Bulletin No. 38

GROUND-WATER RESOURCES OF VANDERBURGH COUNTY, INDIANA

STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
Division of Water

Prepared by
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
Water Resources Division

1977

STATE OF INDIANA

DEPARTMENT OF NATURAL RESOURCES

BULLETIN NO. 38

OF THE

DIVISION OF WATER

Robert F. Jackson, Chief

GROUND-WATER RESOURCES OF VANDERBURGH COUNTY, INDIANA

By

L. W. Cable and R. J. Wolf

Hydrologists, U.S. Geological Survey

Prepared by the

GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

In cooperation with the

STATE OF INDIANA

DEPARTMENT OF NATURAL RESOURCES

1977

CONTENTS

ILLUSTRATIONS

(Plates in pocket)

ILLUSTRATIONS--Continued

TABLES

GROUND-WATER RESOURCES OF VANDERBURGH COUNTY, INDIANA

By

L. W. Cable and R. J. Wolf

Hydrologists, U.S. Geological Survey

ABSTRACT

Sandstone units of Middle and Late Pennsylvanian age and sand and gravel of Quaternary age are the source of fresh (1,000 parts per million of dissolved solids or less) ground water in Vanderburgh County. Aquifers occur in older rocks, but, owing to their depth, the water is too highly mineralized to be useful for most purposes. Three sandstone units occur that are fresh-water bearing and areally extensive enough to be important aquifers. Together these sandstone units underlie most of the county. The fresh-water bearing sandstone units are in the Linton Formation, the Dugger Formation and the Patoka Formation (of local usage) of Wier and Gray (1961), and are herein named the Linton aquifer, the Dugger aquifer, and the Patoka aquifer, respectively. These sandstone units are similar in their lithologic and petrologic characteristics. At present (1966) the Linton aquifer is not a source of fresh ground water in Vanderburgh County. However, in the eastern part of the county the aquifer is near enough to land surface to contain fresh water. The estimated field coefficient of permeability of the sandstone aquifers is 10 gallons per day per square foot, and the maximum coefficient of transmissibility is estimated to be 1,000 gallons per day per foot. Yields reported from wells in the Dugger and Patoka aquifers range from less than 1 to approximately 20 gallons per minute. However, most wells in these aquifers are reported to yield 5 gallons per minute or less. The water in the Dugger aquifer is predominately a moderately hard sodium bicarbonate type, low in iron content. The water in the Patoka aquifer is mostly a hard to very hard calcium bicarbonate type with moderately high amounts of iron.

Sand and gravel deposits of the Ohio River valley are the best aquifer in Vanderburgh County. These deposits form a single hydrologic unit that is herein named the Ohio River valley aquifer. This is the only aquifer in the county capable of accommodating high-yield wells. Properly constructed wells in this aquifer could easily yield 1,000 gallons per minute and more. Transmissibilities in the Ohio River valley aquifer range from 120,000 gallons per day per foot and less near the valley walls to more than 200,000 gallons per day per foot in the thickest parts of the aquifer. The water in the aquifer is predominately a very hard calcium bicarbonate type having a high iron content.

INTRODUCTION

PURPOSE AND SCOPE

The purpose of this investigation is to determine ground-water availability in Vanderburgh County, Indiana, and to provide information to aid water users in the location and development of ground-water resources. No previous attempt has been made to collect and organize the data and present a quantitative evaluation of these resources. Demands for water are increasing constantly throughout the county because of the steady population growth in rural as well as in urban areas, and utilization of these resources is limited by a general lack of knowledge. Where is the water? How much is available? What is its quality? These are questions most often asked. To provide answers to these and other questions concerning ground-water availability, this report includes an identification of the important sources of ground water in the county, an evaluation of hydrologic characteristics and potential of these sources, and a determination of the chemical quality of the water.

The fresh ground water of Vanderburgh County is discussed in detail because of its importance to the growth and development of the county. Fresh water is water in which the dissolved mineral content (dissolved solids) does not exceed 1,000 ppm (parts per million). This definition follows that of Robinove, Langford, and Brookhart (1958).

The data upon which this report is based were compiled from approximately 900 water well and oil well drillers' logs, 230 oil well electric logs, 306 seismic shots, and 18 laboratory and 56 field chemical analyses of ground-water samples. These data are on file in the office of the U.S. Geological Survey, Indianapolis, Indiana. Pertinent literature concerning the soils, the geology, and the water resources of the county was reviewed and utilized. In addition, a geologic and hydrologic reconnaissance was made of the entire county.

COOPERATION AND ACKNOWLEDGMENTS

The ground-water resources of Vanderburgh County have been investigated by the U.S. Department of the Interior, Geological Survey, in cooperation with the Indiana Department of Natural Resources, Division of Water, as a part of the statewide investigation of the ground-water resources of Indiana. The authors wish to express their sincere thanks to all persons who contributed time, information, and assistance during the collection, tabulation, and processing of data for this report. We are especially grateful to the following State agencies for information furnished by them and used in this report: the Geological Survey, the Division of Oil and Gas, and the Division of Water, all under the Department of Natural Resources.

GEOLOGIC AND PHYSIOGRAPHIC SETTING

Geology

Vanderburgh County, in southwestern Indiana (fig. 1), is a part of the Eastern Interior Basin. The Eastern Interior Basin is a prominent structural feature of the central stable region of North America. The basin had its beginning in late Precambrian or Early Cambrian time as part of a larger structural basin which extended from northern Michigan to southern Illinois. This basin was relatively deep and elongate and roughly paralleled the Appalachian geosyncline. The emergence in Devonian time of the northwest-southeast trending Kankakee arch separated the original basin into two structures; the Michigan Basin to the north, and the Eastern Interior Basin to the south. With the exception of temporary regressions and transgressions of the sea, the Eastern Interior Basin continued to subside and receive sediment throughout most of the remainder of Paleozoic time. At the close of the Pennsylvanian Period the sea withdrew permanently from the basin leaving deposited upon the Precambrian basement complex a sequence of sedimentary rock more than 12,000 feet thick (pl. 1).

After the final withdrawal of the sea, there began an interval of subaerial weathering and erosion. The poorly consolidated Pennsylvanian clastic rocks of the basin offered little resistance to erosion, and the area was extensively peneplaned during Mesozoic and most of Cenozoic time. During the Pleistocene Epoch of the Quaternary Period much of the basin was mantled by till, outwash and other deposits resulting from successive waves of continental glaciation. The Recent Epoch began some 10,000 to 12,000 years ago with the northward retreat of the Wisconsinan glacier.

Physiography

The events of the Pleistocene Epoch profoundly affected the physiography of Vanderburgh County. Only a small part of the county, the northwest corner, was actually covered by glacial deposits. (See pl. 2.) Proglacial features rather than direct glaciation were responsible for the present physiography of the county. During Illinoian and Wisconsinan time, bedrock valleys in the county were either occupied by glacial lakes or served as sluiceways for sediment-laden glacial melt water. As a result, these valleys were aggraded by lake sediment and outwash deposits that remain today as broad, flat alluvial and lacustrine plains rimmed by hilly bedrock uplands.

Surface drainage is mostly to the Ohio River by way of Bayou Creek and Pigeon Creek and other small tributaries. However, in the northwest quarter of the county drainage is to the Wabash River through Big Creek and its tributaries.

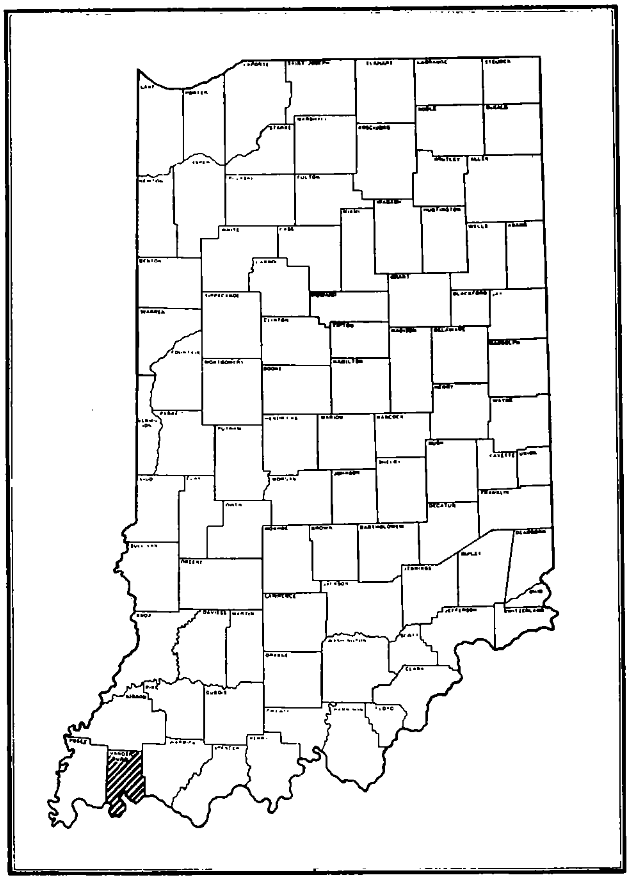


FIGURE I – Location of Vanderburgh County.

A knowledge of land-surface elevation is important in ground-water investigations. The depth to any subsurface stratigraphic horizon can be determined by subtracting the elevation of the horizon from that of land surface at the desired location. U.S. Geological Survey 7.5 minute topographic quadrangle maps are published for the entire county; therefore, a topographic map is not included in this report. These maps may be purchased from the Indiana Department of Natural Resources, Indianapolis, Indiana 46204 or the Distribution Section, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

CLIMATE

Continuous records of precipitation and air temperature at Evansville, Indiana, have been kept since 1895 by the U.S. Weather Bureau. Based on the records for the period 1931-1960 the normal annual precipitation is 41.45 inches. The normal monthly precipitation is shown in table 1. Precipitation is relatively abundant in this area and is spread fairly evenly throughout the year, a condition favorable to a uniform ground-water supply.

Table 1.--Normal monthly precipitation at Evansville, Indiana (1931-1960)

Month	Precipitation (inches)
January	3.98
February	3.18
March	4.31
April	3.98
May	4.19
June	3.74
July	3.32
August	3.07
September	2.87
October	2.57
November	3.16
December	3.08

SOURCES OF GROUND WATER

Ground water is the water in the zone of saturation. The water table marks the top of the zone of saturation, or the zone where the void spaces in the rock are completely filled with water. When the interconnected void spaces in a layer of rock are large enough to supply ground water to wells in sufficient quantities to satisfy domestic, industrial, municipal or other needs, the layer of rock is called an aquifer or source of water.

Oil-well electric logs indicate that aquifers are present in the rock sequence underlying Vanderburgh County from the top of the water table to depths of about 4,000 feet. Aquifers are probably also present in deeper rocks. All aquifers, regardless of depth and water quality, are part of the overall ground-water resources of the county. However, ground water in

Vanderburgh County becomes increasingly mineralized with depth, and water in the deeper aquifers is too mineralized to be useful for most purposes. Thus, this investigation is limited to the relatively shallow rocks of Pennsylvanian and Pleistocene Series because these rocks contain the important fresh-water aquifers.

The general availability of fresh ground water in Vanderburgh County is summarized on figure 2.

THE PENNSYLVANIAN SYSTEM

The Pennsylvanian System of Vanderburgh County extends upward from the unconformity at the base of the Mansfield Formation to and including the lower part of Bond Formation of Kosanke and others (1960). (See fig. 3.) Rocks of Middle and Late Pennsylvanian age constitute the bedrock surface. (See pl. 1.) The maximum thickness of the Pennsylvanian section in Vanderburgh County is about 1,500 feet. Deposition during Pennsylvanian time was cyclical, and alternating layers of shale, sandy shale, and sandstone are the predominant lithologic units of the section with minor amounts of coal, underclay, and limestone present. The great areal persistence of many relatively thin (generally 5 feet or less in thickness) limestone members and coal beds is the most characteristic feature of these sediments, particularly in the middle and upper series. These limestone members and coal beds are important stratigraphic markers.

The Pennsylvanian sediments of Vanderburgh County have undergone no major structural deformation. The structure of individual rock units may be visualized as a gently rolling (undulating) surface dipping to the northwest at an average rate of 25 feet per mile. This uneven surface is probably the result of the differential compaction of sandstone and shale units.

An important zone of faulting, the Wabash Valley fault system, is just to the west of Vanderburgh County. However, no large faults are mapped in the county. Friedman (1954) shows the approximate and inferred location of two small normal faults in the western part of the county. These faults dip to the northwest and have a vertical displacement of approximately 20 feet in Middle and Upper Pennsylvanian strata. Though it is possible that these and other faults of similar vertical displacement exist in the county, the amount of subsurface data available for this investigation was insufficient to ascertain with any degree of certainty the presence of faults of this magnitude.

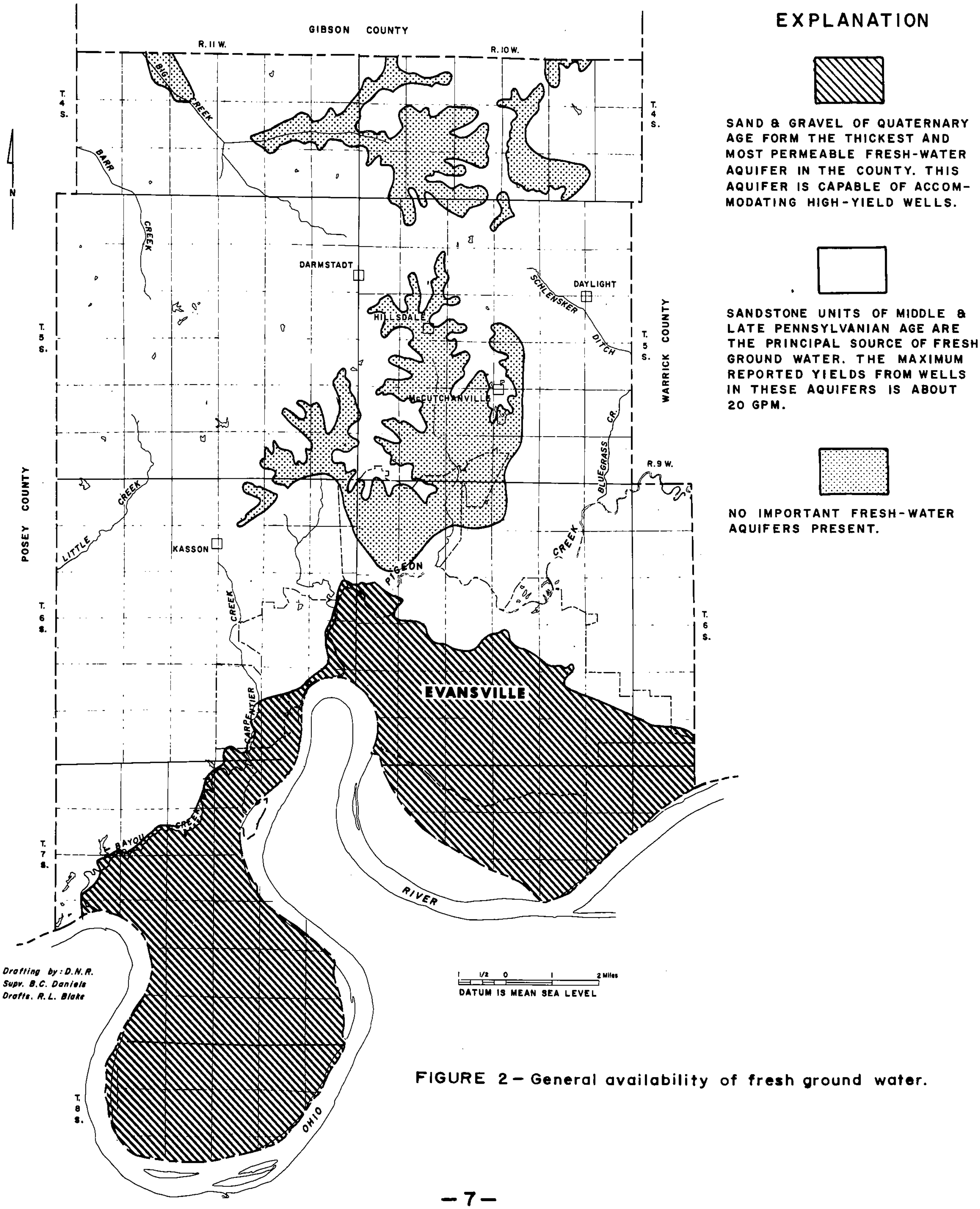


FIGURE 2 — General availability of fresh ground water.

System	Series	Formation and Significant Members
CARBONIFEROUS PENNSYLVANIAN	Upper Pennsylvanian	Bond of Kosanke and others (1960)
		Patoka of Wier and Gray (1961) Inglefield Sandstone Member of Wier and Girdley (1963)
		West Franklin Limestone Member of Wier and Gray (1961) Shelburn
	Middle Pennsylvanian	Dugger
		Petersburg
		Linton Coxville Sandstone Member of Ashley (1899)
		Coal III Staunton
		Brazil
	Lower Pennsylvanian	Mansfield

Figure 3.--Stratigraphy of the Pennsylvanian System for Vanderburgh County.

Where are the Aquifers?

Sandstone units are the best aquifers in the Pennsylvanian sediments of Vanderburgh County although water wells are occasionally made in limestone, coal beds, or shale. Sandstone units occur regularly throughout these sediments and show a great deal of similarity in shape and orientation. However, the sandstone units are difficult to trace in the subsurface. They are subject to sharp variations in thickness in relatively short distances. Abrupt lateral changes in facies result in irregular and discontinuous areal distribution. A series of generalized geologic sections (pl. 2) show the formation boundaries and major sandstone units of the Pennsylvanian System.

The lithologic (physical) character of a rock unit directly affects its water-bearing characteristics. In rock units like those of the Pennsylvanian System of Vanderburgh County, lithology largely determines permeability or the capability of the rock units to transmit water. The lithologic character (and thus the permeability) of the sandstone units is not uniform throughout the Pennsylvanian section. In the Mansfield Formation, for example, sandstone units are composed mostly of rounded, medium-sized grains of quartz with relatively little detrital matrix (Greenburg, 1960). These are probably the most permeable sandstone units of the entire section. Near the top of the section, however, the individual quartz grains of the sandstone units are angular and there is a relatively large amount of detrital matrix in the intergranular void spaces thus decreasing permeability.

The Pennsylvanian sediments of Vanderburgh County are herein subdivided into two parts on the basis of the occurrence of fresh water. With the data available, however, it is not possible to determine the exact depths at which the water in these sediments ceases to be fresh. This varies from place to place and can only be approximated. Coal III of the Staunton Formation (fig. 3) was selected as the basis for subdividing the Pennsylvanian sediments because it is the only easily recognizable stratigraphic marker in the vicinity of the lower limit of fresh water. (See fig. 4.) Sandstone aquifers above coal III are either completely or partially fresh-water bearing. No fresh water-bearing aquifers are present anywhere below coal III. Figure 5 is a map of Vanderburgh County showing structure contours on coal III.

Aquifers Below Coal III

Sandstone units with good aquifer characteristics are present in the Pennsylvanian sediments below coal III. Very little information is available concerning the water-yielding potential of these units. The sandstone units of the Mansfield Formation are the best aquifers. These sandstone units are the thickest, and the most continuous of the entire Pennsylvanian section. (See pl. 2.) In Vanderburgh County, however, the top of the formation ranges in depth from approximately 800 to 1,200 feet below land surface. At these depths the water is highly mineralized as shown by the results of water analysis number 1, table 2.

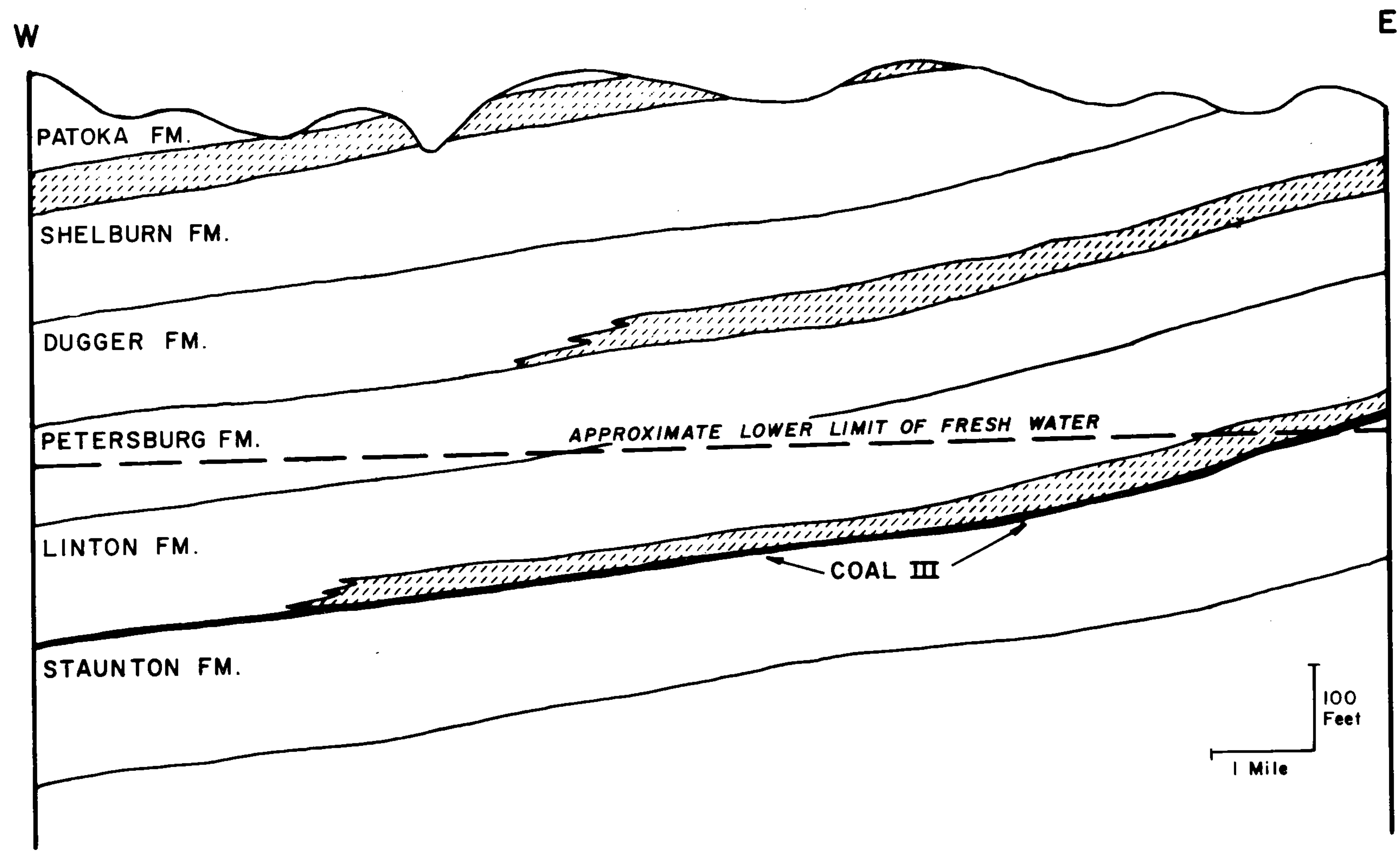
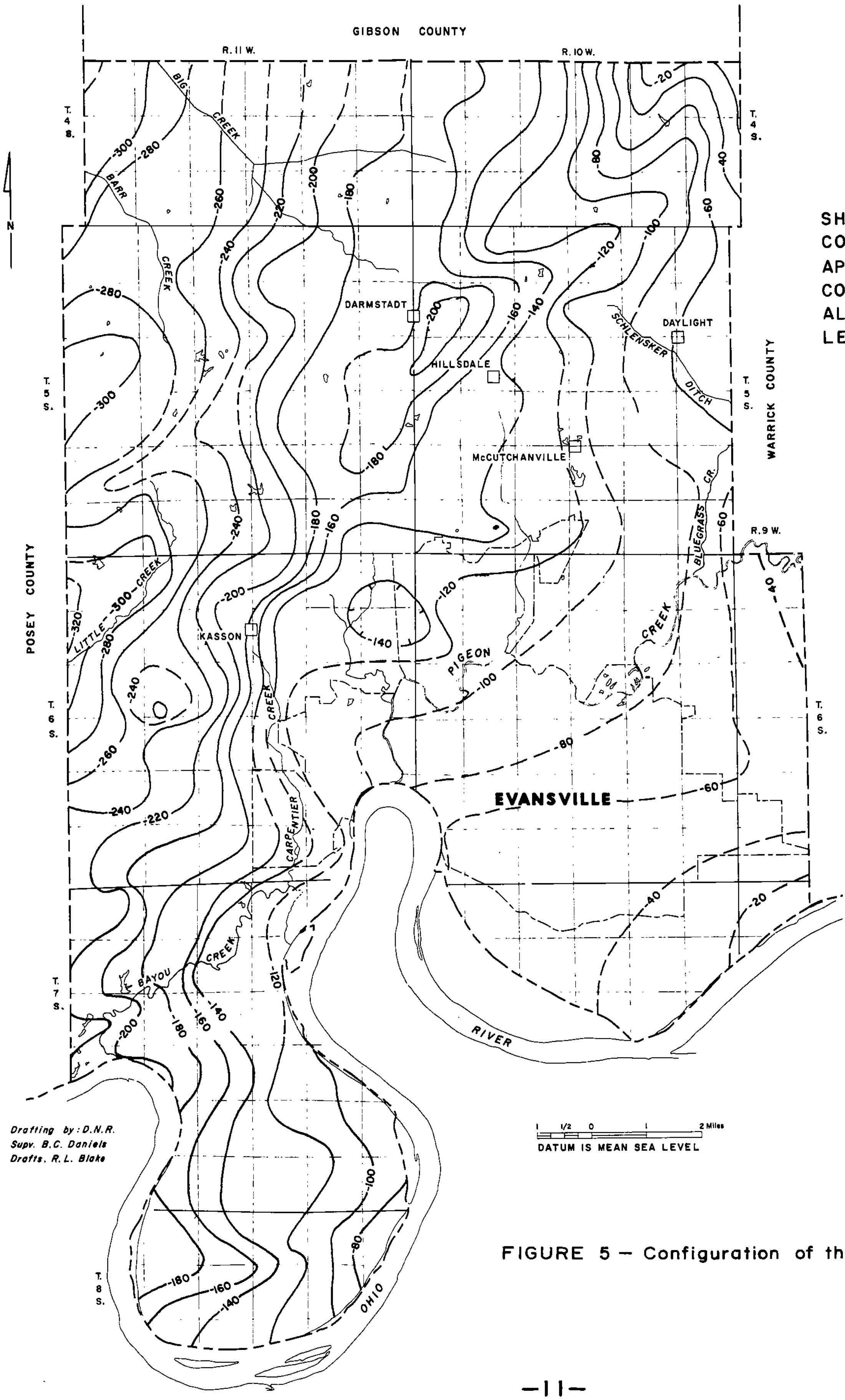


FIGURE 4.-- Generalized geologic section showing approximate lower limit of fresh water in relation to Coal III. Patterned areas represent sandstone aquifers.



EXPLANATION

-200

STRUCTURE CONTOUR

SHOWS ALTITUDE OF TOP OF COAL III. DASHED WHERE APPROXIMATELY LOCATED. CONTOUR INTERVAL 20 FEET. ALL DATUM IS MEAN SEA LEVEL.

FIGURE 5 – Configuration of the top surface of Coal III.

Aquifers Above Coal III

Sandstone aquifers above coal III are the source of fresh water for much of Vanderburgh County. There are three sandstone units above coal III that are areally extensive enough to be important aquifers. These sandstone aquifers are in the Linton and Dugger Formations as recognized by the U.S. Geological Survey, and in the Patoka Formation of Wier and Gray (1961). In this report, these aquifers will be referred to as the Linton aquifer, the Dugger aquifer, and the Patoka aquifer, respectively. North of the Ohio River terrace and flood-plain deposits (pl. 2), these aquifers constitute the principal source of fresh ground water.

The Linton aquifer

The Linton aquifer is at the base of the Linton Formation (fig. 6) and consists of the Coxville sandstone member of Ashley (1899) (fig. 3). This aquifer does not crop out in the county and has a rather limited areal distribution. At present (1966) the Linton aquifer is not used as a source of water in Vanderburgh County. Fresh-water aquifers in the rock sequence above make it unnecessary to drill down to this aquifer. In all probability much of the Linton aquifer is not fresh-water bearing, owing to its depth; however, in the eastern part of the county near the Vanderburgh-Warrick County line the aquifer is near enough to land surface to be fresh-water bearing. The areal extent, thickness, and altitude of top of the Linton aquifer are shown on figure 7.

The Dugger aquifer

The Dugger aquifer is in the upper part of the Dugger Formation (fig. 6). This aquifer is extensively used as a source of fresh water in eastern and southern Vanderburgh County. The aquifer crops out at the bedrock surface in the southern part of the county, and is present in the subsurface over much of the county. The Dugger aquifer is a single hydrologic unit consisting of an upper and lower sandstone unit separated by a relatively thin layer of limestone. It is rare to find all three of the lithologic units present at any one location in the aquifer. The upper sandstone unit and the limestone are present over most of the southern part of the county but shale out toward the north, whereas the lower sandstone unit is present over much of the eastern part of the county but shales out toward the south.

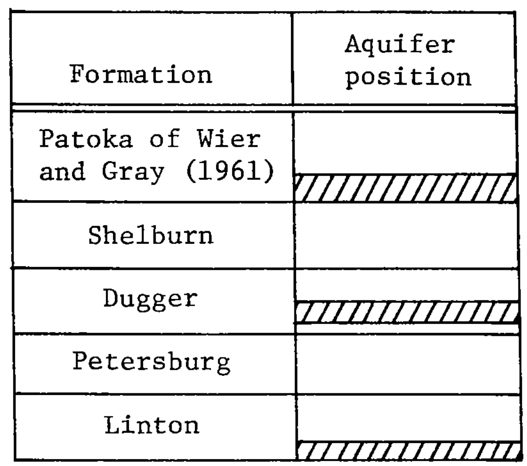


Figure 6.--Stratigraphy of the Pennsylvanian section above coal III with patterned areas showing the position of the aquifers.

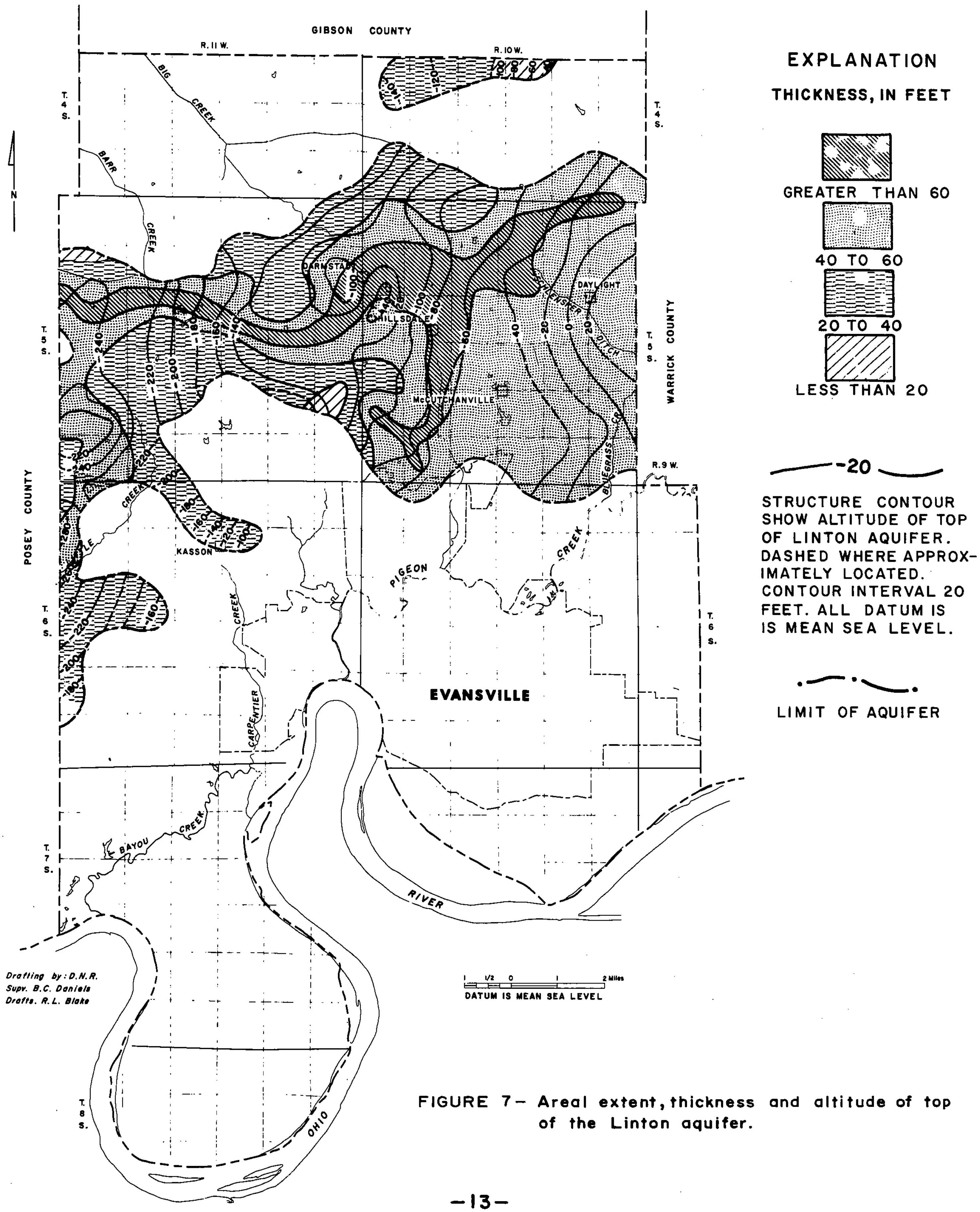


FIGURE 7 – Areal extent, thickness and altitude of top of the Linton aquifer.

The areal extent, thickness, altitude of top, and outcrop of the Dugger aquifer are shown on figure 8. The aquifer is very discontinuous and shows a highly irregular areal distribution. Except for a small area in the northwestern corner of the county, the aquifer shales out completely toward the northwest.

The Patoka aquifer

The Patoka aquifer is the thickest and most areally persistent of the fresh-water bearing sandstone aquifers in Vanderburgh County. More wells are supplied from this aquifer than from any other aquifer in the county. The Patoka aquifer is at the base of the Patoka Formation (of local usage) (fig. 6) and consists almost entirely of the Inglefield Sandstone Member of Wier and Girdley (1963) (fig. 3). In places, however, the underlying West Franklin Limestone Member of the Shelburn Formation of Wier and Gray (1961) (fig. 3) also may be part of the hydrologic unit. The outcrop of the aquifer extends in a broad band diagonally across the county from northeast to southwest, and the aquifer is present either at the bedrock surface or in the subsurface over almost all of the central and northwestern part of the county. The relatively deep, lacustrine-sediment-filled bedrock valley in the northwestern corner of the county cuts completely through the aquifer and exposes the underlying Shelburn Formation. (See pl. 1.) The areal extent, thickness, altitude of top, and outcrop area of the Patoka aquifer are shown on figure 9.

The dry hole problem

The sandstone aquifers of Vanderburgh County are dependable sources of water, and wells drilled into them are rarely reported to be dry. However, many of the dry holes that are drilled in the county seem to be the result of a general lack of understanding of the stratigraphic and structural relationship of the Dugger and Patoka aquifers. Stratigraphically these aquifers are one above the other with approximately 200 feet of shale, sandy shale, coal beds, and limestone separating them. Structurally each aquifer dips northwestward and becomes progressively lower in elevation or deeper below land surface. The aquifers are deepest, therefore, in the northwest parts of the county, and become progressively shallow updip toward the southeast until they end by cropping out at the bedrock surface. Except along the strike there is no uniform depth to any of the sandstone aquifers. In the central and northwest parts of the county, water wells are made in the Patoka aquifer because it is the aquifer nearest to land surface. Southeast of the outcrop of the Patoka, wells must be drilled down to this aquifer. It is in the area just southeast of the Patoka aquifer outcrop that most of the dry holes occur. Here the aquifer depth is significantly greater than in the adjacent area to the northwest where wells are made in the relatively shallow Patoka aquifer. In some parts of this area sandstone is absent, but many dry holes are the result of not drilling deep enough to reach the Dugger aquifer.

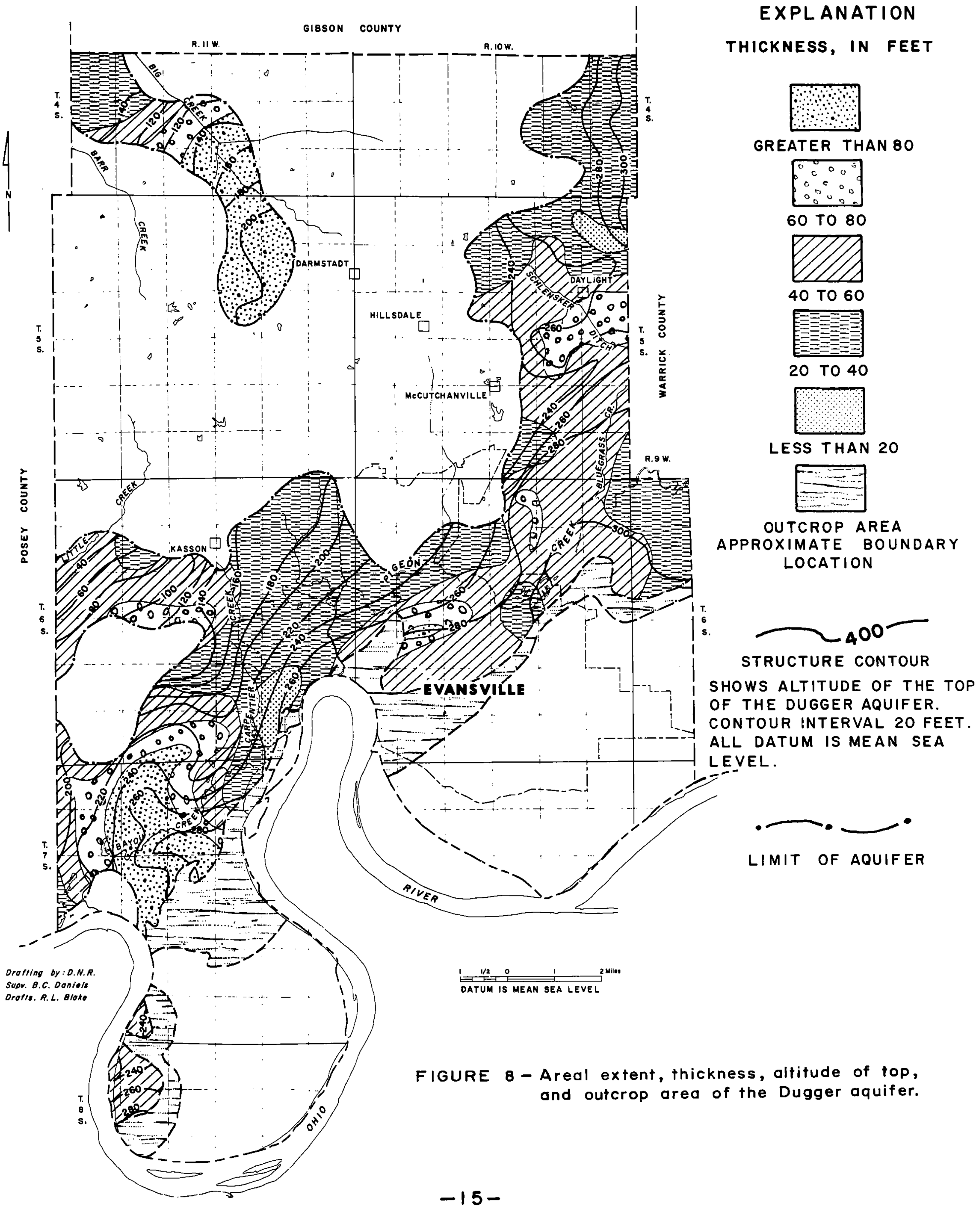


FIGURE 8 – Areal extent, thickness, altitude of top, and outcrop area of the Dugger aquifer.

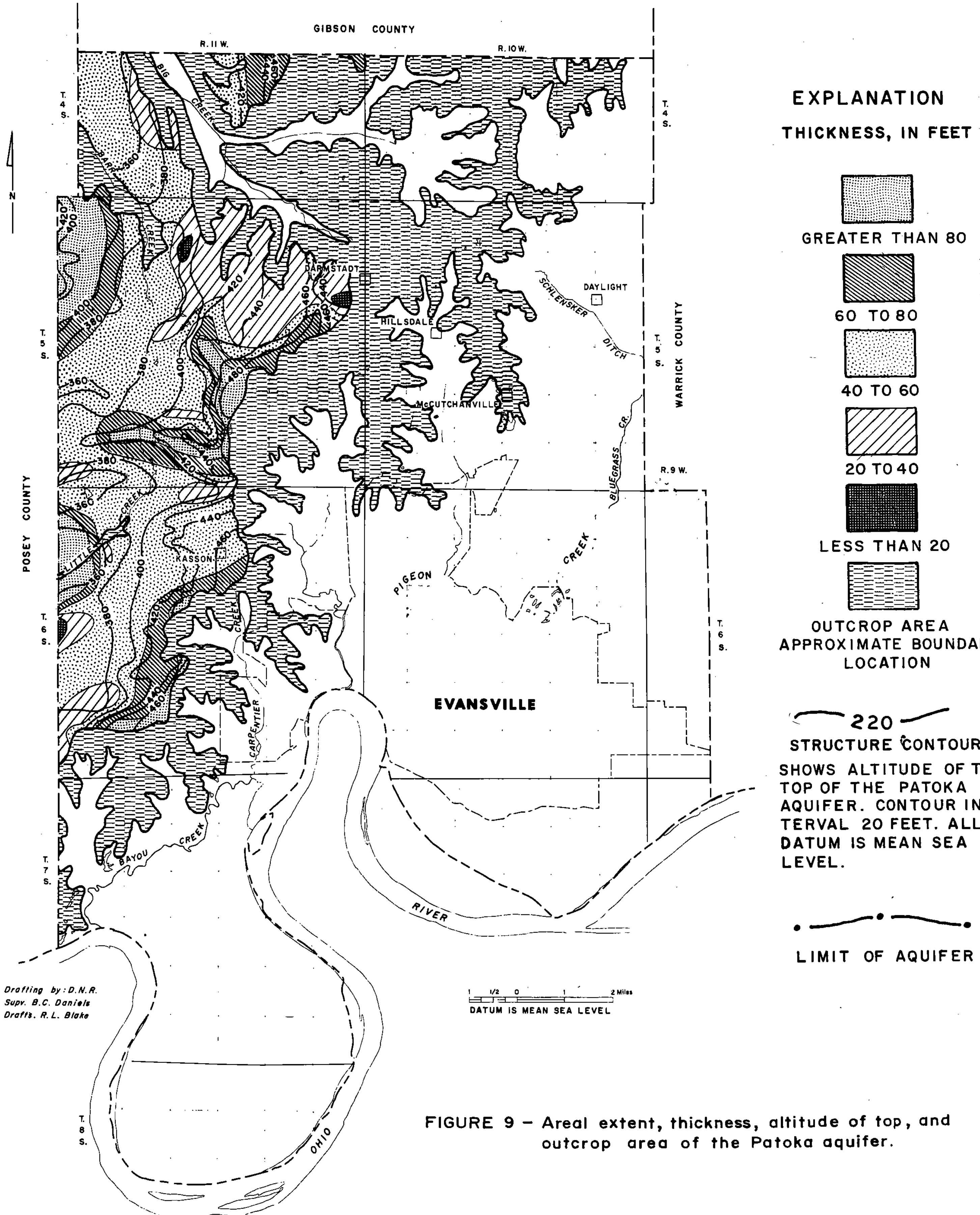


FIGURE 9 – Areal extent, thickness, altitude of top, and outcrop area of the Patoka aquifer.