DEPARTMENT OF THE INTERIOR

WATER-SUPPLY

AND

IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 26

WELLS OF SOUTHERN INDIANA.—LEVERETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1899

IRRIGATION REPORTS.

The following list contains the titles and brief descriptions of the principal reports relating to water supply and irrigation, prepared by the United States Geological Survey since 1890:

1890.

First Annual Report of the United States Irrigation Survey, 1890; octavo, 123 pp.

Printed as Part II, Irrigation, of the Tenth Annual Report of the United States Geological Survey, 1888-89. Contains a statement of the origin of the Irrigation Survey, a preliminary report on the organization and prosecution of the survey of the arid lands for purposes of irrigation, and report of work done during 1890.

1891.

Second Annual Report of the United States Irrigation Survey, 1891; octavo, 395 pp.

Published as Part II, Irrigation, of the Eleventh Annual Report of the United States Geological Survey, 1889-90. Contains a description of the hydrography of the arid region and of the engineering operations carried on by the Irrigation Survey during 1890; also the statement of the Director of the Survey to the House Committee on Irrigation, and other papers, including a bibliography of irrigation literature. Illustrated by 29 plates and 4 figures.

Third Annual Report of the United States Irrigation Survey, 1891; octavo, 576 pp.

Printed as Part II of the Twelfth Annual Report of the United States Geological Survey, 1890-91. Contains "Report upon the location and survey of reservoir sites during the fiscal year ended June 30, 1891," by A. H. Thompson; "Hydrography of the arid regions," by F. H. Newell; and "Irrigation in India," by Herbert M. Wilson. Illustrated by 93 plates and 190 figures.

Bulletins of the Eleventh Census of the United States upon irrigation, prepared by F. H. Newell; quarto.

No. 35, Irrigation in Arizona; No. 60, Irrigation in New Mexico; No. 85, Irrigation in Utah; No. 107, Irrigation in Wyoming; No. 153, Irrigation in Montana; No. 157, Irrigation in Idaho; No. 163, Irrigation in Nevada; No. 178, Irrigation in Oregon; No. 193, Artesian wells for irrigation; No. 198, Irrigation in Washington.

1892.

Irrigation of western United States, by F. H. Newell; extra census bulletin No. 23, September 9, 1892; quarto, 22 pp.

Contains tabulations showing the total number, average size, etc., of irrigated holdings, the total area and average size of irrigated farms in the subhumid regions, the percentage of number of farms irrigated, character of crops, value of irrigated lands, the average cost of irrigation, the investment and profits, together with a résumé of the water supply and a description of irrigation by artesian wells. Illustrated by colored maps showing the location and relative extent of the irrigated areas.

1893.

Thirteenth Annual Report of the United States Geological Survey, 1891–92, Part III, Irrigation, 1893; octavo, 486 pp.

Consists of three papers: "Water supply for irrigation," by F. H. Newell; "American irrigation engineering" and "Engineering results of the Irrigation Survey," by Herbert M. Wilson; and "Construction of topographic maps and selection and survey of reservoir sites," by A. H. Thompson. Illustrated by 77 plates and 119 figures.

A geological reconnoissance in central Washington, by Israel Cook Russell, 1893; octavo, 108 pp., 15 plates. Bulletin No. 108 of the United States Geological Survey; price, 15 cents.

Contains a description of the examination of the geologic structure in and adjacent to the drainage basin of Yakima River and the great plains of the Columbia to the east of this area, with special reference to the occurrence of artesian waters.

1894.

Report on agriculture by irrigation in the western part of the United States at the Eleventh Census, 1890, by F. H. Newell, 1894; quarto, 283 pp.

Consists of a general description of the condition of irrigation in the United States, the area irrigated, cost of works, their value and profits; also describes the water supply, the value of water, of artesian wells, reservoirs, and other details; then takes up each State and Territory in order, giving a general description of the condition of agriculture by irrigation, and discusses the physical conditions and local peculiarities in each county.

Fourteenth Annual Report of the United States Geological Survey, 1892–93, Part II, Accompanying papers, 1894; octavo, 597 pp.

Contains papers on "Potable waters of the eastern United States," by W J McGee; "Natural mineral waters of the United States," by A. C. Peale; and "Results of stream measurements," by F. H. Newell. Illustrated by maps and diagrams.

(Continued on third page of cover.)

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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

WELLS OF SOUTHERN INDIANA

(CONTINUATION OF WATER-SUPPLY AND IRRIGATION PAPER NO. 21)

BY

FRANK LEVERETT

WASHINGTON

GOVERNMENT PRINTING OFFICE

1899

CONTENTS.

WELLS OF SOUTHERN INDIANA.[1]

By FRANK LEVERETT.

DETAILED DISCUSSION OF WELLS.

RANDOLPH COUNTY.

General statement.—Randolph County is situated near the middle of the eastern boundary of the State, with Winchester as its county seat. It has an area of 460 square miles.

This county has the distinction of being the most elevated one in the State. Only a small portion of its surface, along the Mississinewa and White rivers, in the northwestern and western parts, falls below the 1,000-foot contour. Several sections in the southeastern part have knolls and ridges rising above the 1,200-foot contour. The highest of these probably reaches 1,250 feet.

The highest land, found in the southern tier of townships, is occupied by a strong morainic belt, having a breadth of 5 or 6 miles and carrying sharp knolls and ridges 30 to 50 feet in height. Between this morainic belt and White River there is a gently undulating plain several miles in width. Immediately north of White River is a small moraine—the Union City ridge—scarcely a mile in average width, which enters the State at Union City and passes westward entirely across the county. This is a gently undulating ridge 25 to 50 feet in height. From this moraine northward to the Mississinewa River there is a gently undulating plain about 6 miles in width. Immediately north of the Mississinewa River is the Mississinewa moraine, which extends slightly into Randolph County.

[1] The present paper is a continuation of Water-Supply and Irrigation Paper No. 21, on "Wells of Northern Indiana," the division of the whole into two papers being rendered necessary by a statutory provision which limits the size of a single paper in this series to 100 pages.

The drift of this county is composed largely of a compact blue till, though in its deeper portions considerable sand is encountered. The thickness ranges from a thin coating up to fully 300 feet. Outcrops of rock occur along the Mississinewa, in the vicinity of Ridgeville, and on White River, near the west line of the county. With these exceptions the drift forms a continuous sheet, and probably has an average thickness of fully 150 feet. Twenty borings in the vicinity of Winchester, where the drift is scarcely so thick as in the southern portion of the county, show an average of 136 feet and a range from 70 to 334 feet.

Individual wells.—Along the Mississinewa moraine, on the north border of the county, several wells show a depth of 90 to 100 feet before entering rock. The drift is mainly a blue till.

At Ridgeville wells penetrate 30 or 40 feet of drift. A few are obtained without entering rock, but the best supply is to be found in the limestone. Many wells are obtained at a depth of only 40 feet.

On the plain between the Mississinewa moraine and the Union City ridge wells are usually obtained at less than 40 feet, and are mainly through till.

The drift in the vicinity of Union City ranges from 60 feet to fully 200 feet. Ordinary wells at Union City are obtained at a depth of about 35 feet in gravel beneath the blue till. The waterworks wells are estimated to yield about 1,500,000 gallons each per day. Two wells supply the city.

At Winchester the dug wells are often obtained at a depth of but 10 or 20 feet, and water is usually struck at 7 to 10 feet. Such wells being liable to contamination, deeper ones have been sunk, which obtain water near the top of the limestone at about 100 feet.

The deepest drift yet discovered in Randolph County was found in two wells about 1½ miles west and northwest from Winchester. In one well rock was struck at 331 feet; in the other at 334 feet. The upper portion of the drift at these wells is till, but the greater part is sand containing water.

Two water wells a short distance south from Winchester—one at Frank Moorman's, the other at Fountain Park Cemetery—do not reach rock at 205 and 210 feet, respectively. One boring in the east part of Winchester does not reach rock at 160 feet. Aside from this, the wells within the city limits of Winchester all enter rock at less than 150 feet, and one at 80 feet.

At Farmland, in the western part of the county, the drift in two gas wells is 58 and 60 feet, mainly till. Water wells are obtained at about 25 feet.

At the village of Parker, also in the western part of the county, water wells usually are obtained at 20 to 60 feet in thin gravel beds between sheets of till. A boring at the grist mill, however, extends to

the rock at 97 feet, and is mainly through till. A gas-well boring in Parker struck rock at 80 feet.

At the village of Windsor, on White River, south from Parker, the drift is mainly sand and gravel, and a gas-well boring shows its depth to be 107 feet.

At Losantville, on the moraine in the southwestern part of the county, the gas boring penetrates 240 feet of drift, some of it gravel, but mainly blue till. Water wells are obtained in that vicinity at 20 to 40 feet, with an occasional tubular well 60 or 80 feet in depth.

At the village of Lynn, in the south part of the county, a gas boring penetrates 117 feet of drift, of which the upper 50 feet is till and the remainder sand and gravel. Another boring in Lynn strikes rock at 124 feet, and its section is similar to the preceding.

The wells on the moraine in southern Randolph County, near the State line, usually obtain water at 20 to 30 feet, occasionally at 50 to 60 feet, in beds of gravel, between sheets of till.

DELAWARE COUNTY.

General statement.—Delaware County is situated in the eastern part of the State, immediately west of Randolph County. It has an area of 400 square miles, and Muncie, its county seat, is situated near its geographic center. The northeastern corner is crossed by the Mississinewa moraine, the eastern part is traversed by the Union City ridge, and the southeast corner is occupied by a strong moraine, the continuation westward of the one noted in southern Randolph County. There are several sharp gravelly knolls in the vicinity of Muncie and an esker of considerable prominence east of Royerton. These moraines and other knolls and ridges are confined to the eastern half of the county. The western half is a gently undulating plain.

The strong moraine in the southeast corner of the county is composed largely of a gravelly drift, but aside from this and the gravelly knolls and the esker above noted the drift of the county is mainly till. Over the greater part rock is usually struck at depths of 50 feet or less, but it is probable that on the moraine in the southeastern corner its thickness may exceed 200 feet. Many gas wells in the vicinity of Muncie enter rock at less than 20 feet, and rock is exposed extensively along the Mississinewa and White rivers in this county. Even if allowance be made for the existence of deep valleys, such as are encountered near Winchester, the thickness of the drift can scarcely exceed 100 feet. It is much less than in the neighboring counties on the north, east, and south, but is similar to the shallow drift of southwestern Grant County and northern Madison County, situated on the northwest and west.

Wells are ordinarily obtained at depths of 20 or 30 feet, either in

gravelly deposits near the base of the drift or in the upper part of the limestone. So far as the writer is aware, there are few if any water wells in the county whose depth exceeds 60 feet.

Individual wells.—At Selma, on the Union City ridge, in the east part of the county, the gas boring penetrates 92 feet of drift, as follows:

	Feet.
1. Yellow till	12
2. Sand with water	8
3. Blue till	12
4. Sand and gravel, becoming coarse near bottom	60
Total	92

At Daleville the drift is 85 feet, but wells are obtained in sand below till at 12 to 16 feet.

Near Wheeling, in the northern part of the county, wells in some cases reach a depth of 35 or 40 feet without entering rock. At Muncie, and also at Shideler and Eaton, wells ordinarily enter rock at 15 or 20 feet.

The waterworks at Muncie obtain their supply from several flowing wells drilled into rock. Three 8-inch wells are estimated to have a combined daily discharge of 50,000 barrels.[1]

MADISON COUNTY.

General statement.—Madison County is situated in the east-central part of the State, immediately west of Delaware, with Anderson as its county seat. It has an area of 450 square miles. The entire county is a gently undulating till plain, across which the drainage lines pass in a westward or southwestward course in narrow channels seldom cut to depths of more than 75 or 100 feet below its surface. The eastern border of the county rises slightly above 900 feet, and the western is fully 800 feet.

Throughout the entire county rock is frequently encountered at depths of 50 feet or less, but occasional borings have shown the existence of valleys deeply filled with drift, which are now completely obscured. The drift is largely a compact till, but affords a sufficient amount of water-bearing gravel and sand to supply the majority of the wells.

Individual wells.—At Summitville, in the northern part of the county, a gas-well boring penetrates 110 feet of drift, of which the upper 15 feet is till and the remainder gravel. Wells are usually obtained in this gravel soon after reaching the bottom of the till. On low ground in the west part of the village the wells pass immediately into the gravel below the surface soil or muck.

A gas well north of Summitville, near the Grant County line, penetrates 70 feet of drift, largely till.

[1] Manual of American Waterworks.

At Alexandria wells are usually obtained in the rock at a depth of about 60 feet. From this depth water rises about 30 feet. The drift at two gas borings in this village is reported to be 22 feet in depth:

	Feet.
1. Gravel	6
2. Blue till	16
Total	22

West from Alexandria the dug wells are ordinarily obtained in the drift at 15 to 20 feet. Tubular wells are somewhat deeper.

At Elwood wells enter rock at depths of about 40 feet, and some obtain water at 75 to 150 feet. In such wells the water usually rises nearly to the level of the bottom of the drift. The waterworks supply is obtained from a well 150 feet in depth and 8 inches in diameter. This well is estimated to yield nearly 20,000 barrels per day. An analysis of the water is given elsewhere.[1]

Several gas borings at Elwood show the drift to range from 40 feet or less up to 108 feet. One well having 56 feet of drift penetrates—

	Feet.
1. Till	15
2. Sand	4
3. Blue till	25
4. Sand	12
Total	56

At Anderson, the county seat, the ordinary wells range in depth from 15 feet to 100 feet. A portion of the city is underlain by gravel, and there is danger of contamination in the shallower wells. In the east part of the city wells in gravel are 60 to 75 feet. In the south and west parts the wells penetrate till to a depth of 50 to 100 feet before obtaining a strong supply of water. The city waterworks obtain the supply from the White River, but the water is not considered suitable for domestic purposes, being used only for lawns and streets and in baths. Several fountains are maintained in the city by pumping water from a deep well in White River Valley, near the waterworks pumping station. It is forced to the fountains by a pump connected with the waterworks engine. This well is reported to have an inexhaustible supply, and is objectionable only because of the sulphureted hydrogen which its water contains.

The gas wells in Anderson have drift ranging in thickness from 16 feet to nearly 200 feet. At a well in the west part of the city, in White River valley, 194 feet of drift is penetrated. At the crossing of the Panhandle and the Cincinnati, Wabash and Michigan railways, on the bluff north of the river, 191 feet of drift was penetrated. A well three blocks southwest of the court-house penetrates 91 feet of drift,

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 498.

entirely gravel. At the court-house the drift is 48 feet, and is entirely gravel. A well west of the crossing of the Bee Line and Panhandle railways penetrates 104 feet of drift, of which the upper 34 feet is sand and gravel, and the remainder blue till.

In several wells on the plain 2 or 3 miles southeast of Anderson, a bluish-black muck, resembling a soil and carrying considerable wood, is reported to occur at depths of 20 to 40 feet.

At Frankton, in Pipe Creek valley, about 6 miles northwest from Anderson, a gas boring penetrated 85 feet of drift.

At Huntsville and Pendleton, in the valley of Fall Creek, about 8 miles south of Anderson, rock outcrops occur, but the drift in some cases is 90 feet.

At Markleville, in the southeast corner of the county, a gas well penetrates 147 feet of drift. Water wells in that vicinity are obtained at 20 to 40 feet, and often encounter a blue mud, carrying wood.

HAMILTON COUNTY.

General statement.—Hamilton is the center county of the State, with Noblesville as its county seat, and has an area of 400 square miles. The White River valley traverses the southeastern part of the county. The only other streams of importance are Cicero Creek, which enters White River from the north, near Noblesville, and Fall Creek, which touches its southeastern corner. The eastern two-thirds of the county is nearly level and stands about 800 to 850 feet above tide. In the western third there is a gradual rise to a higher plain, 900 to 950 feet, which occupies much of Boone and Clinton counties. This rise is occasioned, not by greater elevation of the underlying rock, but by a thickening of the drift deposits. Indeed, the general rock surface lies lower in the western part of the county than in the central and eastern, as shown by numerous gas-well borings. The upper portion of the drift in this county is principally a compact till, but there are small areas bordering the valley of White River in which the till is replaced by gravel. There are also gravelly terraces along the stream. The deeper portions of the drift throughout the county appear to carry large amounts of gravel and sand.

Individual wells.—In the vicinity of Noblesville the drift has a known range from 33 feet to 186 feet, the shallowest drift being found about a half mile north of the court-house, in the valley of White River, and the deepest about 2 blocks north of the court-house, at the Evans well. In both wells it is mainly gravel. A well in the valley, 1½ miles north of the court-house, penetrates 176 feet of drift, mainly gravel, but having 40 feet of red clay at bottom. Several wells about 2 miles east of Noblesville also penetrate a gravelly drift and enter rock at about 80 feet. A well 1½ miles west of this city penetrates 98 feet of drift, mainly till.

The dug wells in the city of Noblesville obtain the first vein of water at about 20 feet, but a greater quantity and better quality is obtained at a depth of 65 or 75 feet. Wells are therefore often bored to that depth. The city waterworks contains an inexhaustible supply from such wells at a depth of 70 or 80 feet.

At Cicero, 6 miles north of Noblesville, two gas wells reach rock at 141 and 161 feet, and are mainly through till. A well 1 mile south of Cicero penetrates 270 feet of drift, largely sand and gravel, but with 60 feet of hard reddish till at the base.

At Fishers Station, 6 miles south of Noblesville, a gas well penetrates 110 feet of drift.

At Carmel the drift is only 96 feet, but at Westfield, about 5 miles west of Noblesville, one gas well strikes rock at 196 feet and another at 220 feet. The drift is mainly till in both wells. A well 3 miles southeast of Westfield penetrates—

1. Drift	95
2. Till	20
3. Sand and gravel	75
Total	190

At Eagletown, in the west part of the county, a gas-well boring penetrates 200 feet of drift:

	Feet.
1. Till	160
2. Sand and water	20
3. Red clay	20
Total	200

At Jolietville the drift is about 200 feet and mainly till.

At Sheridan a gas well penetrates 233 feet of drift:

	Feet.
1. Till	150
2. Sand and gravel, with water	40
3. Red clay, with white pebbles	43
Total	233

In the east part of the county, at Clarksville, a gas well enters rock at 16 feet, but one a mile north of the village penetrates 82 feet of drift, mainly till.

From the deep sections above given it should not be inferred that water wells are difficult to obtain, for throughout much of the county an abundance of water is found at convenient depths, wells seldom exceeding 40 feet.

BOONE COUNTY.

General statement.—Boone County is situated in the central portion of the State, immediately west of Hamilton, with Lebanon as its county seat. It has an area of 420 square miles. Its elevation is somewhat greater than the counties to the east or west, and the water parting between the Wabash and White rivers traverses its central

portion from north to south. The elevation of this divide is due not to the high altitude of rock strata, for gas borings have shown that the rock strata have a greater elevation on the slope toward the Wabash in western Boone County and in Montgomery County than along the divide. So far as known to the writer there are no outcrops of rock in the county. There is in the eastern and central part of this county, as in the counties to the east and north, a deposit of drift 250 to 300 feet or more in thickness. The surface of the county is almost entirely plane, there being only occasional low swells and ridges scarcely exceeding 20 feet in height.

Individual wells.—In the following list of wells are included sections of several published by Messrs. Gorby and Lee in the fifteenth report of the State geologist. But few well records were personally obtained.

In sections given by Gorby and Lee it appears that in the northwestern part of the county there is in many places a bed of sand between the yellow and blue till. In some cases the sand is but 3 or 4 feet in thickness, but it occasionally reaches a thickness of over 50 feet. There is usually below this sand a thick bed of blue till 50 to 150 feet. The following wells serve to illustrate the above statements.

Witt and Klizer's well at Thorntown penetrates—

	Feet.
1. Yellow clay	21
2. Quicksand	4
3. Blue clay	125
4. Shale, limestone, etc	193
Total	343

Mr. Duke's well, 3 miles north of Thorntown, penetrates—

	Feet.
1. Yellow till	18
2. Quicksand	12
3. Blue clay	153
4. Red sandstone	3
Total	186

A neighboring well at Mr. Wetherald's has a similar section. A well near Union Church, 3 miles east of Thorntown, penetrates—

	Feet.
1. Yellow till	27
2. Quicksand	9
3. Blue till	75
Total	111

Mr. Frank Harris's well, 1 mile south of Thorntown, penetrates—

	Feet.
1. Yellow till	19
2. Quicksand	4
3. Blue till	103
4. Cemented gravel	16
Total	142

William Mills's well, 1 mile west of Thorntown, penetrates—

	Feet.
1. Yellow till	25
2. Quicksand	3
3. Blue till	80
Total	108

At Charles Moffit's, 1½ miles west of Thorntown, a dry gravel was penetrated for 44 feet from the surface and the boring abandoned without obtaining water. Robert Woody's well, 3½ miles west of Thorntown, penetrates—

	Feet.
1. Yellow till	18
2. Fine white sand	55
3. Blue till	71
4. Limestone	3
Total	147

In the vicinity of Sugar Creek, near the west boundary of the county, the drift is only 20 to 40 feet in thickness, and is underlain by cherty limestone.

Wells are usually obtained in the village of Thorntown at 20 to 28 feet, and some wells at a depth of only 14 feet. In the valley bottom wells are mainly through sand and gravel, but on the bluffs they have sections similar to those noted above.

In the vicinity of Northfield, in the northeastern part of the county, wells are usually obtained in sand or gravel below a yellow till, at depths of 20 to 40 feet. In the vicinity of Slabtown, in the eastern part of the county, the water is obtained at depths varying from 20 feet to 50 feet. In this locality some blue till is usually penetrated above the water-bearing gravel.

A well about midway between Slabtown and Elizaville is reported to have penetrated a swamp muck below till at a depth of about 60 feet. The following section is reported by the well borer, Mr. Ball, of Thorntown:

	Feet.
1. Yellow till	18
2. Quicksand	3
3. Blue till	20
4. White sand, with inflammable gas	11
5. Blue clay	6
6. Swamp muck, leaves, twigs, etc	7
7. Blue clay	19
Total	84

A similar swamp muck was penetrated by Mr. Ball in a well for Mr. Vandeveer, 6 miles south of Lebanon. The well penetrates—

	Feet.
1. Yellow till	20
2. Blue till	45
3. Swamp muck, leaves, twigs, etc	10
4. Blue clay	25
5. Sandstone	9
Total	109

A similar muck was found at 48 to 60 feet in a well 4 miles north of Jamestown, and at 60 to 63 feet in a well 2½ miles north of Jamestown.

At the village of Roston, east of Lebanon, wells are usually obtained at from 8 to 20 feet in sand and gravel below a red clay.

In the vicinity of Ratsburg, northeast of Lebanon, water is usually obtained in sand below a gray till at about 20 feet.

At Lebanon the wells are but 12 to 24 feet in depth, with an average of about 16 feet. They are obtained in gravel, which has scarcely a sufficient amount of clay cover to insure freedom from surface contamination. The waterworks wells, however, are deeper.

A gas-well boring in the city of Lebanon penetrates 342 feet of drift. The specimens of the different kinds of material were examined by the writer, and the following section was determined:

	Feet.
1. Black soil	2
2. Yellow till	9
3. Blue till	15
4. Sand, with water	1½
5. Ash-colored till	77
6. Gravel	8
7. Pale ash-colored till	50 to 55
8. A darker ash or gray till, with some sand interbedded	176
Total	342

Below the drift is shale, 108 feet in depth, beneath which limestone of great thickness is penetrated.

Messrs. Gorby and Lee report the section of a well on Washington street, in Lebanon, 108 feet in depth, in which the structure is remarkably variable, as follows:

	Feet.
1. Soil (probably clay)	7
2. Yellow sand	1
3. Yellow clay	3
4. Blue sandy clay	1
5. Sand	4
6. Blue clay	3
7. Sand and gravel	4
8. Blue and gray clays	26
9. Sand and clay	10
10. Blue clay	23
11. Coarse gravel	1
12. Blue clay	25
Total	108

A well on D. M. Burns's farm, 2 miles north of Lebanon, is reported to penetrate—

	Feet.
1. Soil and yellow till	9
2. Gravel and sand	2
3. Blue till	22
4. Gravel	2
5. Gravel and clay	3
6. Blue till	74
Total	112

A well 4½ miles northeast of Lebanon enters rock at a depth of 285 feet. The section of drift was not ascertained.

A well on the farm of Clairborne Cain, 5 miles west of Lebanon, failed to reach rock at a depth of 243 feet. It penetrates—

	Feet.
1. Soil and yellow till	17
2. Quicksand	5
3. Blue till	51
4. Dry gravel with inflammable gas	5
5. Blue till	165
Total	243

Obstructions in the pipes made it necessary to abandon the boring without reaching the bottom of the blue till.

At the village of Jamestown wells are usually obtained at 25 to 30 feet. Gorby and Lee report the following sections at two deeper wells at this village. A well at the sawmill in Jamestown penetrates—

	Feet.
1. Soil and yellow till	11
2. Quicksand	1
3. Blue till	28
4. Gravel	2
5. Blue till	48
Total	90

A well at the gristmill in Jamestown penetrates—

	Feet.
1. Yellow till	11
2. Sand	2
3. Blue till	49
Total	62

Wells at New Brunswick are reported to obtain water at 11 feet to 35 feet. They usually penetrate considerable gravel in the upper 10 to 15 feet, below which there is a blue clay extending to the waterbed.

At Milledgeville the wells range in depth from 12 feet to 42 feet, and obtain water in sand and gravel between beds of till.

At Royalton water is usually obtained at depths varying from 10 feet to 40 feet. Foster and Leap had a well bored to the depth of 96 feet, penetrating—

	Feet.
1. Soil and yellow till	20
2. Gravel	5
3. Blue till, with frequent thin beds of sand and gravel	71
Total	96

A well at a sawmill in the same village, 107 feet in depth, had a similar section.

At Zionsville the wells are 20 to 60 feet, and are usually obtained from thin beds of gravel between till sheets. A gas-well boring in Eagle Creek Valley, near Zionsville, penetrates 165 feet of drift, of which the upper 40 feet is mainly sand and gravel and the remainder mainly blue till.

MONTGOMERY COUNTY.

General statement.—Montgomery County is situated in the west-central portion of the State, with Crawfordsville as its county seat. It has an area of 504 square miles. The altitude is somewhat uniform, the greater part of the county standing between 800 and 900 feet above tide. The surface is generally plane, or but gently undulating. In the northwestern part, however, there are morainic belts of considerable prominence. Moraines of gentle expression also occur east and southeast of the strong belts and traverse the eastern part of the county. The thickness of the drift is much less than in Boone County, rock being exposed on many of the streams at levels 50 feet or less below the bordering upland. There are, however, very deep valleys traversing the county, whose courses do not coincide with those of the present system and which are so completely obscured by the drift deposits which fill them as to be known only where deep borings have been made in them. One of these valleys is brought to light by borings in the vicinity of Crawfordsville. The drift of this county is apparently, in the main, a compact till, in which only thin beds of sand or gravel occur. Exposures along Sugar Creek, in the vicinity of Crawfordsville, show sheets of different constitution and age, testifying to more than one invasion of the ice. The county is well supplied with springs along its valleys, some being from limestone ledges and some from gravel in the Glacial drift.

Individual wells.—Over much of the northern part of the county wells are obtained at depths of 12 to 20 feet in beds of sand or gravel below the yellow till. They seldom reach a depth of 50 feet. A well at Pleasant Hill, in the northwest corner of the county, 47 feet in depth, penetrates a soft till for 37 feet, beneath which a much harder till is encountered.

Along a morainic belt in the western part of the county, near Alamo, wells occasionally reach a depth of 70 feet, mainly through till.

In the vicinity of Crawfordsville several gas wells have been drilled. One at Crawfordsville Junction penetrates 140 feet of drift, as follows:

	Feet.
1. Yellow till	12
2. Soft blue till	60
3. Hard blue till with gravelly beds	64
4. Gravel	4
Total	140

An attempted boring in section 33, near Crawfordsville, penetrated till 50 feet and then entered a bed of quicksand, which continued at least to a depth of 240 feet, where the well was abandoned. A boring in Sugar Creek Valley, near Crawfordsville, has about 200 feet of drift, mainly sand and gravel. Near the bottom there was a gray silt or

mud. In this connection it should be noted that rock outcrops occur within a mile north of Crawfordsville at a higher elevation than the mouth of the gas boring just mentioned.

The waterworks at Crawfordsville obtain the main supply from Van Cleve's springs. The water is collected in an impounding reservoir, from which it is pumped to the standpipe. Wells are also drawn upon, but the depth has not been ascertained. The private wells of the city vary greatly in depth and are obtained from beds of sand or gravel between sheets of till.

In the southern half of the county wells ordinarily obtain water at 25 to 30 feet in gravel or sand beds associated with the till. Blue till is entered at about 15 feet. Wells 50 feet in depth are rare. Near Wayland rock is sometimes struck at 20 or 30 feet, but a well in the village does not reach rock at 50 feet.

FOUNTAIN COUNTY.

General statement.—Fountain County is situated near the middle of the western part of the State, immediately south and east of the great bend of the Wabash River, that stream forming its north and west boundaries. The area is 390 square miles. Covington, the county seat, is situated at the west line of the county.

The greater portion is a very smooth plain underlain by till. There are, however, small morainic ridges traceable across the county. One leads in a southeastward course from Attica across its northeastern corner. This belt has a width of 2 or 3 miles and consists of a series of knolls and low ridges seldom more than 25 feet in height and rather loosely aggregated. A narrower morainic line is found along Coal Creek, in the southwest part of the county. This belt apparently separates into two, one of which follows the west border of Coal Creek northward to the Wabash, while the other passes eastward, through Rynear and Hillsboro, into Montgomery County.

Throughout much of the county rock is encountered at depths of 40 or 50 feet or less. Many wells in the northern portion find their water at the base of the drift at about 20 feet. Nearly all the streams of the county have outcrops of rock along them at levels only 30 to 50 feet above the bordering uplands. It is thought that the average thickness of the drift can not much exceed 50 feet.

There are numerous strong springs along the Wabash, issuing either from sandstone or from drift gravel.

Individual wells.—At Attica a strong artesian well has been obtained in the valley of the Wabash River, which supplies an excellent quality of water amply sufficient for the city. A large part of the population are in the habit of obtaining water from this well. A satisfactory record of the boring could not be obtained at the time of my visit, but it enters rock strata.

On the uplands south of Attica wells are usually obtained at 27 to

35 feet and are mainly through till. In some localities, however, as in secs. 1 and 2, T. 20, R. 8 W., wells enter sand below till at a depth of but 10 to 15 feet and continue in sand to a depth of 25 to 40 feet, where water is obtained. In section 11 of this township wells strike shale at 18 to 20 feet. In section 8 they enter blue till at 6 or 8 feet and reach a water-bearing sand at 15 feet to 25 feet. One well on the Wabash bluffs, near Attica, in sec. 34, T. 22, R. 7 W., reaches a depth of 60 feet without encountering rock.

Wells on the uplands east of Stone Bluff enter rock at about 20 feet. In the valley of Coal Creek, at Stone Bluff and Chambersburg, water is obtained in gravel and sand at a depth of 30 or 35 feet.

At Veedersburg the wells vary in depth from 20 feet up to 70 feet. They are mainly through blue till and seldom strike rock.

At Covington wells are obtained in gravel at 50 or 60 feet. The waterworks supply is from springs. An artesian well boring near the court-house, at an altitude 65 feet above low water in the Wabash, has a depth of 358 feet, terminating in the conglomerate sandstone. It penetrates 85 feet of drift, of which the upper 74 feet is gravel and the lower 11 feet blue till. The well does not overflow. The water is called "sulphur water." But little use is made of it at present.

Several wells in Mill Creek Township, in the southern part of the county, are reported to enter a black muck below till at about 25 feet. Beneath this muck is another till sheet harder than the one above it.

Borings for coal in the northeastern part of Fountain County are reported by Dr. Brown[1] to reach a depth of 100 to 130 feet in several cases before entering rock, though in the vicinity rock is usually found at 20 to 40 feet from the surface.

A salt-well boring in sec. 4, T. 18, R. 8 W., was sunk to a depth of 1,004 feet and passed several veins of salty water, the first being at a depth of only 72 feet. The drift at this point is 40 feet in depth.

A boring near Lodi, on the southern border of the county, was sunk to a depth of 1,155 feet, and obtains a strong flow of salt water. There is also a strong flow of sulphur water, struck at a depth of 1,051 feet. The analysis of the water from this well is given elsewhere.[2]

VERMILION COUNTY.

General statement.—Vermilion County is situated near the middle of the west border of the State, and occupies a narrow strip between the Wabash River and the State line, the length of the county being 36 miles and the width 6 to 10 miles. Its area is 270 square miles. The greater part of the county is a till plain, standing about 200 feet above the Wabash River. It is crossed, however, from west to east by two small moraines, one following the south border of the Big Vermilion Valley, the other the south border of the Little Vermil-

[1] Eleventh Ann. Rept. Indiana Geol. Survey, p. 92.
[2] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 498.

ion. The former comes to the Wabash Valley at Eugene, the latter at Newport, the county seat. In the northern portion of the county the gravel terraces of the Wabash, standing 75 to 100 feet above the river, extend back a mile or more from the stream. There are also extensive remnants of the gravel terrace near Clinton, in the southern part of the county.

Individual wells.—On the till plain, in the northern part of the county, wells enter a blue till at about 6 or 8 feet, and obtain water in the beds of gravel or sand associated with the till at depths of 15 to 25 feet. There are very few deep wells, though the record of one 56 feet in depth was obtained. This is situated near the State line, in the northwest corner of the county, and is mainly through blue till.

Wells on the gravel terrace of the Wabash, in the northern part of the county, are often sunk to depths of 60 or 80 feet, and occasionally 100 feet, through sand and gravel, before entering a water bed. In passing westward from the river the gravel becomes shallower, and till is encountered before reaching the level of the river. It is not rare to find beds of muck containing wood and leaves at the base of the gravel. This muck is thought to be an interglacial flood-plain covered by glacial gravels of a later invasion.

In the villages of Eugene and Cayuga, which are situated on a low terrace of the Wabash near the mouth of Big Vermilion River, wells are ordinarily obtained at 40 feet or less, at about the level of the Wabash River.

On the uplands west of Eugene, in section 8, and at an altitude about 160 feet above the Wabash River, a boring 241 feet in depth failed to reach rock or obtain water. It was mainly in a compact blue till.

At Newport the wells range in depth from 12 feet to 88 feet, and obtain water in gravel between sheets of till.

At Clinton wells are usually sunk to a depth of 60 to 75 feet in gravel, and obtain water at about the level of the Wabash River. A boring for coal at this village, made on the low bottom of the Wabash, penetrated 100 feet of drift before entering rock.

On the uplands, in the southern part of the county, wells are ordinarily obtained at about 30 feet, in gravel between till sheets.

PARKE COUNTY.

General statement.—Parke County is situated in western Indiana, immediately opposite the southern portion of Vermilion County, on the east side of the Wabash River. It has an area of 440 square miles. Rockville is the county seat.

Several large creeks traverse the county in a northeast to southwest direction in valleys cut to a level 100 to 150 feet below the bordering uplands, and these streams, with their numerous tributaries, cause a somewhat broken surface. Between the streams, however,

there are strips of level upland, preserving the original elevation of the plain. A series of drift ridges traverse the central portion of the county in a northeast to southwest direction. These ridges are but 30 to 50 feet higher than bordering plains and have a gently undulating surface. They are, therefore, not conspicuous features.

The southern portion of this county extends beyond the limits of the Wisconsin drift sheet and its surface is covered with a nearly pebbleless white clay, several feet in thickness, which rests upon a sheet of older drift of Illinoian age. The central and northern portions of the county and a narrow belt along the Wabash, in the southern portion, are covered by the later sheet of till. Wells are often obtained at the junction of the two drift sheets at depths of 20 to 40 feet on plane tracts and somewhat greater depth on the moraines or drift ridges. The later drift is readily distinguished from the earlier by its softness and its fresher appearance. Wells may be readily spaded or bored in the newer drift, while in the older a drill or pick must be substituted. The hardness of the older till sheet is largely due to a partial cementation with carbonate of lime.

The thickness of the drift varies greatly, not because of variation in the surface elevation, but because of the greatly eroded rock surface upon which the drift lies. There are numerous outcrops along streams at levels only 50 to 75 feet below the general level of the upland, but it is probable that the average thickness of the drift of the county exceeds 100 feet.

Springs are not so numerous or strong as in the adjoining counties, Fountain and Montgomery, and are not an important water resource.

Individual wells.—Wells are usually obtained in beds of sand and gravel, between sheets of drift or near the base of the drift, at depths varying from 10 or 15 feet up to 100 feet or more. The knowledge of the thickness of drift is obtained from coal shafts or test borings for coal rather than wells, there being numerous shafts and borings in the southern part of the county.

In the northeastern part of the county, on the plain north of Sugar Creek, wells are usually obtained at about 30 feet. They enter blue till at 12 or 15 feet.

On the plain south of Sugar Creek records of several wells show a depth of 30 to 36 feet, but in the village of Annapolis the wells seldom reach 30 feet.

In the northwest part of the county, on the bluffs of the Wabash, wells are occasionally 50 feet in depth. One of these wells, a mile north of the mouth of Sugar Creek, at an altitude 150 feet above the Wabash River, has the following section:

	Feet.
1. Sand	8
2. Gravel	10
3. Sand	25
4. Blue till	5
Total	48

The amount of sand at this point is exceptional, though there is generally a narrow belt of sand along the immediate brow of the bluff.

At the village of Howard, on a terrace 80 feet above the Wabash, wells obtain water near the bottom of the gravel at about 40 or 50 feet. At Lodi, on a lower terrace, 35 feet above river level, wells are obtained at 35 or 40 feet. Near West Union, also on a high terrace, wells obtain water at 75 feet, or about the river level.

At Montezuma an artesian well 1,707 feet in depth, situated on a terrace of the Wabash about 50 feet above the river, penetrates 128 feet of drift. Salt water was struck at a depth of 298 feet and at lower levels, and sulphur water at 1,205 feet. The water has a head at least 100 feet above the mouth of the well. The ordinary wells at Montezuma are usually obtained at a depth of about 60 feet in the gravel, but have a range from 30 feet to 70 feet.

At Bloomingdale wells are obtained at a depth ranging from 12 feet to fully 60 feet. Ordinarily the water-bearing sand and gravel is found beneath the yellow till at 10 to 16 feet. The deeper wells penetrate blue till. Sandstone is occasionally struck at about 50 feet.

On a morainic ridge near Marshall wells are usually obtained at 30 feet or less.

In the vicinity of Bellmore wells sometimes enter rock at about 30 feet. Usually water is obtained without penetrating the rock.

At Rockville, the county seat, there is no definite horizon at which wells are obtained, those on adjoining lots varying greatly in depth and in the character of material penetrated. The depth ranges from 15 feet to about 75 feet. Ordinarily wells reach the bottom of the newer drift at about 25 feet, and encounter considerable wood at that horizon. A gas-well boring located in the higher part of town penetrates 96 feet of drift. A well on the moraine just west of Rockville has 158 feet of drift, of which the upper 35 or 40 feet is newer drift and the lower 125 feet is the older drift. A well 2 miles southwest of Rockville, 92 feet in depth, penetrates a soft till 17 feet, beneath which is a hard till whose bottom is not reached.

The city of Rockville contemplates waterworks from deep wells bored in a valley east of the city. Two borings 260 feet in depth have been sunk for the purpose of obtaining a supply, but the supply scarcely seems adequate.

Wells along the morainic ridge on the east bluff of the Wabash River in the south part of the county have in several instances passed through a black soil below the newer till sheet at about the level of the base of the morainic ridge. The distance to the soil varies in the different wells with the variations in elevation of the ridge, and there is a known range from 17 to 75 feet. Often water is obtained at slight depth beneath this buried soil from the upper portion of the older drift sheet.

On the uplands west of Rosedale coal shafts penetrate 50 to 75 feet

of drift, mainly till and entirely in the older drift sheet. Wells are obtained in the village of Rosedale at depths of 12 to 25 feet.

In the southeastern part of the county coal shafts often encounter much sand and gravel in the lower portion of the drift at depths of 30 to 60 feet from the surface. Wells range in depth from 20 to 100 feet, but are usually obtained at less than 30 feet. Mr. Minchell's well, in section 30, Jackson Township, 62 feet in depth, penetrates—

	Feet.
1. Surface clay and till	15
2. Hard blue till	45
3. Sand with water	2
Total	62

A boring in section 24 of an adjoining township on the west, 96 feet in depth, penetrates—

	Feet.
1. Surface sand	17
2. Hard blue till	29
3. Sand and gravel	10
4. Hard blue till	16
5. Sand and gravel	4
6. Hard blue till	20
Total	96

PUTNAM COUNTY.

General statement.—Putnam County is situated in the west central part of the State, with Greencastle as its county seat. It has an area of 490 square miles. The southern portion of the county is moderately hilly, there being insufficient drift to fill the preglacial valleys. The northern portion, although nearly as elevated as the southern, has a comparatively smooth surface, a result of the greater amount of drift filling. The hilly southern portion of the county carries only the older drift sheet. The northern portion carries also the newer drift. The southern boundary of the newer drift passes from northwest to southeast across the central portion of the county, entering on the west about 10 miles from its north boundary and leaving the county on the east about 5 miles from its south boundary. The city of Greencastle is situated very near the border of this later sheet of drift. Both drift sheets are composed largely of till, but, as in Parke County, the older drift is much harder to penetrate than the newer. The thickness of drift in the portion where both sheets are present probably averages not less than 100 feet, though there are numerous places where the rock is entered at 10 or 20 feet or less. In the southern portion of the county, where only the older drift is present, the thickness on hills and ridges seldom reaches 20 feet, but in the valleys or lowlands it is much thicker and probably in some cases exceeds 100 feet. The wells in this portion of the county usually obtain water in the rock when on the hills and ridges, but when on lowlands they obtain water in the drift.

There are a few springs along the valleys, but they seldom constitute an important water resource.

Individual wells.—At Fincastle, in the northern part of the county, wells on the low ground find no rock at 30 feet, but south from this village on the higher ground rock is struck at 20 or 30 feet. In sec. 8, T. 15, R. 4 W., a well in a valley obtains a flow at 20 feet without entering rock.

In the vicinity of Bainbridge, on an elevated ridge, several wells reach a depth of 80 feet before entering rock. Two such wells are found in the village, one at a sawmill and the other just north of the railway depot. About a mile northeast of Bainbridge, on ground probably 40 feet lower, wells enter rock at a depth of 20 feet.

Records of several wells were obtained in the southwestern part of the county on nearly plane tracts outside the limits of the later drift sheet, which enter rock at about 20 feet.

On the hills in the southern part of the county wells drilled into the rock range in depth from 20 feet or less up to fully 100 feet. There is apparently no definite horizon at which water may be obtained. In the northern portion of the county wells are seldom drilled far into the rock before obtaining water.

HENDRICKS COUNTY.

General statement.—Hendricks County is situated in the central portion of the State, immediately east of Putnam County. Its county seat, Danville, is near the geographic center. It has an area of 400 square miles. This county was entirely covered by the ice at its later as well as its earlier invasion, and has in consequence a smooth surface, with the preglacial ridges and valleys almost concealed. A moraine of moderate proportions traverses the northwestern part of the county in a northwest to southeast direction, passing just west of the city of Danville. It fades away a few miles south of Danville into a gently undulating plain, where its continuation is traceable chiefly by the belt of bowlders which is an accompaniment of the morainic belt. The breadth of this moraine is 2 to 5 miles, being widest in the vicinity of Danville. Aside from this belt, the county has a gently undulating surface.

The drift is principally a compact till, though there are small areas in which it assumes a gravelly constitution. In its deeper portions also it often contains considerable sand and gravel. There are few places in which the writer was able to distinguish the older from the newer drift in this county, and it is thought that the greater portion of the drift belongs with the later ice invasion. In the southern portion of the county rock is often struck in wells at depths of 20 to 50 feet, but in the northern portion the rock appears to be buried to a depth of 100 to 150 feet.

Individual wells.—At North Salem, in the northwestern part of the county, records of two deep wells were obtained, one 70 feet, the other

85 feet, neither of which entered rock and both were mainly through blue till. Wells in that village are often obtained at about 20 feet.

At Lizton, and also at Brownsburg, in the northern part of the county, the wells are obtained at shallow depths, seldom so much as 40 feet. In the farming districts, also, wells are obtained usually at shallow depths. The great thickness of drift in the northern part of the county has been made known by gas borings, of which there are several.

At Plainfield, in the eastern part of the county, wells are usually obtained at 35 or 40 feet, though some are of less depth. Rock is struck in the gas boring at about 90 feet.

At Danville the waterworks obtains its supply from flowing wells 110 feet in depth, which do not reach the rock. A 3-inch well is estimated to furnish about 2,000 barrels per day. There are two 3-inch wells and two 2-inch wells in use. Private wells are obtained in Danville at about 40 feet. A well at the court-house penetrates—

	Feet.
1. Yellow till	15
2. Blue till	25
3. Sand and gravel	5
Total	45

The gas borings at Danville penetrate about 160 feet of drift.

At Clayton wells are obtained at 10 to 25 feet. They are mainly through till, but some have considerable sand and gravel.

At Amo wells 40 to 50 feet in depth do not reach rock. They usually penetrate about 25 feet of yellow till. On the plain north of Amo a blue till is struck at 10 or 15 feet.

At Coatsville wells are mainly through till to a depth of 25 or 30 feet without striking rock. A well 1 mile south of this village, however, enters rock at 8 feet.

At Reno two wells enter rock at about 25 feet, but several obtain water in the drift.

A well on an elevated point about 5 miles north of Reno strikes rock at 70 feet, but a neighboring well on lower ground does not strike rock at 90 feet. There are outcrops of rock along the creek in Sec. 29, T. 16, R. 2 W., in the neighborhood of these wells.

MARION COUNTY.

General statement.—Marion County is situated just south of the center of the State, with Indianapolis, the State capital, and also the county seat, near its geographic center. It has an area of 400 square miles. White River traverses the county nearly centrally from north to south. Throughout much of its course in the county it is bordered by a broad gravel plain, averaging, perhaps, 2 miles in width, though much narrower at the northern border. This gravel plain is underlain by till, and the entire county is covered thickly with a sheet

of compact till. In a few places rock is struck at 30 to 50 feet, but throughout much of the county the drift exceeds 100 feet, and in places is about 250 feet in thickness. In the southern and southeastern part the surface is more undulatory than in the northern and western part, swells 20 or 30 feet in height being numerous, while occasional ridges reach a height of 50 or 75 feet. This undulatory drift is continued on the east in a more sharply defined morainic belt, of which mention is made in the reports on Hancock, Henry, and Randolph counties. West from White River this belt is very poorly defined, and some uncertainty is felt concerning its line of continuation.

The dug wells in this county are often obtained at a depth of 10 to 20 feet, near the junction of the yellow and blue tills, where sand beds often occur. Tubular wells are usually sunk to much greater depth, and in nearly every township several may be found which exceed 100 feet. The great majority penetrate a large amount of blue till. The water appears to be obtained in comparatively thin beds of gravel and sand associated with the till.

Individual wells.—At the city of Indianapolis, which is situated on the gravel plain bordering White River, a large amount of water may be obtained near the base of the gravel at depths of 30 to 50 feet. As there is no overlying stratum of clay contamination is liable to occur. This fact being appreciated, many tubular wells, known as Rouse wells, have been sunk to depths ranging from 60 to 90 feet, and water is obtained in gravel beneath a sheet of blue till. The city waterworks obtains about three-fourths of the supply from wells. These wells obtain water both from the surface gravel and the deeper beds. The remainder of the water supply is obtained from White River, and is filtered before it is pumped to the mains. The waterworks company have sunk a number of deep wells with a view to obtaining a larger and better supply. Rock is entered at about 80 or 85 feet. The deepest well reported has a depth of 343 feet. From these deep wells water rises a few feet above the level of the water in White River. It is hard and contains some sulphur and also considerable iron. The mineral ingredients, however, are not considered objectionable.

The thickness of drift at several points in the county and the sections of a few borings have been obtained from gas companies. The Capital City Gas Company have several wells in the northeast part of the county which penetrate 140 to 230 feet of drift, of which a large part is blue till. There are, however, beds of sand and gravel which would afford an abundant supply for water wells. In the eastern part of the county the thickness of the drift at several villages is as follows: Oakland, 231 feet; Lawrence, 188 feet; Brightwood, 190 feet; Irvington, 130 feet; Cumberland, 230 feet. At Cumberland the drift is reported to consist of till, mainly of blue color, 50 feet, followed by

alternations of till with sand or gravel, each a few feet in thickness, 180 feet.

At Indianapolis the drift usually exceeds 80 feet, and in one well near the Union Depot reaches a depth of 118 feet. This well, which is located between Pine and Delaware streets, has the following section of drift:

	Feet.
1. Sand and gravel	45
2. Gray till	15
3. Alternations of till with sand and gravel	58
Total	118

A well about a mile south of the Union Depot, on Meridian street, enters rock at 80 feet. The drift section is as follows:

	Feet.
1. Sand	10
2. Till	25
3. Gravel, a few feet.	
4. Till, several feet.	
5. Quicksand, extending to the rock.	

At the waterworks borings, referred to above, a section of one well was obtained, as follows:

	Feet.
1. Sand and gravel	45½
2. Blue till	20
3. Sand and gravel	15
4. Limestone struck at 82 feet 7 inches.	

There was continuous limestone from this depth to the bottom of the well at 343 feet.

North from Indianapolis, in the vicinity of Broad Ripple, records of 30 wells were obtained, all located in the White River Valley, which show the drift to range from 45 feet to 90 feet. It is mainly sand and gravel, though thin sheets of till occur. Two wells in the valley, near Allisonville, have 70 feet of drift, mainly blue till. At Castleton, on the uplands east of White River, the drift is 78 feet, mainly till.

A gas boring in the west part of the county, at Bridgeport, has 100 feet of drift, as follows:

	Feet.
1. Creek alluvium	8 or 10
2. Alternations of blue till with sand	30
3. Quicksand	10
4. Blue till	40
5. Gravel and sand	10
Total	100

A well near Bridgeport penetrates 280 feet of drift, but an accurate section was not obtained.

At Glen Valley, in the southern part of the county, on the border of the White River gravel plain, records of two wells were obtained which are through sand and gravel to a depth of 53 and 56 feet. Wells are usually obtained, however, at less depth.

HANCOCK COUNTY.

General statement.—Hancock County is situated in the east-central part of the State, immediately east of Marion County, with Greenfield as its county seat. It has an area of 307 square miles. Like Marion County, it is covered thickly with a sheet of till. The southern half has an undulatory surface, with numerous swells 20 or 30 feet in height. The northern part has a nearly plane surface. The entire county has a gradual descent from east to west, the altitude at the eastern border being about 1,000 feet, while at the western it is scarcely 800 feet above tide. In this county, as in Marion, dug wells may usually be obtained at 10 to 20 feet at the junction of the yellow and blue tills. Tubular wells are usually 50 to 100 feet or more in depth.

Individual wells.—In the vicinity of Greenfield wells usually obtain a good supply of water at about 30 feet below a bed of till. The waterworks wells are sunk to the rock, near the top of which they obtain water at a depth of 176 feet. In these wells the water rises a few feet above the surface, and an 8-inch well is estimated to furnish 150 gallons per minute.

At the village of Philadelphia wells are usually obtained at about 20 feet after penetrating yellow till and a few feet of blue till.

In the vicinity of New Palestine, in the western part of the county, wells are usually obtained at 25 or 30 feet. The gas-well boring at this village penetrates 285 feet of drift.

At McCordsville, in the western part of the county, wells are usually obtained at depths of 40 feet or less. The drift at this point is 186 feet, mainly till.

In the eastern part of the county wells in the villages are usually obtained at about 20 feet, but on farms tubular wells are often sunk to much greater depth. Several gas-well borings in this part of the county penetrate about 200 feet of drift, mainly blue till.

HENRY COUNTY.

General statement.—Henry County is situated in the eastern part of the State, with Newcastle as the county seat. It has an area of 400 square miles. A moraine traverses the county from southwest to northeast (passing west and north of the city of Newcastle), which constitutes the divide between the West White and East White rivers. In the northeastern part of the county it is a prominent feature, with sharp knolls and ridges, in some cases 50 to 75 feet or more in height, among which are winding sloughs and shallow basins. In the western and southwestern part of the county the expression of the moraine is more subdued. From this moraine there is a rapid descent to the northwest; but eastward from the moraine the surface continues elevated and has an altitude 1,000 to 1,100 feet above tide. On the eastern border of the county there is a moraine with gently undulating

surface which constitutes the divide between the East White and the Whitewater River system. There is also a small moraine leading south from the central part of the county, along the border of Flat Rock Creek. Between these moraines there are plane tracts with slightly lower elevation than the morainic ridges. The northwest corner of the county is also a plain.

This county has, perhaps, the thickest drift to be found in the State, one well near Newcastle having penetrated 500 feet before striking rock and one at Cadiz more than 400 feet. The drift of this county, as in the counties to the west, is largely composed of a compact blue till.

Individual wells.—The general depth of wells in this county is no greater than in the counties with lower elevation on the north and west, there being usually an adequate supply of water at 20 to 40 feet. In a few places, water not being abundant, tubular wells have been sunk to depths of 100 feet and occasionally 200 feet, or even more.

At Newcastle the private wells range in depth from 12 to 50 feet, the majority being about 20 feet. The waterworks wells sunk in the valley of East White River range in depth from 90 to 250 feet and are obtained in all cases in gravel, associated with sheets of till. One of the shallower waterworks wells is reported to have the following section:

	Feet.
1. Clay	10
2. Gravel	15
3. Quicksand	25
4. Blue clay	31
5. Gravel	2
6. Hard till	7
7. Coarse gravel, with water at bottom.	
Total	90

The waterworks wells have a head about 20 feet above the surface. Analyses of the water from two of these wells are given elsewhere.[1] Gas-well borings in the vicinity of Newcastle show 300 to 500 feet of drift on the borders of the East White River Valley, but on the upland plain east of Newcastle, at an elevation of 75 feet or more above the valley, rock is struck at about 250 feet.

At Moreland, in the northeast part of the county, in the valley of Flat Rock Creek, the drift is 150 feet, largely till, but a bed of gravel at about 90 feet furnishes a flow of water.

At Mount Summit, in the northern part of the county, on an elevated part of the moraine, the drift is shown by a gas-well boring to be 235 feet, mainly sand and gravel. At Springport, on the north slope of the same moraine, the drift is 170 feet and is largely till. Two miles north of Springport rock is struck at 156 feet.

At Luray a boring for water 240 feet did not reach rock.

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, p. 499.

At Honeycreek station, on the plain in the northwest part of the county, the drift exceeds 200 feet, and at Sulphur Springs is about 250 feet. At Middletown, in the extreme northwest corner of the county, a boring on the upland plain, north of Fall Creek, enters rock at 203 feet. The drift is mainly sand and gravel. About 2 miles south of Middletown a gas boring penetrated more than 200 feet of drift and passed through a log near the bottom. A well in Fall Creek Valley, at Middletown, strikes rock at 160 feet. A flow of water was obtained at 82 feet. In this well also logs were penetrated at a depth of about 75 feet.

At Cadiz, on the moraine in the west-central part of the county, a gas boring penetrates 421 feet of drift. About midway between Cadiz and Newcastle, on a plain east of the moraine, the drift is 303 feet. At Greensboro, about 5 miles below Newcastle, in the East White River Valley, rock is struck at less than 200 feet, and outcrops of rock occur farther down the river in the vicinity of Knightstown. At Kennard, in the west part of the county, a gas well penetrates 247 feet of drift, consisting of alternations of till with gravel and sand.

In the village of Knightstown private wells are usually obtained at a depth of 20 to 40 feet in gravel beds below clay. The waterworks wells are obtained near the top of the limestone, at a depth of 57 and 58 feet.

At Ogden, 5 miles east of Knightstown, the drift is 154 feet, of which the upper 20 or 30 feet is sand and gravel and the remainder till.

In the vicinity of Spiceland, on a plain east of White River, the drift ranges in depth from 90 feet up to 150 feet, and is largely till.

In the vicinity of Dunreith, on the south border of the county, the drift ranges from 160 to 215 feet, the greatest depth being found in a well 1 mile northwest of the village.

At Lewisville, on the border of Flat Rock Valley, 247 feet of drift is penetrated, mainly sand and gavel.

WAYNE COUNTY.

General statement.—Wayne County is situated on the east border of the State, with Richmond as its county seat, and has an area of 380 square miles. Like the bordering counties on the north and west, its altitude is high. Its general elevation falls but little below that of Randolph County, the highest county in the State. At the north boundary, near the Randolph County line, the elevation is 1,150 to 1,200 feet or more. The northern one-third of the county probably has an average altitude of not less than 1,100 feet. There is a gradual southward descent across the county, and its south border is slightly below the 1,000-foot contour, except perhaps for a few miles near the State line.

Several drainage lines, having remarkably large valleys, traverse

the county in a general north to south direction, among which may be mentioned Nettle Creek, West Fork, Martindale Fork, Greens Fork, and Nolands Fork, all of which unite to form the West Whitewater. A profile across the county from west to east, in its northern part, oscillates 100 to 150 feet in crossing these valleys and the ridges which separate them. The valleys or troughs are larger than the present stream channels, for the immediate bluffs rise but a few feet above the stream beds. These troughlike valleys are cut in a sheet of old drift, over which a thin sheet of later drift has been spread, a sheet whose southern boundary is found in counties immediately south. Along the eastern part of the county the rock has a higher general elevation than in the central and western portion, and here the principal drainage line, East Whitewater, has a postglacial channel partly excavated in the rock. With the exception of the southeastern part of the county the drift deposits are generally 150 to 200 feet or more in thickness.

There are extensive gravel plains in the western part of the county, bordering the valleys of Nettle Creek, West Fork, and Martindale Creek. For a few miles above the mouth of Martindale Creek, at Cambridge City, the gravel plain occupies the entire interval between West Fork and this stream, but in the northern portion of the county the valleys are separated by a ridge of till. Narrow, gravelly belts occur also along Greens Fork and Nolands Fork, but they seldom reach a width of a mile. These gravel deposits are apparently the outwash from the ice-sheet at the time it formed the strong moraine at the headwaters of these streams in southern Randolph County. On these gravel plains wells are usually obtained at about the level of the streams, 20 to 40 feet. On the uplands between these gravel plains the drift usually consists of till, and wells are obtained at moderate depths, seldom more than 40 feet.

Individual wells.—At Hagerstown, in the northwest part of the county, flowing wells are obtained in the valley of Nettle Creek at a depth of about 80 feet. They are largely through gravel, but penetrate a bed of till just above the water vein. In eight gas borings made in the vicinity of Hagerstown, along the valley of Nettle Creek, the drift has an average depth of about 100 feet. The least distance to rock is 78 feet.

At Williamsburg, in Greens Fork Valley, in the north part of the county, wells are obtained at 18 to 25 feet, mainly in gravel. At Fountain City, in the valley of Nolands Fork, wells are obtained at similar depth. A gas boring at Fountain City penetrates 185 feet of drift.

At Richmond wells are obtained at from 12 to 40 feet. In a few instances water is obtained in the drift, but usually the wells enter the limestone. The city water supply is obtained from springs. Professor Dennis, chemist of Earlham College, reports that the waterworks supply and also water from the river is of excellent sanitary

quality, but he has found by analysis that the wells contain 10 to 30 times as much chlorine as is found in the river water above the city, and he states that more or less malaria constantly exists where wells are used.

At Centerville, near the valley of Nolands Creek, a gas-well boring penetrates 176 feet of drift, mainly blue till. Ordinary wells are obtained at 30 or 40 feet, more or less. Another gas boring is reported by Dr. Phinney to have about 250 feet of drift, with a flow of water at 246 feet.

At Cambridge City, in the valley of West Whitewater River, wells are usually obtained in gravel at 15 to 25 feet. Two gas-well borings at this city enter rock at about 100 feet. After passing through 15 or 20 feet of gravel the drift is mainly blue till.

On the uplands east of the West Whitewater, in the southern part of the county, water wells in some cases reach a depth of 80 feet without striking rock. On the uplands west of this stream, gas-well borings have shown the drift to have a thickness of 150 to 300 feet, the greatest thickness noted being found in the village of Dublin. There are, however, outcrops of rock along the Whitewater, in the vicinity of Cambridge City, showing that the rock surface has a variation of fully 200 feet within 1 or 2 miles of that city.

On a plain south of Richmond, in the southeast corner of the county, wells have, in some instances, been sunk to a depth of 60 feet through till without entering rock. As a rule, however, rock is found in that part of the county at 50 feet or less, and over quite extensive areas it has outcrops nearly as high as the bordering upland.

Dr. Phinney reports the drift in a gas boring at Dalton, in the northeast corner of the county, to be 275 feet and at Walnut Level, in the western part, 280 feet. At Washington, near the center of the county, it is 212 feet.

UNION COUNTY.

General statement.—Union County is situated on the east border of the State, between Wayne and Franklin counties, with Liberty as its county seat, and has an area of 170 square miles. Its western part is traversed from north to south by the East Whitewater, which occupies a rather broad valley 100 feet or more below the adjacent upland on the east and west. The eastern part of the county is nearly plane. The drift filling is sufficient to give a smooth surface to what would otherwise be a hilly district. Although rock is often struck at depths of 20 to 40 feet where ridges or preglacial uplands occur, it is apparently buried to a depth of 200 feet or more in the larger valleys. The greater part of the drift is a compact till, but wells are usually obtained at convenient depths in beds of sand or gravel associated with it. They rarely exceed a depth of 50 feet and are usually less than 25 feet.

Individual wells.—A few tubular wells in the eastern part of the county reach depths of 50 to 90 feet and penetrate—

	Feet.
1. Yellow till	10 to 12
2. Blue till	40 to 80

At Bechy Mire, in the northeast part of the county, a well at Mr. Lybrook's is reported to have entered a hard yellow till below a soft blue till at a depth of 33 feet. A well 3 miles southeast of Liberty enters a hard yellow till below soft blue till at a depth of 35 feet. A well at the Pyle House, in Liberty, passes through a bed of swamp muck, with leaves below blue till at a depth of 35 feet. Beneath the muck, sand was penetrated, in which water was obtained at 52 feet. At Joseph Coffman's, 2 miles south of Brownsville, a well passes through a bed of swamp muck below gravelly drift at 20 or 30 feet. It seems probable that the swamp muck and the hard yellow till, found in the four wells just mentioned, pertains to a drift sheet much older than the overlying drift.

At Liberty water is usually obtained at 30 to 45 feet in sand and gravel below till. At the waterworks a supply is obtained at a depth of 21 feet in sand below clay. A partial analysis shows the presence of chlorine in sufficient amount to indicate that the water may be contaminated, and suggests the advisability of obtaining water from a better source. The drift at Liberty is 60 to 90 feet in depth and is underlain by a limestone which is likely to yield an abundance of water at convenient depths.

There is a flowing well about 3 miles southeast of Liberty, on Mr. Bratton's farm, 42 feet in depth, from sand below till.

In the extreme southeast part of the county rock is struck at 5 to 20 feet. Wells in the vicinity of Lotus, 35 or 40 feet deep, do not enter rock; they are mainly through till.

FAYETTE COUNTY.

General statement.—Fayette County is situated in the eastern part of the State, with Connersville as its county seat. It has an area of 210 square miles. It is traversed nearly centrally from north to south by the broad valley of the West Whitewater River, which carries a gravel plain 1 to 2 miles in width. At the later ice invasion there was a reentrant angle in the ice sheet in southeastern Indiana which had its northernmost point in the Whitewater Valley, in southern Fayette County. The boundary at this later invasion is marked by a well-defined though not bulky morainic ridge. The ridge formed on the western side of the reentrant angle enters Fayette County from southeastern Rush and northwestern Franklin counties and passes northward, coming to the Whitewater Valley about 4 miles below Connersville. Here it meets the ridge formed on the east side of the reentrant angle, and from that point northward an interlobate moraine

was formed which extends northward into Wayne and Henry counties. Through the midst of this interlobate moraine the Whitewater River has its passage. On either side of the Whitewater, in the south part of the county, there is a small district in which the newer drift is absent, and a coating of white clay or silt several feet in thickness covers the till of the earlier invasion. Here, as has been noted in other counties of Indiana, the older drift sheet is much more highly oxidized and harder than the newer sheet. In the newer drift wells may be easily spaded or bored, while in the older drift a pick or drill must often be used.

Rock is seldom encountered on the uplands of this county at less than 50 feet, and there appears to be generally 100 feet or more of drift. The drift consists mainly of a compact till, though wells are usually obtained in sand or gravel associated with the till at depths of 35 feet or less.

Individual wells.—At Connersville the water vein is found in gravel at a depth of about 30 feet near the level of the Whitewater River. Below this depth till is often found under which there is a water-bearing gravel at a depth of 60 to 80 feet from the surface. There appears to be danger of contamination in the shallower wells, but the deeper wells are thought to be free from such contamination. The city waterworks obtain the supply from the Whitewater River, but the domestic use is mainly from wells.

A few records of farm wells were obtained both on the east and west of the Whitewater Valley. The deepest one, near Alquina, is only 43 feet, the others range from 30 feet down to 20 feet. In nearly all the wells till constitutes the main part of the section. It is probable that those located on the newer drift are not sufficiently deep to reach the older sheet of till.

RUSH COUNTY.

General statement.—Rush County is situated in the eastern part of the State, with Rushville as its county seat, and it has an area of 414 square miles. It has a nearly plane surface, though a small moraine crosses its southeast corner and another one traverses its western half from north to south, following the west border of Flat Rock Creek. There is a general southwestward descent, the altitude in the northeast corner being nearly 1,100 feet, while the southwest corner falls below 900 feet. The drift is composed mainly of till, though the lower part is frequently sand and apparently has an average thickness of fully 100 feet. The county has been covered entirely by the later ice invasion as well as by the earlier one. The extreme limits of the later invasion are, however, just outside the southeastern border of the county, at the moraine above noted. Along Flat Rock Creek, in the northern part of the county, there is a gravel plain covering several square miles, which lies immediately outside and

southeast of the moraine referred to above, and is, in all probability, an outwash from it. There is also a gravel plain along East White River, in the northwest part of the county, probably formed from the moraine situated on its west border.

Individual wells.—In the vicinity of Raleigh, on the gravel plain in the north part of the county, several flowing wells have been obtained at depths ranging from 65 to 106 feet. They have a head 3 to 6 feet above the surface. The water is obtained from gravel below a sheet of till, but the wells penetrate a large amount of surface gravel before entering the till.

Along the moraine in the northern part of the county and on the plain west of it wells usually enter sand below till at 12 to 25 feet. In some cases the wells have been sunk some distance into sand before obtaining water. At Hamilton Station one well penetrates 92 feet of sand.

Near Carthage, in the northwestern part of the county, on the gravel plain along East White River, rock is sometimes struck at a depth of 50 feet, and the drift is mainly gravel. At Arlington, in the western part, wells are usually obtained in sand below till at a depth of 20 to 30 feet.

At Homer the drift is mainly sand after penetrating a few feet of surface till, and water is obtained at 20 feet or less. The gas well enters rock at 53 feet.

A gas well 7 miles north of Rushville penetrates 147 feet of drift—mainly sand, 92 feet; blue till, 55 feet.

At Rushville a gas well near the school building penetrated 60 feet of drift, mainly till. Water wells at Rushville are obtained at depths ranging from 14 to 75 feet. Several flowing wells have been obtained from the drift in and near the city along the valley of Flat Rock Creek. They are strongly chalybeate and also sulphurous.

At Glenwood, near the eastern border of the county, a gas well penetrates 120 feet of drift, of which the upper 60 or 70 feet is till and the remainder sand and gravel. Wells are obtained in the vicinity of that village at depths of 20 feet or less, though an occasional tubular well is sunk to the underlying heavy bed of sand.

At New Salem, in the southeastern part of the county, wells are obtained in sand below till at 40 or 50 feet.

Along the morainic ridge in the extreme southeastern part wells in some cases are sunk to a depth of 60 feet, mainly through till.

Along the southern border rock ledges appear in the bluffs of streams at 20 to 40 feet below the level of the bordering uplands, but wells usually obtain water without entering the rock.

SHELBY COUNTY.

General statement.—Shelby County is situated southeast of the center of the State, with Shelbyville as its county seat, and has an area of 400 square miles. The eastern part is more elevated than the western, but has a generally plane surface, the only morainic development being a small ridge in the southeast corner. The western part has a more diversified surface, produced in part by morainic ridges and in part by channels which were formed apparently prior to the deposition of the moraines and their associated gravel outwash, and which have been in part filled by the outwash from the moraines. The eleventh annual report of the State geologist contains a map which outlines the distribution of the several channels. The map is somewhat misleading in that it represents the island-like areas between these channels to be highland. The altitude is, in fact, only a few feet above the channels, seldom more than 25 feet, except in the case of a morainic ridge in the southwest part of the county, which has points standing fully 100 feet above the bordering channel. The full interpretation of the drainage history of this region has not been made, but it seems probable that considerable erosion of the drift plain had occurred during a retreat of the ice and that subsequently the ice invaded the western half of the county, blocking up portions of the channels, either by morainic accumulations or an outwash of gravel from the ice margin. In the vicinity of Fairland and to the northeast from that village the moraine graduates into a gravelly plain on its east border, and this gravelly plain slopes downward into one of the channels represented on the map accompanying the Indiana report. Well sections are given below, which show the amount of filling these channels have received by this outwash from the ice sheet. The morainic features on the west border of the county are of a strong type only in the southwest township, where the ice margin appears to have made an abrupt curve to the west. The sharp moraine was apparently formed because of this nose-like projection of the ice sheet.

The drift of the uplands in the eastern part of the county is composed largely of till and has a depth of 50 feet or more, if we may judge from outcrops of rock and occasional gas borings. The water wells are usually obtained without entering rock, there being beds of sand or gravel associated with the till. In the western part there appears to have been a preglacial basin with a rock surface much lower than that of the eastern portion of the county. This has been filled to a depth of perhaps 150 feet by the drift deposits, and the preglacial reliefs thus greatly obscured. The well sections given below will serve to illustrate the variability of the drift structure.

Individual wells.—Gas wells in the northwestern part of the county penetrate 150 to 200 feet of drift, of which the greater part is till.

The water wells of that region are usually obtained at depths of 15 to 50 feet, but occasionally reach a depth of 100 feet.

Wells on the gravel plain along East White River, above Shelbyville, have in several instances reached the bottom of the gravel and entered till at a depth of 25 or 30 feet.

The gravel plain along Brandywine Creek, east and northeast from Fairland, carries about 30 feet of gravel, beneath which is a sheet of till.

In Fairland the wells in the north part of the village penetrate 15 to 25 feet of till, at which depths they enter a water-bearing gravel. The southeast part of the village extends into the gravel plain, and wells there are obtained at similar depths without penetrating till.

Along Big Sugar Creek, west and southwest from Fairland, wells sometimes penetrate 50 or 60 feet of gravel without encountering till.

In an abandoned valley leading southward from East White River at Shelbyville to Lewis Creek and thence to Flat Rock, a valley which is generally termed the Slough, the gravel is 35 feet or more in depth and is underlain by till.

Along Flat Rock Creek, in the southern part of the county, wells are usually obtained at 10 to 20 feet.

On a morainic ridge near Mount Auburn, on J. M. Collins's farm, a well 108 feet in depth had the following section:

	Feet.
1. Sandy yellow till	20
2. Blue till	80
3. Sand and gravel	8
Total	108

Two other wells near Mount Auburn enter rock at 50 feet. On a plain north of Mount Auburn, known as "The Flat," in sections 4 and 9, Jackson Township, till is entered below gravel at a depth of 10 or 15 feet, and wells are in some cases obtained at 30 feet.

The following well sections of drift near Manilla are obtained from the eleventh report of the State geologist. Jacob Henry's well penetrates—

	Feet.
1. Soil	3
2. Loamy yellow clay	7
3. Loamy sand	10
4. Bowlder clay, blue	47
5. Fine quicksand	3
6. White sand	1
7. Gravel and sand	2
Total	73

The water rises within 1 foot of the surface.

On the adjoining farm of Arbuckle & Mills a well reaches a depth of 122 feet, penetrating—

	Feet.
1. Soil	2
2. Clay	33
3. Quicksand	3
4. Blue clay	5
5. Clay and gravel	2
6. Bowlder clay	17
7. Sand and gravel	3
8. Blue bowlder clay	57
Total	122

From the same report the following section of the boring on the farm of J. M. Collins, given above in somewhat different form, is obtained:

	Feet.
1. Soil	4
2. Yellow clay	6
3. Sandy clay	10
4. Bowlder clay	80
5. White sand	1
6. Sand and gravel	7
7. Limestone at bottom.	
Total	108

The bottom is estimated to be 50 feet below river level.

At Waldron, in the southeast part of the county, the drift is in places 80 feet in thickness, as shown by gas borings. A water well in the village is reported to have entered rock at 53 feet. It penetrates—

	Feet.
1. Yellow till	10
2. Sand and gravel	14
3. Gray till	28
4. Sand	1
5. Rock, thought to be sandstone	3
Total	56

At St. Paul the drift varies from 15 feet or less to nearly 100 feet in depth. The following depths are reported in gas-well borings: In No. 1, 17 feet; in No. 2, 87 feet; in No. 3, rock at surface; in No. 4, 16 feet; in No. 5, 23 feet. Water wells range in depth from 15 to 90 feet.

At Cynthi Ann, in the east part of the county, wells are usually obtained at 10 or 12 feet on level tracts, but on drift knolls in the village they reach a depth of 25 or 30 feet, and are mainly through till.

In the portion of the county northeast from Shelbyville wells range in depth from 10 to 50 feet or more, and are mainly through till.

Mention is made in the eleventh report of the State geologist of two wells in this county having water of exceptionally high temperature.

One in the east part of Shelbyville, 24 feet in depth, is reported to maintain a constant temperature, winter and summer, of 76° F. The other well, located 4 miles west of Shelbyville, is said to have increased in temperature after it was made, the water becoming too warm for drinking purposes, its temperature having reached 65° F. A pipe was driven in the bottom of the well to a depth of 16 feet, or 39 feet from the surface. The water was then found to have a temperature of 80°, and during that winter increased to 86° F. As these wells were excavated for potable water only, they have been filled.

JOHNSON COUNTY.

General statement.—Johnson County is situated in the south-central part of the State, with Franklin as its county seat, and has an area of 320 square miles. The greater part of the surface is plane, but there are morainic ridges of moderate strength traversing the county. One, which crosses the northern tier of townships from west to east, is known as the Greenwood moraine, the village of Greenwood being situated upon it. It is a belt but 1 to 2 miles in width, and has a relief of only 25 to 50 feet above bordering plane tracts. Another belt leads diagonally across the county from its northwest to its southeast corner, passing west and south of the city of Franklin. This moraine has a width of 2 to 5 miles, and varies greatly in strength. It is, on the whole, a less definite ridge than the one in the north part of the county. It has, however, numerous sharp knolls rising 25 to 40 feet, and occasionally 60 feet, above border tracts. From this morainic belt a small one leads off to the east just south of Franklin. It is scarcely a mile in average width, and has a relief of 20 to 40 feet. There is another moraine on the south border of the county, which is low and inconspicuous in the eastern part, but in the western part becomes a prominent, sharp ridge, with a relief of about 75 feet. This ridge, it is thought, belongs to the earlier ice invasion. The other moraines were formed during the later ice invasion. The southwestern part of the county appears to lie outside the limits of the later invasion.

The drift consists largely of a compact blue till, though the sharpest knolls are usually gravelly. There are gravelly plains in the southeastern part of the county, bordering the East White River, which are intimately associated with the morainic tract of that region as an outwash. In some cases deep wells have shown a large amount of sand or gravel in the lower part of the drift. The thickness of the drift probably averages 200 feet. A basin of Devonian shale which occupied the eastern and northern part of the county has been filled about to the level of the bordering rim on the southwest. The drift of the southwest part of the county is thinner than in the remainder, and wells occasionally enter the rock at depths of 20 to 60 feet. In the remainder of the county wells very rarely reach the rock. Water

is usually obtained at 40 feet or less in the dug wells and 40 to 100 feet in the tubular wells in beds of sand or gravel associated with the tills.

Individual wells.—At Greenwood, in the northern part of the county, the dug wells have a depth of but 12 to 30 feet. Tubular wells range in depth from 30 feet up to 100 feet or more. The best supply of water is obtained at 20 to 60 feet. A well at the Greenwood Sanitarium, 60 feet in depth, has sufficient head to bring the water nearly to the surface. Two wells at the fruit cannery have depths of 85 and 108 feet. The supply is from gravel a few feet in thickness in each well, but is inexhaustible. The village is making arrangements for waterworks supply from wells of this class. The Greenwood Sanitarium uses the water from two gas-well borings. The drift in these borings is 210 feet, and is largely till.

At Franklin the city water supply is obtained from driven wells 40 to 60 feet in depth. There is a small amount of surface gravel, but they are mainly through till. There are a few shallow wells 10 to 20 feet in depth obtained above the till. A well at the court-house is 80 feet, and several other wells in the city are 100 to 115 feet. Several flowing wells have been obtained in the north part of the city, on a tributary of Youngs Creek, at a depth of 40 to 45 feet. At the railway water tank in Hurricane Creek Valley a well obtains a flow of water at 30 feet. One flowing well in the southern part of the city is 90 feet in depth. Some of these wells cease to flow in dry weather. A gas-well boring in Franklin, 1,140 feet in depth, penetrates 170 feet of drift, as follows:

	Feet.
1. Till, yellow and blue	45
2. Sand	20
3. Blue till, with thin sand and gravel beds	105
Total	170

There is much water at 90 feet. There was also a flow of water from limestone at 205 to 210 feet. A well at the Baptist College, 114 feet in depth, penetrates—

	Feet.
1. Sand and gravel	18
2. Blue till	40
3. Fine sand	3
4. Blue till	50
5. Gravel	3
Total	114

Wells along the drift ridge south and east from Franklin usually penetrate 40 feet of till, beneath which water is obtained at a depth of 50 to 60 feet.

In the vicinity of Union Village wells are obtained at 30 to 75 feet in gravel beneath blue till.

A well on the slope of Donnell Mound, near Franklin, 40 feet above base, is mainly through gravel and sand to a depth of 50 feet.

A well at a schoolhouse in sec. 7, T. 12, R. 3 E., 95 feet in depth, penetrates 60 feet of drift, mainly till, beneath which is shale.

A well at Mr. Collins's, sec. 15, T. 13, R. 3 E., enters rock at 20 feet. A well at Mr. Wilkes's, section 14, in the same township, 40 feet in depth, does not reach rock.

At Williamsburg wells 20 to 50 feet in depth are mainly through blue till.

Wells in sec. 29, T. 11, R. 4 E., 20 to 40 feet in depth strike no rock. Wells in secs. 33 and 34, T. 11, R. 3 E., enter sandstone below till at about 20 feet.

Near Nineveh, in the southwest corner of the county, wells are 25 feet or more in depth, mainly in yellow till.

At Edinburg, in the southeast corner, wells are obtained at 25 to 60 feet, the usual depth being 30 to 40 feet. They are mainly through gravel; the city waterworks are supplied from such wells. At a gas boring in Edinburg 115 feet of drift was penetrated; the boring is 1,580 feet in depth. The salt water struck near the bottom rises within 80 feet of the surface.

MORGAN COUNTY.

General statement.—Morgan County is situated in the west-central portion of the State, with Martinsville as its county seat, and has an area of 430 square miles. Along the eastern and northern borders of the county the drift is heavy and the surface plane or but slightly hilly. In the central, southern, and western portions the surface is hilly and broken and the drift deposits thin. White River traverses this hilly district in a valley $1\frac{1}{2}$ to 2 miles in width and 150 to 200 feet in depth. Its broad valley is filled with drift deposits to a depth of about 100 feet. Indian Creek, an eastern tributary entering near Martinsville, also has a broad valley deeply filled with drift.

The northern part of the county was covered by the ice at its later invasion, but the remainder appears to have been covered only at the earlier invasion. The glacial boundary is but a few miles south of the county limits, in northern Brown and northern Monroe counties. A prominent morainic ridge is found in this older drift, leading from Martinsville southeastward past Morgantown into Johnson County. Its relief in places is 75 to 100 feet, and being scarcely a mile in width, it is a conspicuous feature. This ridge, together with the remainder of the earlier drift sheet, is covered by a pebbleless clay or silt several feet in depth, which passes under the later sheet of drift. That sheet has till and bowlders at its surface.

On the elevated portions of the county there is seldom sufficient drift to afford water for wells. They are, therefore, sunk into the rock, and the depth varies considerably even in neighboring wells. Some are obtained at but 20 or 30 feet, while others are sunk to a

depth of 75 to 100 feet or more. On the lower parts of the county and along the valleys, the drift being heavy, wells are usually obtained without entering the rock, at moderate depths, seldom more than 40 feet. Occasional tubular wells, however, are sunk to depths of 75 to 100 feet or more.

Individual wells.—In the northwest part of the county there is a very level tract, known as "The Lake," which borders Mill Creek Valley, and extends eastward nearly to Monrovia. Wells on this plain are 10 to 30 feet in depth. They usually penetrate a few feet of sand at the top and beneath this a sheet of till before entering the water-bearing sand. Wood is sometimes found at the junction of the sand with the till.

At Monrovia wells usually obtain water at a depth of about 20 feet, in sand below till. One well, however, at David Miller's, near the public school building, is 118 feet in depth, mainly blue till. Wells on the border of the uplands, south and southwest of Monrovia, occasionally obtain water at 20 to 30 feet without entering rock. The majority, however, are sunk a short distance into the rock.

Wells on the morainic ridge east and southeast from Martinsville are in some cases 50 feet in depth. Some wells are largely through sand and gravel, others almost entirely through till.

At Morgantown, on the slope of the ridge, wells penetrate a surface clay and yellow till to a depth of 18 or 20 feet, beneath which there is often a blue till, though in some cases wells immediately enter a water-bearing gravel. Their depth ranges from 25 feet to 50 feet. Wells are obtained in drift for about 3 miles south from this village at depths of 30 feet or less.

In Martinsville the wells are usually dug to a depth of 20 or 30 feet through gravel. The city water supply is from a large well 30 feet in depth and 30 feet in diameter. There are a few flowing wells obtained in the northeast part of the city at depths of 40 to 75 feet. They penetrate a sheet of till below the surface sand and gravel. Several deep artesian wells have been sunk at this city, which furnish a soft sulphur water, which has a high reputation. Sanitariums have been built to accommodate the invalids who resort to these wells. Statistics concerning the wells and the character of the water are discussed elsewhere.[1]

OWEN COUNTY.

General statement.—Owen County is situated in the west-central part of the State, with Spencer as its county seat, and has an area of 390 square miles. The entire surface is hilly. In its eastern portion the hills are of limestone and in its western of sandstone. White River traverses its southeastern part in a valley very much narrower than the portion immediately above in Morgan County, the width being seldom so great as one-half mile. The highest parts of the

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, pp. 490-491, 498, 541.

uplands stand about 300 feet above the valley, but the immediate bluffs rise only 100 to 150 feet. The stream is in places in a new course and has its bed upon the rock, while in other places it is flowing on a drift filling 100 feet in depth. The drift deposits vary greatly in thickness, there being on many of the hills scarcely a trace of drift, while in one valley it has a known thickness of 250 feet. This county lies outside the limits of the later ice invasion, but it was almost entirely covered by the earlier invasion. Possibly the extreme southeast corner has escaped glaciation. The drift is variable in structure, some of the heaviest deposits being made up largely of gravel and sand, while neighboring localities are covered with an unmodified till. But little attention was given the depth of wells in this county, except at the three principal towns, Spencer, Gosport, and Quincy.

Individual wells.—At Spencer, the county seat, wells are obtained at various depths, ranging from 25 to 80 feet, with an average of perhaps 40 feet, at which depth they reach the level of the water in White River. Three artesian wells have been sunk at this city, descriptions of which, together with a water analysis, are presented in another report.[1] The drift at these wells is 90 to 97 feet in thickness.

Gosport is situated on the bluff of White River, and obtains wells at depths of 25 to 100 feet or more. Wells being difficult to obtain in some parts of the village, cistern water is substituted. An artesian well has been sunk in the valley to a depth of 926 feet, and obtains sulphur water similar to that at the neighboring cities of Martinsville and Spencer. No use is as yet made of the water, except by a few of the residents who prefer it to the hard water of the shallow wells.

The village of Quincy is situated in a lowland, probably an abandoned valley. The wells are 20 to 30 feet in depth, largely through a sandy drift. The water is said to stand within 5 to 10 feet of the surface.

Many springs are found along the bluffs in this county, which are utilized quite extensively by residents, and also resorted to by the stock.

CLAY COUNTY.

General statement.—Clay County is situated in the western part of the State, with Brazil as its county seat. Its area is 360 square miles. The greater part has a nearly plane surface, but the extreme eastern portion is hilly. The plane portion is underlain by the Coal Measures shales and soft sandstone, while the hilly portion is underlain by a hard sandstone. The drift is generally thin, rock being entered at the majority of the coal shafts within 20 feet of the surface. In the northern part of the county, however, the thickness is greater. There is probably also a deep filling along the valley of Eel River and also in other valleys. The drift is, in the main, a compact till, and in much of the county does not afford an adequate water supply. Wells

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, pp. 492, 499.

are therefore frequently drilled into the underlying Coal Measures strata, where an abundant supply is usually obtained at moderate depth—50 feet or less. There is a white clay or silt several feet thick covering the till throughout the county.

Individual wells.—At Perth, in the northern part of the county, wells are obtained in sandy beds between the yellow and blue till at a depth of about 15 feet. A boring for coal at this village penetrates 65 feet of drift, of which the lower 50 feet is till. A boring near this village in section 3 penetrates—

	Feet.
1. Surface clay	7
2. Sand and clay	8
3. Hard blue till	37
4. Sand and clay	11
5. Yellow till	4
Total	67

In a boring 80 rods north from the preceding the drift is 48 feet and consists of till, with the exception of 7 feet of sand at 30 to 37 feet.

At Carbon the drift is mainly till, and rock is usually struck at about 30 to 35 feet.

At Lena wells are usually 20 or 30 feet, mainly a hard blue till, and rock is not struck. A coal boring 1 mile west of Lena enters rock at 60 feet.

At Harmony the drift is about 30 feet in thickness, and wells are obtained near its base or in the upper part of the rock. At a coal shift between Knightsville and Harmony the drift is 60 feet in thickness.

At Knightsville the drift ranges in thickness from 12 feet up to about 50 feet. Wells are often obtained here at 12 to 20 feet in a sand below the surface clay.

At Brazil, the county seat, wells are usually obtained at about 20 feet, though they range in depth from 15 to 50 feet. The city waterworks are supplied from 8 driven wells, 20 feet in depth, the water being in a gravel beneath the surface clay. It is estimated that each well will yield 5,000 barrels per day. Rock is frequently struck in the vicinity of Brazil at about 20 feet, though there are several borings which penetrate 60 to 80 feet of drift. As a rule, the drift is a compact till.

In the central portion of the county the villages Asherville, Prairie City, and Saline City, obtain water in the upper part of the rock, the drift deposits being very thin, often less than 10 feet in depth. At Cory, in the west part of the county, the drift is about 40 feet, and wells are obtained without entering the rock.

At Bowling Green, in the eastern part of the county, wells enter a sandstone immediately below the soil and obtain water at various depths from 20 feet or less up to 60 feet or more.

In the southern part of the county, in the vicinity of Clay City, rock is usually entered at less than 20 feet and the majority of the wells obtain water near the surface of the rock.

VIGO COUNTY.

General statement.—Vigo County is situated on the west border of the State, with the city of Terre Haute as its county seat. It has an area of 410 square miles. The broad valley of the Wabash traverses its northwest part. This is bordered by a gravelly terrace nearly 5 miles in average width. West from the Wabash is a morainic belt, the continuation of the Shelbyville moraine of Illinois. This occupies perhaps half the upland on that side the river, and consists of a gently undulating or subdued morainic topography, with occasional sharp knolls 30 to 40 feet in height. The bordering uplands have a very plane surface. The moraine and the plain on the north lie within the limits of the Wisconsin or later drift, the moraine being the terminus of that drift. The uplands east of the Wabash are plane and are covered by the older drift sheet. This drift sheet is capped by a deposit of white clay several feet in thickness. On the immediate bluff of the Wabash, and in the northeastern part of the county, there are sand dunes, probably drifted by wind from the Wabash Valley.

The uplands west of the Wabash have drift varying in thickness from 10 feet or less up to more than 100 feet. The drift on the uplands east from the Wabash is generally but 20 to 40 feet in depth. It is probable, however, that tributaries of the Wabash, now obscured by the drift, have a filling of more than 200 feet. In the Wabash Valley borings at Terre Haute show a thickness of 150 feet of drift, the rock floor being nearly 100 feet below the bed of the present stream. Wells are usually obtained in the drift at depths of 20 to 40 feet or less, there being very few deep wells in the county.

Individual wells.—In the sand-covered tracts in the northeast part of the county coal shafts penetrate from 5 to 30 feet of sand, beneath which they are mainly through till to depths of 75 or 100 feet, where rock is entered. Wells are obtained either near the base of the sand or in beds of sand or gravel associated with the till. One well in Fontanet, 54 feet in depth, penetrates—

	Feet.
1. Sand	7
2. Clay and till	47
Total	54

A coal shaft 1 mile north of Fontanet penetrates 90 feet of drift, as follows:

	Feet.
1. Sand	28
2. Till	16
3. Sand	1
4. Till	39
5. Sand	6
Total	90

Another shaft near Fontanet, in section 12, has a similar section,

except that the lower sand bed is wanting. A third shaft in that vicinity penetrates 72 feet of drift, of which the upper 30 feet is sand and the remainder a solid bed of till. A shaft in the extreme northeast corner of the county, on Mr. Southard's land, penetrates 72 feet of drift, as follows:

	Feet.
1. Surface sand	20
2. Till	44
3. Sand	8
Total	72

At Terre Haute the use of private wells is considered unsafe and has been largely discontinued. Water may be obtained at about the level of the river at 30 to 50 feet, but there is no clay bed or impervious stratum of sufficient thickness to prevent contamination. The public water supply is obtained from the Wabash River above the city. Sanitary analyses of the hydrant water, and also of water from several private wells, are presented in another report.[1] The analyses show that a part of the water in each of the wells has been contaminated with organic matter.

Several borings for oil have been made within the limits of the city of Terre Haute which penetrate 100 to 150 feet of drift. In all these wells sand and gravel appear to extend from the surface to the bottom of the drift. These borings are discussed at some length in the Twenty-first Annual Report of the Indiana Survey.

A well near the brow of the Wabash bluff, south of Terre Haute, in sec. 32, T. 11, R. 9 W., penetrated the following interesting series:

	Feet.
1. Surface clay	5
2. Yellow sand	3
3. Fossiliferous loess	4
4. Soil and sandy peat	3
5. Bluish sandy subsoil	5
6. Yellow till	3
Total	23

A similar section was observed in the road grading immediately east of Terre Haute, at the east bluff of the Wabash.

A well in the upland, in sec. 20, T. 12, R. 8 W., strikes rock at 21 feet, and a shaft in the same section enters rock at 15 feet.

A well in sec. 32, T. 10, R. 9 W., enters sandstone at 22 feet, after penetrating the following beds:

	Feet.
1. Brown surface clay	5
2. Loess	2
3. Black soil	1
4. Brown till	14
Total	22

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Part IV, pp. 543-544.

Mr. Kester's well, sec. 20, T. 11, R. 9 W., penetrates 70 feet of drift, mainly till. A well in section 21 of the same township is mainly through sand and gravel to a depth of 63 feet and does not reach rock.

Wells on parts of the Wabash terrace, in the south part of the county, enter rock within a few feet, but the greater part of the terrace is underlain by a heavy bed of gravel and sand.

FRANKLIN COUNTY.

General statement.—Franklin County is situated on the east border of the State, near its southeast corner, with Brookville as the county seat. It has an area of 400 square miles. This county is traversed nearly centrally by the West and main Whitewater rivers and its northern portion is crossed by the east Whitewater, the junction of the East and West Forks being at Brookville. These valleys are 300 to 400 below the level of the bordering uplands; and yet gas-well borings in the vicinity of Brookville and Cedar Grove show a filling of 100 to 180 feet beneath the level of the present stream bed. Notwithstanding the great elevation of the uplands, the surface is plane over wide areas and the valleys are narrow. The northeastern part of the county lies within the limits of the later ice invasion. This invasion also touched the extreme northwest corner of the county. A small moraine was formed along the south border of the later sheet of drift, which, though only 30 or 40 feet in height, is readily traced, the bordering tracts being very plane as well as slightly lower. The moraine carries a few sharp gravelly knolls, but as a rule its surface is gently undulating. The older sheet of drift is covered with a deposit of white clay several feet in thickness, as in counties farther west and south, and the older drift here, as in other counties, is harder and more deeply oxidized than the newer drift.

The thickness of drift on the high uplands is often 10 feet or less, even within the limits of the later ice invasion. But it is probable that great amounts of drift are to be found in filled-up tributaries of the Whitewater system. Where rock is not entered within 10 or 15 feet of the surface the wells are usually obtained in the drift. This fact, together with the absence of gas-well borings or other prospect borings outside the limits of the Whitewater Valley, renders data concerning the thickness of drift rather meager.

Individual wells.—The city of Brookville obtains the supply for waterworks from two large open wells sunk in gravel, within 30 feet of the river channel, just above the city. The wells are sunk 12 feet below the lowest water in the river. They are excavated partly in sand and partly in rock, but the source of supply is by infiltration from the river. There are many cisterns and a few wells, both dug and driven, in use by the citizens of Brookville. The wells are sunk slightly below the level of the low-water stage in the river, a depth varying from 20 feet to 110 feet, according to elevation.

A boring at the brickyards in the south part of the city shows the ancient channel of the river to be about 180 feet below low water, or 440 feet above tide. Several other borings in the valley in the vicinity of Brookville enter rock at less depth. One near the junction of East and West Whitewater rivers penetrates 135 feet of drift, entering rock at about 495 feet above tide. Kimball's well, in Brookville, penetrates 160 feet of drift, but the rock surface here is no lower than at the well just mentioned. Bracken's well, in East Whitewater Valley, also enters rock at about the same level, after penetrating 135 feet of drift. A well at the poor farm enters rock at a similar elevation. A gas boring, 2 miles above Cedar Grove, penetrates 154 feet of drift and enters rock at about 450 feet above tide.

Wells at Fairfield, near East Whitewater, in the northern part of the county, in some instances reach a depth of 50 feet without entering rock, mainly through sand and gravel. Wells on the uplands between Fairfield and Laurel are usually obtained at about 20 feet. In the portion of the county east of East Whitewater rock is frequently entered at 10 to 20 feet, though a depth of 60 feet is occasionally reached without penetrating rock. Several sections were obtained on the plain between Little and Big Cedar creeks, east from Brookville, in which rock was entered at 8 to 20 feet.

At New Trenton, in the Whitewater Valley, wells on a terrace standing 80 or 90 feet above the river obtain water at about 90 feet. They are mainly through gravel.

At Metamora, in the West Whitewater Valley, wells are sunk about to river level, a depth of 30 feet.

Wells at Peppertown, on elevated upland, usually obtain water in sand below till at 20 or 25 feet.

Wells near Oldenburg enter rock at 40 feet or less, but water is sometimes found above the rock.

Several wells in Enochsburg strike rock at 20 feet or less, but water is obtained without penetrating far into the rock.

DECATUR COUNTY.

General statement.—Decatur County is situated in the southeastern part of the State, with Greensburg as the county seat. It has an area of 380 square miles. The county slopes gradually from northeast to southwest and drains mainly to the East White River. A narrow strip on the east border drains to Whitewater and to Laughery Creek. All except the eastern part of the county lies within the limits of the Wisconsin or later ice invasion, and a well-defined, though not conspicuous, moraine marks the limits of the drift of that invasion. It traverses the county from the northeast to the southwest corner, passing Greensburg on the east at McCoy Station. The extreme northwest corner of the county is also crossed by a moraine running parallel with the outer belt. These belts are each 2 or 3 miles or more in width, but

rise only 25 to 40 feet above the bordering plain and have a subdued expression. The sheet of older drift lying outside the limits of the newer drift may also be traced beneath the newer drift, numerous exposures of it being found along the streams in the vicinity of Greensburg. It is separated from the upper drift by both a soil and a pebbleless white clay such as covers the drift outside the moraine.

The thickness of the drift in this county is, as a rule, less than 50 feet, and at many places wells enter rock at 20 feet or less. The streams also are bordered quite extensively by rocky bluffs, although flowing usually in valleys but 25 to 50 feet in depth. It is probable, however, that preglacial valleys of great depth occur which have been completely filled. So far as the writer is aware, no wells or other borings have shown the position of such valleys. Very few records were obtained in which the drift exceeds or even approaches 100 feet. The drift is very largely composed of till, but there are sand and gravel deposits in sufficient amount to furnish water ordinarily at convenient depths.

Individual wells.—The thickest drift of which a section was obtained is that penetrated by a gas-well boring on the Robinson farm, north of Adams, in the northwest part of the county, where rock was struck at about 150 feet. The drift is as follows:

	Feet.
1. Till	19
2. Sand	4
3. Blue till	52
4. Gravel and sand	15
5. Yellow till	5
6. Oily blue clay, with few pebbles	16
7. Coarse gravel	15
8. Hard blue till	20
Total	146

In the village of Adams there are drift knolls 20 or 30 feet in height. Among these knolls rock is entered at 15 to 20 feet, but on the knolls wells are obtained without entering the rock.

At Greensburg, the county seat, shallow wells are obtained at 20 to 25 feet in drift. A few tubular wells obtain their supplies from near the bottom of the drift, at about 50 feet. The waterworks supply was at first obtained from driven wells 48 to 50 feet in depth, which reached the base of the drift and obtained their supply from a layer of gravel 4 or 5 feet thick. As the supply was inadequate in seasons of drought, a well 12 inches in diameter was drilled to a depth of 75 feet, penetrating the rock 25 feet. The main supply of water was struck at 21 feet in the stone. Probably two-thirds the population of Greensburg, or about 3,000 people, obtain their supply from this well, and in addition to this the Big Four Railway Company has a monthly consumption of 2,500,000 gallons.

In the vicinity of Clarksburg and Kingston, in the northeast part

of the county, on the moraine which marks the border of the later drift, wells are obtained at 20 to 40 feet in beds of sand or gravel associated with the till.

At Mechanicsburg, in the eastern part of the county, on the older drift, the wells are obtained at 15 or 20 feet without entering rock.

In the vicinity of Letts, on the moraine in the southwest part of the county, there are several deep tubular wells. One at Boyd's store obtains water from sand below till at a depth of 90 to 98 feet. A well at the tile factory, 117 feet in depth, does not strike rock. A well at H. Mitchell's, about 3 miles west of Letts, 101 feet in depth, enters rock at 80 feet. There is thought to be a buried soil at about 60 feet. Several wells about 2 miles west of Letts enter rock at 30 feet or less, on ground fully as elevated as at Mitchell's well.

At Newburg (Forest Hill post-office) wells are obtained at about 30 feet without entering rock. Wells along a valley west from this village obtain water at a depth of 10 feet.

At Westport, on the south slope of the outer moraine of the later drift, wells in some cases enter rock at about 30 feet, but many obtain water in the drift.

At Sardinia, also near the border of the moraine, wells enter rock at 25 to 35 feet.

BARTHOLOMEW COUNTY.

General statement.—Bartholomew County is situated in the south central part of the State, with Columbus as the county seat, and has an area of 400 square miles. East White River passes through the county from north to south, slightly west of its center, following the axis of a trough or basin in the Devonian shale. There is a gradual westward descent from the east border of the county to the river valley. West from the river there is a low plain, rising gradually westward to the border of the county, where a range of prominent Knobstone hills sets in, which rises several hundred feet above the basin.

The entire county was apparently glaciated, although the glacial boundary lies but little west from the front of the prominent hills on the county line. The portion of the county east from the East White River Valley was nearly all covered by the later ice invasion, and a narrow belt along the west side of the stream in the north part of the county was also covered by that invasion. There remains, therefore, only a narrow strip on the southern and western borders of the county where the older sheet of drift alone is present. There are morainic features along the borders of the East White Valley from the north line of the county southward to the vicinity of Columbus. There are also two well-defined moraines leading eastward and northeastward from this valley across the county. The southernmost one, which lies near the line of Bartholomew and Jennings counties, marks the southern limit of the later or Wisconsin sheet of drift. The other

lies near the borders of Clifty Creek. Each of these moraines has a breadth of 2 or 3 miles, but they stand only 20 to 40 feet above the bordering plain. The surface of the older drift in this county is generally plane. The thickness of the drift ranges from a mere trace to a deposit fully 100 feet in depth. Along the East White Valley there is a gravelly belt 3 to 5 miles or more in width, and the morainic knolls just referred to appear in the midst of this gravelly district. Flat Rock Valley also contains a broad gravel plain. In the remainder of the county the drift is mainly till. Very few deep wells occur, there being generally an abundant water supply within 35 or 40 feet of the surface.

Individual wells.—At Columbus the gas-well borings penetrate about 100 feet of drift, mainly gravel, in which large amounts of water occur from a depth of 30 feet downward. The waterworks supply is from the East White River, and the greater part of the population are dependent upon it. The few private wells in use have a depth of about 30 feet.

On the gravel plain south from Columbus, in the vicinity of Wailesboro and Jonesville, wells are obtained at 20 or 30 feet, or at about the level of the water in East White River.

On the low land west of East White River wells ordinarily penetrate 8 or 10 feet of pebbleless clay, beneath which they enter till. Water is usually obtained at 20 feet or less in beds of gravel associated with the till.

The record of a well was obtained on a prominent part of the Knobstone ridge near the west border of the county in sec. 18, T. 9, R. 5 E., which reached a depth of 38 feet without entering rock. Wells often enter rock on this high land, however, at 10 or 15 feet. The well referred to has the following section:

	Feet.
1. Surface silt	8
2. Sandy material	5
3. Brown till	5
4. Blue till	20
Total	38

At a schoolhouse near this well water was obtained at only 20 feet, in a bed of sand below the surface silt.

A well near the base of the high upland, in sec. 29, T. 10, R. 5 E., 56 feet in depth, enters rock near bottom.

Records of several wells were obtained in the eastern part of the county which have a depth of 30 to 38 feet without entering rock. They are mainly through a soft till of the later ice invasion.

On the gravel plain along Flat Rock Creek, in the north part of the county, wells are usually obtained at a depth of 10 to 20 feet, or about the level of the stream.

JACKSON COUNTY.

General statement.—Jackson County is situated in the southern part of the State, with Brownstown as the county seat, and has an area of 510 square miles. East White River traverses it nearly centrally from northeast to southwest, and Muscatatuck River forms much of its south boundary. The western one-third of the county is elevated and largely unglaciated. The eastern part is mainly a low plain, though there are occasional knobs rising to heights of 200 feet or more above the plain. There is also a sharp drift ridge, 50 to 170 feet in height, leading southward from near Seymour to the vicinity of Mount Sidney. This drift ridge has a breadth of less than a mile, and is in consequence a very conspicuous feature. It is known as Chestnut Ridge, and several well sections along it are presented below.

In the eastern part of the county, between the two forks of the Muscatatuck, the drift deposits are thin, as in neighboring counties on the east, seldom reaching a depth of 50 feet; but in the district between the Muscatatuck and East White River, which includes Chestnut Ridge, the general thickness of drift is probably 100 feet, while on the ridge it may exceed 200 feet. The greater part of the drift is of a sandy constitution, though deposits of till and gravel are known to occur both in the ridge and on the bordering plain. In the southern part of the county, near the Muscatatuck, a compact clay, containing very few pebbles, constitutes the upper portion of the drift.

Individual wells.—No detailed records of wells were obtained in the unglaciated western portion of the county, but it is known that the depth there is variable, some wells being obtained at 20 feet or less, while others are 75 to 100 feet.

At Brownstown, the county seat, wells are usually about 20 feet in depth. In some instances they are obtained in the sand, but in others they enter shale a few feet.

At Seymour wells range in depth from 15 to 50 feet, and are usually driven through sand and sandy clay. The greater part of the water supply is furnished by the waterworks, and is pumped from East White River.

A gas-well boring in the northeast part of Seymour penetrates 75 feet of drift, as follows:

	Feet.
1. Coarse sand	12
2. Very fine sand or silt, almost a clay	43
3. Black muck, probably an old flood plain of the river	10
4. Coarse sand with large amount of water	5
5. Blue clay	5
Total	75

The black muck of this section is found quite widely in the vicinity of Seymour at a nearly uniform elevation. The thickness of the drift in the vicinity of Seymour ranges from 70 feet to 90 feet.

On the plain bordering Chestnut Ridge, south from Seymour, wells are usually obtained at a depth of 30 feet or less, though a few reach 40 feet. They are mainly through fine sand or clay, yellow at top, but of blue color at a depth of 16 to 18 feet. A flowing well on this plain is reported by Professor Cox to obtain water in a soapstone shale beneath alluvium and drift at a depth of 27 feet. The well is located on a branch of Pond Creek, in sec. 7, T. 4, R. 5 E., a few feet below the general level of the plain.

The following sections of wells were obtained on Chestnut Ridge. Harvey Morris's well, near the north end of the ridge, 89 feet in depth, penetrates—

	Feet.
1. Clay containing a few pebbles in lower part	20
2. Fine sand, becoming gravelly near bottom	69
Total	89

Jerry Anderson's well, also near north end of ridge, 95 feet in depth, penetrates—

	Feet.
1. Clay, pebbleless at surface, but quite pebbly below, and assuming a blue color in lower part	52
2. Gray sand too fine to screen, but yielding water	38
3. Gravel	5
Total	95

Hiram Love's well, 57 feet in depth, penetrates—

	Feet.
1. Surface clay and yellow till	20
2. Blue till	30
3. Gravel and sand	7
Total	57

A well at Mr. Wieneke's, on the highest point of the ridge, 77 feet in depth, penetrates—

	Feet.
1. Sandy loam	15
2. Loose sand	18
3. Reddish gravel and sand with clay admixture, probably till	40
4. Coarse gravel	4
Total	77

A strong spring gushes out of the slope of the moraine west of Mr. Wieneke's residence at about the level of the bottom of the well and probably from the same gravel bed. At M. T. Cox's residence, on a low part of the ridge, scarcely 50 feet above the bordering plain, a well 107 feet in depth penetrates—

	Feet.
1. Till	50
2. Fine sand	25
3. Gravelly sand	32
Total	107

Wells in Dudleytown, also on a low part of the ridge, obtain an abundance of water at less than 50 feet. Henry King's well, on the slope of the ridge south from Dudleytown, perhaps 30 feet above the level of the border plain, reaches a depth of 63 feet. John W. Collin's well, near the south end of the ridge, at an altitude nearly 100 feet above the plain, obtains water at 50 feet. A log was penetrated near the bottom in a sandy blue clay.

In the vicinity of Mount Sidney, on the borders of the Muscatatuck River, wells are obtained at 40 to 45 feet in sand and gravel below till. The water bed is apparently a little higher than the level of the river.

SCOTT COUNTY.

General statement.—Scott County is situated southeast of Jackson County, in the southern part of the State, with Scottsburg as its county seat. It has an area of but 190 square miles. The greater part of the county is a low plain lying along the eastern base of the Knobstone escarpment and underlain by Devonian shales. The eastern and southeastern parts, however, are more elevated and are underlain by limestone. The greater part of the county has been glaciated, but the drift deposits are usually only a few feet in thickness, rock being entered as a rule at 20 feet or less. In the north part of the county, however, on the borders of the Muscatatuck there is at least 50 feet of drift.

Individual wells.—At Scottsburg, the county seat, wells are usually obtained at 25 to 35 feet or less. The drift is about 50 feet. A gas-well boring near the railway station penetrates 47 feet of drift, as follows:

	Feet.
1. A yellowish white clay, nearly pebbleless	15
2. Sand	5
3. Blue till	27
Total	47

A boring at the fair ground, a mile southeast from Scottsburg, entered rock at 40 feet. It encountered much wood in a blue till in its lower part.

At Little York, near the west line of the county, wells usually enter shale at 15 or 20 feet, and obtain water at depths of 25 to 45 feet. Within a mile east from Little York a thicker drift sets in and wells are obtained without entering the rock at depths of 25 feet or less.

At Vienna, a well at the canning factory enters rock at 12 feet and obtains water at about 30 feet.

At Summit, or Underwood Station, near the south line of the county, wells usually enter shale at about 8 feet and obtain water at 20 to 30 feet. A well at Mr. Hosea's, one-half mile west of this village, 40 feet in depth, enters shale at 25 feet, but its water supply is from gravel at from 12 to 25 feet.

At Lexington, in the east part of the county, wells enter limestone within a few feet of the surface and obtain water at depths of 20 to 30 feet or less.

LIMESTONE DISTRICT OF SOUTHEASTERN INDIANA.[1]

General statement.—This district embraces Dearborn, Ohio, Switzerland, Ripley, Jefferson, and Jennings counties and the east part of Scott and Clark counties, an area of about 2,000 square miles. It is bordered on the southeast by the Ohio River from Lawrenceburg to Jeffersonville, Indiana.

The entire district has been glaciated, though lying entirely outside the limits of the later ice invasion, if we except a few square miles along the north border of Jennings County. On the higher parts of the upland the drift is usually but 10 to 20 feet in thickness, and is covered with a deposit of white clay nearly free from pebbles, having an average thickness of about 5 feet. The valleys and lowlands are usually filled quite deeply with drift deposits, especially in the case of the larger streams, which are as a rule occupying preglacial valleys. It is not rare to find in these valleys a drift filling to a height of 150 feet above the present beds, and the deposits, if we may judge from the depth of drift along the Ohio, probably extend 75 to 100 feet below the present streams. The drift on the uplands consists mainly of a compact clay, and strong wells are seldom obtained from this deposit. Beneath this clay there are frequently beds of black soil, which in some cases appear to be of interglacial and in other cases possibly of preglacial age. Those thought to be of interglacial age are underlain by sandy deposits, probably due, directly or indirectly, to the ice invasion. There are others which rest upon the rock strata or residuary clay, and these may be of preglacial age. Several instances of the occurrence of such soils are presented in the reports of the Indiana geological survey. In valleys the drift is often, if not generally, composed largely of sand and gravel, but has bowlders and cobble stones mixed with the finer material.

Individual wells.—The data concerning the wells here reported were obtained chiefly from the water-supply schedules sent out to various cities and villages in the district. A few were obtained while in field work, and a few are taken from the reports of the Indiana geological survey.

Along the Ohio Valley wells are usually obtained at about the level of the Ohio River at its low-water stage. The terraces are in some places fully 100 feet above the river, and wells 100 feet in depth on such terraces are not infrequent. They penetrate usually a gravel of medium coarseness, interbedded with fine gravel or sand. In places the deposits are cemented, but this feature is not a common one. The towns are taken in order from Lawrenceburg down the valley.

Lawrenceburg stands on a gravel terrace 80 to 85 feet above the low water of the Ohio, or about 505 to 510 feet above tide. The drift at

this point is shown by gas borings to be about 140 feet, reaching a level 55 or 60 feet below the low water of the Ohio. It is composed largely of gravel, and an abundance of water may be obtained by driving pipes to the level of the river. Professor Orton calls attention, in the Geology of Ohio, to an exposure of a clayey bed near the low-water level which carries timber of several kinds. This is thought to be an old flood plain of the river. Concerning it Professor Orton remarked, "It is perhaps too early to write out this history in its minuter features, but the facts already given show us that we have in this sheet of blackened clay the bottom lands of the Ohio Valley of an earlier day, and, indeed, under very different conditions from those that now prevail. The river then ran in a channel lower by 40 feet at least than that which it now holds, and the great valley was then empty of the immense accumulations of sand, clay, loam, and gravel which constitute its bottom lands and terraces to-day."[1] A similar blackened clay has been noted at several points below Lawrenceburg, near the level of low water.

At Aurora a gas boring shows the drift to be 92 feet in depth on ground standing only 45 to 50 feet above the low water of the river. The wells in this city usually obtained water at about 50 feet near the level of low water of the river.

Rising Sun is situated on a terrace standing about 110 feet above the river in its highest part, but the town extends down the slope to a level only 60 feet above the river. Wells at the level of the top of the terrace have, in some instances, been sunk to the level of the river, one well at Cornelius Harris's being 114 feet and one at J. M. Pate's 112 feet in depth. Mr. Pate's well obtained some water at 27 feet, and weak wells are often obtained at about that level on the terrace. The drift at Mr. Pate's well is mainly sand, but a bed of blue mud was passed through at about 50 or 60 feet. A well at an old mill on the river bank 120 feet in depth reached a level 60 feet below the low water of the river without encountering rock. Only a half mile above the mill, on the Kentucky side, rock extends half way across the river channel at level of low water.

At Vevay wells are usually obtained at a depth of 60 to 80 feet, but occasionally reach a depth of 100 feet. The terrace on which the main part of the town stands is about 80 feet above low water. It is composed largely of fine gravel, which is cemented in places at depths of 20 to 50 feet. The supply for the waterworks at Vevay is pumped from the Ohio River.

At Carrollton, Kentucky, 8 miles below Vevay, Mr. J. F. Jett made a boring at his distillery, near the mouth of the Kentucky River, 107 feet in depth, which reaches a level 50 feet below the low water of the Ohio, without striking rock. The boring was stopped in a cemented gravel.

At the city of Madison, Indiana, several wells on a terrace standing

[1] Geol. Ohio, Vol. I, p. 429.

90 to 100 feet above the river have reached a depth of 120 feet without entering rock. The terrace in the eastern portion of the city is underlain by a coarse gravel, but in the western portion the drift becomes sandy. The waterworks obtain a large part of the supply from the Ohio River by infiltration into a large well excavated at the side of the river. A portion of the supply is from springs in the west part of the city. Probably half of the population still depend upon private wells and cisterns, there being only about 1,200 private connections with the waterworks in a population of 10,000.

At Jeffersonville wells are obtained at a depth of 40 or 50 feet in sand and gravel, water being found at about the low-water level of the river above the Louisville rapids. A few drilled wells enter the hydraulic limestone 8 to 12 feet. This limestone is struck in portions of the city just below the level of low water.

Statistics concerning wells were obtained at several villages on the uplands in these southeastern counties of Indiana, as follows: At Versailles, the county seat of Ripley County, wells are obtained at depths of 18 to 25 feet in the upper part of the limestone. At Osgood wells are usually obtained near the base of the drift at depths of 9 to 15 feet. Occasionally wells are drilled to a depth of 100 feet or more in the northern part of Ripley County. At North Vernon, in Jennings County, wells are obtained at depths of 12 to 35 feet, the majority being about 25 feet. They usually enter the rock a few feet. The waterworks obtain a supply from the Muscatatuck River. The village of Vernon also obtains its waterworks supply from the Muscatatuck River. At Charlestown, formerly the county seat of Clark County, wells are obtained at a depth of 30 to 35 feet, usually in the Corniferous limestone. A few, however, reach this depth without entering rock. In wells where drift 25 to 30 feet in thickness is penetrated it is quite common to find a blue mud carrying tree trunks or small pieces of wood near the base of the drift. Rock is ordinarily struck in this village at about 12 feet. There are four very strong springs within the corporate limits of the town, which are made use of by many of the residents.

The following sections of wells on the uplands, taken from the reports of the Indiana Geological Survey, are of interest in showing the presence of a buried soil. Mr. N. Van Osdel's well, in the broken upland of Ohio County, sec. 6, T. 3, R. 2 W., penetrates—

	Feet.
1. Soil and clay	22
2. Yellow sand, quite hard or cemented	9
3. Blue clay, hard, without pebbles	1½
4. Black soil containing rotten leaves, twigs, and wood, thought to be walnut	1½
5. Coarse sand, gravel, and shelly stone	9
6. Hard blue limestone	1
Total	44

At Mr. J. B. Gordon's, sec. 4, T. 5, R. 12 E., in the northwest part of Switzerland County, a well penetrates—

	Feet.
1. Soil and clay, pale in lower part	22
2. Blue mud resembling recent alluvium	6
3. Black soil, containing leaves, cedar wood, and ocherous particles	3
4. Small stones closely packed together	1
Total	32

It is thought that the bottom bed in this well is native rock. A neighboring well struck leaves and poplar bark at 32 feet. Wells in that vicinity often enter rock at 10 to 14 feet. In the vicinity of Paris Crossing, in the extreme southern part of Jennings County, buried timber is often found in digging wells on land 60 to 70 feet above the bed of Graham Creek. In one well sunk by Mr. John F. Files it is estimated that at least a half cord of wood was taken from a well at a depth of 32 to 40 feet. The wood appears to be birch, and specimens were sent to the State museum. The wood is much crushed and twisted, but it was found suitable for fuel and was thus made use of by Mr. Files. The following is the section of the beds penetrated—

	Feet.
1. Light-colored clay with darker shades below	10
2. Ocher-colored clay with flint pebbles, increasing in hardness toward the bottom	19
3. Very hard bed of clay and gravel	2 to 3
4. Sandy blue clay, with water; also limbs, twigs, and roots of trees	7 to 10
Total	38 to 42

The ingress of water prevented the deepening of the well, and the wall was commenced on the driftwood at its bottom. A well at South Milan, in eastern Ripley County, 54 feet in depth, did not enter rock, though quarries are opened in that vicinity at about the level of the well mouth. The following is a section of the well made by the railway company:

	Feet.
1. Light-colored clay	10 to 14
2. Yellow clay, with flint, gravel, and fossil corals	12
3. Blue glacial clay	12
4. Coarse yellow sand, with recent shells and water	8
5. Blue clay and muck, containing roots and limbs of trees	8
Total	54

KNOBSTONE BELT OF SOUTHERN INDIANA.

The portion of this belt outside the drift border covers the greater part of Brown and Jackson counties, western Bartholomew, northeastern Washington, western Scott, western Clark, and a narrow strip in Floyd and Harrison counties, an area of about 1,200 square miles. Its ridges stand 800 to 1,150 feet above tide and comprise the highest land in that part of the State. The writer is personally

acquainted with but a small part of this belt and has found but few published data bearing upon its capacity for supplying wells. In the roughest portions agriculture is carried on with difficulty, and the few residents depend largely upon cisterns and springs; but in the less rugged and more thickly settled portions wells are said to be in use. Nothing has been learned to indicate that difficulty is experienced in obtaining water of good quality at convenient depths. The few wells reported show an average depth of but 20 to 30 feet.

LIMESTONE BELT OF SOUTHERN INDIANA.

The portion of this belt outside the drift border covers the greater part of Monroe, Lawrence, Washington, Orange, and Harrison counties, also western Floyd and eastern Crawford counties, a combined area of about 2,000 square miles. This limestone belt has generally an abundance of good water within 50 feet of the surface, and good wells 30 feet in depth are not rare. In a few cases wells have been sunk to depths of 100 to 150 feet, with a view to increasing the amount of water. However, the few data at hand seem to indicate that the chances for obtaining fresh water in the upper 100 feet are better than at lower depths. The early settlers made open wells, but in recent years drilled wells are coming into use. The latter are sunk to a greater average depth than the former, but are seldom more than 100 feet. The extreme hardness of the water is also objectionable and has led to extensive use of rain water collected in cisterns.

Some of the strong sulpho-saline wells and springs of southern Indiana which have gained wide reputation for medicinal properties are obtained in this limestone. There are many salt and sulphur springs which have never been brought to public notice on account of their difficult accessibility or other adverse conditions. Some wells and springs were used in the manufacture of salt, on a small scale, in the early days of settlement, before the great salt industries of the neighboring States were developed. Salt Creek, one of the main tributaries of East White River, receives its name from springs of salt water found on its middle and lower courses.

CONGLOMERATE SANDSTONE OF SOUTHERN INDIANA.

This sandstone forms a narrow belt along the west border of the limestone, its average width of outcrop being scarcely 10 miles. Like the Knobstone belt, it is characterized by sharp ridges and hills, which are but sparsely settled, agriculture being carried on with difficulty. The water afforded by springs, together with cistern water collected from roofs of dwellings, often supply the needs of the residents. Wells are apparently less common than in the limestone district on the east, and are far less numerous than in the Coal Measures basin that borders it on the west. The few available data concerning wells in this sandstone indicate that a fair supply of water may be obtained at convenient depths.

COAL MEASURES BASIN OF SOUTHWESTERN INDIANA.

Under this head is included the portion of western Indiana south from Vigo, Clay, and Owen counties covered by the Coal Measures sandstone and shale, an area of about 4,500 square miles. Fully two-thirds of this region has a thin coating of drift. The remainder is driftless, except a coating of loess.

The loess seldom affords a supply of water for wells, as it is usually but 5 to 10 feet in depth. The glacial drift may be depended upon in perhaps half its extent in this region to supply a sufficient amount of good water for the needs of the residents. Where it exceeds 20 feet in depth there is usually present a water-bearing bed which will supply wells for household use. Occasionally wells strong enough to supply the stock on a farm are obtained from drift deposits, but the strong wells are usually obtained from the rock. Along the Wabash Valley, however, strong wells are generally obtained in glacial deposits at shallow depths, there being a heavy deposit of water-bearing gravel in the valley.

Along the Ohio Valley above Mount Vernon there are extensive bottom lands, in which a compact clay must be penetrated 60, 80, and occasionally 100 feet or more before water-bearing sand or gravel is reached. Similar bottoms occur in Evansville and just above the city. Farther east, between Yankeetown and Rockport, wide bottoms are underlain by sand, in which wells are obtained at depths of but 20 to 40 feet. Many of these wells overflow and afford excellent water.

Where wells are not obtained in the drift they are usually obtained in the underlying rock at convenient depths—30 to 60 feet, or less. The wells in the driftless portion also usually obtain water at convenient depths. The water in these shallow wells in rock is in some localities objectionable because of sulphates, and is known as "copperas water," but the great majority of wells yield water of pleasant taste and harmless quality.

A few wells have been sunk to depths of 200 feet or more which obtained fresh water. Coal shafts also have in some cases struck fresh water at similar depth. The chances, however, are against obtaining fresh or potable water from such depths, and the residents usually make use of large cisterns if water can not be obtained in suitable amount from shallow wells.

INDEX TO PLACES.

1895.

Sixteenth Annual Report of the United States Geological Survey, 1894–95, Part II, Papers of an economic character, 1895; octavo, 598 pp.

Contains a paper on the public lands and their water supply, by F. H. Newell, illustrated by a large map showing the relative extent and location of the vacant public lands; also a report on the water resources of a portion of the Great Plains, by Robert Hay.

A geological reconnoissance of northwestern Wyoming, by George H. Eldridge, 1894; octavo, 72 pp. Bulletin No. 119 of the United States Geological Survey; price, 10 cents.

Contains a description of the geologic structure of portions of the Bighorn Range and Bighorn Basin, especially with reference to the coal fields, and remarks upon the water supply and agricultural possibilities.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. H. Newell, 1895; octavo, 176 pp. Bulletin No. 131 of the United States Geological Survey; price, 15 cents.

Contains results of stream measurements at various points, mainly within the arid region, and records of wells in a number of counties in western Nebraska, western Kansas, and eastern Colorado.

1896.

Seventeenth Annual Report of the United States Geological Survey, 1895–96, Part II, Economic geology and hydrography, 1896; octavo, 864 pp.

Contains papers on "The underground water of the Arkansas Valley in eastern Colorado," by G. K. Gilbert; "The water resources of Illinois," by Frank Leverett; and "Preliminary report on the artesian areas of a portion of the Dakotas," by N. H. Darton.

Artesian-well prospects in the Atlantic Coastal Plain region, by N. H. Darton, 1896; octavo, 230 pp., 19 plates. Bulletin No. 138 of the United States Geological Survey; price, 20 cents.

Gives a description of the geologic conditions of the coastal region from Long Island, N. Y., to Georgia, and contains data relating to many of the deep wells.

Report of progress of the division of hydrography for the calendar year 1895, by F. H. Newell, hydrographer in charge, 1896; octavo, 356 pp. Bulletin No. 140 of the United States Geological Survey; price, 25 cents.

Contains a description of the instruments and methods employed in measuring streams and the results of hydrographic investigations in various parts of the United States.

1897.

Eighteenth Annual Report of the United States Geological Survey, 1896–97, Part IV, Hydrography, 1897; octavo, 756 pp.

Contains a "Report of progress of stream measurements for the year 1896," by Arthur P. Davis; "The water resources of Indiana and Ohio," by Frank Leverett; "New developments in well boring and irrigation in South Dakota," by N. H. Darton; and "Reservoirs for irrigation," by J. D. Schuyler.

1898.

Nineteenth Annual Report of the United States Geological Survey, 1897–98, Part IV, Hydrography, 1899; octavo, 814 pp.

Contains a "Report of progress of stream measurements for the calendar year 1897," by F. H. Newell and others; "The rock waters of Ohio," by Edward Orton; and "Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian," by N. H. Darton.

WATER-SUPPLY AND IRRIGATION PAPERS, 1896–1899.

This series of papers is designed to present in pamphlet form the results of stream measurements and of special investigations. A list of these, with other information, is given on the outside (or fourth) page of this cover.

Survey bulletins can be obtained only by prepayment of cost, as noted above. Postage stamps, checks, and drafts can not be accepted. Money should be transmitted by postal money order or express order, made payable to the Director of the United States Geological Survey. Correspondence relating to the publications of the Survey should be addressed to **The Director, United States Geological Survey, Washington, D. C.**

WATER-SUPPLY AND IRRIGATION PAPERS.

1. Pumping water for irrigation, by Herbert M. Wilson, 1896.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis, 1897.
3. Sewage irrigation, by George W. Rafter, 1897.
4. A reconnoissance in southeastern Washington, by Israel C. Russell, 1897.
5. Irrigation practice on the Great Plains, by E. B. Cowgill, 1897.
6. Underground waters of southwestern Kansas, by Erasmus Haworth, 1897.
7. Seepage waters of northern Utah, by Samuel Fortier, 1897.
8. Windmills for irrigation, by E. C. Murphy, 1897.
9. Irrigation near Greeley, Colorado, by David Boyd, 1897.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker, 1898.
11. River heights for 1896, by Arthur P. Davis, 1897.
12. Water resources of southeastern Nebraska, by Nelson Horatio Darton, 1898.
13. Irrigation systems in Texas, by William Ferguson Hutson, 1898.
14. New tests of pumps and water lifts used in irrigation, by O. P. Hood, 1898.
15. Operations at river stations, 1897, Part I, 1898.
16. Operations at river stations, 1897, Part II, 1898.
17. Irrigation near Bakersfield, California, by C. E. Grunsky, 1898.
18. Irrigation near Fresno, California, by C. E. Grunsky, 1898.
19. Irrigation near Merced, California, by C. E. Grunsky, 1899.
20. Experiments with windmills, by Thomas O. Perry, 1899.
21. Wells of northern Indiana, by Frank Leverett, 1899.
22. Sewage irrigation, Part II, by George W. Rafter, 1899.
23. Water-right problems in the Bighorn Mountains, by Elwood Mead, 1899.
24. Water resources of the State of New York, Part I, by George W. Rafter, 1899.
25. Water resources of the State of New York, Part II, by George W. Rafter, 1899.
26. Wells of southern Indiana, by Frank Leverett, 1899.

In addition to the above, there are in various stages of preparation other papers relating to the measurement of streams, the storage of water, the amount available from underground sources, the efficiency of windmills, the cost of pumping, and other details relating to the methods of utilizing the water resources of the country. Provision has been made for printing these by the following clause in the sundry civil act making appropriations for the year 1896–97:

Provided, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be printed in octavo form, not to exceed 100 pages in length and 5,000 copies in number; 1,000 copies of which shall be for the official use of the Geological Survey, 1,500 copies shall be delivered to the Senate, and 2,500 copies shall be delivered to the House of Representatives, for distribution. [Approved June 11, 1896; Stat. L., vol. 29, p. 453.]

The maximum number of copies available for the use of the Geological Survey is 1,000. This number falls far short of the demand, so that it is impossible to meets all requests. Attempts are made to send these pamphlets to persons who have rendered assistance in their preparation through replies to schedules or donation of data. Requests specifying a certain paper and stating a reason for asking for it are attended to whenever practicable, but it is impossible to comply with general requests, such as to have all of the series sent indiscriminately.

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