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Hydrogeology Of Glacial Deposits In Tippecanoe County, Indiana, Systematic Development Of Methodologies In Planning Urban Water Resources For Medium Size Communities

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TECHNICAL REPORT NO. 61

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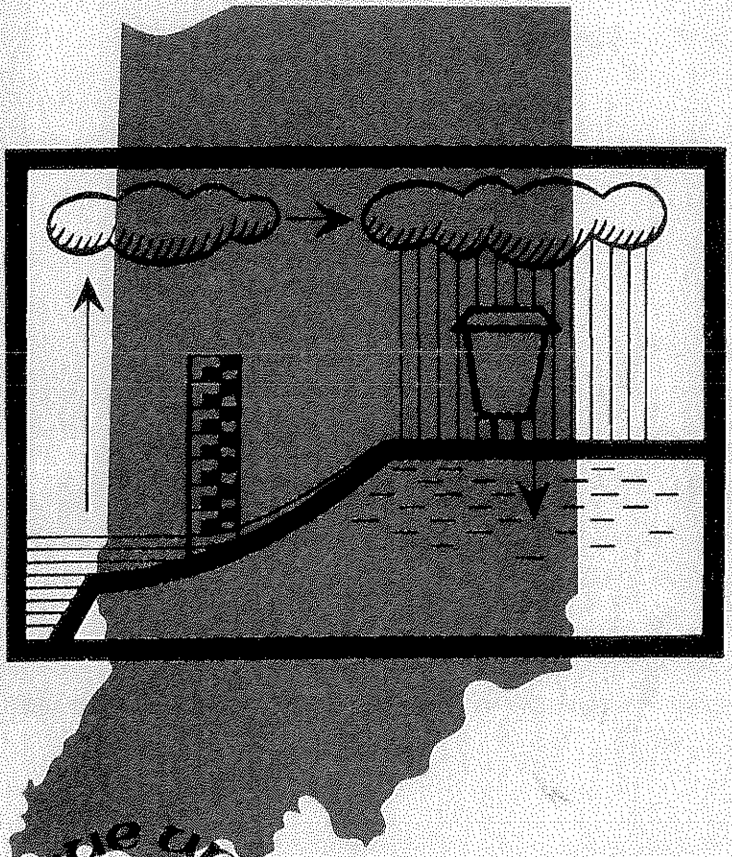
Systematic Development of Methodologies in Planning Urban Water Resourses for Medium Size Communities



by

Abdelrahman M. S. Maarouf

Wilton N. Melhorn

June 1975

PURDUE UNIVERSITY
WATER RESOURCES RESEARCH CENTER
WEST LAFAYETTE, INDIANA

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A completion report for the hydrogeology subproject of OWRT Project No. C-3277 (Grant No. 14-31-0001-3712) entitled "Systematic Development of Methodologies in Planning Urban Water Resources for Medium-Size Communities".

Purdue University

Department of Geosciences

West Lafayette, Indiana

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West Lafayette, Indiana 47907

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ABSTRACT

Tippecanoe County, Indiana was invaded by ice during three major episodes of Pleistocene continental glaciation. Unconsolidated glacial deposits of the county average about 200 feet in thickness, although bedrock crops out locally and geophysical measurements suggest that drift thickness exceeds 400 feet in some places. Distribution and thickness of pre-Illinoian, Illinoian, and Wisconsinan glacial stage deposits and the presence of interglacial Yarmouthian and Sangamonian weathering profiles are mapped or inferred from diagnostic properties of the sediments as recorded in more than 1,400 drill holes and 300 seismic measurements.

Analysis of subsurface data reveals that the pre-Pleistocene drainage system does not coincide with the present drainage network. The most significant changes probably were caused by the Illinoian ice which dammed the preglacial Teays River channel and ponded the relatively small Glacial Lake Lafayette. An outlet channel, developed to drain this proglacial lake, was subsequently perpetuated as the present Wabash River drainage line southwestward from the city of Lafayette.

The glacial drift contains the most significant aquifers. Groundwater occurs under both leaky artesian and water table conditions. Illinoian age outwash deposits are the most extensive and most highly developed aquifer, but pre-Illinoian and Wisconsinan outwash aquifers are also extensive and have not been significantly utilized. Perched water bodies in glacial till, Holocene alluvium and local bedrock aquifers have been tapped but are a limited source of water. In this study, aquifer distribution was mapped and their lithologic, stratigraphic and hydrogeologic aspect analyzed to the degree permitted by data available.

Most water wells in the county are less than 200 feet deep and yield from 5 to 2,000 gallons/minute, depending on thickness of the aquifer and well diameter. The present total pumpage for the county is about 35 million gallons/day, and there is no apparent long-term continuous decline in water levels. Future development of groundwater resources in the Lafayette urban area is most favorable in unexploited areas of thick sand and gravel aquifers which occupy the Teays, Anderson, Clarks Hill and other preglacial valleys in bedrock. These aquifers extend beyond the county boundaries and thus receive continual recharge and undergo continual outflow.

Limited geochemical data suggest that there is no significant deterioration of water quality, although local instances of contamination or pollution have been reported because of improper disposal of wastes. In addition to better monitoring systems for long-term measurement of quality, land use planning should recognize that certain geographic areas overlie the most promising aquifers and proper zoning controls should be enacted so that sufficient groundwater reserves are readily available to meet the growth needs of the expanding Lafayette community.

TABLE OF CONTENTS

FIGURES

Figure Page

Appendix
Figure

TABLES

Table

Page

Appendix
Table

PLATES

FOREWORD AND ACKNOWLEDGEMENTS

This report describes research performed for the hydrogeology subproject of the larger-scale investigation entitled "Systematic Development of Methodologies in Planning Urban Water Resources for Medium Size Communities." This investigation is an interdisciplinary study in which the Department of Geosciences, Agricultural Economics, and Sociology and the School of Civil Engineering are participating.

The Greater Lafayette area of northwestern Indiana is a prosperous and growing urban complex based on an economic mix of agriculture, light and medium-sized industry, and educational facilities. The community has relied on underground water supplies since 1891, and centrally located pumping from glacially-derived aquifers commenced in 1911. Water of good quality and sufficient quantity has been available to support the present population of about 110,000. The present consumption is estimated at 35 million gallons per day with no apparent decline in productivity or deterioration in natural quality.

It is anticipated that the growing Lafayette community will continue to rely primarily on its groundwater resources, and one principal purpose of the hydrogeological study is to outline potential aquifer areas for future development and expansion of the public water systems of the community. However, an equally important aspect of this interdisciplinary study has been to interface with the other co-investigators in determining water demand and consumption needs for a population base to the year 2020, to define possible problems of infiltration, recharge, and surface water runoff related to the subsurface aquifers, and to determine the potential pollution problems arising from increased physical expansion of the community.

Our report is based upon research conducted by Mr. Maarouf for his Master of Science thesis in the Department of Geosciences. Numerous additions and emendations have been completed by Dr. Melhorn. The authors are indebted to other members of the interdisciplinary research committee of the project for their advice and suggestions and for fruitful and stimulating discussions about various facets of water resources planning for metropolitan areas.

Special thanks are owed to Mr. William Steen of the Division of Water, Indiana Department of Natural Resources, for his help and cooperation in assembly and procurement of available well records and other hydrogeological information on Tippecanoe County.

Dr. J.A. Spooner contributed valuable help in project planning and data analysis. Appreciation is also expressed to Dr. R.D. Woodfill, Mr. G.T. Richardson, and Mr. J.B. Frater who at various times assisted the authors.

INTRODUCTION

Purpose and Scope

This report is the geological contribution to the interdisciplinary study entitled "Systematic Development of Methodologies in Planning Urban Water Resources for Medium Size Communities." Other portions of this interdisciplinary study deal with surface flow hydrology, water quality, economics, and sociology and results of these complimentary investigations are reported separately in other numbered Technical Reports of the Purdue Water Resources Research Center.

Tippecanoe County, Indiana was used in this project as an example for a study of planning methodologies for urban water resources. Because all water supplies in the county have historically come from subsurface aquifers, it is essential to (1) locate and delimit zones of groundwater inflow and outflow, and (2) determine the distribution of water within the glacial drift, which is the principal groundwater source in the Lafayette urban area. A better understanding of these factors will help to determine the amount of water that might be developed to meet the demands of a medium-size community without depleting the subsurface water resources. The present study therefore investigates the hydrogeologic conditions that control the development and production of water from the unconsolidated materials of Tippecanoe County.

The Greater Lafayette Community is nearly centrally located in the larger political entity that is Tippecanoe County. Because boundaries of aquifers are no respecters of arbitrary political subdivisions, the limits of the water-bearing units underlying the county extend far beyond its borders. Expediency and convention, however, directed that our study recognize the restraints that will probably restrict future development of water resources to areas of existing political authority or taxing powers.

Previous Investigations

Tippecanoe County was a popular target of research by some earlier investigators. McBeth (1900, 1901, 1902), Leverett and Taylor (1915), Malott (1922), Schneider (1966), and Johansen and Melhorn (1970) have described some of the physiographic aspects of the county. Ulrich *et al*. (1959) mapped the soils. Gorby (1886) wrote the first and only comprehensive geological report on Tippecanoe County. Fidlar (1948) and Thornbury (1958) discuss the alluvial terraces of the Wabash Valley and further reference to their papers occurs in subsequent sections of this report. Wayne (1956), and Burger *et al*. (1966) mapped the drift thickness and contoured the bedrock topography of northern Indiana. Wayne (1963) devised a stratigraphic classification and nomenclature for the Pleistocene formations of Indiana. Wayne *et al*. (1966) published surface and bedrock geologic maps of the Danville $1^{\circ} \times 2^{\circ}$ quadrangle which includes Tippecanoe County.

Harrell (1935) commented briefly on groundwater conditions in the county. Rosenshein and Cosner (1956) compiled basic data on 500 wells for a study of groundwater resources. Rosenshein (1958) analyzed and interpreted the data assembled in 1956 and produced a paleotopographic map for the county. West and Barr (1965) describe some groundwater problems of the Homewood Addition near West Lafayette.

Special mention is warranted of the papers by McBeth (1900 and 1901), particularly the sections of these reports dealing with the physical geography and the geological history of the "Great Bend" of the Wabash. McBeth presented a confusing panorama of numerous drainage diversions, local ponding of meltwaters to create proglacial lakes, sequences of moraine building, and advances and retreats of the different lobes of the last (Wisconsinan) glacier that invaded and covered the region. McBeth (1900, p. 158) also described the present drainage of the "Great Bend" (the sharp southward "hook" of the Wabash River at Lafayette) region as "interesting and peculiar". Apparently he thought that this course of the Wabash, as well as that of Wea Creek was controlled by glacial deposition that diverted the former drainage. (It is unlikely that McBeth was aware of the preglacial Teays River, which was not described until 1903 by W.G. Tight).

McBeth had no topographic maps or aerial photographs to supplement his field observations, and his papers have been largely forgotten. However, examination of recent LANDSAT-1 satellite imagery suggests at least one and possibly two alinements of similarly oriented "bends" on most major streams clear across north-central Indiana. Is there an older structural contral, such as a major fault zone in bedrock, whose influence still persists and which has controlled the location of "bends" in the principal regional drainages?

McBeth also suggested that moraines in southwestern Tippecanoe County south of the Wabash River, were deposited by ice of the Lake Michigan Lobe. Recent work by Bleuer (1974) has shown that Lake Michigan Lobe deposits north of the Wabash River are thinly veneered with ice-disintegration deposits of younger age laid down by the westward advance of the Lake Erie Lobe ice, and Bluer (1974, p. 1) further suggests that many of the major moraines of west-central Indiana south of the Wabash River were deposited by a segment of the Lake Michigan Lobe ice and later truncated by the Crawfordsville Moraine deposits of the Lake Erie Lobe.

The detailed discussion of the three preceding paragraphs does not have direct relevancy to the subsurface hydrogeology of the Lafayette urban area. It does, however, indicate that fundamental problems remain that prevent a complete understanding of the glacial events that have occurred. Our understanding of the hydrogeological complexities of the area will increase as the history of deposition of the aquifers and the glacial deposits that enclose them are slowly unraveled.

GEOGRAPHY

Location

Tippecanoe County is located in the west-central part of Indiana (Figure 1). It is a rectangle approximately 24 miles long and 21 miles wide, and encompasses an area of about 501 square miles. It is bounded on the east by Carroll and Clinton counties, on the west by Benton, Warren and Fountain counties, on the north by White County, and on the south by Montgomery County.

Lafayette, the county seat and largest city, is located in the central part of the county, 60 miles northwest of Indianapolis, and 130 miles south-southeast of Chicago.

Physical Setting

Physiography

The county lies within the Tipton Till Plain of Indiana (Malott, 1922), and is a section of the Till Plains subprovince of the U.S. Central Lowlands physiographic province.

Most of the surface of the county (Plate 1) is a nearly level glacial plain, but is gently undulating where morainic ridges, kames, and eskers occur. Shawnee Mount, 60 feet high, in the southwestern part of the county, is a notable example of kame moraine topography. Scattered among these topographically relatively high features are some closed depressions. A few closed, marshy depressions contain permanent or ephemeral natural ponds. These are the last relicts of formerly more

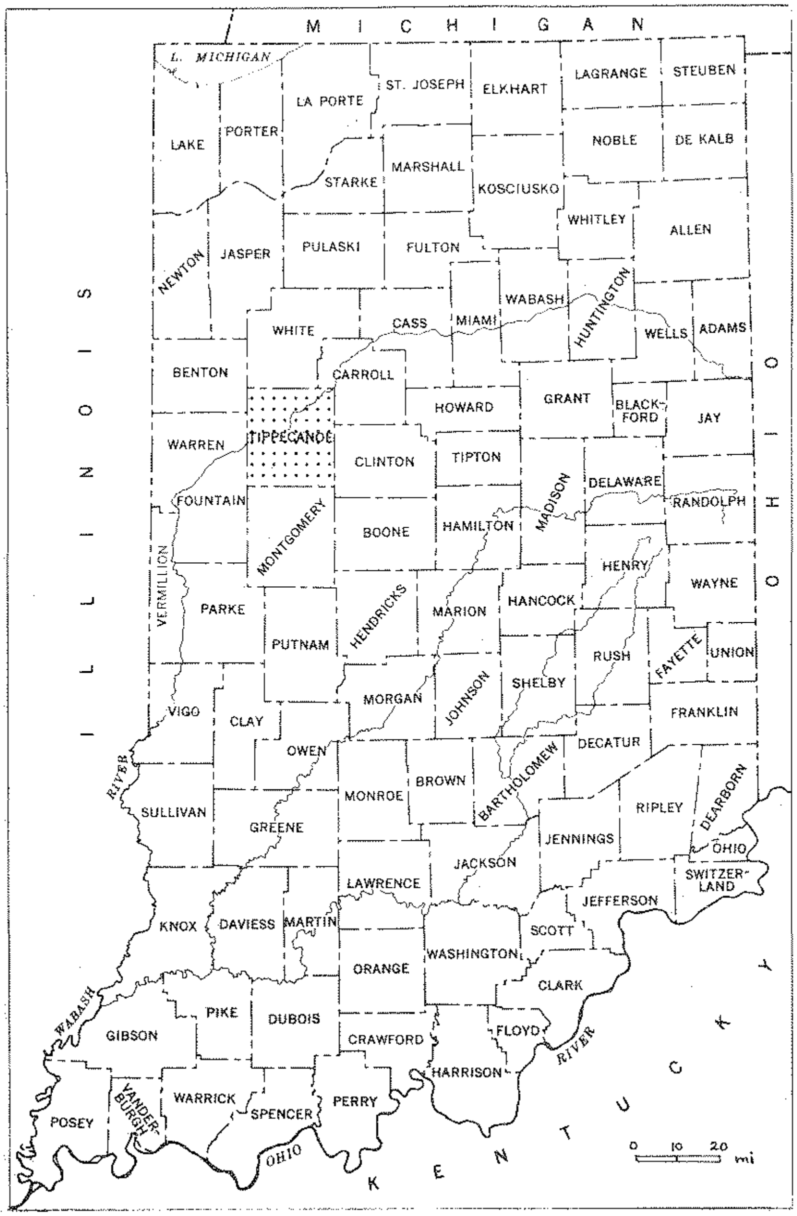

Figure 1. Map of Indiana Showing the Area of Study.

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abundant kettle Lakes of glacial origin that dotted the landscape and which have been mostly eliminated by postglacial drainage integration. Some areas of slope are steep where the Wabash Valley, the most conspicuous physiographic feature, and its tributaries dissect the plains. Two distinct sets of river terraces are associated with the Wabash Valley.

Locally, these flat surfaces are extensive and wide, but elsewhere they are restricted and narrow. The terraces occur in some places as detached tracts of higher ground rising from the old glacial sluiceway (Thornbury, 1958). The upper terrace surface is the Shelbyville Terrace. It is about 130 feet above the river, and represents the highest level of valley fill with Wisconsinan outwash (Fidlar, 1948). The lower surface is 20 to 30 feet above the present stream, and is known as the Maumee Terrace, because it was cut by the torrent from the rapid drainage of Glacial Lake Maumee flowing down the Wabash Valley (Fidlar, 1948) following the breaching of the Ft. Wayne moraine. The present flood plain is at the level that represents approximately the amount of valley downcutting since cessation of the Maumee flood.

Hadley Lake, northwest of Lafayette, lies in a linear depression that also contains the barbed drainage of Indian Creek and a branch of Burnetts Creek. The depression may be a glacial sluiceway that was subsequently abandoned, with stream capture resulting in isolation of Hadley Lake. Alternately, the linear may mark the course of a subice meltwater drainage (rinnentaler) channel (Johansen and Melhorn, 1970).

The highest point, located in the southwestern corner of the county, is 840 feet above mean sea level. The lowest point is 495 feet at the western county line where the Wabash River leaves the county. The average altitude is 680 feet. The maximum total relief is 345 feet, and the maximum local relief is 220 feet, along the river bluffs just north of West Lafayette.

Soils

Most of the soils of the county are derived from glacially deposited parent material. In a few areas soils are of alluvial, colluvial, or organic origin. Extensive upland areas of the county are covered with a thin mantle of loess deposits.

For purposes of the present study, the most important soil characteristic is the rate of infiltration (Plate 2). We have combined extant agricultural soils, engineering soils, and geologic parent materials maps to produce a map showing four general categories of infiltration properties: a) High permeability soils: infiltration rate exceeds two inches per hour. These soils are mostly on flood plains, the Wea Plain high terrace, terraces, kames, eskers, dunes, and steep slopes of the Wabash Valley. b) Moderate permeability soils: Rate is 2-0.6 inches per hour. These are mostly on undulating areas of till plains, and on moderately sloping areas along streams. c) Low permeability soils: Rate is 0.6-0.06 inches per hour. These are mostly on nearly level to gently undulating till plains. d) Very low permeability soils: Rate is less than 0.06 inches per hour. These are confined mostly to poorly drained closed depressions. The authors believe that infiltration maps, constructed in the manner described, are rare if not unique. They may have a useful predictive function in urban water resources studies in terms of potential pollution and runoff problems.

Drainage

The county lies within the middle Wabash River drainage basin. The Wabash courses southwestward from the northeastern corner of the county, and receives most of the natural surface and subsurface discharge. The northern, northeastern, and northwestern parts of the county are mainly drained by Tippecanoe River and Burnetts, Sugar, Buck, Indian, and Little Pine Creeks (Plate 1). The eastern part is drained mostly by Wildcat Creek. The southern and southwestern areas are essentially drained by Wea, Dismal, Flint, and Shawnee creeks. Tippecanoe River and Wildcat, Wea, and Indian creeks have diverted the Wabash River away from their outlets to impinge against the opposite bluffs. The widest part of the Wabash Valley is north of Lafayette where it is joined by Wildcat Creek. The valley is also wide southwest of Lafayette, where joined by Wea Creek. The relatively high crests between the main drainage ways divide the area into subbasins of the middle Wabash River basin.

The course of the Wabash River between sec. 4 and sec. 31, T23N., R.4W., most of the main course of Big Wea Creek with its semi-circular lower reach, Dismal Creek, Middle Fork of Wildcat Creek, and the lower section of Burnetts Creek have been controlled by bedrock topography and structure. These channels probably have been partly filled and subsequently re-excavated at least three times. The possible times of the start of re-excavation were late Kansan, late Illinoian and late Wisconsinan (for relative ages of glacial stages see Fig. 3, page 18). The course of the remaining streams may have been controlled by ice-margin drainage.

Man-made ditches have been constructed to improve the drainage in nearly level, low permeability areas. The county as a whole is well-drained.

Climate

The climate of the county is continental with hot summers and cold winters. The seasons are strongly marked, and the weather is frequently changeable. Climatological data available from the Purdue University Agronomy Department are summarized in Table 1. The table shows the conditions as measured at West Lafayette, where the latitude is 40° 28', the longitude is 87° 00', and the ground elevation is 706 feet.

The average annual temperature is about 50°F. The mean temperature in January, the coldest month, is 23°F, and in July, the warmest month, is 73.3°F. About nine days per year the temperature falls below zero, and about 137 days per year the temperature goes below freezing (32°F).

The average annual precipitation is 35.68 inches. July is the wettest month with 4.74 inches, and February is the driest month with 1.41 inches of precipitation. An average of 64 days per year have measurable precipitation (0.1 inch or more).

The growing season averages 160 days with the average last frost on May 2 and the first killing frost on October 9. Prevailing winds are from the west or southwest during the winter and from the south during the summer. Wind velocity is highest in February and lowest in August.

Population and Economy

The population of the county according to the 1970 census (Bureau of Census, 1970) was 109,378 persons. This was about 2.1% of the State of Indiana population, located within approximately 1.4% of the total state area. The largest center of population, the Lafayette-West Lafayette

Table 1. MONTHLY MEAN VALUES OF CLIMATIC ELEMENTS FOR PERIOD 1953-1970.

		J	F	M	A	M	J	J	A	S	O	N	D	Year
Temperature (°F)	Daily maximum	31.5	36.0	45.3	60.9	71.2	80.6	84.5	82.8	77.4	65.9	49.9	36.5	60.2
	Daily minimum	14.4	18.1	27.0	40.3	49.4	58.5	62.0	59.7	52.2	42.0	31.1	20.3	39.6
	Mean of the day	23.0	27.1	36.2	50.6	60.3	69.6	73.3	71.3	64.8	54.0	40.5	28.4	49.9
	Absolute maximum Year	65 1967	70 1954	80 1963	85 1960	92 1964	98 1954	106 1954	96 1954	98 1954	90 1963	78 1961	66 1966	106 July 1954
	Absolute minimum Year	-18 1970	-23 1963	-12 1960	20 1969	26 1968	39 1966	43 1963	35 1965	32 1959	20 1962	-1 1958	-16 1963	-23 Feb. 1963
Total precipitation (in)		1.81	1.41	2.22	4.31	3.94	3.85	4.74	3.38	2.62	2.69	2.70	2.01	35.68
Snow and Sleet (in)		4.8	5.9	3.5	.7	0	0	0	0	0	T	1.7	3.9	20.5
Daily minimum ‡ Relative Humidity %		70	59	55	50	52	52	50	52	49	49	64	69	56
Pan Evaporation * (in)					4.36	6.08	7.07	7.19	5.99	4.79	3.57			

‡ means for 1966 - 1970

* data for warm months only

urban area, contains 64,112 people. The county population is expected to increase to 166,000 by 1990.

The economy of the region is based mainly on agriculture, manufacturing, and Purdue University. According to the 1969 census of Agriculture, 247,289 acres (85.5% of the county land) are used for farming. The principal crops are corn, soybeans, wheat, oats, and hay. The county also supports important dairy production and livestock feeding. Aluminum, chemicals, food, housing, electronics, plastics, and sand and gravel production are large- and medium-size industries in the county. Purdue University (26,500 students) is also an important contributor to the economy.

METHODOLOGY

Compilation of Data

About 1,500 driller's water well logs were used as prime raw data for this study. Approximately 400 of these were compiled by Rosenshein and Cosner (1956). The rest were available from the files of the Indiana Department of Natural Resources, Division of Water. Field checking of about 100 wells was done to verify precise locations.

Water levels in 12 observation wells for years through 1973, with four or more years of recording, were obtained from the U.S. Geological Survey.

Some field study was made of different stratigraphic sections in the glacial drift and bedrock outcrops.

Mapping and Analyses

The glacial drift deposits of Tippecanoe County were analyzed, by quantitative methods (Figure 2) to produce geologic cross-sections, a fence diagram, and lithofacies-ratio maps. Thickness and distribution of sand and gravel units are shown on these representations.

In the present study clay, silt, and till are not differentiated, nor is sand from gravel. This is because of the lack of standard definitions among the water well drillers. Clay, silt, and till are generally not separable in the drilling records. Most till has a fine-grained matrix, and most drillers do not differentiate between till and clay unless the till is sufficiently stony. The distinction between coarse sand and small gravel is also not noted by most drillers.

The orographic features and surface drainage map (Plate 1) is based on the U.S. Geological Survey 7½ minute series topographic maps. The infiltration properties and surface geology map (Plate 2) is accomplished by combining soil maps (Ulrich et al., 1959) and engineering materials maps with the surface geology material map (Wayne et al., 1966).

The configuration and geology of the bedrock surface map (Figure 4) is derived from well records and seismic data. The same control points are used in compiling the unconsolidated material thickness map (Figure 9).

The interglacial paleosurface maps (Figures 6, 7) are based on the top of oxidized till sections, the top of thick outwash sections, and/or the occurrence of buried units composed of muck, peat, or wood chunks. The maps represent approximately the topography of the interglacial

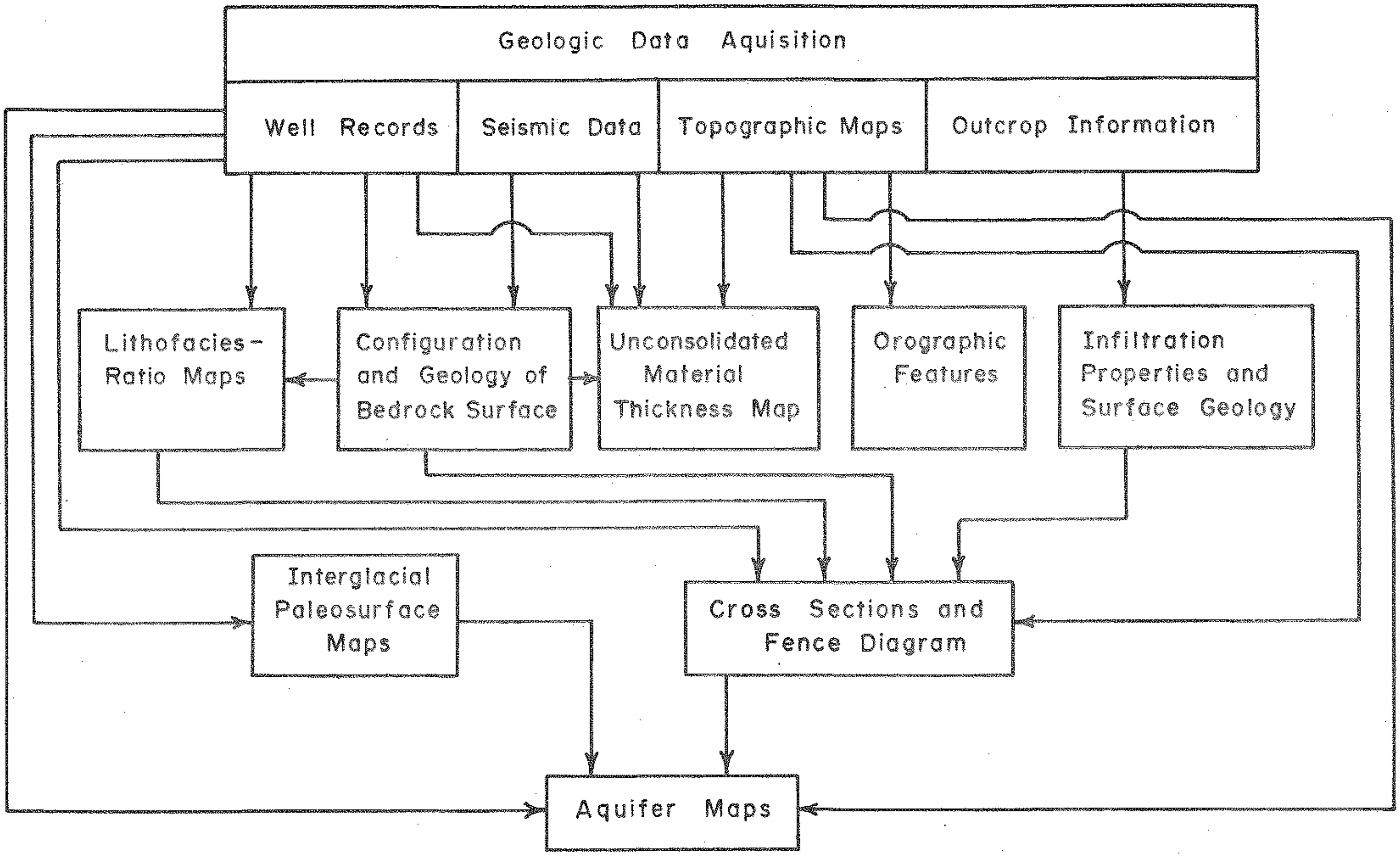


Figure 2. Developmental Model For Study of the Hydogeology of the Lafayette Urban Area.

Yarmouthian and Sangamonian surfaces, as those intervals were the most significant time breaks in glacial sedimentation, and the longest episodes of soil formation. The time involved during the shorter-lived interstadial episodes was not sufficient to allow a strong weathering profile to develop, and thus these events are not observable in well records. However, in some areas the stratigraphic relations are obscure and no interpretations are possible even at the interglacial level.

The unconsolidated material thickness map (Figure 9) is derived from well records and seismic data. A computer mapper program (Program MAPPER) developed at Purdue University was used experimentally in interpolation and partial derivation of this map, and also in the initial stages of construction of the bedrock surface configuration map (Figure 4). This program uses the CALCOMP plotter to construct machine produced printout in the form of contour maps. Although these maps are useful as checks against manually contoured maps, the machine can not "smooth" contours and the product is generally less satisfactory than a visually and manually smoothed map. The machine produced map was somewhat more satisfactory in constructing Figure 9 than Figure 4, but because neither is as good as the conventional product, neither experiment is reproduced in this report.

The cross sections and fence diagram (Plates 3, 4) are built up essentially from well records and the bedrock surface map. Spacing and positional lines of individual cross-sections are determined relative to the available data, the lateral thickness variation of major geologic units , and the need to get a general areal coverage across the country and local, more detailed coverage through Lafayette and vicinity.

The lithofacies-ratio maps (Figures 10-18) are based on known or interpreted lithologic information between the ground surface and the bedrock surface. These nine maps represent nine separate slices. Each slice is 50 feet thick, and shows the ratio of the thickness of sand and/or gravel to the total thickness of the slice. They represent, besides the areal dimensions, the vertical third dimension if they are sucessively overlain on each other in a vertically ascending order.

The aquifer maps (Figures 19-22) are prepared using data from well records, topographic maps, and collateral maps and diagrams (Figure 2).

On most of the illustrations in this report, uncertainties in stratigraphic, lithologic, elevational, or thickness relations are indicated by question marks or dashed lines.

GEOLOGY

General Statement

The county, except for a few bedrock outcrops of limited areal extent, is covered by a relatively thick mantle of unconsolidated deposits, mostly glacial drift. The glacial drift unconformably overlies Paleozoic rocks.

The Paleozoic rocks range in age from Silurian through Pennsylvanian. There was a long interval of sub-aerial weathering that apparently lasted from Pennsylvanian time until the deposition of unconsolidated Quaternary sediments. If younger Paleozoic, Mesozoic, or Cenozoic rocks were originally present they have been eroded. Several major valleys were incised into bedrock before and during glacial times.

During the Pleistocene, at least three major ice advances invaded the region. These glaciers filled existing valleys and covered the uplands with relatively thin deposits of drift. During the interglacial stages, conditions were most favorable for the formation of geosols and deposition of lacustrine, eolian, and alluvial sediments.

After the last ice retreat, the present drainage net was developed. There is some coincidence between present valleys and the bedrock valleys, but there are also many departures from this pattern where the location of the present surface drainage was controlled by ice-margin positions and lines of meltwater discharge.

Pre-Pleistocene Rocks

The principal bedrock formations that directly underlie the drift mantle in the county are shale, siltstone, and limestone (Figures 3, 4). They were deposited in a marine environment during the Silurian, Devonian, Mississippian, and Pennsylvanian Periods of the Paleozoic Era. Paleozoic rocks were subjected subsequently to almost continuous weathering and erosion and had been carved into a highly dissected old age topographic

TIME UNIT			ROCK UNIT	MAXIMUM THICKNESS(ft)	PHYSIOGRAPHIC ASPECTS	HYDROGEOLOGIC ASPECTS
SYSTEM	SERIES	STAGE				
QUATERNARY	HOLOCENE		mostly alluvium, some colluvium and lacustrine deposits of Martinsville Fm	30	development of present drainage lakes and swamps, dunes on lower terrace and flood plains	possible aquifer, if materials are permeable and below the water table
			eolian sand and silt, and lacustrine deposits of Atherton Fm	30	formation of lower Wabash terrace initiation of present drainage	permeable material below water table may yield adequate domestic supplies clay may confine the underlying aquifer
	PLEISTOCENE	Wisconsinan	mostly sand and gravel outwash of Atherton Fm	180	formation of Wabash upper terrace and outwash plains	large supplies along the Wabash Valley, subjected to pollution if not protected
			mostly till; some gravel and sand of ice contact stratified drift (Trafalgar Fm)		ground moraines, end moraines, kames, and eskers; burial of some older drainage lines	till may act as a confining bed to the underlying aquifer
		Sangamonian	soil, alluvium and lacustrine deposits	20	development of local erosion surfaces lakes and swamps	possible water-bearing zones in coarse-grained alluvium
		Illinoian	mostly sand and gravel outwash of Atherton Fm	150	re-excavation of Wabash channel as an outwash sluiceway; drainage west of Lafayette, elimination of the Teays-Mahomet drainage line	contains large supplies of water especially if connected with a surface water resource
			mostly till of Butterville Member (Jessup Fm)		Glacial Lake Lafayette ground moraines, end moraines?, and local outwash plains	till confines the underlying aquifer possible adequate domestic supplies if a sand lens is present
		Yarmouthian	soil, alluvium and lacustrine deposits	50	development of local erosion surfaces lakes and swamps	possible water-bearing zones in coarse-grained alluvium
		Kansan (?)	mostly sand and gravel outwash of Altherton Fm	250	re-excavation of Wabash channel as an outwash sluiceway filling of Otterbein Valley	large under developed water supplies
			mostly till of Cloverdale Member (Jessup Fm)		ground moraines, end moraines? and local outwash plains	may confine the underlying aquifer
PENNSYL-VANIAN	POTT-VILLIAN		mostly sandstone of Mansfield and Brazil Fms	20		water may be adequate for domestic or municipal supplies, possibility of contamination
MISSIS-SIPPIAN	VALM-EYERAN		Mostly shale and siltstone of Borden Group, some limestone of Rockford and lower part of Harrodsburg	300		water in joints may be adequate for domestic or municipal uses, possibility of contamination
DEVONIAN	Kin		New Albany Shale	140		water in joints at top may or may not yield adequate domestic supplies; sulfer contamination high. acts as confining layer to the underlying aquifer
	ERIAN-SEN.		limestone and dolomite of Geneva, Jeffersonville, and N. Vernon Fms	80		water in joints enlarged by solution, supplies adequate for domestic, municipal, and industrial purposes contaminated by sulfer from overlying New Albany Shale
SILURIAN	NIAGARAN		limestone of Liston Creek Member (Wabash Fm)	60		probably aquifer; water in joints enlarged by solutions

Figure 3 CLASSIFICATION OF THE BEDROCK AND OVERLYING DEPOSITS OF TIPPECANOE COUNTY, INDIANA. Rock units adapted from Wayne (1963); and Wayne *et al* (1966)

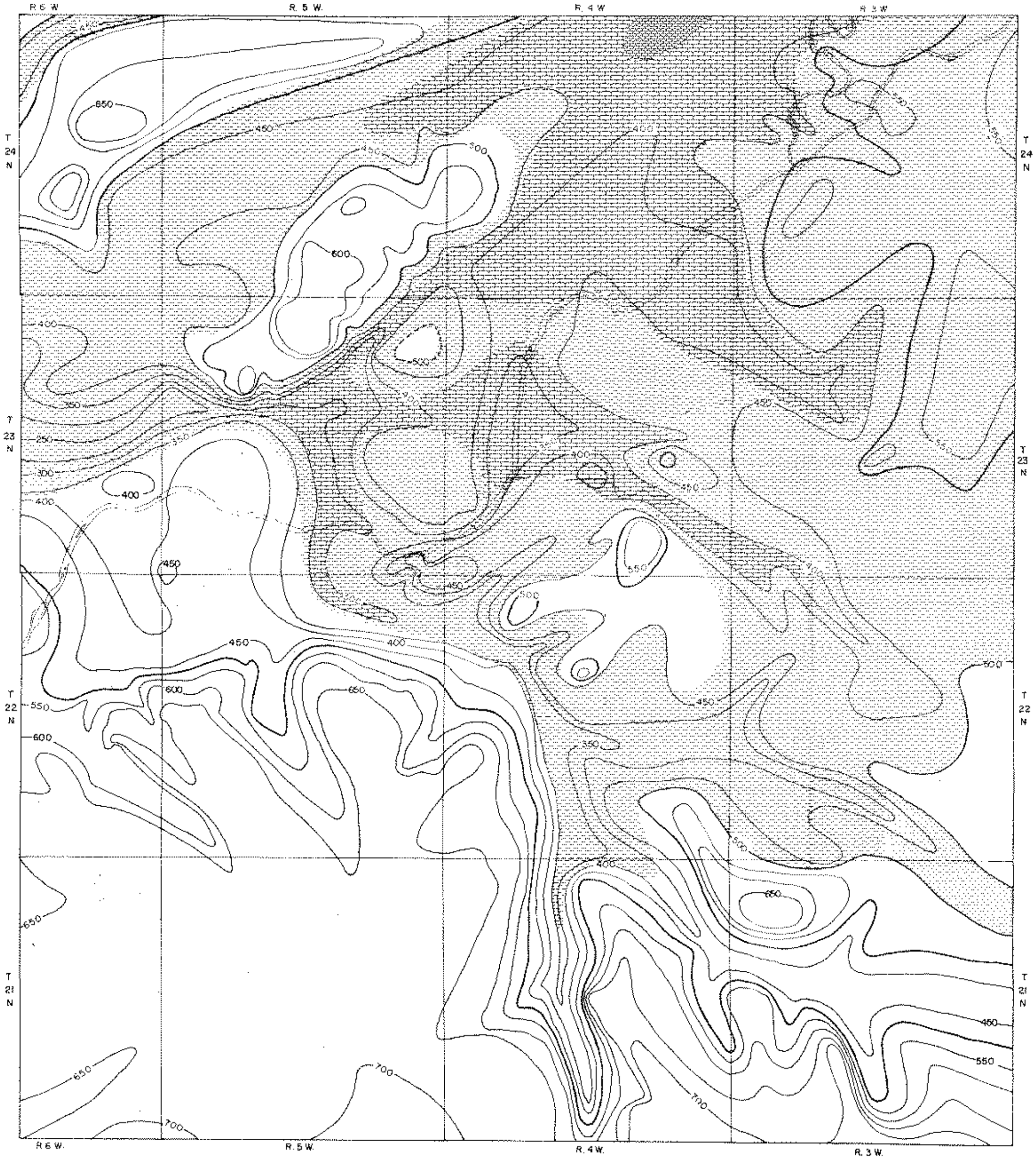


Figure 4 CONFIGURATION AND GEOLOGY OF THE BEDROCK SURFACE IN TIPPECANOE COUNTY

SCALE
0 1 2 miles
0 1 2 kilometers

EXPLANATION

- ☐ Mississippian, mostly Borden shale with some limestone, may include some Pennsylvanian sandstone in the extreme western area
- ▭ Devonian & Mississippian New Albany shale
- ▤ Devonian limestone
- ▦ Silurian limestone
- — Bedrock surface elevation

Contour Interval = 50 ft

surface by the time of the first ice advance. The present boundaries and distribution of the different formations are not definitely known because of the thick overlying cover. However, the bedrock surface configuration, as well as structure and lithology of the formations more or less affect groundwater conditions.

Bedrock Stratigraphy and Lithology

Data obtained from well drilling in Tippecanoe County and adjacent areas indicate that Borden (Mississippian) rocks underlie the greater part of the county, whereas the Liston Creek Member of the Wabash Formation (Silurian) probably underlies only a small area in the extreme north (Figure 4). The principal bedrock formations are listed and described, from oldest to youngest, as follows:

Silurian System

This is represented by the Liston Creek Member of the Wabash Formation. It is yellowish, massive, cherty limestone (Cumings and Shrock, 1928). These Silurian rocks in Tippecanoe County are an extension of the Silurian subcrop in the Teays Valley floor northeast of Tippecanoe County (Wayne *et al.*, 1966).

Devonian System

Mid-Devonian carbonate rocks belong in ascending order to the following formations (Frey and Eckerty, 1968):

Geneva Dolomite: brown, porous, and thin-bedded to massive.

Jeffersonville Limestone: brown to gray, dense to crystalline, and fossiliferous.

North Vernon Limestone: gray to blue, crystalline, hard, and partly argillaceous.

Mid-Devonian rocks occupy the troughs of some bedrock valleys in the middle and northern portions of the county (Figure 4).

Devonian-Mississippian System(s)

New Albany Shale is time-transgressive and is described as mostly black to brown, tough, fissile, carbonaceous and pyritic (Cummings, 1922). It crops out in the vicinity of Americus in the northeastern part of the county (Gorby, 1886), and directly underlies the drift in most of the bedrock valleys (Figure 4).

Mississippian System

Rocks belonging to this sytem overlie the New Albany Shale. They are mostly fossiliferous, greenish-gray shales and brown to gray siltstones of the Borden Group. The Borden is underlain by brown to gray, fine-grained dolomitic limestone of the Rockford Formation, and overlain locally by gray, coarsely-crystalline, crinoidal limestone of the Harrodsburg Formation (Stockdale, 1931). Some Borden crops out on Little Pine Creek and along Flint Creek near the county's western boundary (Plate 2, Figure 9). There are minor surface exposures elsewhere in the county. The Borden subcrops cap many of the bedrock uplands (Figure 4). Figure 4 is based on analysis of about 1,400 well records and 300 seismic points.

Pennsylvanian System

This is represented by coarse-grained, cross-bedded massive sandstones of the Mansfield and Brazil Formations. Sandstone occurs as outliers in the extreme western part of the county, particularly in the valley walls of Flint, Little Pine, and other creeks, where it commonly is seen resting unconformably on Borden Shale. However, Taylor (1974) studied conodont faunas of the Illinois Basin and suggested an older, Morrowan age (Upper Mississippian) for these units.

Structure

Tippecanoe County is located on the northeastern flank of the structural Illinois Basin. Bedrock strata dip southwesterly toward the center of the structural basin. The dip is about 20 feet per mile. The Pennsylvanian rocks successively overlap older formations in a northeastward direction. A structure contour map (Figure 5) drawn on the base of the Waldron Formation (Silurian), suggests the presence of a synclinal warping between two anticlinal warpings. These gentle structures appear to plunge and disappear southwestward. Other small structures such as minor folds and faults are possibly associated with the occurrence of the principal structure, i.e., the Illinois Basin. Joints and fractures are common in the different lithologic units forming the bedrock surface. Size and distribution of joints are related to type of bedrock. In the New Albany Shale, closed joints and fractures are abundant but discontinuous. The Borden rocks have numerous bedding planes and a poorly defined fracture system. In carbonate rocks jointing is well developed and locally enlarged by solution.

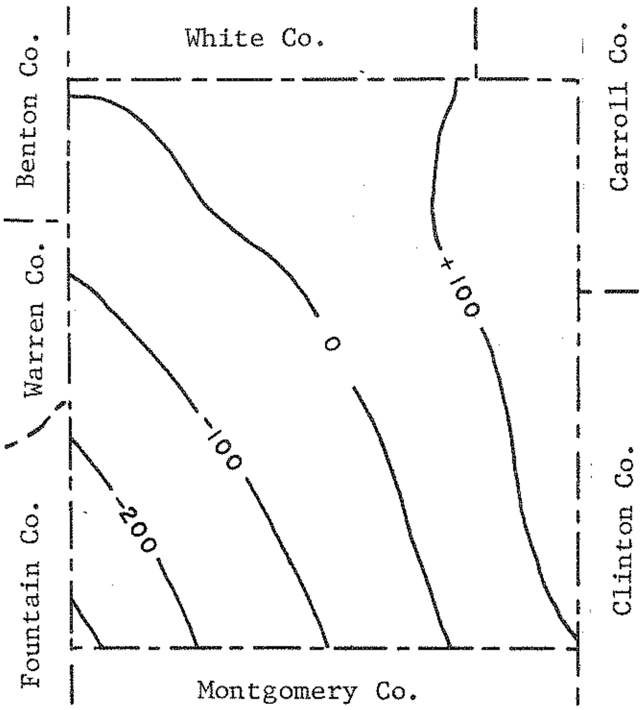


Figure 5. Structure on Base of the Waldron Formation, Tippecanoe County (from Pinsak and Shaver, 1964; datum is Mean Sea Level; contour interval is 100 ft.).

Bedrock Topography and Drainage

The present bedrock topography (Figure 4) is a result of preglacial, glacial, and interglacial deposition and erosion. It is characterized by a well-developed drainage system, in which the Teays, the Anderson, the Clarks Hill, and other bedrock valleys are deeply incised into Paleozoic rocks. The highest point on the bedrock surface is 732 feet above sea level in sec. 35, T.21N., R.3W., whereas the lowest point is 222 feet in sec. 7, T.23N., R.5W. This gives a total maximum relief of about 500 feet on the bedrock surface and thus is more than double the relief of the present surface.

Most of the bedrock surface paleotopography, if exhumed, would be included in two physiographic divisions. The eastern and northern areas would belong to the Scottsburg Lowland physiographic division (Malott, 1922). The relatively higher sites in these areas range between 550 and 600 feet in altitude. They are capped with Borden Group rocks or New Albany shale. The lowlands form a sag and valleys. The sag was mostly developed on a southwestward dipping slope of Mid-Devonian Limestone. The valleys are cut through the New Albany Shale and the Mid-Devonian Limestone. They are wider and deeper where they cross the shale than where they cross the limestone.

South of the glacial border, the Scottsburg Lowland is separated from the Norman Upland by the prominent Knobstone escarpment. In Tippecanoe County, the escarpment trends roughly northwest-southeast. The trend shifts to an east-west direction where it passes across the western border of the county. Preglacial valleys following the base of the escarpment in the county also parallel the trough of the Scottsburg Lowland. These are the deepest bedrock channels in the county. They may have been scoured during the last, most powerful stage of valley deepening. The valleys cut through the Borden rocks and New Albany Shale. They are narrower, shallower, and more steep-sided through the Borden rocks than through the New Albany Shale.

The southern and southwestern areas belong to the buried northward extension of the Norman Upland. Most of this upland lies within the 650 to 700-foot contour interval. It rises steeply more than 400 feet above the lowland bedrock valleys on the north and east. Its nearly flat-topped surface may be correlative with the Highland Rim peneplain of Tennessee (Hayes, 1899), the Kentucky Lexington peneplain (Campbell, 1898), and the Central Illinois peneplain (Horberg, 1950). The Norman Upland is capped by siltstone and shale of the Borden Group, and perhaps some limestone of the Harrodsburg Formation. Some Pennsylvanian sandstone may occur as outliers in the extreme western area.

The bedrock high in the northwestern corner of the county, and developed on Borden rocks, is the southern end of the Rensselaer Plateau (Wayne, 1956; Burger _et_ _al_., 1966).

An integrated drainage pattern is eroded into the bedrock surface to a depth of nearly 400 feet below the uplands. The northwestern quarter of the county is crossed by the Teays River channel--the master valley of the region (Figure 4). It is a reach of the ancient preglacial Teays River, which probably headed in the piedmont of North Carolina (Tight, 1903; Stout and Schaaf, 1931). The valley locally is broad with an average width of about two miles. The sides slope gently except south of Lafayette and west of West Lafayette where it takes on a gorge-like character, cutting through and separating segments of bedrock uplands. The Teays had several tributaries joining it at different angles and forming a dendritic drainage pattern. Five tributaries of various sizes enter the Teays channel from the east and south, and two small tributaries join it from the north. The gradient of the master valley is approximately eight feet per mile in Tippecanoe County. However, Fidlar (1943) estimated the Teays gradient in Indiana as eight inches per mile. Horberg (1945) calculated the average gradient of the Teays-Mahomet Valley between Ohio and Illinois as seven inches per mile. The reasons for this descrepancy are unclear. It may be that the high local gradient in Tippecanoe County is related to the need for an increased declivity to accomodate the tremendous volume of water and load, caused by influx from the Anderson, Clarks Hill and other tributaries.

The Anderson Valley (Wayne, 1952) headed in southeastern Indiana and flowed northwestward to join the Teays Valley northeast of Lafayette. The Wildcat bedrock valley (Wayne, 1956), is considered in the present work as a tributary to the Anderson, joining it at sec. 17, T.23N., R.3W.

There are three more bedrock valleys following the same general southeast-northwest trend as the Anderson. They are herein named the Clarks Hill Valley, the Dayton Valley and an unnamed small valley in the northeastern part of the county. The Dayton Valley runs parallel to the Anderson, but a few miles to the southwest, and joins the Teays east of Lafayette (Figure 4).

The Clarks Hill Valley enters the county from the southeast and continues westward about six miles, then turns northwestward to follow approximately the course of present Big Wea Creek until it joins the Teays a few miles southwest of Lafayette. The Clarks Hill Valley appears longer and has more tributaries, in Tippecanoe County, than the Anderson, but its extension east of the county is not as broad and long as the Anderson (Burger <u>et al</u>., 1966). Clarks Hill Valley has many tributaries. Two of them are conspicuous. The first runs west-northwestward and joins the Clarks Hill Valley in sec. 21, T.22N., R.4W. The second tributary runs northward, starting near Linden in Montgomery County, and joins the Clarks Hill in sec. 28, T.22N., R.4W. The subsurface existence of this northwardly flowing stream remains to be verified by well borings, because present mapping of this valley is dependent on seismic data alone. Seismic techniques commonly overestimate drift thickness owing to the presence of relatively deeply buried clay members within the drift. Also, interpretation of the seismogram may record the drift-bedrock interface deeper than it really is. Assuming the existence of the valley, its deeply incised channel and the steep slopes of the valley walls indicates a youthful stage of valley erosion. This stage may just have been attained prior to partial filling with Illinoian outwash.

Some other bedrock valleys drained the Norman Upland and ran northeastward and northwestward. Most of them join the Clarks Hill Valley as second- or third-order tributaries. One valley in the western area directly joins the Teays near the western county line.

In the northwestern area, the most peculiar drainage feature is the Otterbein Valley. This has a very wide channel through Tippecanoe County, and runs northeast-southwest to join the Teays just west of the county line. This may be another abandoned Teays channel (Wayne, 1956), or a smaller valley which was glaciated and widened sometime during pre-Illinoian time. There are other smaller tributaries of the Teays. One runs southwestward and the other westward. Both join the Teays in sec. 15, T.23N., R.5W.

As noted, all the county was encompassed in the Teays drainage basin. The divide between the Teays drainage and the preglacial Wabash basin was farther south, crossing southern Montgomery County (Wayne, 1952; Wayne, 1956; Cable and Robison, 1974).

It can be speculated also that at some time during the Tertiary, a Scottsburg River (Coffey, 1961) was running northwestward towards the Lake Michigan Basin. Tributary streams, which were separated from each other by upland ridges in Tippecanoe County, ran northeastward to this river. Eventually some subsequent streams of the fluvial network, which ran parallel to Scottsburg River, cut through ridges and captured some of the tributaries. This changed the drainage, establishing a series of northwest-flowing, deeply entrenched valleys which caused progressive westward retreat of the Knobstone escarpment. This continuous process of scarp retreat, accompanied by stream capture, resulted in the formation of the lower Anderson, the Dayton, and the Clarks Hill Valleys. The Borden outliers are remnants of dissection and the retreat of the escarpment. A modern analogy may be seen in the drainage system and scarp retreat of the Blue Ridge front in western North Carolina.

The time of deep entrenchment or "Deep Stage" episode in the history of the major bedrock valleys is probably very early in the Pleistocene. However, some workers have considered the "Deep Stage" to occur as late as early Kansan, pending conclusive evidence of the presence of Nebraskan deposits in the deep channels.

Pleistocene Series

The area was covered during the Pleistocene by ice advances from the Labradorean center along flow lines of the Michigan Lobe, Erie Lobe, or Saginaw Lobe. In the present study no attempt is made to relate the deposition of any specific formation or member to a particular ice lobe. It is possible that members of a specific stage or substage have been deposited by different glaciers from different ice lobes. Successive Pleistocene deposits are separated by unconformities. The well records indicate that the sediments separate into three discrete drift sheets, which are separated by oxidized or otherwise weathered horizons. On the basis of stratigraphic position, a relatively thick upper paleosol is considered as of Sangamonian age, and the thick lower paleosol is considered as Yarmouthian (see Figure 3).

The drift sequences therefore are dated as Kansan (?) or pre-Illinoian, Illinoian, and Wisconsinan on the basis of their position relative to the major paleosols. Other interpretations would be possible, especially if convincing evidence to the contrary becomes available; because absolute age dating is not possible, the paleosols could be interstadial rather than interglacial deposits, for example. In some wells the weathering zone was either not recorded by the driller or is not preserved owing to truncation. In such cases, it is not possible to differentiate between the deposits of different stages. Conversely, if climatic conditions were favorable for the development of soil during an interstadial time, this may show up in the well record. This complicates the correlation procedure, and as a general rule the available data did not permit assignment of the till of a certain stage or substage to different formations and members.

Pleistocene sediments in Tippecanoe County were deposited by glaciofluvial, lacustrine, and eolian processes. The sediments were derived form local bedrock, from imported drift material and from progressive reworking of older drift materials. There is a general tendency for the Pleistocene deposits, in the area as a whole, to be coarser in the lower part than in the upper part. The sediments can be grouped into three general facies--till facies, sand-gravel facies, and silt-clay facies. Normally it is not easy to differentiate from well records, for reasons already stated, between the till facies and the silt-clay facies. Vertical and lateral facies changes are common owing to the complex depositional history. A till unit may contain lenses or pockets of sorted sediments with size ranges from clay to gravel. The extensive sand-gravel bodies occur along the major glacial drainage lines. They were deposited by glaciofluvial processes during ice melting after each advance. The shapes of sand-gravel bodies in the slice maps (Figures 10-18) assume the same configuration as the directions of drainage trends at any given time during the glacial history.

Glaciation disrupted the pre-Pleistocene drainage and there were major or minor changes in drainage systems by the end of each glacial stage.

Nebraskan and Aftonian Stages

There is no persuasive evidence, in the present or previous studies, that there is Nebraskan drift in Indiana. If present, it probably would be preserved in buried valleys. It is currently more reasonable to designate most of the apparently older drift as simply "pre-Illinoian" rather than make any undocumented assumption of a Nebraskan age. There are also no fluvial, lacustrine, or eolian deposits definitely assigned to the Aftonian interglacial stage.

Kansan (?) Stage

The Kansan episode probably started about 400,000 years ago. Climate was cool and moist at the time encroaching ice covered most of the northern and central portions of the county. The pre-Illinoian drift filled the valleys approximately up to the 500-foot level. The preserved thickness is controlled by the level of the older bedrock topography and the amount of post-depositional erosion. Where pre-Illinoian debris was deposited in a deeply incised bedrock channel and was not later eroded, the thickness is about 250 feet as in sec. 19, T.23N., R.5W. The Yarmouthian paleotopographic map (Figure 6), and the absence of a paleosol in well records from the Norman Upland sector suggest that the southern and southwestern high area of the county may not have been covered by pre-Illinoian ice.

The pre-Illinoian till in Tippecanoe County is probably assignable to the Cloverdale Till Member (Wayne, 1963). It is sandy, gravelly mudstone. It includes lenses of sediments finer- or coarser-grained than the general matrix. Locally, there are two tills separated by outwash and these can be interpreted as two pulsations separated by an interstadial interval.

Sand and gravel outwash material belongs to the Atherton Formation (Wayne, 1963). It appears to be concentrated in older valleys as valley

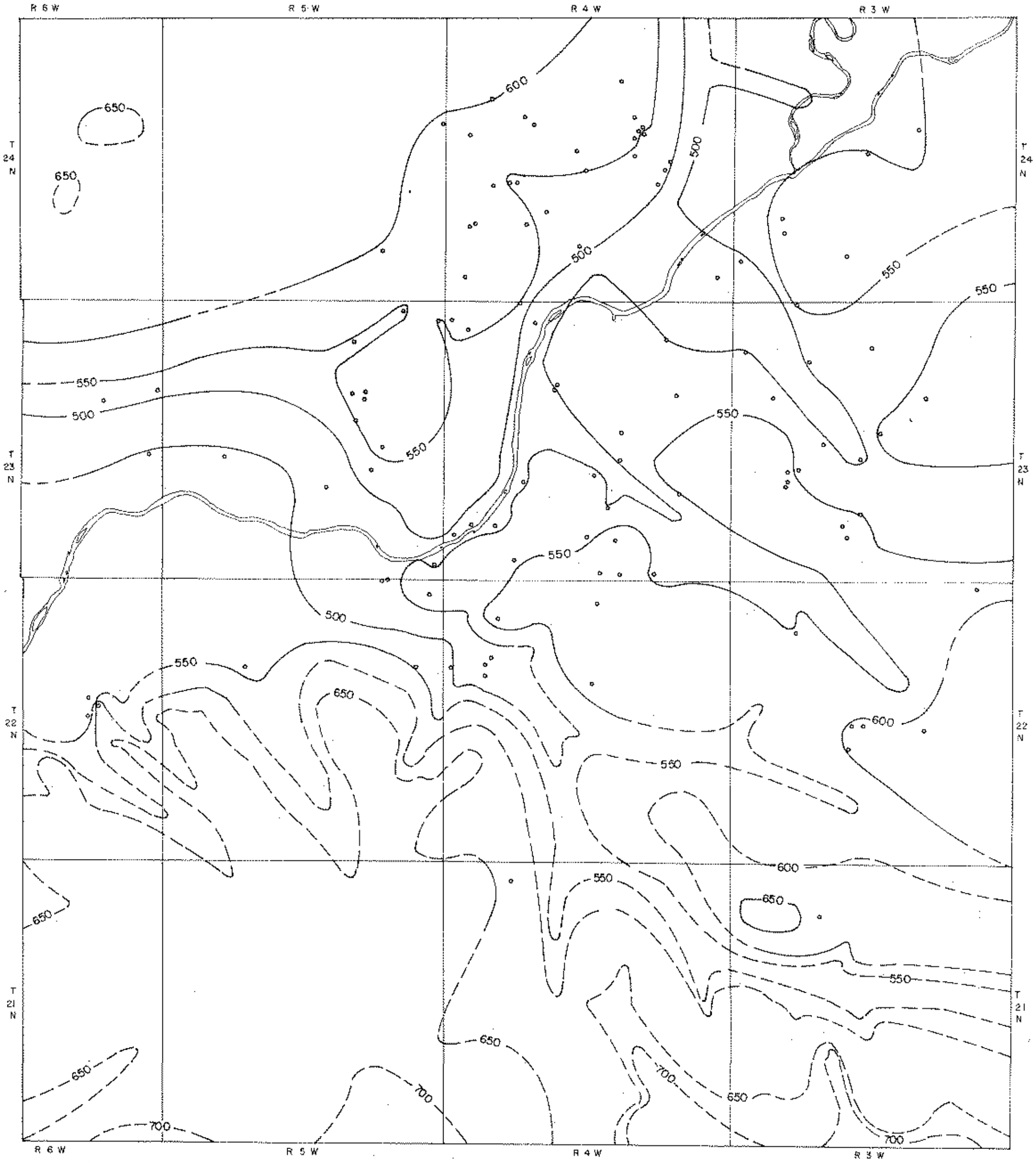


Figure 6 APPROXIMATE YARMOUTHIAN PALEOTOPOGRAPHY, TIPPECANOE COUNTY

EXPLANATION

SCALE
0 1 2 miles
0 1 2 kilometers

—— - - Yarmouthian surface elevation; dashed where uncertain

o Well location

Contour Interval = 50 ft

train deposits. The pre-Illinoian drift (Figures 15-18) contains more permeable material than younger deposits (Figures 10-13). General coarsening of the valley fill with depth is common.

Ice deformation of the pre-Illinoian drift likely has occurred but can not be determined from the records. Thrust faulting and folding are reported not too far to the southwest of Tippecanoe County, in the center of Vermilion County, Illinois (Johnson, 1971) where pre-Illinoian deposits are exposed near the surface.

The pre-Illinoian deposits are covered by younger drift in Tippecanoe County. Deposits classed as Kansan are exposed some distance away to the south, southeast, and southwest (Wayne, 1958; Gooding, 1966; Johnson, 1971).

Pre-Illinoian drift is encountered in many wells which penetrate Wisconsinan and Illinoian drift. Interpretation of a pre-Illinoian section from a well located in the NW.¼, NW.¼, sec. 14, T.23N., R.3W, ground elevation 665 ft., is given below:

	Thickness (ft)	Depth to Base (ft)
Pleistocene Series		
Wisconsinan-Illinoian Stages		
Clay, yellow	18	18
Clay, blue	11	29
Gravel	3	32
Clay, blue	43	75
Yarmouthian Stage		
Muck, blue, sandy	12	87
Pre-Ilinoian Stage		
Clay, blue	5	92
Sand, muddy	3	95
Hardpan, sandy	5	100
Quicksand	17	117
Hardpan, blue	5	122
Sand, gray, coarse	1	123

The sequence from another well in the SW.¼, SE.¼, NW.¼, sec. 20, T.24N., R.4W., ground elevation 660 ft., is interpreted as follows:

	Thickness (ft)	Depth to Base (ft)
Pleistocene Series		
Wisconsinan Stage		
Clay, yellow	20	20
Clay, blue	5	25
Clay, sandy	14	39
Sangamonian Stage		
Sand, brown, fine	15	54
Illinoian Stage		
Clay, blue	19	73
Sand and gravel	8	81
Clay, blue	17	98
Sand	1	99
Clay, blue	24	123
Pre-Illinoian Stage		
Sand, gray	13	136
Gravel and sand	6	142

Yarmouthian Stage

This stage is represented by the next oldest major interval of weathering and organic accumulation beneath the Sangamonian surface. Climate was likely warm and humid by the end of the Kansan and during the early Yarmouthian ages. It was less moist in the middle and late Yarmouthian (Leonard, 1950). Regionally, a thick soil profile and relatively deep carbonate leaching indicate that the Yarmouthian was a lengthy episode of weathering relative to any interstadial period or even to the Sangamonian interglacial.

Yarmouthian soil was formed in situ with an oxidized profile where it is developed on well-drained pre-Illinoian drift, or residuum over weathered Paleozoic rock. In poorly drained lowlands dark, heavy textured Yarmouthian soil known as accretion gley was formed by the accumulation of fine-grained sediments under wet, chemically reducing conditions. Loess material was transported by wind from Kansan outwash plains, and deposited during Yarmouthian time on the uplands. Thickness of Yarmouthian deposits is as much as 50 feet. It is generally thicker in depressions than on uplands. Locally, it is almost impossible to determine the Yarmouthian surface, because the disconformity between truncated, unaltered pre-Illinoian till and the Illinoian till is not determinable from the subsurface record.

Figure 6 shows the approximate Yarmouthian topographic surface. There are a number of similarities between bedrock and Yarmouthian topographic features.

Yarmouthian deposits are exposed in southern Montgomery County, sec. 5, T.17N., R.5W. (Wayne, 1958).

Illinoian Stage

Climate probably was cool and moist when the Illinoian ice invaded most of the county. Some parts of the uplands possibly were mantled only with thin ice cover during the Ilinoian glaciation. Thicker ice filled the existing valleys with drift deposited up to the 650-foot level. Drainage conditions in many areas were disrupted.

The Illinoian stage is identified in this report as the deposits encountered between the Yarmouthian and the Sangamonian surfaces. Because the base and the top of the Illinoian deposits are surfaces of erosional unconformity, thickness is extremely variable (Wayne, 1963). It differs according to the Yarmouthian topography, the type of Illinoian depositional features, and post-depositional erosion. Although none of these features can be observed directly, their presence is deduced from the well record descriptions. Thickness of Illinoian deposits in Tippecanoe County ranges from zero on the southwestern upland to about 150 feet in sec. 11, T.21N., R.3W.

The Illinoian till in Tippecanoe County belongs to the Butlerville Member of Wayne (1963). It is gravelly, sandy, compact mudstone. The unoxidized color is mostly blue, but turns brown by oxidation. It is commonly described by well drillers as clay or hardpan. It includes lenticular bodies of sand and gravel.

The clay-silt facies also is represented by lacustrine deposits south of Lafayette and in some other localities where drainage lines were blocked by Illinoian ice and glacial lakes were formed.

Illinoian till is commonly overlain, in glacial sluiceways, by thick sand-gravel outwash. The outwash is a part of the Atherton Formation (Wayne, 1963). This formation may include till, indicative of ice readvance followed by renewed withdrawal. Interbedding of fine- and coarse-grained sediments may be caused by ice contact deposition, for example in sec. 6, T.23N., R.4W.

No definite surface exposures of Illinoian drift are known in the county. However, it is exposed extensively farther south and west. Illinoian drift is encountered in most wells. An Illinoian section as interpreted from a well located in the SE.¼, SE.¼, SW.¼, sec. 14, T.22N., R.6W., ground elevation 598 ft., is as follows:

	Thickness (ft)	Depth to Base (ft)
Holocene Series		
Soil, black	3	3
Pleistocene Series		
Wisconsinan Stage		
Clay, sandy	15	18
Illinoian Stage		
Gravel	33	51
Clay, blue, sandy	27	78
Yarmouthian Stage		
Wood and mud	2	80
Pre-Illinoian Stage		
Clay, dark blue	5	85
Sand and clay, gray	5	90
Mississippian System		
Stone, gray, and shale	148	238
Devonian-Mississippian		
Shale, black		

The sequence of Illinoian drift from another well in the NE.¼, SW.¼, sec. 4, T.22N., R.4W., ground elevation 650 ft., is as follows:

	Thickness (ft)	Depth to base (ft)
Pleistocene Series		
Wisconsinan Stage		
Clay, brown	20	20
Sand and gravel, gray	4	24
Clay, gray, hard	4	28
Sangamonian (?) Stage		
Sand, brown	13	41
Illinoian Stage		
Sand and gravel	8	49
Sand, fine	2	51
Gravel	2½	53½
Clay, gray	2	55½
Gravel	7	62½

Sangamonian Stage

This stage comprises the next youngest major interval of soil development. Climate was warm and humid. Depth of oxidation is shallow relative to both the present and the Yarmouthian oxidized profiles.

The profile formed on the Sangamonian surface is either an oxidized in situ profile or an accretion gley profile, depending on oxidizing and drainage conditions. Deposition of loess materials has also affected the type of profile developed. A transition interval between Illinoian drift and the loess is represented by 1½ to 3 feet of dark brown altered materials (Leverett and Taylor, 1915). This may indicate that the deposition of loess took place some time after the exposure of Illinoian drift to oxidation processes. Sangamonian deposits thickness ranges from zero to 30 feet in Tippecanoe County. It is thicker and heavier textured in depressions than on higher lands. Locally, where unoxidized Wisconsinan till overlies any older, truncated and unaltered till, it is difficult or impossible to locate the Sangamonian surface.

Figure 7 shows some agreement between bedrock and Sangamonian topographic features. This relationship is most pronounced in the central and southeastern parts of the county. There is some resemblance to the present topography. This is most obvious in the middle and western Wabash Valley areas.

Wisconsinan Stage

The Wisconsinan age was the coldest period during the Quaternary (Emiliani, 1957). Ice advanced and covered the entire county.

The Wisconsinan drift is defined by its stratigraphic position above the Sangamonian surface and below the modern soil profile. Thickness

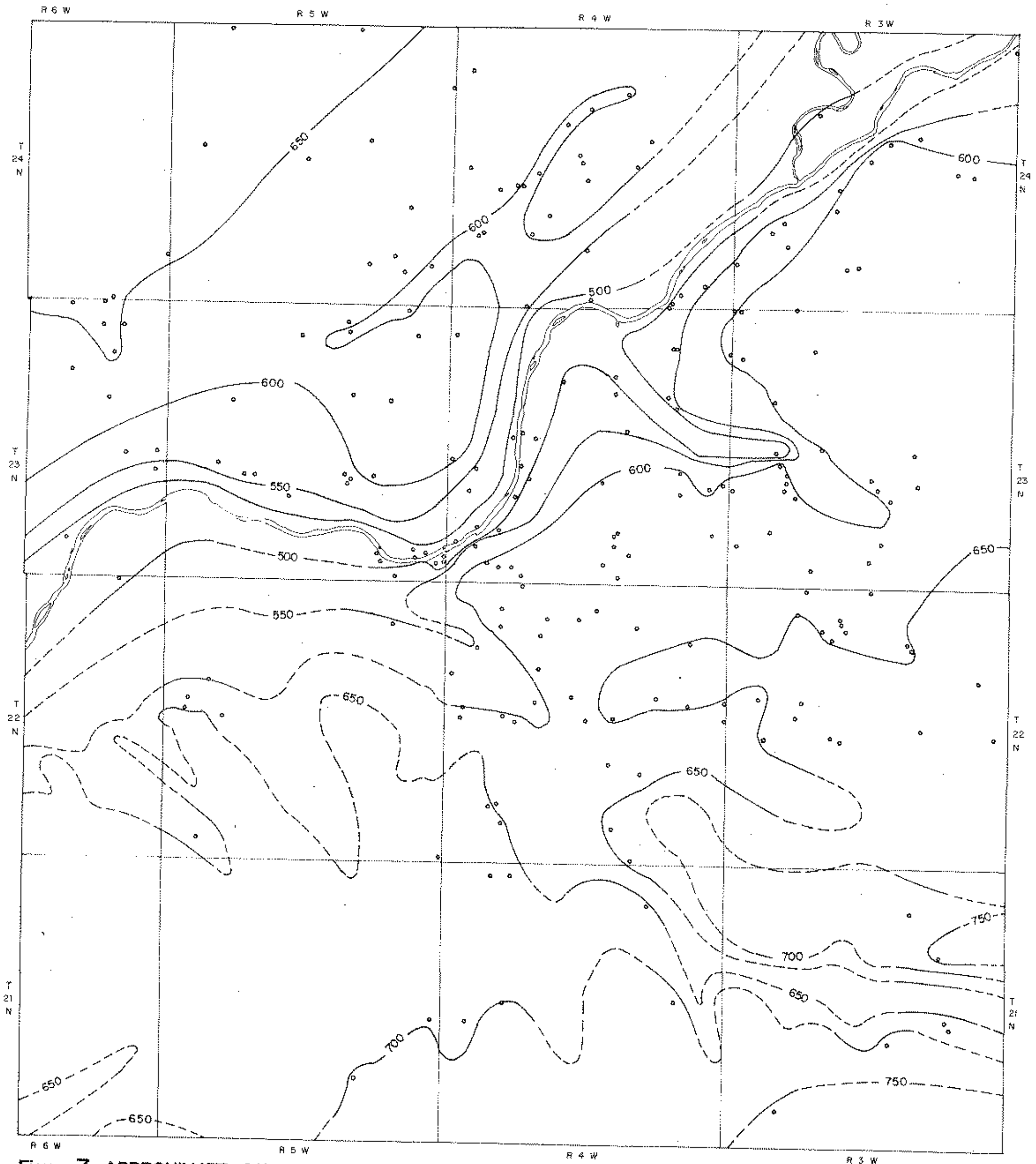


Figure 7 APPROXIMATE SANGAMONIAN PALEOTOPOGRAPHY, TIPPECANOE COUNTY

EXPLANATION

— - - Sangamonian surface elevation; dashed where uncertain

o Well location

Contour Interval = 50 ft

varies in accordance with Sangamonian topography and the Wisconsinan depositional landforms such as eskers, recessional moraines, kames, and kettles. Variation in thickness is also affected by post-Wisconsinan erosion. Thickness of Wisconsinan deposits in the county ranges from zero in the areas where bedrock crops out (Figure 9), to 180 feet in sec. 19, T.23N., R.3W.

The Wisconsinan till belongs to the Trafalger Formation of Wayne (1963). It is more clayey and silty than the older tills, probably owing to advance across periglacial lakes to the northwest. Flow lines of the ice reworked these lacustrine materials and redeposited them as till in the local area. The till is gray to blue in color where unoxidized, but yellow to yellowish-brown where oxidized. It is more clayey and silty in the northeastern part of the county than in the south. It contains black shale fragments where the New Albany shale is near the surface in the northeastern part of the county(Rosenshein, 1958). The till has pockets of sand and gravel, limited in lateral extent (Plates 3, 4). Their thicknesses rarely exceed 25 feet. Kames are also stratified sand-gravel mounds, as high as 40 feet. They were formed in crevasses and moulins in the ice.

Sand-gravel outwash facies, as in the older drifts, is a part of the Atherton Formation. It was deposited in sluiceways and outwash plains. Changes in the rate of ice melting controlled the amount of water in sluiceways and consequently produced some stratification in the outwash. Late Wisconsinan outwash was superimposed on the older drift in valleys. In some areas, as in the Wabash Channel through

Lafayette, Illinoian outwash materials were partly truncated by late Wisconsinan outwash during a cut-and-full episode.

Lacustrine deposits in slack water areas resulted during glacial retreat and outwash accumulation. Clay, silt, peat, muck, and marl were deposited in Wisconsinan lakes and bogs in depressions on the till plains and in a backswamp environment on the flood plains. Some sands associated with these lakes were subsequently reworked by aeolian processes.

During late Wisconsinan time large amounts of water discharged down the Wabash Spillway owing to the rapid drainage of Glacial Lake Maumee. This "Maumee Torrent" eroded the Wisconsinan drift in the valley and reduced the elevation of valley fill to about the 520-foot level.

Wisconsinan drift is encountered in almost every well drilled in the county. A representative Wisconsinan section from a well located in the NW.¼, NE.¼, NW.¼, sec. 14, T.23N., R.5W., ground elevation 690 ft., is given below.

	Thickness (ft)	Depth to Base (ft)
Pleistocene Series		
Wisconsinan Stage		
Clay	18	18
Clay, blue, sandy	72	90
Illinoian Stage		
Clay, brown , sandy	20	110
Quicksand	15	125
Yarmouthian Stage		
Sand and gravel, chunks of wood	4	129
Pre-Illinoian Stage		
Clay, brown, gritty	24	153
Sand, gray	15	168
Gravel, gray, coarse	6	174

Another section of Wisconsinan till from a well in the NE.¼, SE.¼, NE.¼, sec. 13, T.24N., R.5W., ground elevation 685 ft., is as follows:

	Thickness (ft)	Depth to Base (ft)
Pleistocene Series		
Wisconsinan Stage		
Clay, yellow	14	14
Clay, blue	75	89
Illinoian Stage		
Hardpan, blue, gritty	14	103
Yarmouthian Stage		
Sand, brown fine	17	120
Pre-Illinoian Stage		
Sand and gravel	6	126

These records, which are illustrative of the latest glacial deposits, also show a rather complete section of pre-Wisconsinan glacial and interglacial deposits. Nomenclatural assignment of the Pleistocene materials was based on: 1) lithologic breaks in individual wells, and 2) correlation of these interpreted hiatuses across the county.

Holocene Series

During Wisconsinan deglaciation, the climate gradually warmed and wind acted on the extensive outwash plains, transporting sand and silt and redepositing this material as dunes and loess. A loess blanket covered the majority of the county to an average thickness of two feet. Dunes are confined essentially to the terraces and the Wea outwash plain. These dunes have been stabilized by vegetation. Water was trapped in some closed depressions, slackwater areas, and kettle basins, to form lakes. The eolian and lacustrine facies were grouped by

Wayne (1963) as a part of the Atherton Formation deposited during the late Pleistocene-Holocene.

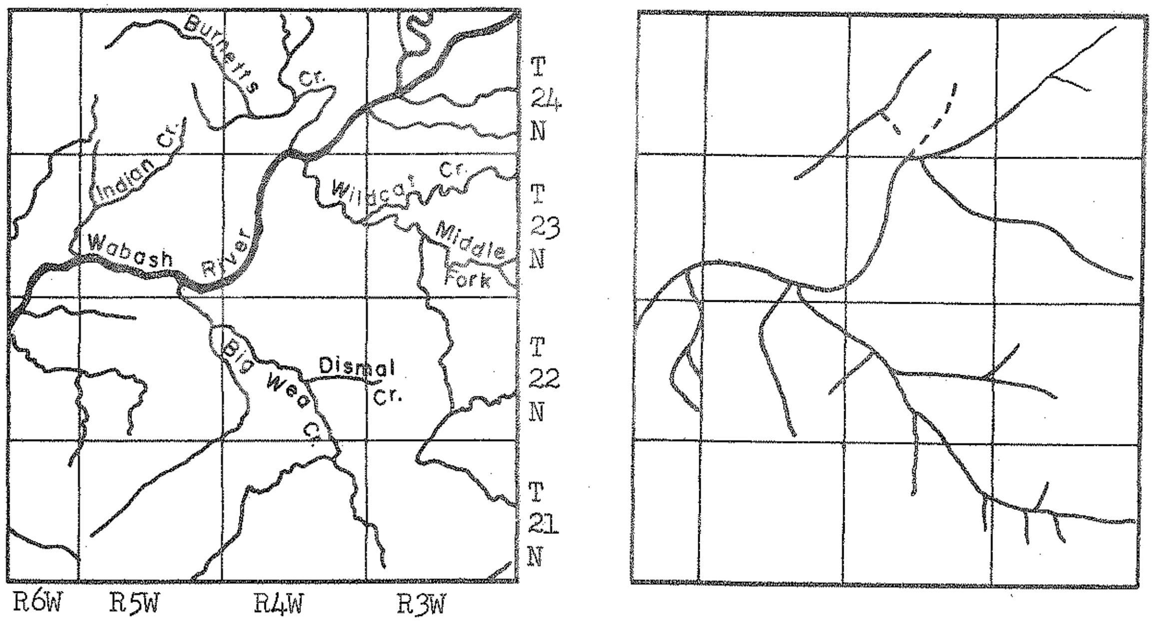
Other Holocene facies are alluvial, colluvial and paludal. They were assigned by Wayne (1963) to the Martinsville Formation. Alluvium was deposited in stream channels and on flood plains as sand, silty clay, and gravel in decreasing order of abundance. Some slope wash materials have accumulated at the base of steep slopes. Paludal deposits include clay, silt, peat, muck, and marl. They are concentrated in poorly drained areas.

Evolution of Drainage

The pre-Pleistocene drainage (Figure 8-D) partly resembles the present drainage pattern (Figure 8-A). There are some similarities and many differences. The changes that have occurred resulted from the several glaciations of the area. Yarmouthian and Sangamonian paleotopographic maps (Figures 6, 7) and the drainage pattern (Figures 8-B, C) lead to some interpretations about the evolutionary stages of the drainage.

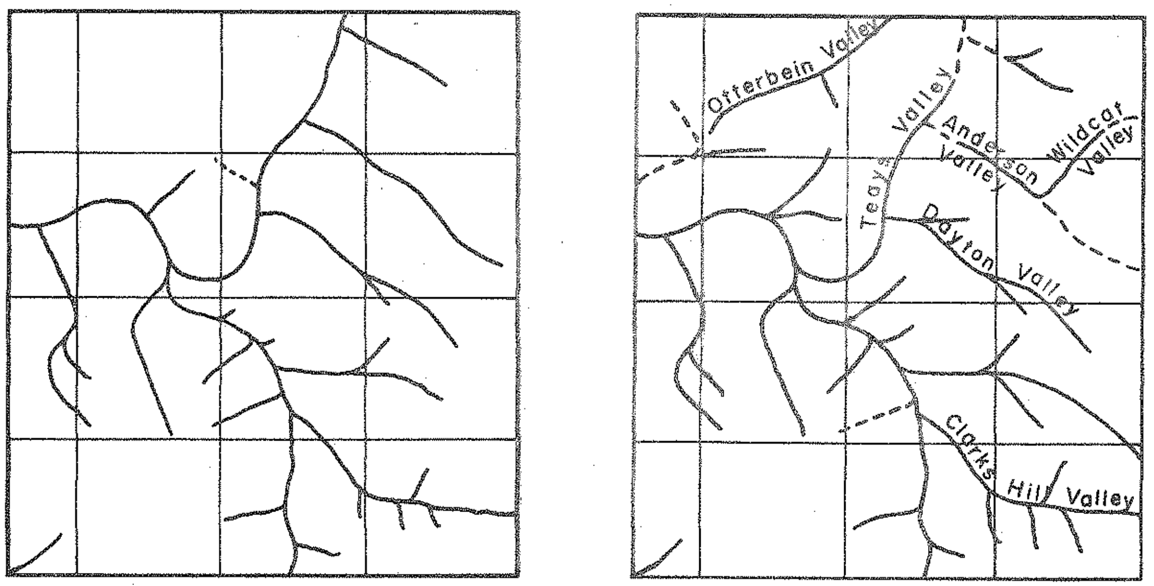
The Kansan glacier apparently did not change the existing drainage. Some first- and second-order tributaries were blocked as indicated on Figure 8-C. The Otterbein Valley was filled. Most of the channels continued to operate throughout Yarmouth time until the advance of the Illinoian ice.

Illinoian ice caused the majority of changes in the drainage pattern (Figure 8-B). The ice sheet blocked the Clarks Hill Valley in T.21N.,



A. Present Drainage

B. Sangamonian Drainage



C. Yarmouthian Drainage

D. Pre-Pleistocene Drainage

Figure 8 CHANGES IN DRAINAGE, PRE-PLEISTOCENE THROUGH PRESENT

R.3,4W., and stagnated long enough for melt water to deepen the existing south-north preglacial tributary. This steep-walled valley subsequently was almost filled by outwash deposits. After the ice receded, Clarks Hill channel was partly reopened for active drainage. Dayton Valley southeast of Lafayette was completely buried by drift and ceased to function as a drainage line.

Another change took place when the retreating Illinoian ice dammed the lower Anderson River. The meltwater established a curved, ice marginal stream a few miles southwest of the lower Anderson Valley. This channel is followed now by the lower reaches of Wildcat Creek, which is flowing on and dissecting an Illinoian drift sheet.

Two other changes occurred along the Teays channel during the retreat of the Illinoian glacier. The ice probably stagnated southwest of Lafayette, blocking the westward drainage and forming Glacial Lake Lafayette upstream from the ice dam. This episode is clearly shown on the fence diagram (Plate 4). Silt and clay deposited in this proglacial lake, while deposition of sand and gravel outwash continued upstream. As the highest elevation of the lacustrine clay is 550 feet, the lake level for a time must have been higher, possibly as high as 560 (?) feet, and the lake occupied an area of at least 4 square miles. At this time the ice had apparently melted at Lafayette, but still covered the area to the west, including the locale of the preglacial Teays channel. The lake was drained through a newly developed ice marginal drainage way flowing west, then southwestward to the western county line (Figure 8-B). This new drainage way presumably joined the preglacial Wabash Valley somewhere far to the south. Consequently, the result was the final diversion of the permanent drainage to the south, *i.e.*, approximately to the present position of the Wabash Valley, and the Teays-Mahomet River was eliminated in this area. When the Illinoian ice melted, the ancestral Wabash River continued to occupy the newly cut valley southwest of Lafayette.

Another change in drainage along the Teays course occurred northeast of Lafayette, when the Illinoian ice blocked its channel. Escaping melt water was forced to bypass the blocked drainage way and cut a new channel a few miles to the east—a course now followed by the Wabash River northeast of Lafayette (Figure 8-B). The blocked channel in T.24N., R.4W. operated later as a minor sluiceway. It is now occupied by the lower part of Burnetts Creek.

By late Illinoian and Sangamonian times probably there was a minor drainage way, north of the Wabash great bend, running northeast-southwest. It is now followed by the linear depression occupied by Hadley Lake, other small ponds, Indian Creek and a part of Burnetts Creek (Johansen and Melhorn, 1970).

Wisconsinan ice brought some additional changes in the drainage pattern. The Clarks Hill Valley segment across T.21N., R.3W., its southern tributary, and the two valleys running northward in the midwestern part of the county, were buried by Wisconsinan drift. Other minor changes also occurred.

During Wisconsinan deglaciation other drainage lines, controlled by ice-margin conditions, were developed on the Wisconsinan drift sheet and continue to function at present.

Unconsolidated Material Thickness

Unconsolidated material thicknesses are of prime importance to water well-drillers, geologists, planners, and construction engineers. These materials, listed in order of their decreasing abundance in Tippecanoe County, are glacial till, outwash sand and gravel, alluvial deposits, lake and bog deposits, and eolian deposits.

The orographic map (Plate 1), the bedrock map (Figure 4), and the unconsolidated material thickness map (Figure 9) suggest that most of the areas underlain by thick unconsolidated materials are the site of older valleys cut into bedrock. Relatively thin drift mantle is associated with bedrock topographic highs and areas affected by present drainage degradation. Those areas having unconsolidated material thicker than 350 feet (Figure 9) coincide with bedrock valleys and are not degraded by the present drainage.

County-wide, the average thickness of unconsolidated materials is about 200 feet. There is none where bedrock crops out, and a maximum thickness of 448 feet (determined by the seismograph) is in the SW.¼, SW.¼, SW.¼, sec. 7, T.23N., R.5W. The maximum unconsolidated thickness reported in well records is 288 feet in the NE.¼, NE.¼, sec. 5, T.23N., R.4W.

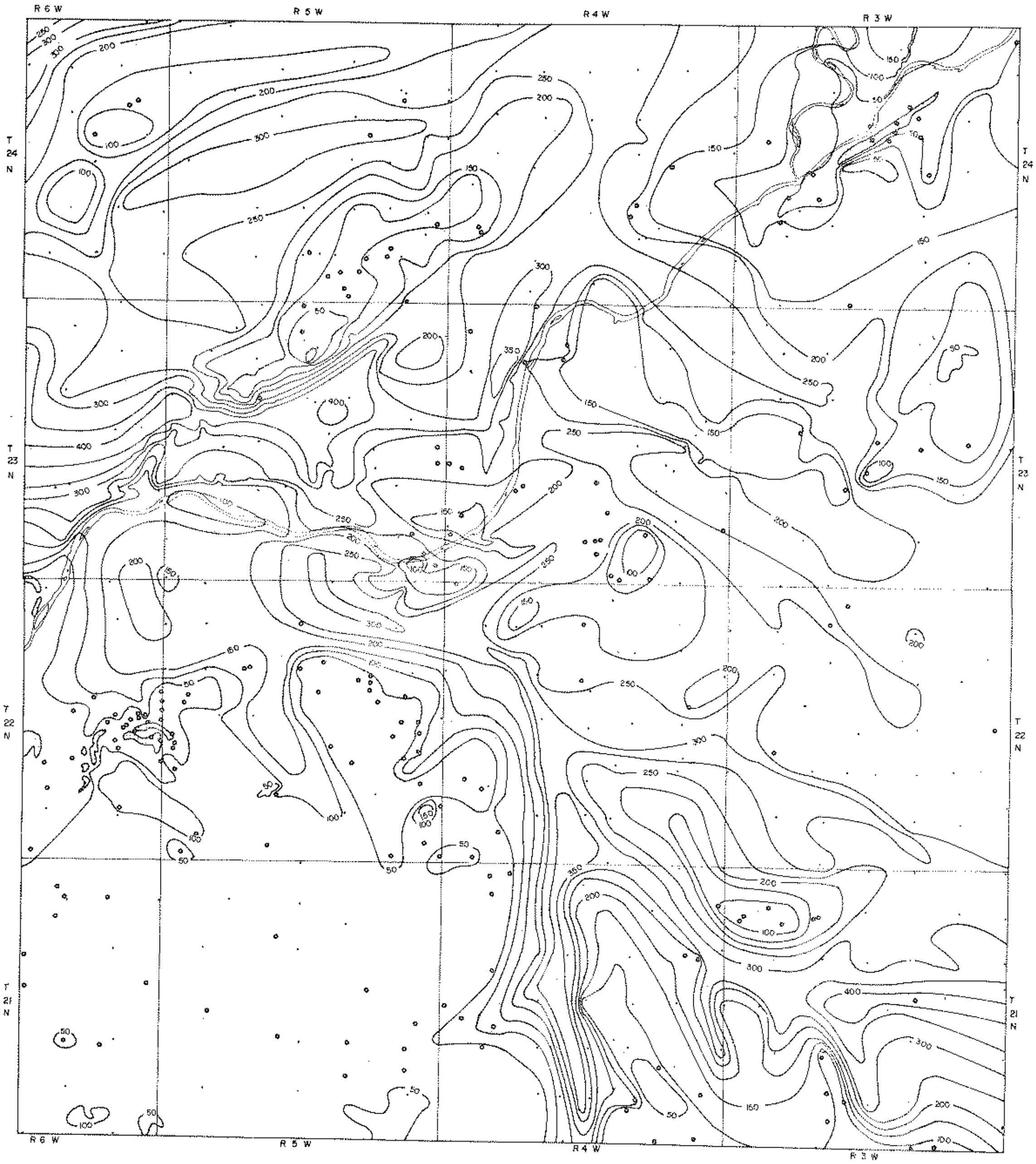


Figure 9 UNCONSOLIDATED MATERIAL THICKNESS, TIPPECANOE COUNTY

SCALE
0 1 2 miles
0 1 2 kilometers

EXPLANATION
- ○ Well location
- · Seismic shot location
- ▦ Bedrock crops out or < 10 ft. below ground surface

Contour interval = 50 ft.

Groundwater conditions are most favorable where there are thick, water-saturated sand and gravel deposits. These are commonly most abundant in areas having the greatest unconsolidated materials thickness. Conversely, areas with a thin mantle of drift have little, if any, water-bearing sand and gravel.

The properties and characteristics of the unconsolidated materials are also important in determining the agricultural soil types, the engineering properties, the feasibility of industrial and municipal waste disposal, and the location of mineral resources for construction.

GROUNDWATER

General Statement

Groundwater is the most important natural resource in Tippecanoe County. Its development is less expensive than that of surface water. Sufficient or abundant supplies are available throughout most of the county, and groundwater development potential exceeds the rate of present consumption. Groundwater historically and presently fills all domestic, farm, municipal, and industrial requirements. Most wells are less than 200 feet deep and yield from 5 and 2,000 gpm depending on well design and aquifer properties. Rosenshein (1958) estimated a total daily withdrawal of 20 mgd from all sources in the county. Withdrawal rates for municipal pumpage are known, but industrial consumption is considered as proprietary and figures are not available. Only estimates can be made, based on census figures of the number of non-municipal households, of production from individual wells. The total present pumpage is estimated therefore as approximately 35 mgd. Assuming exponential annual increase slightly in excess of 1 mgd, pumpage is expected to be 100 mgd by the year 2020. There is a good possibility that this future consumption from groundwater resources can be met without recourse to surface supplies.

Glacial outwash is the principal source of groundwater. However, shallow bedrock, sand and gravel lenses within the till, and the Holocene alluvium can contribute some water for domestic and farm purposes. Deposits having the greatest potential lie along the Teays, Clarks Hill, Anderson, and other buried valleys in bedrock.

Groundwater in the county commonly occurs under leaky artesian conditions where fine-grained material overlies a saturated, porous rock. However, a water table condition prevails where the aquifer is overlain by unsaturated, coarse-grained material, and thus lacks a confining cover.

This section discusses distribution of aquifers, some hydrologic aspects, and quality of the groundwater.

Distribution of Aquifers

The occurrence and extent of the aquifers in Tippecanoe County is shown on the aquifer maps (Figures 19-22), the fence diagram and cross-sections (Plates 3, 4), and the slice maps (Figures 10-18). The boundaries of these aquifers are hydrologic in terms of the attitude of the groundwater surface, sedimentologic in terms of the geometrical shape or boundary conditions of the sedimentary environment in which the coarse-grained materials forming the aquifers have been deposited, and stratigraphic in terms of the age of their deposition.

A complex series of erosional and depositional events during the successive glacial and interglacial stages caused changes in the preexisting drainage systems, and resulted in a number of episodes of excavation and refilling of some of the major drainage lines. The manner and

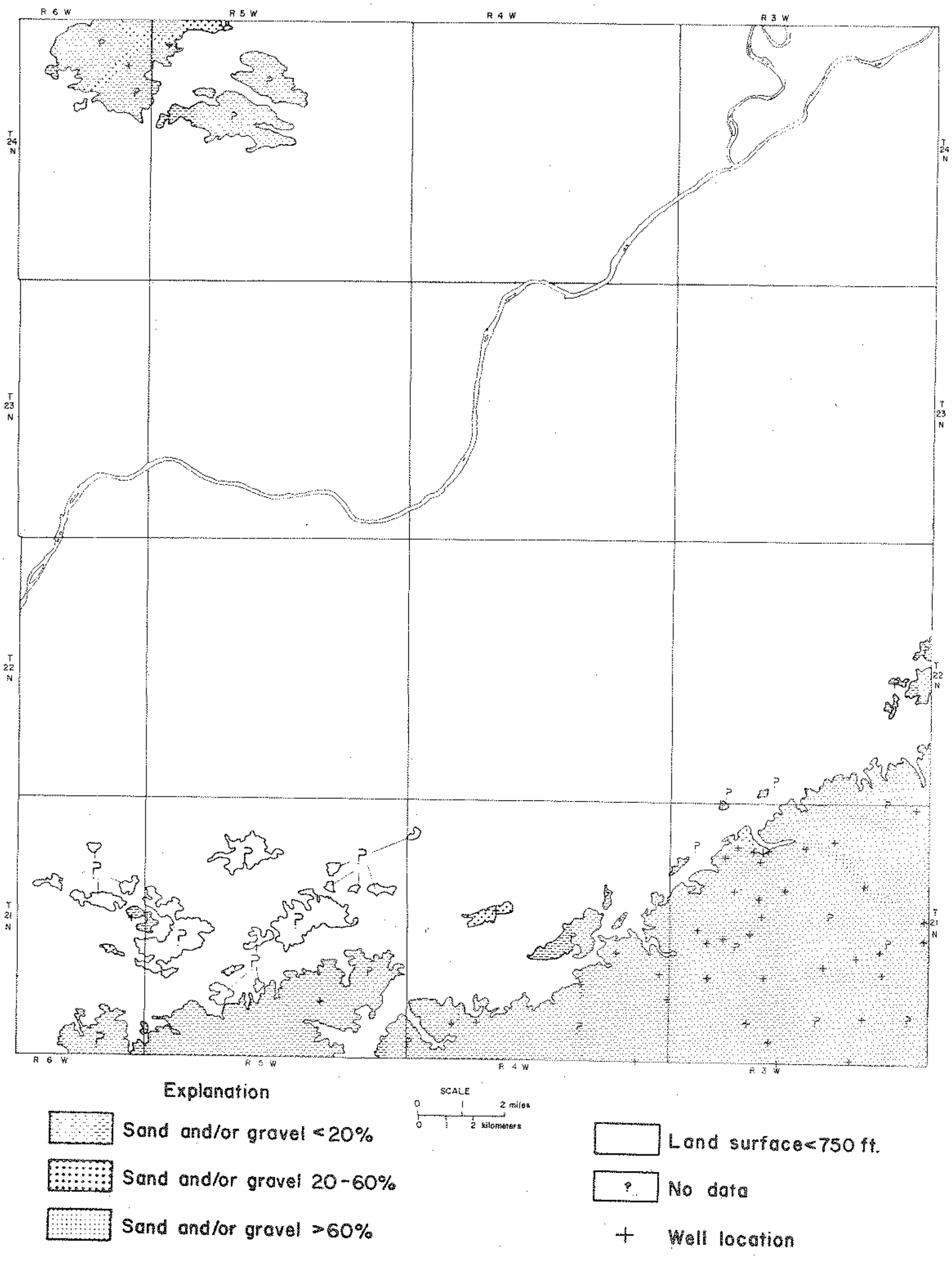


Figure 10. Lithofacies-Ratio Map of the Slice 750-800 ft.

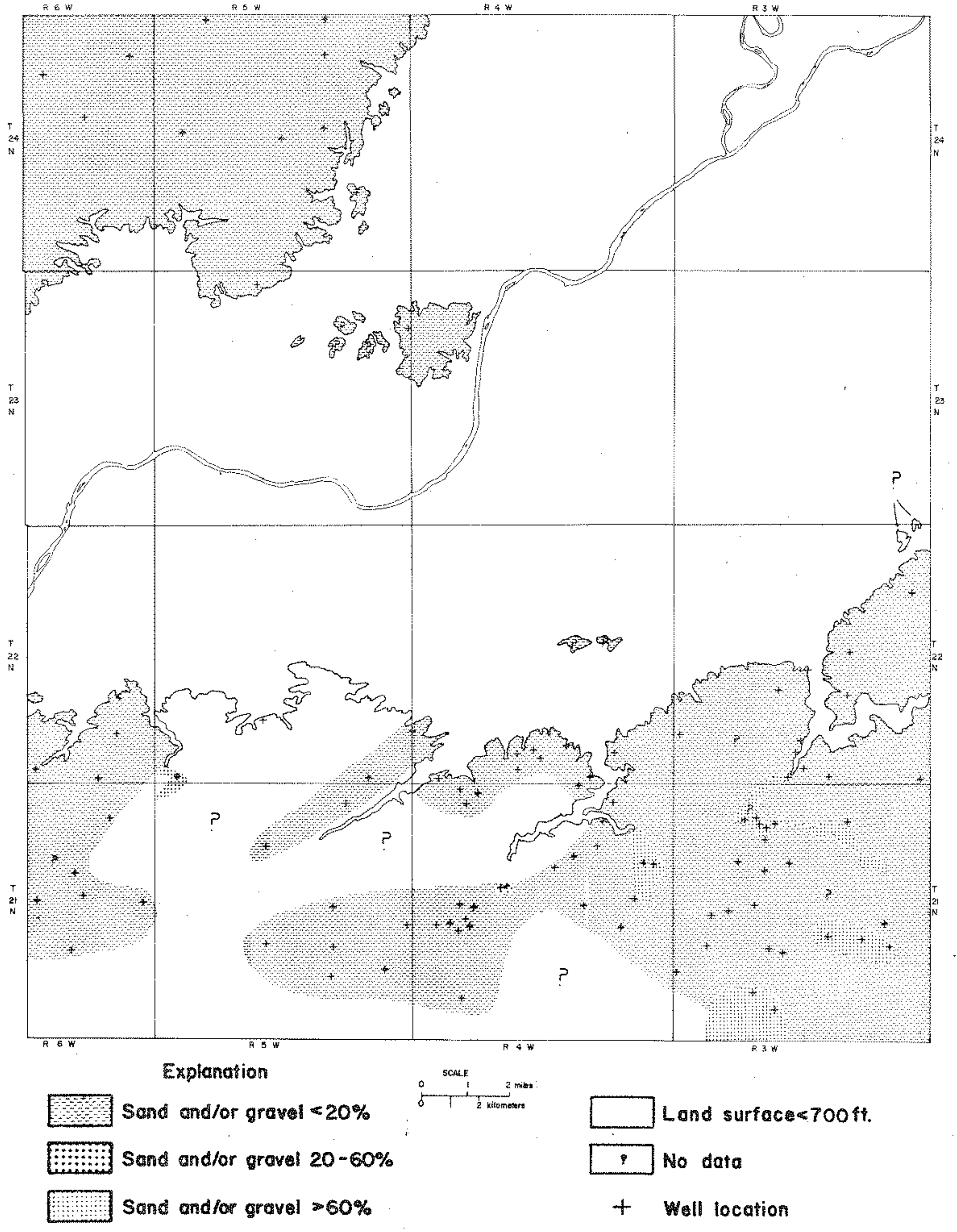


Figure 11. Lithofacies-Ratio Map of the Slice 700-750 ft.

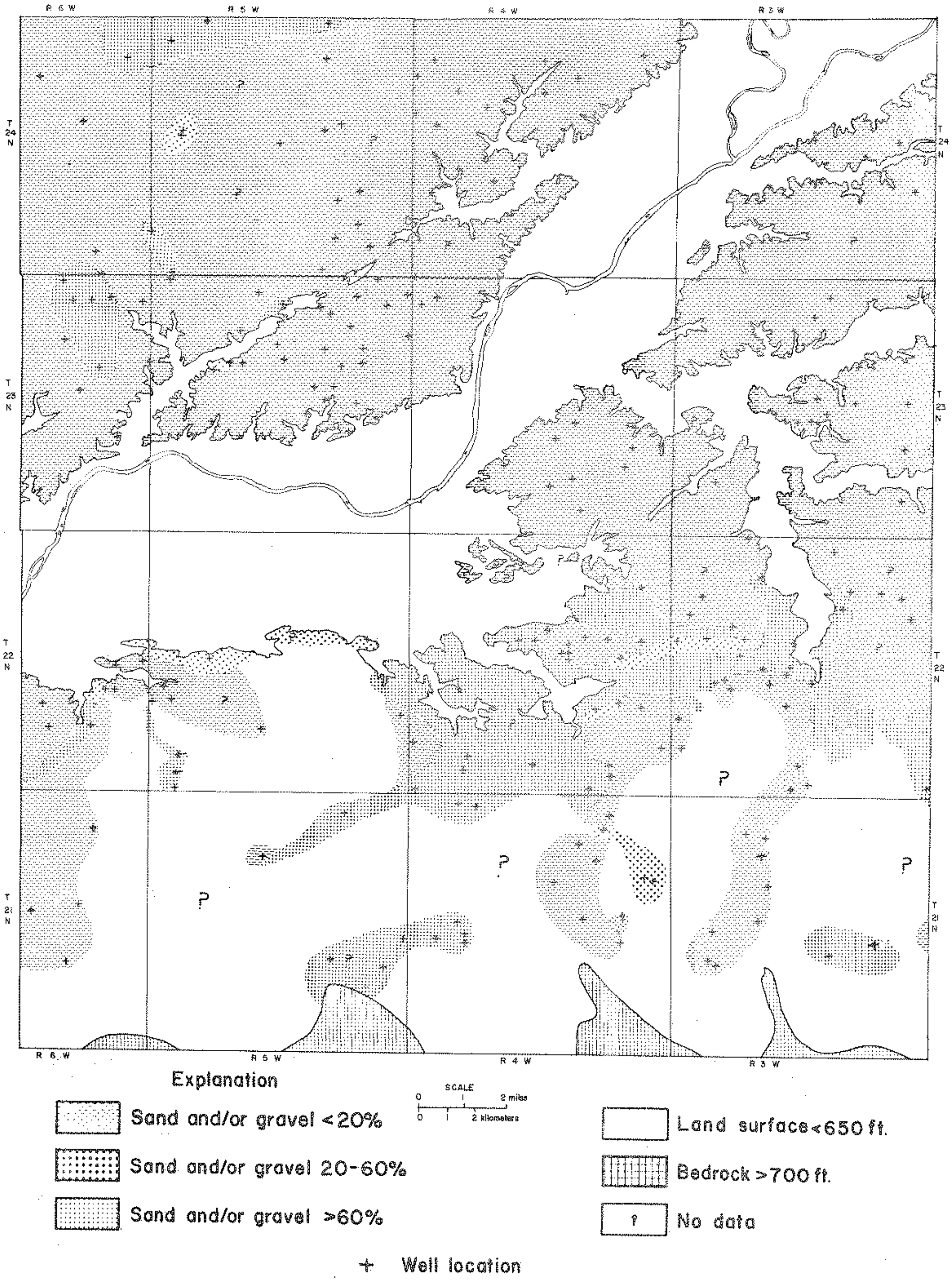


Figure 12. Lithofacies-Ratio Map of the Slice 650-700 ft.

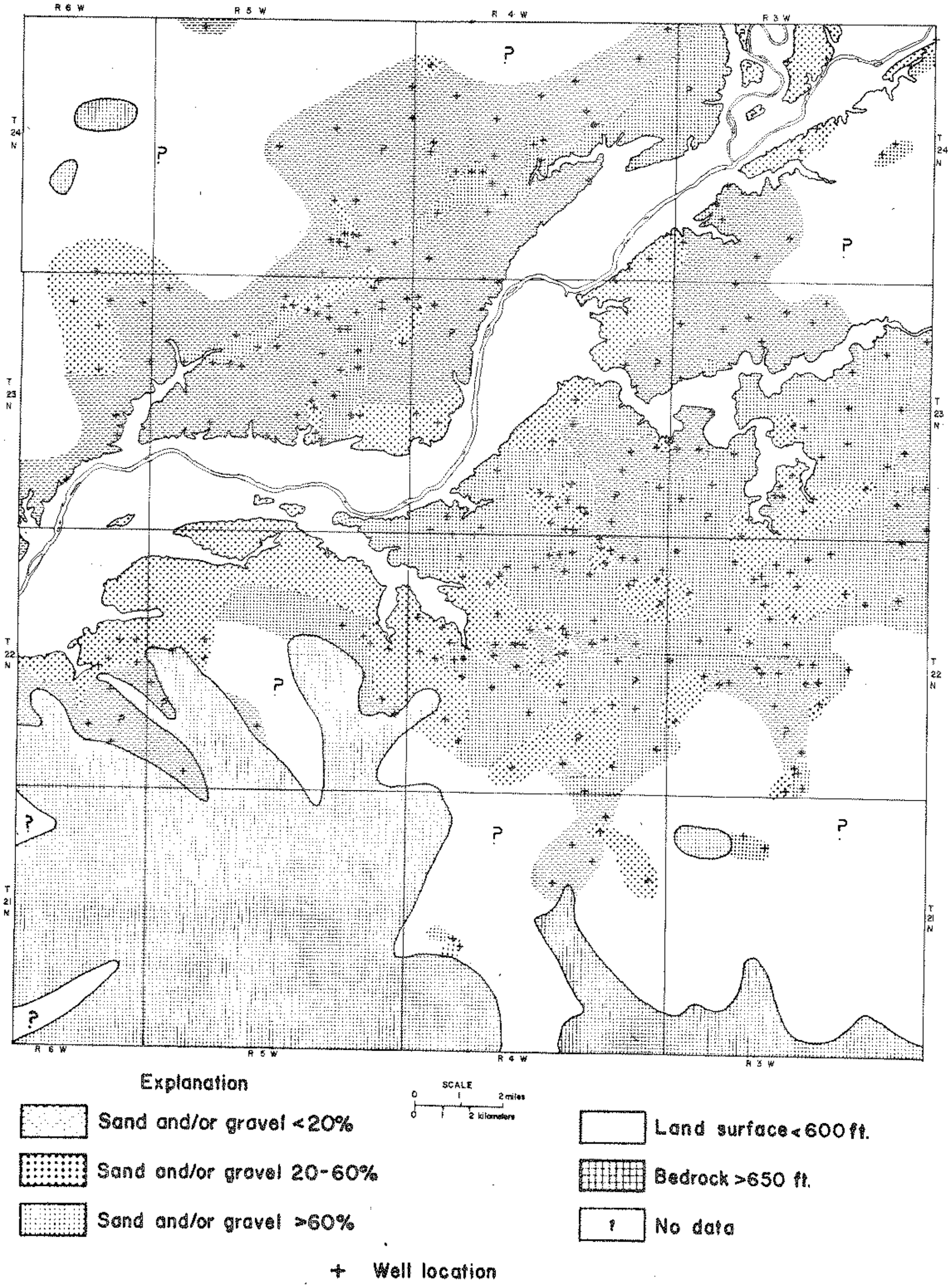


Figure 13. Lithofacies-Ratio Map of the Slice 600-650 ft.

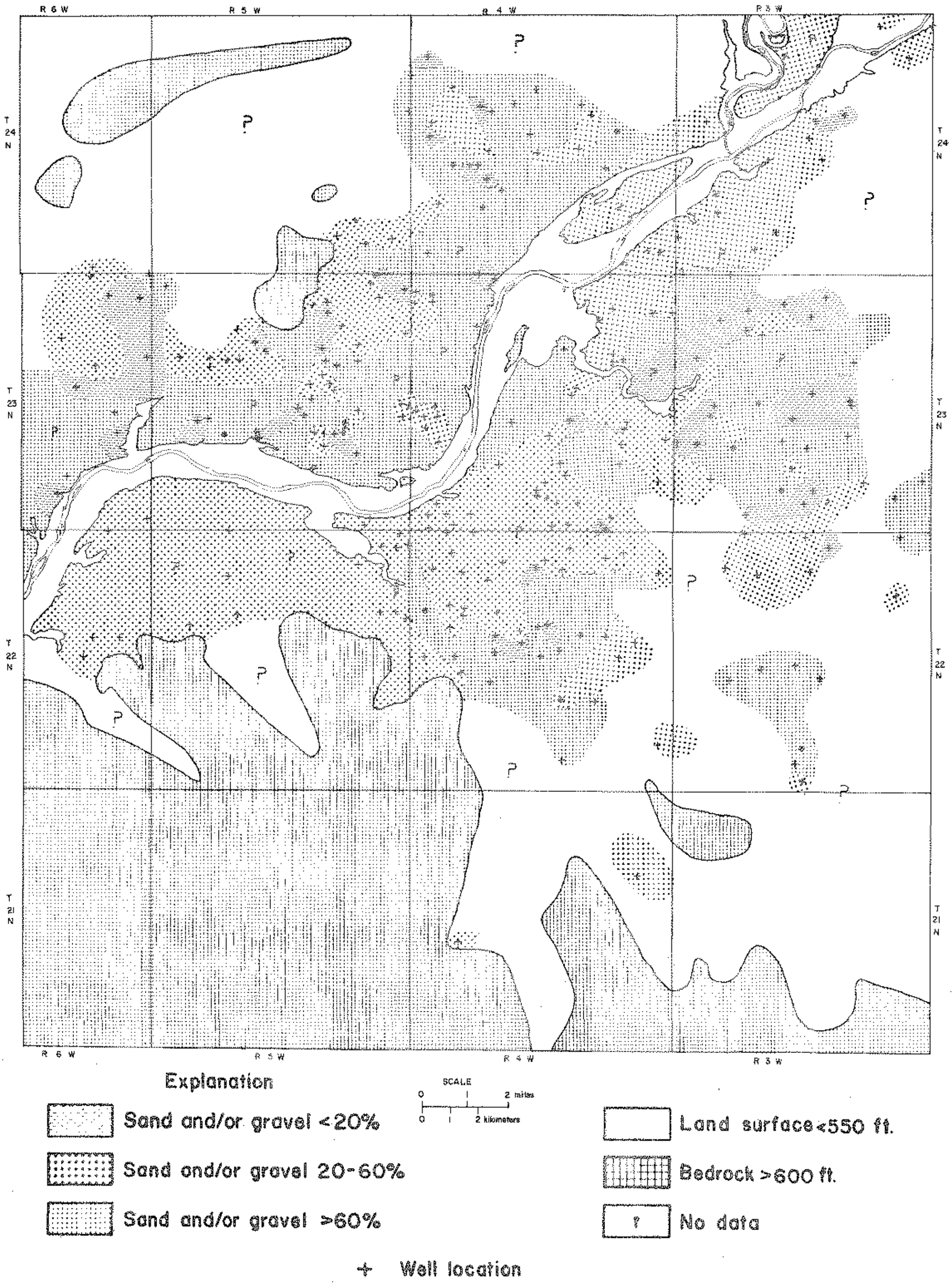


Figure 14. Lithofacies-Ratio Map of the Slice 550-600 ft.

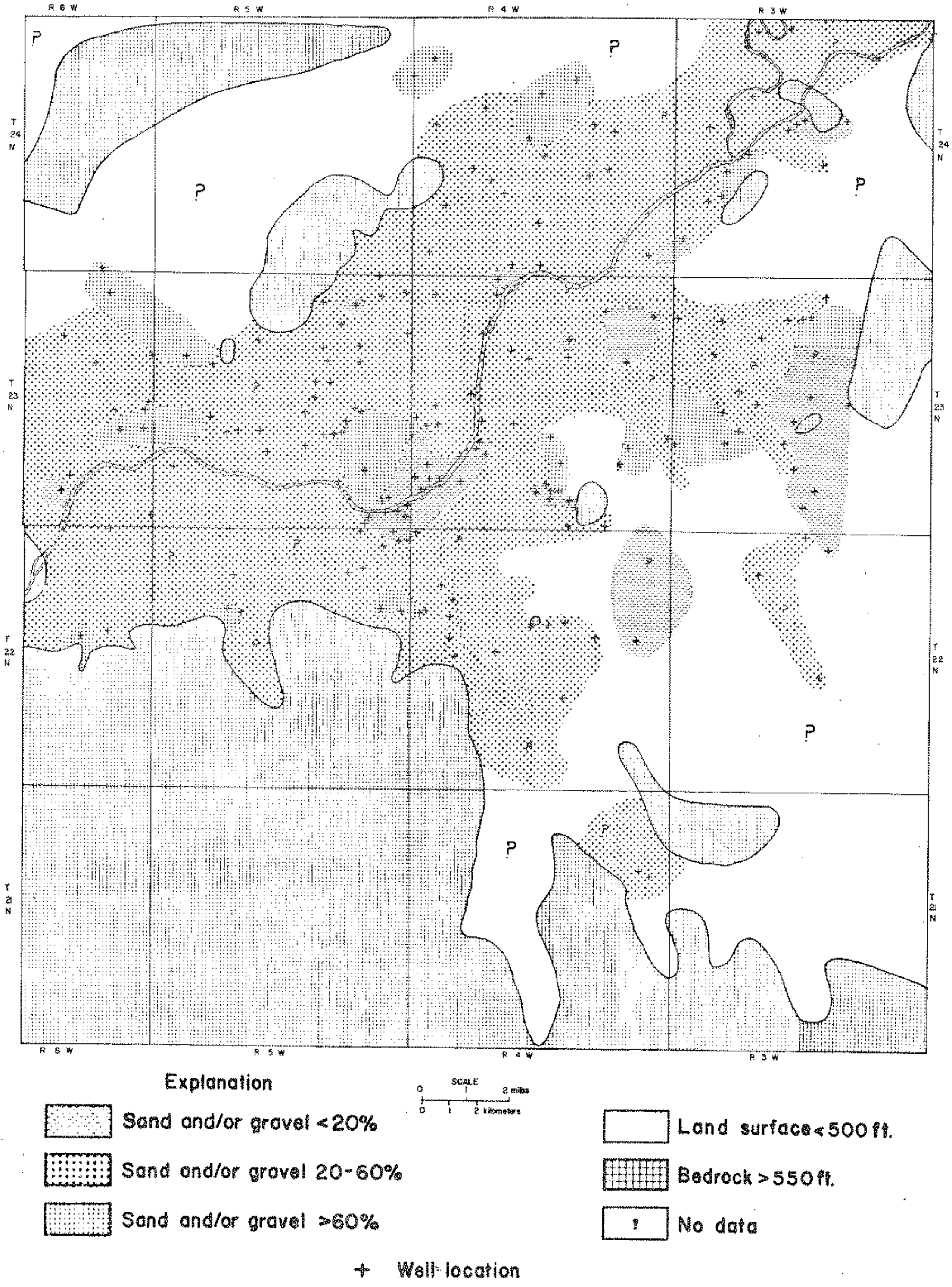


Figure 15. Lithofacies-Ratio Map of the Slice 500-550 ft.

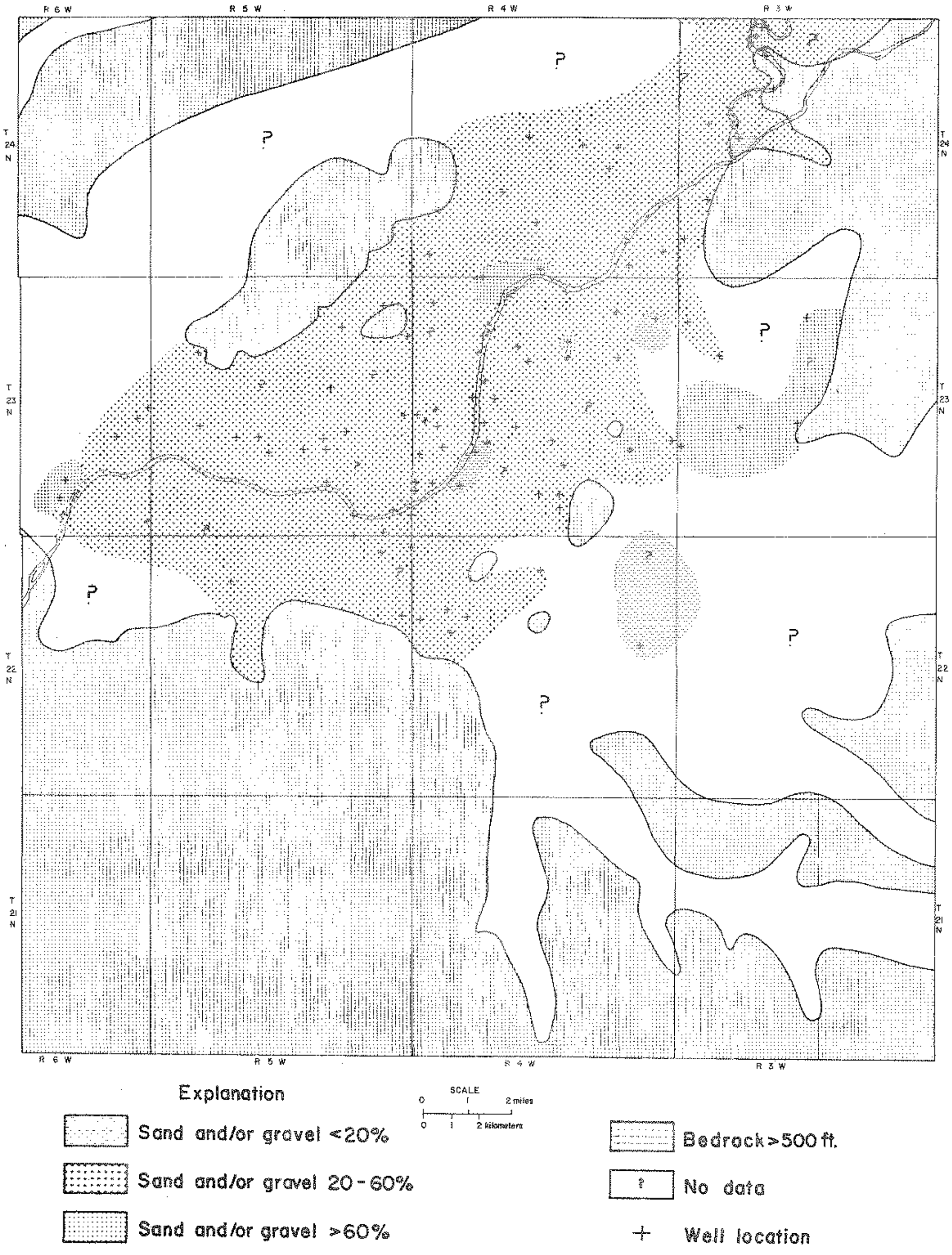


Figure 16. Lithofacies-Ratio Map of the Slice 450-500 ft.

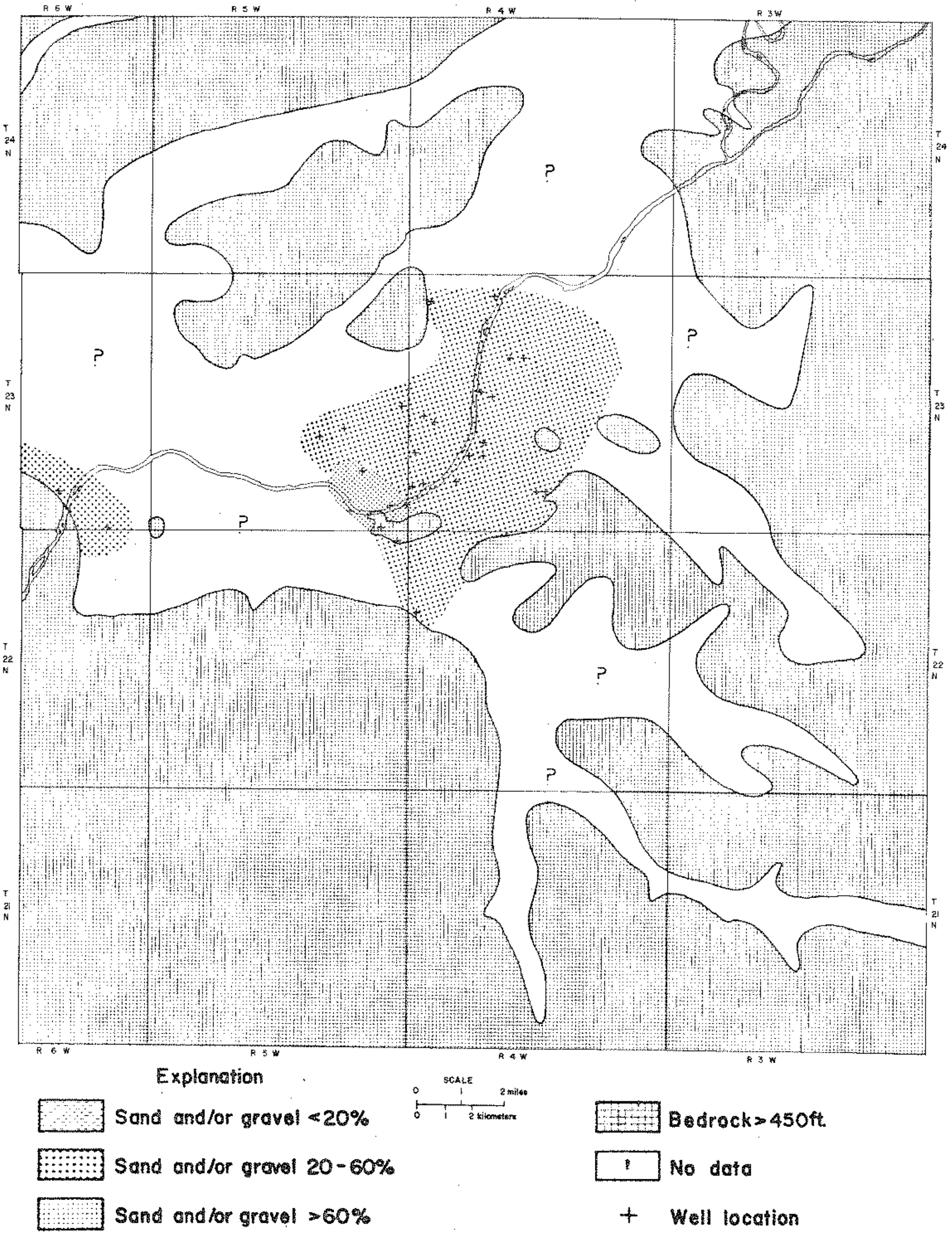


Figure 17. Lithofacies-Ratio Map of the Slice 400-450 ft.

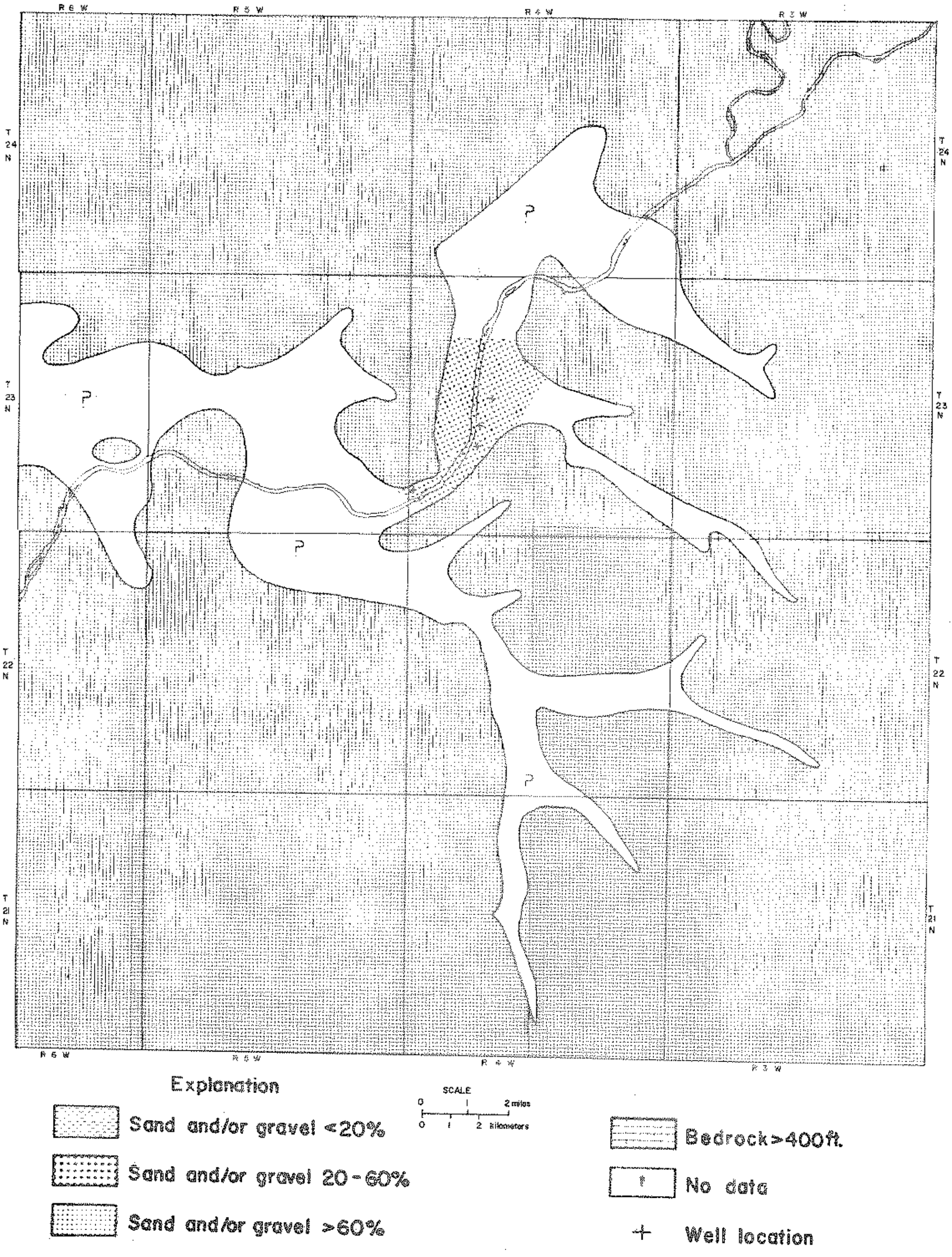


Figure 18. Lithofacies-Ratio Map of the Slice 350-400 ft.

place of deposition of sand and gravel was much affected owing to this complex history.

In terms of these conditions, aquifers within the unconsolidated deposits in Tippecanoe County may be described and classified. Pre-Illinoian, Illinoian and Wisconsinan outwash aquifers are the major sources of groundwater in the county. Holocene alluvium and numerous disconnected sand and gravel lenses within the till are potential aquifers, but only for limited uses. Many wells fail to strike any of these aquifers in passing through the unconsolidated deposits above the bedrock.

It is more advantageous to explore groundwater aquifers in the low elevation bedrock areas because in these areas the drift is thicker and generally more sand and gravel is encountered. The areas of largest yield and best for future intensive development are those where outwash aquifers are hydraulically connected to the Wabash River.

It should be noted that the aquifer maps (Figures 19-22) and classification scheme are given on a regional scale. Plans for future development of large supplies in specific areas will require more detailed evaluation and should be based on more data about the hydrologic characteristics of different aquifers.

The distribution of aquifers is discussed, from older to younger as follows:

Shallow Bedrock Aquifers

The Silurian Liston Creek Member of the Wabash Formation has not been developed as a water supply in Tippecanoe County. Potable groundwater may be expected in the subcrop area in the northern part of the county where joints may be enlarged by solution (Figure 4). In this area the top of the Liston Creek Limestone is about 300 feet above msl. Elsewhere the water in this limestone is probably too highly mineralized for normal human usage.

The Devonian carbonate rocks are water-bearing. A few wells tap good water from these formations in the northeastern quarter of the county. However, it is not uncommon to get dissolved H_2S in the water. The depth to the Devonian carbonate rocks in the Lafayette area is about 220 feet. They might be considered as a receptor for liquid wastes, in areas where they will not be used as an aquifer, for example in downdip areas in the southwestern part of the county. However, the shallow depth and the possibility of hydraulic connection with overlying units that are aquifers suggests that any disposal project should rather consider use of more deeply-seated Paleozoic rocks for injection of wastes.

The New Albany Shale does not yield much water except from the upper few feet where the rock may be closely fractured. Some wells in T.24N., R.3W. discharge limited amounts of potable water from near the top of this shale. The New Albany Shale acts as a thick, confining unit between the Devonian carbonates and the Borden rocks.

The Borden rocks and the overlying Harrodsburg Limestone are a commonly used but limited capacity aquifer in the southwestern part of the county. The average depth to this aquifer is about 30 feet in this area.

Pre-Illinoian Outwash Aquifer

This aquifer is extensive (Figure 19), but has not been greatly developed. Thickness ranges from zero where there is no pre-Illinoian sand or gravel, to approximately 200 feet in the buried Teays channel in T.23N., R6W. The aquifer is covered by Illinoian till which acts as a confining bed. However, it may be covered directly by Illinoian or Wisconsinan outwash. Wells at West Lafayette in sec. 19, T.23N., R.4W. are examples of the pre-Illinoian, Illinoian, and Wisconsinan outwash materials forming a single aquifer. In this locality the aquifer was essentially formed by re-excavation of the major sluiceway at the end of each glaciation by erosion of glacial till and deposition of a new layer of outwash material. The aquifer is composed principally of outwash sand and gravel, with some clay and/or till interbedded with the coarser material.

The pre-Illinoian outwash aquifer in Tippecanoe County is bounded by bedrock at the base and generally laterally also abuts against rock. It is overlain by Illinoian till. It is continuous with the pre-Illinoian aquifer in Carroll, Clinton and Warren counties (Figure 19).

Illinoian Aquifers

Illinoian till has some sand and gravel lenses which provide limited water supplies. The Illinoian outwash aquifer (Figure 20), is the most extensive in the county. The deposits filled the valleys during the Illinoian stage and extended elsewhere as outwash plains. This

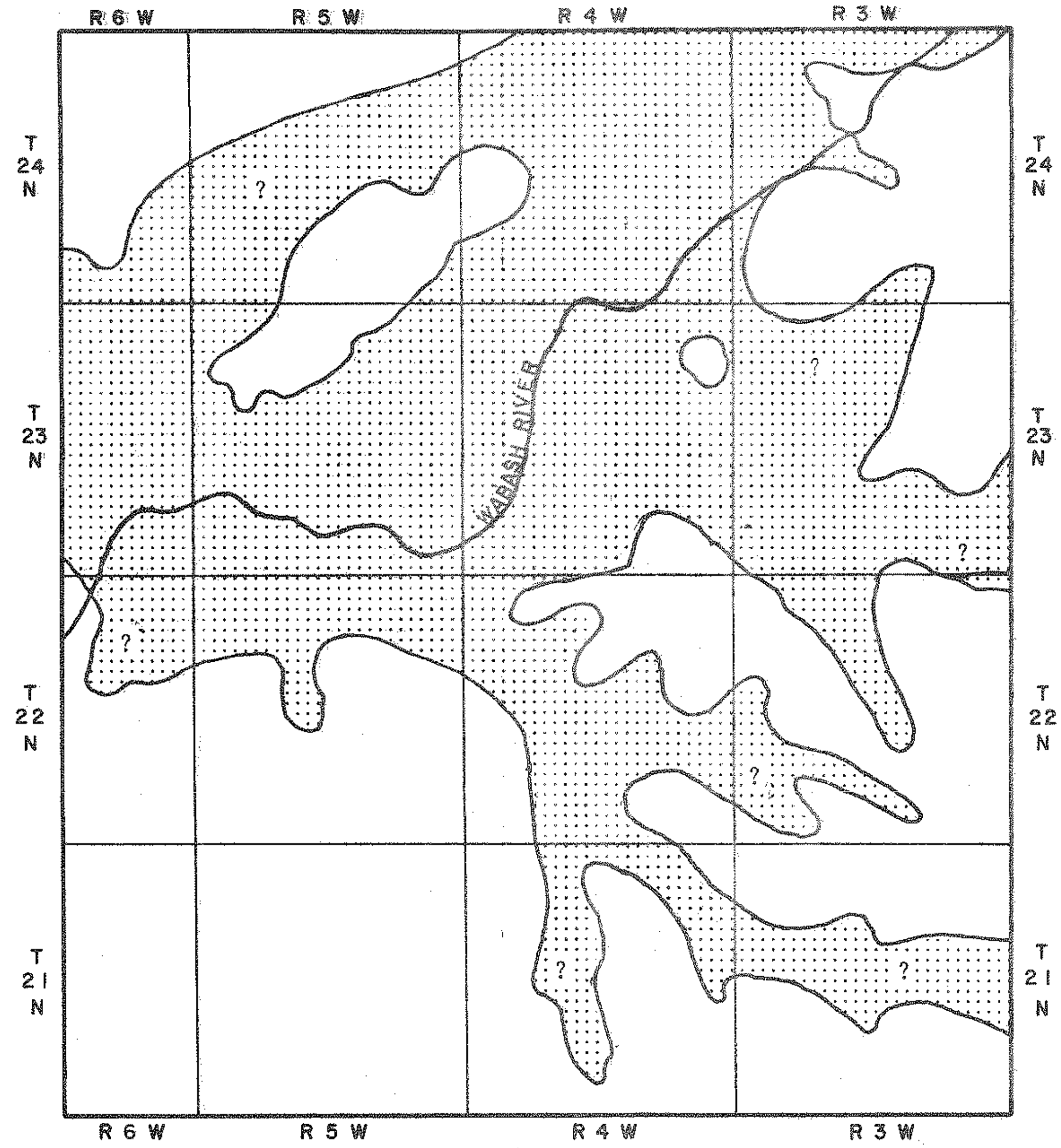


Figure 19 GENERALIZED MAP SHOWING DISTRIBUTION OF THE PRE-ILLINOIAN OUTWASH AQUIFER, TIPPECANOE COUNTY

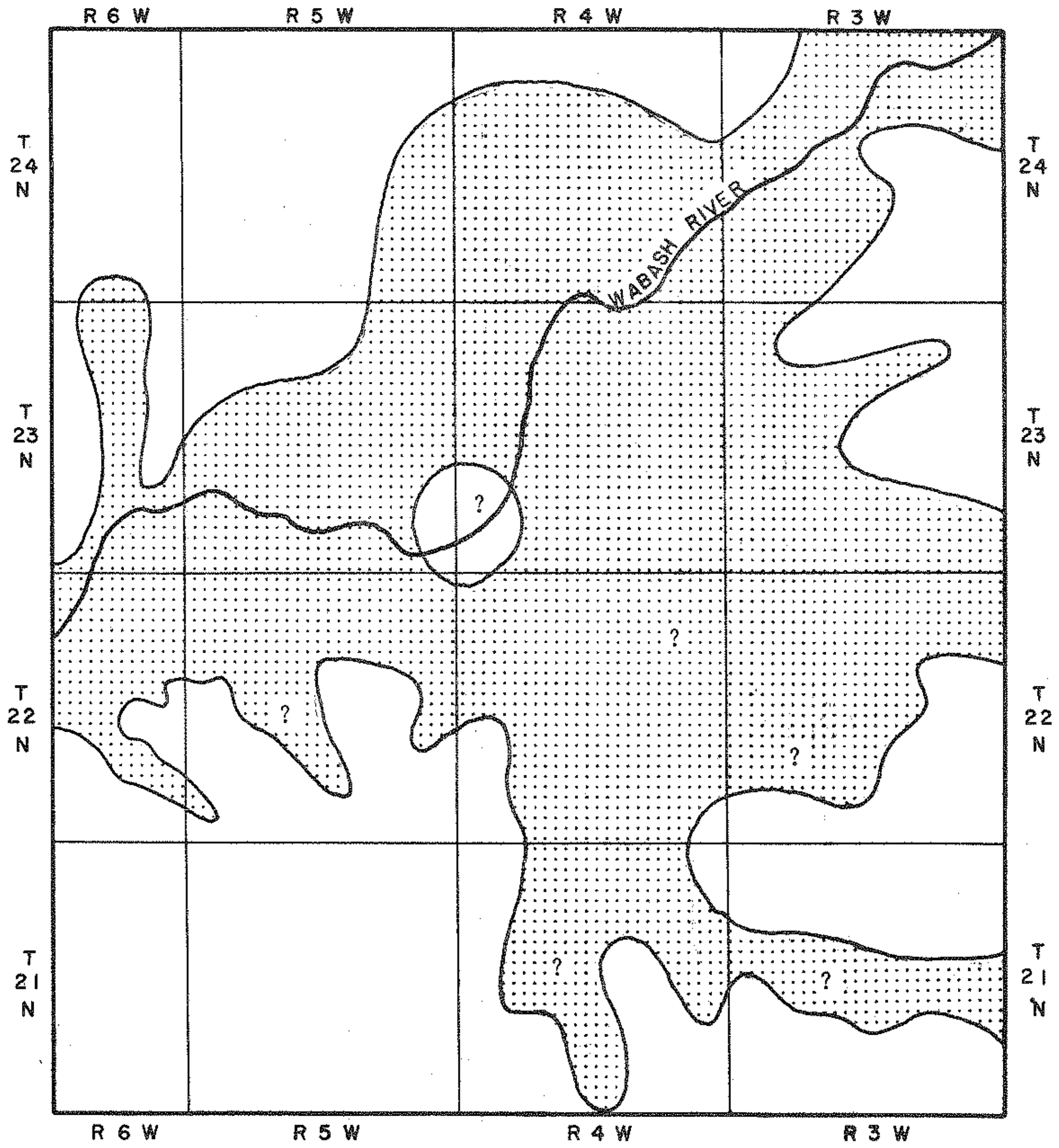


Figure 20 GENERALIZED MAP SHOWING DISTRIBUTION OF THE ILLINOIAN OUTWASH AQUIFER, TIPPECANOE COUNTY

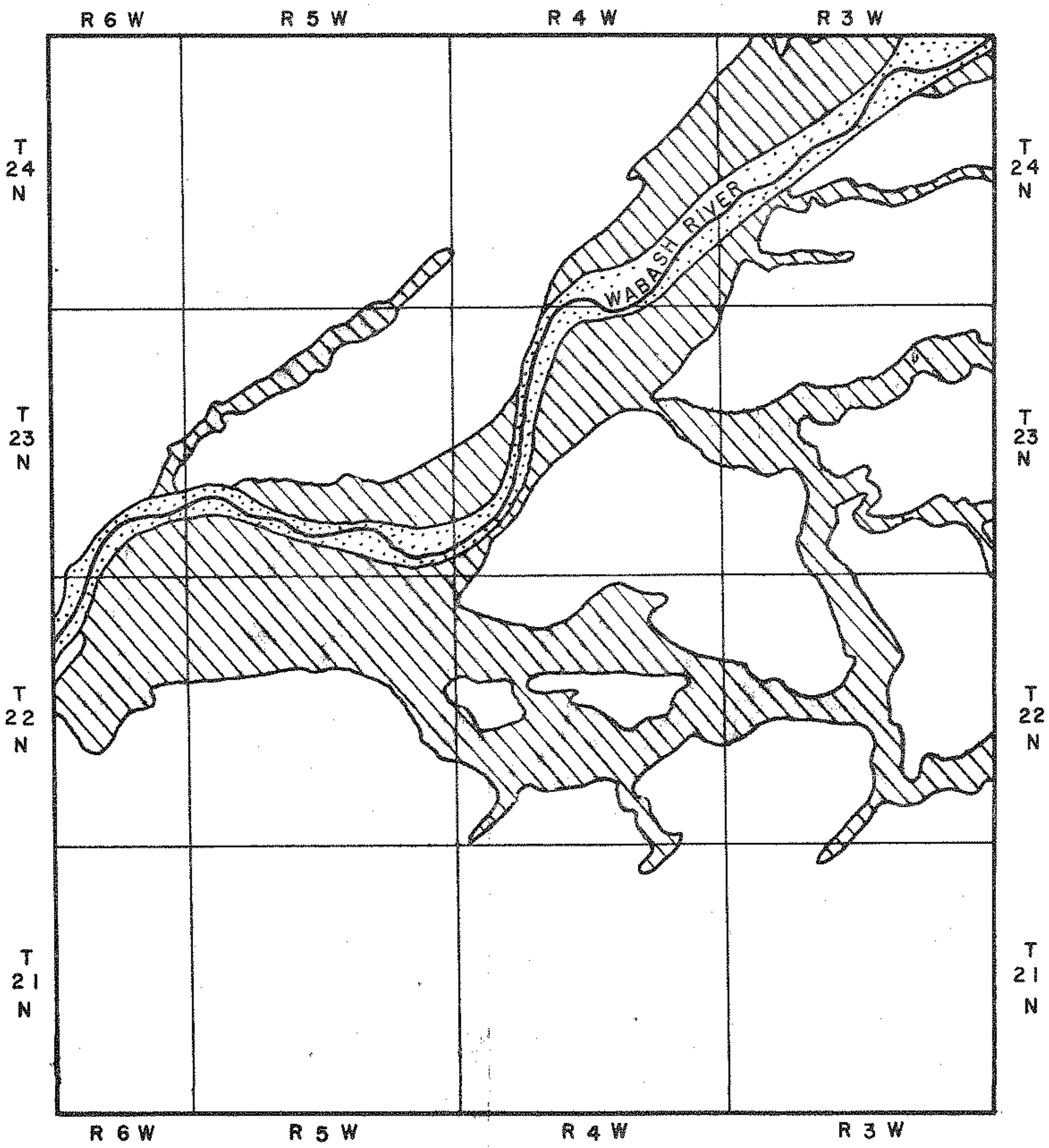
aquifer is widely used for various purposes. The thickness ranges from zero to more than 100 feet in the buried Clarks Hill Valley in T.21N., R.3W. Most of the aquifer is covered by Wisconsinan till as a confining bed. The aquifer material is mainly sand and gravel, commonly interbedded with finer-grained material.

The Illinoian outwash aquifer is bounded below by Illinoian till, by Wisconsinan till above, and laterally by the bedrock high areas. At West Lafayette the aquifer is unconfined; thus it is bounded upward by the water table. The aquifer is connected hydraulically with the Illinoian aquifer in the surrounding counties.

Wisconsinan Aquifers

Wisconsinan till contains a few discontinuous sand and gravel lenses which may yield limited water supplies. Wisconsinan outwash extends over a large area (Figure 21), but most of it is unsaturated. Most of the saturated Wisconsinan outwash is in the Wabash Valley. However, some Wisconsinan outwash far from the Wabash Valley may be saturated by perched water. The total thickness of outwash ranges from zero to about 50 feet. The aquifer material is mostly sand and gravel. It is associated and interbedded with finer-grained material. The aquifer is not widely utilized. However, more development in the future should decrease the current reliance on the Illinoian aquifer.

The Wisconsinan outwash aquifer in the Wabash Valley is connected downward with the Illinoian aquifer. It is bounded laterally by the



EXPLANATION

░ Wisconsinan outwash aquifer

▨ Wisconsinan outwash, generally unsaturated

Figure 21 GENERALIZED MAP SHOWING DISTRIBUTION OF THE WISCONSINAN OUTWASH DEPOSITS, TIPPECANOE COUNTY water table or by confining, fine-grained deposits. Away from the Wabash Valley, the few saturated Wisconsinan outwash aquifers are bounded below and laterally by Wisconsinan till, and upward by the water table or by a confining bed.

Holocene Alluvium Aquifer

The Holocene alluvium aquifer in the Wabash Valley is a continuation of the Wisconsinan aquifer. In Wildcat, Wea, Indian, and other creeks the water-bearing alluvium is limited in area and thickness. The aquifer material is mainly sand with some gravel. Locally, finer-grained material is contained in the alluvium.

The Holocene aquifer (Figure 22) is less important and less developed than the underlying aquifers because of its limited distribution and hydrologic potential.

Hydrology

The hydrologic properties of water-bearing formations in Tippecanoe County are related to the water budget, and to recharge, movement within, and discharge from these formations. Changes of groundwater levels are much affected by the balance between recharge and discharge.

Budget

The relation between total water gains and losses for a certain time period is expressed as the hydrologic budget. It can be stated in the following form:

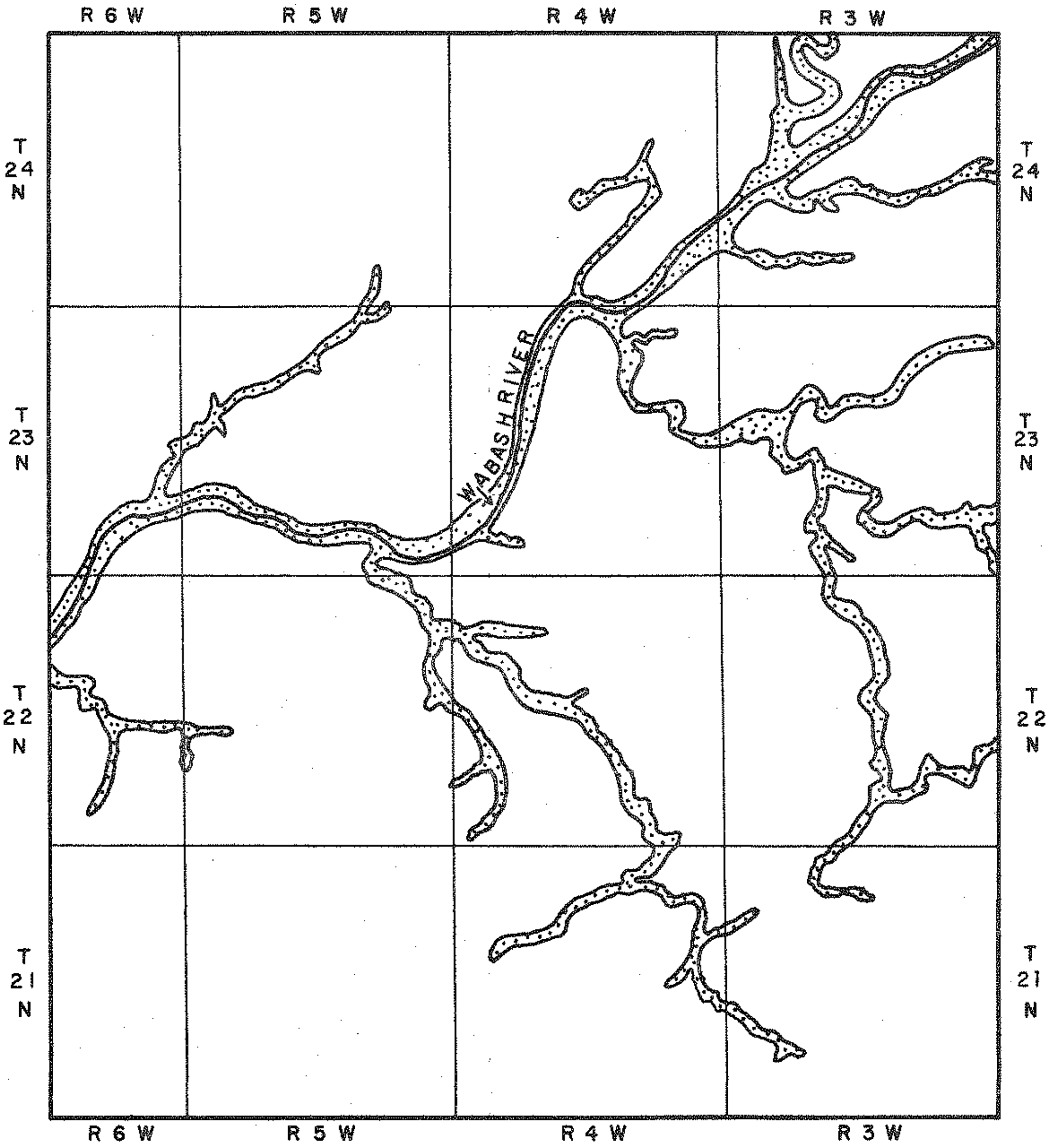


Figure 22 GENERALIZED MAP SHOWING DISTRIBUTION OF POSSIBLE HOLOCENE AQUIFER, TIPPECANOE COUNTY

Inflow = Outflow ± Change in Storage

The significant inflow items are precipitation, surface inflow and subsurface underflow, whereas the significant outflow items are surface outflow, subsurface underflow, evapotranspiration and consumptive uses. The different items may fluctuate from year to year. Precipitation and runoff vary considerably. Changes in evapotranspiration and water storage may occur. Underflow is fairly constant. If water entering and leaving the area and the change in storage can be determined, it will be possible to know how much water is available for development.

Table 2 summarizes the monthly water balance for the Lafayette area. It is clear from the table that the dry season, when potential evapotranspiration is greater than precipitation, is from June through September, whereas the wet season is from October through May. Figure 23 indicates that soil moisture recharge takes place in October through December, because of the decrease in temperature and plant transpiration. There is a water surplus from December through May. This surplus goes to subsurface moisture. In May, the monthly surplus decreases as evapotranspiration increases until it exceeds precipitation in June and at this time soil moisture is withdrawn from storage. A moisture deficit exists in August and September, when potential evapotranspiration is more than actual evapotranspiration and soil moisture in storage is depleted.

Recharge

Recharge to groundwater in Tippecanoe County is from direct precipitation, intermittent influent streams on the uplands, influent seepage

Table 2. Monthly Water Balance for Lafayette Area* (water depth in inches).

	January	February	March	April	May	June	July	August	September	October	November	December	Year
P	1.81	1.41	2.22	4.31	3.94	3.85	4.74	3.38	2.62	2.69	2.70	2.01	35.68
PET**	0.00	0.00	0.43	1.73	3.50	5.08	5.87	5.16	3.62	1.89	0.47	0.00	27.75
P-PET	1.81	1.41	1.79	2.58	0.44	-1.23	-1.13	-1.78	-1.00	0.80	2.23	2.01	
ΔST	0.00	0.00	0.00	0.00	0.00	-1.23	-1.13	-1.64	0.00	0.80	2.23	0.97	
ST	4.00	4.00	4.00	4.00	4.00	2.77	1.64	0.00	0.00	0.80	3.03	4.00	
AET	0.00	0.00	0.43	1.73	3.50	5.08	5.87	5.02	2.62	1.89	0.47	0.00	
D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.00	0.00	0.00	0.00	
S	1.81	1.41	1.79	2.58	0.44	0.00	0.00	0.00	0.00	0.00	0.00	1.04	

*PET = potential evapotranspiration; P = precipitation; ΔST = change in soil moisture storage since previous month; ST = soil moisture storage at the end of the month; AET = actual evapotranspiration; D = water deficit; S = water surplus.

**PET taken from Carter, D.R., Basic Data and Water Budget Computation.

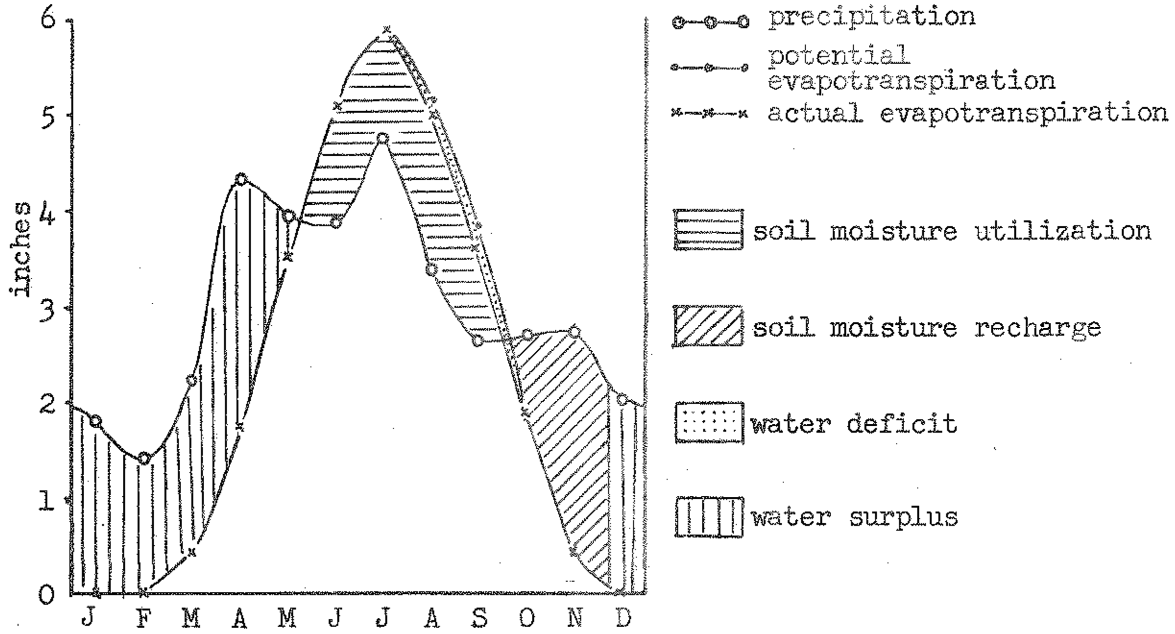


Figure 23. Water Balance for Lafayette Area.

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of perennial streams' high stage (Rosenshein, 1958, 1959), induced infiltration of surface water, vertical leakage from overlying deposits, or subsurface underflow from the east and northeast (Figures 19, 20).

The main recharge source of bedrock aquifers is water leakage from overlying glacial drift. The pre-Illinoian and Illinoian outwash aquifers are recharged vertically though younger deposits, and laterally through their extensions from the east and northeast. Vertical leakages takes place in areas where there is a difference in head between water levels in shallower deposits and the water level in pre-Illinoian or Illinoian aquifers. The Wisconsinan outwash and Holocene alluvium aquifers are mainly recharged by percolated precipitation and surface runoff. Percolated precipitation is greatest in spring and least in fall, as shown in Table 2.

Recharge rates for glacial sand and gravel aquifers in Illinois (Walton, 1965), range from 115,000 to 500,000 gpd/sq mi. A similar range is expected in Tippecanoe County because of similarity in physiographic and geologic conditions. The Holocene alluvium and Wisconsinan outwash aquifers' rate of recharge may exceed 300,000 gpd. sq mi. whereas the deeper Illinoian, pre-Illinoian and bedrock aquifers, if overlain by thick deposits of low permeability, will be vertically recharged at lower rates. The rate of vertical recharge of deeper aquifers is controlled by vertical permeability, thickness of overlying drift, and the difference between the potentiometric surface in deeper aquifers and the overlying water source.

Artificial recharge to groundwater aquifers is not urgently needed at present in Tippecanoe County, but it may be important in the future. Groundwater can be artificially recharged by construction of small check dams on creeks to retard runoff and increase infiltration, changing the route of some streams to pass across coarser-grained deposits that overlie aquifers, or discharging uncontaminated, clear waste-water from air-conditioning or other sources to aquifers through recharge wells, shafts, or pits About 10 mgd are being recharged currently into a gravel pit on the Purdue campus. Heavy pumpage near surface water bodies recharges groundwater by induced infiltration as soon as the potentiometric surface in the pumped well becomes lower than the surface water level.

Movement and Discharge

Groundwater moves vertically and laterally, from recharge areas to discharge sites. The rate of movement is dependent on the difference in head and permeability of the media. Land surface configuration affects the regional directions of groundwater flow, *i.e.*, groundwater moves from the higher lands where it is recharged toward the Wabash Valley. Infiltration properties of surficial material (Plate 2), also control the distribution of recharge areas. High permeability soils on outwash plains, flood plains and terraces are the most favorable intake areas. The recently constructed municipal golf course on the flood plain and low terrace of the Wabash River in Lafayette is an excellent example of land use in terms of groundwater management. This area is only a short distance from the municipal well field and overlies the same aquifer. Much of the water which floods the golf course during peak flows of the river goes toward direct recharge of the aquifer.

The permeability of glacial drift also controls the rate of water movement and discharge, as well as rate of recharge. Movement through till is relatively slow. However, recharge to and discharge from aquifers does take place through till.

Groundwater in Tippecanoe County is discharged by surface streams, springs, pumpage, evapotranspiration and subsurface underflow to Warren and Fountain counties.

Aquifers are discharged principally to maintain base flow of the Wabash River and its tributaries. Rosenshein (1958) estimated the groundwater discharge into streams as 140 mgd. In constructing the deterministic groundwater model for hydrological evaluation of the Lafayette urban area only, Dr. J.A. Spooner (in press, 1975) suggests that base flow contribution to the Wabash River and the Wildcat Creek is on the order of 49 mgd over a total reach of eight miles. Extrapolation of these values suggests that the figure given by Rosenshein is quite reasonable.

The shallower Holocene and Wisconsin aquifers are discharged to the Wabash River at a slower rate than the deeper aquifers. The water elevation at the discharge point will affect the storage available in the unconsolidated material such as in the case of the extensively distributed but unsaturated Wisconsinan outwash (Figure 21).

The outwash aquifers outside of the valleys are a potential source for industrial and municipal water supplies. Wells of intermediate diameter generally yield more than 100 gpm. The Holocene alluvium aquifer, bedrock aquifers and disconnected sand and gravel lenses within the till are potential but minor sources for domestic supplies. The generally yield less than 12 gpm.

Changes of Water Levels

Groundwater levels in observation wells in Tippecanoe County have been measured periodically since 1935. Levels fluctuate, and fluctuations reflect changes in the amount of water stored in the aquifers. Annual range of change is from less than a foot to more than 25 feet, depending on geological setting of the aquifers, and the gain or loss in groundwater storage. Maximum and minimum annual groundwater levels are recorded at different times from year to year, but generally levels are highest in spring and lowest in fall, depending primarily on the climatic conditions and stage of the Wabash River.

The magnitude of annual fluctuatuation is affected by the quantity of water available for recharge, pumpage, and changes in stream stage. In Observation well no. 7 in sec. 13, T.23N., R.5W., the difference between annual high and low levels was 2.5 feet in 1970, while the difference in the same year was 13 feet in Observation well no. 8 in sec. 17, T.23N., R.4W.

High rainfall during the summer is utilized as soil moisture because evapotranspiration is at a maximum High precipitation in spring is added to groundwater storage because soil moisture utilization and recharge are satisfied (Figure 23). Water levels in wells in the pre-Illinoian and Illinoian aquifers generally fluctuate less than do the shallower aquifers. Wells in shallow aquifers, far from the Wabash Valley, tend to go dry in drought years when precipitation is below normal, whereas deeper aquifers are partly recharged in drought years from water stored in the overlying confining beds. Therefore, below normal precipitation has less effect on deeper aquifers than on shallow ones.

The historical record of observation wells across the county does not suggest any significant or continuous record of long-term decline of water levels.

Quality

The extent to which groundwater resources can be developed depends on water quality as well as quantity.

All groundwater contains dissolved minerals, and the mineral content is related to the materials through which the water flows or percolates, the length of time it is contact with the materials (flow rate), and internal pressure-temperature relations of the aquifer. Thus, groundwater quality in Tippecanoe County varies between different aquifers and also within the same aquifers. Chemistry, temperature, and pollution are the quality aspects discussed in the following sections.

Chemistry

Groundwater in the Lafayette area moves through glacial drift materials derived in large part from the erosion and redeposition of sedimentary and granitic rocks, and is especially high in calcium and magnesium carbonates and bicarbonates. The water is generally slightly alkaline. The total dissolved solids range between 300 and 500 mg/l (milligrams per litre) in most of the aquifers. Water having a hardness of more than 200 mg/l is considered "hard", and thus groundwater of the Lafayette area is "very hard". Generally the water is suitable for most human activities (Table 3), but softeners are required to save soap and to avoid scale formation in boilers, pipes, and water heaters.

Manganese content in West Lafayette and Battle Ground is higher than the recommended limit (.05 mg/l). Iron content also is generally

Table 3. Fresh Water Tolerance Limits for Various Uses.

Quality Indicators	*Units of Measurement*	*Raw Municipal Water*	*Recreation (body contact)*	*Tolerant Fish and Aquatic Life*	*Intolerant Fish and Aquatic Life*	*Livestock and Wildlife*	*Irrigation*	*Industrial Cooling Water*	*Esthetics*
Maximum temperature	°F	95	95	93	75	95	95	95	
Coliform bacteria	nmbr./100ml	5,000	1,000	—	—	—			
Streptococci	nmbr./100ml	100	100						
Dissolved oxygen (min)	mg/l	some		4	6	some	some	some	some
Acidity range	pH	5–9	5–9	6–9	6–9	5–9	5–9	5–9	n.a.
Phenolics	mg/l	0.05	0.2	0.2	0.2	n.a.	n.a.	n.a.	0.2
Chloride ions	mg/l	250	n.a.	—	—	1,500	150 or more	n.a.	n.a.
Ammonia nitrogen	mg/l	n.a.	n.a.	1.5	0.4	5,000	beneficial	n.a.	n.a.
Dissolved solids	mg/l	500	n.a.	10,000	5,000	7,000	1,000 to 3,000	—	n.a.
Phosphates	mg/l	0.4	n.a.	small amounts are beneficial		n.a.	beneficial	beneficial	—
Cyanides	mg/l	0.2	0.2	0.05	0.025	0.2	—	n.a.	n.a.
Fluorides	mg/l	0.8 to 1.7	n.a.	1.5	1.5	0.8 to 1.7	10	n.a.	n.a.
Odor Oil Floating solids Bottom deposits Turbidity Color		not to be substantially visible or noticeable							

SOURCE: *Water Quality Criteria* by Engineering and Technical Research Committee, American Petroleum Institute, 1967 higher than the objectionable limit (.03 mg/1). High iron content gives water objectionable characteristics for taste and laundry purposes. West Lafayette and Clarks Hill municipal water supplies add phosphate compounds to prevent iron deposition. However, the iron concentrations seem to be localized and in general are less than that encountered in similar areas elsewhere in the glacial drift region. It does not present much of a treatment problem in municipal, industrial, or individual water supply systems.

Fluoride concentration is about 0.2 mg/1. This is less than the desirable standard value for drinking water (0.8-1.7 mg/1). Therefore, fluoride is added to natural waters to prevent dental decay in the Lafayette community. Although abundant data are available on bacteriological quality of waters in the area, complete chemical analyses are scanty. Rosenshein (1958, p. 34) presents data on a dozen wells in the county. Table 4 gives concentrations in mg/1 of some constituents in water wells used for public supplies in the Lafayette area. Calcium, magnesium, sodium, potassium, chloride, sulfate and nitrate concentrations, and pH meet most requirements for various uses. Table 5 presents historical data obtained from Lafayette and West Lafayette municipal wells for the period from 1958 to 1975. Because different wells were tested at different times, and because certain analyses for certain elements was not performed at the earlier dates, it is impossible to determine whether any trends exist over time. There is a slight suggestion that nitrogen is increasing but this trend may be more apparent than real. Changes and

Table 4. Chemical Analyses of Groundwater in Tippecanoe County.*

Locality	pH	Hardness ($CaCO_3$)	Calcium (Ca)	Mangnesium (Mg)	Sodium (Na)	Potassium (K)	Iron (Fe)	Manganese (Mn)	Alkalinity ($CaCO_3$)	Chlorides (Cl)	Fluorides (F)	Sulfates (SO_4)	Nitrates (N)
Lafayette PWS	7.7	436	116	36	16	3.5	.03	.03	322	26	.2	94	2.9
West Lafayette PWS	7.9	348	89	31	11	3	.9	.13	280	11	.3	68	.6
Battle Ground PWS	7.5	312	78	29	10	2.5	1	.2	308	3	.1	27	0
Indian Brook PWS	7.6	297	79	24	8	2	2.1	.03	314	3	.1	0	<.1
Clarks Hill PWS	7.3	388	88	41	14	2	4.3	.04	376	5	.5	25	0

*Values except pH, are in mg/l (milligram per litre)

Source: Data on Indiana Public Water Supplies. Indiana Stage Board of Health, Bull. S.E. 10 1968.

Table 5. Chemical Analyses of Groundwater in the Lafayette Public Water Systems.

Year	1958				1965			1969		1971					
Well	WL^{1}2	WL 3	WL 4	WL 5	WL 4	WL 6	L^2 8	L 2	L 7	L 54	L 5	L 7	L 12	L 12(new)	L 13
p.H.	8.0	8.0	8.1	8.1	7.9	8.0	7.6	7.7	7.2	7.6	7.3	7.3	7.8	7.6	7.5
sediment	0	VS*	VS	5.0											
turbidity	0.3	1.0	0.7	3.0	1.0	2.0	<0.1			8.0	0.1	3.0	15.0	2.5	0.3
Hardness, as $CaCO_3$	354	354	360	348	360	336	462	280	445	332	288	456	285	282	274
Alky., as $CaCO_3$	286	278	278	284	288	272	352	212	338	234	214	342	224	216	202
Ca	89	90	93	88	94	84	120	75	116	61	76	118	60	78	74
Mg	32	31	31	31	31	31	39	22	38	44	24	39	33	21	22
Na	11	7	7	5	14	8	14	10	23	12	12	28	11	12	13
K	3	3	3	2	3	3	4	3	5	3	4	5	3	3	4
Fe	0.08	0.8	0.3	1.3	1.3	0.5	0.4	0.9	0.2	0.5	0.1	0.4	1.1	2.1	0.2
Mn	<0.05	0.1	005	0.1	0.2	<0.05	0	0.29	0.6	0.35	<0.2	0.37	0.39	0.13	0.34
As								<0.1	<0.1		<0.01	<0.01		<0.01	<0.01
Pb															
Cl	11	22	15	15	14	8	24	20	40	24	20	43	22	18	26
SO_4	70	61	68	56	74	62	84	56	74	82	64	90	58	61	62
PO_4					0.4										
F	0.1	0.1	0.2	0.1	0.5	0.1	0.1	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.03
N as NO_3	0.8	0	0.4	0	1.1	0	3.5	0.3	1.9	234	214	342	224	216	202

Year	1972							1975				
Well	WL 2	WL 3	WL 7	L 6	L 7	L 8	L 13	L 5	L 7	L 8	L 9	L 13
p.H.	7.6	7.5	7.4	7.3	7.1	7.3	7.5	7.6	7.3	7.3	7.7	7.6
sediment												
turbidity	0.1	20.0	0.5	0.06	2.0	0.05	0.05	0.1	3.0	0.1	5.0	0.08
Hardness, as $CaCO_3$	300	318	356	404	452	464	284	304	424	466	266	280
Alky., as $CaCO_3$	230	239	280	316	346	354	210	208	326	352	194	198
Ca	83	85	91	108	118	121	74	80	110	123	74	76
Mg	22	26	31	33	38	39	24	25	36	38	20	22
Na	13	8	7	20	29	19	11	14	31	23	12	13
K	3	3	3	4	5	3	3	3	4	4	3	4
Fe	<0.1	1.5	0.4	0.1	0.5	<0.1	<0.1	<0.1	0.4	<0.1	1.0	0.1
Mn	0.08	0.12	0.09	0.20	0.09	0.05	0.41	0.5	0.09	<0.02	0.6	0.4
As	<0.01	<0.01	<0.01	<0.01		<0.01		<0.01	<0.01	<0.01	0.01	<0.01
Pb								<0.02	0.03	0.02	0.02	0.02
Cl	20	12	13	37	52	34	21	27	54	38	25	25
SO_4	64	72	62	78	87	93	66	80	78	94	64	70
PO_4	0.2	0.4	0.2	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1
F	0.2	0.2	1.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
N as NO_3	<0.1	<0.1	<0.1	1.1	1.6	2.2	0.4	2.0	1.3	2.4	0.1	0.1

[*] very slight

[1] West Lafayette

[2] Lafayette

improvements in analytical procedures, sampling methods, or other control factors could account for this apparent change.

Water quality may differ between aquifers. Quality is excellent in the Holocene alluvium and Wisconsinan outwash if the aquifers are protected from surface pollution. The Illinoian outwash aquifer has good quality water. However, mineralization could be slightly greater than in the upper aquifers because water is in contact for a longer time with the rock materials and has more chance to dissolve minerals. Enough data may exist to determine the quality of the pre-Illinoian aquifer, but it has not been studied in connection with this project. If this aquifer is overlain by and recharged through a relatively thick till section, it is probably somewhat more mineralized than the shallower aquifers. It is also possible that some highly mineralized water, at least locally, is discharged from deeper bedrock formations into the pre-Illinoian aquifer.

The chemical quality of water reflects the origin and speed or rate of recharge to aquifers. The lesser mineral content generally indicates faster recharge. Heavy pumpage near the Wabash River lowers the water table below the surface water level in the river. Pumped water with less mineral content is a mixture of groundwater in the aquifer before pumping and the induced infiltration of river water.

The shallow bedrock aquifers generally have potable water where they are easily recharged, such as in area where bedrock is overlain by outwash deposits, thin till, or a surface water source. For example, well 22-6-14-1e taps a bedrock aquifer overlain by sand and gravel. Well 22-5-23-1e yields water from a bedrock aquifer covered by thin till. Well 22-6-24-2f taps water from a bedrock aquifer hydraulically connected with Flint Creek.

The abundance of good quality groundwater undoubtedly has been an attraction to industry and a major factor in the increased number of food-processing and other water consumptive industrial developments in the community in recent years. This trend is likely to increase as water shortages or limits to supply become apparent elsewhere. Decrease in use of boilers or other hot water processing procedures by industry has resulted in a great diminution of problems of scaling and iron precipitates which result in inefficiency or periodic shutdowns in manufacturing. Other dissolved solids do not appear to present any problems.

It seems to the writers, however, that the monitoring of chemical quality of groundwaters of the Lafayette area is far from satisfactory. It seems sensible to recommend that an observation network of wells should be established and routine chemical analysis performed. This should be done on at least an annual basis, and preferably seasonally, in order to determine what influence seasonal decline of water tables and increased pumpate rates have on water quality.

Temperature

Groundwater temperature varies during the year but the range of fluctuation is much less than that of surface water bodies. This gives groundwater an advantage over surface water for cooling purposes.

The temperature fluctuation range of groundwater in the shallower aquifers or aquifers recharged from surface water bodies is more than that in the deep aquifer. This results from heat exchange between surface runoff and the subjacent groundwater. Changes in groundwater temperature may also occur from returning water used for cooling purposes.

Pollution

Pollution of groundwater resources is a serious environmental problem. It must be avoided wherever and whenever possible. Potential pollution should be carefully considered, because it is not always quickly discovered, and even then the problem may not be remedied merely by stopping the point or diffuse sources. It may also be economically unfeasible to reclaim this water. Meanwhile, health hazards may not be avoided.

The most common pollution sources are disposed wastes. The common pollutants are microorganisms, dissolved solids, hardness, pH, odor, heat, detergents, phenols, pesticides, and toxic materials.

Pollutants percolate through the soil toward the water table. They are then easily transported within the flow system. Poor well location, design, or construction provides an easy access for pollutants to reach groundwater. The damage can be caused directly by the polluting substance, or indirectly as a consequence of induced changes in an aquifer's chemical properties. An increase in groundwater hardness was caused by acidic water seepage from a lagoon at a tomato processing plant in

Lafayette (H.R. Wilke, personal communication).

Rainfall, snow melt, and overland flow dissolve and leach inorganic and organic pollutants and add them to the groundwater aquifers. The aquifers in Tippecanoe County are not equally susceptible to pollution. Holocene alluvium and Wisconsinan outwash aquifers are more susceptible to pollution than the Illinoian and pre-Illinoian aquifers, because the latter are more protected except in stream valleys and other local areas where overlain by permeable materials. Bedrock aquifers can be polluted by land surface pollutants where they are not protected by thick, low permeability deposits.

Disposed wastes are the most common contributors to groundwater pollution. Septic tanks, municipal sewage, and landfills are examples of waste disposal in Tippecanoe County, as elsewhere.

Septic tanks, unless properly designed and maintained, represent a constant and important source of pollution. Detergents and sewage drained to septic tanks move through the ground, and possibly pollute groundwater to yield foaming, taste and odor problems.

Unlined landfills sited in permeable materials are important pollution sources, especially if they are in recharge areas or where the groundwater flow is toward a pumping well. Such a case occurred in Lafayette, where a water well near an old open dump was taken out of service after the water became contaminated (T.R. West, personal communication).

Refuse leachate produced by infiltrated water leaves the landfill and migrates through the ground to the water table. The texture and chemical exchange capacity of rock material through which leachate moves determines the extent of pollution. Fine-grained materials, e.g., till, clay, or silt are more capable of retaining dissolved solids and filtering microorganisms than are coarse-grained materials (Figures 24, 25).

Sodium, potassium, calcium, iron, chloride, and bromide ions decrease with distance away from the landfill, whereas sulfate, phosphate and nitrate increase in concentration after leaving the landfill. Those components increasing in concentration cannot exist in the reducing medium caused by the large organic content of the leachate (Hughes, et al., 1971). Decomposition of organic matter by aerobic bacteria releases carbon dioxide and ammonia. The carbon dioxide combines with water to increase its solution capability. Therefore, water hardness and total dissolved solids increase.

Table 6 shows the percentage of material leached from domestic refuse deposited in an unsaturated environment and leached only by natural precipitation.

As leachate leaves the disposal site it moves veritcally downward toward the water table. Upon reaching the water table, leachate takes a flame-like plume shape oriented parallel to the groundwater flow direction and also follows the flow pattern. Some mixing and dilution with groundwater take place downflow until the point is reached where the contamination effect is insignificant.

Chemical pollutants mobilize faster than biological pollutants in the zone of aeration, because the ground acts as a filter that retains

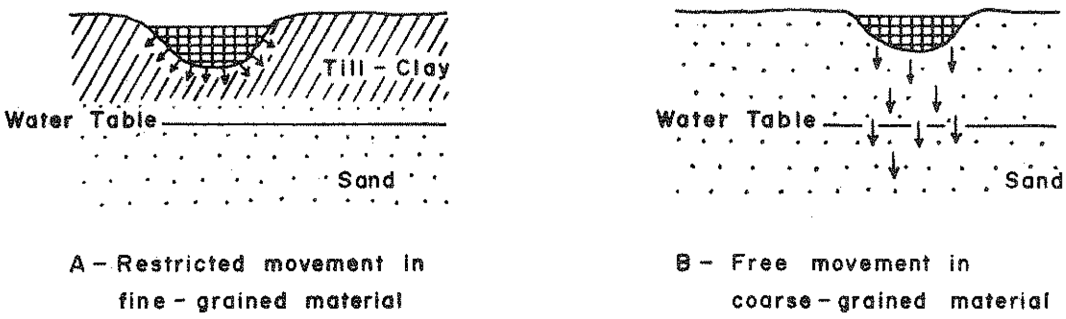

Figure 24 MOVEMENT OF LEACHATE

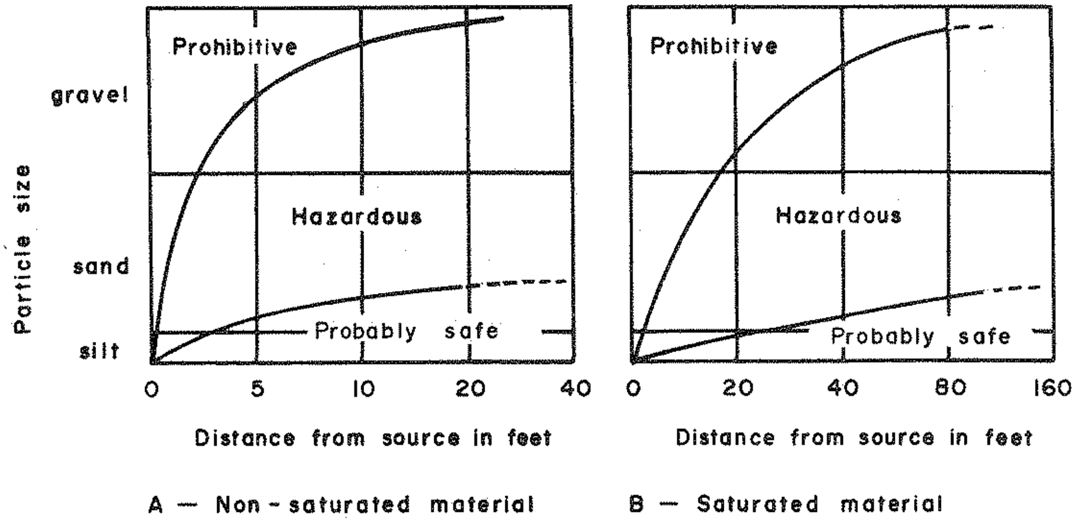

Figure 25 BIOLOGICAL POLLUTION TRAVEL. (Adapted from Romero, 1970)

Table 6. Percentage of Materials Leached from Domestic Refuse. (adapted from Hughes, 1967).

Material Leached	Percentage
Permanganate value 4 hr	0.037
Chloride	.127
Ammonia nitrogen	.037
Biochemical oxygen demand	.249
Organic carbon	.163
Sulfate	.084
Organic nitrogen	.072

most of the microorganisms. The travel of pollutants through the unsaturated zone is less than that through the saturated zone (Figure 25). Although the safe distances between a domestic well and a potential source of pollution are variable according to different conditions (Romero, 1970), a summary of recommended distances is shown in Table 7.

Industrial wastes are potential pollution sources unless they are properly located. Poisons and radioactive wastes could be hazardous unless the hydrogeology of the disposal site is well understood and the spread limits of any dangerous toxicity are established.

Water used for cooling purposes is polluted by heat. Pollution effects can be eliminated by a recooling process before water is returned to the ground.

Pesticides, insecticides, weed killers and agricultural chemicals are widely used in farms and gardens. They are potential pollutants if they infiltrate to the water table. Manure from feed lots and barnyards cause serious groundwater pollution if not disposed of properly.

Table 7. Recommended Safe Distances Between Domestic Wells and Pollution Sources. (Adapted from Romero, 1970)

Source of Pollution	Recommended Distance in Feet	
	U.S. Public Health Service	Federal Housing Authority
Septic tank	50	50
Sewer lines with water tight joints	10	10
Other	50	50
Percolation field	100*	100*
Absorption bed	100*	---
Seepage pit	100*	100*
Dry well	50	50
Cesspool	---	150

*Distance (horizontal) may be reduced to 50 ft, if point of beginning of well casing perforations and percolating fields are separated by a well-defined continuous impervious stratum.

Pollution by petroleum products is possible from gasoline tanks or petroleum wells. Leakage from gasoline tanks, because of corrosion or other reasons, may find access to shallow aquifers. Gasoline polluted groundwater was reported in 1969 in Lafayette. Petroleum wells or test holes are also potential sources of pollution. Head difference of different aquifers in an abandoned well causes vertical flow. Salt water, hydrogen sulfide, or hydrocarbons may move under the difference in head and pollute a shallower, good quality aquifer.

Sulfate and iron are pollutants if they exceed the recommended percentage for human use. Sulfate, as already described, increases in concentration in the refuse leachate. It can be also produced by leaching and oxidation of the sulfide in the New Albany Shale. Iron pollution is possibly caused by dissolved iron minerals from rock materials, or by certain bacteria causing corrosion and incrustation of steel pipes under favorable conditions. Iron pollution has occurred in some wells in Lafayette.

Building on the foregoing general discussion of pollution sources and pollutants, it is worth noting that water wells themselves contribute in accelerating the mobilization of objectionable substances to aquifers. These substances can enter the aquifer when the well is drilled, during the life of the well, or after its abandonment. The entrance of surface-derived pollutants into an aquifer can take place through or under the pump, around the casing, or through the gravel pack. Subsidence at the well-site may destroy the surface protection so that contaminants can enter (Ham, 1971). Pumping water from a deep bedrock aquifer may cause salt water intrusion and contamination of the shallower waters.

The presently unpolluted groundwater resources in Tippecanoe County are in danger of pollution unless the points cited are carefully considered and monitoring is undertaken to insure that no widespread deterioration occurs in the principal aquifers.

SUMMARY AND CONCLUSIONS

The bedrock topography in Tippecanoe County is characterized by a well-developed drainage system. During the Pleistocene Epoch, at least three major ice invasions of the area filled the existing valleys and covered the uplands with glacial drift. The three major drift sheets are pre-Illinoian, Illinoian, and Wisconsinan in age. They are separated by two major, buried paleosols. The Yarmouthian soil developed on the uppermost Kansan deposits, whereas Sangamonian soil developed on the surface of Illinoian drift.

Glaciation disrupted the pre-existing drainage and there were major or minor changes in the drainage system by the end of each glacial or interglacial stage. The most significant changes were caused by Illinoian ice which dammed the Teays Channel and formed the relatively short-lived Glacial Lake Lafayette.

Most of the areas of thick unconsolidated deposits are underlain by the deep bedrock valleys. The thickness range of unconsolidated deposits is zero to 448 feet, with an average of about 200 feet.

Pleistocene sediments in Tippecanoe County were deposited by glacial, fluvial, lacustrine, and eolian processes. The two main sedimentary facies have clay-silt-till and sand-gravel as the predominant constitutents. The fine-grained facies was deposited either directly by ice or in ponded water, whereas the coarse-grained facies was deposited by fluvial action.

Holocene deposits of sand, gravel, clay, silt, peat, muck, and marl were formed by eolian, alluvial and lacustrine processes under gradually changing surficial environments.

Extensive sand-gravel bodies occur along the major pre-glacial drainage lines, *i.e.*, the Teays, Anderson, Clarks Hill, and other valleys. These sediments were deposited by glaciofluvial processes from ice melt during the waning stages of each glacial invasion. The three-dimensional shapes of these stratified units show the geometric characteristics and the probable surface drainage lines at any given time during the glacial history.

The aquifers in the county are delineated, mapped, and classified according to their stratigraphic position. They are ranked in decreasing order of productivity as follows: (1) pre-Illinoian outwash aquifer, (2) Illinoian outwash aquifer, (3) Wisconsinan outwash aquifer, (4) Holocene alluvium aquifer, (5) bedrock aquifer, and (6) disconnected sand and gravel lenses within the till.

The outwash aquifers are potential sources for industrial and municipal water supplies as they generally yield more than 100 gpm from intermediate diameter wells. The Holocene alluvial aquifer, bedrock aquifer, and disconnected sand and gravel lenses within the till are potential aquifers for domestic water supplies but generally yield less than 12 gpm per well.

Wisconsinan outwash is geographically extensive, but at a distance from the Wabash Valley most of these deposits are unsaturated, because the water elevation at the discharge point is lower than the minimum basal elevation of the deposits throughout most of the outwash area.

Groundwater is abundant in Tippecanoe County. The use of this resource has the advantages of uniform and constant quality, lower cost, and the fact that an elaborate treatment and distribution system is not as great as with surface sources. The groundwater occurs under both leaky artesian and water table conditions. Areas of largest yield and best potential for intensive future development are those where outwash aquifers are hydraulically connected to the Wabash River. Recharge is by direct precipitation, influent streams, induced infiltration of surface water, vertical leakage from overlying deposits, or subsurface underflow from the east and northeast. Discharge from groundwater is principally by loss to surface streams, springs, pumpage, evapotranspiration, and subsurface underflow in a westward direction. At the present extraction level of about 35 mgd, there is no apparent long-term continuous decline in water levels. The threshold which, if exceeded, would result in water level deadline is unknown. Pumpage, if limited to the amount of probable recharge should not produce decline in water levels in the future.

Groundwater in Tippecanoe County is of the calcium-magnesium bicarbonate type. Total dissolved solids range between 300 and 500 mg/1. The quality is suitable for many uses. However, it is very hard, with high iron and low fluoride content before treatment. Groundwater mineralization increases slightly with depth.

Groundwater pollution is possible. Many minor cases have been recorded in the county. The most common potential sources of pollution are disposed wastes. Common pollutants are microorganisms, dissolved solids, hardness, pH, odor, heat, detergents, phenols, pesticides, and toxic materials.

RECOMMENDATIONS

Based on the results of this study of the hydrogeology of Tippecanoe County, certain recommendations are made to guide future planning, operational, or environmental studies of the area.

1. Detailed surficial mapping should be completed and correlated with the present subsurface study.

2. Collect more data on depth to bedrock in those areas lacking adequate information, either by controlled drilling or detailed geophysical studies.

3. Collection of aquifer performance test data. Detailed study is needed of hydrologic properties of aquifers and determination of transmissibility and storativity values for different aquifers, to obtain an accurate estimate of the aquifer's optimum potential development.

4. Detailed sampling and analyses on a timely basis of groundwater from the pre-Illinoian and Illinoian aquifers to ascertain their chemical quality.

5. Exclude principal groundwater recharge areas, as identified in this report, from extensive paving, building or other kinds of sealing. Protection of potential groundwater resources should be given priority in any long-term land-use planning program or decision-making context.

6. Pollution of groundwater resources in the county should be avoided at all costs because the future welfare of the Lafayette urban area is totally dependent on a managed program of development and protection of subsurface waters.

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APPENDIX

Well Records

Well Numbering System

The system used in this report is based on township, range, and section units. Sections are divided into eight rows numbered from east to west, and eight columns lettered from south to north. This form 64 1/8-mile squares assuming that the normal section is one square mile. Each square contains ten acres and corresponds to a quarter of a quarter of a quarter of a section.

If there is more than one well in a 1/8-mile square, each is identified by total depth, owner, year of construction, etc.

Example: 23-4-17-5b means that the well is located in Township 23 North, Range 4 West, in the northeast quarter of the southeast quarter of the southwest quarter of section 17 (Figure 26).

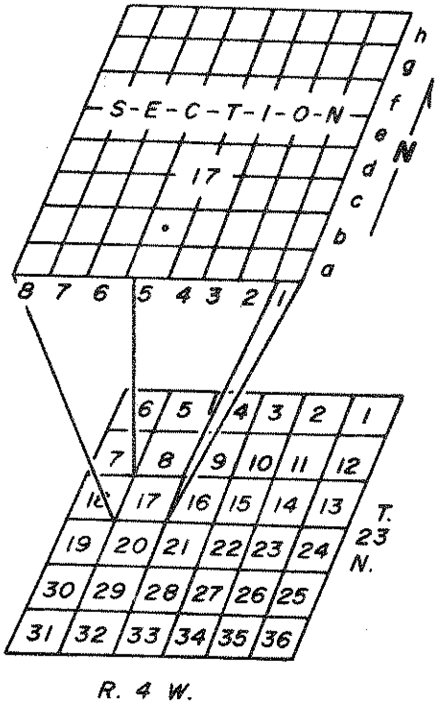

Figure 26. Sketch Showing Well-Numbering System

Relation between slot number and grain size is summarized in Table 8.

Table 8. Slot Number and Equivalent Grain Size. (Modified from Rosenshein and Cosner, 1956).

Texture	Grain Size		Slot Number
	Millimeter	Inch	
Gravel	≥2	≥	100 - 80
Very coarse sand	2-1	0.08-0.04	80 - 40
Coarse sand	1-0.5	0.04-0.02	40 - 20
Medium sand	0.5-0.25	0.02-0.01	20 - 10
Fine sand	0.25-0.125	0.01-0.005	10 - 5

Table 9. Summary of Well Records in Tippecanoe County, Indiana.*

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
T.21N., R.3W.															
1-3h	Eberhart	Lister	1954	785	196			4				50*	9		
3-2a	Fulty	do	1961	785	74			4	4	3		30	12*		2
5-1a	Scott	Feaster	1964	765	120			4½	3	4	30	35*	300	10	4
5-2a	Boyer	Higer	1962	765	116			4	2	3	40	26*	15	1	1
5-4a	Kennedy	N.L. Exc.		760	129			4	2	4	50	45*	20		1
8-2f	Donaldson	N.L. Exc.	1964	770	62			4	2	3	40	35*	16*	0	1
8-7f	Moile	Lister	1959	760	39			4	2	3	50	15*	12*		1
8-1h	Fitzgerald	N.L. Exc.	1963?	775	203			4	2	3	40	65*	10*	0	1
8-1h	Logan	Lister	1961	775	180			4							
8-2h	Stockwell Fire Dept.	Higer	1964	765	45			4	3	3	40	8*	60		1
9-8e	Gordon	Higer	1962	775	134			4	2	3¾	50	34*	10		2
9-8f	Stingley	N.L. Exc.	1963	770	170			4	2	3	40	45*	10	10	2
9-8g	Court	Higer	1961	770	49			4	2	3	40	22*	10*	2	1
9-8g	Funk	N.L. Exc.	1961	770	156			4	4	3	40	45*	10*	0	1
9-7h	Tammons	Higer	1965	760	109			4	2	3	40	28*	15		1
9-8h	Stockwell Lumber Co.	Higer	1968	770	119			4		3		32*	13*	2	1
10-1h	Bray	Dilden		780	82							0*	10	1	
10-1h	Cornell	do	1961	780	57			4	3	4	40	35*			
10-7h	Metzger	Holt	1961	775	34			4	2	3¾	50	14*	10	0	1
11-2a	Lewis	Dilden	1965	800	75			4	3	4	40	16*			
11-4a	Deppe	Norris	1972	800^{c}	114			4½				15*	8*	10	1
12-8e	Bailey	Bir	1972	810^{c}	35			6	3	5¼	50	7*	14*	5	1
13-2c	Brunton	Lister	1960	820	82			6	3	5	50	10*	15*	5	1
16-2c	Moutz	Higer	1966	790	60			4	2	3	40	15*	15*	3	1
16-4h	Knight	do	1967	790	98			4	2	3	40	30*	15*	9	1
17-1d	Johnson	Lister	1954	790	83			4	3			21*	9		
17-1g	Sanders	English	1964	785	190			4	2	4	80	40*			
17-5h	Sears	Lister	1959	770	83			4	2	3	50	32*	15*	2	1
18-4a	Kerkhoff	do	1954	775	56			4	3			32	9*		
19-3a	Jones	do	1967	775	135			4	3	3	80	38*	12*	2	1
19-2f	Metzger	Holt	1960	785	111			4	2	3¾	40	50*	7	5	1
20-7g	Kennedy	Lister		775	103										
20-2h	Irtman	Higer	1966	790	113			4	2		48				
22-4a?W.mag		Lister	1961	815^{c}	95			4	2	3	50	20	12		2
23-1a	Shudley	N.L. Exc.	1970	825^{c}	95			4	2	4	30	15*	20		3
23-6b	Town of Clarks Hill	Lister	1954	825	90			6	5		60	20*	100	10	
23-6d	Clarks Hill Wtr. Wks	do	1938	825	90								150	9	18
23-2c	Hodgen	do	1944	825	159			4							
23-3f	Cemetery Assn.	do		815	172										
24-2g	Reichle	do	1953	815	163				3			40*			
26-5a	Johnson	Higer	1963	820	83			4	2	3	40	15*	12	0	1
28-5h	Stanton	Lister		800	80	80	sh	4							
28-8h	Ellis	English	1966	790	108			4½	2½	4	80	30*	5*	3	
30-2h	McDole	Higer	1968	770^{c}	94			4	2	3	40	24*	13		1
32-8g	Stinzel	do	1954	790^{c}	50			4	2	3	30	18	10	4	2
32-3h	Morris	Lister	1954	790	87				3			37	9*		
33-5a	Wright	do	1962	810	67			4	3	3	80	14*	12*	6	1
33-8a	Charloted	Higer	1969	810	58			4	2	3	40	14	15*	8	1
33-7e	Steiner	do	1964	800	126	108	ls	4				20*	10		1
35-7a	Jenkins	Lister		813	48			4							
T.21N., R.4W.															
1-5h	Beisel	Lister		720	135			4							
2-6a	Gordon	Higer	1964	730	142			4	2	3	40	20	15*	10	1
2-6a	McKinzie	Bir	1963	720	105			6	3	4	100	24*	20*	0	2
2-4d	Richard	Lister	1959	730	79			4	2	3	60	35	12	3	2
2-5d	Freiberger	do	1946	700	87			4							
3-2g	Baxler	Holt	1963	720	23			4	2	3¾	40	10*	10*	0	½
5-7d	Moline	Dilden	1942	735	110	70	ls	4				37	8	10	
5-5f	do	do	1949	710	520	81	sh	4							
6-3h	Plaster	Lister	1951	720	55	50	ls	4							
6-4h	do	do	1959	715	44			4	2	3	60	28*	10		1
10-3h	Carpentor	Dilden	1948	740	55			4	3		80	10*			
10-	Knight	Lister		700	80			4							
11-7d	Mercer	do		740	120			4							
13-5h	Summers	Hassett		730	342	239	sh	10							
14-1a	Smith	Norris	1968	735	67			4½	3½	3	80	F*	17	0	1
14-1a	Atkinson	Higer	1971	740^{c}	63			4	2	3	40	F*			
15-2a	Stair	Feaster	1964	740	72			4½	3½	3	30	F*	17		5
15-7g	Waples	Lister		740	120			4							
17-8a	Lodge	C & C	1963	740^{c}	59			4	3½	3¾	100	21*	10*	2½	1
17-1c	Tarm	Lister	1966	760	76			4	3	3	80	31*	12*	4	1
17-1d	Harris	Holt	1967	770^{c}	58			4	2	3¾	40	32	10	0	½
17-1d	Paliseman	Lister	1966	760	79			4	3	3	80	32*	15*	5	1
18-1a	Atten	Holt	1959	730^{c}	44			4	2	3¾	50	12*	12	0	1
19-1d	McKinsey	do	1960	740^{c}	39			4	2	3¾	40	15*	7	15	1
19-1e	Wong	do	1960	740^{c}	138			4	2	3¾	40	18*	12	0	1
19-1e	Methodist Church	do	1961	740^{c}	75			4	2	3¾	40	11*	10	0	1
19-3a	Conner	Norris	1972	730^{c}	112	65	sh	4½				12*	5	10	1
19-5e	McKay	Lister	1933	740	98			4				12*			
19-1h	Bilt	do	1962	730	61			4				6*	15*	4	¾
20-8d	Reeder	Coy	1944	740	165							14			
20-8d	Stoops	Bir	1960	740	70			6	3	4	100	15*	16*	6	1
20-7e	Harington	English	1965	740	92			4½	2½	4	80	18*	10*		
20-8c	Wolf	Treece	1960	750	88			4	3	3	100	50	10	0	2
20-7f	Firkins	Holt	1966	750	89			4	2	3¾	40	16*	20*	0	½
20-8f	Royle	do	1962	740	58			4	2	3¾	40	11*	10	0	½
20-8g	Allen	Bir	1967	745	60			6	2½	5¼	50	14*	24*	0	1
20-6h	Anderson	Armstrong	1966	750	64			4	4½	3	100	14*	30	0	3
20-7h	Homes	do	1965	750	70			4	3		100	19*	30*	0	3
20-7h	Craig	Dilden	1963	750	64			4	3	4	25	20*	12*	6	
20-8h	Followay	Holt	1961	750	53			4	2	3¾	40	20*	10*	0	1
23-3e	Hart	Higer	1963	760	103			4	2	3	40	17*	15*	0	1
24-2a	Wiseley	Higer	1959	780	45			5	5	4	80	18*	10	2	1
25-1d	Vance	Lister		796	100			4				15*			
31-1g	Bennett	Holt	1966	760	94			4	2	3¾	40	20*	20	0	½
32-4g	Linden Conserv.	do	1963	760	27			4	2	3¾	40	12*	10*	0	½
36-a7	Grimme	Newlin	1967	810	60			4	2	4	30		15*	0	1
T.23N., R5W.															
2-5d	Shaw Farms	Dilden	1961	760	58			4	3	4	30	21*			
	do	do	1954	740	68	62	ls	4				10*	12	10	
21-4a?Purdue National Bk.		N.L. Exc.		750	97	60		4				60	20		1
23-8h	O'Dell	Wolf	1961	750	35			4	2	3¾	40	5*	15	0	1
23-8a?Baung		Dilden	1964	750	77	77	sh	4	2	4	25	29*			
24-2e	Leaming	Dilden	1961	740	58			4	2	4	30	16*	18	3	5
25-6d?Kellerman		do	1969	760	74			6	8	6	50	26*	50	2	
25-6h	Andrews	Lister	1945	750	80			4							
26-8c	Malsbary	Holt	1966	760	78			4	2	3¾	40	30*	15*	0	½
T. 21., R.6W.															
2-2a	Henry	Lister	1961	740	70	56	ls	4				12*	15*	4	1½
10-1b	Mattox	Treece	1960	750	35			4½	3	3	100	19*	10	0	2
13-3a	Moore	Coy		760	80	75	ls	4							
13-3a	do.	Lister		760	68			4							
14-7c	Hook	Swisher & Swack	1964	735	90	48	sh	4				10*	10	0	2
14-8f	Pearl	Bir	1962	750	27			6	6	5½	35	20	5*	0	1
14-8f	Todd	do	1959	745	42			6	3	4½	100	20*	20*	2	1
15-7a	Meharry	Lister	1946	720	72	60	ls	4							
26-3g?McCarty				715	68	58	ls	4				10			
27-1h	McCorkle	Dilden	1969	720	53	40	sh	4				14*	25	0	
T.22N., R.3W.															
1-7g?Dunk		Dilden	1949	645	81			4	2		50	30*	8		
2-7g?McCoy		do	1950	680	40			4	3		100	13*	12		
3-7a	Johnson	do	1961	620	30			4	2	4	40	10	20	0	
3-8d	Lenz	do	1947	650	31			4	3		80	7*	15		
3-4e	Moyer	do	1948	670	139			4				49*	8	1	
4-1a	Hathe	Dilden	1949	630	35			4	3		80	12	10		
4-3a	Strader	do	1963	640	34			4	2	4	50	7	20		
4-5a	Warren	do	1959	670	70			4	2	4	60	52	35	0	2
4-7a	Capitol Builders	Melvin	1968	675	68			4	3	4	80	50	25	0	2
4-8a	Connelly	Dilden	1952	670	69			4	3		80	32*	10		
4-8a	Bridewell	Dilden	1949	670	79			4	3		80	38*	8		
4-3b?Johnson		do	1949	650	26				3		80	3			
4-5b	Dilden	do	1947	660	76			4	4		40	51*	8		
4-5b	Michael	do	1947	660	76			4	3		100	42*	8		
4-6h	Mitchell	Bir	1966	675	75			6	2½	5¼	50	53	16*	0	1
4-7b?Paul		Dilden	1948	670	68			4	3		80	45	8		
4-7b?Bowers		do	1950	670	70			4	3		80	41*	10		
4-7b	Gibson	do	1950	665	72			4				40*	8		
4-7b	Sheffield Twp Dayton School	do	1959	670	80			6	10	6	60	47*	55	¾	4
4-7b	Smith	do	1948	665	73			4	3		80	49	8		
4-7b	Reinecke	Dilden	1951	660	70			4				54	7		
4-6c	Dixon	do	1953	655	72			4				52	10		
4-1h	Downham	do	1962	675	136			4	3	4	40	58*			
5-1a	Pierson	do	1950	670	71			4	3		80	35*	10		
5-1a	Downham	do	1950	670	78			4	3		100	36*	8		
5-7a?Widmer		Dilden	1950	665	79			4	3		80	41*	8		
5-5d?Glaze		do	1948	670	51			4				35*	12		
5-4h	Pruitt	do	1951	665	75			4				56	10		
5-4h	Short	do	1951	665	75			4				56	10		
6-8e	Irwin House	do	1949	659	64			4	3		80	14*	6	1	
6-8e	Irwin House	Dilden	1953	660	46			4	3		100	26	10		
7-5e	Foresman	do	1959	670	24			4	2		50	9*	12*	1	
7-7a	Ricks	do	1965	670	35			4	3	4	30	14*			
7-7a	Diemar Hill	Bir	1966	670	29			6	2½	5¼	60	13*	20*	0	1
7-5f	Biery	Dilden	1950	668	70			4	3		100	30*	8		
8-1h	Adams	Dilden	1970	675	83			4	3	4	50	40*	10*	0	
8-2h	Mitchell	Bir	1961	675	169			6	3	5½	50	38*	16*	0	1
9-7a	Widmer	Dilden	1953	670	46			4	3		100	20*	12		
9-2b	Schlie	Bir	1964	670	59			6	5	2	100	34*	16*	0	1
9-6b	Wallace	Lister	1963	690	83			4	3	3	80	42*	10*	3	1½
9-7b	Bolyard	Bir	1964	680	66			6	2	5	100	28*	16*	0	1
9-2g	Ostrander	Dilden	1953	655	42			22	3		80	12	15	1	
9-5g	Rothenberger	Higer	1963	675	80			4	2	3	40	50*	10	0	1
9-7g?Longden		Dilden	1951	670	78			4	4		100	44*	8		
9-5h	Lodge	do	1963	660	57			4	3	4	50	31*			
9-8h	Dix	Dilden	1948	670	78			4	2		50	59*	10		
10-2b?Arms		do	1951	680	35			4				14*			
10-1f	Newton	English		685	72			4½	2½	4	80	42*	15*	25	
10-2g	Mink	Bir	1967	690	64			6	2½	5¼	50	42*	16*	3	1

Table 9. Continued.

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
11-5d	Buckley	Bir	1971	690	58			6	2½	5½	50	33*	12*	2	1
11-3c?	Grand	Dilden	1951	685	79			4	3		80	49*	8		
12-5a	Whitteberry	Bir	1963	730	91			6	2½	5½	50	64*	16*	0	1½
12-4c	?Morgan	Dilden	1971	725	91			4	3	4	40	59*			
12-7e	Smith	Ortman	1962	705	140			4½	3	4½	100	53	90		1½
12-8e	Ricks	do	1962	710	78			4½	3	4½	100	49	30		2½
15-6a	?Ray	Niger	1972	650	54			4	2	3	40	24*	15e	0	1
16-6d	Batoge	Dilden	1960	695	68			4	2	4	40	40*	10	0	
17-5a	Newmark	do	1968	690	70			4	3		80	27*	12		
17-3d	McClain	Lister	1954	680	75			4				35*	10		
17-4c	?Lambirth	Dilden	1971	680	91			4	3	4	50	30*			
17-7g	Dunwoody	Dilden	1953	680	53			4				33	10		
18-3d	?Elliot	do	1951	670	62			4				20	15e	0	
19-1c	Long	do	1964	700	122			4	3	4	50	42*	10*	0	
19-2e	Sessenac	do	1966	700	61			4	3	4	50	31	12*	0	
19-3f	Kirkpatric	do	1954	680	63				3		80	11*	10	0	
20-3c	Nelson	Norris	1968	715	70				3½	3	80	15*	5		2
20-6d	?Ade	Dilden	1971	700	161			4	4	4	20	57*	25		
20-7e	Hitchcock	Holt	1966	710	168			4	2	3¾	16	56*	7e	4	½
20-1g	Hatke	Bir	1966	705	177			6	2½	5½	50	52*	20e	13	1
20-1g	?Beeler	Dilden	1970	695	85			4	3	4	40	39*	12	0	
21-6a	Beeler	Dilden	1964	740	203			4	3	4	60	73*	10*	0	
21-8e	Robinson	Holt	1960	725	70			4	2	3¾	40	40*	7	5	1
21-5f	?Loft	Dilden	1970	710	100			4	4	4	25	54*	25		3½
21-8f	?Robins	do	1948	715	61			4	3		80	40*	8	2	
21-1h	Michael	do	1960	700	129			4	3	4	40	38*			
21-2h	Floyd	Dilden	1964	690	134			4	4	4	25	48*	12*		
21-4h	Bray	do	1952	705	130			4	3		80	32*	10		
22-5b	?Morris	do	1951	675	72			4	3		100	59*			
22-5e	McFaddan	Bir	1962	670	148			6	3	5½	50	15*	24*	0	1
22-8e	Beeler	Dilden	1965	735	192			4	3	4	40				
23-8h	McFadden	Dilden	1971	740	130			4	6	4	20	87*			
24-3g	Charles & Emerson	Niger	1960	755	108			4	3	3	25	66*	8	0	1
25-8a	Yundt	Lister	1954	750	68			4				38	10e		
26-2g	Lucas	Niger	1967	700	51			4	2	3	40	31*	13e	1	1
27-1h	Piscia Cont.	do	1963	735	90			4	2	3	40	70*	15		1
28-2a	Jewell	Bir	1963	740	36			6	5	4	100	20	6*	10	2
30-8a	Kemper	Niger	1960	720	123			4	2	3	40		14e		4
30-8f	Wise	Farner	1966	705	91			6	3	5½	60	40	15	0	3
33-4a	Stoltz	Lister	1954	720	112			4				4*	9		
33-1b	Hutchinson	do		725	180			4							
33-2d	Schulze	Dilden	1962	735	114			4	3	4	20	20*	25	4	
33-2e	Frantz	N.L. Exc.		745	192			4	2	4	30	50*	30	50	1
33-1h	Hurst	English	1963	740	185			4½	2½	4	80	65*	20*	45	
34-4a	Garrett	Dilden	1965	765	78			4	3	4	40	14*	10	13	3
34-6a	Cornell	Treece	1967	760	42			4½	3	3	60	15	12	0	2
36-3a	Pilley	N.L. Exc.		795	157			4	2	3¾	50				
36-4b	Burk	Lister	1960	750	107			4	2	3	60	25*	10	2	2
T.22N., R.4W.															
1-3b	Osterling	Dilden	1951	660	53			4					12		
1-7d	?March	do	1949	645	51			4	3		80	24*	10e	0	
1-5e	Kohler	Holt	1971	660	74			4	4	3¾	40	24*	10	0	½
2-6a	Stegman	Dilden	1953	664	72			4	3		100	37*	10	0	
2-5c	Richard	Lamb	1946	640	73							12	60		2½
2-2d	Weedon	Dilden	1947	640	69			4	3		80	43*	8	0	
2-4e	Homes Inc.	Norris	1972	650	95			4½				15*	10		
2-6f	Hollenback	Dilden	1948	645	40			4	3		80	20	12	0	
2-6h	Koppes	do	1947	640	69			4	3		80	46	8e	0	
3-4a	Beeler	do	1970	645	64			4	2	4	50	46	12	0	
3-8c	Miller	Dilden	1961	640	56			4	2	4	50	26			
3-5d	J.M. Cont.	Feaster	1966	643	60			4½	4	3	30		10*		1
3-7d	Realty	Dilden	1962	645	53			4	2	4	40	30			
3-7d	Cayner	do	1954	635	53			4	2		50	32*	10	0	
3-3e	Smith	do	1952	640	63			4	3		80	27	10	0	
3-4e	Ritchie	Dilden	1953	635	60			4	3		80	28	10	0	
3-7e	Meadowbrook Development Co.	do	1960	650	61			4	3	4	35	40			
4-1b?	C.C.C. & Louis R.R.	Winks	1929	642	246	192	ls	12	4			43	110		
4-1b?	do	do	1929	642	194			12	8			32	240		
4-2b	do	Lamb	1946	645	106			12				43			
4-7b	Borders	Bir	1959	650	63			4	3	3½		50	11	2½	1½
4-7b	Norman Karner Bldg.	Ortman	1963	650	82			4½	3	3	100	43	40		1
5-8a	Jackson	Newlin	1960	650	85			6½	5½	3½	80	60	8	0	2
5-8a	Gobat	Dilden	1946	640	84			4				61	8	0	
5-7d	Pistenga	Bir	1962	650	79			6	3	4	100	66*	16	0	1
5-8d	Brand	Bir	1961	650	78			6	2½	5½	50	62	16*	0	1
5-4h	Reed	Dilden	1952	648	63			4				35	10		
6-4a	Mahan	Bir	1964	615	64			6				32	15	2	10
6-1b	Munger	Dilden	1947	640	80			4	4		80	39	7	0	
6-1d	Bennett	do	1950	640	80			4	3		50	56	8	0	
6-8g	Miller	Lister	1959	620	80			4	3	3	80	68*	8		4
6-3h	Slavens	Feaster	1965	635	86			4½-4	3		30	60*	15	10	4
6-5h	Burkhardt	Dilden	1947	620	49			4	3			35	6	4	
6-8h	Daily	do	1947	610	157			4	3		80	48*	8	0	
7-6a	Lehnen	Bir	1964	630	150			6	2½	5½	30	32	16*	3	2

Well location	Owner	Driller	Year Constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
7-7a	Powers	Norris	1968	630	215							60*	6.7		3
7-7b	Davis	Bir	1963	590	104			6	2½	5½	30	22*	12*	0	1½
7-2h	Mohan	do	1960	590	107			6	3	4	100	16*	25*	3	1
7-3h	Petri	Dilden	1965	600	111			4	3	4	30	27			
7-1c	Coble	Bir	1964	595	81			6	2½	5½	50	27	16*	4	1
7-2c	Wilcox	Bir	1961	585	86			6	3	4	100	10	30*		1
7-3e	Young	do	1959	575	84			4	2		30	7*	12	1½	1½
7-3f	Rush	do	1960	575	127			6	3	4		F*		0	
7-1h	Barkhouse	Dilden	1960	620	73			4	3	4	35	46			
8-3a	Pierce	do	1950	635	50			4	3		80	18	10	0	
8-7a	Killian	Bir	1960	593	139			6	3	4½		F*	32	33	1
8-7b	Glass	do	1962	595	61			6	2½	5½	50	F*	16*	3	1
8-7b	Johnson	do	1964	600	67			6	2½	5½	60	27*	5½		
8-8c	Corbett	do	1961	600	69			6	3	4	100	16*	24	20	1
8-1g	Ovorato	Dilden	1962	640	60			4	3	4	60	36			
8-1g	Walberg	Norris	1965	650	155			4½		3		35*	7.5	70	1
8-2g	Warden	English	1966	640	88			4½	2½	4	80	60	10*	0	
8-8h	Borders	Lister	1960	650	80			4	3	3	80	66	10*	2	1
9-8h	Gregory	Holt	1960	650	64			4	2	3¾	40	63	12	0	1
11-1c	Stone	do	1966	665	34			4	2	3¾	40	19	10	0	½
11-1g	Swartz	Dilden	1947	645	38			4	4		80	15	12	0	
11-5h	Mooney	do	1947	645	32			4	3			12*	8	3	
12-7g	Price	do	1960	690	57			4	3	4	25	37*	12*	3	
12-3h	Kochert	Bir	1965	620	60			6	2½	5½	60	33	20*	0	1
13-7h	?Petre	Dilden	1948	647	32			4	3		80	12	8	0	
13-1a	Kirkpatrick	Dilden		667	57			4	4		80	12	12		
13-7c	?Thompson	do	1951	675	220	203	sh								
13-1f	Kirkpatrick	do	1954	669	35			4	3		100	10*	15	0	
14-5e	Pilette	Norris	1972	690	122			4½				14*	8	10	1
14-5d	Williams	Bir	1963	685	109			6	2½	5½	50	63*	16*	0	1
14-7d	Pritts	English	1966	680	168			4½	2½	4	80	60*	15*	45	
14-7h	Kirkpatrick	Dilden	1960	655	25			4	2	4	40	8*	30	3	
15-4a	Blair	do	1968	700	82			4	3	4	30	55			
15-5a	?Thompson	do	1951	680	147			4	3		80	70*	8	0	
15-4b	Ritschinger	do	1963	700	82			4	3	4	60	64			
15-4e	Hill	Dilden	1962	700	75			4	2	4	50	62*			
15-1e	Kenny	do	1964	690	126			4	3	4	25	54*			
15-4f	Overman	Bir	1961	700	74			6	3	4	100	66	10*	2	1
15-8f	Reiteema	English	1967	700	166			4	2½	4	80	80*	10*	40	
15-8f	?Hensley	Ortman	1971	700	174				3			78*			
15-5g	Downham	Holt	1963	665	128			4	2	3¾	25	39*	12	0	24
16-1a	Baley	Bir	1963	635	90			6	2½	5½	50	8*	24*	0	1
16-5c	Beeler	Dilden	1965	680	63			4	2	4	50	43			
16-3d	Hicks	Miller	1962	685	69			4	3	5	80	46	15*	9	1
16-6d	Frank	Ortman	1963	695	160			4	3	4	100	59*	50		2
16-6e	?Pitts	Bir	1962	695	156			6	3	5½	30	64*	16	6	1
16-3f	Hart	do	1963	675	148			6	2½	5½	50	61*	16*	2	1
17-7a	McCoy	Dilden	1950	660	55			4	2		80	34*	10	0	
17-1b	Ludwig	do	1950	625	112			4	3		80	29*	10		
17-1d	Schaler	do	1953	620	47			4				35	12		
17-1d	Ludwig	Holt	1961	640	100			4	2	3¾	40	26	10	2	1
17-7h	Grenard	Bir	1960	595	135			6				F*			
18-1a	Mayflower Mill Elementary School	Hamilton	1970	664	125			6	11	5½	50				
18-5a	Cooley	Holt	1969	650	50			4	2	3¾	50	37	10	0	½
18-6a	Etzel	Dilden	1966	650	84			4	3	4	50	59			
18-6a	Mason	Wingate	1968	650	70			4½	4	3½	80	35*	30	10	2
18-7c	Davis	Holt	1963	660	52			4	2	3¾	40	35	10*	0	½
18-7a	Lewis	Dilden	1965	670	78			4	3	4	60	54			
18-6b	Dickerson	do	1964	660	60			4	3	4	50	45	12		3
18-7d	Perriter	Holt	1963	655	58			4	4	3¾	45	38	15*	0	½
18-1d	?Town & Country Lumber Company	Moss	1967	650	118			4½	5	3	100	60			
18-2g	Traumer	Bir	1961	605	145			6	3	4	100	F*	16*	24	1
18-3g	Sigman and Gear	Dilden	1965	625	105			4	3	4	40	20*			
18-2h	Sims	Norris	1968	600	147			4½	3½	3	80	20*	8.3		1
20-2d	Vaughan	Dilden	1947	660	109			4	4		80	36*	8	2	
20-8f	Chatfield	N.L. Exc.	1964	655	72			4	4	3¾	40				
20-8g	Houser	Bir	1961	660	59			6	3	4	100	30*	15*	0	1
20-4h	Butler	Lister	1959	655	55			4	2	3	60	25*	15*	3	1
20-5h	McCoy	Dilden	1954	655	56			4	2		60	41*	8	0	
20-8h	Hemmer	Bir	1961	655	66			6	3	4	100	37*	12*	0	1
21-6h	?Dougherty	Lister	1943	650	185			4							
22-5a	McKinney	Dilden	1950	640	98			4	2		60	58	8		
22-6d	Cornell	Bir	1965	640	32			6	2½	5½	50	10*	15*	0	1
23-4a	Miller	Dilden	1960	675	44			4	2	4	60	19			
23-7a	do	do	1963	665	97			4	3	4	30	30			
25-8h	Ray	Dilden	1963	680	60			4	3	4	35	23*			
26-7h	?McCoy	do	1948	673	62			4	3		80	30*	10		
28-3g	Kerkhoff	do	1963	660	53			4	2	4	50	16*			
29-8a	Bookin	Bir	1967	675	42			5⅝	2½	5½	50	5*	16*	5	1
29-8b	Wilson	Dilden	1950	650	42			4	3		80	16	10	4	
30-1b	Tyner	Bir	1961	680	118	46	ls	6				26*	4½*	0	1
30-1e	Agenell	Holt	1961	655	42	42	sh	4	2	4	40	16*	10*	0	
30-1e	McCaw	Bir	1963	655	52	35	sh	6				19*	24*	0	1
30-2e	Hassold	Norris	1968	660	180	48	sh	4½				35*	5		2

Table 9. Continued.

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
30-2f	Wea Woodlands, Inc.	Greene	1960	660	38			4½	3	3	100	12	10*	0	1
30-5g	Bitts	Dilden	1967	670	120	13	sh	4							
31-3e?	Waters	Lister	1942	715	68	48	ls	3							
32-8e	Coy	Bir	1959	690	35			6	3	4½	100	32#	16*	1	1
32-8e	Spikes	Dilden	1967	695	47			4	3	4	50	23#	15*	0	
32-8f	Koning	Bir	1962	690	115	70	sh	6				23#	3		
32-?g		Dilden		675	92	59	sh	4				31*	8	20	
33-6b	Mahan	Bir	1971	730	70			6	2½	5¼	50	32#	12	0	1
33-2d	McCoy	Dilden	1950	725	36			4				17#	10	0	
33-7d	Fox	Bir	1962	720	74			6	3	4	100	54	16*	0	1
33-6e	Leavitt	Dilden	1971	710	82			4	3	4	40	53#	10*	0	
33-3f?	Ray	Dilden	1951	725	60			4	3		100	43#	8	0	
34-1e	Ricks	Norris	1968	730	157			4½				60#	8.3		1½
34-4f	Driscal	Dilden	1950	725	156			4	3		80	83#	8		
34-3f	Hicks	Bir	1962	725	160			6	3	5	40	87#	16*	2	1
34-5f	Bouldin	do	1962	720	85			6	3	4	100	58	16*	0	1
35-5c	Owen	Higer	1964	675	27			4	2	4	40	4#	10	3	1
35-6c	Cloyd	Lister	1960	720	83			4	2	3	50	49#			
35-5e	Ross	Dilden	1970	700	52			4		4		5#	25	3	3
36-3h	Jackson	Higer	1967	730	144			4	2	3	40	54#	15*	0	1
T.22N., R.5W.															
1-3d	Gee	Bir	1966	600	119			6	2½	5¼	40	64	16*	6	1
1-6e	Schuh	Dilden	1954	575	124			4	2		80	86#	8	0	
1-1f	Gravel	Titus		624	155			4				90			
1-1f	Shumate	Lister	1962	620	134			4	2	3	30	82	10	3½	2
1-3f	Jewell	Dilden	1952	630	170			4	3		80	86#	7	0	
1-2h	Smith	English	1963	625	87			4	2½	4	80	67	10*		
1-3h	Faustich	Dilden	1952	625	92			4	3		80	70	7	0	
1-4h	Richardson	do	1948	675	130			4	3		80	90#	10		
2-1a	Williams	do	1966	625	106			4	3	4	50	83	10	0	
2-3a	Shoemaker	N.L. Exc.		620	107			4	2	4	50	90	15		1
2-2b	Benson	Holt	1962	620	94			4	2	3¾	40	82	10	0	1
2-2h	Shoaf	Feaster	1962	530	51			4	3½	3	30	40	7*		2
2-3h	Peterson	Bir	1962	535	64			6	1	5¼	40	12	7*	0	1
2-3h	Bridges	do	1964	530	60			6	2	5	100	8#	24*	0	1
5-2h	Chin	do	1964	610	107			6	3	4	100	79	20*	0	2
8-1a	Korber	Bir	1964	600	84	84	sh	6				40#	8*	0	1
8-2a	Grace	do	1967	605	109			6	2½	5¼	50	58#	16*	0	1
8-1g?	Runyon	Lister		607	129										
9-1a	Foreman	Bir	1960	620	80	24	sh	6				35	28*	22	1
9-8a	Vollmer Cons. Co.	do	1966	605	103			6	2½	5¼	40	53#	20*	0	1
11-4h	Hockeman	Bir	1965	620	99			6	2½	4	100	81	10*	3½	1
12-7a	Edens	Holt	1964	615	147			4	2	3¾	40	40#	10	0	4
12-3a	Burkert	Bir	1960	605	85			6	3	4	100	55#	20*	8	1
12-6a	Geisler	do	1967	620	100			6	2½	5¼	50	61#	16*	5	1
12-5b	do	do	1967	580	29			6	2½	5¼	50	17	6	0	1
13-4c	Benson	Holt	1963	640	44			4	2	3¾	40	27	10	0	½
13-8d	Jordan	do	1960	680	125	70	sh	4							
13-8d	do	do	1960	680	55			4	2	3¾	40	32#	15	0	2
13-2g?	Nelson	Dilden	1947	630	144			4							
14-3c?	Morrison	Golden	1945	660	140	20	ls	4				37			
14-1d	Chase	Holt	1961	675	75	75	sh	4							
14-1d	do	do	1961	670	60			4	2	3¾	40	47#	10	0	1
14-5e	Fleeman	Bir	1960	660	80	16	sh					17#	8*	0	1
14-5g	High	do	1966	630	95	31	sh	6				17#	16*	25	1
14-5h	Bonch	do	1967	620	150	37	sh	6				56	10*	90	1
17-6d	Ferrell	Norris	1973	635	70	30	sh	4				25#	8¾*	5	½
19-5a	Valars	Dilden	1952	690	89	45	sh	4				23#	15	0	
19-9a	Allen	Norris	1971	680	161	24	ls	4½				45	8½	30	2
23-1e	Farm	Holt	1964	680	55	10	sh	4				12	25*	0	½
24-6b?	Jackson	Lister		648	60	58	ls	4							
24-7g?	Murdock	Golden	1945	655	120	30	sh	4							
25-1b	Riley	Lister	1953	705	140	84	sh	4							
25-3f	Boerger	Norris	1972	695	181	81	ls	4½				50#	2½*	10	2
25-4f	Mahan	Bir	1968	700	177	38	sh	6	2½	5¼	50	7	10*	33	1
25-4g	Helms	Dilden	1961	700	54	43	ls	4				7#	20	13	
28-4d	Bickett	English	1963	715	150	111	sh	4½				20#	10*		
28-7d?	Bone	Coy		700	135	40	ls								
30-6h?	Greer	Dilden	1970	700	100	27	sh	4				23#	5		6
30-6h	Weaver	Lister	1954	707	67	67		4				18	10	3	
31-4a?	Lancaster	Bir	1972	725	37			6	2½	5¼	50	22#	10*	0	1
31-2d?	Tryitle	Norris	1973	720	180	146	sh	4½				80#	4	10	1½
31-2f	Byers	Bir	1972	710	132			6	2½	5¼	50	0#	10	0	1
35-1a	Tippecanoe Sch. Corp.	Holt	1966	740	110	43	sh	6				20#	34	38	24
36-1a	Clarkson	Dilden	1950	700	70	50	sh	4				4#			
T.22N., R.6W.															
1-8h	Acheson	Bir	1963	590	147			6	2½	5¼	50	89	16	0	1
13-3a	Conrad	Lister	1946	645	96	55	sh	4							
13-4a	West Point Medical Center	Fox	1959	670	115	62		6⅝				36#	12*	26	
13-4a	Marks	Lister	1946	645	102	35	sh	4				10			
13-3d	Cheesman	English	1963	655	135	76	ls	5½				58	10	22	
13-7d	Sandefur	Bir	1965	645	69			6	4½			59	8*	0	1
14-1e	Freed	Fox	1957	602	260	99		6⅝							
22-5a	Griffin	English	1966	695	80	37	sh	4½	2½	4	100	27#			
23-8h	Kerr	English	1966	695	90	30	ss	4½				60	8*	24	
23-1c	Buckley	Bir	1971	690	71	48	sh	6				44	10*	9	1
23-3d	Shumaker	Holt	1961	680	61	10	sh	4				21	10	0	1
24-8c	Kerr	Norris	1972	680	206	114	sh	4				50#	3½		2
24-3f	Frazier	Bir	1959	630	42	14	ls	5⅝				12	24*	2	1
24-7g	Lester	do	1960	655	110	21	sh	6				15	5*	0	1
24-1b	Whitehead	do	1959	680	89	40	sh	6				36	16*	2	1
24-2h	Rosen	Feaster	1964	670	36			4½	2½	4		20#			
24-3h	Hinton	Bir	1962	670	50			6	3	5¼	40	34	10*	0	1
24-4h	Littleton	do	1965	670	62	43	sh	6				19	16	10	1
25-8a	Fouts	Lister	1953	716	111			4				30	10		
26-4d	Burgin	Treece	1960	690	134	87	sh	4½			100		10	25	2
26-2e	Bucklew	Norris	1971	710	235	62	ls	4½				45	8½	35	2
26-3h	Lester	Lister		670	116	70	sh	4							
27-4d	Turner	Bir	1963	710	40			6	2½	5¼	50	23#	16*	3	1
34-7c	Risk	Holt	1959	740	88			4				20#	10	0	1
35-4a	Farm	do	1963	735	47			4	2	3¾	40	20#	10*	0	½
T.23N., R.3W.															
3-8c	Fisher	Lister	1959	668	176			4	2	3	30	60#	12		1
3-5d	Jonker	N.L. Exc	1963	670	146			4	2	3¾	40	45#	15	0	2
4-1a	Schringer	Dilden	1962	610	172			4	3	4	50	74#			
4-5c	Bartly	Treece	1966	660	123				3	3	80	65#	10	0	2
5-4h?	Gunkle	Dilden	1951	660	119			4	5		80	77#	8	0	
5-7h	Davisson	Bir	1961	658	106			6	3	5¼	50	73#	8*	15	1
6-7h	Runda	Lister	1959	650	83			4	2	3	60	75	10*	0	3
6-8h	Dixon	Dilden	1963	650	71			4	2	4	50	67	10		3
6-8h	Hazelgrove	Hayden	1960	633	75			4	4	3	30	65#	15	0	
7-2b?	Stine	Dilden	1948	645	155			4	3		40	100#	17		
7-1g	Wilcox	English	1966	660	120			4	2½	4	80	100#	10*	15	
7-8g	Ketterer	Bir	1962	650	71			6	2½	5¼	50	57	16*	0	1
7-6h	Brown	Treece	1960	650	130			4½	3	3	100		12*	0	
7-7h	Wilson	Dilden	1963	650	168			4	3	4	30	109#			
7-8h	Taylor	Bir	1963	660	168			6	2½	5¼	40	95#	16*	6	1
7-8h	Magey	Holt	1959	660	84			4	2	3¾	30	68	10	0	1
8-1e	Hamm	Bir	1970	650	112			6	2½	5¼	50	82	16*	0	1
8-4f	Parton	Dilden		650	121			4	3		80	83#	7	6	
8-1h	Pane	Feaster	1963	650	105			4½	3½	3	30	90	8	4	
9-4h	Tippecanoe Sch. Board	Holt	1966	660	132			8	20	7¾	100	93	300	6	2
11-1c	Casad	Dilden	1962	660	64			4	3	4	30	49	8*	0	
12-7a	Lewis	Bir	1961	670	25			6	3	4	100	34#	10*	0	1
12-2e	Smith	Lister	1954	640	69			4				35#	9		
14-7g?	Remaly	Dilden	1947	665	123			4				65#	15		
15-2a	Buckley	Bir	1973	660	65			6	2½	5¼	50	41#	16*	3	1
15-7a?	Redinbo	Dilden	1949	675	218	196	sh	4				67#	7	6	
17-5c?	Hirt	Coy		625	151	151	sh								
18-2h	Stine	Dilden	1949	647	125			4	3		40	98#	7	2	
18-5h	Widener	do	1963	650	140			4	3	4	25	101#			
19-5a	Mahan	Bir	1967	660	112			6	2½	5¼	50	96#	16*	0	1
19-8a	Purcifull	Norris	1971	668	198			4				120#	7*	10	1
19-1f	Carpenter	Dilden	1966	640	133			4	3	4	50	67#	10*	0	
19-2f	Best	do	1966	650	124			4	4	4	20	93	10	1	
19-2g?	Calloway	Lister	1941	650	200			6							
20-8a	Smith	Dilden	1952	652	134			4	3		100	80#	10	0	
20-8b	Baumgartner	Dilden	1961	630	132			4	3	4			10	0	
20-8c?	Russell	do	1953	650	103			4	3				10	0	
20-5d?	Boy Scouts of Amer.	do	1948	625	135			6	8				40		
20-6d?	do	do	1953	600	135			8	10		6	[illegible]#			
20-8e	Lawman	English	1963	650	129			4½	2½	4	80	75	20*	40	
20-8f	Gregory	Dilden	1962	650	119			4	3	4	50	83#	10*	0	
20-7h	Bauer	do	1950	625	116			4				97	10		9
21-5a	Yoste	do	1953	600	143	141	ss	4				F*	12		
21-1c	Feldt	do	1950	650	32			4				4*	8	1	
21-2c	Steele	do	1947	650	39			4	3		100	25#	9		
21-1d?	Steele	Coy	1946	655	110	100	sh					F*			
21-1e	Spitznagle	Dilden	1948	670	71			4	3			39#	10	1	
21-3e	Mentor School	Lister	1945	664	196			4							
22-1b	Yoodt	Dilden	1961	660	82			4	3	4	35	44#	11*	9	
22-7b?	Dook	do	1950	625	72			4	3		80	57	10		
22-6f	Foster	Dilden	1954	673	53			4	3		100	40	12		
22-1g?	Hines	do	1947	680	65			4	3		100	45	8	0	
23-6f	Bell	do	1953	680	49				3		100	17#	10	0	
23-8h	Cause	Norris	1973	667	140			4½				60#	5	20	2
24-6b	Booher	Dilden	1970	617	58			4	3	4	40	37#	10*	0	
25-3a?	Newton	Dilden	1949	675	119			4				30#	12	1	
25-7b	Fenstemaker	Lister	1946	683	83			4							
26-5b?	Foltz	Dilden	1946	650	102			4				40#	12		
26-1f	Mills	do		675	75			4	3		100	42#	8	0	
27-5g?	Council of Girl Sct.	do	1950	660	62			6	6			47#	55	3	4
27-8b	Ritchie	Dilden	1952	600	55			4				4#	23		
28-6b	Feldt	do	1950	650	100			4				5#	8	1	
28-3d	Robinson	do	1948	665	144			4	3		80	49	5	1	
29-6b	Fox	do	1952	650	104			4	3		100	89	10	0	
30-2b	Ritenour	do		664	84			4				64#	8	0	
30-5h?	Shaw	Dilden	1952	654	59			4	3		80	42#	10	0	
31-7h?	do	do	1952	655	63			4	3		100	43#	10	0	
32-3c?	Dilden	do	1949	660	121			4				45#	9	0	

Table 9. Continued.

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
13-1e	Crope	Dilden	1962	660	132			4	3		80	48*	8	6	
13-5b	Feldt	do	1959	660	81			4				F*	100		
13-6b	Edward	Dilden	1950	650	84			4				F*	112		
14-2b	Yess	do	1952	630	110			4				55*	11		
36-2b?	Beivard	do	1958	628	75			4	3		100	12*	8	1	
36-4g?	Balkema	do		613	131			4	3		80	60*	8	0	
36-6b	Reis	do	1960	680	153			4	3	4	60	69*			
T.23N., R.6W.															
1-1b	Scott	Bir	1962	660	126			6	3	5½	50	108	16*	0	1
2-2b	Johnson	do	1962	630	33			6	3	5	60	55*	8*	0	1
2-3a	Beckner	Dilden	1963	630	81			4	3	4	30	43*	12	6	
2-4a	Cranini	Ortman	1964	605	115			5	3		80	100*	30		6
2-5a	Bays	Dilden	1961	605	132			6	3	4	40	90*	10	2	
5-1e	Ind. State Soldiers Home			540	125				20			40*	600		
5-1b	do	Layne		683	298	288	sh								
6-4d	W. Lafayette Water	do	1966	700	269	269	sh								
6-3d?	Frelhaffer	Dilden	1948	695	199			4	3		80	71*	5	0	
6-3e	W. Lafayette Water	Layne		690	245										
6-2e?	Murphy	Golden	1950	693	192							158			
8-6b	Sharp	Bir	1962	545	67			6	2½	5¼	40	30	15	0	4
8-3e	Bouthilt	Dilden	1962	530	54			4	3	4	20	23	12*	0	
8-4g	W. Lafayette Water	Layne	1965	600	72			6				4			
9-3e?	Anheuser-Busch Inc.	do		530	180			6				13			
9-6a	Schweidler	Dilden	1949	555	93			4	3		100	40*	8	0	
9-6b	Duncan Elec. Co.	Lamb	1953	555	134			12	20		90	40		3	
9-6b	Lafayette Instru. Co.	Dilden	1965	555	89			6	4	5⅝	50	41*	30		18
9-5c	Miller Const. Co.	do	1963	550	97			4	3	4	30	60*			
10-6a	Senne	do	1964	580	96			4	3	4	40	41*	12*	0	
10-4b	Ratke	Bir	1959	580	70			5⅝	3	4½	50	55*	16*	3	1
10-4d	Klutzke	Lister	1953	550	97			4	2			15*	10		
11-4a	Johnson	Dilden	1963	620	181			4	3	4	30	105*			
11-6b	Carzer	do	1964	600	117			4	3	6	30	68*	12*	4	
12-1b	Hiatt	Feaster	1966	660	76			4½	3	2	30	30*	10		2
12-4b	Central Ind. Homes	Ortman	1962	670	200			4½	5		40	130*	6		3
14-2g	Cunningham	Dilden	1949	550	77			4	3		80	F*	10		
14-2b	McKinney	do	1966	650	159			4	4		60	88	8	0	
14-4b	Pickerill	do	1960	620	175			6	5	4	45	104*		0	
15-2b	Mienser	Bir	1965	650	115			6	3	4	100	94	16*	0	1
15-2c	Woods	Dilden	1964	625	102			4	6	4	40	76*		0	
17-2b?	Lafayette Water Works	Layne	1953	520	94			18							
17-4b	do	Dilden	1952	520	179							27			
17-5b	W. Lafayett Water	Layne	1960	540	88			38	20	18		26*	1300	14	8
17-5b	do	Lamb	1955	540	100			12	20	12	100		750		
19-4a	Purdue University	Layne	1959	590	165							77			
19-6b	do	do	1953	625	201			12							
19-4e	do	do	1955	620	206			10							
19-4e	do	do	1954	620	192			16				106			
19-6f	do	do	1968	625	207			12		16					
19-8f	Purdue University	Layne	1968	625	216	210	sh	6							
19-8g	do	do	1958	625	212			26				104			
19-4b	do	Holt	1962	625	173			6	5	5½	80	110	56*	3	8
20-4a	Tippecanoe Co. Courthouse	Boyd	1900	550	231	170	sh					25			
20-4e	Lafayette Ia & Coal	Pegg	1945	535	150			12	20		100	25			
20-4c	City of Lafayette	Layne	1971	535	94			72	20	18	90	25*	2080	47	48
20-4f	do	Dunbar	1963	520	85			16	20	16		15*	2100	26	8
21-6a	Culligan Soft Water	Holt	1961	570	82			10	20	9⅝	40	44	500	6	8
22-7b	Peerless Wire Goods	Layne		675	220	219	ls	8							
22-3e	Brown Rubber Co.	Winks	1935	666	150			8				175	190		
23-3d	Baumgartner	Dilden	1963	680	124			4	3	4	25	98	10*	0	
23-1d	do	do	1963	680	180			4	3	4	35	121*		0	
24-4a	Eberehoff	do	1954	672	99			4	4		50	75*	8	0	
24-3b	Marshall	do	1960	665	130			4	3	4	40	97	10*	0	
24-2b	Graham	do	1960	665	171			4	3	4	60	96	10*	0	
24-2b	Neher	Hilger	1959	665	256	252	ls	4				98*	7	6	2
24-3f?	Hoffine	Dilden	1953	645	28			4	3		100	16	6	0	
25-1a	Shaw	do	1952	654	62			6	3		80	12*	10	0	
25-3b?	Pikeiser	do	1952	653	67			4	3		100	43	10	0	
26-2e	Glick	English	1963	665	150			4½	2½	4	80	80*	10	45	
26-2f	Dammeyer	English	1963	665	150			4½	2½	4	80	200*	8	42	
26-1b	Portman	Dilden	1952	671	171			4				111	7	0	
26-2h	Progress Builders	Lister	1959	665	90			4	3	3	60	76	10	2	1½
26-2h	Mohr	Bir	1964	665	146			6	2½	5½	60	102	16	0	1
27-4a	Weirenga	Dilden	1947	660	95			4	4			76	8	0	
27-8a	Alcoa	Layne	1966	665	240			26	50	14		88*			9
27-3b	Johnson	Dilden	1948	660	76			4	3		80	58	12		
27-4c	Bren Mech. & Elec.	do	1970	670	101			6	3	4	50	81	12		4
27-5e	National Homes	Layne	1943	670	233	222	sh								
28-8e	Beckman	Holt	1960	680	127			8	10	7½	50	97	240	7	6
29-8b	Ralston-Purina	Layne		535	150	135	sh	6,4				25*			
29-3g	Crown Laundry	Holt	1965	560	93			10	15	9⅝	65	35*	183	3	1
29-5g	Minardo Bros. Inc.	Dilden	1962	540	81			6	9	6	65	40			
29-5b	Alcoa Box Board	Layne	1966	545	115			6							
30-5a	Eli Lilly & Co.	Ranney	1952	518	97				5						
30-5a?	Eli Lilly & Co.	Ranney	1952	515	95										
30-6a	do	do	1952	514	93										
30-8a	Eli Lilly & Co.	Ranney	1952	517	159	157									
30-4h	do	Layne	1971	520	175			50	25	10		16*		42	0
30-4h	do	Ranney	1952	517	115			7	3			15			
30-5h	Eli Lilly & Co.	Ranney	1952	515	97										
30-8h	do	do	1952	513	96										
30-6e	W. Ind. Aggregates	Dilden	1963	520	148	148	sh	[illegible]	12	6	10	66*	55	16	5
30-7g?	W. Ind. Gravel Co.	Krauss	1946	[illegible]	141			24	21			65*	470	21	4½
30-5h	Verplank Concrete	Dilden	1961	560	153			6	12	6	35	57			
31-1a	Crowder	Bir	1963	665	81			6	2½	5½	40	67	15	0	1
31-5a	Rack	Dilden	1947	628	70			4	3		80	54	8		
31-1b	Jewell	do	1962	665	82			4	2	4	50	68			
31-1b?	Kyle	do	1956	635	90			4	3		100	73	8	0	
31-4b	Sparks	Bir	1961	630	84			6	3	4	100	56	24	0	1
31-4b	Rhoda	Bir	1959	630	73			6	3	4	100	59	15	2	1
31-5c	Hack	do	1961	630	78			6	3	4	100	59	16	0	1
31-2d	Coyner	Dilden	1953	640	81			4	3		80	61	8	0	
31-1d	Roth	Bir	1961	635	83			6	3	4	100	63	16	0	1
31-4d	Holt & Brelt, Inc.	do	1961	630	72			6	3	4		56	12	0	1
31-4e?	Ind. Lock Joint Concrete Pipe	Dilden	1962	625	67			8	10		60	47.05			
31-4f	do	do	1952	625	65			6	6		50	47	90		
31-4g	Huston	Bir	1959	640	76			6	3	4½	100	30*	16	2	1
31-7g	Eli Lilly & Co.	Ranney	1952	515	56			7				13			
31-7h	do	do	1952	514	129										
32-1a	Gipson	Bir	1963	645	81			6	2	4		61	16	0	1
32-4h	Ross	Dilden	1951	665	72				3		100	54	10		
32-8c	Gold Key Builders	English	1966	655	91			4½	2½	4	80	75*	15		
32-5d	Crum	Dilden	1950	650	85			4	2	4	50	71			
32-5d	Sigel	Bir	1963	640	166			6	2½	5½	40	83	16	20	1
32-6d	Lock	Bir	1959	660	73			4	⅔	3½	50	66*	7	1	1½
32-5e	Tobal	Lister	1961	600	43			4	3	3	80	30	9	2	1½
33-1g	Alcoa	Layne	1969	660	237	231	sh	50	40	16	35	81*	608	13	8
33-1h	Layne	do	1972	660	245	242	sh	6							
34-1b?	Fairfield Mfg. Co.	do	1953	665	152	136	sh								
34-4h	Fairfield Mfg. Co.	Layne	1963	655	202	176	sh								
34-6h?	Continental Freezer	do		662	170										
34-7c	Wilhayre & Assn.	Dilden	1953	660	89			4	3		100	56	10	0	
34-6d	Holmes	do	1952	660	86			4	3		100	56	10	0	
34-2e	Runnels	Bir	1964	665	86			6	4⅛	5⅝	50	60	12	0	1
34-1f?	Feaster	Dilden	1950	660	76			4				9			
34-1f	Beckman	do	1950	663	76			4	3		100	60*	8	0	
34-4f	Hoonon Const. Co.	Layne	1962	665	199			10				75*			
34-3f?	Alcoa	do	1963	662	204	202	sh								
34-4g	Plasty	Dilden	1965	668	111			4	3	4	40	76	12		
34-7g?	Alcoa	Layne	1941	662	203	201	ls					61*	500	37	8
34-8g	do	do	1941	661	203	200	ls					63*			
34-5h	Hiser	Dilden	1949	665	95			4	4		80	75	8	0	
34-6h	Alcoa	Layne	1943	662	208	208	ls					65*			
34-7h	do	do	1942	662	233							75*			
34-8h	Alcoa	Layne	1960	662	248	247	sh					82*			
35-5a	Werden	Dilden	1953	640	71			4	3		100	47*	10	0	
35-5b?	do	do	1952	645	118			4	3		80	23*	10	3	
35-4c	Ratte	do	1942	645	76			4				47*	8	1	
T.23N., R.5W.															
1-8c	Erick	Bir	1962	670	180			6	3	4	100	160	13*	0	1
1-6d	Fine	do	1962	670	178			6	3	5¼	50	160	16*	0	1
1-2e	Purdue University	Titus	1950	690	184			4	8		50	154	20		
1-3g	Deitman	Golden	1930	670	177										
1-7h	Stockton	Holt	1959	680	161			4	4	3¾	14	140	8	10	3
1-7h	Williamson	Holt	1959	680	155			6	2	3¾	40	131	12	0	3
2-8h	Ellis	Lister	1954	692	189			4				160	8		
2-3c	Ind. Gas Co.	Fox	1971	690	200			6	5	5⅝	30	165*	10*	9	1
2-8d	Overman	Bir	1964	660	123			6	3	4	100	83*	15	0	12
2-3e	Saville	Coy		683	42										
3-1c	W. Lafayette Water	Layne	1966	660	192	150	sh	6							
3-2c	do	do	1966	660	132	125	sh								
3-3e?	Klondike Canning Co[illegible]		1935	653	60			6				10	100		
3-4e?	Clifford Builders	English	1971	660	130	13	sh	4				15*	10*		
3-1d	W. Lafayette Water	Layne	1966	647	160	154	sh	4	4	4		80*			
3-1d	W. Purdue	Dilden	1966	655	128			4	4			79*	8	5	
3-3d	Agric. Alumni Seed	do	1959	650	42			4	2		40	15	20*		
3-6d	Livingston	Bir	1963	665	40			6	2½	4	100	14	12*	0	1½
3-6d	do	do	1960	645	44			6	3	4	100	4*	24*	1	1
3-8d	Erwin	Holt	1959	670	49			4	2	3¾	40	35*	10	0	1
3-1e	Williamson	Dilden	1959	660	36			4	3	4	20	23	14	3	
3-1f	B.P.O.E. 143	do	1949	650	40			6	10		50	15	40	0	
3-8d	Jones	Coy		680	85								40		
4-2c?	Erwin	do		680	50	30	ls								
4-6e?	Purdue University	Golden	1950	705	90	60	sh								
4-5f	Purdue University	Golden	1950	705	70	62	sh								
4-1h	McKinnie	do	1941	700	1000	95	ls	4				80*	2		
6-5g	Smith	N.L. Exc.		690	132			4	2	4	30	30*	20		1
6-6g	Morehouse	Bir	1964	690	59			6	2½	5¼	60	31*	24	6	1
6-4h	Vaolk	Titus	1964	690	29			4	2	3¾	40	9*	15	8	1
7-2a	Martin	Holt	1965	660	194			4	2	3¾	50	135*	15		48
8-2a	DeLange	do	1961	670	319	105	sh								
8-5a	Baumgartner Cont.	Dilden	1962	650	229	150	sh	6							

Table 9. Continued.

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
8-6a	Baumgartner Cont.	Dilden	1962	590	102			6							
9-8a	Felex	Higer	1962	690	126			4	2	3	40	117	7		1
9-1h	Cadwallider	Holt	1959	695	41			4	2	3¾	40	15*	10	5	2
9-3c	Zahn	Bir	1965	700	179			6	2½	5	50	154	10*	0	1
9-3d	Wong	Dilden	1971	690	116			4	3	4	50	92*			
9-5d	Bramer	do	1965	660	142			4	3	4	60	105*			
9-8g	Armby	Lister	1960	670	106			4	2	3		42*	10	3	1
10-1c	Sullivan	Dilden	1971	700	198			4	3	4	50	172			
11-5a	Stewart	do	1960	695	188			6	8	6	45	156	43*	2	3
11-8a	Stok	Bir	1960	690	180			6			25	168	13*	2½	1
11-2c	Wilhelm	Dilden	1967	695	201			4	4		100	175	5		
11-4h	W. Lafayette Water	Layne	1967	700	243	240									
11-5h	W. Lafayette Water	Layne	1967	700	229			6	3	2					
12-2e	Ind. State Police Barracks	Kersey	1942	710	216			4							
12-2e?	Crum	Dilden	1936	715	237			4							
14-3a?	Sterner	do	1970	680	58			4	2	4	60	47	22		2
14-6c	Howe	Holt	1962	650	161			4		3¾	40	127*	10*	0	1
14-7d	Shrimplin	Bir	1961	660	172			6	3	5	50	144	15*	0	1
14-8f	Easton	Holt		680	176			4	2	3¾	40	150	10	0	2
14-2h	Bowers	Dilden	1962	695	180			4	3	4	25	164		0	
14-6h	Orman	do	1951	690	174			4				153	6		
15-2a	Degorff	Holt	1960	655	157			4	4	3¾	40	135	10	0	1
15-3a	Smith	Holt	1962	670	165			4	2	3¾	40	140	10	0	1
15-3d	Grenard	Dilden	1962	690	184			4	3	4	40	161		0	
15-2e	Overman	do	1963	695	194			4	3	4	40	172*		0	
17-5h	Bands	Golden	1946	655	158							129			
20-1c	Reser	Dilden	1952	670	191			4	3		80	167	7		
20-3c	Gardner	Holt	1967	670	185			4	2	3¾	40	157	10	0	1
20-7e	Vaughan	Golden		670	180			4				167	10		
20-5f?	Klutzke	Dilden	1949	675	188			4	4		50	167	10		
21-4b	Runsone	Holt	1963	625	148			4	2	3¾	30	124*	10	0	1
21-5b	Smith	do	1961	610	125			4	2	3¾	40	98*	10	0	2
21-5b	Gallun	Holt	1962	640	163			4	2	3¾	40	136	10	0	½
21-5c	Nelson	do	1963	650	181			4	2	3¾	40	150	10*	0	½
22-1a	Pedico & Yovne	Whihite	1968	600	118			4	5¼	3	60	93	10*	0	1
22-2a	Cohan	Bir	1964	610	108			6	2½	5¼	60	78	16*	0	1
22-4a	Pedico & Yovng	Wilhite	1966	575	118			4	5	3	60	65*	10*	0	2
22-1b	Willis	Ortman	1963	625	215			4½	3	4	100	108	70		¾
22-1b	Pridemore	Holt	1963	620	115			4	2	3¾	40	91	10	0	½
22-2b	Mlynarik	Bir	1964	600	108			6	2½	5¼	50	90	16*	0	1
22-2c?	Kyle	do	1966	650	114			6	2½	5¼	50	70*	16*	0	1
22-4g	Gipsen	Holt	1959	665	170			4	2	3¾	40	145*	12	0	3
22-5g?	Liptrap	Norris	1972	670	172			4½				155	5	3	2
23-5c	High	Dilden	1959	660	158			4	3	4	40	138		0	
23-5c	Moses	Holt	1960	660	157			4	2	3¾	40	135	2	0	1
23-6c	Palmer	do	1960	655	166			4	2	3¾	40	137*	10	0	1
23-6c	Trinka	do	1959	655	148			4	2	3¾	30	136	12	0	2
23-5d	American Homes	Ortman	1962	655	215			4½	3	3½	100	136*	45*		2½
23-5e	do	do	1962	665	195			4	3	3½	100	139	40		4
23-2g	Cork Builders	Feaster	1965	670	158			4½	4	3	30	100*	10*	10	2
23-3g	Purdue University	Bir	1960	675	174			6	4	5¼	40	148	15	2	2
24-1f	do	Layne	1965	620	208	208	sh	42				102*			
24-1f	Purdue University	Layne	1973	612	209	207	sh	6¾	21		100	100*			
24-2g	do	do	1973	612	206	206	sh	6¾	21	2					
24-1g	do	do	1973	615	208	208	sh	6		2					
24-2g	do	do	1973	615	210	210	sh	6		2					
24-1h	do	do	1973	620	216	216	sh	6		2					
24-2h	Purdue University	Layne	1973	630	215	215	sh	6		2					
26-6a	Stinebaugh	Dilden	1964	525	62			4	3	4	40	28*			
26-8b	Ashby	do	1969	515				4	3	4	40	8*	15*	0	
26-1d	Purdue University	do	1946	580	159			4				75*	12		4
26-2g?	Henderson	Holt	1962	600	62			4	2	3¾	40	30*	10	0	1
28-3g	Crum	Bir	1961	550	98			6	3	4	100	43	16*	0	1
28-3h	Overman	do	1960	565	105			6	3	4	100	61	20*	2	1
28-4h	do	do	1961	550	74			6	3	4	100	49	16*	0	1
30-5d	Marsh	Higer	1961	535	40			4	2	3	30	26	12	0	1
35-1b	Eli Lilly & Co.	Bir	1963	615	119			6	2½	5¼	40	91	18*	0	1
35-3d	Eli Lilly & Co.	Ranney	1951	512	94							9*			
35-4e	do	do	1951	515	74										
36-6a	do	do	1952	510	127	124		7	3						
36-2c	do	do	1952	518	135										
36-3c	do	do	1951	550	157										
36-4c	Eli Lilly & Co.	Ranney	1951	560	67	63									
36-8c	Irvin's Sand & Grav.	Bir	1964	590	254	182	sh	6				85*	21	80	2
36-1d	Eli Lilly & Co.	Ranney	1951	522	82										
36-2d	do	do	1952	518	58			7	3						
36-3d	do	do	1951	510	58										
36-5d	Eli Lilly & Co.	Ranney	1951	513	40										
36-7d	Myers	Titus	1946	550	90										
36-1e	Eli Lilly & Co.	Ranney	1951	512	55			7	3			12			
36-2e	do	do	1951	511	72			7	3			11			
36-3e	do	do	1951	510	64										
36-4e	Eli Lilly & Co.	Ranney	1952	513	146	143		12	10						
36-6e	do	do	1952	517	144	139	sh	7	3			8			
36-5f	do	do	1952	514	50			7	3			9			
36-6f	Eli Lilly & Co.	Ranney	1952	514	52			7	3			9			
T.23., R.6W.															
1-2d	Hille	Dilden	1961	690	191			4	3	4	25	39*	10*	2	
1-8e	Davis Homes Inc.	Norris	1972	680	157			4½				60*	9	3	2
2-4d	Kemple	Bir	1965	690	67			6	2½	5¼	50	15*	24*	5	1
2-4d	Hayworth	do	1966	690	67			6	2½	4		15*	20*	5	1
2-7d?	Roch	Coy		690	60			4							
2-3h	Purcell	Dilden	1963	690	153			4	3	4	50	20*	20		
3-1h	Roch	Coy		696	60			4					40		
10-1e	Fulke	do		684	165										
11-2h	Borramell	do		681	55										
12-1a	Kerker	Golden	1952*	665	155			4				130			
14-6d	Ade	Feaster	1964	675	181			4½	4	3	30	161			
14-2h	Wiggins	Bir	1967	680	178			6	2½	5¼	50	150*	16*	0	8
24-7c	Cossick	Golden	1950	680	219							147*			
24-2d	Dickey	Bir	1964	560	36			6	3	5	30	28	15*	0	1
24-3f	English	English	1965	530	51			4½	2½	4	80	19*	10		
24-7g	Dickey	Bir	1965	590	65			6	2½	5½	50	40	16*	0	1
24-7g?	Bennett	Dilden	1970	670	171			4	3	4	50	131*		0	
24-1h	Purdue University	Bir	1965	540	85			6	5	6	50	27	40	2½	1
26-8c	do	Golden	1962	670	222			4½	5	3	100	150*	10*	2	3½
27-6b	Helnser	Dilden	1964	640	34			4	2	4	40	21*	8*	0	
34-2g?	Purdue University	Layne	1948	664	225								15	3	
36-1c	Conrad	Lister	1954	590	106			4	3			80	6		
T.24N., R.3W.															
1-1f	Kitchlaff	Foley	1959	630	160	90	sh	6				70*	4	45	3
1-1f	Delta Engrg. Inc.	Ortman	1962	630	82	80	sh	5	6	4	80	68	23	3	15
2-2g?	Childers	do	1972	560	67			5½	3		80	29	90		
4-5a	Smith	Titus	1965	620	114			4	2	3¾	50				
4-4g	Rector	Bir	1961	560	74			6	2	5¼	50	44*	16*	0	1
5-4e	Bickett	Bir	1965	530	50			6	2½	5¼	40	5*	24*	7	1
5-6f	Wolsieffer	do	1967	540	59			6	2½	5¼	50	5*	16*	5	1
5-2g	Gish	Titus	1966	545	109			4½	2		50	94	16		6
5-4g	Woods	Bir	1966	536	58			6	2½	5¼	40	7*	20*	2½	1
8-6h	Griggs	do	1968	550	50			6	2½	5¼	50	24	10*	3	1
8-5b	Wallace	Feaster	1962	530	66			4½				17*	2*	6	2
8-6h	Boorom	Bir	1964	536	62			6	2½	4	100	16*	24*	0	1
8-3c	Griggs	do	1968	556	90			6	2½	5¼	50	23*	16*	0	1
8-4c	Bennett	do	1968	534	37			6	2½	5¼	50	9	16*	0	1
8-4c	do	do	1963	530	38			6	3	4	100	12*	20*	1	1
8-4c	Bennett	Bir	1963	530	39			6	2½	5¼	40	14*	10*	8	1
12-5b	Mitchell	Ortman	1972	630	73	71	sh	5½	3		60	46*	50		
13-8a	Pattingale	Farner	1968	664	66			4½	4½	3	25	34*	10*	0	2
13-8b	Wallace	Sidden	1961	655	59			4½				30*	8	11	1
15-7a?	Dunk	Dilden	1950	680	88			4	2		60	78	10		
15-6e	Benker	N.L. Exc.		640	95	85	sh	6	2	4	50	70*	15		1
15-1f	White	Dilden	1953	625	153	96	sh	4							
15-6f	Cheek	Ortman	1971	640	262	72	sh	5				115	5		
15-5g	Benker	Wingate	1966	586	90	27	sh	4½				15*			
16-2a	Schomers	Sidden	1961	662	117			4½				81	4	18	2½
16-2b	Chappel Const.	Feaster	1965	659	108			4½	4	3	30	100	12		1
16-2h	Ket	do	1964	650	118			4	4	3	25	100	18		2
16-2d	Tull	English	1966	560	190	46	sh	4½				60	3		
16-4d	Harrington	Treece	1967	550	42			4½	3	3	60	2*	14	0	1
16-1e	Smith	Foley	1961	655	26	19	sh	4½				12*	4	6	2
16-3e	Smith	Sidden	1961	555	67	23	sh					6*	2	61	2
16-1f	Soloman	Wingate	1967	558	135	38	sh	4				40	16	40	3
17-6b	Cavanauger	Harvy	1961	530	57			2	3	1¼	60	13*	7	0	1
18-2e?	Lafayette Country Club	N.L. Exc.		600	152			12	12	11	50	60	800		20
20-3c	Michael	Bir	1961	600	124	28	sh	6				20*	3*	0	1
20-8c	Chaplin Co.	Ortman	1963	624	108			4	3	4	100	86*	5*		1
20-8d	Stair	Dilden	1959	540	33	33	sh	4	2	4	40	24*			
20-4g	Kingery	Bir	1964	530	89	13	sh	6				25*	10*	0	1
21-8a	Arvin	Dilden	1971	660	74			6	4	6	50	56	20*	0	
21-7e?	Bettey	do	1951	600	40			4					12		
22-5e	Dubes		1944	590		80	sh								
23-2h	Rowe	Dilden	1959	655	62			4	3		20	41			
24-7h	Justice	Farner	1968	658	60			4½	4½	3	25	33*	12	0	1
24-8h	Hale	Sidden	1961	655	59			4½				30	8*	15	2
25-5h	Pettit	Lister	1954	670	64			4				28*	9		
30-1d	Rausch	Bir	1963	645	92			6				63*	20*	0	3
30-4f	Treasure Homes	Ortman	1963	600	108			4	3	4	100	77	20		1½
30-4f	Gorham	Bir	1961	600	100			6	3	4	100	78	6½*	0	1
30-1g	Burke	Norris	1969	650	130			4½	3½	3	80	80	6	30	3
30-2g	Kelly	do	1969	650	187	114	sh	4½				75*	7	20	2
31-8g	Deckard	Bir	1966	625	157			6	2½	5	100	109*	15*	0	1
31-8h	Pattee	Feaster	1966	620	79			4½	4	3	30		10*		1
32-2e	Mahan	Bir	1971	660	88			6	2½	5¼	50	54	16*	5	1
33-4g	Riffey	Lister	1954	660	71			4				30*			
33-4h	Hawk	Feaster	1963	660	87			4½	3	3	25	53*	5	3	2
33-6h?	Kelter	Dilden		650	101				3		100	49*	8	6	
36-5e	Carter	do	1969	672	76			4	2	4	50	66*	15		2
T.24N., R.4W.															
1-7a	McCoy	Dilden	1952	661	97			4	3		100	87	12		

Table 9. Continued.

Well location	Owner	Driller	Year constructed	Land surface elevation (ft) above msl	Well depth (ft)	Depth to bedrock (ft)	Type of bedrock	Well diameter (in)	Screen length (ft)	Screen diameter (in)	Slot number	Depth to static water level	Yield (gpm)	Draw down (ft)	Hours tested
1-2a	Smith	Dilden	1951	651	91			4	3		100	86	10		
6-5a	Brown	Bir	1966	690	155			6	2½	5¾	60	85a	16*	40	1
8-8c	Martin	Dilden	1962	685	132			4	3	4	35	101			
9-1b	Stock Beet Inc.	Ortman	1962	670	160			4	3½	3	40	105a	30		3
10-2e	Vohle	Feaster	1961	630	147			4½	3½	4½	40	108a	14	11	2
10-8b	Bopright Builder	Titus	1966	620	42			4½	2½	3	50	25a	15		14
14-1c	Mitchell	do	1961	600	82			4½	5½	1½	40	37a	20*	0	16
14-6c	Irene Hall	English	1966	620	104			4½	2½	4	80	30a	10*		
14-8d	Fishchang	Dilden	1971	650	118			4	3	4	25	90a			
14-2e	Rutherford	Titus	1965	650	142			4	3	4	50		15*	0	1
14-8c	Bailey	Bir	1969	630	101			6	3	4½		74	16*	0	1
14-7f	Breitwieser	Farner	1968	630	96			4½	4	3	30	22a	10*	0	16
14-8g	Switzer	Dilden	1967	655	114			4	3	4	40	86a	10*	0	
14-8g	do	do	1959	665	112			4	3	4	40	95	10*	0	
15-1a	O'Dell	R.L. Exc.	1965	620	130			4	2	4	80	50a			
15-8c	Eason	Wingate	1967	660	156			4½	2½	1½	80	100	20*	10	2
16-2h	Dunn	Bir	1965	650	125			6	2½	5¾	60	66	10*	0	1
16-3h	Pierce	L & A	1967	660	167			4	2½	4		80a	10*		
16-5h	Retreat	Bolt	1969	657	98			4	2½	3	40	85	10*	0	½
17-1e	Pittig	Dilden	1965	675	108			4	2	4	50	72a	10*	0	
17-3b	Lemley	do	1966	675	144			4	5	4	35	94a	10*	0	
18-5b	Craig	Elskay	1961	675	129			4	3	3	80	55a	10*	5	0
18-8d	Bacey	Ortman	1972	675	137			5½	3		80	17a	125		
18-4e	Firth	Bir	1972	694	93			6	2½	5¾	40	64a	12	3	1
19-3e?	Wilson	Dilden	1969	660	61			4	3	4	40	32a	10	0	
19-5b	Brumbaugh	Moore	1968	679	69			5½	4	4	100	31a	40		1
20-2b	New Am. Homes	Ortman	1971	675	160			5	3		60	107a	60		
20-4e	Ferrell	Dilden	1968	650	113			4	3	4	50	78a	10	0	
20-6e	Kolb	do	1968	660	142			4	3	4	35	74a			
20-8e	Peterson	Bir	1963	670	107			6	2½	5¾	50	71a	16*	0	1
20-2a?	Homere			650	76										
21-1g	Patterson	Titus	1965	645	136			4	11	3½	20	75	18	0	60
22-1h	Sheaf	Norris	1972	620	83			4				55a	6	10	1
23-8c	Chalin	English	1961	650	135			4½				85a	5*		
23-4d	Lehman	L & A	1967	566	112			4½	2	4		80	10*	20	
23-3h	Town of Battleground	Layne	1961	590	141	141	ls	6				22a			
27-2g?	N.W. Conf. of M.E. Church	Coats-Smith	1932	554		165	ls								
27-3h?	Watt	Bir	1959	630	81			4	2½	4	40	62a	12	1	2
28-1h	Fauber Const. Co.	Dilden	1970	585	124			8	15	8	80	F	400	7	4
28-8h?	Davis Homes Inc.	Norris	1972	655	185			4½				50a	8		2
29-3e	Verplank	Dilden	1970	650	113			4	3	4	50	87	10	0	
30-3e	Tippecanoe School Corp.	Holt	1968	650	174	169	sh	10				90a			
30-3e	do	do	1968	635	119	119	sh	6	10	6	40	93	325	14	3½
30-3f	do	do	1968	660	128	128	sh	10	20	10	20	95	250	11	24
30-5b	Chase	Holt	1959	665	38			4	2	3¾	40	31a	12	0	1½
31-5e	Buckley	Bir	1972	670	161			6	2½	5¾	50	106	12*	0	1
32-4d	Johnson	do	1963	680	184			6	2½	5¾	60	160a	16*	0	2
33-1b	Brookbank	Dilden	1959	535	65			4	2	4	40	25a			
33-6c	Vanderas	Bir	1966	580	64			6	2½	5¾	50	37	20	0	1
35-4a	Lowman	Bir	1962	615	130			6	3	5¾	40	100a	16*	0	4
35-3b	Plummer	Feaster	1963	630	124			4½	3½	3	30	89a	8	5	2
35-1c	Holmes	Bir	1965	615	133			6	2½	5¾	50	99a	16*	0	4
36-4e	Fish	English	1966	620	168			4½	2½	4	80	115a	10*		
36-4c	Shafer	Bir	1960	625	77			6	3	4		65	10*	0	1
36-6e	Cox	Ortman	1963	620	140			4½	3	3½	100	103a	25		1
T. 24 N., R. 5W.															
7-8a	Christopher	Hofstetter	1964	720	61			4	2	4	35	40a	15	5	4
3-1g	Clymer	Dilden	1951	720	58			4	3		80	7a			
6-5d	Summers	Titus	1969	760	75			4	2	1½	50	40a	15*	20	2
12-1d	Schaeffer	Dilden	1970	690	109			4	3	4	40	87a	10*	0	
12-1f	Pierce	Bir	1966	695	186			6	2½	5¾	50	97a	16*	11	1
13-1f	Hoen Contr.	Dilden	1963	685	126			4	3	4	25	18a	25	2	
14-6e	Lannerd	Ortman	1963	715	134			4½	3	4	100	40a	120		1
15-1c	Decamp	Holt	1962	735	65			4	2	3¾	30	50a	4	13	1
16-1a	Marehouse	Bir	1965	750	170			6	2½	5¾	50	77a	16	0	1
18-2c?	Marshall	Dilden	1951	730	54			4	3		80	21a	15		
18-2d	Marshall	Dilden	1951	740	58			4	3		100	19a	30	0	
24-8a	Henderickson	do	1967	680	51			4	3	4	40	32a			
26-2a	Sullivan	do	1970	700	141			4	3	4	50	115		0	
26-3a	Smith	do	1964	690	146			4	3	4	40	120			
26-4a	Bost	do	1950	692	129			4				110	8		
26-2b	Schroyer	Dilden	1966	700	139	139	sh	4	3	4	60	129	12		2
26-5b	Riley	Golden	1964	692	134	124		4				40			
26-3g	Community Homes Inc.	Ortman	1972	710	105			5½	3		80	39a	30		
26-6g	Riley	Bir	1963	690	71			6	2½	5¾	60	24a	30*	0	2
26-6h?	Davis	do	1963	700	71			6	2½	5¾	40	40a	8	4	1
31-5a	Rees	Bir	1966	700	53			6	2½	5¾	60	24a	24	0	1
31-5e	Harkness	Dilden	1966	700	57			4	3	4	40	13a	30	3	7
34-1b	Carlson	Bir	1965	660	200	65	sh	6				30a	10	0	10
34-2c	Klinker & Leery	Titus		692	170	90	sh								
35-1f	Reddos	R.L. Exc.	1970	680	135			4	2	4	40	105a	20		2
35-5g	Tenke	Holt	1962	680	119			4	2	3¾	40	106	17	0	1
35-5h	Welton	Holt	1965	670	90			4	2	3¾	50	21a	10	0	½
35-6b	D. Lumber Co.	Ortman	1962	690	170	98	sh	4½				55a	11		2
35-6h	Nevrkla	Dilden	1960	680	126	101	sh	4				55a	4		
35-7h	D. Lumber Co.	Ortman	1962	690	105	102	sh	5	1	4½	100	18a	90		2½
36-3a?	Marlean	Coy	1941	662	110			4				90			
T. 24N., R. 6W.															
1-5a	Roose	Dilden	1966	760	96			4	3	4	40	37a	12	0	
10-5e	Lard	Hofstetter	1971	760	41			4	4	4	25	10a	20	10	
14-5e	Young	Dilden	1963	765	85	55	sh	4				18a	6		5
14-5e	do	do	1963	765	76	55	sh	4				15a	10	12	45
25-1a	Muller	Bir	1964	700	51			6	2½	4	100	31a	20	0	1
35-2a	Fearier	Bir	1962	690	151			6	3	3¾	50	27a	16*	0	1
35-2a	Smith	Dilden	1963	690	152			4	3	4	50	23a	18	2	
35-2a	Schella	Ortman	1963	700	155			4	3	4	100	27	60		3
35-1c	Schepen	Dilden	1970	690	50			4	3	4	30	16a	12	0	
35-2e	Christman	do	1964	690	45			6	8	4	40	16			

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* Land surface elevation is feet above mean sea level. for some wells, elevation is taken from the 7½ minute series topographic maps, and is indicated by the letter "c" after the elevation. Depth to water level is as measured on date of well completion. It is followed by letter "a" if it is artesian. F. means a flowing well. Yield is followed by "*" if it was estimated by pumping test, otherwise it was estimated by bailer test.