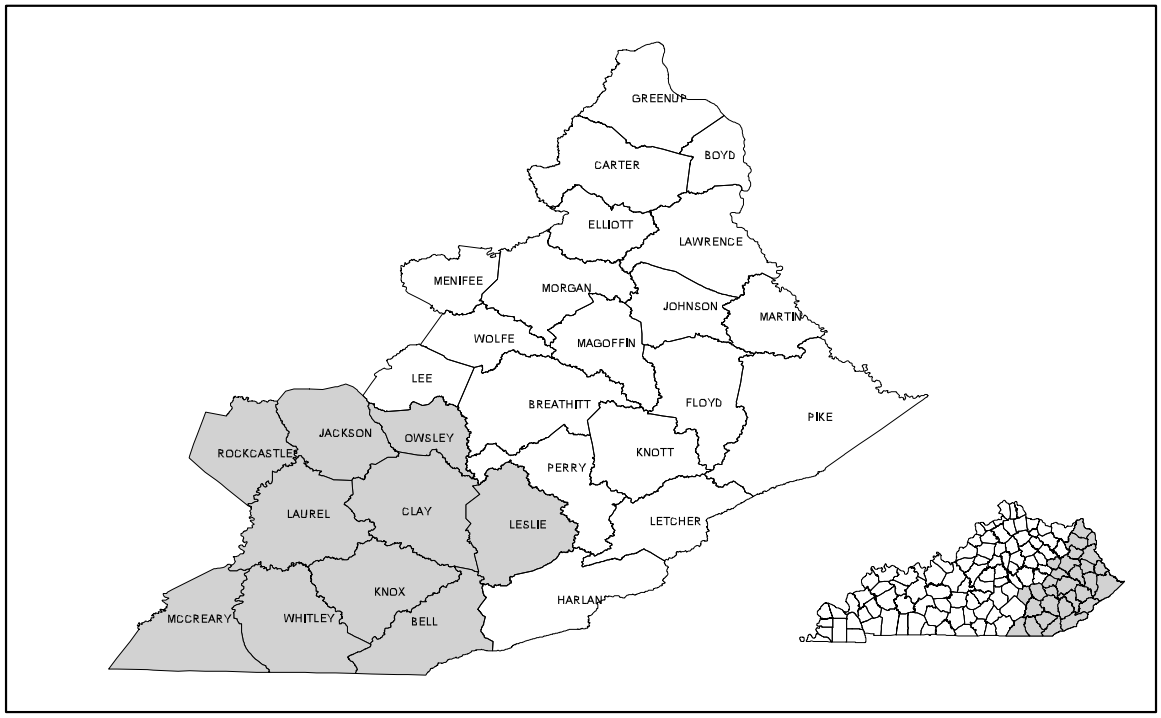
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

AVAILABILITY OF GROUND WATER IN BELL, CLAY, JACKSON, KNOX, LAUREL, LESLIE, McCREARY, OWSLEY, ROCKCASTLE, AND WHITLEY COUNTIES, KENTUCKY

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

HYDROLOGIC INVESTIGATIONS
ATLAS HA-38



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

HYDROLOGIC INVESTIGATIONS
ATLAS HA-38 (SHEET 1 OF 3)

EXPLANATION

- Qal — Alluvium — QUATERNARY
- Pbt — Breathitt formation — PENNSYLVANIAN
- Pple — Post-Lee Pennsylvanian rocks, undifferentiated — PENNSYLVANIAN
- Ple — Lee formation — PENNSYLVANIAN
- Mu — Mississippian rocks, undifferentiated — MISSISSIPPIAN
- MDu — Mississippian and Devonian rocks, undifferentiated — DEVONIAN AND MISSISSIPPIAN
- MDcl — Chattanooga shale and Devonian limestones, undifferentiated — DEVONIAN AND MISSISSIPPIAN

CARBONIFEROUS

Contact

Fault

Dashed where approximately located; dotted where concealed

SOURCES OF GEOLOGIC INFORMATION

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

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GEOLOGIC MAP OF BELL, CLAY, JACKSON, KNOX, LAUREL, LESLIE, MC CREARY, OWSLEY, ROCKCASTLE, AND WHITLEY COUNTIES, KENTUCKY

By

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

1962

SCALE 1:250 000

0 4 8 12 MILES

HYDROLOGIC INVESTIGATIONS
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THE KENTUCKY GEOLOGICAL SURVEY, UNIVERSITY OF KENTUCKY
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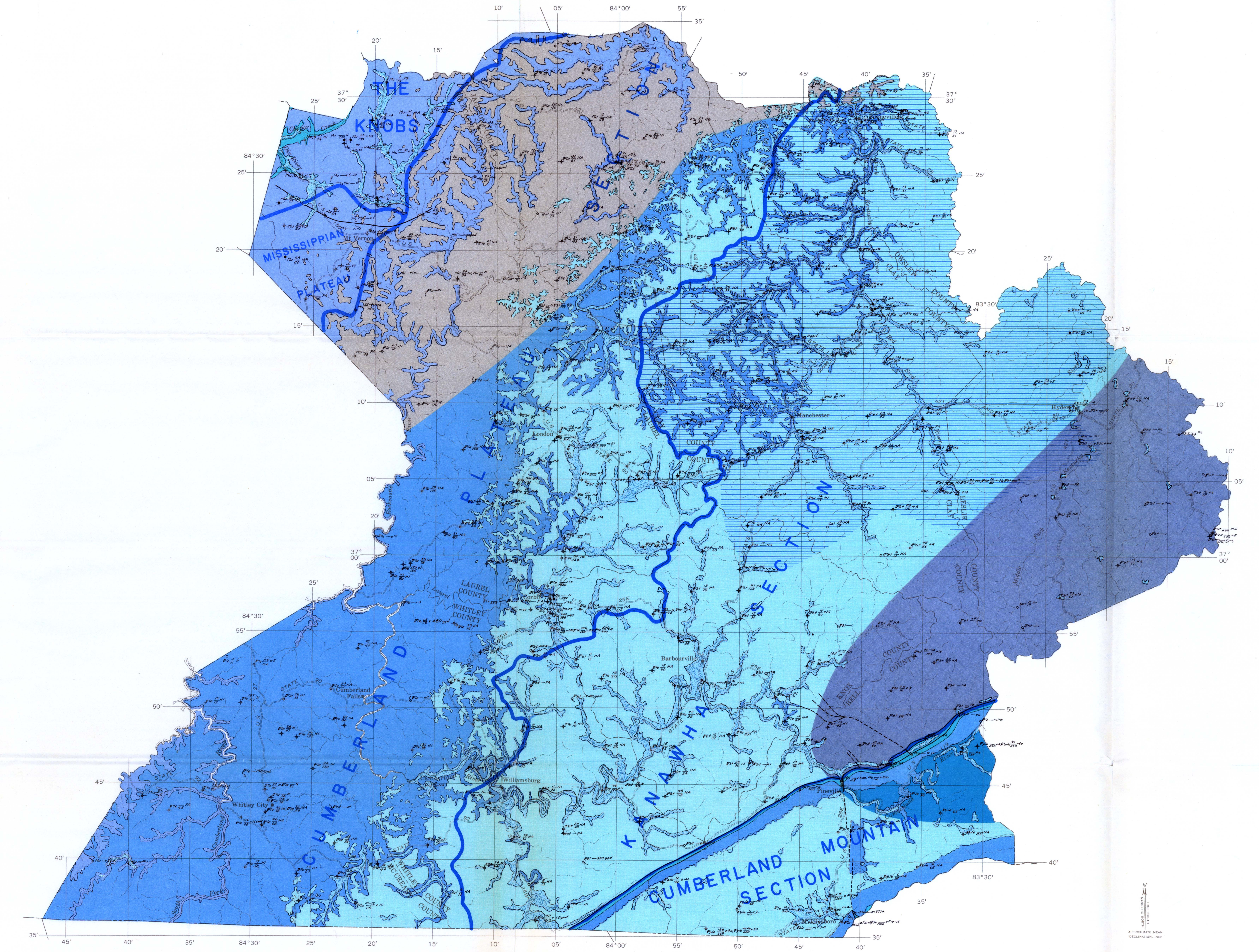


EXPLANATION

Symbol	Unit	System
Qal	Alluvium	QUATERNARY
Pbt	Breathitt formation	CARBONIFEROUS — PENNSYLVANIAN
Pple	Post-Lee Pennsylvanian rocks, undifferentiated	CARBONIFEROUS — PENNSYLVANIAN
Ple	Lee formation	CARBONIFEROUS — PENNSYLVANIAN
Mu	Mississippian rocks, undifferentiated	CARBONIFEROUS — MISSISSIPPIAN
MDu	Mississippian and Devonian rocks, undifferentiated	DEVONIAN AND MISSISSIPPIAN
MDcl	Chattanooga shale and Devonian limestones, undifferentiated	DEVONIAN AND MISSISSIPPIAN

Contact

Fault
Dashed where approximately located; dotted where concealed

THE KNOBS

The Knobs is a belt of conical hills and isolated ridges, underlain chiefly by Devonian and Lower Mississippian shales, lying between the Blue Grass region on the west and the Cumberland Plateau and Kanawha sections 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 domestic supply with bucket or hand pump (more than 100 gpd). A few are adequate for a modern domestic supply with a 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 yield smaller quantities of water than wells drilled in valley bottoms.

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

Water in the Chattanooga shale

Drilled wells.—Most wells drilled in valley bottoms are adequate for a minimum domestic supply. Wells on hillsides yield smaller quantities of water than wells drilled on valley bottoms

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 drilled 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 sandy material is present and the saturated thickness is 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 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 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.

Most of the water from drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water is found in few 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 suuply.

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 for a modern domestic supply.

Dug wells.—Wells on hillsides and in valleys yield larger quantities of water, but very few will produce more than 15 gpm. In this area, salty water is found in a few 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 the 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 water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms. Below 100 feet, probably no fresh water will be found.

Dug wells.—Most wells dug in valley bottoms are adequate for a minimum domestic suppy.

Most wells dug on hills are inadequate even for a minimum domestic supply.

Springs.—Springs with flows as large as 100 gpm occur near stream level. Most springs, however, yield less than 5 gpm

MISSISSIPPIAN PLATEAU

The Mississippian Plateau is a rolling upland marked with solution features. Because the plain is developed predominantly in Mississippian limestones, rocks in this region 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

Water in the Lee formation

Because the Lee formation in these areas lies above drainage and is of very small areal extent, it yields little water to wells

Water in Mississippian rocks

Drilled wells.—Fewer than half the wells drilled in valley bottoms underlain by shale and sandstone are adequate for a modern domestic supply. More than three-quarters of the wells drilled in valley bottoms underlain by shale and sandstone are adequate for a minimum domestic supply.

About three-quarters of the wells drilled in valley bottoms underlain by limestone are adequate for a modern domestic supply. Nearly all wells drilled in the valley bottoms underlain by limestone are adequate for a minimum domestic supply.

Most wells drilled on uplands underlain by limestone are adequate for a modern domestic supply. More than three-quarters of the wells drilled on uplands underlain by limestone are adequate for a minimum domestic supply.

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

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

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

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

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 obtained 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 sandy material is present and the saturated thickness as much as 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 because they are expensive and probably would yield only small quantities of water

Water in the Breathitt formation (subarea 1)

Drilled wells.—Most wells drilled 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 obtained from drilled wells is extremely hard and contains noticeable amounts of iron. Salty water may be found less than 100 feet below the level of the principal valley bottoms in places.

Dug wells.—Most wells 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 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 may yield enough water for small municipal or industrial supplies.

Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. In places along the northwestern margin 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 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.

Almost 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.—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 places in this area, at depths less than 100 feet. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

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

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

CUMBERLAND MOUNTAIN SECTION

The Cumberland Mountain section consists of two parallel mountain ridges trending to the northeast. Between them lies a rugged hilly area similar in topography to the Kanawha section, but of much greater relief. Because most of the people live along streams, nearly all wells are drilled in valley bottoms. Rocks in this area generally yield ample supplies of water for domestic use

Water in alluvium

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

Water in post-Lee Pennsylvanian rocks (subarea 1)

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

Wells drilled on hilltops yield smaller quantities of water than wells drilled on hillsides.

Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Probably few drilled wells in this area yield salty water less than 300 feet below the level of the principal valley bottoms.

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 post-Lee Pennsylvanian rocks (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 drilled in valley bottoms 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 drilled on hillsides are adequate for a minimum domestic supply.

Nearly all wells drilled on hilltops are adequate for a minimum domestic supply. About a third of the wells drilled on hilltops are adequate for a modern domestic supply.

Wells drilled more than 200 feet below the level of the principal valley bottoms may yield enough water for small municipal or industrial supplies.

Probably few wells in this area drilled less than 300 feet below the level of the principal valley bottoms will yield salty 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.

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

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

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

Wells drilled on hilltops yield smaller quantities of water than wells drilled on hillsides.

Wells in valley bottoms drilled through the entire thickness of the Lee formation may yield enough water for small municipal or industrial supplies.

Wells drilled into the Lee formation near the foot of Pine and Cumberland Mountains may flow.

Ground water obtained from most drilled wells in this area is soft but contains noticeable amounts of iron. Wells penetrating the full thickness of the Lee formation near the base of Pine Mountain or Cumberland Mountain probably will yield fresh water. Where the top of the Lee formation lies several hundred feet below the level of the bottoms of the principal valleys, the Lee formation may contain salty 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.

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

Water in rocks of Mississippian and Devonian age

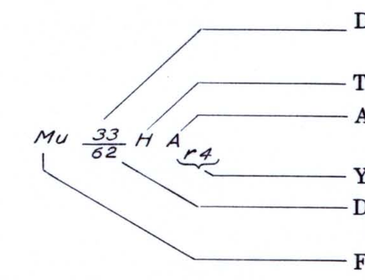
Drilled wells.—Wells drilled into Mississippian rocks lying below drainage in faulted areas may yield as much as several hundred gallons per minute. Wells that are drilled through the Mississippian rocks downdip from their outcrop on Pine and Cumberland Mountains may yield large quantities of water.

Springs from Mississippian rocks, principally limestones, yield more than 50 gpm; most, however, yield less than 10 gpm.

Devonian shales yield small amounts of water to wells and springs

Drilled well — Dug well

Drilled well yielding salty water — Spring



TYPE OF PUMP

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

ADEQUACY

- *A* Adequate
- *I* Inadequate

YIELD

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

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

AVAILABILITY OF GROUND WATER IN BELL, CLAY, JACKSON, KNOX, LAUREL, LESLIE, MC CREARY, OWSLEY, ROCKCASTLE, AND WHITLEY COUNTIES, KENTUCKY

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HYDROLOGIC INVESTIGATIONS
ATLAS HA-38 (SHEET 3 OF 3)

SYSTEM	SERIES	GROUP	FORMATION	SYMBOL	THICKNESS (IN FEET)	MINOR DIVISIONS	CHARACTER OF MINOR DIVISIONS	GENERAL CHARACTER OF FORMATIONS	TOPOGRAPHY	HYDROLOGY
QUATERNARY	Pleistocene and Recent		Alluvium	Qal	0–60			**Alluvium** Silt, clay, and minor amounts of sand and gravel.	**Alluvium** Forms narrow flood plains and underlies terraces. At least one well-developed terrace is present along the principal streams of the region.	**Alluvium** Yields more than 100 gpd to most dug wells. Where sandy material is present and saturated thickness great enough, would yield more than 500 gpd to screened drilled wells.
PENNSYLVANIAN	Pleistocene and Recent		Breathitt formation, post-Lee Pennsylvanian rocks	IPbt IPple	0–2500±	Magoffin beds [1]	Magoffin beds Limestone, fossiliferous, thin.	**Breathitt formation or undifferentiated post-Lee Pennsylvanian rocks** Siltstone, sandstone, and claystone, with lesser amounts of coal and clay. Very few limestones are present. Siltstones are gray, micaceous, and contain plant fragments. Some of the sandstones and claystones also contain fossil plants. Sandstones are gray and are characterized by an abundance of minerals of the clay-mica type and rock fragments. In the upper part of the formation the sandstones are feldspathic. Claystones are dark and light gray and contain ironstone at many places. Clays commonly underlie coal beds.	**Breathitt formation or undifferentiated post-Lee Pennsylvanian rocks** Underlies valleys and forms the hills of southeastern Whitley, Knox, Clay, Leslie, central and southeastern Owsley, and central Bell Counties. The topography is rugged, particularly in the southeastern part of the area. 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.	**Breathitt formation or undifferentiated post-Lee Pennsylvanian rocks** 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 on hillsides and about half the wells on hilltops. In southwestern Leslie and eastern Bell Counties yields more than 500 gpd to more than three-quarters of the wells drilled in valleys. Yields more than 500 gpd to about three-quarters of the wells on hillsides and more than 100 gpd to nearly all wells on hilltops. In the remainder of the area yields more than 500 gpd to almost half the wells on hillsides and smaller quantities of water to wells on hilltops. Yields water from sandstone, shale, and coal. Joints and openings along bedding planes supply 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 of Clay and Owsley Counties, and in northwestern Leslie County.
						Fire clay coal	Fire clay coal Coal with distinctive flint-clay parting.			
			Lee formation	IPle	350–1100±	Corbin sandstone member [2]	Corbin sandstone member Conglomeratic sandstone, pink, coarse-grained, friable; contains layers of thin-bedded hard sand. Weathers to rounded masses. Ranges in thickness from 0 to 200 feet.	**Lee formation** Two or three conglomeratic sandstones separated by claystones, siltstones, and a few thin coals. The sandstones are quartzose, massive, and crossbedded. Pebbles, in the conglomeratic phases of the sandstones, are quartz and may be distributed equally through the rock or concentrated in bands.	**Lee formation** Thick, resistant sandstones form the high ridges of Pine, Cumberland, and Rocky Face Mountains in Bell County, and underlie an extensive upland (Cumberland Plateau section) in McCreary, eastern Whitley, Laurel, southeastern Jackson, and northwestern Owsley Counties. Shaly facies of the Lee formation, cropping out in northwestern Laurel and Jackson Counties, form a highly dissected area of winding ridges and steep-sided hills.	**Lee formation** In northwestern Laurel, most of Jackson, and the western tip of Owsley 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. Elsewhere in the Cumberland Plateau section 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 on hillsides and about half the wells on hilltops. In the Kanawha section yields more than 500 gpd to most wells drilled in valley bottoms. Yields more than 500 gpd to almost half the wells on hillsides, and more than 500 gpd to almost three-quarters of the wells on hilltops. In the Cumberland Mountain section yields more than 500 gpd to about three-quarters of the wells drilled in valley bottoms. Yields more than 500 gpd to about half the wells on hillsides. Yields smaller quantities of water to wells on hilltops. Some wells in Middlesboro flow. Sandstone is the principal aquifer, but shale yields water to some wells and coal to a few. Joints and openings along bedding planes, best developed in sandstone, supply most of the water to wells. Perched and semi-perched water tables are common in the western part of the area. Waters are generally soft or moderately hard and contain noticeable amounts of iron. Salty waters are known to be present at shallow depth in most of Clay, Owsley, and northwestern Leslie Counties.
						Rockcastle sandstone member [2]	Rockcastle sandstone member Conglomeratic sandstone, coarse-grained, massive, cliff-forming. Ranges from 0 to 200 feet in thickness.			
						Livingston conglomerate [3]	Livingston conglomerate Sandstone, and conglomerate with well-rounded pebbles, poorly cemented; forms channel deposit.			
MISSISSIPPIAN	Upper Mississippian		Pennington shale	Mu	0–508			**Pennington shale** Shale, reddish and greenish; contains minor amounts of limestone and sandstone.	**Pennington shale** Forms moderate slope beneath outcrops of the Lee formation along the northwestern face of Pine Mountain and western margin of the area.	**Upper Mississippian rocks** Yields more than 500 gpd to almost all the wells drilled in valley bottoms and to most wells drilled on hills. Yields little water where overlain by Pennsylvanian rocks. May yield as much as 400 gpm to wells at Pineville. Water is chiefly from solution cavities in limestone, but sandstone and shale yield water from fractures to a few wells. May contain salty water at shallow depth in a few places. Springs yield more than 20 gpm from solution cavities in limestone.
			Glen Dean limestone		0–68			**Glen Dean limestone** Limestone, dark- to bluish-gray, fine- to medium-grained, with shaly beds near top.		
			Limestones of early Chester age Ste. Genevieve limestone St. Louis limestone Spergen limestone [4] Warsaw limestone		190–625			**Warsaw limestone—limestones of early Chester age** From top to bottom, consists of the following units: Limestone, whitish- to dark-gray, fine- to medium-grained, oolitic in places; contains green- to dark-gray shale, and shaly limestone in upper portion. Limestone, light-gray to whitish, fine-grained, oolitic, crossbedded; contains small amount of chert. Limestone, dark-gray to black, fine-grained, cherty; replaced in some areas by medium- to dark-gray geodiferous siltstone. Limestone, gray; contains beds of dark-gray to black shale, and light-brown, medium-grained sandstone. Limestone, light- to dark-gray, and light-brown medium-grained sandstone; replaced in some areas by medium- to dark-gray siltstone.	**Warsaw limestone—Glen Dean limestone** Forms steep slopes and cliffs along the northwest face of Pine Mountain in Bell County. Forms precipitous walls along streams in northwestern Jackson County and in the gorge of the Cumberland River in McCreary County. Forms cliffs on hillsides and underlies upland areas marked by solution features such as caves, sinks, and underground streams in western Rockcastle County.	
	Lower Mississippian	Borden [4]	Muldraugh formation [5] Floyds Knob formation [4] Brodhead formation [5] New Providence shale [5]	MDu	151–465			**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. **Price and Maccrady formations** Shale, grayish green and red, interbedded with very fine-grained sandstone; grades downwards into reddish and greenish shale with limonite stringers.	**Price and Maccrady formations** Forms moderate slopes along the northwestern face of Pine Mountain in Bell County.	**Borden group** Yields more than 500 gpd to almost half the wells drilled in valley bottoms, and smaller quantities of water to wells on hills. Reported to yield as much as 55 gpm (gallons per minute). Shale is the most common aquifer. Sandstone yields water to some wells and limestone to a very few. Fractures chiefly supply water to wells. Commonly contains salty water at depths less than 100 feet below the level of the principal valley bottoms. **Price and Maccrady formations** May yield more than 500 gpd to wells drilled into the formation near the foot of Pine Mountain. Will yield much less than this amount throughout most of its outcrop area.
DEVONIAN			Chattanooga shale	MDcl	66–500±			**Chattanooga shale** Shale, black, fissile.	**Chattanooga shale** Forms wide valleys in which Copper Creek and Dix River in northwestern Rockcastle County flow, and moderate slopes at the base of Pine Mountain in Bell County.	**Chattanooga shale** In Rockcastle County yields more than 100 gpd (gallons per day) to most wells drilled in valley bottoms. Yields smaller quantities of water to wells on hillsides. Water is from fractures, and may be salty, sulfurous, or high in iron. On Pine Mountain yields little or no water to wells.
			Duffin and Boyle limestones [6]		0–12±			**Duffin and Boyle limestones** Limestone, brown, sandy, porous; contains small quartz pebbles.	**Duffin and Boyle limestones** Forms the valley bottoms of the lower part of Copper Creek and Dix River in northwestern Rockcastle County.	**Duffin and Boyle limestones** Yields small quantities of water to wells.

[1] Of Morse (1931)
[2] Member, as used by Stockdale (1939)
[3] Of Miller (1908)
[4] As used by Stockdale (1939)
[5] Of Stockdale (1939)
[6] Of Foerste (1905, 1906); as used by Savage (1930)

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GENERALIZED COLUMNAR SECTION IN BELL, CLAY, JACKSON, KNOX, LAUREL, LESLIE, MC CREARY, OWSLEY, ROCKCASTLE, AND WHITLEY COUNTIES, KENTUCKY

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