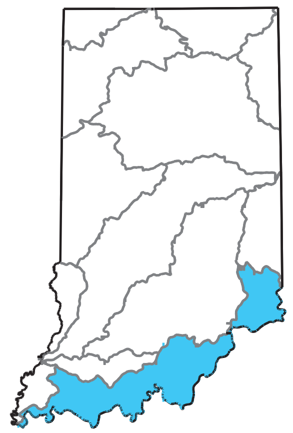


OHIO RIVER BASIN

By M. Catharine Woodfield and Joseph M. Fenelon

General Description

The Ohio River basin is the southernmost water-management basin in Indiana. It extends approximately 200 mi across southern Indiana, from Lawrenceburg in eastern Indiana to about 10 mi southwest of Mt. Vernon in western Indiana (fig. 78). The Ohio River basin, the fourth largest basin in the State, encompasses 4,224 mi^2. The basin includes all of Ohio, Switzerland, Floyd, Harrison, and Perry Counties and large parts of Dearborn, Ripley, Jefferson, Clark, Washington, Crawford, Spencer, Warrick, and Vanderburgh Counties. Principal cities within the basin include Evansville, New Albany, Madison, Lawrenceburg, Jeffersonville, Mt. Vernon, Salem, Boonville, Tell City, and Charlestown.

Previous Studies

Pettijohn and Reussow (1969) authored a study of ground-water resources in the Ohio River basin. Their report defined the geohydrology of the principal water-bearing units, well yields to streams, and the ground-water quality within the water-bearing units.

Ground-water resources were assessed in comprehensive reports on Posey County (Robison, 1977), Vanderburgh County (Cable and Wolf, 1977), and Gibson County (Barnhart and Middleman, 1990). These county reports include well yields and thicknesses for bedrock and unconsolidated aquifers, and maps of the surfaces of some of the sandstone aquifers. Results of water-quality analyses are also reported and discussed. Gallaher and Price (1966) wrote a comprehensive report of the hydrogeology of the alluvial deposits within the Ohio River Valley in Kentucky and the availability and quality of the ground water within these deposits. Price (1964a, 1964b, 1964c) prepared hydrogeologic sections and mapped the hydrology and geology of the alluvial deposits along the Ohio River in Kentucky. Harvey (1956) described the geology and ground-water resources of the Henderson, Ky., area along the Ohio River. He included chemical composition, yield, and recharge and discharge areas for selected geologic formations.

Several general references on ground-water hydrology of Indiana include the Ohio River basin. Clark (1980) described the various types of aquifers and their potential yields. Bechert and Heckard (1966) delineated ground-water provinces on the basis of well yields and the sources of ground water. Ground-water resources of each county in Indiana were described by Harrell (1935).

Physiography

The physiography of the Ohio River basin is primarily bedrock controlled but was affected by the relocation of the pre-Pleistocene Teays River drainage into the Ohio River valley during the Pleistocene. The basin is characterized by considerable relief and a wide variety of topographic features that are the result of weathering, stream erosion, and mass movement. During Pleistocene time, the western two-thirds of the Ohio River basin was not glaciated; thus, the topography strongly reflects bedrock control. The eastern one-third of the basin was glaciated, but glacial deposits are not thick enough to obscure the bedrock relief.

The seven physiographic regions in the Ohio River basin trend north-northwest in conformity with the strike of the bedrock (fig. 79). East to west, these regions are the Dearborn Upland, Muscatatuck Regional Slope, Scottsburg Lowland, Norman Upland, Mitchell Plain, Crawford Upland, and Wabash Lowland (Schneider, 1966, p. 42).

The Dearborn Upland is a dissected plateau underlain by flat-lying limestones and shales. Streams that originate in this area are short; they have steep slopes and are entrenched as much as 450 ft in the upland plain (Schneider, 1966, p. 43). Parts of the plateau are thoroughly dissected; however, broad plains of virtually unmodified land remain well above the dissecting streams. The western boundary of the Dearborn Upland is defined by an escarpment that marks a major drainage divide between the generally west-southwest-flowing streams of the East Fork White River and Muscatatuck River drainage basins and the south and southeast-flowing streams of Indian-Kentuck Creek and Laughery Creek drainage basins.

A structurally controlled area, referred to as the Muscatatuck Regional Slope, lies west of the Dearborn Upland. Resistant, westward-dipping Silurian and Devonian carbonate rocks underlie this gently sloping plain. Near the Ohio River, the plain slopes westward from 875 ft to about 500 ft above sea level (Malott, 1922, p. 87).

The Muscatatuck Regional Slope subtly grades westward into the Scottsburg Lowland. The Scottsburg Lowland is an asymmetric trough underlain by New Albany Shale. The Lowland attains an elevation of 500 ft above sea level near the Ohio River and is primarily an expansive valley of little relief (less than 75 ft) (Schneider, 1966, p. 45). The western boundary of the Scottsburg Lowland lies at the base of a 400 to 600-ft high scarp, known as the Knobstone Escarpment (R. 6 E. in section 12L–12L′, fig. 82). The escarpment, one of the most prominent topographic features in Indiana, marks the boundary between the pre-Wisconsinan drift and the driftless area.

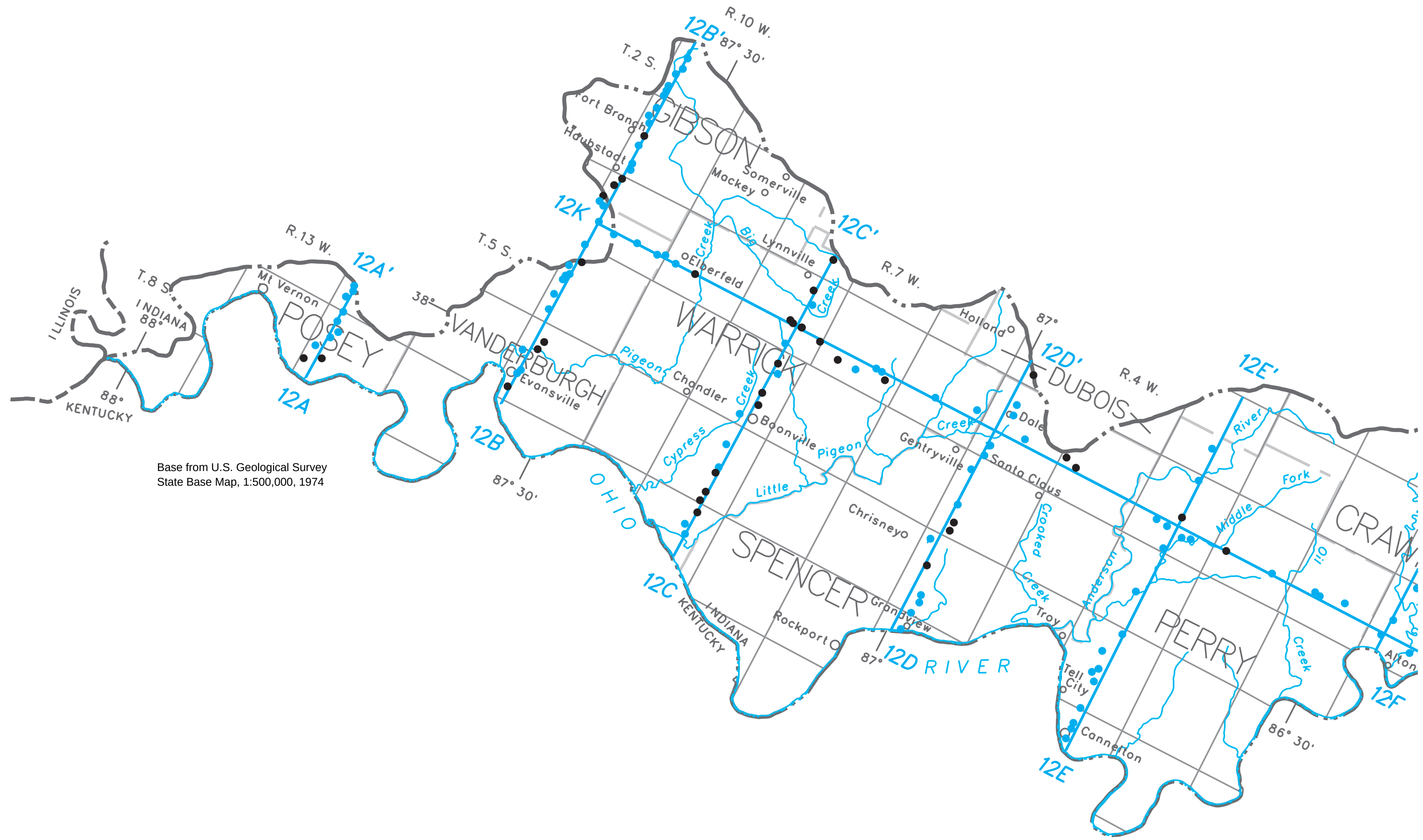
The Norman Upland, a dissected plateau above the Ohio River underlain by siltstones interbedded with soft shales, lies west of the escarpment (Schneider, 1966, p. 46). The area is characterized by flat-topped narrow divides and steep, V-shaped valleys. The western boundary of the Norman Upland extends along a line between deeply dissected clastic rocks and a limestone valley plain called the Mitchell Plain (Malott, 1922, p. 93-94).

The Mitchell Plain is formed on the dip slope of a thick sequence of limestones. The area has low relief and is marked by sinkholes and other solution features. In a few places, the Mitchell Plain is crossed by deeply entrenched streams, but much of the drainage is underground. Streams generally traverse the surface for only a short distance before disappearing into sinkholes.

The Crawford Upland, west of the Mitchell Plain, is characterized by a considerable increase in altitude and by a great diversity of relief and landforms. The relief is due to differential erosion of alternating beds of sandstone, shale, and limestone (Schneider, 1966, p. 48). Abundant stream valleys in the upland form a mature drainage system.

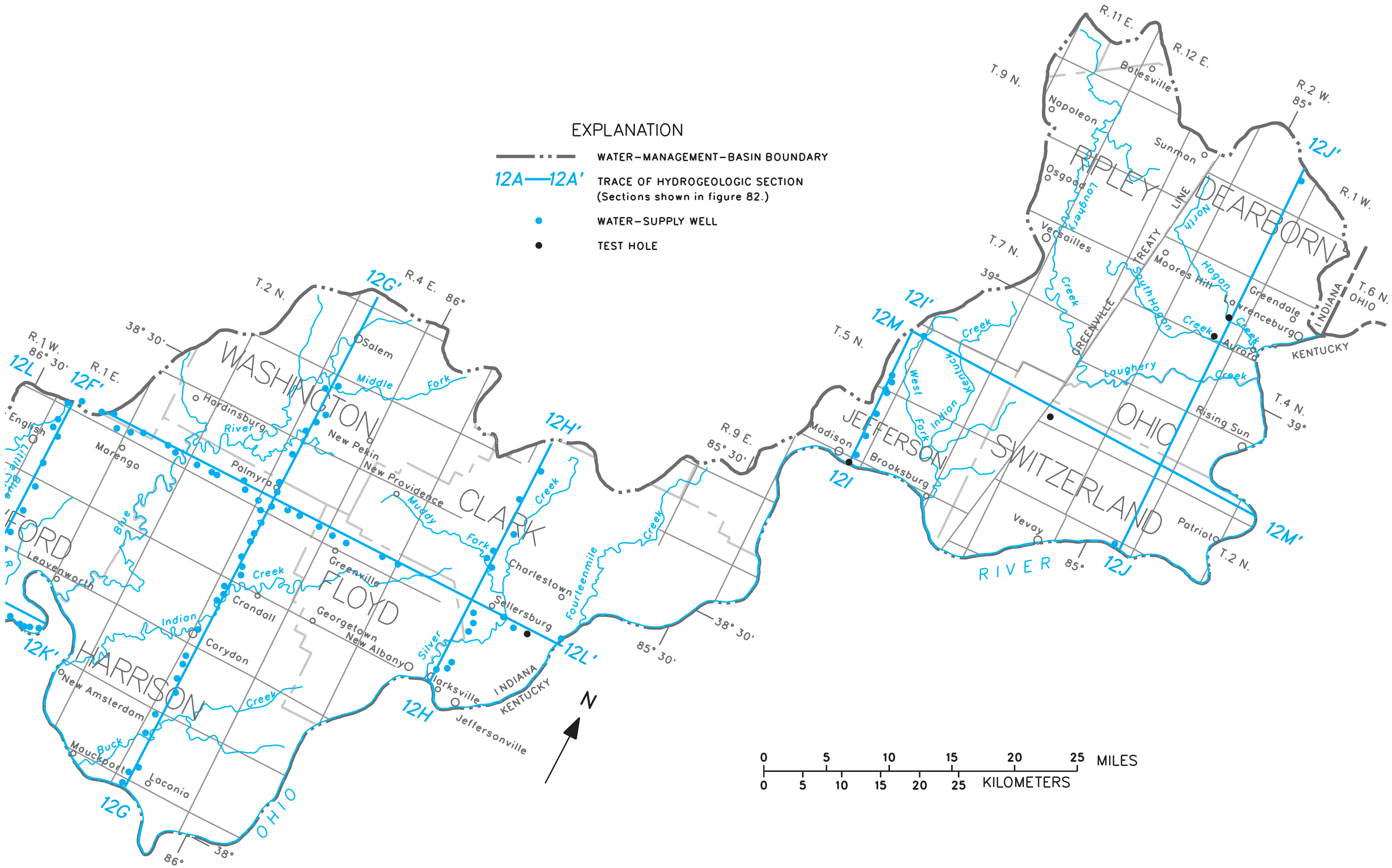
The Wabash Lowland is the farthest west of the physiographic regions. It is underlain primarily by sandstone and shale of Pennsylvanian age and is characterized by broad aggraded valleys and rounded hills. Thick lake (lacustrine) and river (alluvial) sediments and outwash deposits overlie the bedrock in places. Along the Ohio River are broad, terraced valley-fill sediments.

One of the most important hydrogeologic and physiographic features of the Ohio River basin is the Ohio River valley. It is widest in the Wabash Lowland and extends along the entire southern boundary of the basin. The width of the Ohio River valley in Indiana ranges from a few hundred feet near Leavenworth to about 6 mi near Evansville (Pettijohn and Reussow, 1969, p. 4). The Ohio River flows in only a small part of this old glacial drainageway. The drainageway is a deeply entrenched U-shaped valley that is very shallow in most places relative to its width. Tributary streams drain the valley floor, depositing fine-grained alluvium over coarse-grained outwash deposits (Pettijohn and Reussow, 1969, p. 10).



Base from U.S. Geological Survey
State Base Map, 1:500,000, 1974

Figure 78. Location of section lines and wells plotted in the Ohio River basin.


EXPLANATION
WATER–MANAGEMENT–BASIN BOUNDARY
12A—12A′ TRACE OF HYDROGEOLOGIC SECTION (Sections shown in figure 82.)
WATER–SUPPLY WELL
TEST HOLE
WASHINGTON
CLARK
FLOYD
HARRISON
JEFFERSON
SWITZERLAND
OHIO
RIPLEY
DEARBORN
INDIANA
KENTUCKY
OHIO RIVER
0 5 10 15 20 25 MILES
0 5 10 15 20 25 KILOMETERS
N

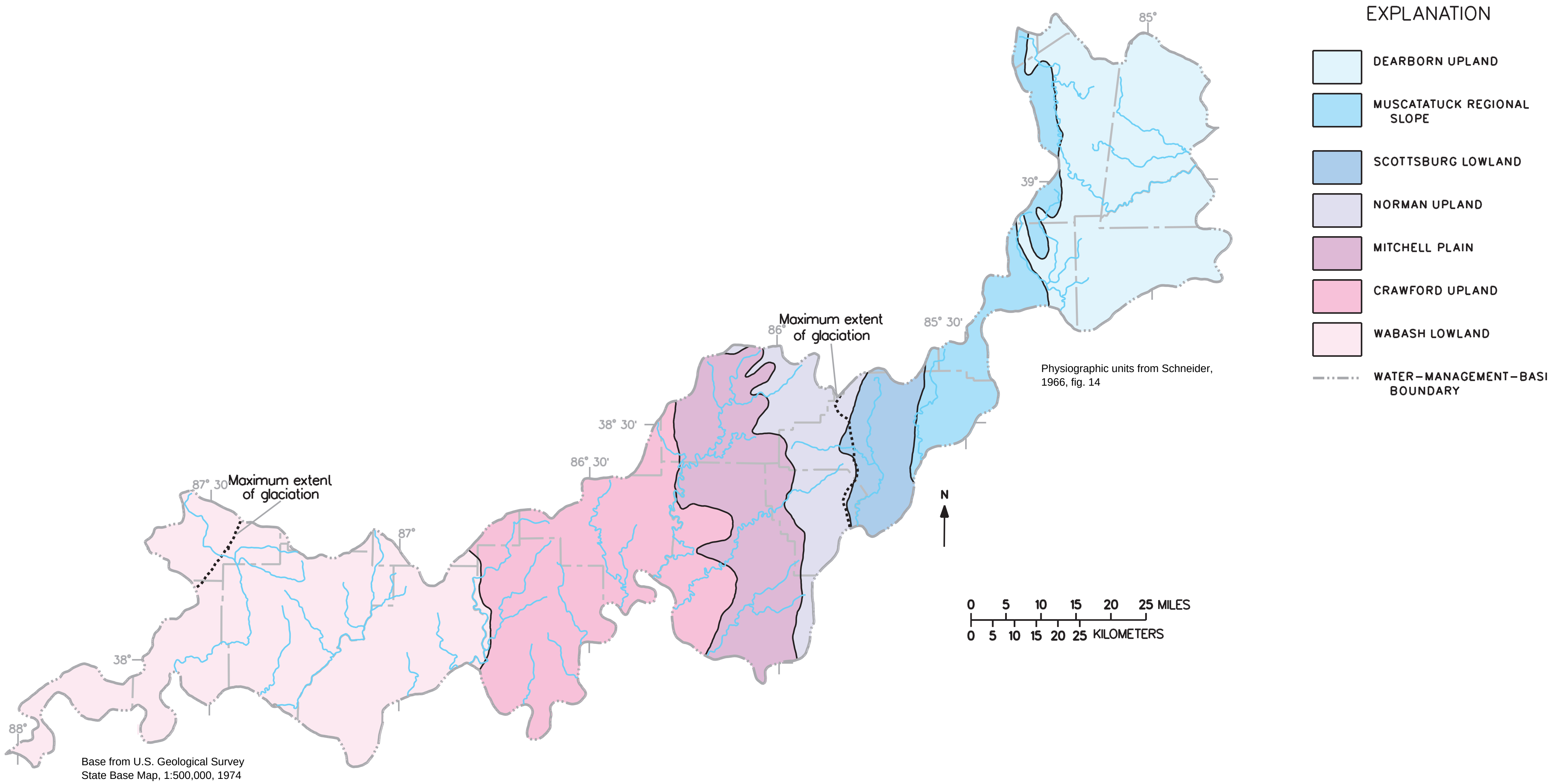


Figure 79. Physiographic units and extent of glaciation in the Ohio River basin.

Surface-Water Hydrology

The Ohio River is a major eastern tributary of the Mississippi River and forms the entire State boundary between Indiana and Kentucky. The total drainage area of Indiana streams that discharge into the Ohio River, excluding the Wabash and Whitewater River basins, is 4,224 mi^2. The Lower Ohio River was the name given to the Indiana part of the Ohio River by the State of Indiana in the State Water Plan (Pettijohn and Reussow, 1969, p. 4), but for the purpose of this report, it will be referred to as the Ohio River.

Meandering along Indiana's southern border for 357 mi, the Ohio River flows in a general southwesterly direction. River segments upstream of Cannelton follow bedrock fractures through many angled turns. The river descends 135 ft in elevation from the eastern side of the basin to the western side, resulting in an average gradient of 0.38 ft/mi. The flow of the river is affected by numerous dams operated by the U.S. Army Corps of Engineers.

Tributary streams with more than 100 mi^2 of drainage area that flow into the Ohio River are from east to west, Hogan Creek, which includes the North and South Forks (128 mi^2); Laughery Creek (343 mi^2); Indian-Kentuck Creek (153 mi^2); Fourteenmile Creek (101 mi^2); Silver Creek (219 mi^2); Indian Creek (257 mi^2); Blue River (524 mi^2); Little Blue River (172 mi^2); Anderson River (258 mi^2); Little Pigeon Creek (360 mi^2); and Pigeon Creek (368 mi^2). Some of the streams (including South Hogan Creek, Indian-Kentuck Creek, Silver Creek, and Middle Fork of Anderson River) have gone dry at times during most years of record (Arvin, 1989).

All of the tributary streams of the Ohio River in Indiana originate within 30 mi of the Ohio River, with the exception of the Blue River, which originates approximately 52 mi from the Ohio River (Malott, 1922, p. 75). Just west of Madison, the drainage divide between the Ohio River and the East Fork White River is within 2 mi of the Ohio River.

Geology

Bedrock Deposits

The major geologic structures within the Ohio River basin are the Cincinnati Arch and the Illinois Basin (fig. 4). The crest of the Cincinnati Arch trends northwest and crosses the eastern part of the Ohio River basin. The bedrock at the crest of the arch is nearly horizontal. West and southwest of the arch crest, the rocks dip at an average of 25 ft/mi into the Illinois Basin (Gutschick, 1966, p. 10).

The Paleozoic carbonate rocks that underlie the Ohio River basin range in age from Cambrian to Pennsylvanian (fig. 5). The deeply buried Cambrian rocks are composed of a sequence of sandstone, shale, limestone, and dolomite. Several thousand feet of buried Ordovician rocks overlie the Cambrian rocks (Gray and others, 1987). The Ordovician rocks are predominantly composed of dolomite, limestone, and some sandstone. Ground water is not withdrawn from these rocks because of their depth and because the water has high concentrations of dissolved solids.

The buried Ordovician rocks are overlain by the Ordovician Lexington Limestone, the oldest exposed rock unit in the basin. This fossiliferous limestone attains a maximum thickness of 256 ft in southeastern Indiana (Shaver and others, 1986, p. 78). The upper part of the Lexington Limestone is exposed at the bedrock surface in discontinuous stretches along the banks of the Ohio River in eastern Switzerland County (sections 12J–12J′ and 12M–12M′, fig. 82).

The Ordovician Maquoketa Group, consisting of the Kope, Dillsboro, and Whitewater Formations (fig. 80) overlies the Lexington Limestone. The Kope Formation is a 300- to 400-ft-thick sequence, 95 percent of which is shale (Shaver and others, 1986, p. 72). The formation is exposed mainly along the lower reaches of the deeply entrenched streams of North and South Hogan Creeks, Laughery Creek, Indian-Kentuck Creek, and along other smaller tributaries to the Ohio River. A transitional contact between the Kope Formation and the overlying Dillsboro Formation is marked by an upward increase in the proportion of limestone (Gray, 1972, p. 14). The Dillsboro Formation is a 400-ft-thick sequence consisting of about 30 percent fossiliferous and clayey limestones and 70 percent calcareous shale (Shaver and others, 1986, p. 37). It is conformably overlain by the Whitewater Formation, which is composed of less than 60 to 100 ft of bluish-gray limestone interbedded with calcareous shale (Shaver and others, 1986, p. 168). The Whitewater Formation is exposed in a north-northeastern band along the eastern margin of the basin and in the entrenched headwaters of Laughery and Indian Creeks.

The Whitewater Formation is overlain unconformably by the Silurian Brassfield Limestone, Salamonie Dolomite, Waldron Shale, and Louisville Limestone (fig. 80). The Brassfield Limestone consists of 4 to 20 ft of medium- to coarse-grained fossiliferous limestone containing minor amounts of shale (Shaver and others, 1986, p. 20). The Salamonie Dolomite overlies the Brassfield Limestone and consists predominantly of limestone and dolomite with minor amounts of shale and chert. The Salamonie Dolomite is 0 to 60 ft thick along the eroded edges of the outcrop area in southeastern Indiana. The Waldron Shale overlies the Salamonie Dolomite and is composed of about 5 ft of shale that contains siltstone and fossiliferous limestone beds, which are reeflike in many places. The Louisville Limestone, a fine-grained, thick-bedded, clayey and dolomitic limestone that is approximately 40 to 75 ft thick overlies the Waldron Shale (Shaver and others, 1986, p. 83). Outcrops of the Louisville Limestone in the southeastern part of the basin are overlain unconformably by the Devonian Muscatatuck Group (fig. 80).

The Muscatatuck Group is composed predominantly of fine-grained to granular dolomite and limestone. The carbonate rocks range from pure to sandy or shaly. The lower part of the Muscatatuck Group contains some anhydrite and gypsum (Shaver and others, 1986, p. 99). The Muscatatuck Group is exposed on the western side of the Cincinnati Arch and is zero to more than 250 ft thick in the basin.

Overlying the Muscatatuck Group is the Devonian and Mississippian New Albany Shale, composed primarily of brownish-black, carbon-rich shale and greenish-gray shale. The New Albany Shale is about 100 ft thick near its outcrop area in Clark County.

Rocks of Mississippian age in the Ohio River basin include the Borden, Sanders, Blue River, West Baden, Stephensport, and Buffalo Wallow Groups (fig. 80). The Borden Group overlies the New Albany Shale and is composed primarily of gray clayey siltstone and shale with fine sandstone. Sparse interbedded limestones form discontinuous lenses. This group, extending from the Ohio River in southern Floyd County northward, is about 500 ft thick in the basin, and has an outcrop width of about 6 to 12 mi within the east-central part of the basin.

Carbonate rocks of the Sanders and Blue River Groups overlie and crop out west of the Borden Group. A complex relation among a variety of carbonate rocks exists within the Sanders Group (Shaver and others, 1986, p. 136). At the base is a mixture of fine-grained dolomite and limestone with chert. Above these rocks lies a sequence of well-cemented bioclastic limestones and dolomites. The thickness of the Sanders Group is about 120 ft in the outcrop area. The Blue River Group is composed primarily of carbonate rocks but contains significant amounts of gypsum, anhydrite, shale, chert and calcareous sandstone (Shaver and others, 1986, p. 16). The Blue River Group is about 540 ft thick at outcrops in southern Crawford and Harrison Counties.

Complexly interbedded rocks of the West Baden, Stepensport, and Buffalo Wallow Groups overlie the Blue River Group. The West Baden Group is composed predominantly of shale, mudstone, thin-bedded to cross-bedded sandstone, and limestone (Shaver and others, 1986, p. 16). Along the outcrop area in the central part of the basin, the thickness ranges from 100 to 140 ft. The Stephensport Group, which is 130 to 230 ft thick, is composed of approximately equal parts of limestone, shale, and sandstone (Shaver and others, 1986, p. 150). The Buffalo Wallow Group consists of a shale, mudstone, and siltstone sequence with thin, laterally extensive beds of limestone and sandstone (Shaver and others, 1986, p. 24). Its maximum exposed thickness is 270 ft near the Ohio River. The Buffalo Wallow Group does not crop out north of southwestern Orange County because it was truncated by pre-Pennsylvanian erosion.

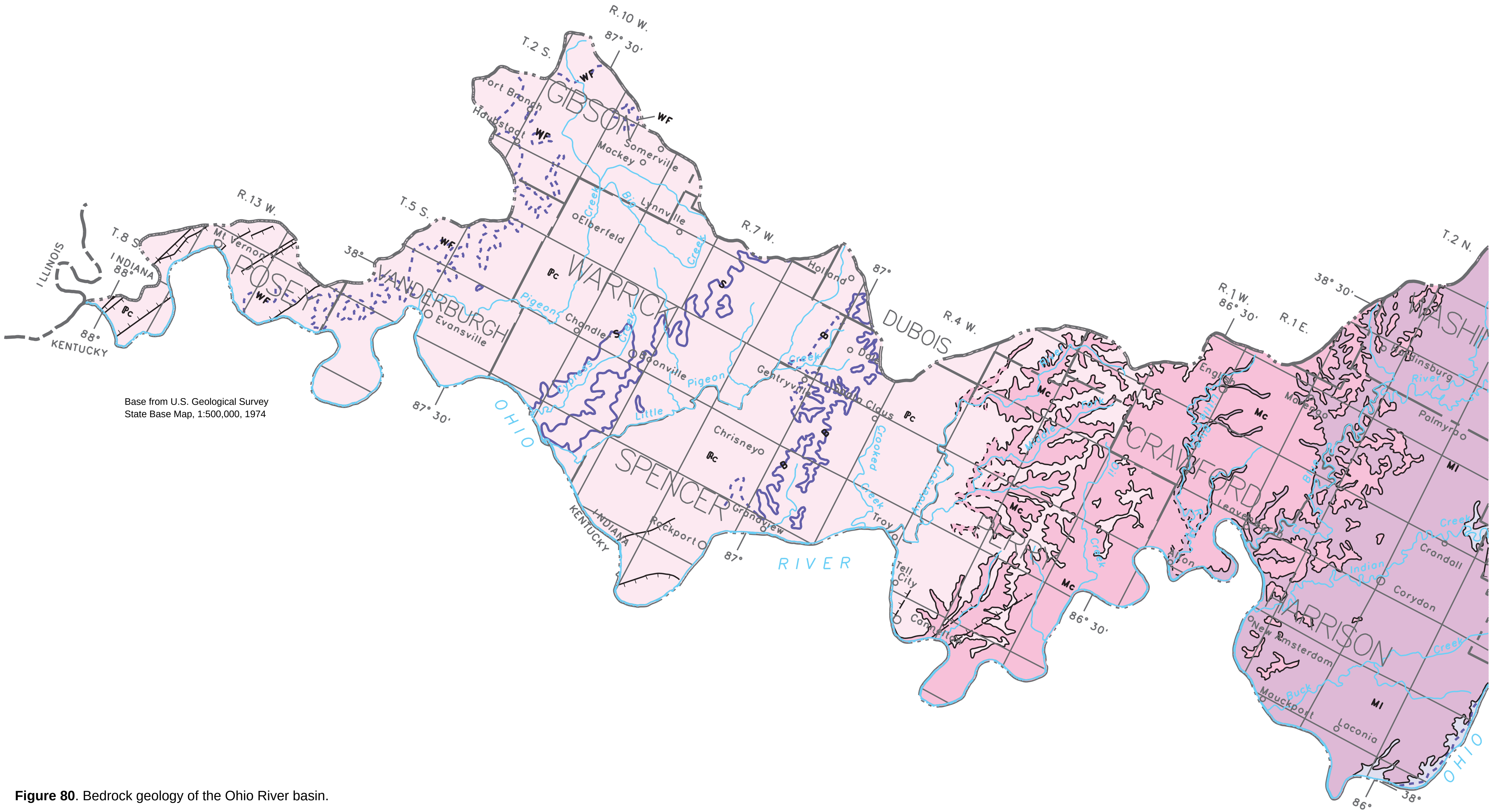
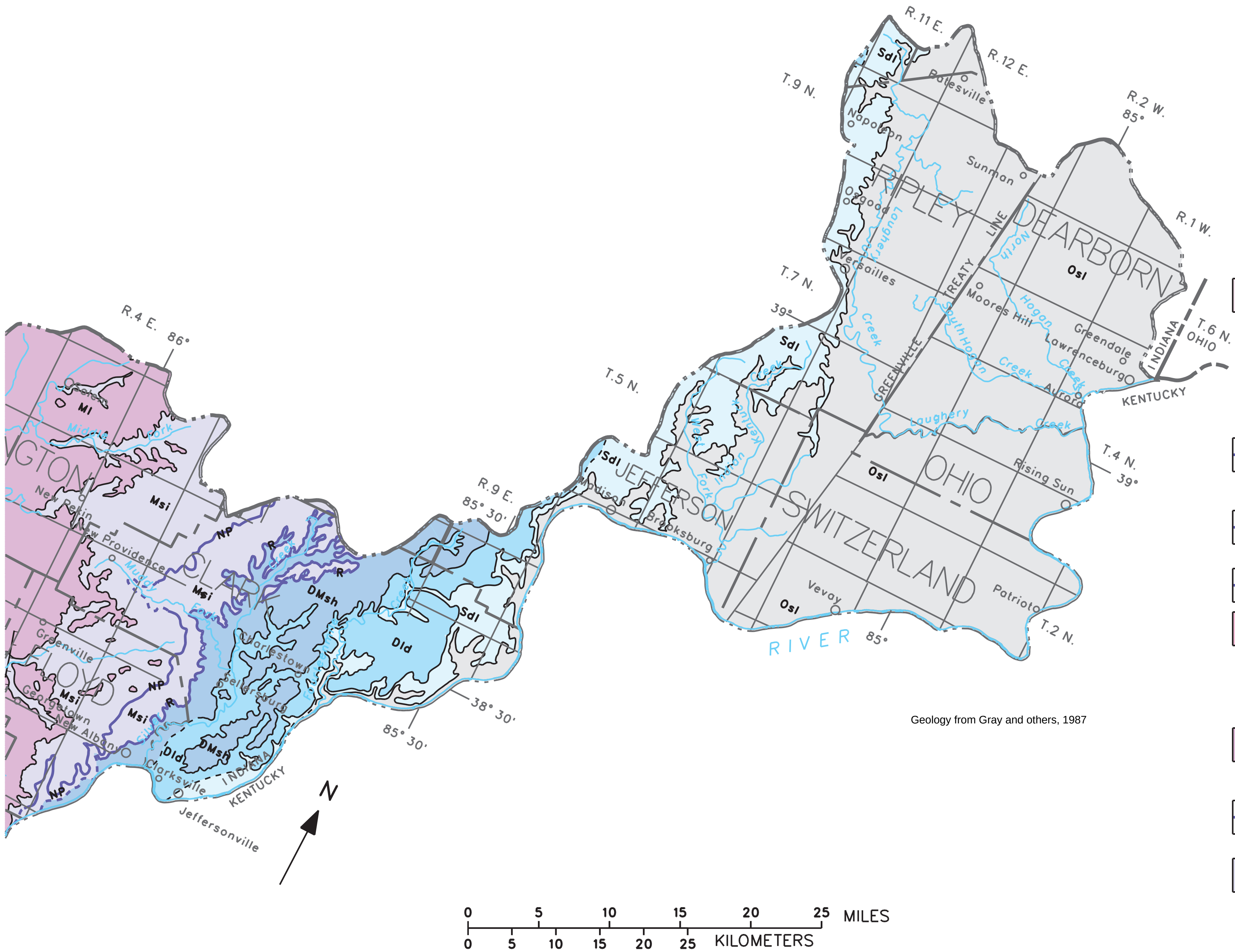


Figure 80. Bedrock geology of the Ohio River basin.



Geology from Gray and others, 1987

EXPLANATION

- **Pc** — PENNSYLVANIAN COMPLEXLY INTERBEDDED SHALE AND SANDSTONE, WITH THIN BEDS OF LIMESTONE AND COAL-- Composed of the Racoon Creek and Carbondale Groups and the Shelburn, Patoka, and Bond Formations of the McLeansboro Group
- **WF** — WEST FRANKLIN LIMESTONE MEMBER OF SHELBURN FORMATION
- **S** — SPRINGFIELD COAL MEMBER (COAL V)
- **B** — BUFFALOVILLE COAL MEMBER
- **Mc** — MISSISSIPPIAN COMPLEXLY INTERBEDDED SHALE, SANDSTONE AND LIMESTONE-- Composed of the West Baden, Stephensport, and Buffalo Wallow Groups
- **Ml** — MISSISSIPPIAN LIMESTONE-- Composed of the Sanders and Blue River Groups
- **NP** — TOP OF NEW PROVIDENCE SHALE
- **Msi** — MISSISSIPPIAN SILTSTONE AND SHALE WITH MINOR SANDSTONE AND DISCONTINUOUS LIMESTONE-- Composed of the Borden Group
- **R** — ROCKFORD LIMESTONE
- **DMsh** — DEVONIAN AND MISSISSIPPIAN SHALE-- Composed of the New Albany Shale
- **Dld** — DEVONIAN LIMESTONE AND DOLOMITE-- Composed of the Muscatatuck Group
- **Sdl** — SILURIAN DOLOMITE AND LIMESTONE-- Composed of the Louisville Limestone through Brassfield Limestone
- **Osl** — ORDOVICIAN SHALE AND LIMESTONE-- Composed of the Lexington Limestone, and the Kope, Dillsboro, and Whitewater Formations
- NORMAL FAULT-- Hachures on downthrown side. Dashed where approximately located
- GEOLOGIC CONTACT-- Dashed where approximately located
- WATER-MANAGEMENT-BASIN BOUNDARY

The youngest exposed bedrock in the Ohio River basin is of Pennsylvanian age (fig. 80). In ascending order, the groups that compose this rock assemblage are the Raccoon Creek, Carbondale, and the McLeansboro Groups. The Raccoon Creek Group is 95 percent shale and sandstone and 5 percent clay, coal, and limestone (Shaver and others, 1986, p. 120); small amounts of chert and sedimentary iron ore are found in the lower part of the group. The shale varies from soft and nonsilty to hard, silty, and sandy. The sandstone contains crossbedding and is mostly fine grained. The thickness of this group is variable because of the irregular unconformity between the Mississippian and Pennsylvanian rocks. The Raccoon Creek Group thickens southeastward from 100 ft in west-central Indiana to more than 1,000 ft in Vanderburgh County. The Carbondale Group consists primarily of about 300 ft of shale and sandstone (Shaver and others, 1986, p. 27). The Group contains four of Indiana's commercially important coals and some thin but laterally extensive limestones. The McLeansboro Group crops out in Gibson, Vanderburgh, Posey, and northwestern Warrick Counties. Shale and sandstone comprise more than 90 percent of the group (Shaver and others, 1986, p. 85-86). Minor amounts of siltstone, limestone, clay, and coal also are present. The McLeansboro Group is composed of the Shelburn, Patoka, and Bond Formations.

Unconsolidated Deposits

Unconsolidated deposits within the Ohio River basin are in three distinct regions: an eastern glaciated region, a western unglaciated region, and a southern river region.

The eastern glaciated region is primarily east of Floyd and Washington Counties. The thickness of the unconsolidated deposits in the upland area of the region is generally less than 50 ft (fig. 81). The material covering this area is predominantly composed of pre-Wisconsinan loam to sandy-loam till of the Jessup Formation and an upland silt complex of poorly stratified and poorly sorted sand and silt (Gray, 1989). The upland silt complex was derived from underlying weathered material and from windblown silt (loess). The composition of this material, and its topographic location, limit its potential as a source of ground water. A surficial deposit known as the lowland silt complex is present in narrow valleys of the glaciated region (Gray, 1989). The complex is composed of poorly stratified sand and silt from alluvial, colluvial, and wind-blown material. Even though this complex may contain some favorable material for aquifers, it is not considered to be a reliable source of ground water.

The unconsolidated surficial deposits are less than 50 ft thick in the uplands of the western unglaciated region of the basin (fig. 81). The unglaciated region contains terrace remnants of the lowland silt complex along many of its narrow major tributary valleys (Gray, 1989). What differentiates the unglaciated region from the glaciated region is the lack of till and the presence in the unglaciated region of large areas of loess in the upland areas. In many places, the loess is greater than 5 ft thick.

Along the Ohio River and in the middle to lower reaches of the major tributaries, the unconsolidated deposits are 50 ft to more than 100 ft thick (fig. 81). The sediment contained within the Ohio River Valley is mostly valley-train material deposited from melting glaciers. This material is undifferentiated outwash composed of sand and gravel, and it is the major source of ground water in the Ohio River basin. The outwash is commonly overlain by more than 10 ft of fine-grained sediments. In the lower to middle reaches of many of the tributaries are wetland or lake silts and clays. Covering the outwash and slack-water deposits in many areas is recently deposited alluvium composed of clay, silt, and sand. Colluvium is present along some of the tributary-valley margins.

Aquifer Types

Thirteen hydrogeologic sections (12A–12A′ to 12M–12M′, fig. 82) were drawn to show the hydrogeology of the Ohio River basin. Hydrogeologic sections 12A–12A′ to 12J–12J′ (fig. 82) are oriented south-north and are roughly perpendicular to the Ohio River. These hydrogeologic sections are spaced on average 18 mi apart; the average density of logged wells plotted along the sections is 0.64 wells per mile (fig. 78). Hydrogeologic sections 12K–12K′, 12L–12L′, and 12M–12M′ (fig. 82) are oriented west-east. These sections were spaced 21 mi apart on average; density of wells along the sections averages 0.46 wells per mile (fig. 78).

Because of the scarcity of water-well logs for the Ohio River basin, approximately 20 percent of the well logs used were from test holes. Many previous maps and reports were used in the production of these sections: (Gallaher, 1963a, 1963b, 1963c, 1964a, 1964b; Gallaher and Price, 1966; Price, 1964a, 1964b, 1964c; Bassett and Hasenmueller, 1979a, 1979b, 1980; Hasenmueller and Bassett, 1980; Geosciences Research Associates, Inc., 1982; Bassett and Keith, 1984; Gray, 1982, 1983, 1989; Gray and others, 1987). These maps and publications were especially helpful where well logs were scarce or wells were shallow.

Unconsolidated and bedrock aquifers are used as a water source in the Ohio River basin. The unconsolidated aquifers are mapped as buried sand and gravel aquifers (fig. 83). The buried sand and gravel aquifer is composed of outwash and alluvium that was deposited in the Ohio River valley, in lower reaches of the major tributary valleys, and in glacial lakes. Throughout the basin, the outwash is overlain by more than 10 ft of fine-grained sediments; therefore, the aquifer type is denoted as "buried" sand and gravel. The bedrock aquifers were subdivided into sandstone aquifers, carbonate bedrock aquifers, an upper weathered-bedrock aquifer, and a complexly interbedded sandstone, shale, limestone, and coal aquifer. The thicknesses, typical yields, and common names of these aquifer types are shown in table 14 at the back of this section.

Unconsolidated Aquifers

Buried Sand and Gravel Aquifer

An extensive zone of buried sand and gravel extends along nearly all of the Ohio River basin's southern border and along some of the lower reaches of the major tributaries (fig. 83). This zone of outwash and recently deposited alluvium is restricted to the Ohio River valley. The buried sand and gravel aquifer is shown in all 13 hydrogeologic sections (fig. 82). The aquifer is typically 35 ft to 150 ft thick, but it thins toward the valley margins. It is typically covered by 10 ft to 30 ft of clay, silt, and fine sand, although these fine-grained surface deposits can range from 0 to 100 ft in thickness. The coarseness of the deposits in the Ohio River valley generally increases with depth. Gravel is common near the bedrock surface, and boulders are sometimes found (Gallaher and Price, 1966, p. 44). The deposits also become finer with distance from the Ohio River. Sand deposits are thin or absent near the valley margins. Most of the valley-margin deposits consist of a mix of fine sand, silt, and clay and are commonly called "mud" or "quicksand" by drillers. The valley margin deposits are shown on the sections as nonaquifer material because they are not generally used for water supply; however, in some areas, low-yielding water-bearing units occur. Generally, where a tributary joins the Ohio River, the deposits in the tributary valley are fine-grained lake deposits and produce water only in some locations.

The buried sand and gravel deposits in the Ohio River valley are the most productive water-bearing units in the entire basin and yield the largest supplies of ground water. Properly constructed wells can yield as much as 2,000 gal/min, although typical yields are generally several hundred gallons per minute. This aquifer is extensively used by many of the major cities and industries along the Ohio River (Clark, 1980).

Horizontal hydraulic conductivities calculated from about 100 aquifer tests made in the buried sands and gravels along the Ohio River in Kentucky ranged from about 13 to 375 ft/d; the median was 61 ft/d (Gallaher and Price, 1966, p. 21). Specific capacities ranged from about 1 to 500 (gal/min)/ft with a median of 30 (gal/min)/ft (Gallaher and Price, 1966, p. 21). Water levels in the aquifer generally slope toward the Ohio River; ground water discharges to the river. During flooding, river water can flow into the aquifer near the stream (Gallaher and Price, 1966, p. 12). Infiltration of river water can be induced by heavy pumping in the outwash deposits; this infiltration reverses the natural pattern of ground-water discharge to the river and enables large sustained well yields.

A small buried sand and gravel aquifer in the northwestern part of the basin is about 50 ft thick and covers about 40 mi^2 (fig. 83; section 12B–12B′, fig. 82). Most of the aquifer material consists of fine sand; however, small deposits of gravel also are present. The aquifer is confined above and below primarily by deposits of fine sand, silt, and clay. Where present, the aquifer provides an adequate supply of ground water for domestic use.

Bedrock Aquifers

The bedrock aquifers in the Ohio River basin are less productive but more widespread than the unconsolidated aquifers. Several conditions limit the availability, quantity, and quality of the ground water contained within the bedrock: (1) the lack of thick, permeable, unconsolidated deposits above the bedrock throughout most of the basin; (2) low hydraulic conductivity of much of the bedrock; (3) deep water levels; and (4) highly mineralized ground water at depth.

Sandstone Aquifers

Sandstone aquifers underlie two large areas in the western one-half of the basin (fig. 83). Most of the sandstone aquifers are of Pennsylvanian age. These thick, laterally discontinuous sandstones are shown in hydrogeologic sections 12A–12A′, 12B–12B′, 12D–12D′, 12E–12E′, and 12K–12K′ (fig. 82). These sandstones are a dependable source of ground water, and they are very important aquifers in the western one-half of the basin. Wells in some of the thick sandstones can yield as much as 75 gal/min (Pettijohn and Reussow, 1969, p. 20); however, typical well yields from the sandstones are 1 to 20 gal/min.

Some of the sandstone aquifers in the far western part of the basin have been named and mapped in previous studies and are shown, but not labeled, on sections in figure 82. These sandstone aquifers include the Inglefield aquifer (Barnhart and Middleman, 1990, p. 4-7), also known as the Inglefield Sandstone aquifer (Robison, 1977, p. 9) or the Patoka aquifer (Cable and Wolf, 1977, p. 14), which is shown in the northern part of section 12A–12A′ and the central part of section 12B–12B′ (fig. 82). A second, less important aquifer, the Busseron Sandstone Member, generally lies at the base of the Danville Coal Member (Coal VII) (Shaver and others, 1986, p. 34; Barnhart and Middleman, 1990, p. 4). The Busseron Sandstone Member, (mapped by Barnhart and Middleman, 1990, pl. 1) is shown in the northern part (T. 2 S.) of section 12B–12B′ (fig. 82). The Dugger aquifer (Cable and Wolf, 1977, p. 13-15) is a discontinuous sandstone aquifer within the Dugger Formation that is present in parts of Vanderburgh, Gibson, Warrick, and Pike Counties. It is shown on the southern part of section 12K–12K′ just above the Springfield Coal Member (Coal V). Major sandstone aquifers are found in the Mansfield Formation at the base of the Raccoon Creek Group. In Vanderburgh County, the sandstone aquifers are 800 to 1,200 ft below land surface; the water in these deep sandstone aquifers is too mineralized to be used (Cable and Wolf, 1977, p. 9). Further east in Spencer County, these sandstone aquifers are only several hundred feet below land surface and can be used as a water source. These aquifers are shown at the base of section 12D–12D′ and near the land surface (above the Mississippian-Pennsylvanian unconformity) in Perry County in the northern part of section 12E–12E′ (fig. 82).

Water-bearing sandstones at the bedrock surface, such as those shown in the central part of 12B–12B′ or the northern part of 12E–12E′ (fig. 82), are recharged by precipitation infiltrating through the thin soil or glacial cover. Deeper sandstones are recharged much more slowly by overlying shales and siltstones or by limestones or coals, which can function as conduits of flow to the sandstones. Flow in the sandstone aquifers could be restricted because of their discontinuity and the abundance of surrounding shale and siltstone. The average hydraulic conductivity of the sandstones in the basin was estimated to be 1.6 ft/d (Pettijohn and Reussow (1969, p. 20).

In general, water quality diminishes with depth, but the depth to potable ground water is highly variable. In Vanderburgh County, freshwater was found in sandstone at depths of more than 500 ft; the ground water was highly mineralized at 800 ft below land surface (Cable and Wolf, 1977, p. 9, 22). Locally, ground water can be salty at depths of less than 300 ft. In section 12E–12E′ (fig. 82), a well near the intersection of T. 4 S. and T. 5 S. contained “saltwater” at a depth of about 280 ft.

Complexly Interbedded Sandstone, Shale, Limestone, and Coal Aquifer

A complexly interbedded sandstone, shale, limestone, and coal aquifer has been mapped over the western one-half of the basin (fig. 83). The complexly interbedded aquifer was mapped as “aquifer—potential unknown” because its aquifer characteristics are so widely variable throughout the basin. The aquifer is a poorly productive, secondary source of water, yet it is areally and vertically extensive; in general, it can supply enough water to support a household. Where sandstone aquifers have been mapped (fig. 83), the complexly interbedded aquifer is typically not used unless the sandstone aquifers are very deep (several hundred feet below land surface).

The complexly interbedded aquifer includes the West Baden, Stephensport, and Buffalo Wallow Groups of Mississippian age and the Raccoon Creek, Carbondale, and McCleansboro Groups of Pennsylvanian age. Where the sandstones are mapped as separate aquifers from the complex material (fig. 83), then the complexly interbedded sandstone, shale, limestone, and coal aquifer is dominated by shale and siltstone. Aside from the major sandstone bodies, shale and siltstone compose about 80 percent of the bedrock in well logs from sections 12A–12A′ to 12C–12C′ (fig. 82); however, large sandstone bodies may be present where complex material is shown with no well log information. Shale and siltstone, even though widespread, are not the primary water-bearing units in the complex aquifer. Although some well logs note shale and sandy shale as water bearing, about one-half of the well logs indicate that water is derived from thin (less than 10 ft), discontinuous sandstone bodies (not shown on the sections). The remaining wells get water from coal and limestone.

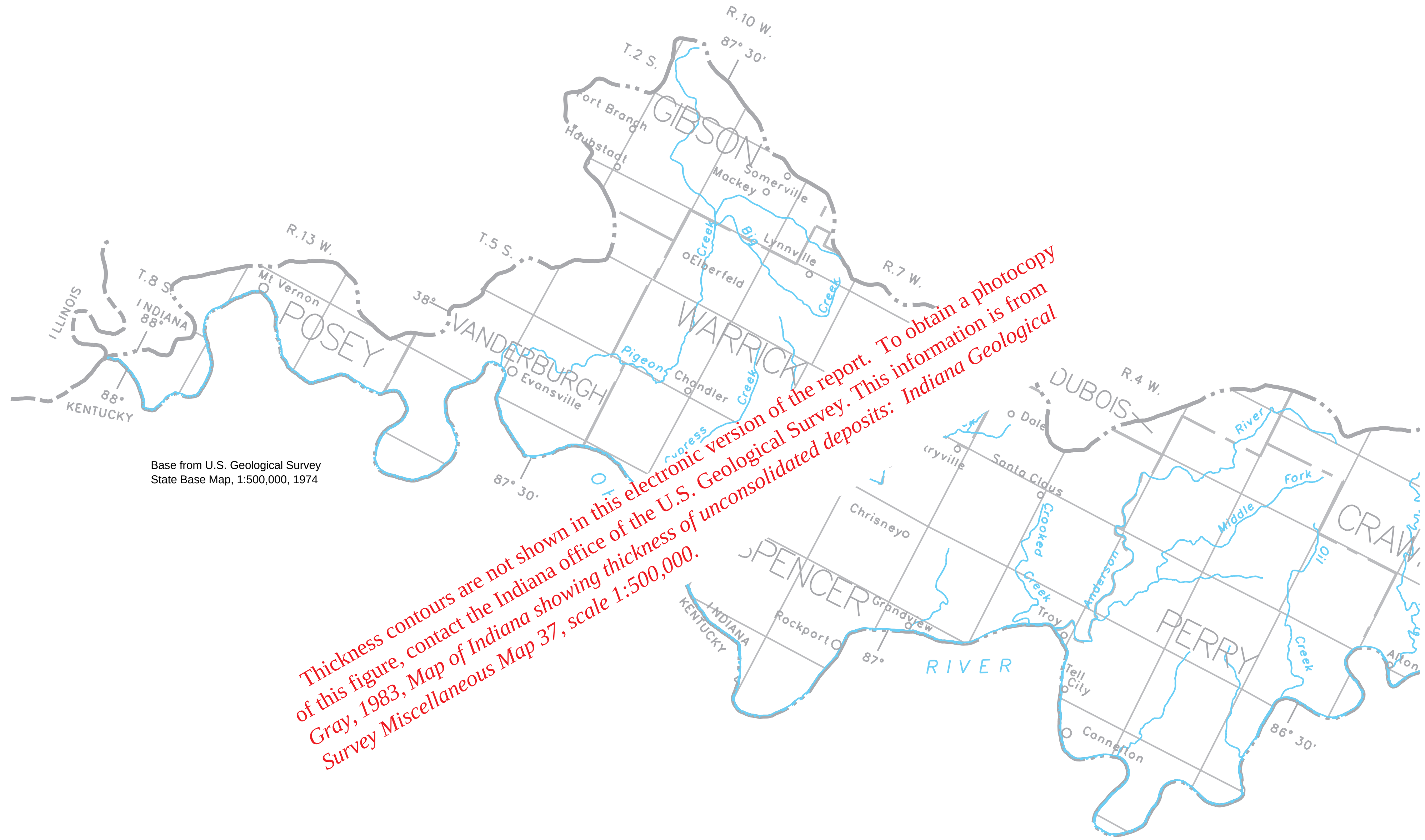
Most wells are uncased throughout the bedrock and, therefore, can produce water from several low-yielding units that are penetrated by the well. Yields of wells in the complex material range from 0 to about 20 gal/min. Commonly, yields are less than 2 gal/min.

Carbonate Bedrock Aquifers

Limestones and dolomites of Silurian, Devonian, and Mississippian age are another source of ground water in the Ohio River basin. The Mississippian carbonate rocks, consisting of the Blue River and Sanders Groups, are the most extensive and thickest of the carbonate bedrock aquifers in the Ohio River basin. They underlie most of Perry, Crawford, and Harrison Counties and the western one-half of Washington County (fig. 83). These thick, massive Mississippian carbonate bedrock aquifers are shown in hydrogeologic sections 12F–12F′, 12G–12G′, the eastern part of 12K–12K′, and the western part of 12L–12L′ (fig. 82). In western Perry and Crawford Counties, the carbonate rocks are overlain by younger complexly interbedded rocks.

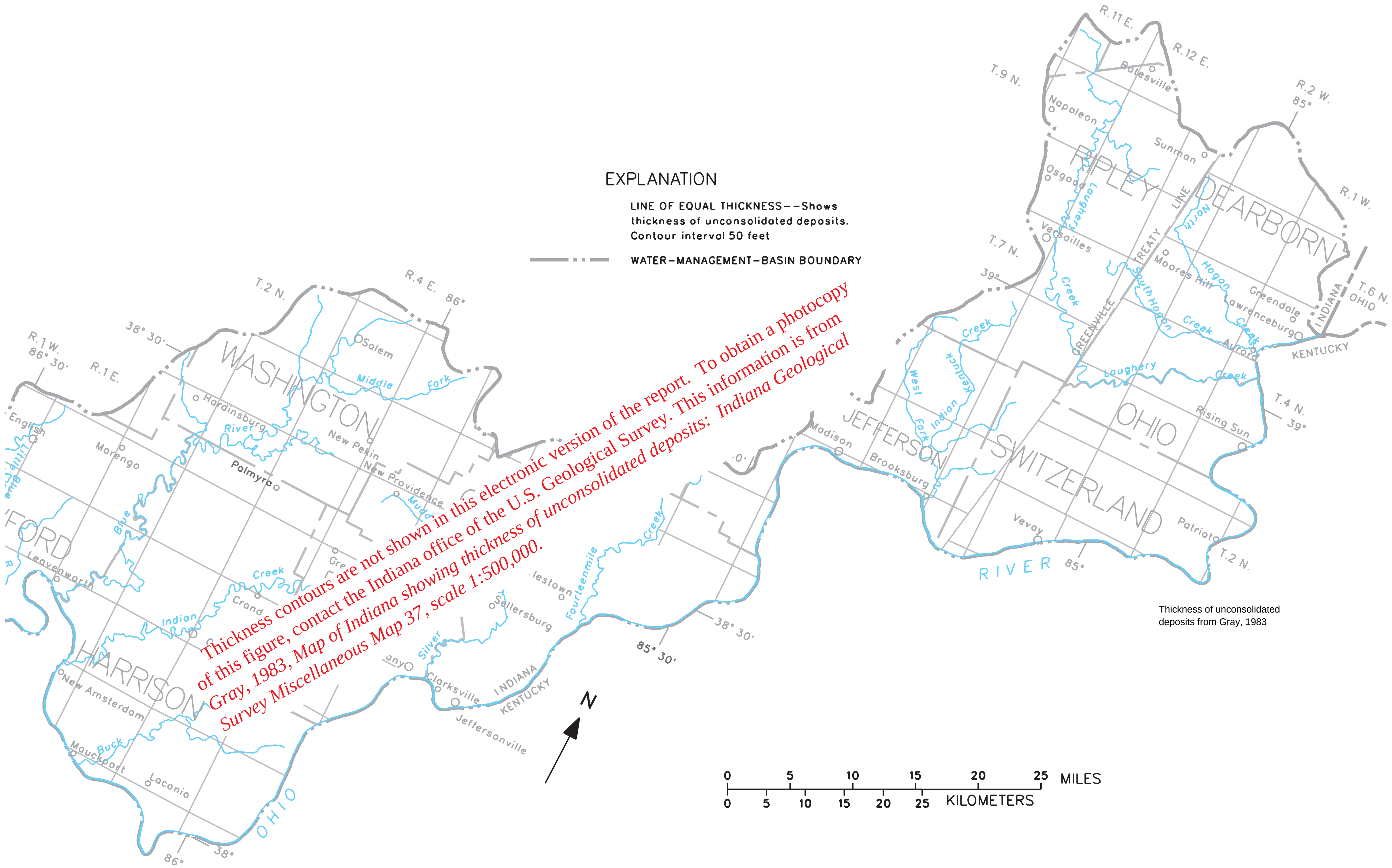
Wells in the Mississippian carbonate rocks have yields of 1 to 100 gal/min; typical yields are 3 to 15 gal/min (Bechert and Heckard, 1966; Pettijohn and Reussow, 1969; Clark, 1980). These moderate yields are attributed to the presence of highly transmissive solution features, joints, cracks, and bedding planes (fig. 9b). Most of the solution features and greatest permeabilities are in the Blue River Group, which constitutes the upper two-thirds of the carbonate bedrock aquifer. Low well yields and dry holes are common where the aquifer thins toward the east, as shown along R. 5 E. of section 12L–12L′ (fig. 82). Several spring horizons have formed within the Mississippian limestones where permeable limestone overlies relatively impermeable limestone.

The Silurian-Devonian carbonate bedrock aquifer is in the east-central part of the Ohio River basin in Clark, Jefferson, and Ripley Counties (fig. 83). The aquifer can be seen in hydrogeologic sections 12H–12H′ and the far eastern part of 12L–12L′ (fig. 82). Most of the extractable ground water within the carbonate rocks is in joint planes, fractures, and solution features. The carbonate rocks identified as an aquifer are a reliable source of ground water, and well yields are generally less than 20 gal/min (Bechert, and Heckard, 1966; Pettijohn and Reussow, 1969; Clark, 1980).



Thickness contours are not shown in this electronic version of the report. To obtain a photocopy of this figure, contact the Indiana office of the U.S. Geological Survey. This information is from Gray, 1983, *Map of Indiana showing thickness of unconsolidated deposits: Indiana Geological Survey Miscellaneous Map 37*, scale 1:500,000.

Figure 81. Thickness of unconsolidated deposits in the Ohio River basin.



Thickness contours are not shown in this electronic version of the report. To obtain a photocopy of this figure, contact the Indiana office of the U.S. Geological Survey. This information is from Gray, 1983, Map of Indiana showing thickness of unconsolidated deposits: *Indiana Geological Survey Miscellaneous Map 37*, scale 1:500,000.

Thickness of unconsolidated deposits from Gray, 1983

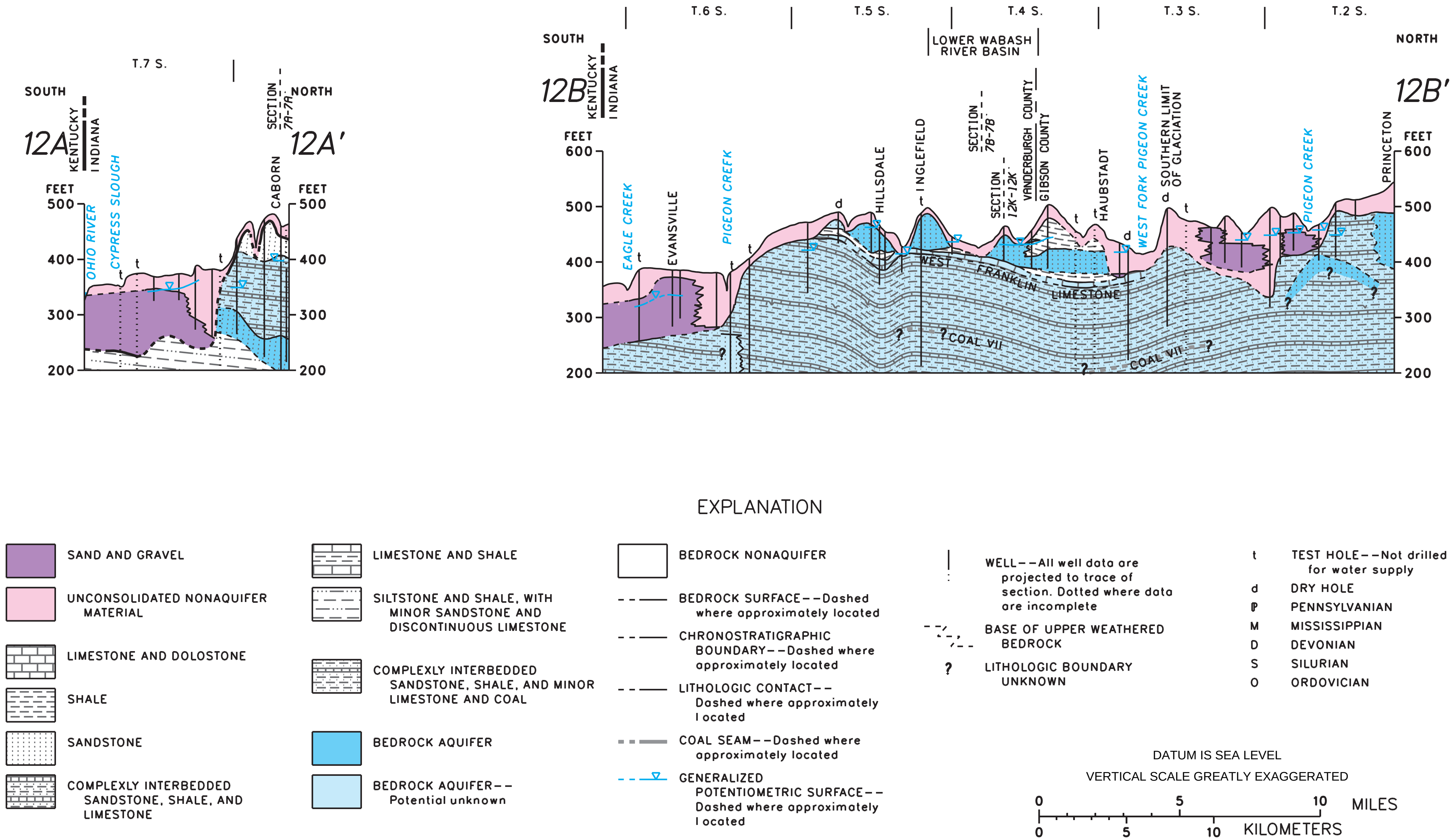
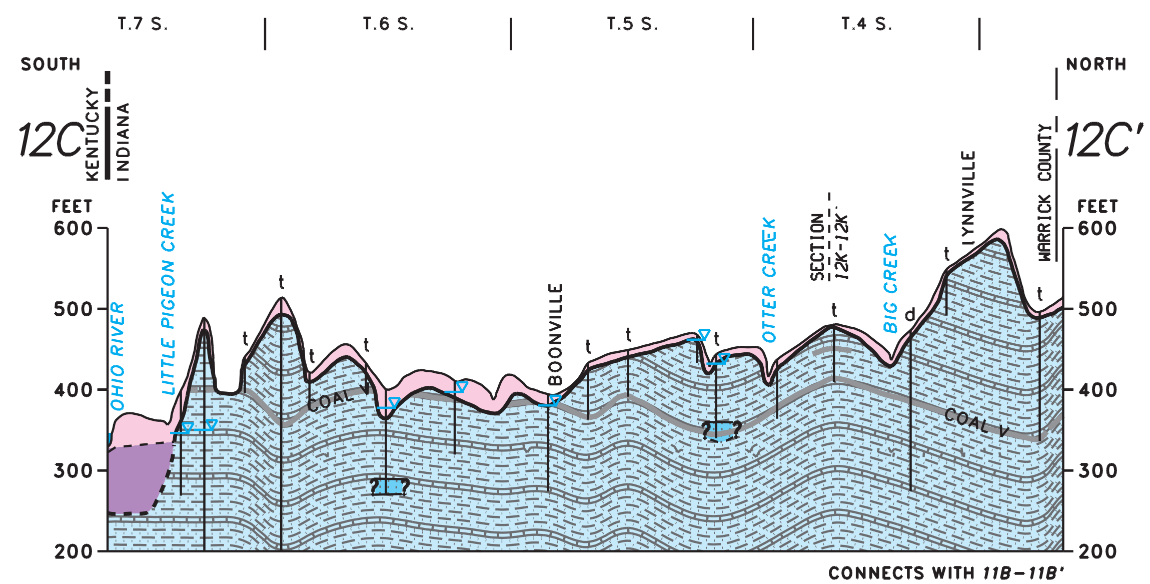
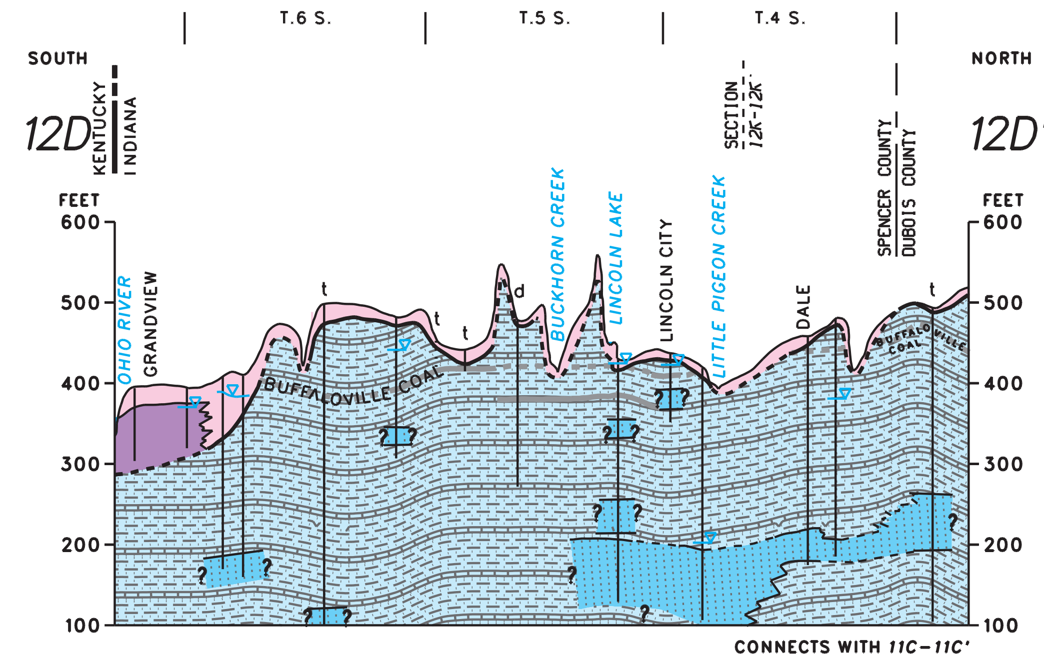
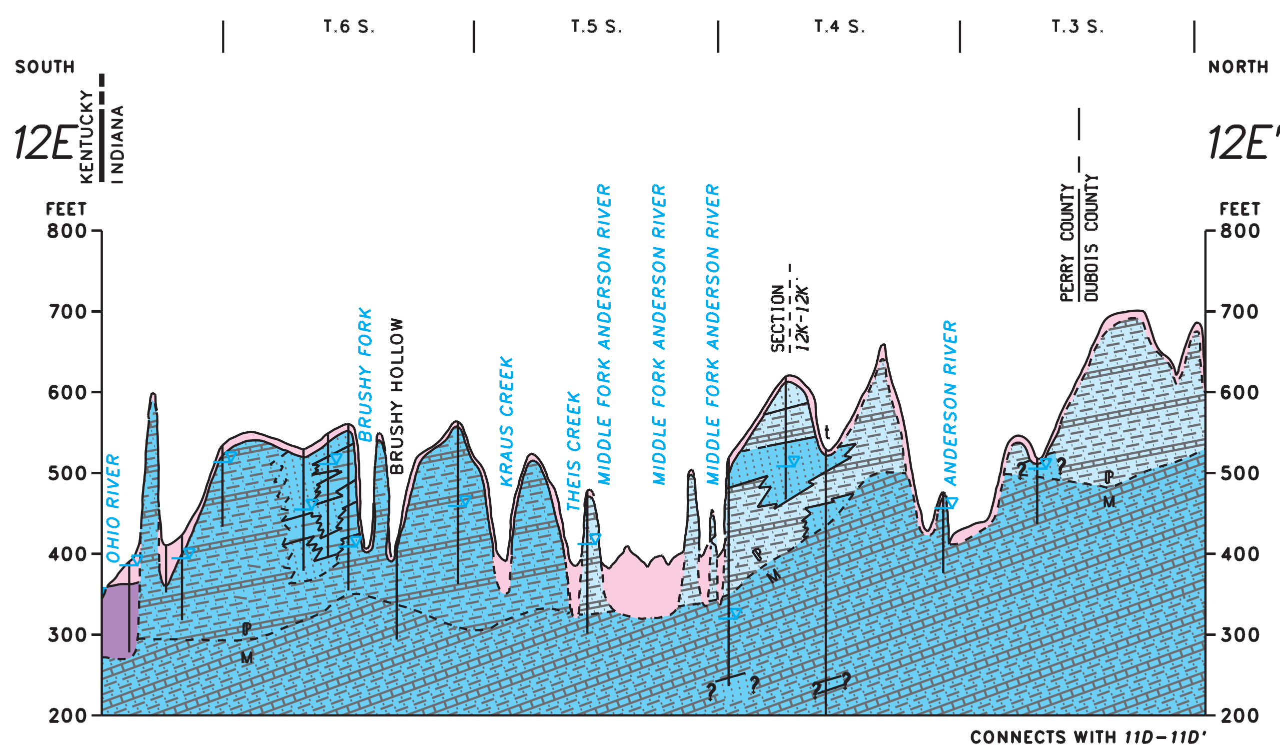
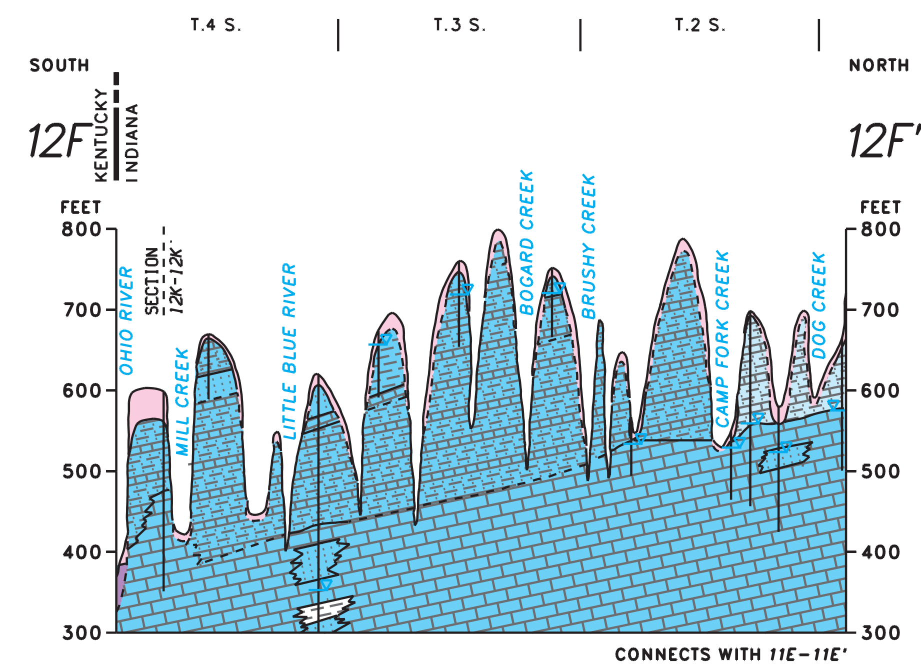


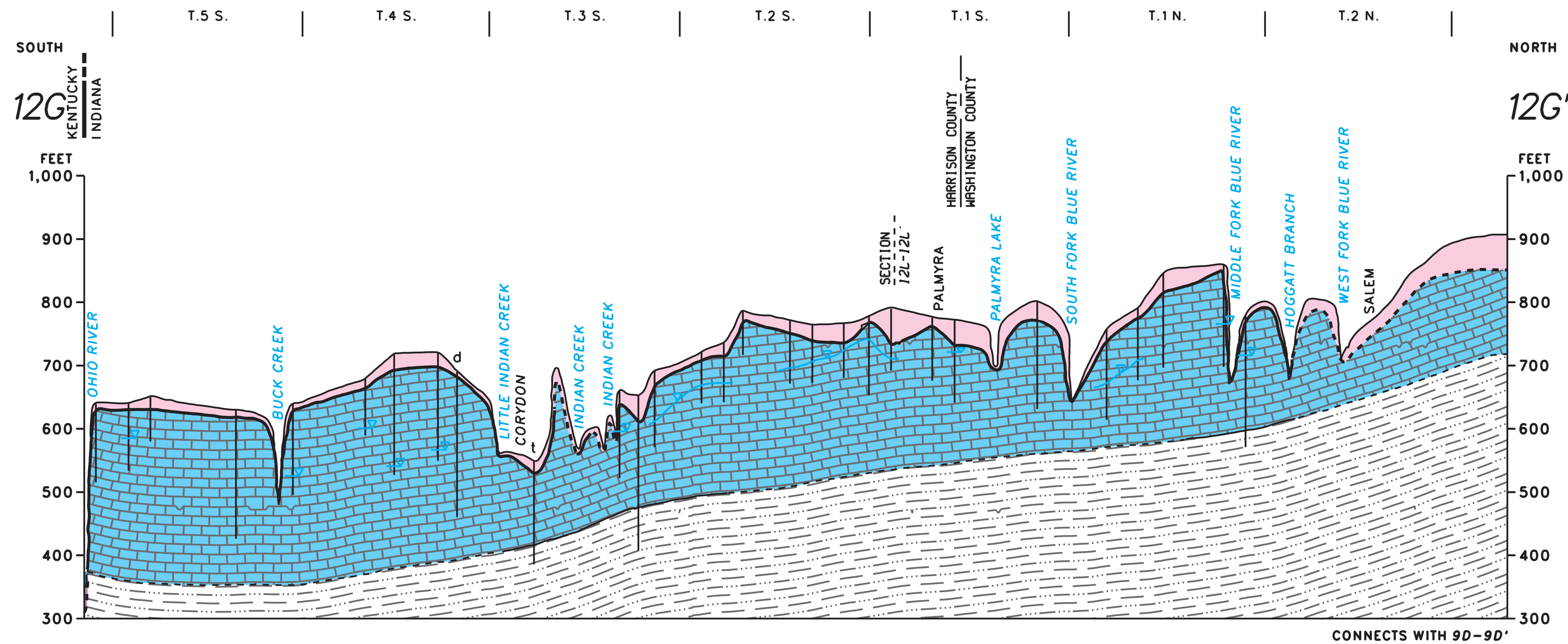
Figure 82. Hydrogeologic sections *12A–12A′* to *12M–12M′* of the Ohio River basin.

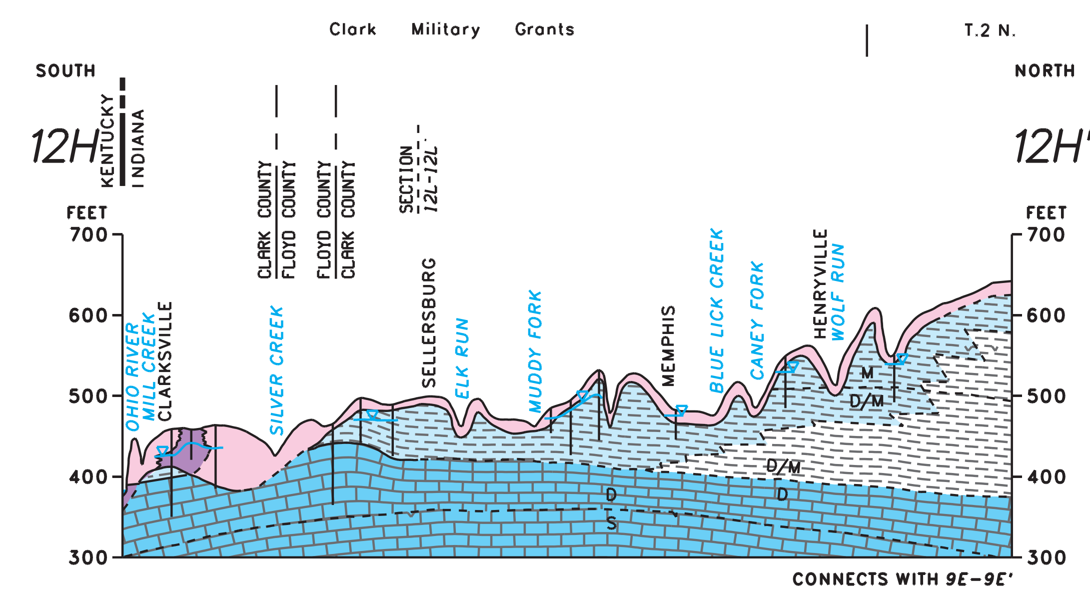

T.7 S.
T.6 S.
T.5 S.
T.4 S.
SOUTH
NORTH
12C
12C′
KENTUCKY
INDIANA
FEET
600
500
400
300
200
OHIO RIVER
LITTLE PIGEON CREEK
COAL V
BOONVILLE
OTTER CREEK
SECTION 12K-12K′
BIG CREEK
LYNNVILLE
WARRICK COUNTY
CONNECTS WITH 11B–11B′


T.6 S.
T.5 S.
T.4 S.
SOUTH
NORTH
12D
12D′
KENTUCKY
INDIANA
FEET
600
500
400
300
200
100
OHIO RIVER
GRANDVIEW
BUFFALOVILLE COAL
BUCKHORN CREEK
LINCOLN LAKE
LINCOLN CITY
LITTLE PIGEON CREEK
SECTION 12K-12K′
DALE
SPENCER COUNTY
DUBOIS COUNTY
CONNECTS WITH 11C–11C′


T.6 S.
T.5 S.
T.4 S.
T.3 S.
SOUTH
NORTH
12E
12E′
KENTUCKY
INDIANA
FEET
800
700
600
500
400
300
200
OHIO RIVER
BRUSHY FORK
BRUSHY HOLLOW
KRAUS CREEK
THEIS CREEK
MIDDLE FORK ANDERSON RIVER
MIDDLE FORK ANDERSON RIVER
MIDDLE FORK ANDERSON RIVER
SECTION 12K-12K′
ANDERSON RIVER
PERRY COUNTY
DUBOIS COUNTY
CONNECTS WITH 11D–11D′


T.4 S.
T.3 S.
T.2 S.
SOUTH
NORTH
12F
12F′
KENTUCKY
INDIANA
FEET
800
700
600
500
400
300
OHIO RIVER
SECTION 12K-12K′
MILL CREEK
LITTLE BLUE RIVER
BOGARD CREEK
BRUSHY CREEK
CAMP FORK CREEK
DOG CREEK
CONNECTS WITH 11E–11E′





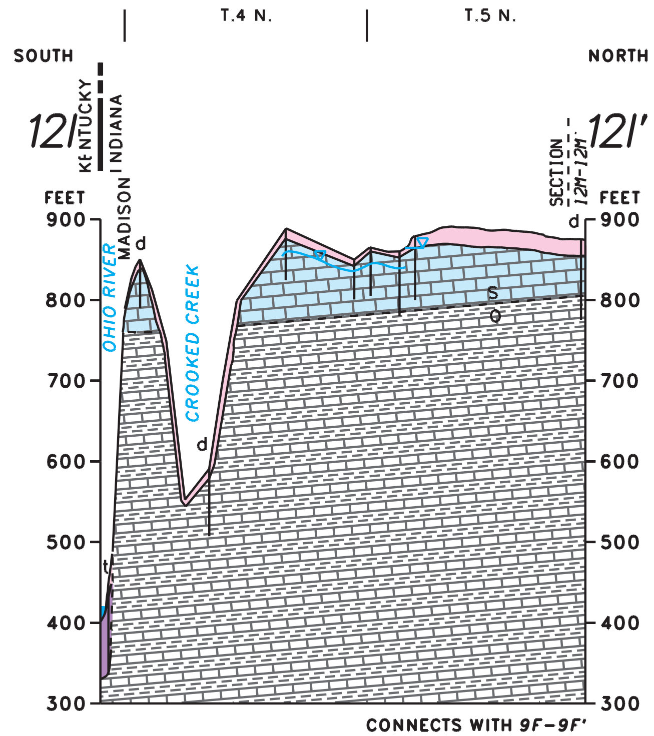
DATUM IS SEA LEVEL

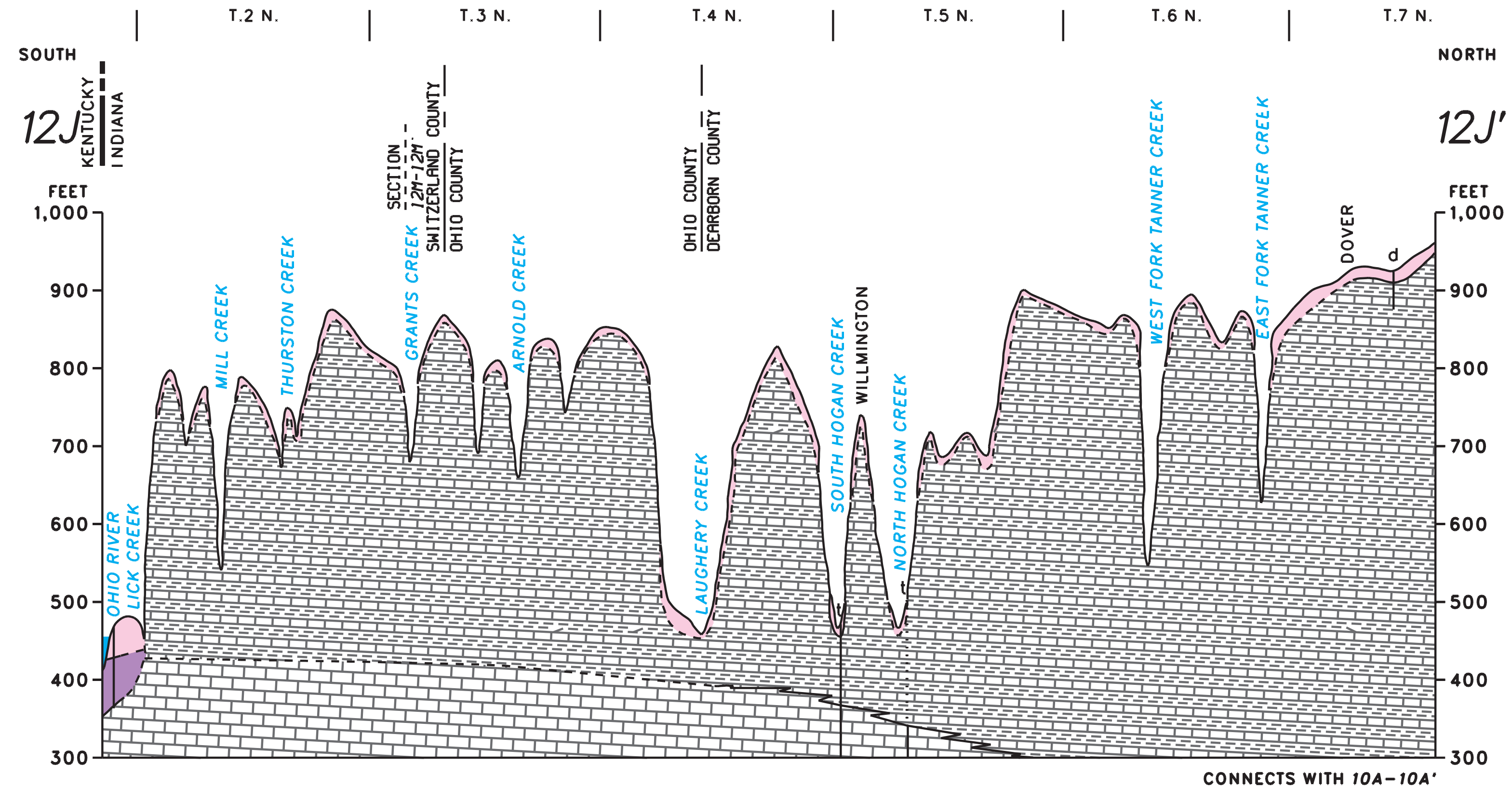
VERTICAL SCALE GREATLY EXAGGERATED

0 5 10 MILES

0 5 10 KILOMETERS

Figure 82. Hydrogeologic sections *12A–12A′* to *12M–12M′* of the Ohio River basin—Continued.





The eastern edge of the Silurian-Devonian carbonate bedrock aquifer, where only the lower part of the Silurian carbonate rocks remain, is mapped as "aquifer—potential unknown." (See the eastern part of section 12I–12I′ and the western part of section 12M–12M′; fig. 82). Well yields are highly variable, and dry holes are common. Many wells that produce water in this area are on lineaments and fracture traces (Greeman, 1981; 1983). Lineaments and fracture traces are commonly surface expressions of subsurface fractures and solution features. Yields of wells that intersect these fractures are usually less than 20 gal/min; holes can be dry if they do not intersect a fracture. Another source of water within the Silurian carbonate bedrock aquifer is from minor solution features at the Ordovician-Silurian unconformity.

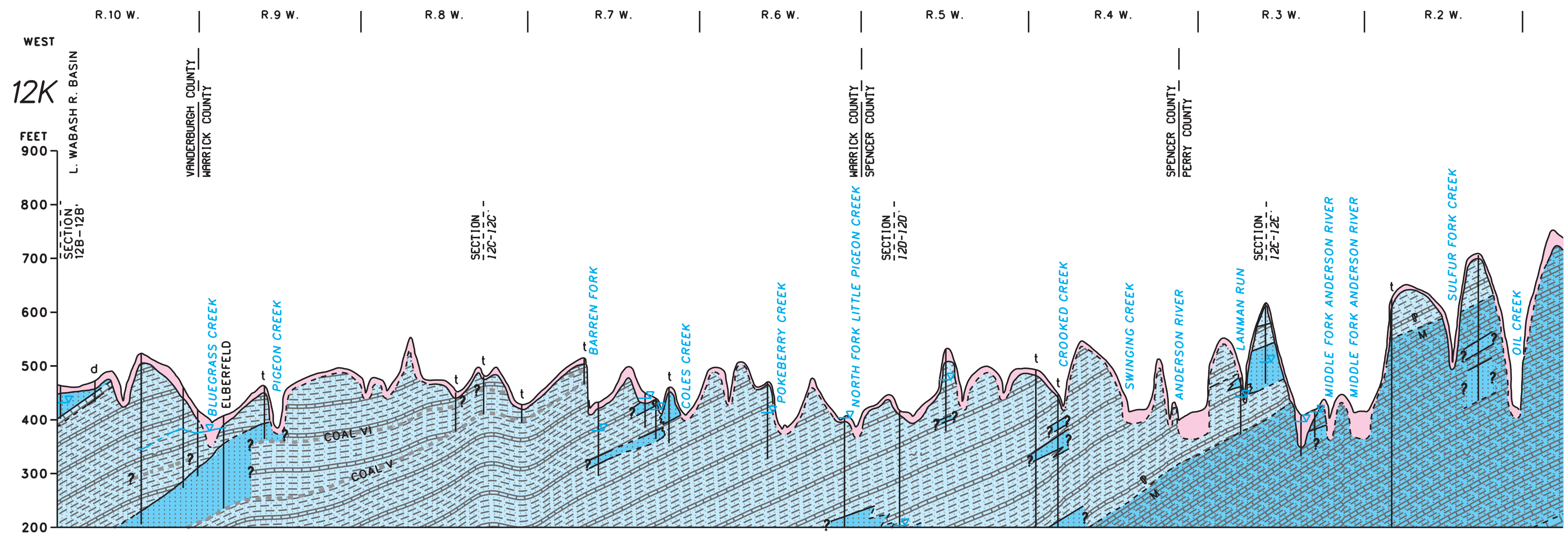
Upper Weathered-Bedrock Aquifer

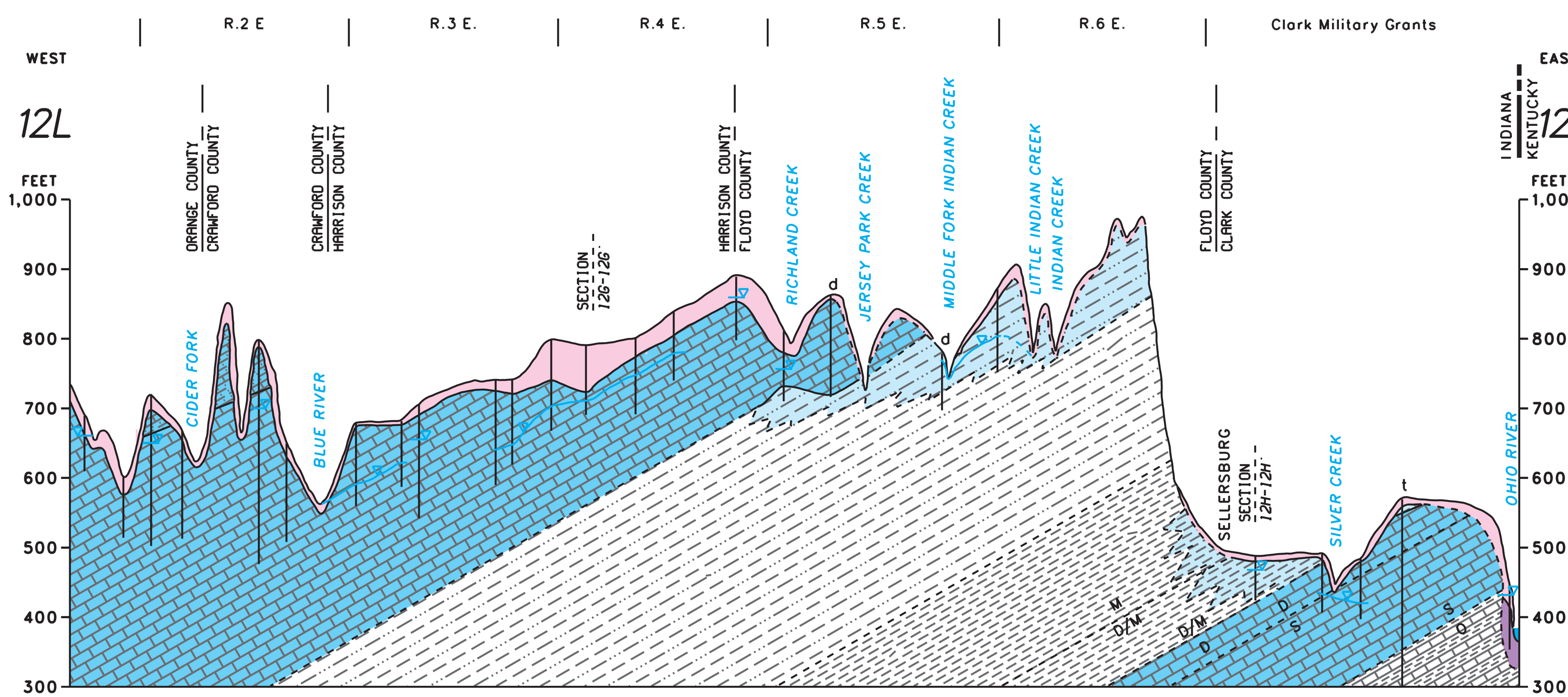
An upper weathered-bedrock aquifer in shales and siltstones underlies Washington, Clark, and Floyd Counties in the east-central part of the basin (fig. 83). The aquifer, composed of the Devonian and Mississippian New Albany Shale and Borden Group, lies between Silurian-Devonian carbonate rocks and Mississippian carbonate rocks (section 12L–12L′, fig. 82). The weathered bedrock was mapped as "aquifer—potential unknown" because of the low water-yielding character of the rocks and the frequency of dry holes reported by well drillers. Ground water is obtained from joints and bedding planes that are common in the upper 50 to 100 ft where the permeability has been enhanced by weathering. The weathered shales (section 12H–12H′, fig. 82) appear to be better water producers than the weathered siltstones, possibly because of better development of bedding planes in the shales.

The upper weathered-bedrock aquifer is a useful aquifer only where it is at or very near the bedrock surface. At depth, the shales and siltstones are not considered an aquifer because they yield very little or no water because of low permeabilities and limited recharge. In addition, the productive Mississippian carbonate bedrock aquifer is available at shallow depths.

Generally Nonaquifer Material

No bedrock aquifer is present in the far eastern part of the basin (fig. 83). Furthermore, few unconsolidated deposits overlie the bedrock, which consists predominantly of Ordovician shale and limestone. Most of the shale in the Ordovician bedrock is soft and does not enable joints to develop; therefore, permeabilities in the Ordovician rock are low (Gray, 1972, p. 22). Conventional water wells are rare in this area (sections 12J–12J′ and 12M–12M′, fig. 82); most people living there obtain drinking water from cisterns, small reservoirs, large-diameter bucket-rig wells, the Ohio River, or rural water utilities which obtain ground water from the alluvium along the Ohio River (Clark, 1980; W.J. Steen, Indiana Department of Natural Resources, written commun., 1991).





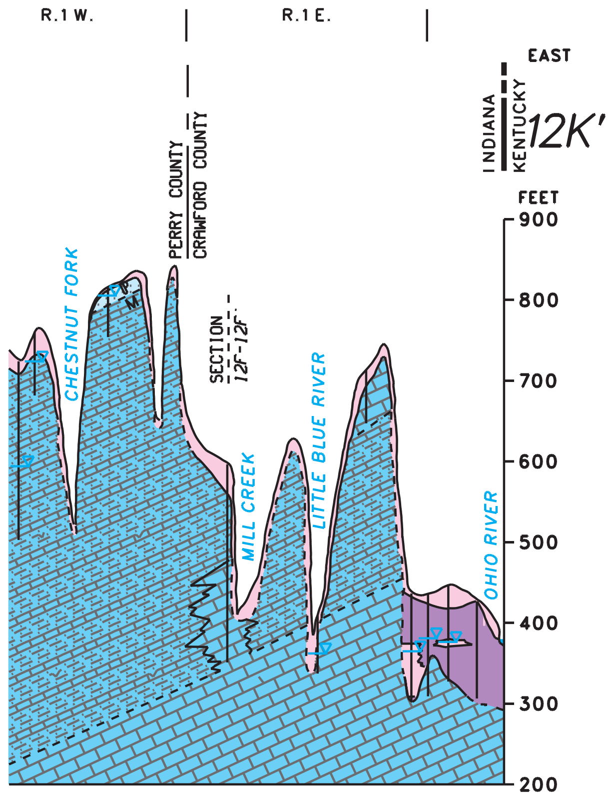
DATUM IS SEA LEVEL

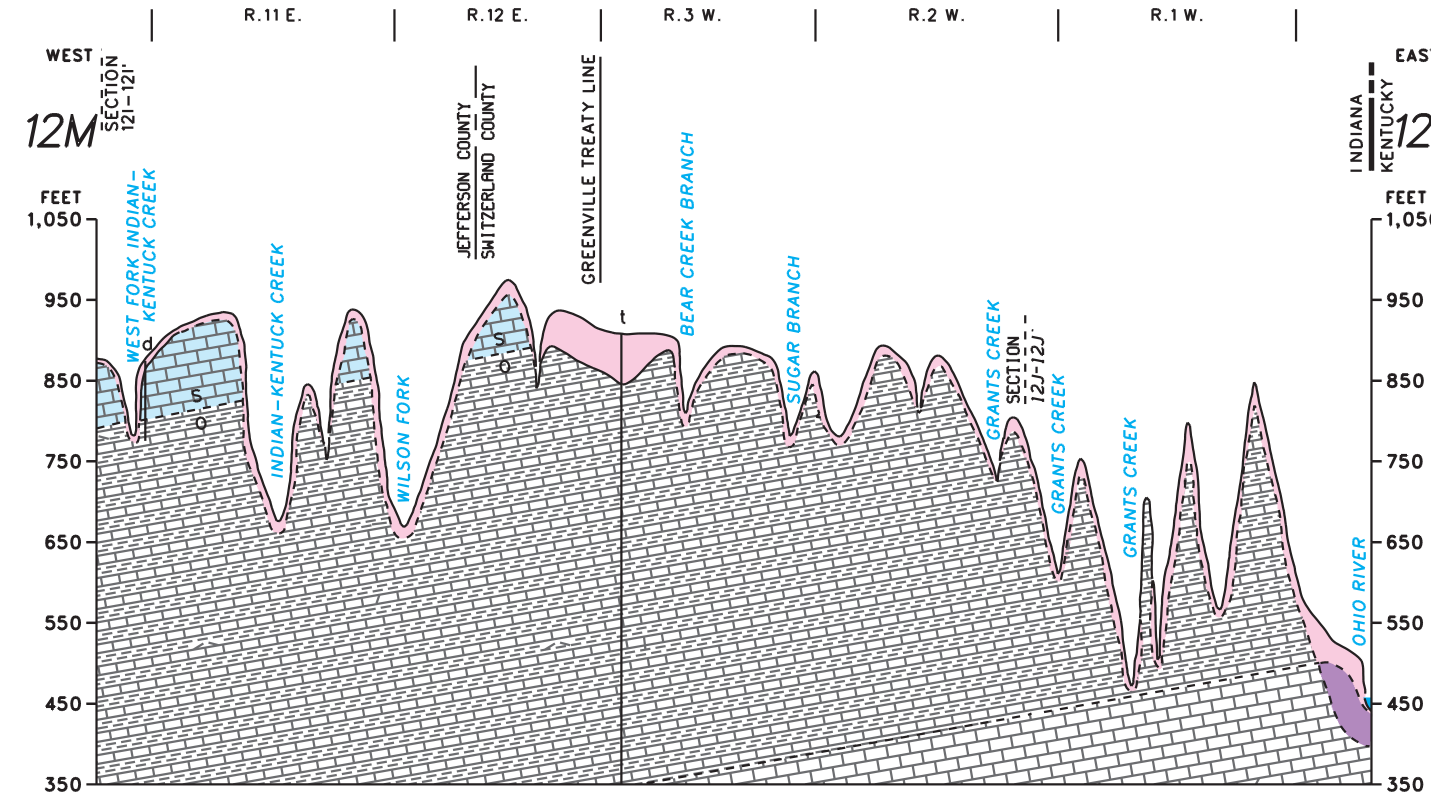
VERTICAL SCALE GREATLY EXAGGERATED

0 5 10 MILES

0 5 10 KILOMETERS

Figure 82. Hydrogeologic sections *12A–12A′* to *12M–12M ′* of the Ohio River basin—Continued.





Summary

The Ohio River basin encompasses 4,224 mi^2 of southern Indiana. The oldest exposed rocks in the basin (Ordovician in age) are in the eastern part of the basin and the youngest rocks (Pennsylvanian in age) are exposed in the western part of the basin. These Paleozoic rocks are covered by as much as 100 ft of loam to sandy-loam till, lake silt and clay, alluvium, loess, and outwash sand and gravel deposits.

Five aquifer types were delineated in the Ohio River basin: (1) buried sand and gravel, (2) sandstones of Pennsylvanian age, (3) complexly interbedded sandstone, shale, limestone, and coal, (4) limestone and dolomite of Silurian, Devonian, and Mississippian age, and (5) an upper weathered zone of siltstone and shale. Buried sand and gravel is found primarily in the Ohio River valley. The sand and gravel yields the largest supply of ground water for the basin; well yields typically range from 10 to 1,000 gal/min. The bedrock aquifers are a less productive supply of ground water for the basin and generally support only domestic use. Well yields from the bedrock aquifers normally range from 0 to 20 gal/min. The highest yields from bedrock come from the sandstone and carbonate bedrock aquifers. The complexly interbedded aquifer, upper weathered-bedrock aquifer, and the eastern edge of the Silurian-Devonian carbonate bedrock aquifer were all mapped as "aquifer—potential unknown." These areas are characterized by generally low yields (less than 5 gal/min) and dry holes. The eastern end of the basin contains no mappable aquifer.

Four factors greatly limit the distribution, quantity, and quality of the ground water contained within the Ohio River basin: (1) the lack of thick, permeable unconsolidated deposits over most of the basin, (2) low hydraulic conductivity of the bedrock, (3) deep water levels, and (4) highly mineralized ground water at depth.

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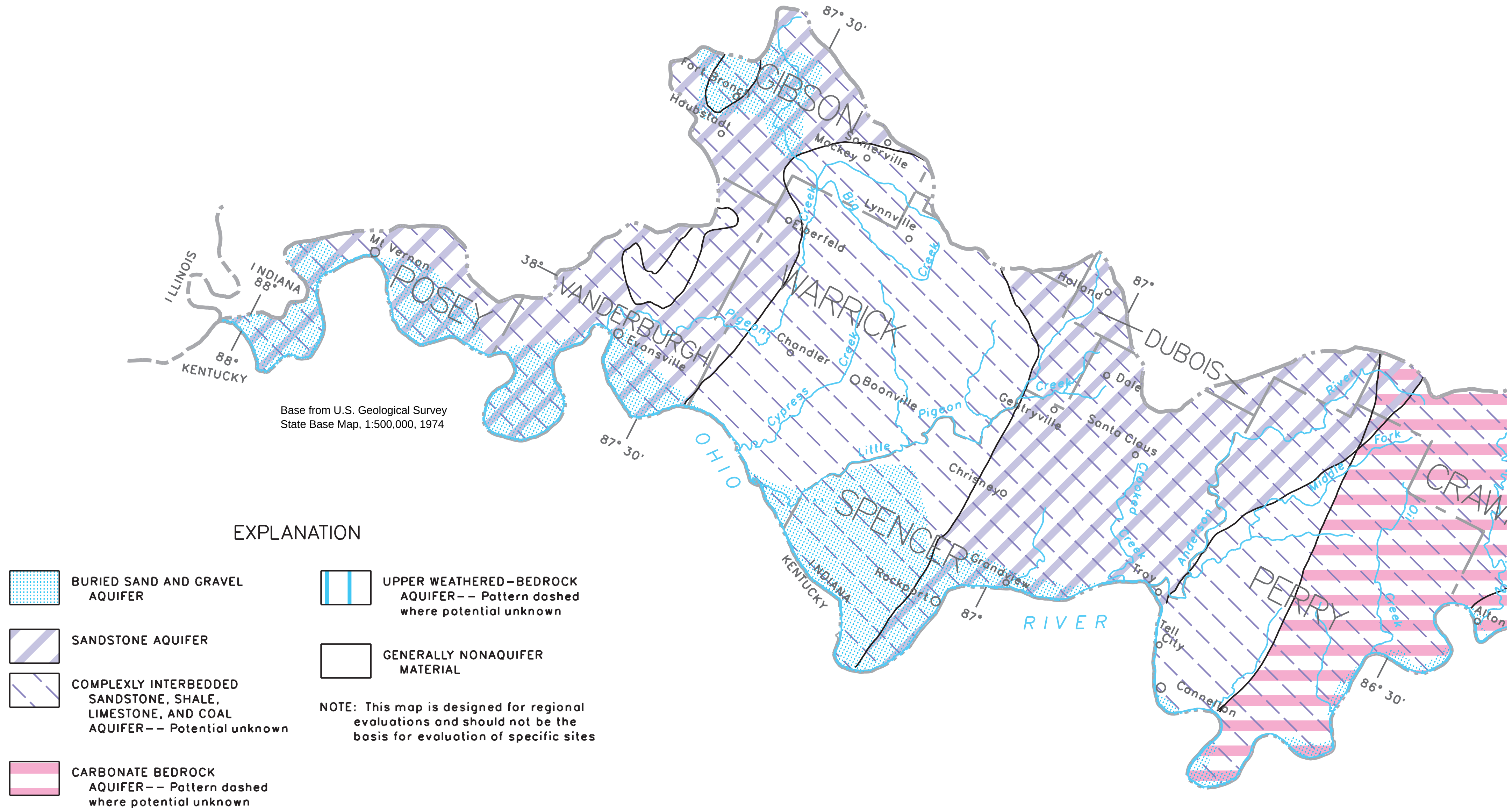

Figure 83. Extent of aquifer types in the Ohio River basin.

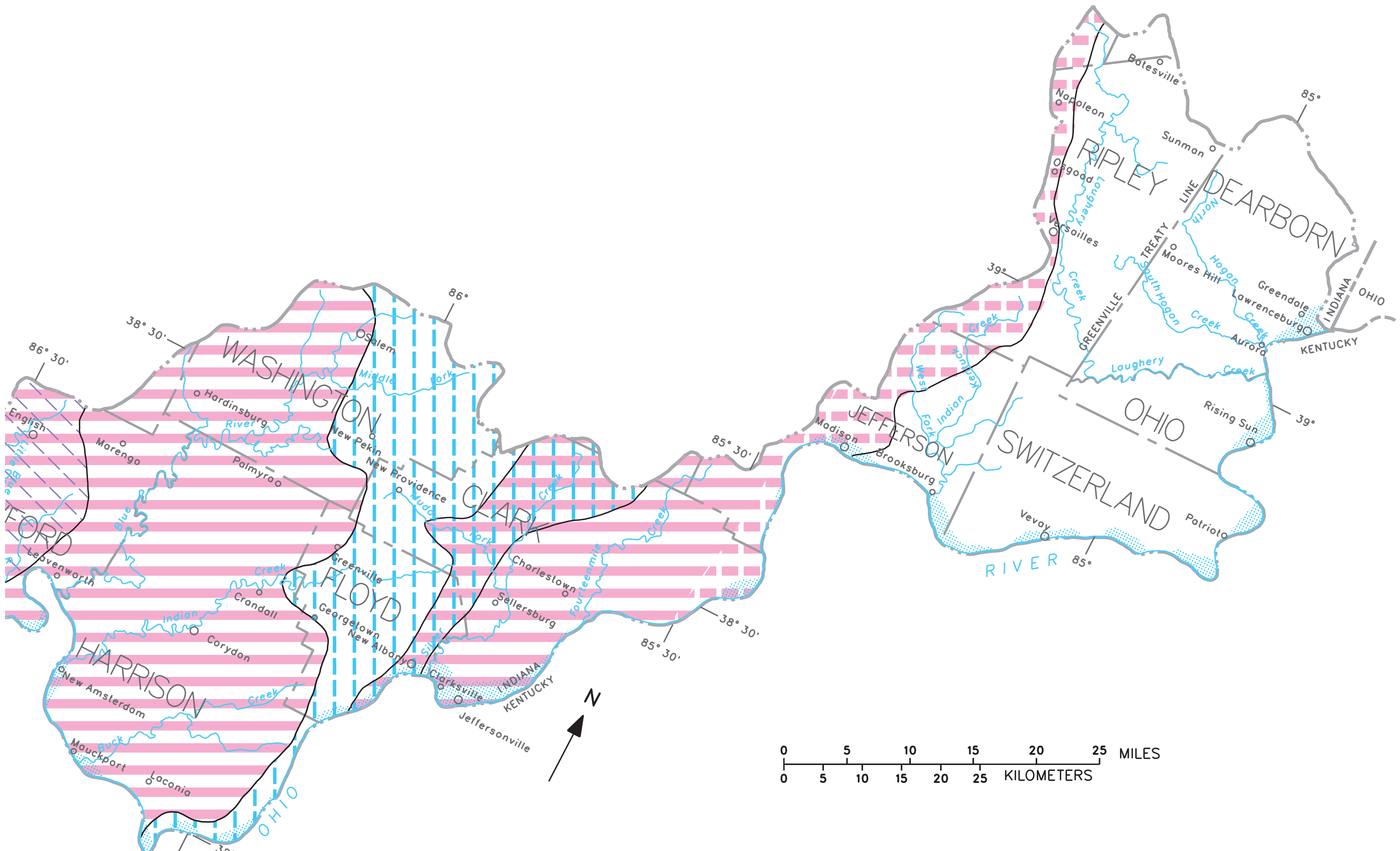
WASHINGTON
CLARK
FLOYD
HARRISON
JEFFERSON
RIPLEY
DEARBORN
OHIO
SWITZERLAND
Salem
Hardinsburg
English
Marengo
Palmyra
New Pekin
New Providence
Leavenworth
Greenville
Crandall
Corydon
Georgetown
New Albany
Clarksville
Jeffersonville
Charlestown
Sellersburg
New Amsterdam
Mauckport
Laconia
Madison
Brooksburg
Vevay
Patriot
Rising Sun
Aurora
Lawrenceburg
Greendale
Moores Hill
Versailles
Osgood
Napoleon
Batesville
Sunman
INDIANA
KENTUCKY
OHIO
OHIO RIVER
GREENVILLE TREATY LINE
86°
86° 30'
38° 30'
85° 30'
39°
85°
38°
N
0 5 10 15 20 25 MILES
0 5 10 15 20 25 KILOMETERS

Table 14. Characteristics of aquifer types in the Ohio River basin
[Locations of aquifer types shown in fig. 83]

Aquifer type	Thickness (feet)	Range of yield (gallons per minute)	Common name(s)
Buried sand and gravel	35-150	[1,2,3,4,5]10-1,000	Ohio River sand and gravel[1]; valley train deposits[3]; alluvial deposits[5]
Sandstone	10- 50	[1,2,3,4,6]1- 75	Inglefield Sandstone Member[1]; Linton, Dugger, and Patoka aquifers[2]
Complexly interbedded sandstone, shale limestone, and coal	highly variable[7]	0- 20	West Baden, Stephensport, Buffalo Wallow, Raccoon Creek, Carbondale, and McCleansboro Groups[8]
Carbonate bedrock			
Mississippian	100-600	[1,4,6]1- 100	Blue River and Sanders Groups
Silurian-Devonian	50-250	[1,4,6]0- 20	Muscatatuck Group through Louisville Limestone[8]
Upper weathered bedrock	50- 100	[1,4,6]0- 5	New Albany Shale and Borden Group[8]

[1]Clark, 1980.
[2]Cable and Wolf, 1977.
[3]Robison, 1977.
[4]Bechert and Heckard, 1966.
[5]Gallaher and Price, 1966.
[6]Pettijohn and Reussow, 1969.
[7]Water commonly found in thin beds within complexly interbedded sequence.
[8]Shaver and others, 1986.

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