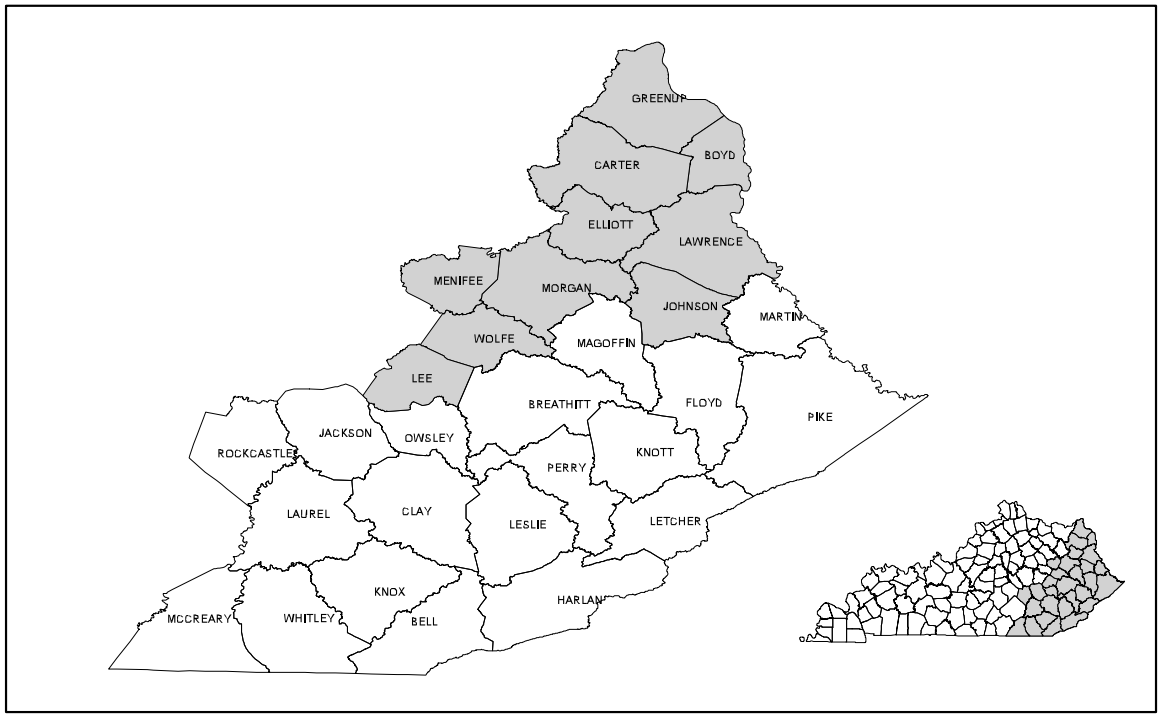
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE COMMONWEALTH OF KENTUCKY
AND THE KENTUCKY GEOLOGICAL SURVEY
UNIVERSITY OF KENTUCKY

AVAILABILITY OF GROUND WATER IN BOYD, CARTER, ELLIOTT, GREENUP, JOHNSON, LAWRENCE, LEE, MENIFEE, MORGAN, AND WOLFE COUNTIES, KENTUCKY

By
W.E. Price, Jr., Chabot Kilburn, and D.S. Mull

HYDROLOGIC INVESTIGATIONS
ATLAS HA-37



INDEX MAP OF THE EASTERN COAL FIELD REGION, KENTUCKY, SHOWING COUNTY GROUPS AND AREA OF THIS ATLAS

This is 1 of 3 atlases (HA-36, HA-37, HA-38) showing geology and availability of ground water in the Eastern Coal Field region, Kentucky U.S. Geological Survey Water-Supply Paper 1607 contains a text description and illustrations providing further information on the occurrence and quality of ground water in the Eastern Coal Field region.

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UNITED STATES GEOLOGICAL SURVEY

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KENTUCKY GEOLOGICAL SURVEY, UNIVERSITY OF KENTUCKY
AND THE DEPARTMENT OF ECONOMIC DEVELOPMENT

HYDROLOGIC INVESTIGATIONS
ATLAS HA-37 (SHEET 1 OF 3)

EXPLANATION

Qal	Alluvium	QUATERNARY
Pcm	Conemaugh formation	PENNSYLVANIAN
Pbt	Breathitt formation	PENNSYLVANIAN
Ple	Lee formation	PENNSYLVANIAN
Mu	Mississippian rocks, undifferentiated	MISSISSIPPIAN

May include some Devonian strata in valleys of extreme western Menifee County

Contact

Fault

Dashed where approximately located; dotted where concealed

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APPROXIMATE MEAN DECLINATION, 1962

Base maps are county highway maps and adjacent county groups may not match

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—61013

GEOLOGIC MAP OF BOYD, CARTER, ELLIOTT, GREENUP, JOHNSON, LAWRENCE, LEE, MENIFEE, MORGAN, AND WOLFE COUNTIES, KENTUCKY

By

W. E. Price, Jr., Chabot Kilburn, and D. S. Mull

1962

SCALE 1:250 000

4 0 4 8 12 MILES

HYDROLOGIC INVESTIGATIONS
ATLAS HA-37 (SHEET 1 OF 3)

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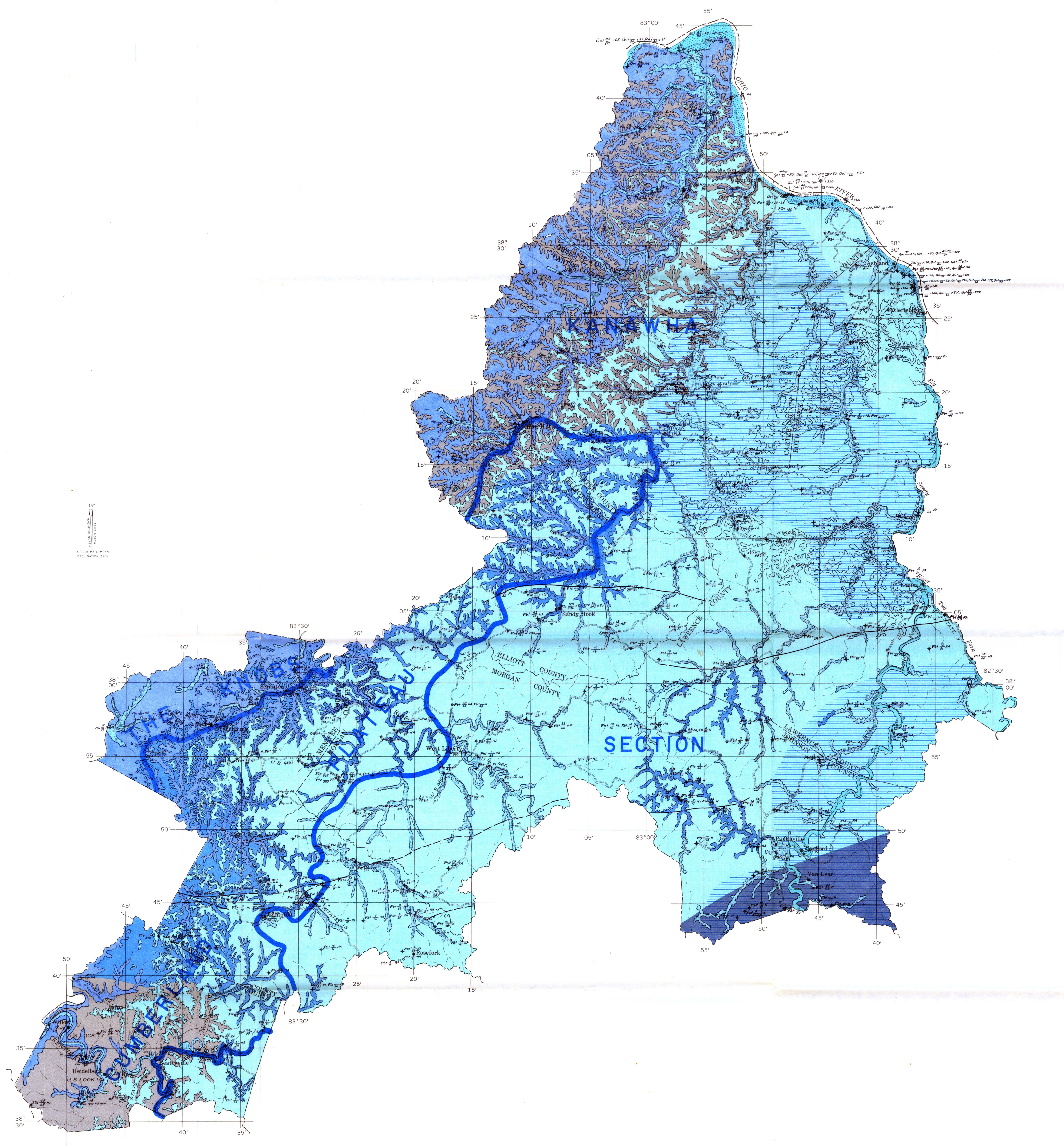

Base maps are county highway maps and adjacent county groups may not match

EXPLANATION

Symbol	Unit	Age
Qal	Alluvium	QUATERNARY
Pcm	Conemaugh formation	PENNSYLVANIAN
Pbt	Breathitt formation	PENNSYLVANIAN
Ple	Lee formation	PENNSYLVANIAN
Mu	Mississippian rocks, undifferentiated. *May include some Devonian strata in valleys of extreme western Menifee County*	MISSISSIPPIAN

Contact

Fault

THE KNOBS

The Knobs is a belt of conical hills and isolated ridges underlain in this area chiefly by Lower Mississippian shale and lying between the Blue Grass region on the west and the Cumberland Plateau section on the east. Rocks in this area generally yield small supplies of water for domestic use.

Water in alluvium

Dug wells.—Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum supply with bucket or hand pump (more than 100 gpd). A few are adequate for a modern domestic supply with power pump (more than 500 gpd).

Water in the Lee formation

Because the Lee formation in these areas caps small conical hills and narrow ridgetops and is of very small areal extent, it yields little or no water to wells.

Water in Mississippian rocks

Drilled wells.—Fewer than half the wells drilled in valley bottoms are adequate for a modern domestic supply. More than three-quarters of the wells drilled in valley bottoms are adequate for a minimum domestic supply. Wells on hills generally will yield smaller quantites of water than wells in valley bottoms.

Salty water may be found locally in wells drilled to depths of less than 100 feet below the level of the principal valley bottoms. At greater depths probably no fresh water will be found.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. Most wells dug on hills are inadequate even for a minimum domestic supply.

Springs.—Springs in limestone may supply enough water for domestic use.

CUMBERLAND PLATEAU SECTION

The Cumberland Plateau section is a broad upland, in most places of low relief, but highly dissected along its western and northern margins. The plateau is supported by the resistant sandstone and conglomerate beds of the Lee formation. Because the majority of houses are on upland surfaces, most wells are on broad ridgetops or hilltops. Rocks in this area generally yield from small to ample supplies of water for domestic use.

Water in alluvium

Dug wells.—Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply.

Drilled wells.—Screened drilled wells probably can be developed in the alluvium where it is predominantly sand and the saturated thickness is at least several feet. Some of these wells may yield enough water for a modern domestic supply, but most wells probably would be adequate only for a minimum domestic supply. Few screened wells have been developed in the alluvium because they are expensive and probably would yield only small quantities of water.

Water in the Breathitt formation

Drilled wells.—Nearly all wells drilled in valley bottoms are adequate for a minimum domestic supply. Some wells in valleys are adequate for a modern domestic supply.

More than half the wells drilled on hillsides are adequate for a minimum domestic supply. A few wells on hillsides yield enough water for a modern domestic supply.

About half the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. A few wells on ridgetops or hilltops yield enough for a modern domestic supply.

Water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water is found in few, if any, drilled wells.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. A few wells dug in valleys are adequate for a modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Springs.—A few springs supply sufficient quantities of water for domestic use. Almost all springs yield less than 5 gpm.

Water in the Lee formation (subarea 1)

Drilled wells.—About three-quarters of the wells drilled on hilltops and ridgetops are adequate for a minimum domestic supply. Some wells yield enough water for a modern domestic supply.

Wells on hillsides and in valleys yield larger quantities of water, but very few produce more than 15 gpm. In this area, salty water is found in a few wells.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. A few wells dug in valleys are adequate for a modern domestic supply. About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Springs.—A few springs supply sufficient quantities of water for domestic use. Almost all springs yield less than 5 gpm.

Water in the Lee formation (subarea 2)

Drilled wells.—More than three-quarters of the wells drilled in valleys are adequate for a modern domestic supply. Nearly all wells in valleys are adequate for a minimum domestic supply.

Most of the wells drilled on hillsides are adequate for a modern domestic supply. Nearly all wells on hillsides are adequate for a minimum domestic supply.

About half the wells drilled on hilltops and ridgetops are adequate for a modern domestic supply. More than three-quarters of the wells on ridgetops and hilltops yield enough for a minimum domestic supply.

Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies.

Water obtained from most wells in this area is soft or moderately hard and contains noticeable amounts of iron. Salty water may be found in wells drilled into the basal part of the Lee formation along the eastern margin of the Cumberland Plateau section; elsewhere water in the Lee formation generally is fresh.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. A few wells dug in valley bottoms are adequate for a modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Springs.—A few springs supply sufficient quantities of water for domestic use. Most springs yield less than 5 gpm.

Water in Mississippian rocks

Drilled wells.—Most of the wells drilled in valley bottoms are adequate for a modern domestic supply. Nearly all wells in valleys are adequate for a minimum domestic supply.

About half the wells drilled on hillsides are adequate for a modern domestic supply. Most wells on hillsides yield enough for a minimum domestic supply.

Wells on ridgetops and hills yield smaller quantities of water.

Water from most wells drilled in this area is hard and contains noticeable amounts of iron. Salty waters are tapped in some wells drilled less than 100 feet below the level of the principal valley bottoms. At depths greater than 100 feet, probably no fresh water is found.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. Most wells dug on hills are inadequate even for a minimum domestic supply.

Springs.—Springs yielding as much as 100 gpm occur near stream level. Most springs, however, yield less than 5 gpm.

KANAWHA SECTION

The Kanawha section is a highly dissected area characterized by narrow valleys and irregular steep-sided ridges. Although shale is the predominant rock type, beds of sandstone form resistant ledges in the sides and on the tops of hills, and underlie some of the broad valleys. Because most of the people live along the streams, nearly all wells are drilled in the valley bottoms. Rocks in this area generally yield ample supplies of water for domestic use.

Water in alluvium

Drilled wells.—Nearly all drilled wells are adequate for a modern domestic supply. The median yield of large-capacity wells is 150 gpm. The maximum reported yield is 360 gpm. Compound horizontal wells could be constructed that would yield more than this amount. Ground water in this area is very hard.

Water in alluvium of the Big Sandy River and lower reaches of its forks

Dug wells.—Nearly all wells in the alluvium of the Big Sandy River and lower reaches of its forks are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Ground water obtained from most dug wells in this area is soft.

Drilled wells.—Because this alluvium in many places contains much sandy material and has a saturated thickness of about 30 feet, screened wells yielding as much as 20 to 25 gpm probably could be developed in it. Most screened wells would be adequate for a modern domestic supply.

Water from wells drilled in the alluvium is moderately hard and contains large amounts of iron.

Water in alluvium of streams tributary to the Ohio River, with the exception of the Big Sandy River and the lower reaches of its forks

Dug wells.—Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Water from most dug wells in this area is moderately hard and contains noticeable amounts of iron.

Drilled wells.—Screened drilled wells probably can be developed in the alluvium where it is sandy and the saturated thickness it at least several feet. Some of these wells may yield enough water for a modern domestic supply, but most probably would be adequate only for a minimum domestic supply. Few screened wells have been developed in the alluvium beacuse they are expensive and probably would yield only small quantities of water.

Water in the Breathitt formation (subarea 1)

Drilled wells.—Most wells in valley bottoms are adequate for a modern domestic supply. Nearly all wells in valleys are adequate for a minimum domestic supply.

Fewer than half the wells drilled on hillsides are adequate for a modern domestic supply. More than three-quarters of the wells on hillsides are adequate for a minimum domestic supply.

Wells on hilltops and ridges yield smaller quantities of water.

Most of the water from drilled wells is extremely hard and contains noticeable amounts of iron. Salty water may be found in the northern and eastern parts of the area less than 100 feet below the level of the principal valley bottoms.

Dug wells.—Most wells dug in valleys are adequate for a minimum domestic supply. A few wells dug in valleys are adequate for modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Springs.—A few springs supply sufficient quantities of water for domestic use. Almost all springs yield less than 5 gpm

Water in the Breathitt formation (subarea 2)

Drilled wells.—More than three-quarters of the wells drilled in valley bottoms are adequate for a modern domestic supply. Nearly all wells in valleys are adequate for a minimum domestic supply.

About three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply. Nearly all wells on hillsides are adequate for a minimum domestic supply.

Nearly all wells drilled on hilltops are adequate for a minimum domestic supply. Some wells on hilltops or ridgetops are adequate for a modern domestic supply.

Drilled wells more than 200 feet deep in valleys yield enough water for small municipal or industrial supplies.

Ground water from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. In the southeastern part of the area, salty water may be found in wells tapping the Breathitt formation less than 100 feet below the level of the principal valley bottoms. Elsewhere, salty water in drilled wells probably will not be found at depths less than 200 feet below the level of the principal valley bottoms.

Dug wells.—Most wells dug in valleys are adequate for a minimum domestic supply. A few wells dug in valleys are adequate for a modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Springs.—A few springs supply sufficient quantities of water for domestic use. Almost all springs yield less than 5 gpm

Water in the Lee formation (subarea 1)

Drilled wells.—Fewer than half the wells drilled in valley bottoms are adequate for a modern domestic supply, but nearly all are adequate for a minimum domestic supply.

Wells on hillsides and on hilltops and ridges yield smaller quantities of water.

Salty water may be found in wells in the eastern part of the subarea less than 100 feet below the level of the principal valley bottoms; elsewhere, the water is fresh.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. A few wells dug in valley bottoms are adequate for a modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Water in the Lee formation (subarea 2)

Drilled wells.—Most wells drilled in valley bottoms are adequate for a modern domestic supply. Nearly all wells in valley bottoms are adequate for a minimum domestic supply.

Fewer than half the wells drilled on hillsides are adequate for a modern domestic supply. Nearly all wells on hillsides are adequate for a minimum domestic supply.

Fewer than three-quarters of the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. About a third of the wells on hilltops or ridgetops are adequate for a modern domestic supply.

Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies.

Most water in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in the northern part of this area, at depths less than 100 feet. Nearly all wells tapping the Lee formation will yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

In northern Magoffin County, however, some wells may penetrate the entire thickness of the Lee formation under these conditions and yield fresh water.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. A few wells dug in valley bottoms are adequate for a modern domestic supply.

About half the wells dug on hills are adequate for a minimum domestic supply. A few wells dug on hills are adequate for a modern domestic supply.

Water in Mississippian rocks

Drilled wells.—About a third of the wells drilled in valley bottoms are adequate for a modern domestic supply, but more than three-quarters are adequate for a minimum domestic supply.

Wells drilled on hillsides and hilltops yield smaller quantities of water.

Most of the water from drilled wells in the area is very hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms. Probably no fresh water will be found at greater depths.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic supply. Most wells dug on hills are inadequate even for a minimum domestic supply.

Water obtained from most dug wells in this area is moderately hard.

Springs.—Springs in limestone may supply enough water for domestic use.

Salty water

Drilled wells.—Salty water may be found in wells drilled into the Breathitt formation or Lee formation in this area less than 100 feet below the level of the principal valley bottoms.

Drilled well

Dug well

Drilled well yielding salty water

Spring

Example: Ple 16/35 H A r35

- Depth to water, in feet, below land surface (16)
- Type of pump (H)
- Adequacy (A)
- Yield (r35)
- Depth of well, in feet, below land surface (35)
- Formation (Ple)

TYPE OF PUMP

H	Hand-powered pump-bucket, bailer, pitcher, or force
P	Power pump
N	No pump
F	Flowing

ADEQUACY

A	Adequate
/	Inadequate

YIELD

e	Estimated - from pump capacity if a well
r	Reported
m	Measured
50	Gallons per minute where known
600gpd	Gallons per day where known, when less than 1 gpm

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—61013

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SYSTEM	SERIES	GROUP	FORMATION	SYMBOL	SECTION	THICKNESS (IN FEET)	MINOR DIVISIONS	CHARACTER OF MINOR DIVISIONS	GENERAL CHARACTER OF DIVISIONS	TOPOGRAPHY	HYDROLOGY
QUATERNARY	Pleistocene and Recent		Alluvium	Qal		0–96			Alluvium Alluvium in the Ohio Valley is composed of a layer of silt, clay, and some sand underlain by a layer of silt, sand, and gravel. Alluvium in valleys tributary to the Ohio Valley is fine-grained sand, silt, and clay.	Alluvium Forms narrow flood plains and terraces of varying width along streams. At least one well-developed terrace is generally present.	Alluvium Yields more than 500 gpd to nearly all wells drilled into the alluvium along the Ohio River. Reported to yield as much as 360 gpm to large industrial wells. Yields more than 100 gpd to most wells dug in the alluvium of valleys tributary to the Ohio River. Probably will yield as much as 20 or 25 gpm to wells drilled and screened in the alluvium of the Big Sandy River and its Tug and Levisa Forks.
	Pleistocene		High gravel deposits			0–45			High gravel deposits (unnamed) Silt, fine sand, and gravel containing boulders of quartz and chert as much as 12 inches in diameter	High gravel deposits (unnamed) Underlies area of low relief marking an ancient drainage channel about 700 feet above sea level.	High gravel deposits (unnamed) Yield to wells is unknown.
PENNSYLVANIAN			Conemaugh formation	Pcm		0–600	Morgantown(?) sandstone member[1]	Morgantown(?) sandstone member Sandstone, very massive in places; averages 50 feet in thickness.	Conemaugh formation Variegated siltstones and claystones with massive sandstones in the lower part. Contains a few thin coals and limestones.	Conemaugh formation Forms hilly area of moderate relief in Boyd County, western Carter and Greenup Counties, and northern Lawrence County.	Conemaugh and Breathitt formations Along the western margin of the area, in the Cumberland Plateau section, yields more than 500 gpd to almost half the wells drilled in valley bottoms. Yields more than 100 gpd to more than half the wells drilled on hillsides and about half the wells drilled on hilltops. Nearly everywhere else in the area yields more than 500 gpd to most of the wells drilled in valley bottoms. Yields more than 500 gpd to almost half the wells drilled on hillsides, and smaller quantities of water to wells on hilltops. Most common aquifers are sandstone and shale, but coal supplies water to a few wells. Joints and openings along bedding planes yield most of the water to wells. Waters are highly variable in chemical character. May contain salty water at depths less than 100 feet below the principal valley bottoms in most parts of the area with the exception of the Cumberland Plateau section and Irvine-Paint Creek uplift.
							Ames limestone member[1]	Ames limestone member Limestone, siliceous and highly fossiliferous; 8 to 10 feet thick.			
							Buffalo sandstone member[1]	Buffalo sandstone member Sandstone, very massive in places; averages about 45 feet in thickness.			
							Brush Creek limestone member[1]	Brush Creek limestone member Limestone, silty, fossiliferous; locally contains abundant layers and nodules of fossiliferous chert; about 2 feet thick.			
							Mahoning sandstone member[1]	Mahoning sandstone member Sandstone, locally conglomeratic and massive, maximum thickness 100 feet.			
							Vanport limestone member[1]	Vanport limestone member Limestone, light-gray, massive. Contains marine fossils and is replaced in a few localities by fossiliferous chert. The member is 2 to 5 feet thick.			
							Homewood sandstone member[2]	Homewood sandstone member Sandstone, coarse-grained and massive, ranging in thickness from a few feet to 100 feet.			
			Breathitt formation	Pbt		475–1300±	Magoffin beds[3]	Magoffin beds Siltstone containing marine fossils or, in the northern part of the area, a thin limonitic "ore bed". In the southern part of the area the unit is an argillaceous or arenaceous limestone containing abundant marine fossils. Spheroidal concretions or lentils of concretionary limestone are common at the top. The unit is 0 to 15 feet thick.	Breathitt formation Siltstone, sandstone, and claystone. Minor constituents are coal, clay, ironstone, limestone, and chert. Siltstones are gray and micaceous. Sandstones are gray, "dirty," and of the subgraywacke type; some are feldspathic. Claystones are dark and light gray and may contain ironstone concretions. Plant fossils are common in all the clastic rocks. Ironstones occur in discontinuous beds. Clays with rootlets commonly underlie coal. Calcareous rocks make up a very small part of the formation; several zones contain thin beds of limestone while others include silty or sandy limestone concretions. Cherts are fossiliferous and occur in bands or nodules.	Breathitt formation Forms rounded hills and caps many ridgetops along the western margin of the area. Underlies valleys and forms the rugged hills of the entire eastern portion of the area with the exception of western Carter and Greenup Counties, and northern Lawrence County. Sandstones form narrow valleys and cliffs or steep slopes on hillsides. Tops of hills and ridges commonly are capped by sandstone. Shales form wide valleys and moderate or gentle slopes on hills.	
							Fire clay coal	Fire clay coal Coal containing a flint or semi-flint clay parting. The parting is more common in the southern part of the area than in the northern parts.			
							Kendrick shale[4]	Kendrick shale Shale, dark or sandstone with silty, ellipsoidal, calcareous concretions. Contains marine fossils.			
			Lee formation	Ple		100–500±	Sharon conglomerate member[1]	Sharon conglomerate member Conglomeratic sandstone, massive, ranging from 40 to 100 feet in thickness.	Lee formation Sandstone and siltstone with lesser amounts of clay, claystone, coal, ironstone, and limestone. Sandstones are conglomeratic in places and quartzose. In the northern part of the area, the sandstones consist of one or two beds from 2 to 3 feet thick. In the southern part of the area sandstones in the Lee formation are massive, cliff-forming, and from 200 to 300 feet thick.	Lee formation Thick, resistant sandstones form an extensive upland (Cumberland Plateau section) in most of Lee County, western Wolfe, Morgan, and Elliott Counties, and in southern Elliott County. The upland is highly dissected along its western margin and northern part, and is characterized by steep-sided ridges and cliffs 100 to 200 feet high. Waterfalls and rock bridges, such as Natural Bridge and Sky Bridge, are common. Shaly areas of the Lee formation in western Lee County and in western Carter and Greenup Counties form steep-sided, rounded hills and ridges.	Lee formation In the Cumberland Plateau section with the exception of most of Lee County, yields more than 500 gpd to more than three-quarters of the wells drilled in valley bottoms. Yields more than 500 gpd to about three-quarters of the wells drilled on hillsides and about half the wells drilled on hilltops. In most of Lee County, yields more than 100 gpd to about three-quarters of the wells drilled on hilltops. Yields larger quantities of water to wells on hillsides and valley bottoms. In the Kanawha section with the exception of most of Carter and all of Greenup Counties yields more than 500 gpd to most wells drilled in valley bottoms. Yields more than 500 gpd to almost half the wells drilled on hillsides, and more than 100 gpd to almost three-quarters of the wells drilled on hilltops. In most of Carter and all of Greenup Counties yields more than 500 gpd to almost half the wells drilled in valley bottoms. Yields smaller quantities of water to wells on hills. Chief aquifer is sandstone, but shale and coal yield water to a few wells. Joints and openings along bedding planes, best developed in sandstones, supply most of the water to wells. Intergranular openings yield water to joints, and probably directly to some wells. Perched and semi-perched water tables are common. Yields moderately hard waters containing noticeable amounts of iron to wells. In some places, may yield salty water to wells drilled below drainage level
							Olive Hill fire clay[5]	Olive Hill fire clay Clay, of three refractory grades: (a) flint, (b) semi-hard, and (c) No. 2 plastic. The flint clay is generally buff or gray, and may contain oolites, pyrite concretions, or gypsum. The semi-hard and No. 2 plastic clays are softer and are characterized by numerous slickensided surfaces. From 0 to 27 feet thick.			
MISSISSIPPIAN	Upper Mississippian		Glen Dean limestone			0–48			Glen Dean limestone Limestone, bluish gray, fine to coarsely crystalline, fossiliferous, thick-bedded. May be interbedded with black, gray, or greenish shale.	Glen Dean limestone Crops out as thin ledges, generally high on hills, as far north as Carter County.	Upper Mississippian rocks Yields more than 500 gpd to nearly three-quarters of the wells drilled in valley bottoms, and to most wells drilled on hills. Yields little water where overlain by Pennsylvanian rocks. May yield more than 50 gpm to a few wells penetrating large solution cavities in limestone, the most common aquifer. Sandstone and shale yield water from fractures to a few wells. Waters generally are hard, and may be salty at shallow depth in a few places. Springs from solution cavities in limestone near stream level flow as much as 100 gpm.
			Limestones of early Chester age Ste. Genevieve limestone St. Louis limestone Spergen limestone[6] Warsaw limestone			0–210			Warsaw limestone—limestones of early Chester age Limestone, bluish, coarse-grained, oolitic, thick-bedded or massive; contains a few shale partings. Underlain by oolitic limestone containing quartz pebbles and dark limestone containing chert.	Warsaw limestone—limestones of early Chester age Underlies valleys in south-central Carter and western Elliott Counties. Forms steep hillsides and cliffs in western Lee, Menifee, Wolfe, and Carter Counties, in northwestern Morgan County, and in a few places in western Greenup County. Massive limestones form cliffs and solution features such as sinkholes, caves, and hanging valleys. Carter and Cascade Caves in southwestern Greenup County are well-known tourist attractions.	
	Lower Mississippian	Borden[6]	Muldraugh formation[7] Floyds Knob formation[6] Brodhead formation[7] New Providence shale[6]	Mu		340–600			Borden group Siltstone, containing beds of sandstone, claystone, and beds or lenses of limestone. Siltstones are dark, greenish, or yellowish gray to buff, and contain worm marks and *Taonurus*. Sandstones are fine to very fine grained and micaceous. Variegated shaly claystones are prominent in the uppermost part of the formation. Carbonate concretions are common throughout the section, but bedded limestones are prevalent only in the upper part. The limestones may contain beds, lenses, or patches of chert.	Borden group Underlies valley bottoms in Lee, Wolfe, and northwestern Morgan Counties. Underlies valley bottoms and lower hillsides in Carter and Greenup Counties. Forms hills and the bottoms of wide valleys in western Menifee County. Limestones and massive siltstones form ledges; shales produce dissected slopes.	Lower Mississippian rocks Yields more than 500 gpd (gallons per day) to almost half the wells drilled in valley bottoms, and smaller quantites of water to wells on hills. Maximum reported yield is 10 gpm (gallons per minute). Because shale makes up most of the unit, it is the most common aquifer; however, sandstone yields water to some wells and limestone to a very few. Water is supplied to wells chiefly through fractures. Commonly contains salty waters at depths less than 100 feet below the level of the principal valley bottoms.

[1]Member as used by Stockdale (1939)
[2]As used by Phalen (1912)
[3]Of Morse (1931)
[4]Of Jillson (1919)
[5]Of Crider (1913)
[6]As used by Stockdale (1939)
[7]Of Stockdale (1939)

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By

W. E. Price, Jr., Chabot Kilburn, and D. S. Mull

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