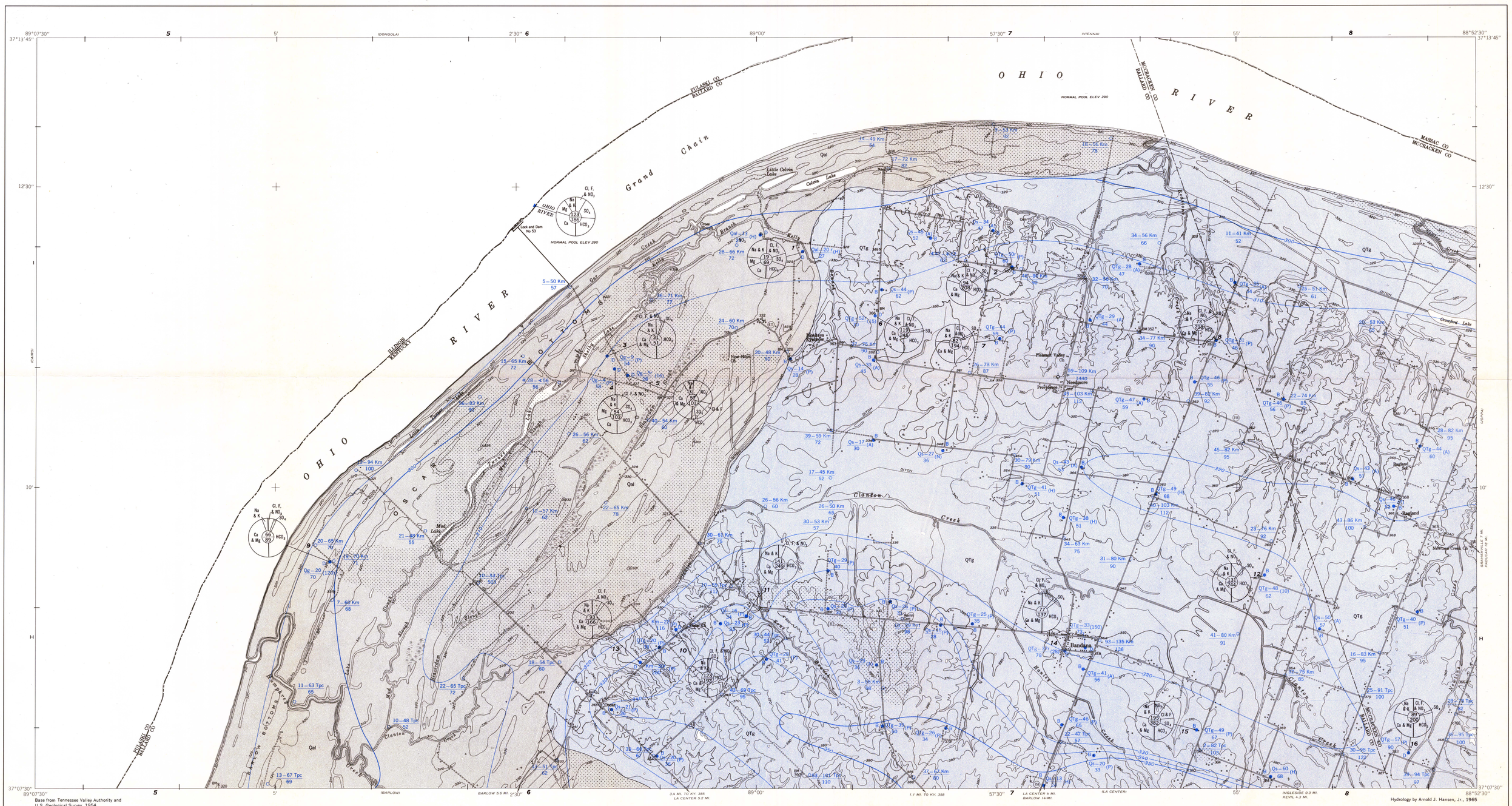
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WILLIAM T. PECORA, DIRECTOR

PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF KENTUCKY, UNIVERSITY OF KENTUCKY
KENTUCKY GEOLOGICAL SURVEY
WALLACE W. HAGAN, DIRECTOR AND STATE GEOLOGIST

HYDROLOGIC INVESTIGATIONS
ATLAS HA-176



Base from Tennessee Valley Authority and U.S. Geological Survey, 1954

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

Hydrology by Arnold J. Hansen, Jr., 1965

MAP SHOWING AVAILABILITY OF GROUND WATER, LOCATION OF WELLS, AND QUALITY OF WATER

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

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

System	Series	Group	Formation	Section	Thickness in feet	Lithology	Topography and geologic setting	Hydrology
Quaternary	Pleistocene and Recent		Younger alluvial, sand, silt, and clay		0–81'	In Area 1, yellow-brown to medium-gray very fine-grained sand with some silt, sandy silt, or fine- to medium-grained sand. Some layers of clay and silty clay; a few streaks of coarse-grained sand and gravel. Often lignitic and micaceous. Trace of green and dark minerals southwest of Little Colvin Lake. In the valleys of Clanton Creek and the Ohio River in Area 2, yellow-brown, brown, or gray-brown silty clay or clay with a trace of silt and/or sand. Some layers of silt and sandy silt.	Flood-plain deposits in the valleys of Clanton Creek, Humphrey Creek, and the Ohio River. The sandy alluvium and the green and dark minerals in Area 1 were deposited by streams that flowed from the north. The alluvial clay in Area 2 was deposited by streams from the east. Most of the alluvium is of Recent age; that with traces of green and dark minerals may be of Pleistocene age.	In Area 1, yields from driven wells generally are reported adequate for domestic use. In the southwestern part of Area 1, drilled wells may yield as much as 50 gpm (gallons per minute). However, where the saturated permeable alluvium is less than 10 feet thick, yields may be inadequate for modern homes; larger yields may be had from the underlying older alluvial sand and gravel. In Area 2, the younger alluvium is mostly clay and is not an aquifer; to obtain yields adequate for domestic use, wells must penetrate the underlying gravel of Pliocene(?) and Pleistocene age.
Quaternary	Pleistocene		Older alluvial, sand, and gravel		0–56'	Medium-gray to brown coarse-grained sand and fine-grained gravel with some fine- to medium-grained sand. Usually lignitic; occasionally micaceous. The sand is mostly quartz with a trace of green and dark minerals; the fine-grained gravel is predominantly chert.	Underlies the younger alluvial sand and silt in Area 1, except east of Colvin Lake. It is in contact with the gravel of Pliocene(?) and Pleistocene age where it was deposited against valley walls cut in the older gravel. The green and dark minerals suggest that it was deposited by the melt water of the Pleistocene continental glaciers; the glacial melt water probably flowed here via the present Cache River sag in southern Illinois.	Yields from bored wells are adequate for domestic and/or stock use. Except where the sand and gravel is less than 10 feet thick, drilled wells may supply as much as several hundred gallons per minute for irrigation. The water generally is soft and contains about 100 ppm (parts per million) of dissolved solids. The iron content exceeds 0.3 ppm; more than 0.3 ppm of iron imparts a bitter taste to water and causes stains on fabrics and fixtures. Generally, the water contains little nitrate; however, in 1 of 4 samples, it has more than 45 ppm. Water containing more than this amount may cause methemoglobinemia ("blue baby" disease), sometimes fatal, in infants and should not be used in their formulas.
Quaternary	Pleistocene		Loess		0–47'	Yellowish-brown or brown unstratified silty clay.	Wind-laid deposits covering entire upland areas.	Above the zone of saturation. When saturated by precipitation, transmits some water to underlying aquifers.
Quaternary	Pleistocene		Clay, silt, and sand		0–56'	Yellow-brown, orange, or light-gray silty clay, some very fine- to fine-grained sand, trace of medium-grained sand; occasional fine-grained gravel and thin layers of clay. Often micaceous. Locally, yellow-brown clay or silty clay, some medium-grained sand, trace of coarse-grained sand and/or fine-grained gravel.	Continental deposits underlying loess and overlying gravel and sand of Pliocene(?) and Pleistocene age throughout most of Area 2.	Yields from bored wells generally are reported adequate for domestic use. However, yields probably are inadequate for modern homes; larger yields are available from the underlying gravel. Most of the wells in this aquifer penetrate about 7 to 16 feet into the zone of saturation; generally, these wells are completed at the contact with the underlying gravel. The water generally is moderately hard and has about 230 ppm of dissolved solids. It contains about 0.1 ppm of iron and about 25 ppm of nitrate.
Tertiary	Pliocene(?) and Pleistocene		Gravel and sand [1]		0–93'	Orange and red-brown sandy gravel; occasionally in red-brown matrix of sandy clay, as east of Needmore and probably near Ragland and Oscar Church. Trace of silt and clay; occasional layers of clay.	Continental deposits covering an erosion surface on sediments of Paleocene and Cretaceous ages. The erosion surface is irregular, consisting of channels and terraces cut by an intricate drainage system.	Yields from bored wells are adequate for domestic and/or stock use in most of Area 2. Locally, as east of Needmore, the gravel with a matrix of sandy clay may yield enough water only to drilled wells that penetrate deeply into it. Except in the small areas where the gravel has a sandy clay matrix or where the saturated gravel is less than 10 feet thick, drilled wells may yield as much as 1,000 gpm for irrigation or industry. Near Oscar Church, the gravel may have a clay matrix; yields from bored wells may be inadequate for modern homes and/or stock use. Additional storage (obtained by penetration of the Porters Creek Clay or by using more than one well) may be necessary to meet daily peaks of consumption. If coastal-plain sediments of Eocene age are present south of Bandana, the overlying gravel probably is above the zone of saturation. The water generally is moderately hard and contains about 135 to 250 ppm of dissolved solids. In 3 of 7 samples, the iron content exceeds 0.3 ppm. It contains about 15 to 40 ppm of nitrate; in 1 of 7 samples, it contains more than 45 ppm.
Tertiary	Eocene		Clay, silt, and sand		0–7	White to gray sandy clay, clay boulders, and scattered lenses of clay and of coarse-grained sand. Dark-gray clay, silt, or fine-grained sand; lignitic.	Coastal-plain sediments of Eocene age which may underlie the Pliocene(?) and Pleistocene gravel along the south edge of the map south of Bandana.	Yields from wells may be inadequate because of the high content of clay and silt. The shallowest alternative aquifer is the sand in the underlying McNairy Formation. The shallowest alternative aquifer adequate for irrigation or industrial use may be the Paleozoic limestone at depths of about 250 or 350 feet.
Tertiary	Paleocene	Midway	Porters Creek Clay		0–125'	Dark-gray montmorillonitic clay, often silty; occasionally micaceous. Glauconitic at the base and in the upper part.	Marine deposit underlying the Pliocene(?) and alluvial sands and gravels along most of the south edge of the map, except where absent southwest of Bandana because of probable northeastward-trending faults. Pinches out at it's northern limit south of Clanton Creek; thickens southward.	Not an aquifer. Retards movement of ground water between the overlying alluvial and Pliocene(?) gravels and the underlying McNairy Formation.
Cretaceous	Upper Cretaceous		McNairy Formation [2]		4–220'	Light- to dark-gray micaceous clay, often silty, interlaminated with white to brown silt or very fine-grained sand. The upper part is predominantly clay; the lower part is mostly micaceous very fine- to fine-grained sand.	Deltaic deposits underlying the Porters Creek Clay along most of the south edge of the map, except where that formation is absent because of faulting. In the faulted area southwest of Bandana and north of the limit of the Porters Creek Clay, the McNairy underlies the Pliocene(?) and alluvial gravels.	Drilled wells may yield enough water for domestic use; however, the water contains considerably more than 0.3 ppm of iron and may need iron-removal treatment to be satisfactory for many uses.
Cretaceous	Upper Cretaceous		Tuscaloosa Formation		0–20'	White or light-gray chert gravel with tripolitic clay material.	Discontinuous stream-laid deposits lying on post-Paleozoic erosion surface.	Not an aquifer because of fine-grained matrix and poor sorting.
Mississippian			Limestone and chert, undifferentiated		0–450'	The Paleozoic consolidated rocks underlying the Cretaceous sediments are the "bedrock" of well drillers. The upper surface of the limestone and chert is weathered to form chert rubble, which contains chert blocks in a clay matrix. Dark-gray interbedded limestone and chert, often containing fractures and solutional openings; shale at base.	Probably underlies the Cretaceous sediments northeast of Bandana.	One well penetrated the bedrock in this area and was not successfully completed. The chert rubble probably is not an aquifer because of fine-grained matrix. Wells in the consolidated rock may obtain water from solution openings. In adjacent Illinois, industrial wells penetrating Mississippian limestone yield 1,000 gpm. Probably, the water is hard.
Devonian	Upper Devonian		Chattanooga Shale		0–250'	Black siliceous shale. Jointed.	Probably underlies Mississippian rocks northeast of Bandana; may underlie the Cretaceous sediments southwest of Bandana.	Not an aquifer. Retards movement of ground water between the Mississippian limestone and underlying Devonian rocks.
Devonian	Upper Devonian		Devonian rocks, undifferentiated		800±	White or gray coarsely crystalline dolomitic limestone, often siliceous, interbedded with chert.	Underlies the Chattanooga Shale in the entire area.	Wells may obtain water from fractures and solution openings.

[1] Age undetermined but estimated to range from Pliocene or older to Pleistocene
[2] Upper part may be of Clayton age

EXPLANATION

Gravel, Sand, Silt, Clay or shale, Loess, Mica, Glauconite, Lignite, Limestone, Cherty limestone, Dolomite

EXPLANATION

Qal	Younger alluvium of Pleistocene and Recent age
Qg	Older alluvial sand and gravel of Pleistocene age
Ql	Loess
Qs	Sand and silt of Pleistocene age
QTg	Upland sand and gravel of Pliocene(?) and Pleistocene age
Tpc	Porters Creek Clay of Paleocene age
Km	McNairy Formation of Cretaceous age
Kt	Tuscaloosa Formation of Cretaceous age
Mu	Mississippian rocks, undifferentiated
Du	Devonian rocks, undifferentiated (including Chattanooga Shale)

AVAILABILITY OF GROUND WATER IN THE PARTS OF THE OLMSTED AND BANDANA QUADRANGLES, IN JACKSON PURCHASE REGION, KENTUCKY

Ground water for domestic, irrigation, and industrial use is abundant in the parts of the Olmsted and Bandana quadrangles in Kentucky. This atlas, one of a series for the entire Jackson Purchase region, presents ground-water data in northern Ballard County and northwestern McCracken County.

The availability map shows the occurrence and quality of ground water in the shallowest aquifer that may yield a water supply adequate for domestic use. Ground-water availability at any site is shown by the map pattern and the data for nearby wells and test holes. Chemical quality is shown by circular diagrams.

The principal aquifers are the gravel of Pliocene(?) and Pleistocene age and the older alluvium of Pleistocene age. Older alluvial gravel and sand of Pleistocene age underlies younger alluvial sand and silt of Pleistocene and Recent age throughout Area 1, except east of Colvin Lake. East of Colvin Lake in Area 1 and throughout Area 2, Pliocene(?) and Pleistocene gravel underlies Pleistocene clay and silt in the upland; it underlies younger alluvium in the valleys of Clanton Creek and the Ohio River.

Throughout Area 1, except east of Colvin Lake, the saturated thickness of the older alluvial gravel and sand ranges from 5 to 56 feet. This older alluvium was deposited against valley walls cut in the Pliocene(?) and Pleistocene gravel; ground water moves freely across the contact between the two deposits. Except where the saturated thickness of the older alluvium is less than 10 feet, yields from drilled wells may be as much as several hundred gallons per minute.

In most of Area 2 and the eastern tip of Area 1, the principal aquifer is the Pliocene(?) and Pleistocene gravel. Below the water-level contour of 330 feet, its saturated thickness ranges from 2 to 93 feet. Properly constructed wells should supply yields as great as 1,000 gpm (gallons per minute) for irrigation or industrial use, except where the gravel has a matrix of sandy clay, as east of Needmore, or has less than 10 feet of saturated thickness.

Above the water-level contour of 330 feet in Area 2, yields are less because of thinner saturated gravel and more clay matrix. Near Oscar Church, many wells are reported to be inadequate. The gravel here may have a large amount of clay as a matrix. Bored wells may not yield enough water for modern domestic use; however, yields may be larger where the saturated gravel is thick. Where yields are inadequate, additional storage to meet the peak demands of household activity may be created by deepening bored wells into the Porters Creek Clay or by use of large pressure tanks combined with low pumping rates. Another solution is to pump alternately from more than one bored well or to drill a well into the sand in the deeper McNairy Formation. Throughout the upland of Area 2, many wells obtain water from the Pleistocene clay and silt, which overlies the gravel. Although yields generally are reported adequate for domestic use, they probably are inadequate for modern homes; larger yields are available from the underlying gravel.

The water level in the saturated Pliocene(?) and alluvial gravels slopes westward from about 350 feet above sea level along the south edge of the map south of Bandana to about 285 feet at the Ohio River in the southwest corner of Area 1. The annual range of water-level fluctuation is about 9 feet near the Ohio River but decreases inland to about 4 feet in the upland. In Area 1 and most of Area 2, the water in the two gravels is confined by overlying relatively impermeable material. Locally, in Area 2, the contact with the overlying Pleistocene clay and silt is above the zone of saturation so the water is unconfined and is under water-table conditions.

In most of Area 1, the younger alluvium may yield enough water for domestic use to driven wells, which often may be installed by the individual homeowner. The younger alluvium is thickest in the southwestern part of the area and may yield as much as 50 gpm to drilled wells. Yields may be inadequate where the saturated thickness of the younger alluvium is less than 10 feet; larger yields are available from wells penetrating the underlying older alluvial gravel of Pleistocene age.

Coastal-plain sediments of Eocene age may underlie the Pliocene(?) gravel along the southern part of the area south of Bandana. If present, they probably are the shallowest saturated strata. However, the high content of clay and silt in the Eocene strata may cause yields from wells to be inadequate for domestic use.

The Porters Creek Clay is not an aquifer; instead, it retards movement of ground water between the overlying Pliocene(?) and alluvial gravels and the underlying McNairy Formation. The clay overlies the McNairy Formation along most of the south edge of the map. It is absent in a small area southwest of Bandana, probably because it is cut off by northeastward-trending faults. The clay pinches out northward in the area immediately south of Clanton Creek; it thickens southward to about 125 feet southwest of Oscar. The McNairy Formation ranges from 4 to about 220 feet in thickness. It may yield enough water for domestic use to drilled wells; however, the water from the upper part of the formation contains large amounts of iron.

Paleozoic bedrock of Mississippian and Devonian age, consisting of interbedded limestone and chert, with some shale, underlies the Cretaceous sediments. Where saturated gravel and sand is less than 10 feet thick, the limestone is the shallowest aquifer that may yield water sufficient for irrigation or industrial use. Water from the bedrock generally is hard.

The water in the alluvium of Pleistocene and Recent age generally is soft and contains about 70 to 105 ppm (parts per million) of dissolved solids. It is slightly acidic, pH of 6.7 or lower, and may be corrosive. The nitrate content generally is less than 4 ppm; however, in 1 of 5 samples, it exceeds 45 ppm. The iron content is so high that it may need to be removed to make the water satisfactory for most uses.

The quality of water in the deposits of Pliocene(?) and Pleistocene age is satisfactory for most uses. Generally, the water is moderately hard and contains about 190 to 250 ppm of dissolved solids. It is slightly acidic, pH generally between 6.5 and 6.7, and may be slightly corrosive. The nitrate content generally is less than 30 ppm; however, in 1 of 9 samples, it exceeds 45 ppm. In 3 of 9 samples, the iron content exceeds 0.3 ppm. The temperature ranges from 58° to 61°F.

The water in the upper part of the McNairy Formation is moderately hard, has about 180 ppm of dissolved solids, a pH of 6.8, and almost no nitrate; however, it contains so much iron that it may need iron-removal treatment to be satisfactory for many uses. Based on the quality of ground water in adjacent areas, the water in the lower part of the McNairy contains less iron than that in the upper part.

The following table lists the iron content, in part per million, and the hydrogen-ion concentration, as pH, of the water analyses on the availability map. An iron content of more than 0.3 ppm imparts a disagreeable taste to the water and may cause staining of clothing and utensils. A pH of 7.0 indicates neutrality. Values higher than 7.0 denote alkalinity; lower values indicate acidity. Below 7.0, corrosiveness generally increases as pH decreases.

Analysis number	1	2	3	4	5	6	7	8	9	10
Iron content	3.0	0.67	0.90	6.4	0.48	0.21	0.22	0.14	19	5.6
pH	6.2	6.6	6.7	6.7	6.0	6.5	6.6	6.6	6.7	6.8

Analysis number	11	12	13	14	15	16
Iron content	0.06	0.05	4.4	0.52	0.23	0.96
pH	6.9	7.3	6.9	6.5	7.1	6.6

EXPLANATION

Each availability area on this map shows the occurrence and availability of ground water in the shallowest aquifer that may yield enough water for domestic use. This report considers that an adequate domestic supply will yield about 500 gallons per day to a well equipped with a power pump and a pressure-distribution system. The shallowest aquifer is underlain by other aquifers whose water-bearing properties are described in the generalized columnar section

Qal — AREA 1
Water in alluvium of Pleistocene and Recent age
Dotted pattern indicates areas where the saturated permeable younger alluvium is less than 10 feet thick
Diagonal ruling indicates areas where the younger alluvium is either above the zone of saturation or consists predominantly of clay
Yields from driven wells may be adequate for domestic and/or stock use, except where the saturated thickness of permeable younger alluvium is less than 10 feet. In the southwestern part of the area, drilled wells may yield as much as 50 gpm (gallons per minute) from the younger alluvium. The saturated thickness of younger alluvial sand, silt, and clay ranges from less than one to 45 feet. Where it is less than 10 feet thick, wells can be deepened into the underlying older alluvial sand and gravel to obtain larger yields
Yields from wells bored into the older alluvial sand and gravel are adequate for domestic and/or stock use. Drilled wells may yield enough water for irrigation or industrial use except where the older alluvium is less than 10 feet thick. The saturated thickness of the older alluvium ranges from 5 to 56 feet. Where it is less than 10 feet thick, the shallowest aquifer that may supply irrigation or industrial wells probably is the Paleozoic limestone

QTg — AREA 2
Water in gravel and sand of Pliocene(?) and Pleistocene age
Dotted pattern indicates where the saturated gravel is less than 10 feet thick
In most of Area 2 below the 330-foot water-level contour, yields from bored wells are adequate for domestic and/or stock use, and properly constructed drilled wells will yield as much as 1,000 gpm for irrigation or industrial use. The specific capacities of drilled wells at Bandana are reported to range from 10 to about 150 gpm per foot of drawdown, when pumped at rates ranging from 30 to about 150 gpm. The saturated gravel ranges from 2 to 93 feet thick. Locally, as east of Needmore, the Pliocene(?) sand and gravel is in a matrix of sandy clay and may yield a domestic supply only to wells drilled deeply into it. In the small part of the area where the deposit either has a sandy clay matrix or is relatively thin, as along the Ohio River, wells must be drilled deeper into the Paleozoic limestone to obtain large yields
In most of Area 2 above a water level of 330 feet, the saturated sand and gravel is thinner, ranging from 2 to 53 feet thick. Where it either has a clay matrix, as near Oscar Church, or is thin, it may not yield enough water for domestic use. The shallowest alternative aquifer is the sand in the McNairy Formation. The deeper Paleozoic limestone and chert may yield enough water for irrigation or industry

Area boundary
Oil-test well
Test hole
11–41 Km 52 — Saturated thickness of gravel, in feet (< means not less than); Depth to base of gravel, in feet below land surface (Data for oil test from interpretation of gamma-radiation log); Formation underlying gravel (see formation symbols below); Depth of test hole, in feet below land surface

D — Water well
B, *Bored or dug well, generally 6-inch vitrified clay pipe or 24-inch concrete tile, open at the bottom*
D, *Drilled or jetted well, generally 6-inch steel casing with well screen*

Qg 20 (120) 70 — Aquifer (see below); Water level in well, in feet below land surface; r, if reported; Yield in gallons per minute, or adequacy (see below); Depth of well, in feet below land surface

AQUIFER AND FORMATION SYMBOLS

Qal	Younger alluvium of Pleistocene and Recent age
Qg	Older alluvium of Pleistocene age
Qs	Clay and silt of Pleistocene age
QTg	Gravel and sand of Pliocene(?) and Pleistocene age
Tpc	Porters Creek Clay of Paleocene age
Km	McNairy Formation of Cretaceous age

YIELD OR ADEQUACY

(120)	Gallons per minute, where known
(P)	Reported adequate for power pump for domestic and/or stock use
(H)	Reported adequate for bailer or hand pump
(N)	Inadequate
(A)	Abandoned or destroyed

Quality-of-surface water data collection site

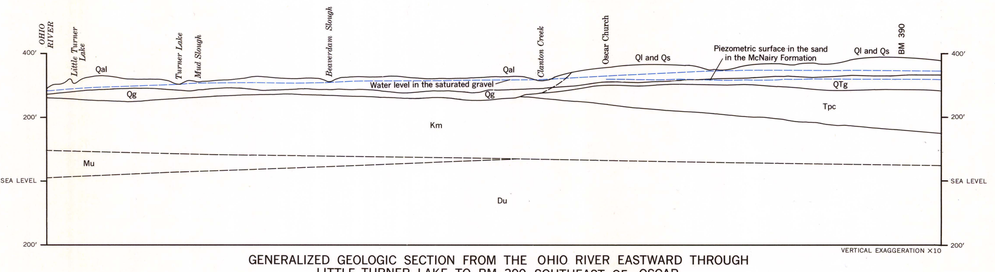
290 — Water-level contour
Shows altitude of water level in the saturated alluvial and Pliocene(?) sands and gravels. The water is confined by overlying clay and silty clay beds, except locally in Area 2, where it is unconfined. The depth to the water level is the difference between the land-surface altitude and the water-level contour. Water levels measured in April and May 1964. Contour interval 10 feet; datum is mean sea level

QUALITY

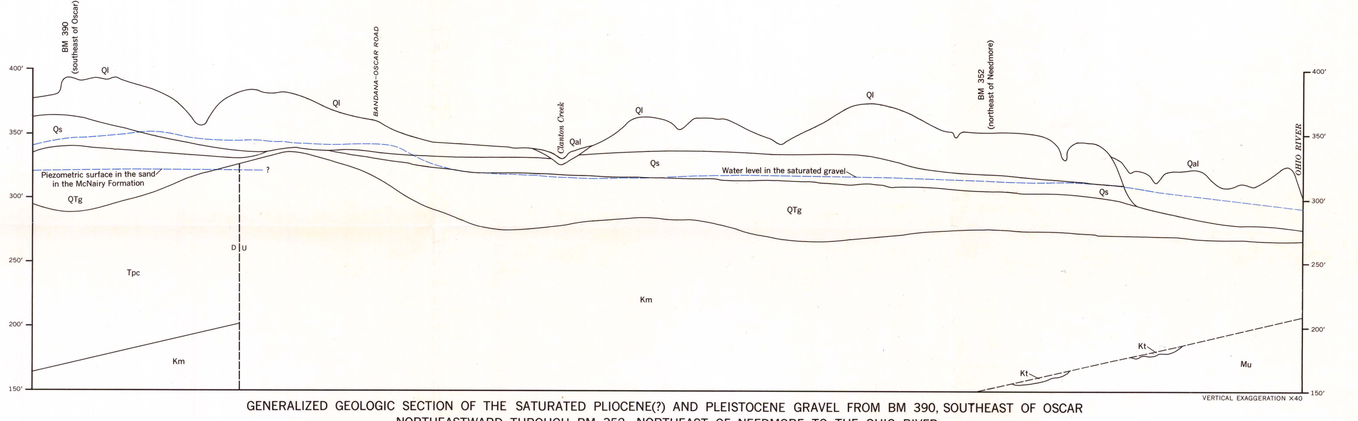
Na & K, Cl, F, & NO_3, SO_4, Ca & Mg, HCO_3, 96, 89, 9

Chemical composition of dissolved solids

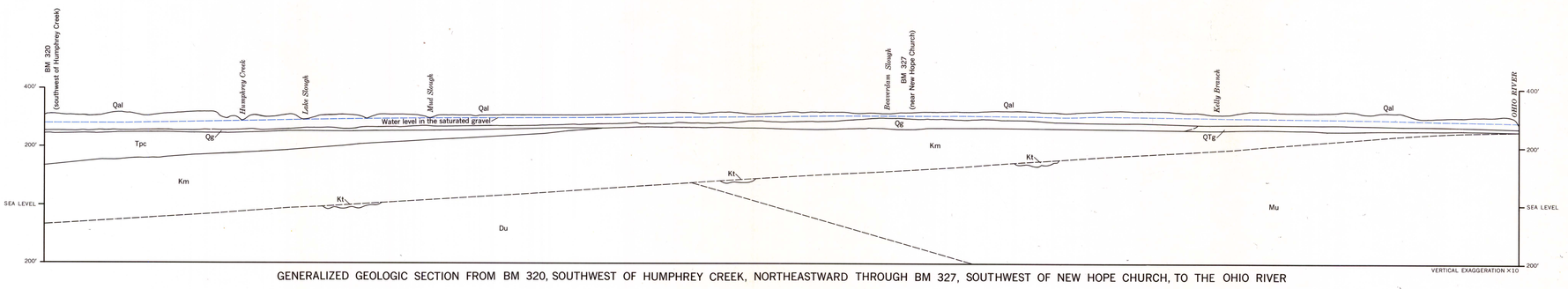
Figure between circular diagram and well symbol is analysis number in table at end of text. Figure above line at center of circle is carbonate hardness (calcium magnesium hardness, as $CaCO_3$) in parts per million. Hardness of water is classified by the U.S. Geological Survey as follows: 0–60 ppm, soft; 61–120 ppm, moderately hard; 121–180 ppm, hard; and 181 ppm or more, very hard. Figure below line is dissolved solids in parts per million; dissolved solids in partial analyses are computed from specific conductances and are only approximate. Each segment in the circle is proportional to the mineral component dissolved in the water. Percentages are computed from equivalents per million of the anions and cations. Calcium and magnesium are shown together as one segment in partial analyses. Nitrate is shown separately if present in amounts greater than 45 ppm. Water containing more than 45 ppm of nitrate may cause a type of methemoglobinemia in infants ("blue baby" disease), sometimes fatal, and should not be used in infants formulas



GENERALIZED GEOLOGIC SECTION FROM THE OHIO RIVER EASTWARD THROUGH LITTLE TURNER LAKE TO BM 390, SOUTHEAST OF OSCAR



GENERALIZED GEOLOGIC SECTION OF THE SATURATED PLIOCENE(?) AND PLEISTOCENE GRAVEL FROM BM 390, SOUTHEAST OF OSCAR NORTHEASTWARD THROUGH BM 352, NORTHEAST OF NEEDMORE, TO THE OHIO RIVER



GENERALIZED GEOLOGIC SECTION FROM BM 320, SOUTHWEST OF HUMPHREY CREEK, NORTHEASTWARD THROUGH BM 327, SOUTHWEST OF NEW HOPE CHURCH, TO THE OHIO RIVER

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AVAILABILITY OF GROUND WATER IN THE PARTS OF THE OLMSTED AND BANDANA QUADRANGLES, IN JACKSON PURCHASE REGION, KENTUCKY

By
Arnold J. Hansen, Jr.
1967

For sale by U.S. Geological Survey, price 75 cents