STATE OF OHIO

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

THE WATER RESOURCES OF MADISON COUNTY, OHIO

BULLETIN 33

Columbus, Ohio

1959

STATE OF OHIO

MICHAEL V. DISALLE, *Govenor*

DEPARTMENT OF NATURAL RESOURCES

HERBERT B. EAGON, *Director*

DIVISION OF WATER

C. V. YOUNGQUIST, *Chief*

* * *

THE WATER RESOURCES OF MADISON COUNTY, OHIO

By

STANLEY E. NORRIS
District Geologist, U. S. Geological Survey

Prepared in cooperation with the U. S. Geological Survey

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FOREWORD

Madison County is endowed with a large resource of underground water most of which is undeveloped. Its surface streams have low-flow indices below the State average. Reservoir storage at available sites, however, would make large supplies available from streams.

A survey of water use in the County conducted in 1955 showed that about 2 million gallons of water per day were being used. Of this quantity about half was pumped by municipalities and the remainder by industry and other users. All of the pumpage is from underground sources.

There are few places in the County where supplies of underground well water cannot be developed. Some potentially large supplies are available from glacial outwash sands and gravels especially where they are recharged from streams. Smaller farm supplies are available from pockets of sand and gravel in the glacial clays. Fortunately where sand and gravel sources are not present almost everywhere in the County the underlying dolomite and limestone rocks are highly productive.

The ground-water supplies are replenished annually and there appears to be no evidence of depletion. London's water supply in a buried preglacial valley was developed in 1890. It survived the severe drought of 1895 and all subsequent droughts. Plain City's supply developed in the underlying bedrock has been in continuous service since 1894 with no apparent diminution in supply.

The underground water resources of Madison County are not such as to sustain large individual drafts such as are required by heavy water-using industries. Nevertheless the County has many sources of low-cost ground water capable of sustaining withdrawals on the order of one million gallons per day suitable for moderate industrial water users or for irrigation.

C. V. YOUNGQUIST

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THE WATER RESOURCES OF MADISON COUNTY, OHIO

ABSTRACT

Madison County, which embraces an area of 464 square miles in west-central Ohio, is predominantly agricultural but seems destined for large industrial growth owing to its favorable location about midway between the rapidly expanding industrial centers of Columbus on the east and Springfield and Dayton on the west. Water resources may be the key to the speed of this industrial development, and the availability of water will almost certainly decide which of the five incorporated communities will grow into important cities in the years ahead.

Madison County lies about on the drainage divide between the Miami and Scioto Rivers. The county's two principal streams, both tributaries of the Scioto River, are small compared to typical Ohio creeks and rivers. Darby Creek, which flows south along the eastern border of Madison County, has a mean flow at Darbyville (Pickaway County) of 405 cfs (cubic feet per second) and the maximum and minimum daily discharges recorded are 17,900 cfs and 1.4 cfs. Deer Creek, which drains central and southeastern Madison County, has a mean flow of 284 cfs. Darby Creek and Deer Creek offer good possibilities for the development of surface-water supplies in Madison County.

Ground water in Madison County comes from two sources: the bedrocks, chiefly limestone and dolomite, and the glacial deposits of sand and gravel. Sand and gravel valley-train deposits in the valleys of Deer Creek and Little Darby Creek, in the eastern part of the county, may yield up to 300 gpm (gallons per minute) to wells. Ground-water supplies in the magnitude of 1 mgd (million gallons per day) possibly are available from groups of wells receiving stream infiltration.

Large supplies of ground water also are available in Madison County from the limestone and dolomite bedrocks. Supplies as large as 0.5 mgd have been developed locally from these sources and even larger quantities may be available. Individual wells in the limestone and dolomite rocks yield up to 500 gpm from zones of relatively high permeability, such as the so-called Newburg zone at or near the top of the Middle Silurian.

Ground-water supplies in the magnitude of 0.5 to 1 mgd have been developed in west-central Madison County from buried outwash-plain deposits of sand and gravel. These buried deposits form important artesian aquifers which, in undeveloped areas, should provide large additional ground-water supplies for industrial use.

In certain areas in central Madison County that are generally adjacent to, or underlain by the buried Teays Valley, most wells obtain water from small, discontinuous beds of sand and gravel interbedded with till. Water supplies from these interbedded deposits are adequate for home and farm use. Additional water is available in most places from the underlying limestone and dolomite rocks, except where the buried Teays Valley is deepest.

The poorest areas in Madison County for the development of ground-water supplies are underlain by clay (Minford silt) and fine sand in the buried Teays Valley and its tributaries. These fine-grained deposits are not a source of ground water, and they present a serious problem to well drillers who use the churn drills.

The chemical quality of water from the aquifers in Madison County is within the common range for water from a limestone region. Softening and iron removal would be desirable for most purposes.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

Madison County, though presently devoted almost entirely to agriculture, is rapidly becoming important as an area for industrial development. The industrial growth is due to the county's favorable geographic position midway between the rapidly expanding Columbus metropolitan area on the east and the large industrial centers of Springfield and Dayton on the west. Substantial population growth in Madison County may be expected to increase greatly the demand for water. For example, the population of the greater Dayton area and of the city of Columbus rose respectively 26.6 percent and 15.7 percent between 1940 and 1950, while municipal water use increased by 86.8 percent at Dayton and 31.3 percent at Columbus.[1] To meet the need for water facts in Madison County, the Water Resources Division, U. S. Geological Survey, in cooperation with the Division of Water, Ohio Department of Natural Resources, has prepared this report as a guide for the development of farm, public, and industrial water supplies. It is the latest in a series of county reports designed to aid in the development and use of Ohio's water resources in accordance with sound conservation practices. Data on which this report is based include drillers' logs of wells from the files of the Ohio Division of Water, information acquired during a field inventory of wells made largely in 1949, the results of geological and geophysical studies made in 1950-53, the results of a test-drilling program conducted in 1952 and 1953, and streamflow records collected since 1921.

ADMINISTRATION AND PERSONNEL

The investigation leading to this report was made principally by the writer working under the general supervision of A. N. Sayre, chief of the Ground Water Branch, U. S. Geological Survey. The Ohio Division of Water is represented in this investigation by C. V. Youngquist, chief. The surface-water section of the report was prepared with the assistance of W. P. Cross, hydraulic engineer, from data collected by personnel of the Surface Water Branch, U. S. Geological Survey, working under the supervision of O. H. Jeffers, formerly acting district engineer, and L. C. Crawford, district engineer. R. P. Goldthwait, geologist, Ohio Division of Water, and professor of geology, Ohio State University, mapped the glacial deposits in Madison County, interpreted the chronology of glacial events, and helped prepare the section on Pleistocene history. Chemical analyses of the water samples collected in Madison County were made by personnel of the Quality of Water Branch, U. S. Geological Survey, working under the supervision of W. L. Lamar, district chemist. H. C. Spicer, geophysicist, Geophysics Branch, U. S. Geological Survey, assisted by G. J. Edwards and R. E. Miller, of the same branch, determined the approximate depths to bedrock and the general character of the unconsolidated deposits at more than 70 places in Madison County by earth-resistivity methods. Mr. W. H. Nicholson, Jr., of the U. S. Geological Survey, inventoried several hundred wells in the field and compiled much of the information presented in the well tables that accompany this report. The illustrations in this report were prepared by John C. Krolczyk, and Mrs. Evelyn Wheaton, of the Ohio Division of Water, and Mrs. Catherine Feulner of the U. S. Geological Survey.

METHODS OF INVESTIGATION

The hydrology of an area must be studied by determining the nature and attitude of the earth materials and their relationship to various phases of the hydrologic cycle. The principal water-bearing beds, or aquifers, in Madison County are of two main types: consolidated rocks, chiefly limestone and dolomite, and unconsolidated sand and gravel of glacial origin. The consolidated rocks, commonly referred to as the bedrock, were deposited many hundreds of million years ago as sediments in shallow seas which covered most of the interior United States. The glacial deposits are much younger, the youngest being only a few thousand years old, and were deposited by or derived from the continental ice sheets which transported vast quantities of rock debris into Ohio.

Buried-Valley Studies

The consolidated rocks in Madison County are deeply trenched by valleys whose drainage cycles were ended by the great ice invasions of the glacial, or Pleistocene, epoch. These ancient valleys are buried under a deep covering of till and glaciofluvial clay, silt, sand, and gravel. The sand

[1] Computation based on figures furnished by waterworks officials.

and gravel are good sources of ground water, especially where the deposits extend to the surface and are recharged directly by rainfall or the infiltration of streamflow. Thick beds of till, clay, and silt, on the other hand, are poor sources of ground water and have caused costly drilling failures at several localities in Madison County. Because of the importance of the deposits in the buried valleys with respect to water supplies, two principal objectives of this investigation were to map the buried valleys and to determine the character of the deposits they contain.

Earth-Resistivity Prospecting

Few wells in Madison County have been drilled to bedrock in buried-valley areas. Logs of these wells do not reveal the bedrock topography in as much detail as was desired to map the buried valleys adequately. Prior to the present investigation no well had been drilled to bedrock in the deepest part of the principal buried valley. To acquire the desired information on the configuration of the bedrock surface, earth-resistivity prospecting was done and was supplemented by test drilling at critical sites. The earth-resistivity work was done mostly in May, June, and August, 1951; some work was done also in September and October 1950, and a few measurements were made in June 1949 and May 1952.

In the earth-resistivity method of subsurface exploration an electric current is passed through the ground and the effects produced on this flow of current are measured and interpreted in terms of the nature of the material underlying the site being tested. The method depends upon the rocks containing some water, for if they were dry they would be nearly nonconductive. Spicer[1] has described the techniques used in Madison County. Briefly the apparent resistivity of the earth was computed by the Wenner formula; interpretation of the three resistivity curves obtained for each depth profile was done by methods based on the theory of images.

Test Drilling

As a check on the earth-resistivity work, and to provide correlation between the apparent-resistivity curves and the local geology, test drilling by the hydraulic rotary method was done by a private firm under contract with the U. S. Geological Survey and the Ohio Division of Water in the summers of 1952 and 1953. Drilling in unconsolidated deposits in Madison County amounted to a total of 3,112 feet in 10 test holes. The depth to bedrock at the test-hole sites ranged from 185 to 530 feet. The test holes are identified by numbers[1] as follows: in Fairfield Township, 335L; in Oak Run Township, 623L, 624L, 625L, 626L, 627L; in Pleasant Township, 943L, 944L, 945L; in Union Township, 1362L.

Considerable money was saved in the investigation by the substitution of comparatively inexpensive resistivity determinations for costly test holes at many points where subsurface information was needed. The difference in cost was in the ratio of 1 test hole to about 25 sites prospected by resistivity methods. Intensive preliminary investigations were made of the thickness of the glacial drift, and a detailed contour map, showing clearly the courses of the buried valleys, was prepared in advance of test drilling. The map made it easy to locate the test holes along the axes of the valleys, where the valley-fill deposits are thickest.

PREVIOUS WORK

Two early reports on the geology and water supply of Madison County are those by former State Geologist Edward Orton, Jr. (1878, 1898).

Frank Leverett (1897) presented tables listing characteristics of wells and water supplies in many Ohio towns and villages, including those at London, Mount Sterling, and Plain City, all of which had public water systems at the time of his investigation.

The most recent prior work on the water resources of Madison County is that by Wilber Stout, Karl Ver Steeg, and G. F. Lamb, (1943). These authors give a general summation of water resources in Ohio, including chapters dealing specifically with each of the 88 counties. In the chapter on Madison County the authors briefly describe the geology at each town and village and offer suggestions on the best areas in which to prospect for additional supplies of water.

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[1] In Norris, S. E., and Spicer, H. C.; see references at end of report.

[1] Records and locations of wells and test holes referred to in this report are shown in table 8 and on plate 1, respectively. Logs of representative wells and test holes are shown graphically on fig. 12.

ACKNOWLEDGMENTS

The author is indebted to the many residents of Madison County and public officials who provided information on wells and water supplies. The generosity of the following landowners, who permitted test holes to be drilled on their premises, is greatly appreciated: J. R. Patton, Mrs. Rea Chenoweth, Earl Anderson, R. H. Graham, Emmitt Morris, Harmon Boss, and Mrs. Mary Bricker. The many courtesies extended by W. S. Amerine, former superintendent of the London Prison Farm, and by his successor, R. B. Eckle, in permitting extensive geophysical prospecting to be done on the prison grounds and in allowing a test hole to be drilled there, contributed greatly to this investigation. Gratitude is expressed to the well drillers of the Madison County area, especially the firms of Arnold and Cook; W. D. Wood; Homer Robinson; Edgar Bussard; S. A. Burnham; H. C. Parrott; C. A. Bushong and Sons; Tom Underhill; N. J. Higgins; the Layne-Ohio Co.; and G. M. Baker & Son, all of whom provided information and records of wells. The earnest effort of D. J. Roe, Vandalia, Ohio, who drilled the test holes, to provide as much geologic data as possible in the course of drilling, is likewise appreciated.

Duncan McConnel, professor and former chairman of the Department of Mineralogy, Ohio State University, was kind enough to examine in considerable detail samples of the unconsolidated deposits from the test holes drilled in Madison County and to offer helpful comments on their general mineral composition and possible source rocks. John Droste, of the Department of Geology, University of Illinois, also examined samples of the unconsolidated deposits from the test holes and reported on their clay-mineral composition.

GEOGRAPHY

LOCATION AND SIZE OF THE AREA

Madison County, having an area of 464 square miles, is one of the largest counties in west-central Ohio. London, the county seat, lies about midway between Columbus and Springfield, approximately 3 miles south of U. S. Route 40. On the U. S. Geological Survey topographic maps Madison County occupies parts of nine quadrangles, namely: Dublin, Era, London, Mechanicsburg, Milford Center, Mount Sterling, Octa, South Charleston, and West Columbus. Figure 1 shows Madison County in relation to the other Ohio counties and the principal streams.

TOPOGRAPHY AND DRAINAGE

Madison County is part of the Till Plains section of the Central Lowlands physiographic province. The surface is very flat in the northeastern part, undulating in most parts, and moderately hilly in the central and western parts. The elevation ranges from less than 840 feet above sea level in the extreme southeastern corner of the county to slightly more than 1,180 feet above sea level near the western edge. Local relief is greatest, about 60 feet, along the main valleys where there has been dissection by short, steep tributary streams.

Except for a small area in the southwest corner, Madison County lies in the Scioto River drainage basin, immediately east of the drainage divide between the Scioto basin on the east and the Miami and Little Miami River basins on the west. The headwaters of three streams, Darby, Deer, and Paint Creeks, lie within Madison County. All these streams flow south or southeast (fig. 1). There are no natural lakes within the county, though a small artificial lake (Madison Lake), about 100 acres in extent, has been formed by raising the level of Deer Creek at a point 4 miles east of London.

The principal stream in Madison County is Darby Creek, which flows south through Plain City and along the eastern border of the county in the vicinity of West Jefferson. Darby Creek drains an area of 577 square miles, principally in Madison, Pickaway, Franklin, Union, and Champaign Counties. The stream enters the Scioto River at Circleville, (Pickaway County) about 647 feet above sea level.

The U. S. Geological Survey has maintained a gaging station on Darby Creek at Darbyville (Pickaway County) since October 1921, except for the period between December 1935 to January 1938. On figure 2-A is a hydrograph showing the annual flow in Darby Creek, expressed in inches over the drainage basin. The drainage basin of the creek above the gaging station includes 533 square miles; therefore, 1 inch on the hydrograph is equivalent to an average flow of more than 17,000 gpm (gallons per minute), or about 25 mgd (million gallons a day) for a year. Extreme annual flows during the period of record ranged from a low of little more than 2 inches, in 1934, to a high of about 19 inches, in 1951. Very low annual flows occurred also in 1925, 1931, and 1954. The mean flow of Darby Creek, during 21 years of record was 405 cfs (cubic feet per second)[1] or about 262 mgd. The maximum daily discharge was 17,900 cfs (about 11,600 mgd), and the minimum daily discharge was 1.4 cfs (0.9 mgd).

Deer Creek drains an area of 408 square miles, principally in Madison, Pickaway, and Ross Counties. Deer Creek flows into the Scioto River in northern Ross County at about 620 feet above sea level. A gaging station was maintained on Deer Creek at Williamsport (Pickaway County) from August 1926 to September 1956, except for a 2-year period, December 1935 to January 1938. The drainage area above the gage is 331 square miles.

A hydrograph of Deer Creek, expressed in inches over the drainage basin, is shown on figure 2-B. One inch on the hydrograph of Deer Creek is equivalent to a flow past the gaging station of nearly 11,000 gpm, or about 15.5 mgd, for a year. The mean flow of Deer Creek, determined for 26 years of record, is 284 cfs or about 183 mgd. The maximum daily discharge was 15,300 cfs (9,884 mgd) and the minimum daily discharge was 1.6 cfs (1.0 mgd).

Paint Creek has its headwaters in the southwestern part of Madison County and flows southeastward through Fayette and Ross Counties to the Scioto River south of Chillicothe. The upper reaches of Paint Creek consist of small streams, little more than runs and drainage ditches. Paint Creek is relatively unimportant in Madison County.

[1] One cubic foot per second is equal to 1.9 acre-feet per day, or 449 gallons per minute.

Figure I. Map of Ohio, showing county boundaries and principal streams.

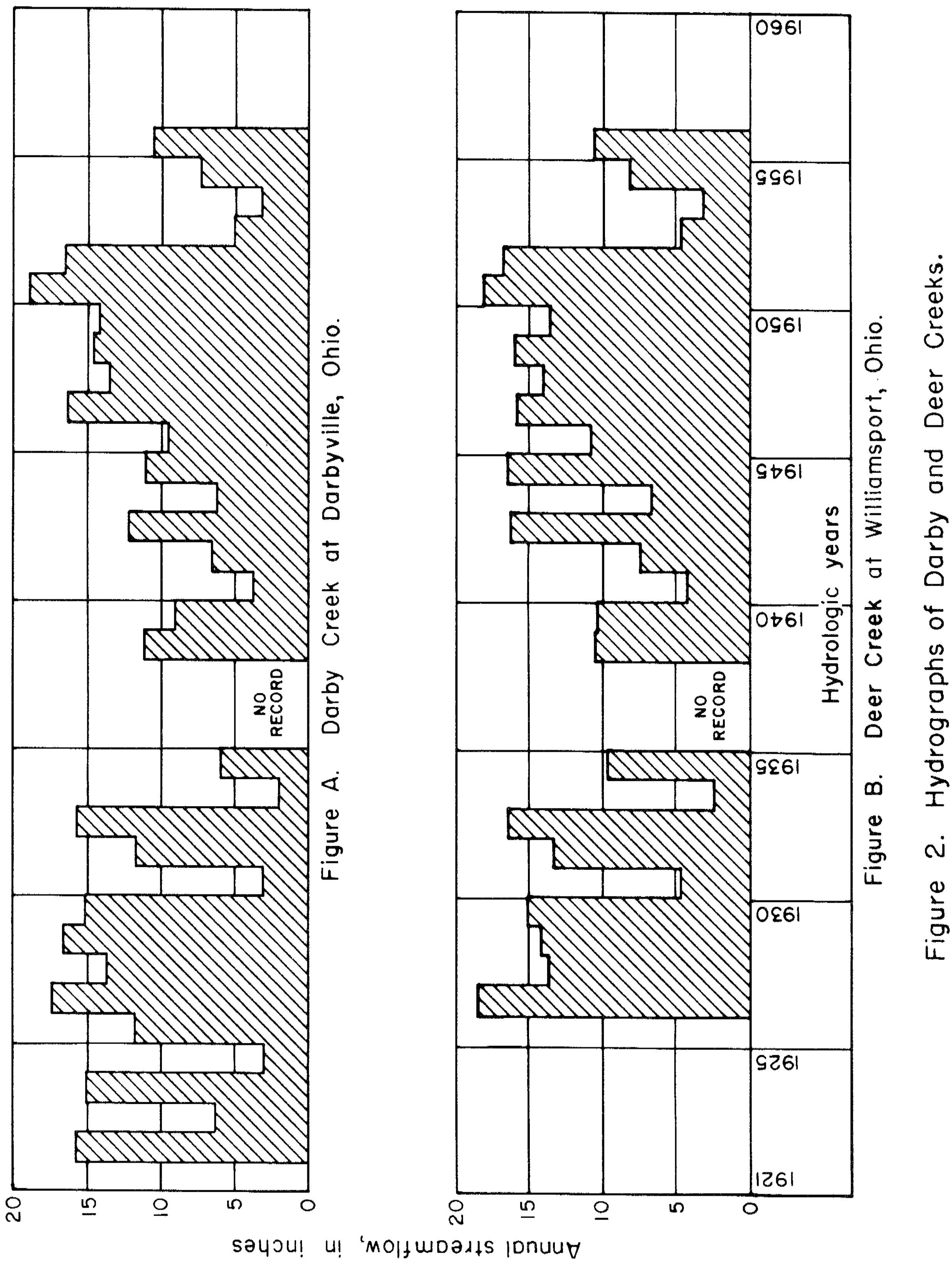


Figure A. Darby Creek at Darbyville, Ohio.

Figure B. Deer Creek at Williamsport, Ohio.

Figure 2. Hydrographs of Darby and Deer Creeks.

CLIMATE

Madison County has three U. S. Weather Bureau stations, at London, Sedalia, and near Mount Sterling. At London the period of record began in 1918, at Sedalia in 1941, and near Mount Sterling in 1945. The station near Mount Sterling was established cooperatively by the Weather Bureau and the U. S. Engineers, as a "hydrologic network" station. In 1948 it became a regular Weather Bureau station.

The average annual precipitation at London during the 25-year period 1921-45, was 38.84 inches, and the average annual temperature during the same period was 51.6° F. The average annual snowfall in Madison County was about 19 inches, and the length of the growing season during almost the same period was 169 days, between April 30 and October 17, in the average year. Tables 1 and 2 show, respectively, monthly and annual precipitation and temperature data for the London station from 1921 to 1957.[1]

Madison County, with a climate that is about average for the State, has been singularly free of destructive storms or floods. Flood damage to crops is a potential, though not a serious, hazard in Madison County. Of greatest importance in this connection are very heavy rains of short duration. According to Yarnell (1935, p. 45,), western Ohio may expect once in 10 years a 2-hour rainfall of about 2.5 inches. Once in a hundred years, Yarnell reports, parts of Ohio may expect over 3.5 inches of rain in a 2-hour period, and 5 inches of rain in a 24-hour period. Table 3 shows the greatest 24-hour precipitation recorded at London for each month during the period 1918-47.

POPULATION, FARMS, AND INDUSTRIAL DEVELOPMENT

In 1950 Madison County ranked 73d among the 88 Ohio counties in population, having 22,300, about evenly divided between urban and rural. London had a population of 5,222; Plain City, 1,715; West Jefferson 1,647; Mount Sterling, 1,172; South Solon, 414; Midway, 276.

According to the U. S. Census of Agriculture, about 93 percent of the land area in Madison County, or 277,208 acres, was in farms in 1954. The average farm area was 222 acres, and several farms were larger than 1,000 acres. The average value of the land in 1954 was $208 per acre. Madison County ranks among the important livestock counties in Ohio and lies within the eastward extension of the so-called Little Corn Belt.

The soils in Madison County are developed on glacial materials or on limestone bedrock and range from light-colored and moderately productive soils to dark-colored and highly productive. The chief source of farm income is hogs. The principal crops grown are corn, wheat, oats, and soybeans.

Present industrial development in Madison County, though small, is notable for its diversity. Articles manufactured in London include motor-vehicle parts, abrasive products, tile, metal pipe, and grave vaults. Mount Sterling has a plastics factory, a glove factory, and a woodworking concern. A plant near Plain City employs more than 300 people in the manufacture of mechanical measuring and controlling instruments. In recent months the Battelle Memorial Institute completed a nuclear test facility and laboratory near West Jefferson. The total number of people employed by industry in Madison County is approximately 1,200. It is significant to future water use that in per capita retail trade Madison County rose in rank from 44th to 5th place in the State between 1938 and 1948.

MINERAL RESOURCES

Madison County has only a minor place in Ohio's large mineral industry. Two sand and gravel pits, a small clay pit, and a small limestone quarry account for the county's entire mineral production. In 1954, 109,526 tons of sand and gravel were taken from the two pits. Most of this material was used in road work; the remainder went for building purposes. One of the sand and gravel pits is on Little Darby Creek 2 miles west of West Jefferson. The other pit is in Oak Run valley about 5 miles southeast of London. The sand and gavel in both pits is outwash from the Wisconsin glacier, the last of the Pleistocene epoch. Sand and gravel deposits are present in most valleys in Madison County, though the deposits are small in extent and thickness compared to the outwash deposits in most of the surrounding counties.

Limestone and dolomite production is comparatively small in Madison County (35,000 tons in 1954), ranking far below that of neighboring counties. Madison County's only quarry is on Little Darby Creek about 2 miles southwest of West Jefferson, near the Franklin County line. Most of the limestone produced in 1954 was for

[1] Climatological data in part from Sanderson, 1950.

Table 1.--Precipitation at London, Ohio, for the period January 1921 to December 1957. Monthly and annual amounts in inches and hundredths.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1921	2.78	2.38	7.82	5.43	4.58	2.10	1.08	4.47	2.80	1.95	3.30	2.25	40.94
1922	1.53	1.33	5.10	5.32	5.92	1.58	3.21	3.72	1.22	2.78	6.35	3.26	41.32
1923	3.40	1.87	2.38	2.30	2.22	2.68	5.16	7.53	2.09	1.15	1.75	3.02	35.55
1924	3.64	1.58	3.78	1.86	3.89	6.95	3.86	0.56	2.85	1.75	2.16	6.36	39.24
1925	1.00	1.36	2.50	4.46	3.12	3.00	2.96	1.20	4.90	0.21	1.83	2.67	29.21
1926	2.10	2.90	2.38	3.31	3.15	1.94	4.23	6.60	7.06	3.74	5.38	1.40	44.19
1927	3.84	2.44	3.29	5.05	4.90	3.50	3.05	2.64	3.45	4.64	1.90	2.55	41.25
1928	1.31	2.07	2.75	3.10	1.51	8.00	3.70	1.55	0.65	1.43	6.31	3.10	35.48
1929	5.15	3.60	3.23	4.78	7.40	2.32	5.58	3.55	3.66	4.05	3.53	2.68	49.53
1930	5.46	2.48	1.65	1.80	2.69	2.40	1.22	2.97	1.86	4.80	4.15	3.10	34.58
1931	1.10	1.28	1.17	4.22	2.09	2.40	5.30	6.10	5.20	0.52	1.35	0.97	31.70
1932	5.93	1.11	1.65	1.81	1.49	6.14	5.27	0.67	2.02	3.33	2.82	4.56	36.80
1933	1.95	2.10	7.37	3.93	6.81	0.59	1.27	4.02	3.57	3.33	2.96	3.41	41.31
1934	1.50	1.70	2.41	1.40	0.82	3.08	2.49	3.63	2.50	1.50	1.11	3.06	25.20
1935	1.89	1.20	2.22	1.97	4.19	3.40	4.45	9.26	3.89	0.37	1.16	1.29	35.29
1936	1.13	1.93	2.87	4.83	3.98	0.87	0.56	3.45	5.04	2.41	3.58	3.47	34.12
1937	11.35	2.30	1.87	3.97	4.07	5.40	4.37	2.10	2.06	3.85	2.63	2.30	46.27
1938	1.76	4.02	7.57	4.45	7.45	3.05	9.37	2.13	4.59	3.19	1.50	3.74	52.82
1939	4.44	4.04	4.02	4.64	1.90	9.55	8.90	0.52	2.30	0.49	3.27	1.93	46.00
1940	2.03	3.65	2.30	8.83	5.84	3.16	1.58	2.19	1.21	4.25	1.95	1.62	38.61
1941	1.60	0.88	0.71	1.35	2.45	7.27	4.67	3.38	1.85	1.29	3.68	2.60	31.73
1942	1.96	3.14	2.89	2.33	5.42	2.75	4.39	4.55	2.92	5.88	1.35	1.95	39.53
1943	1.31	2.17	4.80	2.72	6.31	1.82	8.01	4.49	2.66	1.94	4.21	5.63	46.07
1944	0.97	2.68	6.25	5.34	3.32	4.51	0.78	3.90	0.83	1.48	1.19	1.07	32.32
1945	1.63	4.06	8.39	5.64	4.25	5.75	3.91	1.08	2.61	0.42	1.93	2.40	42.07
1946	1.05	4.12	3.78	1.94	6.38	6.63	4.07	1.27	1.09	2.61	3.80	1.84	38.58
1947	5.18	0.34	1.80	7.34	8.14	6.17	3.79	3.80	4.11	2.08	2.29	1.49	46.53
1948	2.96	2.92	5.95	4.83	3.62	3.91	2.66	1.34	3.15	1.95	4.79	4.18	42.26
1949	8.05	2.71	3.56	2.68	2.30	6.15	3.33	2.93	4.28	1.50	1.19	2.90	41.58
1950	7.96	4.28	2.01	5.11	2.27	2.40	3.15	3.32	3.52	2.68	4.67	1.68	44.20
1951	3.92	3.90	4.46	4.33	5.39	2.15	2.50	1.22	2.48	1.50	5.53	3.99	41.37
1952	6.88	2.30	4.31	4.36	5.21	3.69	2.37	1.57	3.00	0.91	1.92	3.32	39.84
1953	4.05	1.08	2.54	2.92	4.02	1.77	6.92	2.62	0.63	0.52	1.13	1.56	29.76
1954	2.09	1.86	2.67	3.51	1.76	4.77	3.71	4.85	0.71	4.96	1.06	2.22	34.17
1955	1.33	3.45	4.50	2.16	2.36	2.64	4.13	1.89	4.01	2.76	5.45	0.55	35.23
1956	2.15	3.60	4.20	4.03	6.59	1.89	2.41	2.39	2.18	1.56	1.38	3.42	35.80
1957	1.92	2.12	2.11	7.21	7.27	7.37	4.30	1.10	4.14	2.22	3.46	4.42	47.64
Average	3.19	2.45	3.60	3.92	4.19	3.88	3.86	3.09	2.89	2.32	2.92	2.75	39.13

Table 2.--Temperature at London, Ohio, for the period January 1921 to December 1957. Monthly and annual temperature in degrees Fahrenheit.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1921	33.0	33.9	50.3	54.8	61.8	72.7	77.7	70.2	69.8	59.4	39.8	33.4	54.7
1922	25.1	33.0	42.3	53.3	64.2	71.2	73.0	70.8	68.6	53.2	42.5	33.2	52.2
1923	32.5	26.8	37.8	49.0	58.8	70.6	73.9	71.2	64.1	56.8	43.6	32.4	51.5
1924	24.1	28.2	35.4	50.8	54.6	68.5	70.0	72.5	61.2	51.8	40.6	40.7	49.9
1925	26.5	36.8	42.0	55.2	57.0	72.8	73.2	72.4	70.6	58.8	40.8	27.4	52.8
1926	25.6	30.9	32.0	44.7	59.6	65.0	72.8	62.8	66.2	44.2	39.4	28.3	48.4
1927	27.4	36.6	41.6	49.0	58.7	60.4	71.0	66.6	68.2	52.1	38.6	29.2	49.9
1928	28.4	30.2	37.4	45.9	59.0	65.0	63.8	65.2	60.6	57.2	46.0	31.2	50.8
1929	24.8	24.8	44.5	51.6	57.0	65.0	74.7	70.2	63.8	57.6	42.0	33.8	50.8
1930	-	38.4	37.4	51.6	61.8	68.8	77.0	71.8	66.0	51.8	37.0	-	-
1931	31.2	35.6	35.6	48.6	57.6	71.6	77.0	71.6	70.4	50.7	41.3	29.8	51.7
1932	38.8	38.2	34.0	48.0	61.0	70.6	72.4	72.5	66.1	57.0	49.6	39.4	54.0
1933	36.8	31.0	38.3	49.4	62.7	74.6	74.4	72.2	67.6	52.8	38.6	30.0	52.4
1934	41.2	19.7	33.8	49.5	63.6	76.2	79.3	71.2	67.3	51.6	38.4	32.6	51.2
1935	29.6	31.8	47.2	46.8	55.0	67.8	77.2	73.2	64.6	54.4	45.0	29.4	51.8
1936	21.2	22.1	42.9	45.4	65.2	71.6	79.8	78.0	70.4	54.6	42.8	24.4	51.5
1937	36.2	30.6	35.4	49.8	60.0	69.2	72.4	74.3	63.2	54.4	37.4	36.4	51.6
1938	29.6	38.1	44.8	54.4	61.2	67.8	73.0	73.8	62.8	52.0	38.6	28.4	52.0
1939	32.9	31.2	40.6	46.3	63.0	72.3	72.2	73.0	70.8	54.0	43.2	31.8	52.6
1940	15.1	29.6	36.8	46.4	57.8	71.3	74.6	74.7	64.4	56.6	39.6	34.2	50.1
1941	28.8	26.4	33.8	55.8	63.9	70.6	74.6	71.6	69.2	55.4	39.8	37.5	52.3
1942	26.8	26.4	41.9	55.0	61.8	71.2	74.4	70.8	65.0	58.2	42.2	36.0	52.5
1943	29.0	31.5	34.8	44.2	60.2	74.2	73.4	72.1	61.6	54.6	42.6	26.6	50.4
1944	31.6	33.2	36.0	48.8	66.0	72.7	76.2	74.6	66.4	52.6	38.2	28.7	52.1
1945	20.4	29.2	50.1	52.0	55.5	67.4	70.6	70.6	67.6	53.6	41.2	24.3	50.2
1946	29.5	32.0	50.2	50.1	58.0	68.2	71.7	66.3	65.9	51.4	41.2	23.4	50.7
1947	33.4	21.6	32.2	50.0	56.8	67.1	68.4	75.9	65.0	61.6	38.3	29.9	50.0
1948	19.6	30.0	41.3	53.8	57.9	68.9	73.8	71.8	67.4	50.8	45.9	34.4	51.3
1949	35.5	35.6	41.4	48.3	62.4	73.1	76.3	71.9	60.2	58.4	41.5	34.5	53.3
1950	37.9	32.0	36.4	45.1	61.5	67.8	71.1	69.4	63.5	57.2	35.5	23.7	50.1
1951	30.8	29.8	39.7	48.7	62.2	69.8	73.3	71.8	64.5	57.8	35.2	29.9	51.1
1952	33.7	33.5	38.5	30.9	59.5	74.3	76.3	73.1	66.6	49.8	43.0	34.1	52.8
1953	33.7	34.8	41.9	46.8	63.9	72.9	74.6	73.2	66.3	57.7	43.0	32.9	53.5
1954	31.1	38.3	37.5	57.2	56.9	72.0	74.3	71.6	69.5	56.6	41.8	31.7	53.2
1955	27.6	32.2	41.5	56.5	63.3	66.3	75.7	74.8	67.3	53.5	38.2	28.5	52.1
1956	25.7	33.5	39.1	47.5	60.8	69.8	72.1	71.8	62.2	56.8	40.6	38.0	51.5
1957	23.2	34.0	38.7	51.9	59.8	69.1	71.6	70.2	63.5	49.8	41.8	35.6	50.7
Average	29.1	31.3	39.5	49.5	60.2	69.9	73.9	72.1	65.9	54.5	40.9	31.5	51.6

Table 3.--Greatest 24-hour precipitation at London, Ohio for the period May 1918 to December 1947. Monthly and annual amounts in inches and hundredths.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1918					.95	.60	1.10	1.50	1.50	.90	.72		
1919	.85	.46	1.00	.70	.85	.60	.90	.53	.40	.96	.98	.73	1.00
1920	.30		1.20	2.16	.93	.87	2.14	1.83	.90	1.37	1.52	.62	
1921	.89	.91	1.87	1.22	1.08	.82	.30	2.21	1.29	1.14	1.30	1.15	2.21
1922	.50	.28	1.33	1.80	1.43	.43	1.58	1.54	.87	.41	.47	.58	1.80
1923	.75	.41	.70	.40	.80	.63	1.22	3.25	.84	.56	.93	1.55	3.25
1924	.98	.45	1.61	.55	.69	2.80	1.26	.19	1.36	.15	.89	.60	2.80
1925	.30	.65		1.96	1.42	.70	.96	.50	3.00	1.17	1.72	1.25	
1926			.73	1.13	.94	.62	2.80	1.60	1.30	1.00	.80		
1927	.80	.48	1.10	1.00	1.04	.78	.95	.76	2.00	.72	2.00	.70	2.00
1928	.48	.60	1.00	1.80	.33		1.05	.40		1.25	1.90	1.10	
1929	1.90		1.00	1.50	1.30	.55	1.70		.90	1.60	1.05		
1930		.60	.95	.85	.90	1.25	.90	1.35	.55	.35	.65	.60	
1931	.75	.50	.28	1.09	.65	.95	2.90	1.10	2.00	1.80	.50	1.20	2.90
1932	1.10	.35	.36	.50	.76	3.92	1.28	.32	.55	.85	1.10	1.27	3.92
1933	.64	.88	1.40	1.00	1.43	.22	.50	1.56	1.20	.85	.64	1.60	1.60
1934	.67	.50	.55	.50	.34	1.05	1.25	1.60	.95	.31	.40	.80	1.60
1935	.70	.40	.55	.65	1.40	1.00	1.00	2.40	2.05	.80	.90	.70	2.40
1936	.40	.74	.81	.95	.93	.35	.50	1.25	1.90	1.02	.82	.70	1.90
1937	2.05	.90	.55	1.10	1.05	1.10	1.60	.65	1.25	1.65	.50	2.24	2.24
1938	.60	1.04	2.10	1.60	1.50	1.15	2.25	1.03	1.90	.27	1.60	.90	2.25
1939	1.20	1.00	.90	1.25	1.00	2.10	2.85	.22	1.00	2.00	1.10	.75	2.85
1940	.75	1.00	1.00	2.20	.95	.50	.58	1.20	.92	.45	1.10	.75	2.20
1941	.48	.25	.37	.35	1.35	1.80	1.19	1.25	.59	1.40	.46	.95	1.80
1942	.62	.70	.72	1.20	1.05	1.23	1.59	1.69	1.05	.74	1.09	1.00	1.69
1943	.40	.53	2.45	.56	1.10	.85	2.61	1.61	1.70	.42	.52	.65	2.61
1944	.68	.97	1.48	1.05	1.12	2.73	.30	.96	.50	.30	.47	.79	2.73
1945	.30	1.45	2.65	.92	.95	1.07	1.49	.44	.97	1.21	.84	.72	2.65
1946	.16	1.25	.70	.59	1.17	2.58	2.52	.52	.91	.98	1.34	1.02	2.58
1947	1.26	.15	.95	1.40	2.46	3.29	.73	1.70	1.32	1.30	.48	.45	3.29
Most	2.05	1.45	2.65	2.20	2.46	3.92	2.90	3.25	3.00	2.00	2.00	2.24	3.92

road material; about 2,500 tons was for agricultural use.

The small clay pit, mentioned above, is at the east edge of London and is operated by a tile-manufacturing company. The main product is drain tile in sizes up to 2 feet in diameter. Some brick also has been produced in past years. The clay is of glacial origin, of common occurrence in the glaciated portion of the State.

There is no oil or gas production in Madison County or in the surrounding area, and no exploratory holes have been drilled in the county for many years. In recent months, however, several thousand acres in Madison and adjacent counties have been leased and, according to newspaper reports (1957), a major oil producer plans to drill for oil. If the venture proves successful it will, or course, have a tremendous impact on the economic development of the area.

WATER USE

Estimated ground-water pumpage in Madison County in 1956 for municipal, industrial, and rural purposes was about 2 mgd. Five communities have public water supplies; their combined pumpage in 1956 averaged about 900,000 gpd (gallons per day), divided as follows: London 424,000; Plain City, about 200,000; West Jefferson 150,000; Mount Sterling 90,000; South Solon 30,000. London gets its water from wells in gravel deposits; the other communities obtain their supplies from limestone beds. Ground water pumped by industries and institutions in Madison County in 1956 averaged about 750,000 gpd. Most of this, approximately 600,000 gpd, was used by the London Prison Farm. Table 4 shows water costs and treatment facilities for the public water supplies of Madison County.

Surface water is not now pumped for municipal or industrial use.

Table 4.--Meter rates, water use, and treatment facilities for Madison County communities1/

City or village	Population (1950 census)	Average daily pumpage 1956 2/	Services		Minimum annual charge		Average monthly meter rate, cents per 1000 gal.					Treatment
			Total	Percent metered	Cost in dollars per 5/8" meter	Water allowance 1,000 gallons	0-5 M. gal.	5-25 M. gal.	25-250 M. gal.	250-1000 M. gal.	over 1000 M. gal.	
London	5,222	424,000	1,625	96	27.00 (14.83)3/	24.0 (31.2)	90 (47)	65 (37)	27 (25)	15 (21)	15 (20)	Softening by lime-soda process.
Plain City	1,715	200,000	500	0	20.00 (18.62)	---- (31.5)	-- (49)	-- (33)	-- (25)	-- (21)	-- (16)	None
West Jefferson	1,647	150,000	460	100	12.00 (18.87)	20.0 (28.8)	55 (58)	48 (41)	28 (32)	25 (27)	25 (25)	Softening by lime-soda process.
Mount Sterling	1,172	90,000	446	100	16.00 (18.87)	20.0 (28.8)	65 (58)	41 (41)	25 (32)	25 (27)	-- (25)	Softening by lime-soda process.
South Solon	414	30,000	125	0	36.00 (18.62)	---- (31.5)	-- (49)	-- (33)	-- (25)	-- (21)	-- (16)	Iron removal only.

1/ Based in part on brochure of Ohio Department of Health, published in 1954, entitled "Data on meter rates, meter installations and water consumption for Ohio municipalities, 1952-53".

2/ Municipal pumpage at London is metered at the source; pumpage figures for the other municipalities are estimates.

3/ Numbers in parentheses are averages of Ohio communities of comparable size having similar treatment facilities.

SURFACE-WATER CONDITIONS

WATER-SUPPLY POSSIBILITIES

Darby and Deer Creeks offer abundant possibilities for the development of surface-water supplies in Madison County, and it seems only a matter of time before water from these sources will be utilized extensively for industrial and municipal purposes. At present none of the communities in Madison County depend on surface-water sources. However, if these communities continue to grow they will eventually reach a point where all economically feasible sources of water must be developed to meet their water requirements. When this point is reached the advantage will go to those communities that are favorably located with respect to both ground-water and surface-water sources. As expressed by Sherman (1932, p. 1):

> Our largest cities have grown on abundant water supplies. A number of early settlements in Ohio were laid out on hill-tops or highlands, with the expectation of their becoming large towns, as shown by their original town bounds. The difficulty of getting cheap water stunted their growth, and they have remained villages. Examples of these unrealized hopes can be cited in the four quarters of the State. On the other hand, later settlements, along the abundant waters of Lake Erie, and Ohio River, have grown into prosperous cities. So have interior towns which were located on the larger streams.

The streamflow data presented herein show the general conditions controlling the potential development of surface-water supplies and the use of streams for the disposal of wastes. Detailed studies of chemical quality, sediment load, water temperatures, and reservoir sites will more clearly define the water-supply possibilities in specific areas.

CHARACTERISTICS OF STREAMFLOW

Duration of Flows

The hydrograph of annual flows, such as shown on figure 2 for Darby and Deer Creeks, has obvious limitations in water-supply studies which ordinarily are concerned with fluctuations over much shorter periods. We know, for example, that the flow in Darby Creek ranges from very low, when the stream is in pool stage and the only perceptible flow is over the riffles, to very high, when the stream is in flood. The fluctuations in daily or even hourly flow may be highly important to water-supply or storage problems. Information on the frequency of occurrence and magnitude of various rates of flow also is desirable. This leads to an important method of streamflow analysis based on flow-duration data. A flow-duration curve shows the number of times a given flow has been equaled or exceeded. Plotted in percent of time, the duration curve is essentially a hydrograph of average flows (generally daily or monthly flows) arranged in order of magnitude. Duration curves ordinarily are plotted in terms of flow per unit of drainage area for purposes of comparison. The duration curves shown on figure 3 of the flows of Darby and Paint Creeks and the Mad River are expressed in cubic feet per second per square mile. The general shape of the flow-duration curves is due to climatic factors, principally precipitation. Differences in slope are related to the characteristics of the drainage basins. As explained by Cross and Bernhagen (1949, p. 4):

> During dry weather the flow of streams is almost entirely from ground-water sources. The lower ends of duration curves therefore indicate in a general way the characteristics of the shallower ground-water bodies in the drainage basin above the gaging station.

Generally speaking, a gently sloping flow-duration curve reflects the smoothing effect of ground-water storage, which reduces the range of fluctations to produce low flood peaks and relatively large dry-weather flows. Conversely, a steep curve indicates rapid runoff with high flood peaks and correspondingly small dry-weather flows. Thus, the flow-duration curve, by showing differences in the natural storage properties of otherwise comparable basins, has its greatest usefulness in separating unfavorable areas from those which offer the best prospects for the development of ground-water supplies. The differences in the slopes of the duration curves shown on figure 3 are readily apparent. The duration curve for the Mad River is flatter than that for any other stream in Ohio; the duration curves for Paint and Darby Creeks are among the steepest, indicating relatively little

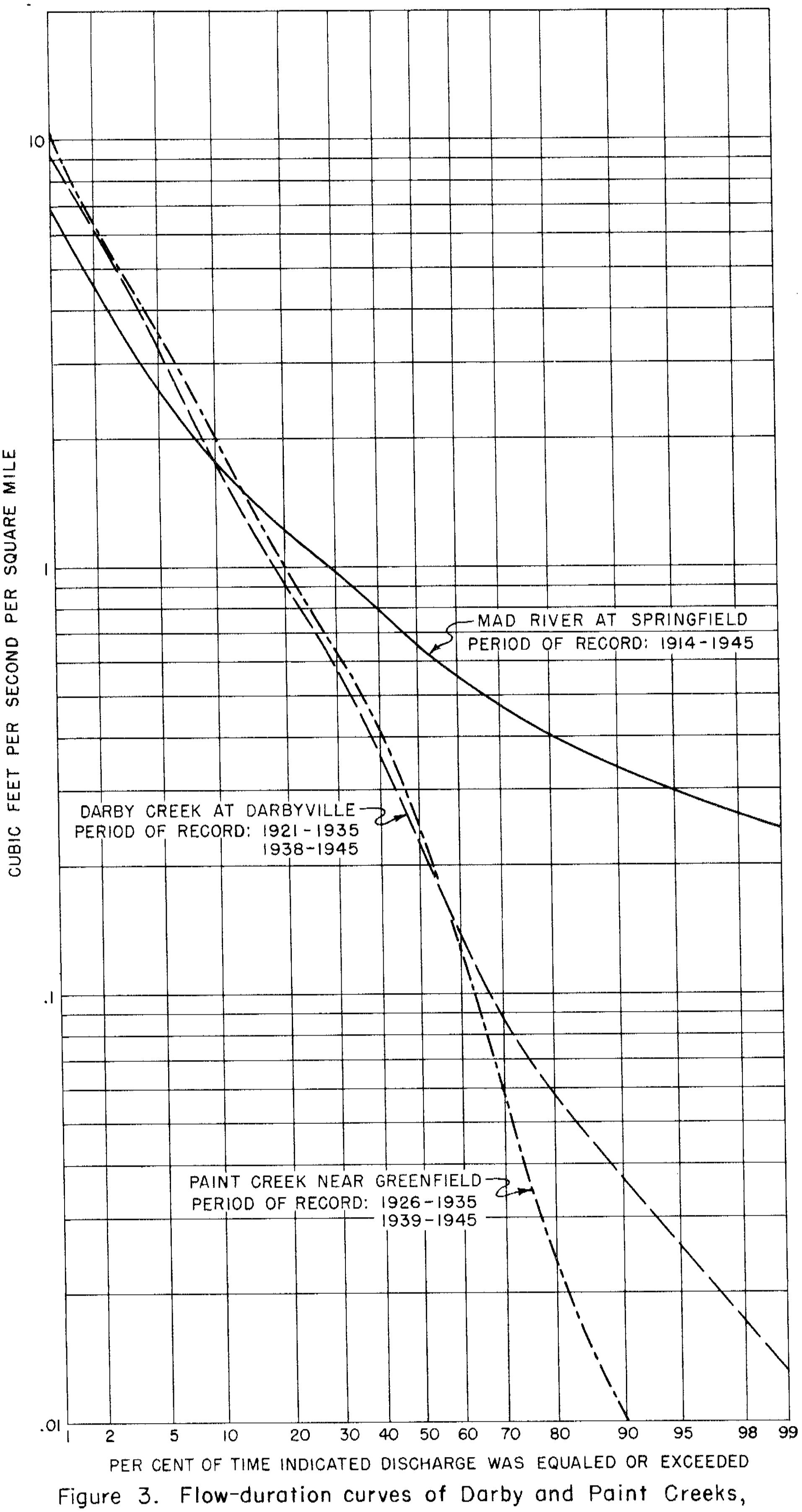


Figure 3. Flow-duration curves of Darby and Paint Creeks, compared to the curve of the Mad River.

storage in the less permeable deposits drained by the creeks.

To illustrate still another use of flow-duration curves, Cross and Bernhagen (1949, p. 6) have made hypothetical calculations, based on flows in Darby Creek, showing the relationship between degree of sewage treatment required and the number of people that could be served if the stream were used for sewage disposal. They have calculated that populations ranging from 1,050 to 10,000 could be served, according to the degree of treatment. Obviously many other considerations will enter the picture before development of a large water supply is undertaken, or before a sewage-treatment plant is constructed, but flow-duration data will roughly define the possibilities.

Minimum Flows

The duration curve, by indicating only the percentage of time during which certain rates of flow are equaled or exceeded, obscures the chronology of events and fails to reveal how frequently flows of a specified magnitude may be expected, or their probable duration. The graph of figure 4-A taken from a report by Cross and Webber (1950), overcomes these deficiences, and shows the discharge available in periods of drought. This graph (discharge available without storage) is a plotting of drought flows in Darby Creek for various periods, ranging from 1 day to 84 months, compared to the average flow for the entire period of record.[1] The graph shows that the lowest recorded daily flow in Darby Creek was about 0.003 cfs per square mile[2], or approximately 900,000 gallons. The lowest flow recorded for 10 consecutive days averaged 0.005 cfs per square mile, or about 1.6 mgd. This may be compared to the mean flow of 0.758 cfs per square mile, or approximately 266 mgd.

The results of a frequency analysis of the minimum flows that have occurred in each year of record during various periods ranging from 1 day to 6 months taken from the report by Cross and Webber (1950) are also shown on figure 4. Plotted in percent of time, the graph shows for selected periods the minimum discharge in 50 percent and in 75 percent of the years of record. These flows are taken from frequency graphs at the 2-year and the 4-year recurrence intervals; that is, on the average they may be expected to recur once in 2 years and once in 4 years, respectively. As shown by the graph, the lowest daily flow during 50 percent of the years was 0.02 cfs per square mile, or 6.9 mgd. The lowest flows recorded in any 7-day period during 50 percent of the years exceeded 0.025 cfs per square mile, or 8.6 mgd.

When a greater number of years is considered it is to be expected that the chances for more extreme drought flows will be correspondingly increased. The graph shows that the lowest daily flow in 75 percent of the years was 0.01 cfs per square mile, or 3.4 mgd. The lowest flows in a 7-day period during 75 percent of the years averaged about 0.014 cfs per square mile, or about 4.5 mgd.

Another important use of minimum-flow data is in computing storage requirements. According to the availability of reservoir sites, many problems involving pollution control or water supply can be solved by providing storage for use during periods of drought. The amount of storage required to maintain specific flows is the critical factor in design problems. The "storage-required" curve, or unit-storage graph, shown in figure 4-B is corrollary to the graph of discharge available without storage. The unit-storage graph can be used to estimate the approximate amount of artificial storage that must be provided to give a specific flow continuously at selected points in the basin, neglecting losses from evaporation and channel seepage. According to the curve (fig. 4-B), approximately 5,000 acre-feet[1] (9.4 acre-feet per square mile) would be required to maintain a flow of 10 mgd (0.019 mgd per square mile) at the gaging station. Or, to take another point on the curve, if Columbus' new Hoover Dam, with its 60,000 acre-feet (112 acre-feet per square mile) of storage, were constructed on Darby Creek there would be a minimum flow of about 65 mgd (0.122 mgd per square mile).

The unit storage curve is useful in conveying a general idea of the minimum-flow characteristics of Darby Creek. A comparison of the unit storage curve for Darby Creek with similar curves for the other streams in Ohio shows that Darby Creek ranks among the 10 percent of the streams that have the smallest natural storage in their drainage basins.

Low-Flow Studies

To determine specifically the areas that contribute the most water to the streams during periods of low flow, discharge measurements were made at several places in Madison County on November 2, 1949, during a drought period. The

[1] The minimum-flow curve, because of a gap in the record, has been adjusted to the 25-year period 1921-45, which is used for comparative purposes as the standard or base period in Ohio.

[2] More accurately, 0.0025 cfs/sq. mi., recorded Oct. 7, 1931.

[1] An acre-foot of water is equivalent to 325,829 gallons.

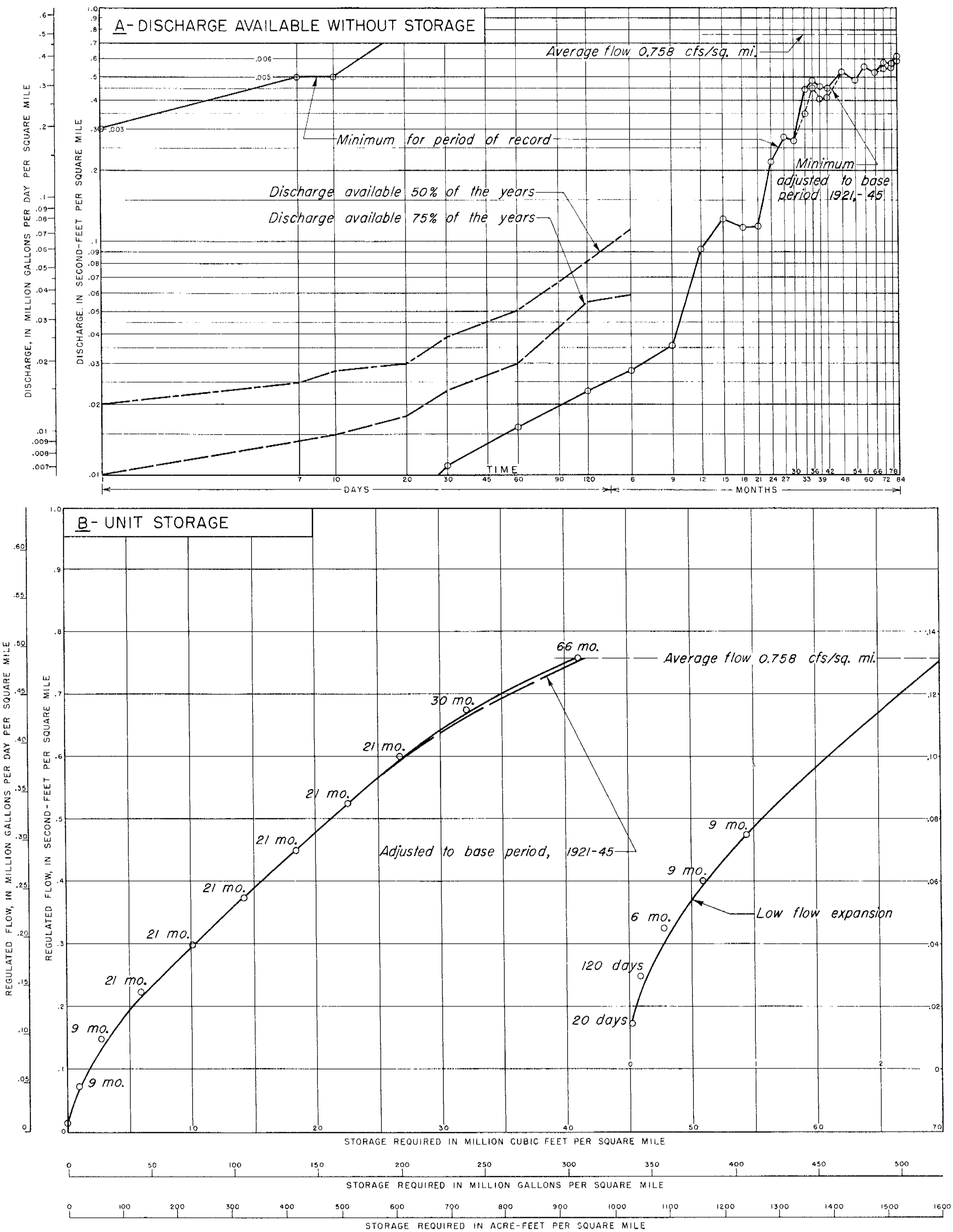


Figure 4. Flow characteristics, Darby Creek at Darbyville. (Drainage area 533 square miles)
Period of record: 1921-35, 1938-46.

locations of the points where measurements were made, the drainage areas of the streams above these points, and the flow indices are shown on figure 5. The flow measurements are given in table 5. At the time the measurements were made the flows were near the 75- to 80-percent points on the flow-duration curves. The unit flows, as was expected, were all lower than the average unit flow for the State, again pointing up the comparative scarcity of permeable deposits in Madison County.

The slightly greater yield per square mile in the headwater area shown in table 5 cannot be due to permeable deposits having large storage capacity, because the channels of these streams are cut in till. Instead, the drought flow in the upper reaches may be maintained by isolated springs or by the discharge from seepage areas. Farther downstream, transpiration by riparian vegetation or other channel losses may tend to deplete any such accretion.

Flood Flows and Flood-Control Projects

The largest flood recorded (U. S. Geological Survey, 1956, p. 417) on Darby Creek at Darbyville during the period 1921-36, 1938-50 was 22,600 cfs on February 27, 1929. During the period since 1950, no flow higher than that of February 27, 1929, has occurred.*

To provide flood protection in the Ohio River Basin, the U. S. Corps of Engineers has built nearly a score of flood-control reservoirs on Ohio streams, and preliminary plans for the construction of several more have been drawn. Among the new projects authorized but yet to be started are flood-control reservoirs on Big Darby Creek at Darbydale (Franklin County) and on Deer Creek at Crownover Mill (Pickaway County).

* Since this was written a flood occurred at this point on Jan. 22, 1959 of 49,000 c.f.s.

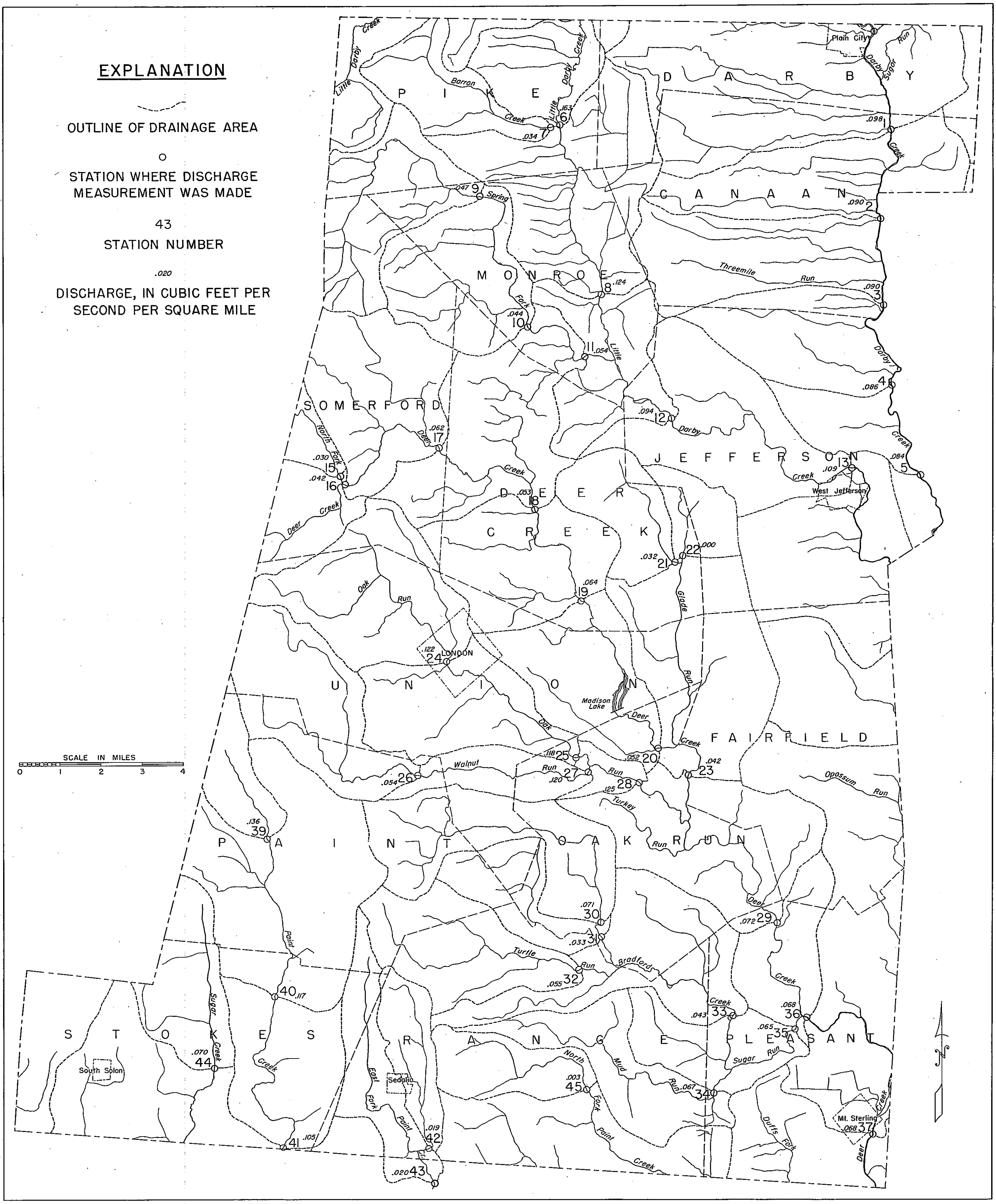


Figure 5. Map of Madison County, Ohio, showing the present drainage areas and points where discharge measurements were made.

Table 5.--Miscellaneous streamflow measurements, Madison County, Ohio.
November 2, 1949

Station No.	Stream	Drainage area (sq.mi.)	Flow (cfs)	Flow index (cfs/sq.mi.)
1	Darby Creek	195	19.2	.098
2	Darby Creek	207	18.7	.090
3	Darby Creek	224	20.1	.090
4	Darby Creek	239	20.6	.086
5	Darby Creek	248	20.8	.084
6	Little Darby Creek	78.4	12.8	.163
7	Barron Creek	6.1	.21	.034
8	Little Darby Creek	101	12.5	.124
9	Spring Fork	19	.89	.047
10	Spring Fork	29.6	1.29	.044
11	Spring Fork	35.3	1.92	.054
12	Little Darby Creek	145	13.6	.094
13	Little Darby Creek	159	17.3	.109
14 1/	Darby Creek	533	43.5	.082
15	North Fork Deer Creek	11.2	.34	.030
16	Deer Creek	18.8	.79	.042
17	Deer Creek	33.0	2.03	.062
18	Deer Creek	41.5	2.20	.053
19	Deer Creek	52.6	3.39	.064
20	Deer Creek	62.7	3.24	.052
21	Glade Run	5.7	.18	.032
22	East Branch Glade Run	3.4	0	0
23	Deer Creek	87.1	3.70	.042
24	Oak Run	13.0	1.58	.122
25	Oak Run	22.9	2.70	.118
26	Walnut Run	12.2	.66	.054
27	Walnut Run	16.3	1.95	.120
28	Oak Run	40.8	5.12	.125
29	Deer Creek	142	10.2	.072
30	Bradford Creek	11.6	.82	.071
31	Bradford Creek	17.1	.56	.033
32	Turtle Run	9.6	.53	.055
33	Bradford Creek	38.7	1.65	.043
34	Mud Run	8.5	.57	.067
35	Sugar Run	53.9	3.48	.065
36	Deer Creek	202	13.8	.068
37	Deer Creek	233	15.8	.068
38 1/	Deer Creek	331	18.8	.057
39	Paint Creek	5.8	.79	.136
40	Paint Creek	26.4	3.10	.117
41	Paint Creek	35.8	3.76	.105
42	East Fork Paint Creek	4.2	.08	.019
43	East Fork Paint Creek	11.0	.22	.020
44	Sugar Creek	9.0	.63	.070
45	North Fork Paint Creek	3.6	.012	.003
46 1/	Paint Creek	251	9.5	.038

1/ Station locations not shown on figure 5.

GEOLOGY AND GROUND-WATER HYDROLOGY

SOURCE AND OCCURRENCE OF GROUND WATER

Ground water is that portion of the precipitation that neither runs off directly into streams nor evaporates, but instead, after seeping into the soil, fills the cracks or pore spaces in the rocks below the water table. Ground water flows through the rocks, as streams flow on the surface, from points of higher to points of lower head. Ground water moves so slowly that it is commonly thought of as being stationary or static; hence the term "static water level", which is used to denote the level of water in a well that is not being pumped. Water levels in wells are never "static" in a literal sense, for the water in the ground is constantly changing in quantity, either draining away or being replenished in response to variations in weather and other factors.

The physical characteristics of the rocks are among the principal factors determining the mode of occurrence and movement of ground water. Water in consolidated rocks occurs mostly in crevices and solution channels, which generally permit flow from one part of the formation to another, much as in a system of pipes. Water in sandstone may occur also in pores, although the pores in some sandstones are completely filled with cement. Wells drilled into limestone commonly show great differences in yield, according to the number, size, and interconnection of the openings intercepted. Water in unconsolidated deposits, principally sand and gravel, occurs in and moves through the pore spaces between the constituent particles or grains. Water moving through sand and gravel obeys the laws governing flow through porous materials. For this reason, sand and gravel aquifers lend themselves especially well to methods of quantitative evaluation based on pumping tests, whereby yields of wells and drawdowns in wells can be predicted if the character of the aquifer and its role in the hydrologic cycle are sufficiently defined.

Artesian and Water-Table Conditions

Ground water occurs naturally under artesian (confined) and water-table (unconfined) conditions. The difference between these modes of occurrence may be understood by considering water in a surface reservoir. If rain descends into a watertight depression in the earth's surface at a rate sufficient to overcome evaporation, the depression eventually becomes a pond or lake in which the water is retained until it has reached a high enough level to overflow, after which the water will begin to move in the direction of the outlet. Under these simple conditions of inflow and outflow the water in the lake is unconfined and the surface is a free surface; that is it is at atmospheric pressure. These basic conditions obviously are not changed if a few small pebbles or grains of sand are deposited in the lake. Neither are the conditions altered if grains of sand are added until they fill the entire basin and obscure the water from view. To be sure, the water will move much more slowly through the body of sand, and will move by laminar instead of turbulent flow, but it will move nevertheless, just as it did in the former lake to the reservoir outlet or discharge area. This can be verified by sinking wells and observing the water surface, now called the water table, in the sand-filled lake.

Now if, in our sand-filled reservoir, we place extensive beds having relatively low permeability, such as layers of clay or till, and if we position these relatively impermeable beds in such a way that they form a barrier to the natural movement of the ground water, the water between impermeable bodies becomes confined and is termed "artesian." An artesian aquifer functions largely as a conduit between areas of recharge and discharge, although its elasticity gives it some capacity to act as a storage reservoir also.

Artesian and water-table conditions have radically different effects on the extent and rate of growth of the cones of influence produced by discharging wells. When a well in an unconfined aquifer is pumped, water flows toward the well by gravity and drains from storage as the cone of influence develops. Dewatering the aquifer slows the effects of pumping, and the drawdown that occurs within any specified time is smaller than it would have been had little or no stored water been available. When a well in an artesian aquifer is pumped the aquifer is not drained by gravity, except perhaps in the immediate vicinity of the well if the water level is drawn below the upper confining bed. As only a little water is made available from storage, by elastic compression of the aquifer and expansion of the water, the cone of influence must extend over a greater area to induce the amount of water being pumped to flow into the well, and the effects of pumping are quickly transmitted from one part of the aquifer to another. Artesian and water-table conditions are of practical importance with respect to problems of well interference and well spacing. However, the hydraulic properties of an aquifer alone do not determine its perennial yield. The upper limit of yield is set by the average annual recharge, just as in a surface reservoir, though the hydraulic properties are important in determining how much of the recharge can be captured economically.

PRINCIPAL AQUIFERS IN MADISON COUNTY

Approximately half the wells in Madison County are drilled into sand and gravel beds which underlie or are interbedded in the glacial till that generally forms the land surface. These buried sand and gravel beds are thickest and most extensive in the west-central part of the county, which they are sources of water to London and the London Prison Farm.

Sand and gravel beds occur at the surface in the Darby Creek and Deer Creek valleys, where they are favorably located to receive recharge by induced infiltration of streamflow. Though of potential importance as sources of water for large-scale industrial use, the sand and gravel beds in Darby Creek and Deer Creek valleys are practically untapped.

The limestone and dolomite strata of Madison County are sources of water for 4 of the 5 communities that have public water systems, and generally are dependable sources of water supply for farms and suburban homes. Most wells drilled in the limestone and dolomite deposits are in the northern part of the county, where the glacial deposits are comparatively thin. Other areas in which wells in limestone and dolomite predominate are in the east-central and southern parts of the county, where the glacial deposits contain few permeable beds. The average depth of 470 wells drilled into the limestone and dolomite deposits in Madison County is 125 feet.

Water Levels in Wells

Water levels in wells in Madison County are relatively shallow; their general depth is between 10 and 40 feet, but the range is from a few feet above the land surface, in flowing artesian wells, to about 90 feet below the land surface, reported at a few places. Under nonpumping conditions, the water level is not lower than 90 feet in any well inventoried in Madison County.

Ground-water levels fluctuate seasonally in response to climatic factors. Usually, they rise during the late winter and spring, and decline during the growing season when evapotranspiration losses are high. Kaser (1954, p.6) states that the magnitude of the annual cyclic fluctuations in Ohio may range from less than a foot to as much as 20 feet. A hydrograph on figure 6, showing water levels in an observation well (940)[1] near Mount Sterling, reveals an annual fluctuation ranging from 2 to 5 feet.

LIMESTONE AND DOLOMITE

Stratigraphy, Structure, and Areal Distribution

The bedrock of Madison County consists mainly of limestone and dolomite strata of Silurian and Devonian ages, listed in table 6. Beneath the limestone and dolomite is several hundred feet of shale of Ordovician age. The strata lie on the east flank of the Cincinnati anticline and dip northeastward about 20 feet per mile toward the Appalachian basin. The top of the Ordovician shale (Richmond group) declines in elevation from about 800 feet above sea level in southwestern Madison County to about 300 feet above sea level in the northeastern part of the county. At London the shale is 565 feet above sea level.

The limestone and dolomite reach an aggregate thickness of about 500 feet in the eastern part of the county but they are missing in parts of the buried valleys, having been removed by erosion. The carbonate rocks are exposed at three localities in Madison County: at points on Darby Creek and Little Darby Creek near West Jefferson, and on Barron Creek 2 miles east of Rosedale. Elsewhere these rocks are thickly covered by glacial and alluvial deposits. Figure 7 shows the distribution of the consolidated rocks in Madison County and structure contours drawn on the Newburg zone of drillers.

The Brassfield limestone of Early Silurian age is so deeply buried in Madison County as to be unimportant as an aquifer. This limestone generally marks the lower limit of ground-water supplies, as the underlying shale of the Richmond group is only rarely a source of water to wells.

The Middle Silurian rocks above the Osgood shale include three formations named, in ascending order, the Euphemia dolomite (of Foerste), the Springfield limestone, and the Cedarville dolomite. These carbonate rocks form a generally

[1] Designated as observation well M-1 in Ohio Division of Water bulletins on ground-water levels in Ohio.

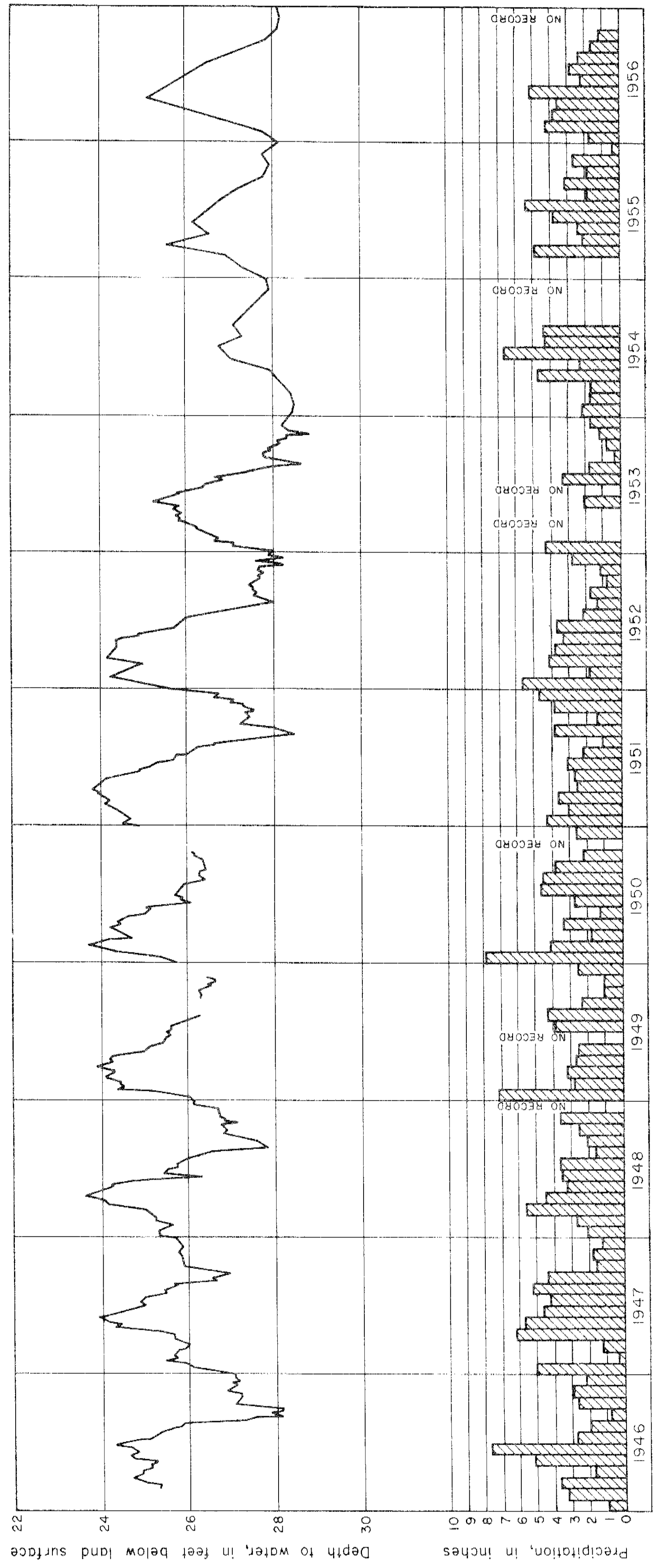


Figure 6. Hydrograph of well 940 (State and U.S. observation well M-1) and precipitation at Mount Sterling, Ohio.

TABLE 6. STRATIGRAPHIC SEQUENCE OF THE CONSOLIDATED ROCKS ABOVE THE SO-CALLED TRENTON LIMESTONE OF DRILLERS, MADISON COUNTY, OHIO

System	Series	Group	Formation	Section	Average thickness (feet)	Character of material	Water-bearing properties
Devonian			Columbus limestone		?	Light in color, massive to thin bedded, contains chert	Adequate water supplies generally available for farm and domestic requirements, except from the Osgood-shale. Water supplies for municipal or industrial use are generally available from the Bass Islands dolomite. Wells drilled to the so-called Newburg zone, at or near the top of the undifferentiated pre-Bass Island rocks, yield 400 gpm or more in the eastern part of the county.
Silurian	Upper Silurian	Cayuga	Bass Islands dolomite (called Waterlime or lower Monroe in old reports.)		375	Variable in structure and texture; siliceous	
	Middle Silurian		Cedarville limestone, Springfield limestone, and Euphemia dolomite of Foerste, undifferentiated		75	Variable in structure and texture	
			Osgood shale		60	Calcareous; contains limestone beds	
	Lower Silurian		Brassfield limestone		35	Massive to irregularly bedded	
Ordovician	Upper Ordovician	Richmond, Mayesville, and Eden groups, undifferentiated			1150	Shale, soft, calcareous, interbedded with thin hard limestone layers; called Cincinnatian shale in old reports.	Wells generally yield less than 1 gpm. In places water is high in salt and hydrogen sulfide. Water, where present, generally occurs in top few feet of strata.
		Rocks of pre-Eden age	So-called Trenton limestone of drillers		650	Limestone or dolomite and some shale	Generally yields salt water from so-called Blue Lick horizon, which in Madison County occurs about 600 to 700 feet below the top of the formation

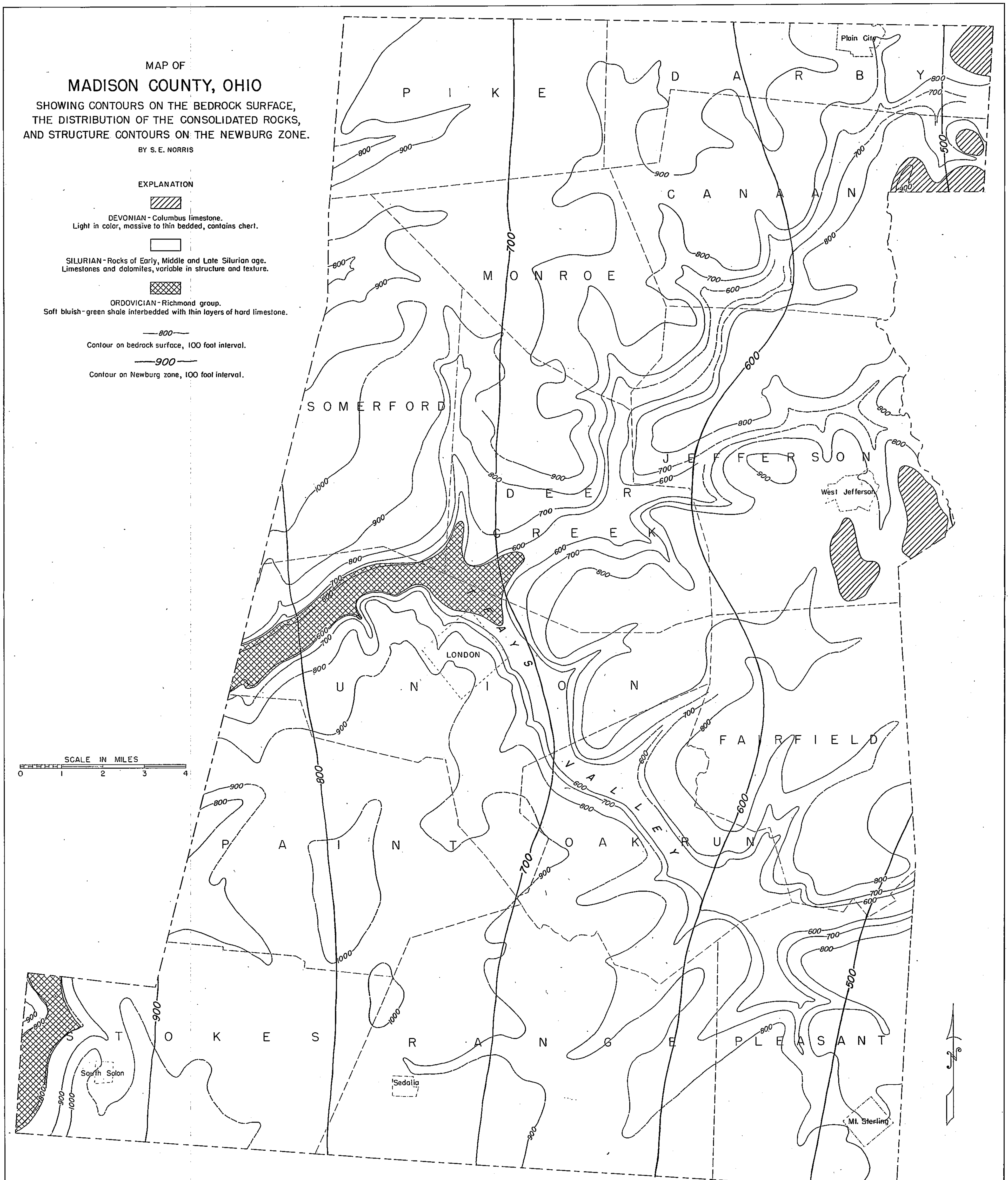

MAP OF
MADISON COUNTY, OHIO
SHOWING CONTOURS ON THE BEDROCK SURFACE, THE DISTRIBUTION OF THE CONSOLIDATED ROCKS, AND STRUCTURE CONTOURS ON THE NEWBURG ZONE.
BY S. E. NORRIS
EXPLANATION
DEVONIAN - Columbus limestone. Light in color, massive to thin bedded, contains chert.
SILURIAN - Rocks of Early, Middle and Late Silurian age. Limestones and dolomites, variable in structure and texture.
ORDOVICIAN - Richmond group. Soft bluish-green shale interbedded with thin layers of hard limestone.
800
Contour on bedrock surface, 100 foot interval.
900
Contour on Newburg zone, 100 foot interval.
SCALE IN MILES
0 1 2 3 4
PIKE
DARBY
Plain City
CANAAN
MONROE
SOMERFORD
JEFFERSON
West Jefferson
DEER CREEK
LONDON
UNION
FAIRFIELD
PAINT
OAK RUN
PAYSON VALLEY
STOKES
South Solon
RANGE
Sedalia
PLEASANT
Mt. Sterling
N

Figure 7.

homogeneous stratum in which the individual formations are distinguished mainly by their bedding. The Middle Silurian limestone and dolomite rocks are a dependable aquifer for farm and home use in areas of southwestern Madison County where the beds immediately underlie the glacial deposits and attain nearly maximum thickness. The beds are a poor source of water in some areas where they have been substantially thinned by erosion. A zone of relatively high permeability, correlated with what has been called the Newburg sand zone by drillers, lies at or near the top of the Middle Silurian and is a source of municipal water supply at Plain City.

The most important aquifer in the carbonate rocks in Madison County is the Bass Islands dolomite. Called by Orton (1878, p. 421) the Helderberg limestone, or Waterlime, the Bass Islands dolomite is generally known to drillers as the Monroe dolomite. Figure 8 shows the general character of the Bass Islands dolomite in a quarry in eastern Champaign County, about 10 miles northwest of Madison County. The stone is thinly to massively bedded and ranges in color from brown to dark gray. The beds are slightly siliceous. In northeastern Ohio the Bass Islands dolomite contains salt beds, which are the basis of the State's large salt industry. The Bass Islands dolomite also is a source of gypsum in northern Ohio, and contains thin beds of gypsum and anhydrite in areas as far south as central Ohio. Neither gypsum nor anhydrite, however, has been reported by drillers in Madison County.

The Columbus limestone is restricted to small areas along the eastern border of Madison County and is a source of water to a few farms and homes in Jefferson Township. Small quantities of Columbus limestone formerly were quarried on the Roberts farm, 2 miles southeast of West Jefferson. The stone is extensively quarried at Columbus, its type locality, by the Marble Cliff Quarries Co.

Water-Bearing Properties

Most wells drilled into the limestone and dolomite rocks in Madison County obtain water in the top few feet of the bedrock from crevices opened or enlarged by weathering when the rocks were exposed at the surface. The weathered layer probably has a wide range in thickness, but the lack of exposures precluded definition of this range by the writer. The Columbus limestone is weathered, and sizable solution openings have been developed to depths of 50 feet or more near Columbus; it seems reasonable to expect the Bass Islands dolomite also to show comparable effects of weathering. The weathered layer forms a fairly homogeneous aquifer, contiguous in places with overlying sand and gravel beds. It is more permeable in some areas than in others, owing to differential weathering, and yields of wells differ from place to place. Generally, wells drawing principally from the weathered layer yield enough water for home or farm use. Larger supplies, for municipal or industrial use, commonly are obtained from wells penetrating crevices below the weathered layer.

Newburg Zone

Wells drilled below the weathered layer in the limestone and dolomite rocks usually increase little in yield until they encounter discrete zones of relatively high permeability, which commonly occur at certain stratigraphic horizons; these zones serve as important avenues of circulation in the carbonate rocks. The most important such zone in Madison County was discovered at Plain City in 1889, when wells were drilled for oil and gas. Water from a depth of 397 feet rose 18 feet above the land surface, and the combined flow of two wells was estimated at 2 mgd, or nearly 1,400 gpm[1]. The relatively large yield from the wells at Plain City, and the fact that the water occurs under artesian pressure, are evidence of a widespread zone of relatively high permeability in the carbonate rocks. This permeable zone has been identified as the source of water yielded to several wells east of Madison County and is correlated with the water zone believed by the writer (1956, p. 95) to be associated with the Newburg sand zone of drillers[2]. As shown by the structure contours on figure 7, the Newburg is of widespread occurrence in Madison County. The contours are highly generalized and mark the position of the Newburg only approximately in most areas; they are based on the records of selected wells and the regional rock structure.

Drillers of these wells reported finding water at a specific place in the carbonate rocks, usually after penetrating a considerable thickness of impermeable rock. In most instances the water was under strong artesian pressure and rose considerably above the level at which it was encountered. The contours on figure 7 show that the Newburg zone declines in elevation from about 900 feet above sea level in western Madison County to about 500 feet above sea level along the eastern border of the county. The dip of the Newburg zone thus is 20 or 25 feet per mile, about the same

[1] Madison County Democrat, Sept. 25, 1889.
[2] Referred to hereafter as Newburg zone, or simply Newburg.

Figure 8. Photograph of the Bass Islands dolomite at quarry in eastern Champaign County about 10 miles northwest of Madison County.

as the regional dip. In most of Madison County the Newburg zone is below the common depths of wells. In the deep buried valleys the Newburg has been removed by erosion.

The Newburg's exact position in the geologic column and its lithologic character are poorly defined. Few wells have been drilled entirely through the carbonate rocks in west-central Ohio, and the stratigraphic intervals between the Newburg and marker beds either above or below this zone are known at only a few places, most of them east of Madison County. At Plain City the Newburg is about 375 feet below the top of the Bass Islands dolomite and about 150 feet above the Ordovician shale, near the top of the Middle Silurian. This conforms to the general position of the Newburg zone in eastern Ohio, where it is the source of what the oil and gas driller terms the Big Water or Second Water in the so-called Big Lime.

The Newburg, according to Stout (1935, p. 907), is generally an impure, porous dolomite. Locally, he reports, the dolomite gives way to thin lenses of sandstone, evidently marking a disconformity. No lithologic changes associated with the Newburg have been reported by drillers in Madison County, and sample analyses have not been made. A precise description of the Newburg zone, and detailed knowledge of its hydraulic properties, must await further study.

The Newburg is a potentially important source of water for large-scale industrial or municipal use in Madison County. This fact is strikingly demonstrated by the records of the Plain City wells. Yields from these wells are appreciably greater than yields available generally from wells tapping only the weathered layer in the carbonate rocks. The Newburg is doubly attractive as a water-supply possibility because of the low pumping lifts associated with it in the eastern part of Madison County. The quality of the water from the Newburg zone at Plain City is within the common range for waters from a limestone region. Water from certain wells in the Newburg east of Madison County is excessively hard (Norris, 1956, p. 98), and it is possible that the Newburg may yield water of objectionable hardness in some areas in Madison County.

Permeable Zones Above the Newburg

Permeable zones also occur in the carbonate rocks in Madison County above the level of the Newburg zone. A yield of 400 gpm, one of the largest from the limestone and dolomite rocks in Madison County, is reported for a well at the Stokely Corp. plant in West Jefferson. The Stokely well (429L) is 132 feet deep and is drilled 54 feet into the bedrock. The water comes principally from a zone of high permeability in the Bass Islands dolomite, above the Newburg zone. Other large yields from permeable zones above the Newburg are reported from the wells that supply the villages of West Jefferson and Mount Sterling. Each of two wells at West Jefferson yields 150 gpm; each of two wells that supply Mount Sterling yields 110 gpm.

Origin of Permeable Zones

Permeable zones probably develop as the result of solution by percolating ground water moving laterally along a plane of weakness. The susceptibility of any particular zone to solution may stem from several causes, and the problem has received special attention from geologists studying the accumulation and migration of oil. Howard and David (1936, p. 1397) suggest that such factors as "close spacing of joints, or large volume of circulating water, may lead to the development of zones of continuous porosity or even cavernous conditions along some beds." The authors state also (p. 1398) that "the presence of impermeable or less soluble bedding planes is probably one of the instrumental causes for the development of porous zones parallel with the bedding."

Howard and David refer primarily to solution above the water table. Indeed, some investigators have contended that no solution takes place below the water table (Murray, 1930, p. 459), which would imply that when the permeable zones were formed in the carbonate rocks in Madison County the water table stood very much lower than it does now. This condition did occur prior to the glacial epoch, when the streams draining Madison County flowed at levels many feet lower than the present streams. However, it is the opinion of Rich (1938, p. 918) that subaerial exposure may not be necessary for the production of solution cavities in limestone. Rich states:

> Artesian circulation of water should accomplish the same result, even at very considerable depths, particularly if the circulation is so vigorous that the water is essentially fresh . . . The question might be raised: how could the artesian circulation begin unless the limestone were already porous? The reply might be made that as porosity due to solution tends to increase, very small initial openings would gradually be enlarged; furthermore, as limestone is a brittle rock, which fractures easily, sufficient jointing

might readily be developed along shatterbelts or zones of bending to permit the beginnings of artesian circulation. Progressive enlargement of solution channels would then follow as a matter of course.

Permeable zones, roughly parallel to the bedding, may represent a buried former erosion surface. As stated by Murray (1930, p. 469):

> The porous limestone reservoirs in the northeastern United States and Ontario . . . have been shown to have been subjected to erosion before the time of deposition of the formation now overlying them . . . It is therefore suggested that erosion caused the development of porosity in the case of all these limestone reservoirs.

The condition described by Murray would apply to the upper part of the Middle Silurian, which was subjected to weathering during the interval of emergence that preceded deposition of the overlying Bass Islands dolomite.

Whatever factors produce permeable zones, it is certain that the zones are not entirely regular in development or continuity. This feature makes it difficult to trace the zones laterally from place to place or even to identify them with certainty in many places. Wells drilled to similar depths within small areas may show great differences in yield. A specific zone of high permeability may be prominently indicated in some wells by exceptionally high yields, whereas the same zone in nearby wells may yield very much less. Great differences in yield among closely spaced wells are noted in oil fields, where producing wells are commonly surrounded by dry holes or wells having but a fraction of the yield of the best well in the field. Despite their variability, however, and the difficulties inherent in their study, permeable zones are often the key to practical development of water supplies from the carbonate rocks.

Rocks Below the Newburg Zone

Little is known of the water-bearing properties of the rocks below the Newburg zone in Madison County. The records of a few scattered wells suggest that the rocks between the Newburg zone and the underlying Osgood shale, where deeply buried, may be a poor source of water. An example is well 1335L in Union Township. The bedrock, at a depth of 300 feet, is the Middle Silurian reached a few feet below the inferred position of the Newburg zone. The well was drilled 85 feet into the Middle Silurian rocks, to the top of the Osgood shale, and yielded barely sufficient water for household use. Conditions illustrated by the record of this well do not apply in southwestern Madison County, where carbonate rocks of Middle Silurian age below the Newburg are a dependable aquifer for farm and home use.

The Brassfield limestone is below the depths to which wells in Madison County are generally drilled, and little is known of its water-bearing properties. It is a common source of water in areas a few miles west of Madison County, though where deeply buried it yields water of poor quality. The shales of the Richmond group, of Late Ordovician age, which crop out in the deeper parts of the buried valleys are not generally a source of ground water. Circulation in these rocks is poor, and any water they contain may carry large amounts of salts or hydrogen sulfide. Wells in Greene County that tap shales of the Richmond group commonly yield less than 1 gpm (Norris and others, 1950, p. 23). There is no reason to believe that yields of wells drilled into these rocks in Madison County would exceed this amout appreciably.

Below the Richmond group are several hundred feet of non-water-bearing shales of the Maysville and Eden groups, overlying a hard light-colored limestone, called by drillers the Trenton limestone. The drillers' Trenton limestone is a source of oil and gas in northwestern Ohio. It is reached at depths of about 1,400 to 1,800 feet in Madison County, where it has been prospected for oil and gas at several places. Generally it yields small amounts of brine from what the drillers call the Blue Lick water zone, about 600 to 700 feet below the top of the Trenton. No wells have been drilled below the Blue Lick zone in Madison County, but in Clark County (Norris and others, 1952, p. 55) a well was drilled 4,647 feet deep to Precambrian crystalline rocks. No water was reported below the Blue Lick zone.

Recharge to the Consolidated Rocks

Recharge to the consolidated rocks occurs from local precipitation, a part of which seeps downward through the overlying glacial deposits. Recharge is greatest in areas where the consolidated rocks are closest to the surface or are adjacent to permeable sediments even though deeply buried. The Newburg zone crops out beneath the glacial deposits in the central part of Madison County, where the consolidated rocks are deeply trenched by the buried Teays valley and its tributaries. It is probable that in these buried-valley areas the Newburg receives the major part of the recharge that sustains the wells and produces the artesian head at Plain City.

GLACIAL AND ALLUVIAL DEPOSITS

Teays Preglacial Drainage System

Before the great ice invasions of Pleistocene time, which began in Ohio about a million years ago and ended perhaps 15,000 or 20,000 years ago, the principal streams flowed generally northwestward. The Ohio River was not yet in existence, and most of the drainage of the present Ohio Basin was carried by the Teays River and its tributaries. The Teays River rose in the Piedmont Plateau of Virginia and North Carolina and flowed generally northwestward across West Virginia, Ohio, Indiana, and Illinois to the ancestral Mississippi River. The river entered Ohio near Portsmouth and flowed north along the course of the present Scioto River to the vicinity of Chillicothe. Near Chillicothe it turned northwest to flow through Ross, Pickaway, Madison, Clark, Champaign, Shelby, and Mercer Counties into Indiana (Stout, and others, 1943, p. 51-77).

The Teays drainage cycle was brought to a close by an early glacier, which forced the drainage into new outlets and, whose deposits, together with those of subsequent ice advances, filled the valleys and obliterated them from view over wide areas. In Madison County there are no surface indications of the buried Teays Valley and its tributaries. The buried valleys have been mapped entirely from well records and geophysical studies which reveal differences in depth to bedrock from place to place.

Bedrock Surface

Plate 1 and figure 7 show contours on the bedrock surface in Madison County, based on drillers' records of wells, records of the test holes drilled during this investigation, and results of geophysical studies. It is evident from the contour maps that Madison County prior to Pleistocene glaciation was a relatively flat upland, deeply incised by wide, steepsided valleys. The elevation of the bedrock surface ranges generally from 800 to 900 feet above sea level and up to 1,000 feet above sea level in the southwestern part of the county. The valleys that cross this well-developed surface are the former courses of the Teays River and its tributaries. The Teays River entered Madison County at a point north of Mount Sterling and left the county west of London. Near London it was joined by a large tributary stream which flowed southwest to this confluence from the vicinity of Plain City. Smaller tributary streams joined the main stem at other points.

The gradient of the Teays Valley in Madison County is approximately 1 foot per mile. The valley floor is 568 feet above sea level at Chrisman, in the south-central part of the county, and descends to 556 feet above sea level at the London Prison Farm. The steepness of the valley walls is revealed by the records of 5 closely spaced test holes (623L - 627L) drilled near Chrisman. On the southwest side the valley wall descends more than 200 feet in a lateral distance of about 1,000 feet. At the level of the former flood plain the buried valley is about 3,000 feet wide. (See pl. 1.)

Between Chrisman and the London Prison Farm the Teays River cut below the Silurian rocks and flowed in the somewhat less resistant Ordovician shale. Probably this resulted in some undercutting of the valley walls, widening the valley in the downstream direction. Earth-resistivity determinations made at closely spaced intervals at the site of test hole 1362L indicate the probable width of the Teays Valley at that point to be about 3,500 feet.

Minford Silt

The Teays River was dammed in its lower course, possibly in northeastern Indiana (Norris and Spicer, 1958), by an early glacier. This ponded the waters and produced widespread finger lakes in the Teays Valley and its tributaries, in which were deposited large quantities of silt and clay, known as the Minford silt (Stout and Schaaf, 1931) from exposures in southern Ohio. Test drilling has revealed that clay, similar to Stout and Schaaf's Minford, is the principal deposit in the buried Teays Valley in Madison County, where it occurs in association with scattered deposits of fine-grained sand. The clay is dull blue gray to brown, soft, and highly plastic. It is 264 feet thick at the London Prison Farm, where test hole 1362L was drilled, and more than 200 feet thick near Chrisman, at the site of test hole 625L. The upper surface of the clay ranges in elevation from 691 feet above sea level at the sites of test holes 943L, 944L, and 945L, near Kiousville, to 850 feet above sea level at the site of test hole 627L, near Chrisman. The clay is not a source of ground water and is difficult to drill with an ordinary cable-tool rig.

Fine sand, associated with the buried clay in some areas (see logs of test holes 624L, 626L), yields very little water to wells. Called "quicksand" by drillers, the fine sand commonly is forced inside the well casings by water pressure, which makes drilling difficult or even impossible. Despite these difficulties, some drillers have reached depths of 300 or 400 feet in Madison County in efforts to drill through the fine-grained deposits in the buried valleys.

Glacial (Pleistocene) History

Four times in the past million years or so northern North America has undergone widespread glaciation. The glacial stages are named, from oldest to youngest, the Nebraskan, Kansan, Illinoian, and Wisconsin. The Wisconsin glacier made at least two major advances into the central Ohio area, separated by a long interglacial stage. The glacial drift at the surface in Madison County was deposited during the last Wisconsin invasion, about 15,000 or 20,000 years ago. Some of the subsurface glacial deposits originated during an earlier invasion by the Wisconsin ice or the glacial stages that preceded the Wisconsin.

Origin of Deposits

Till.—The most widespread glacial deposit is till, an unstratified mixture of clay and rock fragments, commonly called clay or hardpan. Till, forming a ground moraine or till plain, covers nearly all of Madison County to depths ranging from a few feet to about 200 feet. Figures 9-A and B, are photographs of a till exposure along a stream near Somerford and of the till plain just west of Madison County. The till plain in the vicinity of Plain City is little eroded and is one of the flattest areas in central Ohio. Elsewhere in Madison County the plain has been eroded by streams and as a result has become generally undulating.

Till in places forms hummocky ridges, called end moraines, which mark former edge positions of the glaciers when the rate of melting and the rate of growth of the ice were approximately equal. This condition of equilibrium prevented further advance of the ice for a comparatively long time while debris accumulated along its front (fig. 9-B). As shown on figure 10, several end moraines in Madison County form long, crescent shaped ridges, in part discontinuous, which coalesce in the western part of the county. The end moraines west of Somerford rise to an altitude of over 1,100 feet, about 200 feet higher than the general level of the till plain near Plain City. The positions of the end moraines show that the Wisconsin ice front retreated from the area in a northeasterly direction. For a time during its retreat the ice front occupied the approximate position shown on the map (fig. 11) and deposited the end moraine near London.

Till is of low permeability and therefore a poor source of ground water. Dug wells are common in till areas, because such wells provide large storage space for water which seeps in slowly and accumulates between periods of pumping.

Outwash.—When the glaciers melted, torrents of water were discharged, either along a broad front or in streams. In these discharge areas the water sorted the glacial drift, washed out the clay, and silt, and concentrated the larger particles into deposits of sand and gravel called outwash. Long, narrow bodies of outwash confined between valley walls are called valley trains. Broader outwash deposits, brought from a glacier and spread laterally by melt water, are known as outwash fans or outwash plains.

Glacial drainage in Madison County, unlike that in many other areas of the State, did not follow previously established courses. Melt waters from the receding glaciers, following topographic lows at random, cut valleys into the glacial till and later, as deglaciation continued, partly filled them with sand and gravel outwash. The valleys in Madison County are relatively small and the outwash deposits they contain likewise are small compared to the valley-train deposits in both the Mad River Valley and the Scioto River Valley. Those two valleys, which were well established as major drainage courses prior to late Wisconsin time, became the principal outlets for melt water from the Wisconsin glacier.

By postglacial erosion the streams in Madison County have removed much of the valley-train deposits, leaving remnants of sand and gravel as terraces above the flood plains on the sides of the valleys. Terrace deposits are the source of the sand and gravel being excavated along Little Darby Creek near West Jefferson and in the Oak Run valley near Chrisman. The maximum thickness of the valley-train deposits, including the terrace deposits, is about 40 to 50 feet. The present streams flow 20 feet or more below the terrace levels. A test hole (943L) drilled on the flood plain of Deer Creek about 3 miles northwest of Mount Sterling, on the R. H. Graham farm, revealed about 25 feet of sand and gravel underlying the valley floor. Below the sand and gravel the driller logged "clay and hardpan" to a depth of 239 feet, where he struck the limestone bedrock.

Buried by till in a broad area centering near London and the London Prison Farm are extensive outwash-plain deposits. These buried bodies of sand and gravel were deposited along the margins of the ice sheet chiefly during the retreat of the first of the two major advances of the Wisconsin glacier. They were covered by till during the final Wisconsin glacial advance. The buried outwash-plain deposits range in texture from fairly coarse gravel to sand, and in thickness from more than 20 feet to less than 5 feet. They form an important artesian aquifer which is the source of public water supplies at London and the London Prison Farm.

With the retreat of the front of the first Wisconsin glacier there came a period, possibly lasting several hundred years, during which the central Ohio area was temporarily free of ice. Scattered evidence of this ice-free interval may be found in a buried zone of oxidation or a buried soil zone containing the remains of plants and other organic matter. Drillers at the London Prison Farm report, in logs of some of the wells, a change in color of the glacial deposits at a depth of about 200 feet. Commonly, this color change is noted when the drill passes abruptly from blue-gray, unweathered material into an oxidized yellow or reddish material. Such a color change was reported in the log of test hole 1362L, at a depth of 200 feet. Color changes were noted also above 200 feet, at depths of 100 feet and 140 feet. Organic remains in the buried soil zone are sources of carbon dioxide gas, sometimes called "choke damp," which, in the days before well drilling became common, was an element of danger to well diggers. Several attempts to dig wells at Kiousville, in Fairfield Township, were unsuccessful for this reason, and Orton (1878) reports on it thus:

> The trouble has been in every instance that after reaching a certain depth, choke damp or carbonic acid gas escaped in such quantity as to render further work impossible. Several lives have been lost in these attempts and one during the summer of 1872. The section traversed is:

	Feet
Yellow clay	10
Blue clay-abruptly bounded on upper surface	20-31
Cemented sand and gravel	

> On breaking through the crust of cemented gravel, the gas issues in strong volume. No water has ever been found in the gravel. The section is somewhat anomalous, but it seems safe to conclude that some such accumulations of buried vegetable matter as have been described in previous reports as existing in Montgomery, Warren, and Highland Counties, are to be found here.

Outwash deposits of small areal extent, often reported by drillers as gravel "streaks" or "pockets," are common in the glacial till and are the source of water for approximately half the farm and home wells in Madison County. In many areas underlain by the buried Teays Valley and its tributaries these small, discontinuous deposits of sand and gravel are the only practical sources of water supply.

Alluvium

Where the present streams have overflowed their banks silt and sand have been deposited on their flood plains. These deposits are called alluvium. In Madison County the alluvium is thin, relatively impermeable and not an important source of ground water.

WATER-BEARING PROPERTIES

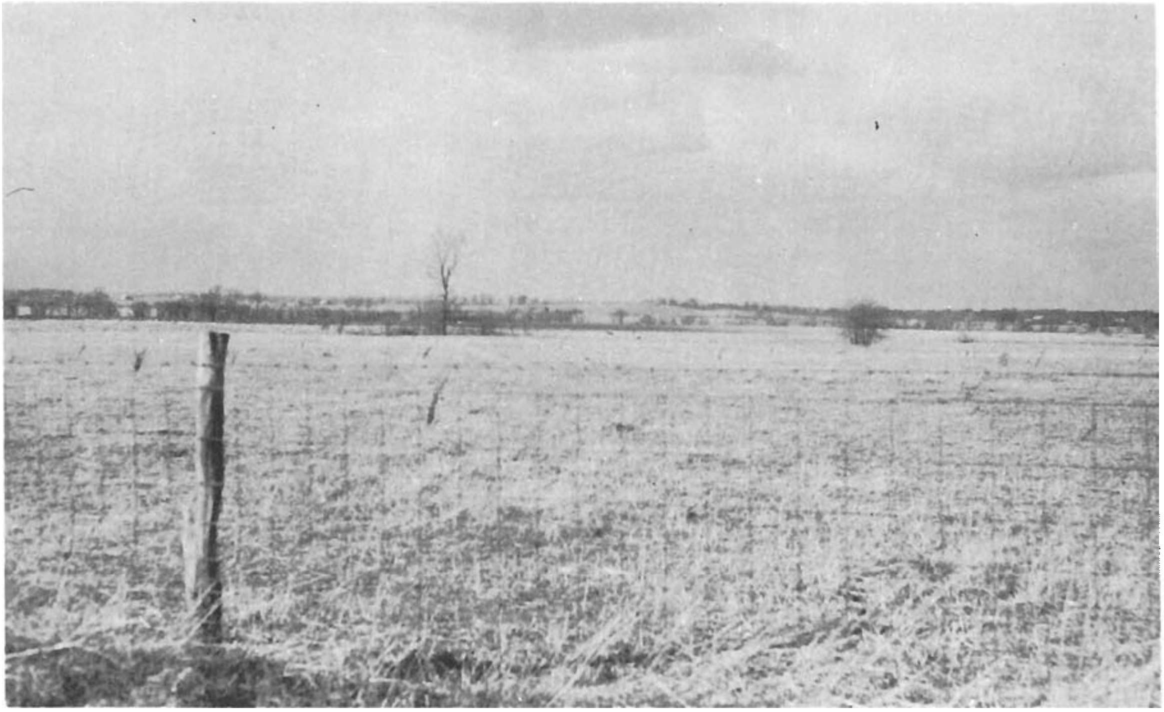
Valley-Train Deposits

Ohio's most abundant sources of ground-water supply are valley-train deposits of sand and gravel which receive recharge, when wells in them are pumped heavily, by the induced infiltration of streamflow. Such aquifers have not been developed in Madison County, though deposits of sand and gravel occur in all the principal valleys, either at the surface or under a thin cover of alluvium (fig. 10). The most extensive valley-train deposits are in the Deer Creek valley below the mouth of Glade Run, and in the Little Darby Creek valley near West Jefferson.

Among the factors to be considered in the development of a ground-water supply, by inducing infiltration from streams, are (1) the permeability and thickness of the aquifer; (2) the amount of water available from storage in the aquifers, which can be tapped between periods of abundant replenishment; (3) the streamflow in dry periods; and (4) the rate at which infiltration can be induced into the aquifer. The latter two factors become increasingly important where ground-water storage is small, as in the valley-train deposits in Madison County.

By drilling test wells in the sand and gravel deposits and pumping them to determine the hydraulic properties of the aquifers it is usually possible to arrive at quantitative estimates of their potential yields. Approximation of yield can be based also on water-supply developments in other areas and on inferred characteristics of the aquifers. As an example consider the hypothetical development of an industrial ground-water supply of 1 mgd from valley-train deposits in the Deer Creek valley below the mouth of Glade

A. Photograph of a stream cut 2 miles northwest of Somerford, showing an exposure of glacial till.



B. Photograph taken 2 miles west of Madison County, showing flat ground moraine in the foreground and an abruptly rising end moraine in the background.

Figure 9. Glacial deposits in or near Madison County.

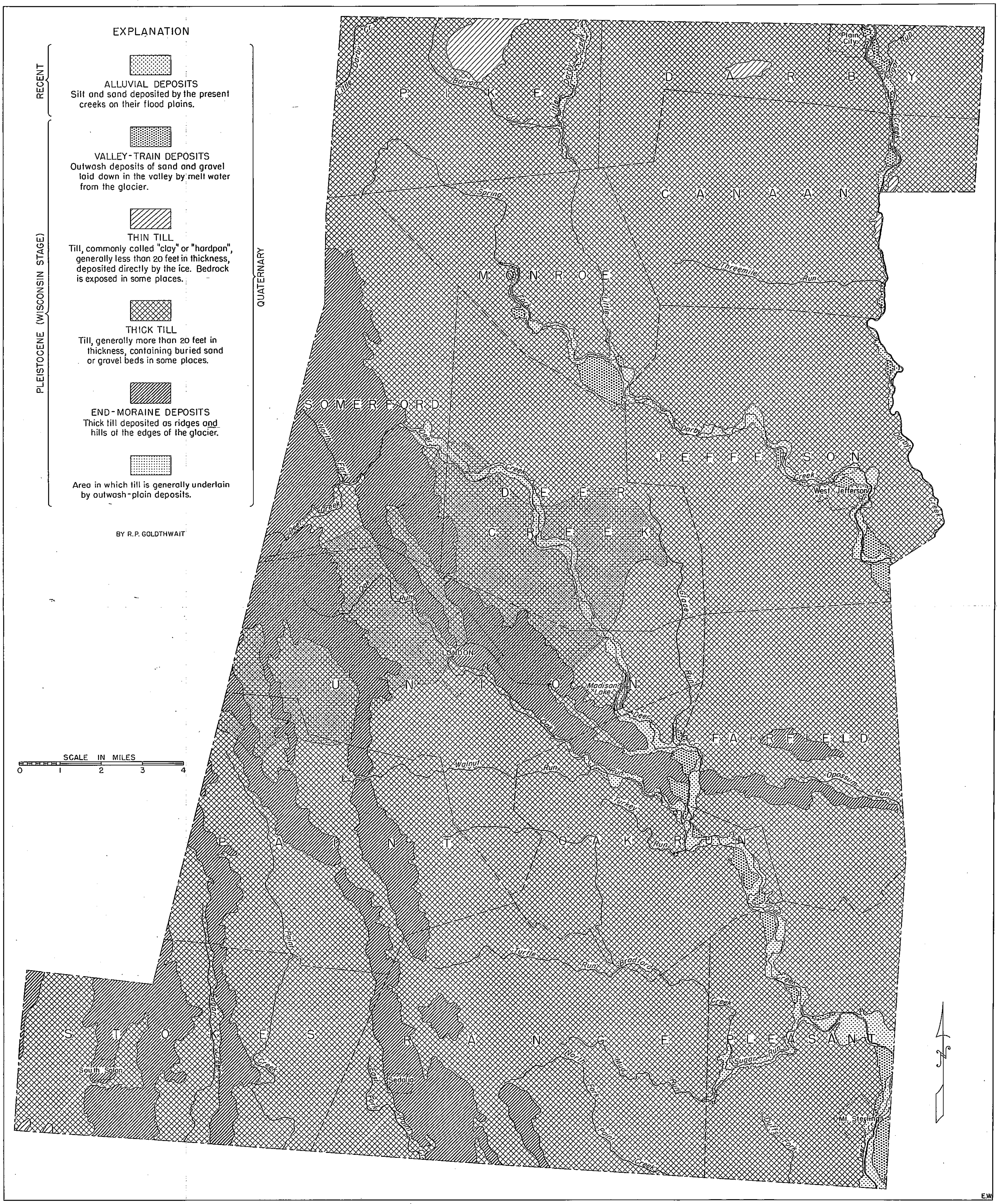


Figure 10. Map of Madison County, Ohio, showing the distribution of the glacial and alluvial deposits.

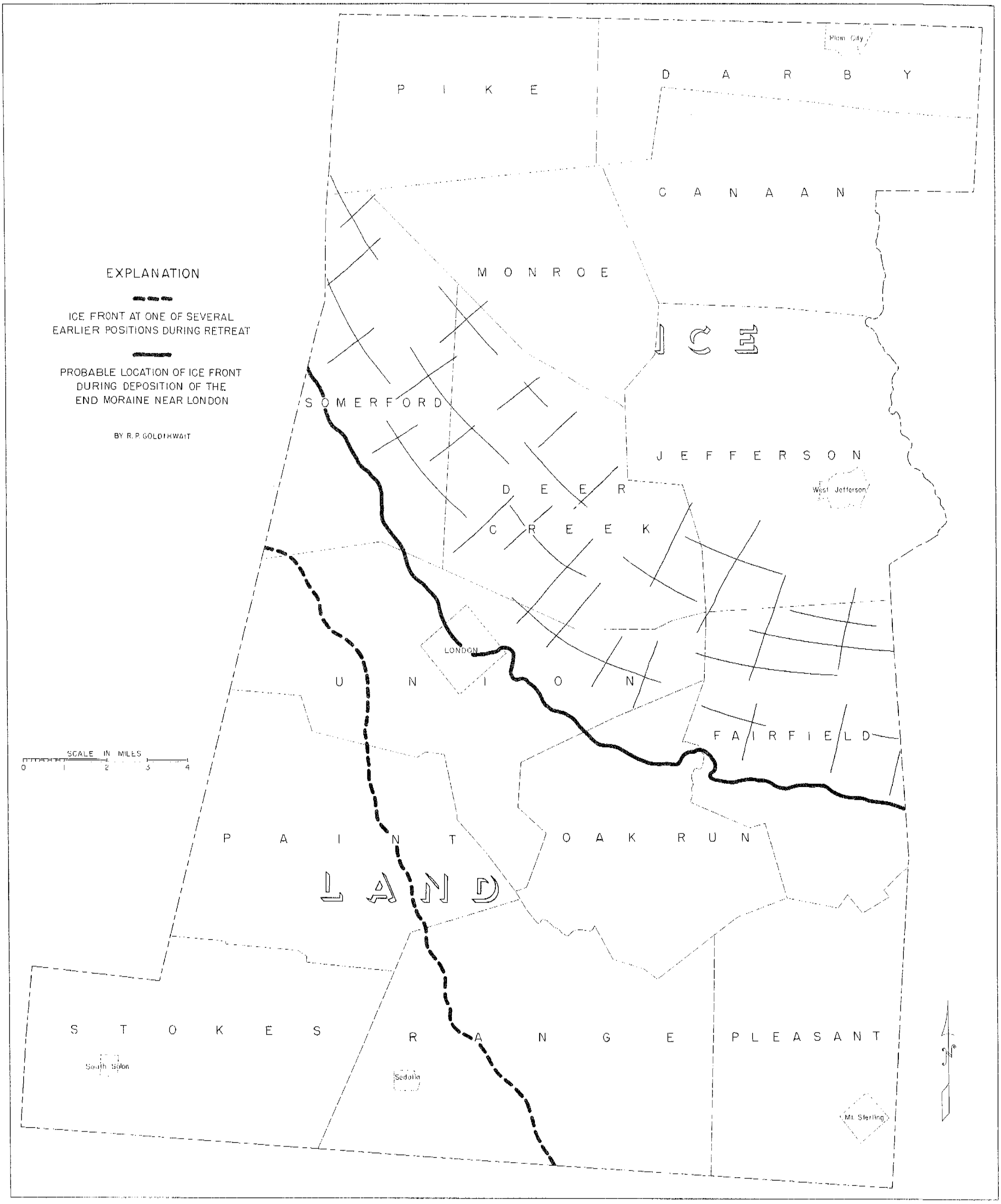


Figure 11. Map of Madison County, Ohio, showing the areas covered by ice at the time of formation of the end moraine near London.

Run. Consideration of the problem must begin with an appraisal of the hydraulic properties of the aquifer.

The coefficient of permeability of an aquifer is a unit measure of its property to transmit water at 60° F, through its intertices in response to a hydraulic gradient. The field coefficient of permeabiliy is the same except that it is measured at the prevailing temperature of the water. A related term, the coefficient of transmissibility, indicates the property of the aquifer as a whole to transmit water and is the product of the average field coefficient of permeability and the saturated thickness of the aquifer. The coefficient of transmissibility is defined as the rate of flow of water, in gallons per day, through a 1-foot-wide vertical section of the aquifer under a hydraulic gradient of 100 percent, or through a section a mile wide under a gradient of 1 foot per mile.

According to pumping-test data in the files of the U. S. Geological Survey and the Ohio Division of Water, the field coefficient of permeability of outwash sand and gravel in Ohio commonly ranges between 2,000 and 3,000. If, for the sake of conservation, the smaller of these figures is chosen and multiplied by 25 feet, which is the saturated thickness of the outwash deposits underlying the site of test hole 943L, the product, 50,000, is the assumed coefficient of transmissibility, expressed in gallons per day per foot. The coefficient of transmissibility may now be used to calculate the theoretical yield from one well or a group of wells screened in the outwash deposits along Deer Creek, on the assumption that stream infiltration will serve as a source of recharge. A formula is given by Rorabaugh (1956, p. 156) for determining the yield available from each well in a line of wells, neglecting screen losses:

$$Q = \frac{\frac{m_1 + m_2}{m_1} \pi T s}{2.30 \log \left\{ \left[\frac{2x}{r_w}\right] \left[1 + \left(\frac{2x}{d}\right)^2\right] \left[1 + \left(\frac{2x}{2d}\right)^2\right] \cdots \left[1 + \left(\frac{2x}{nd}\right)^2\right] \right\}}$$

where:

Q = gallons per day per well

m_1 = thickness of aquifer prior to pumping, in feet

m_2 = thickness of aquifer at pumped well during pumping, in feet

T = coefficient of transmissibility, in gallons per day per foot

s = drawdown in aquifer outside well, in feet

x = distance from the center of the well screen to the line source, in feet

d = well spacing, in feet

r_w = radius of well, in feet

n = number of intervals between wells

Suppose it is deemed advisable to drill three 12-inch wells 500 feet apart, in a line 100 feet from the stream. If m_1 is 25 feet; m_2 is 15 feet; and s is 10 feet; the formula becomes:

$$Q = \frac{\frac{25 + 15}{25} (3.1416)(50{,}000)(10)}{2.30 \log \left\{ \left[\frac{200}{0.5}\right] \left[1 + \left(\frac{200}{500}\right)^2\right] \left[1 + \left(\frac{200}{1000}\right)^2\right] \right\}} = 408{,}000 \text{ gpd}$$

Thus, a supply of 1 mgd from 3 wells would seem to be feasible under the stated conditions. However, in this hypothetical calculation it has been assumed that the infiltration rate through the stream bed would be high enough to satisfy the needs of the system. Whether this would be true is difficult to predict, for estimates of stream infiltration rates are, at best, uncertain.

The rate at which infiltration can be induced from a stream depends on several factors, chiefly the streamflow and the permeability of the stream bed. The permeability of the stream bed probably varies with river stage, sediment load, and other factors. The infiltration rate also varies with the hydraulic gradient between the source stream and the center of pumping, and with the water temperature. A unit infiltration rate greater than 1 mgd per acre of stream bottom has been reported for dredged ditches at the Dayton municipal well field (Norris and others, 1948, p. 53), but this rate may be too high when applied to the bed of Deer Creek. An assumed unit infiltration rate no greater than 0.5 mgd per acre would seem advisable in the present discussion. If this assumption is valid, sufficient water should be available by induced infiltration from Deer Creek to sustain the hypothetical 3-well system at the desired rate of 1 mgd. Three wells spaced 500 feet apart would draw from a stretch of the stream somewhat more than 1,500 feet long. The stream is about 50 feet wide; therefore, if all its bottom is permeable, the total area of infiltration is about 2 acres. Thus, the dependable yield of an infiltration supply in the Deer Creek valley would seem to be at least 1 mgd. By coincidence this happens to be about the minimum recorded flow in the stream.

The chief "bottleneck" in the development of infiltration supplies in Madison County is the thinness of the valley-train deposits, which would permit only small drawdowns in wells developed at typical sites. Selection of sites for well development should be made on the basis of thorough geologic study, including test drilling, specifically directed toward finding areas where the valley-train deposits attain their maximum thickness and areal extent. Unfavorable factors are the small storage capacity of the valley-train deposits in most places and the relatively low streamflow in drought periods. These factors combine to place potential limits on the dependable yield of infiltration supplies.

Valley-train deposits in the Little Darby Creek and Darby Creek valleys also are worth investigating for the possible development of infiltration supplies. The best possibilities in the Little Darby Creek valley exist in areas near West Jefferson. The best areas in the Darby Creek valley are outside Madison County, below the mouth of Little Darby Creek, where infiltration supplies substantially larger than those available along Deer Creek probably can be developed.

Buried Outwash-Plain Deposits

Outwash-plain deposits of sand and gravel, covered by relatively impermeable till, comprise important artesian aquifers in much of Union Township, southern Deer Creek Township, and small parts of Somerford and Paint Townships. The principal aquifer, which is the chief source of public water supplies at London and the London Prison Farm, is a 10- to 20-foot-thick bed of sand and gravel, at a depth ranging generally from about 150 feet to 240 feet. Above the principal aquifer are less extensive sand and gravel beds, which also are important sources of water in some areas. The principal aquifer is poorly developed at the site of test hole 1362L, being represented by a layer termed by the driller "stony till," between depths of 240 and 250 feet. A "stray" bed of sand and gravel, in which a household well probably could be developed, was reported in log 1362L between depths of 15 and 43 feet. Locally, water confined in the buried aquifers is under sufficient pressure to flow.

Pumping tests.—Pumping tests of wells at London and the London Prison Farm have provided important information on the water-bearing properties of the buried outwash-plain deposits. Specific capacities of wells open in the principal sand and gravel aquifer range from 5 to 15 gpm per foot of drawdown. The London waterworks well 1371L, screened between depths of 157 and 172 feet, yielded 550 gpm with a drawdown of about 55 feet during a short acceptance test. Thus, the short-term specific capacity is 10 gpm per foot of drawdown. Another well at the London waterworks, 1370L, was pumped continuously for a period of nearly 3 months at rates of 400 to 600 gpm, and the specific capacity was about 15 gpm per foot of drawdown. The specific capacities of wells 1371L and 1370L are not directly comparable, because well 1370L is screened in two sand and gravel aquifers. The upper screen is between depths of 70 and 78 feet and the lower is between 156 and 168 feet. The aquifers are separated by about 65 feet of till.

At the London Prison Farm, short pumping tests were run on two wells, both open in the principal sand and gravel aquifer. In October 1950 well 1361L, 201 feet deep and finished with 10 feet of screen, was pumped for 12 hours at the rate of 200 gpm. When pumping started, the water level in the well was about 23 feet below the ground surface; by the end of the test it was 64 feet below the ground surface. Thus, the drawdown was 41 feet, and the specific capacity approximately 5 gpm per foot of drawdown.

At the London Prison Farm on May 20, 1957, a 5-hour pumping test was run on a 6-inch test well (1369L) screened in the principal sand and gravel aquifer between depths of 220 and 240 feet. At the start of pumping which was at the average rate of 192 gpm, the water level in the well was 58 feet below the land surface. By the end of the test the water level had declined to about 77 feet below the land surface. Thus, the drawdown was 19 feet and the specific capacity was 10 gpm per foot of drawdown.

In neither of the tests at the London Prison Farm were observation wells, other than the pumped wells, available for water-level measurements. Time-drawdown data from the test of well 1361L are available, but cannot be used in computations of the coefficient of transmissibility. When plotted on semilogarithmic graph paper the points describe a gentle curve, rather than a straight line as required by the modified nonequilibrium formula (Brown, 1953, p. 855). Even though the more rigorous methods of aquifer analysis described by Brown cannot be applied, the specific capacities of the pumped wells are useful in making general appraisals of the buried sand and gravel aquifers. Specific capacities of 5 to 15 gpm per foot of drawdown, the observed range for the wells at the London waterworks and the London Prison Farm, suggest that the transmissibility coefficient lies in the range between 10,000 and 25,000. If the thickness of the principal sand and gravel aquifer is 10 to 20 feet, a coefficient of permeability of 1,000 to 1,250 is indicated. The estimated transmissibility and permeability coefficients are not high, compared with sand and gravel aquifers elsewhere in the State. Test data in the files of the U. S. Geological Survey and the Ohio Division of Water suggest transmissibility coefficients as high as 150,000 or more, for thick sand and gravel aquifers in the Mad River valley. The coefficients of permeability of those aquifers commonly range between 2,500 and 3,500. Although these buried aquifers at London and the London Prison Farm are not the best in the State, they are capable of transmitting large quantities of water to wells; the fact that they yield more than 0.5 mgd of water to each of two groups of wells underscores their importance with respect to the overall water resources of Madison County.

Relatively small declines in ground-water levels at the London waterworks suggest that the aquifers have not been overdeveloped locally, and that additional large quantities of water are available for municipal or industrial use. It must be conceded, however, that the ultimate yields of the buried sand and gravel deposits are not known. With respect to possible future expansion of the London municipal supply, it is important to keep in mind the fact that municipal pumpage at London, roughly half a million gallons per day is not great in comparison with the water requirements of typical industrial plants. The addition to the town of only one large manufacturing plant, requiring, say, 1 or 2 mgd of water, could radically alter the present water-supply picture.

The total quantity of water available locally from the principal sand and gravel aquifer depends largely on recharge conditions, which are not well defined by the data presently available. The sand and gravel beds are not exposed at the surface, and water pumped from the aquifer is replenished by leakage through the overlying till or by flow from the limestone beds which underlie the aquifer along the sides of the buried Teays Valley. Leakage of water through the till doubtless is a slow process and may not be sufficient to sustain the quantity of water now being pumped at London and the London Prison Farm, or at least not sufficient to support any large increase in withdrawal. Flow from the limestone beds probably is a strong factor in the replenishment of the principal aquifer. The magnitude of this flow, in terms of average annual recharge, depends on the transmissibilities of the limestone beds and of the principal sand and gravel aquifer, neither of which is known. Although these hydraulic properties cannot be evaluated on the basis of present data, they should be considered in planning new water-supply developments in the area. Wells preferably should be located close to the walls of the buried Teays Valley to take maximum advantage of the natural discharge from the limestone beds into the buried sand and gravel aquifers.

GROUND-WATER CONDITIONS IN SPECIFIC AREAS

In the following discussions of ground-water conditions in each township in Madison County, the water-resources map, (pl. 1) should be used as a general guide.

Canaan and Darby Townships

Canaan and Darby Townships embrace parts of a flat plain underlain by till, beneath which in places are fluvial deposits; the bedrock is the Bass Islands dolomite. The till contains few sand and gravel beds and the fluvial deposits are fine grained; more than 90 percent of the wells inventoried in the field were drilled into the bedrock. The depth to bedrock ranges generally from 75 feet to about 150 feet, and is more than 200 feet in eastern Canaan and Darby Townships, in an area underlain by a buried Teays-stage tributary valley.

Large supplies of ground water for municipal or industrial use are available in Canaan and Darby Townships from wells drilled to deep water-bearing zones in the limestone and dolomite. An example is the Plain City municipal water supply, which comes from wells tapping the Newburg zone of drillers, near the top of the Middle Silurian.

Plain City Municipal Water Supply

The first wells of the Plain City municipal water system were drilled in 1889 in search of oil or gas. At a depth of 397 feet water unexpectedly was encountered in the limestone under sufficient artesian pressure to rise 18 feet above the land surface. The combined flow of two wells was estimated at 2 mgd. According to Orton (1898, p. 662) the water was not immediately used, and the wells were allowed to flow to waste until 1894, when a destructive fire swept through the village and made the people aware of the imperative need for an adequate water supply. A waterworks plant was then built and the water from the flowing wells was used to supply the village.

The original wells at Plain City have been replaced by two other wells (106 and 107) of approximately the same depth. Plain City has no storage reservoir and the water is pumped directly into the distribution system. According to Cecil

Converse, Chief Engineer, the supply wells are pumped most of the time at a combined rate of about 300 gpm by a suction system connected to both wells. One of the wells also is equipped with a turbine pump and in the summer, when the demand goes up to about 500 gpm, this well furnishes all the water. The drawdown in the well at this rate of withdrawal evidently is small, as the pump bowls are only 45 feet below the surface. Additional large supplies of water can be obtained from the Plain City wells or from other wells drilled to the same water-bearing zone in surrounding areas.

Deer Creek Township

Most wells in the northern part of Deer Creek Township are drilled into the limestone and dolomite bedrock or tap small "pockets" of sand and gravel interbedded in the till of the ground moraine. The central and southern parts of Deer Creek Township are underlain by buried outwash-plain deposits, at depths of about 200 feet. The outwash deposits yield large ground-water supplies in adjacent Union Township, and they are a good source of ground water in parts of Deer Creek Township.

Small areas in Deer Creek Township, traversed by the buried Teays Valley and its principal tributary valley, are underlain by thick deposits of clay and fine sand, which have caused drilling failures and unsatisfactory wells. In an unsuccessful attempt to drill a well (260) on the C. F. Cecil farm, about 2 miles southwest of Lafayette, the drill reached a depth of 425 feet before the fine-grained materials in the buried valley made further drilling impractical. Another example in the same area is a well (261) on the farm of Loy Snider, drilled to a depth of 309 feet. The well has not been satisfactory, according to Mr. Snider, because of silt which several times has clogged the pump. The water is cloudy most of the time and silt is brought up whenever the well is pumped. At the time of the field investigation Mr. Snider pointed out a sizable quantity of silt that had accumulated in one of the stock-watering troughs. It is doubtful whether such wells as Mr. Snider's can be made wholly satisfactory.

Fairfield and Jefferson Townships

Large supplies of ground water are available in Fairfield and Jefferson Townships from limestone and dolomite which generally underlie about 100 or 150 feet of till. At West Jefferson, a well (429L) at the Stokely Corp.'s plant, and two wells (430 and 431) at the village waterworks tap permeable zones in the Bass Islands dolomite. The Stokely well was tested at 400 gpm and each of the two village wells yields 150 gpm. The permeable zones in the Bass Islands dolomite lie well above the Newburg zone of drillers, from which additional large water supplies should be available, as at Plain City.

Other sources of ground water in Fairfield and Jefferson Townships are outwash sand and gravel deposits in the Deer Creek and Little Darby Creek valleys. Fairly large groundwater supplies, sustained by induced infiltration of streamflow, probably could be developed from these aquifers in favorable areas.

Rural wells in Fairfield and Jefferson Townships obtain water either from the limestone and dolomite bedrock or from small deposits of sand and gravel interbedded in the till of the ground moraine. Typical rural wells range between 140 and 155 feet in depth.

The buried Teays Valley underlies the southern tip of Fairfield Township. The record of test hole 335L, near the center of the buried valley, shows 355 feet of till and clay overlying the limestone bedrock. Other buried valleys, tributary to the Teays Valley, extend into Fairfield and Jefferson Townships from the south and southwest. Wells in the buried valleys generally obtain water from sand and gravel deposits interbedded in the till.

Monroe Township

The principal source of ground water in Monroe Township is the Bass Islands dolomite, which underlies generally thick till deposits. Typical rural wells range from 60 to 120 feet in depth and are drilled 15 to 25 feet into the bedrock. A few wells range from 180 to 250 feet in depth and penetrate 50 feet or more of the bedrock. Some of these deeper wells, most of which are in the eastern part of the township, probably tap permeable zones in the Bass Islands dolomite. These zones are similar to the Newburg zone, which lies many feet lower near the top of the Middle Silurian.

Along the west side of Little Darby Creek, in the southern part of Monroe Township, are terrace deposits of outwash sand and gravel (shown on fig. 10 as valley train). These terrace deposits are not an important source of ground water, as shown by the records of well 530, 531, 532, and 533, all of which obtain water from deeper sources.

Oak Run Township

Outwash sand and gravel deposits in Deer Creek valley offer the best possibilities for the development of ground-water supplies in Oak Run Township. As previously stated, in the discussion of water-bearing properties of the valley-train deposits, wells recharged by induced infiltration of streamflow may yield several hundred gallons per minute. Ground-water supplies of 1 mgd may be available from groups of wells in favorable areas.

The Bass Islands dolomite is a potentially important source of ground water in the western half of Oak Run Township. The dolomite generally has not been tapped, however, because most farm wells obtain water at comparatively shallow depths, ranging from 60 to about 200 feet, from sand and gravel deposits interbedded in the till of the ground moraine.

The buried Teays Valley, which underlies the eastern part of Oak Run Township, has been intensively prospected by earth-resistivity methods and by test drilling. As shown by the records of test holes 623L, 624L, 625L, 626L and 627L, bedrock is more than 400 feet below the surface in an area about a mile southeast of Chrisman, along the axis of the Teays Valley. Most of the fill in the buried valley is clay and fine sand, which are not sources of water. Supplies adequate for farm and domestic use fortunately have proved to be available at comparatively shallow depths in the buried-valley area, and no drilling failures have been reported where wells have been drilled into the underlying clay and fine sand.

Paint Township

The Bass Islands dolomite is the principal source of water in the central and eastern parts of Paint Township, where it forms the bedrock beneath generally thick glacial deposits. Large ground-water supplies are available at moderate depth from highly permeable zones in the Bass Islands dolomite, or from the Newburg zone which lies at a depth of about 300 feet. Other important sources of water in the central and eastern parts of Paint Township are sand and gravel "pockets" in the till. Typical wells that tap these interbedded sand and gravel deposits range in depth from 80 to 135 feet.

In the western fourth of Paint Township the glacial deposits are about 300 feet thick and, near the bedrock, include thick beds of clay and fine sand. Most wells are drilled to bedrock, from which supplies adequate for farm and home use generally are available. A few wells in western Paint Township tap gravel "pockets" in the glacial till.

Pike Township

The source of water for more than four-fifths of the farm wells in Pike Township is the Bass Islands dolomite, which crops out along Barron Creek, 2 miles east of Rosedale. The depth to bedrock in Pike Township ranges typically from about 40 feet in the eastern and central parts to a little more than 200 feet in the extreme western part of the township, in areas underlain by buried Teays-stage tributary valleys. Farm wells in Pike Township average less than 100 feet in depth, which is less than the average depth of wells in any other township in Madison County.

Large ground-water supplies are available in Pike Township from permeable zones, such as the Newburg zone, in the limestone and dolomite bedrock.

Pleasant Township

Large supplies of ground water are available in Pleasant Township, from the outwash sand and gravel in the Deer Creek valley or from the underlying Bass Islands dolomite. As stated in the discussion of water-bearing properties of the valley-train deposits, groups of properly spaced wells drilled into the sand and gravel beds in the Deer Creek valley may yield up to 1 mgd at favorable sites. Individual wells may be expected to yield several hundred gallons per minute from the valley-train deposits.

The Bass Islands dolomite is generally a good source of water in Pleasant Township. Typical farm wells are drilled a few feet or a few tens of feet into the bedrock; wells of larger yield are commonly drilled to greater depths and tap widespread zones of high permeability in the limestone and dolomite.

The depth to bedrock in Pleasant Township ranges generally from 50 to 150 feet. The buried Teays Valley underlies an area along the north border of the township, and a buried tributary valley extends from this area southeast toward Mount Sterling. The depth to bedrock in the buried valleys is more than 300 feet in places. The deeper valley-fill deposits are chiefly clay, such as is common in the buried valleys in the county.

Numerous farm wells in Pleasant Township tap small deposits of sand and gravel interbedded in the glacial till. Such wells are common in the northern and western parts of Pleasant Township, where the bedrock is deeply buried.

Springs flowing from the glacial deposits are common in Madison County. A typical spring is Anderson Spring (946), in Pleasant Township about 2½ miles northeast of Mount Sterling. The water issues from a sand and gravel deposit about 30 feet above the level of Deer Creek and the spring flows the year round. The flow on September 3, 1953, when a sample was collected for chemical analysis, was estimated at 10 to 15 gpm. Anderson Spring is boxed and the water is piped to the highway where it is used as a public supply.

Mount Sterling Municipal Water Supply

The largest ground-water development in Pleasant Township is the Mount Sterling municipal supply, which comes from two wells (932 and 933L) about 280 feet deep, drilled nearly 200 feet into the Bass Islands dolomite. The wells tap a permeable zone in which water occurs under artesian pressure, rising to within 48 feet of the land surface. This permeable zone is similar to the Newburg zone, though it occurs at a substantially higher elevation than the Newburg. Pumpage at the Mount Sterling waterworks averaged about 90,000 gpd in 1956. The wells are pumped at rates of 110 gpm and 140 gpm, respectively. The total pumpage is more than 130,000 gallons on peak days in the summer. The total available yield appears to be substantially greater than the present demand.

Range and Stokes Townships

Most wells in Range and Stokes Townships are drilled into the limestone and dolomite bedrock, which underlies 50 to 300 feet of glacial deposits. Supplies of several hundred thousand gallons a day, from small groups of wells, probably are available from highly permeable zones in the carbonate rocks. The largest ground-water development in the area is the South Solon municipal supply in Stokes Township, which comes from a well 179 feet deep, drilled to or nearly to the Newburg zone, at or near the top of the Middle Silurian. On test, this well (1247) was pumped for 30 hours at 70 gpm. Daily pumpage in 1956 averaged about 30,000 gallons; on peak days pumpage was about 50,000 gallons. Pumpage at the South Solon waterworks is much less than the probable yield available in the area.

In eastern Range Township water is available generally from deposits of sand and gravel interbedded in the glacial till. Typical farm wells in this area range in depth from about 50 to 140 feet. A buried Teays-stage tributary valley underlies the extreme western part of Stokes Township, and wells in that area encounter clay and fine sand at depth. This is the least favorable ground-water area in Range and Stokes Townships.

Somerford Township

Wells in Somerford Township obtain water from gravel deposits interbedded in the till, or from the limestone and dolomite bedrock. Depths of typical wells tapping buried gravel deposits range from about 50 to 150 feet; those of wells drilled into the limestone and dolomite bedrock typically range from about 60 to 225 feet. Water supplies adequate to meet small industrial requirements probably are available from wells drilled into the limestone and dolomite. The most favorable area for the development of ground-water supplies is the central part of the township, where the depth to bedrock is comparatively shallow. Elsewhere in the township the cover of unconsolidated deposits is generally thick, and the depth to bedrock is more than 400 feet in places. There are no prominent buried valleys in Somerford Township, though there are deep buried valleys in the townships to the east and south, toward which the surface of the consolidated rocks descends sharply. Near the east and south borders of Somerford Township fine sand or clay, which is characteristic of the fill in the buried valleys, probably would be encountered in deep wells.

Union Township

Large supplies of ground water are pumped in Union Township from wells drilled into buried sand and gravel beds which were laid down as an outwash plain during the retreat of the front of the first Wisconsin glacier. The Wisconsin ice readvanced and till was deposited over the outwash-plain deposits as a relatively impermeable cap, ranging in thickness from about 150 to a little more than 200 feet. The till confines water in the sand and gravel beds, creating artesian conditions. Artesian pressures in some areas are sufficient to cause wells to flow, except where pumping has reduced the head. The buried outwash-plain deposits are sources of public water supplies at London and the London Prison Farm. Combined pumpage at these two places averages more than 1 mgd.

Above the buried outwash-plain deposits are less extensive deposits of sand and gravel, interbedded in the till at depths ranging from 20 to about 80 feet. These shallower sand and gravel beds are important sources of water in many places in Union Township.

A third important source of water in Union Township is the Bass Islands dolomite, which, except in buried-valley areas, forms the bedrock beneath relatively thick glacial deposits. The Bass Islands dolomite was removed by preglacial erosion in the buried Teays Valley and its tributaries.

Poor ground-water conditions prevail locally in Union Township in a few areas underlain by the buried Teays Valley. In these areas, some wells have been drilled through the glacial deposits into the underlying silt and clay. Costly drilling failures have resulted in several wells in which drillers have been unable either to drive casing through the fine-grained materials or to pull casing out of these materials after deciding to abandon drilling. The clay in the buried Teays Valley is more than 250 feet thick, and the depth to bedrock is 530 feet at the London Prison Farm where test hole 1362L was drilled. The bedrock in the Teays Valley in Union Township is Ordovician shale, which is not a source of ground water.

London Municipal Water Supply

The municipal water supply at London comes from wells screened in two sand and gravel aquifers. The lower, and principal, aquifer lies between depths of about 150 and 185 feet and is part of the buried outwash-plain deposits. At London the outwash rests directly on the limestone bedrock. The upper sand and gravel aquifer at London is about 25 feet thick and is interbedded in the glacial till between the approximate depths of 60 and 85 feet. Thus, the upper and lower aquifers are separated by about 65 feet of till.

The London municipal supply was established about 1890 when two wells were drilled into the lower of the two aquifers. In the following few years at least one additional well was drilled into the lower aquifer and two wells were drilled into the upper aquifer. The deep wells ranged in depth from 160 to 190 feet; the two shallow wells were about 60 feet deep. On April 15, 1898, Mr. Frank C. Smith, Superintendent of the London Water Works Co., in a letter to the U. S. Geological Survey stated that the water level in the three deep wells would rise to about 20 feet above the land surface when the wells were not being pumped, and the combined flow from these three wells, at ground level, was about 165 gpm. Mr. Smith stated also that water levels in the two 60-foot wells were about 6 feet below the land surface. One of the 60-foot wells, he said, supplied about 150,000 gpd for 6 months "in the drought of 1895."

Though the London water-supply system is basically the same, with respect to the sources of water, as it was when Mr. Smith described it, new wells have been drilled and all the original wells have been replaced. About 1931 a 26-inch well (1358L) was drilled to a depth of 173 feet and was screened in both the upper and the lower aquifers. On test the well yielded 600 to 700 gpm, but the water failed to clear to the satisfaction of waterworks officials because of fine sand which seemed to come from the lower aquifer. A new well (1357L) then was drilled 82 feet deep, and was screened only in the upper aquifer. The 82-foot well was the main source of the London supply from 1932 until 1953. On test, the 82-foot well yielded 1,200 gpm and when first placed in service it was pumped at a rate of about 1,000 gpm. The yield declined over the years, however, and in 1953 was only about 400 gpm.

In 1953 another well (1370L) was drilled at London, this one also screened in both aquifers. The upper aquifer was screened between depths of 70 and 78 feet and the lower aquifer was screened between depths of 156 and 168 feet. The well was pumped to waste almost continuously from May until August 1953, at rates varying from 400 to 600 gpm to eliminate the fine sand which appeared in the water in objectionable amounts, apparently coming from the lower aquifer. During the testing or development period, the sand accumulated around the discharge pipe in large quantities, covering the ground over several hundred square feet to a depth of several inches. The well was placed in service late in 1953 and was used continuously as the main source of supply for about a year.

In 1954 the newest well of the London system was drilled. This well (1371L) is screened only in the lower aquifer, between depths of 157 and 172 feet, and is the main source of the London supply. It is pumped 3 weeks per month at a rate of 300 gpm. Well 1370L is pumped 1 week per month, also at a rate of 300 gpm.

Water use at London has varied only moderately during the past 20 or 30 years. Pumpage in 1956 averaged about 424,000 gpd which represents a small decline in water use from that of the preceding several years, due principally to the repair of several leaks in the distribution system. Average daily pumpage in 1955 was about 454,000 gallons; in 1954, about 512,000 gallons; and in 1953, 643,000 gallons, according to figures supplied by Mr. George Woodard, waterworks superintendent.

The main problem at London has been the decline in yield of wells over a period of time, requiring their frequent redevelopment or replacement. The decline in yield results in part from the fine sand, which tends to clog the wells and also to cloud the water.

Another factor which has caused the wells to lose efficiency is the chemical quality of the water, which causes incrustation of the well screens and precipitation of limy material in the sand and gravel immediately surrounding the wells. These conditions probably cannot be prevented but they can be made less troublesome by various methods which tend to reduce the velocity of flow through the screen openings (Briggs, 1949). These methods include pumping from several wells of smaller yield to take the place of one or two wells of relatively large yield, reducing pumping rates, and pumping the wells longer, and using longer well screens or screens having larger slot openings.

Ground-water levels at London have not declined to an alarming extent since the first wells were drilled, as is noted in the discussion of the water-bearing properties of the outwash-plain deposits. The fact that each new well yields initially about as much as did its predecessor is additional evidence that the aquifers have not been overpumped. One reason for the large yield at London is the fact that the two sand and gravel aquifers are not naturally connected, at least locally. Thus each aquifer contributes independently to the total yield of the system, as pumping from one does not deplete the supply of the other. The separation of the aquifers is shown by differences in artesian head and in the chemical quality of the water from the aquifers.

The difference in head between the two aquifers causes water from the lower aquifer, which is under greater artesian pressure, to flow into the upper aquifer through wells screened in both aquifers. Recharge of water to the upper aquifer from the lower aquifer undoubtedly was an important factor, over the years, in maintaining a comparatively high yield from the 82-foot well (1357L) that formerly was the main source of the London supply.

Proof that a recharge cone is built up around the upper screen of a combination well when it is not being pumped is seen in the results of chemical analysis of water samples collected at different times. In table 7 are shown the results of analysis of water from well 1370L, which is screened in both the upper and the lower aquifers, and from well 1371L, which is screened only in the lower aquifer. Well 1370L was sampled twice; the first time was on April 12, 1957, when the well had not been pumped for several days, and the second time was on May 7, 1957, after the well had been pumped almost continuously for about a week. The first sample from well 1370L was practically identical to the water from well 1371L. This shows that water from the lower aquifer had flowed into and recharged the upper aquifer during the time well 1370L was idle. The analysis of the second sample from well 1370L, made after the well had been pumped for several days, shows a wide difference in chemical quality between this water and that collected during the first sampling. The difference in quality of water from the two aquifers showed up only after well 1370L had been pumped long enough to remove from the upper aquifer most of the water previously received as recharge from the lower aquifer. This evidence is in accord with the experience of waterworks officials, who report a decided difference in cost of softening the water from the two wells. The water from the lower aquifer at London is of much better quality than the water from the upper aquifer. This is the chief reason why repeated efforts have been made to develop wells in the lower aquifer, despite difficulties caused by the fine-grained material in that aquifer.

A possibility for increasing the water supply at London, and avoiding troubles caused by the fine-grained material in the lower aquifer, would be to drill wells into the underlying limestone and dolomite deposits, in the hope of obtaining water from permeable zones such as the Newburg. This possibility is underscored by the record of a test hole drilled at the waterworks in 1954 by Homer Robinson. The hole was drilled to a depth of 324 feet, a few feet above the assumed position of the Newburg zone. Bedrock was struck at a depth of 184 feet, and the driller reported water at depths of 227-229 feet, 245-272 feet, and 275-321 feet. The water level in the test well stood about 18 feet below the land surface at the completion of drilling. The well was not test pumped, unfortunately, and the yield is not known. Hardness tests made by waterworks officials indicated a range of 424 to 480 ppm for water from the lower part of the test well, which is within the common range of hardness for water from limestone and dolomite. Tests should be made to determine the water-bearing properties of the limestone and dolomite rocks at London. The new test wells should be drilled at least several feet below the assumed position of the Newburg zone, say to a depth of about 400 feet, and adequately pumped so as not to overlook the possibility that the Newburg may yield large supplies of ground water here as it does at Plain City.

London Prison Farm Water Supply

The sources of water at the London Prison Farm are the same as or similar to the sources at the London municipal well field. Most of the water used at the prison farm is pumped from four wells (1309 is representative) which range in depth from 110 to 128 feet and tap a relatively shallow sand and gravel deposit, which corresponds to and may be part of the upper sand and gravel aquifer at the London waterworks. These four main wells are pumped by an air-lift system, installed many years ago when the prison was built. Each of the wells yields about 100 gpm. Two other wells (1361L is representative) at the prison farm are 12 inches in diameter and are screened in the buried outwash-plain deposits, which locally consist of a 10- to 20-foot-thick bed of coarse sand and gravel, at a depth ranging from about 200 to 220 feet. The deeper sand and gravel aquifer at the prison farm probably is contiguous with the lower aquifer at the London waterworks well field. Only one of the two deeper wells is now in use; it is pumped for short periods at a rate of about 200 gpm.

The two deeper wells at the prison farm were used for a few years, 1954-57, as the main sources of supply and were pumped initially at rates of about 300 gpm. The wells declined in efficiency, however, and the yields were so reduced that the four shallower wells, which had been kept as a standby source of water, were redeveloped and put back in service. Average pumpage from all sources at the London Prison Farm was about 680,000 gpd in 1956.

CHEMICAL QUALITY OF THE WATER

The results of chemical analysis of 23 samples of ground water collected in Madison County and 4 samples of surface water collected in Pickaway County are given in table 7. Data on the wells and 1 spring from which the ground-water samples were taken are given in table 8; the locations of the wells and the spring are shown on plate 1. Samples of water from Darby Creek were collected at Darbyville and those from Deer Creek at Williamsport, both places being about 20 miles downstream from Madison County. The analyses were made by the Quality of Water laboratory of the U. S. Geological Survey at Columbus.

The waters from the various aquifers are all of the calcium magnesium bicarbonate type. All were high in iron and were very hard and iron removal and softening of the water would be desirable for most uses. Water from the consolidated rocks, is somewhat harder than water from the glacial deposits. The sample from well 1335L, which taps a limestone aquifer, had an exceptionally high iron content. A sample from well 409, which taps the same aquifer, contained about the same amount of iron as many of the samples from wells in the glacial deposits. Significant differences in chemical quality between waters from the upper and lower aquifers at London have been discussed.

The surface-water samples, two of which were collected during periods of low flow and two during periods of comparatively high flow, were not notably different in their chemical characteristics and were, in general, comparable in quality to the ground-water samples though somewhat less mineralized.

CHEMICAL AND PHYSICAL PROPERTIES COMMONLY AFFECTING THE USE OF WATER

The source and significance of the mineral constituents in natural waters have been discussed by White (1947) and Lamar (1953), and also in other publications of the Ohio Division of Water and the U. S. Geological Survey. The most important chemical properties of water, in regard to general uses, are hardness and iron content.

Hardness

In many industries, such as the manufacture of chemicals, paper, and textiles, hard water is objectionable. Soft water is more desirable also in canning, laundering, and ice-making. When heated, hard water deposits a scale in boilers and water heaters which must be removed for efficient operation. In the home hard water is objectionable for most purposes, although the use of chemical detergents has changed this picture considerably so far as use for washing is concerned.

Hardness of water is caused principally by calcium and magnesium. Hardness caused by calcium and magnesium equivalent to the bicarbonate is called "carbonate" hardness; the remainder is "noncarbonate" hardness. These terms are roughly equivalent to the older terms "temporary" and "permanent." Hardness is usually expressed as calcium carbonate in parts per million or grains per gallon. Water that has a hardness of less than 60 ppm is generally rated as soft. Hardness between 60 and 120 ppm does not seriously interfere with the use of water for most purposes. Usually, it is profitable to soften water having a hardness above 120 ppm. Water is softened either by the lime-soda process, which generally is used in municipal softening plants, or by the base-exchange, or zeolite, process, used in home water softeners. In the lime-soda process the content of the hardness-forming constituents is reduced by treatment of the water with lime or lime and soda ash and a coagulant. In the zeolite method of softening, hard water is passed through natural or artificial "zeolites" which exchange sodium for calcium and magnesium ions in the water. Periodically, the active mineral in zeolite softeners is treated with brine to replace the accumulated calcium and magnesium ions with sodium ions. The municipalities of London, Mount Sterling, and West Jefferson soften their water by the lime-soda process. The water furnished residents of Plain City and South Solon is not softened.

Iron

Iron content is an important quality of natural water, because if it exceeds about 0.3 ppm the water stains clothing, cooking utensils, and kitchen and bathroom fixtures. Iron concentrations of 0.5 to 1.0 ppm can be tasted by most persons. In domestic water supplies one of the

Table 7.--Analyses of water from wells in Madison County, Ohio, and from Darby Creek and Deer Creek in Pickaway County, Ohio. (Analyses by Quality of Water Branch, U. S. Geological Survey; chemical constituents given in parts per million.)

Well number	Owner	Approximate location	Water bearing material	Depth (ft.)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180° C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25° C)	pH	Color	Temp. (°F)
																		Calcium, magnesium	Non-carbonate				
26	Eli N. Yutzy	Amity	Dolomite	30	1-24-50	6.5	.64	119	52	29		524	80	22	.7	36	604	511	81	1,000	7.4	3	54
106	Village of Plain City	Plain City	Limestone	402	2-15-55	11	.75	143	52	19	3.5	420	235	12	1.7	.2	724	573	226	1,040	7.2	5	55
261	Loy Snider	Lafayette	Sand and silt	309	1-23-50	6.4	3.3	54	37	68		356	92	28	.7	7.8	468	287	0	813	8.0	5	51
265-L	Dorsey Reed	Lafayette	Limestone	385	1-22-57	10	2.3	73	44	58	3.6	414	111	36	.9	4.1	558	377	36	903	7.5	1	
409	R. H. Rotruck	Gillivan	Dolomite	336	1-24-50	7.5	2.7	108	53	40		430	192	12	1.6	.2	648	487	134	1,000	7.7	4	53
427	C. E. Carr	West Jefferson	Sand and gravel	58	1-24-50	16	2.5	108	49	18		474	97	12	1.4	.5	545	471	82	893	7.6	5	54
430	Vill. of West Jefferson	West Jefferson	Dolomite	100 ?	4-19-57	13	.52	98	50	26	2.3	440	120	12	1.2	.6	565	450	90	886	7.1	2	53
454	Clarence Corbitt	West Jefferson	Sand and gravel	30	1-24-50	14	.41	96	50	34		450	73	34	1.1	28	558	445	76	933	7.7	5	51
465-L	Battelle Memorial Inst.	West Jefferson	Dolomite	138	10-15-56	7.7	1.3	104	44	22	1.5	428	129	.4	1.5	3.6	549	440	90	844	7.5	2	
933-L	Village of Mt. Sterling	Mt. Sterling	Dolomite	285	4-12-57	14	1.8	101	40	26	1.5	445	120	2.6	1.5	.0	555	446	82	846	7.5	1	53
938-L	Pleasant Cemetery	Mt. Sterling	Sand and gravel	35	1-23-50	8.0	2.0	76	30	4.0		324	34	2.8	.2	20	330	313	47	579	7.7	3	53
946[5]	J. B. Anderson	Antioch	Sand and gravel	-	9- 3-53	12	.10	79	53	2.9	1.5	434	35	3.8	.1	25	432	416	60	736	7.2	0	
1007	Mrs. Procter	Sedalia	Dolomite	165	1-23-50	14	2.9	100	40	21		478	59	1.2	1.6	.2	486	414	22	803	7.6	5	50
1120	G. D. Stroupe	Somerford	Sand and gravel	74	1-23-50	15	3.3	110	47	26		526	84	1.5	1.8	.0	558	468	36	903	7.5	3	53
1212	Pat Mallon	South Solon	Sand and gravel	118	1-24-50	9.0	2.7	78	32	62		396	120	2.2	1.8	5.3	501	326	1.0	834	7.6	5	52
1247	Village of South Solon	South Solon	Dolomite	179	4-12-57	14	2.0	125	52	63	1.1	478	258	4.4	.4	.1	786	532	140	1,110	7.6	1	55
1309	London Prison Farm	London	Sand and gravel	110	5-30-57	19	2.6	107	42	23	1.3	465	94	2.8	1.0	.1	530	440	58	795	7.8	2	
1335-L	Grace Williams	London	Limestone	385	1-23-50	7.6	17	83	39	36		406	90	10	2.0	.0	465	367	34	802	7.8	4	52
1361-L	London Prison Farm	London	Sand and gravel	201	4-12-57	16	1.2	74	36	33	1.2	448	35	2.6	.8	.1	432	338	0	700	7.8	1	55
1369-L	London Prison Farm	London	Sand and gravel	246	5-21-57	18	1.2	80	35	35	1.8	443	43	1.2	.9	.1	447	344	0	724	8.0	7	
1370-L	London Water Company	London	Sand and gravel	168[6]	4-12-57	17	1.7	83	36	30	1.4	456	46	2.4	1.2	.1	463	369	0	733	7.7	1	54
1370-L	London Water Company	London	Sand and gravel	168[6]	5- 7-57	17	.79	94	44	23	1.1	445	69	8.0	.6	.0	509	416	51	787	7.5	3	53
1371-L	London Water Company	London	Sand and gravel	172	4-12-57	18	1.1	81	37	30	1.4	457	46	2.2	1.0	.1	462	368	0	733	7.8	1	54
	Darby Creek	Darbyville			4-30-46[1]	0.8	0.02	74		4.9		284	83	8.0	0.3	3.7	370	329	96	603	7.9	10	60
		(Pickaway Co.)			9-12-46[2]							300								604	7.7	8	68
	Deer Creek	Williamsport			4-30-56[3]	1.6	0.05	62		5.7		270	73	4.9	0.4	2.1	356	303	82	555	8.0	7	61
		(Pickaway Co.)			9-12-46[4]	.8	.02	67		6.5		296	69	5.0	.4	1.4	351	315	72	590	7.8	5	68

[1] Discharge 88 cu.ft./sec.
[2] Discharge 30 cu.ft./sec.
[3] Discharge 88 cu.ft./sec.
[4] Discharge 19 cu.ft./sec.
[5] Anderson spring
[6] Screened in two aquifers

most objectionable troubles associated with iron in excess of about 0.2 ppm is the growth of Crenothrix or other iron bacteria. These organisms form a slimy growth which may clog pipes, well screens, or gravel around the wells. Sometimes these growths are pumped up and appear in the water as red or brown sludges.

Methods of controlling iron-forming bacteria include disinfection and regular treatment of the well and pumping equipment with chlorine compounds. Inorganic iron content is reduced by ordinary softening. Iron can be removed also by aeration and filtration, or it can be made less troublesome by adding phosphate compounds directly to the distribution main at the wells, to prevent precipitation of iron in the distribution system.

Sulfate, Fluoride, and Nitrate

Other chemical constituents of the natural waters in Madison County that are of general interest or importance in the use of water include sulfate, fluoride, and nitrate. Sulfate sometimes is important because, when it is acted upon by sulfate-reducing bacteria, hydrogen sulfide gas is produced, which has an objectionable odor and may cause corrosion of pumping equipment. Corrosion due to water rich in hydrogen sulfide may be accelerated by sulfide- and sulfur-oxidizing bacteria which may be introduced into the water as a pollutant. Sulfide and sulfur-oxidizing bacteria are similar to iron-forming bacteria, in that they form thick, slimy growths which may clog wells and pumping equipment. Sulfate is dissolved from practically all rocks and soils and especially from gypsum. Gypsum deposits occur sparingly in the carbonate rocks in the Madison County area, and water from wells drilled into the limestone and dolomite deposits generally is high in sulfate. Owners of such wells complain of "black sulfur water" or they report a "sulfur" taste in the water. Trouble with sulfur often may be eliminated by thorough disinfection of the well and distribution system, followed by periodic treatment with chlorine compounds or some other disinfecting agent.

Fluoride is important in drinking water because of its effect on childrens' teeth (Dean, H. T. and others, 1943). In concentrations of about 1 ppm fluoride lessens the incidence of tooth decay in growing children. Fluoride concentrations in excess of about 1.5 ppm in drinking water, however, may cause mottling of the tooth enamel if the water is used for drinking by children. Fluoride is common in the ground water of Madison County, slightly higher concentrations being noted in water from the limestone and dolomite than in water from other sources.

Nitrate likewise is an important constituent in drinking water, in concentrations greater than about 45 ppm it is considered unsafe for baby feeding (Maxcy, K. F., 1950). Nitrate in ground water generally results from oxidation of organic matter in the soil, and unusually high nitrate concentrations may indicate organic pollution of the water. In shallow wells, high nitrate may be due to the use of nitrate fertilizer on the fields. Small quantities of nitrate occur in most ground waters and have little or no significance with respect to the use of the water.

Temperature

Temperature is important in the use and treatment of water, as water is commonly used as a heat-exchange agent. Temperature also affects the rate of chemical and biological activity, such as corrosion and algae growth. It may be important also for its effect on the yield of wells. Since the rate of flow is inversely proportional to the viscosity of the water, an increase in viscosity due to a lowering of the temperature will reduce the rate of percolation of the water through permeable materials. The rate of percolation is twice as high at 90° F as it is at 40° F, if all other conditions remain constant. The temperature factor is especially important in the design of infiltration systems because the temperature of ground water derived from stream infiltration depends largely on the season and thus may vary widely.

The temperature of ground water at depths within the common range of wells, 20 to 200 feet, ordinarily is within 3° to 6° F of the average annual air temperature. Temperatures of water from wells 30 to 60 feet deep in the eastern half of the United States range generally from about 40° F, in parts of Maine, Michigan, Minnesota, and other northern States, to the middle 70's in Florida. In Madison County the temperature of the ground water averages about 53° F.

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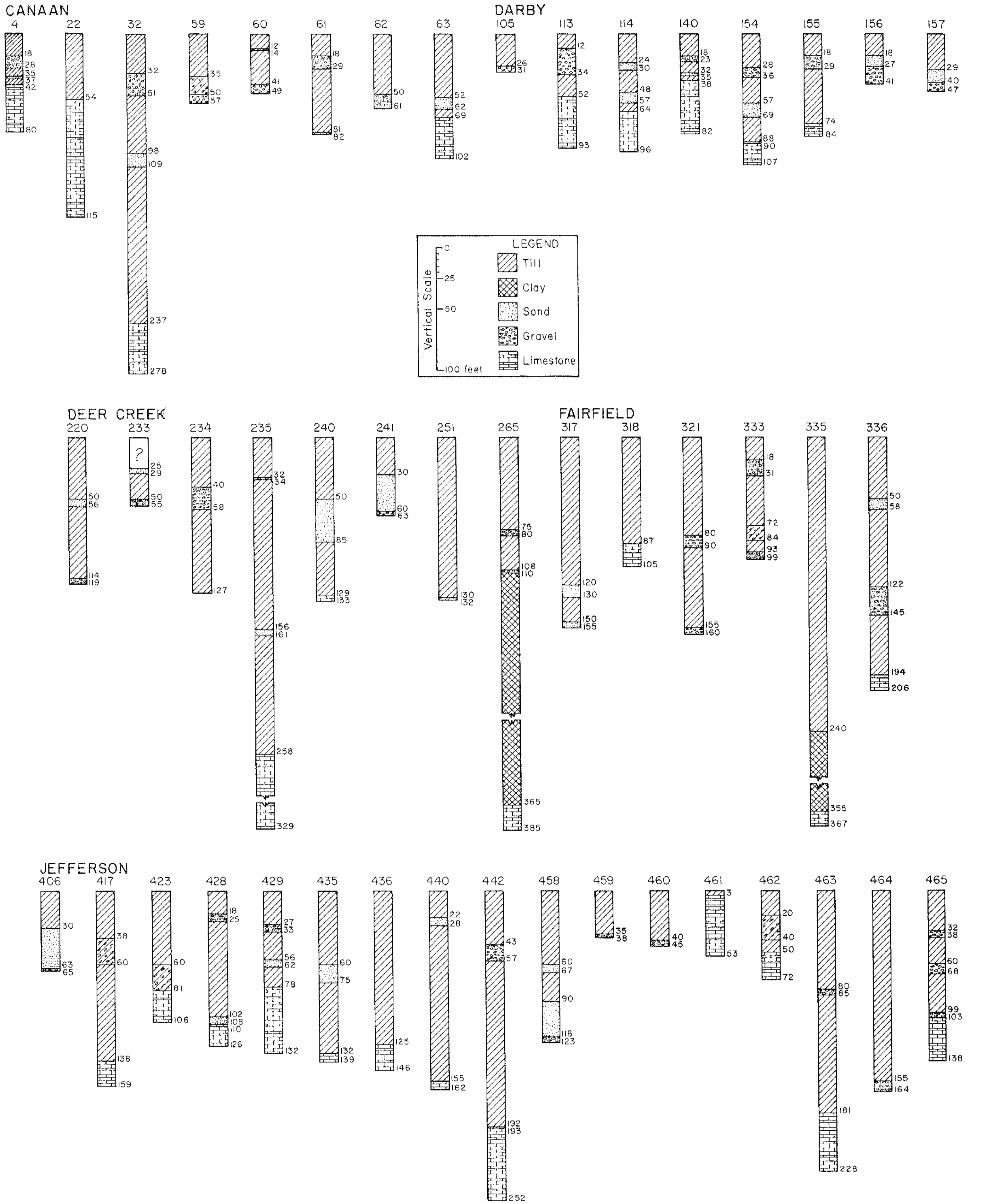

Figure 12a. Logs of wells and test holes in Canaan, Darby, Deer Creek, Fairfield, and Jefferson Townships. (Numbers refer to locations shown on plate 1.)

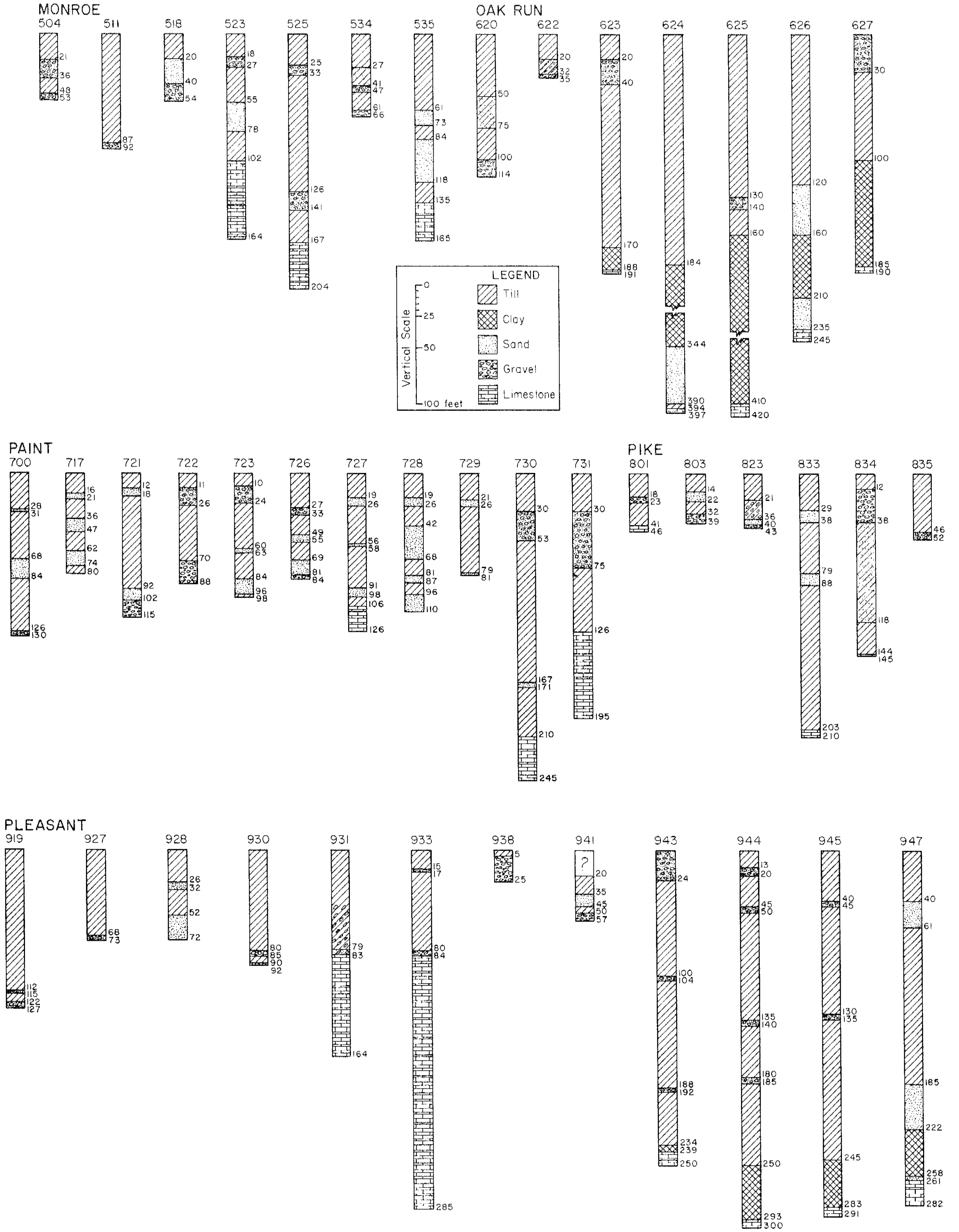

Figure 12b. Logs of wells and test holes in Monroe, Oak Run, Paint, Pike, and Pleasant Townships. (Numbers refer to locations shown on plate 1.)

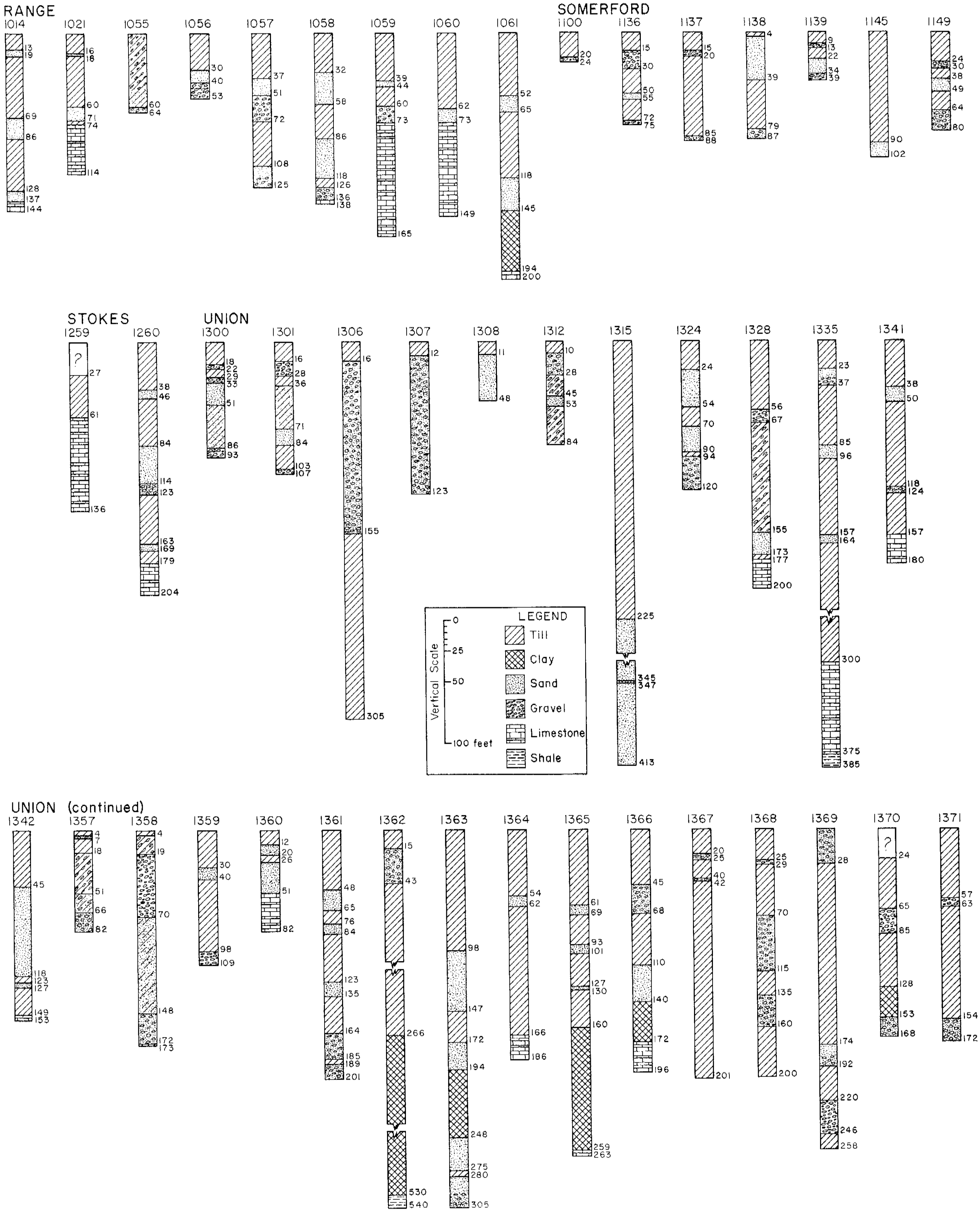

Figure 12c. Logs of wells and test holes in Range, Somerford, Stokes, and Union Townships. (Numbers refer to locations shown on plate I.)

TABLE 8

RECORDS OF WELLS AND TEST HOLES IN MADISON COUNTY, OHIO

Explanation of terms and symbols:

Number.......................................The number of the well or test hole shown on the map, plate 1: letter L following well number refers to log shown on figure 12; number underlined refers to water analysis shown in table 7.

Owner or name.........................The name of the landowner or tenant at the time the well was drilled or at the time of the well inventory.

Elevation of well......................Determined approximately from the topographic maps of the United States Geological Survey.

Depth to bedrock......................Depth to the surface of the consolidated rocks.

Depth of well.............................Depth reported by driller, owner or tenant.

Character of material..............Geologic material in which water was obtained or in which well was terminated; Dol, dolomite; G, gravel; Ls, limestone; S, sand; Sh, shale.

Geologic horizon.......................Refers to the geologic age of the consolidated rocks; Sca, Silurian system, Cayuga group; Sn, Silurian system, Niagara group; Sc, Silurian system, Clinton age; Or, Ordovician system, Richmond group.

Water level................................The depth below land surface of the water level in the well as reported by the driller, land owner or tenant.

Date...Date of determination of the water level.

Rate...The rate, in gallons per minute, at which the well was pumped or bailed.

Drawdown..................................The amount of lowering of the water level in the well caused by the withdrawal of water at the rate indicated in the rate column.

Type of well...............................Dr, drilled; Dug, dug by hand.

Type of pump............................D, deep-well, lift or ejector; S, shallow-well suction; T, turbine; E, electrically powered; G, gasoline-driven; H, hand-operated; W, wind-driven.

Diameter of well.......................Approximate inside diameter of well or casing.

Use..D, domestic supply; I, industrial use; P, public supply; S, stock.

Table 8. RECORDS OF WELLS AND TEST HOLES IN MADISON COUNTY, OHIO

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed		Water level		Yield		Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
					Character of material	Geologic horizon	Below land surface (feet)	Date	Rate (g.p.m.)	Drawdown (feet)					
CANAAN TOWNSHIP															
1	J. M. Cramer	974	80	115	Dol	Sca	12				Dr	DH	$4\frac{1}{4}$	D,S	
2	Eli Troyer	974	100	112	Dol	Sca	10				Dr	DH	$4\frac{1}{4}$	D,S	
3	Abe Yoder	974	85	104	Dol	Sca	10				Dr	DW	$4\frac{1}{4}$	D,S	
4L	Edward Greenbaum	971	42	80	Dol	Sca	10	4-12-48	28		Dr	DE	$4\frac{1}{4}$	D,S	
5	Arnold Greenbaum	972	60	85	Dol	Sca	14				Dr	DH	$4\frac{1}{4}$	S	
6	Charles Atchison	973	111	179?	Dol	Sca					Dr		$4\frac{1}{4}$		Well not finished at time of inventory.
7	M. M. Hostetler	970	80	110	Dol	Sca	15				Dr	DH	$4\frac{1}{4}$	D	
8	Perry Stutzman	974	90	121	Dol	Sca					Dr	DG	$4\frac{1}{4}$	D,S	
9	Ben W. Miller	974	100	126	Dol	Sca					Dr	DG	$4\frac{1}{4}$	D,S	
10	A. B. Yoder	972	100	125	Dol	Sca					Dr	DG	$4\frac{1}{4}$	D,S	
11	Noah Hostetler	971	100	125	Dol	Sca					Dr	DG	$4\frac{1}{4}$	D,S	
12	Mrs. Huber	970	56	168	Dol	Sca					Dr	DG	$4\frac{1}{4}$	D	
13	Bennett Wilson	952	140	150	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
14	Chauncey Headings	941	195	205	Dol	Sca	15				Dr	DE	$4\frac{1}{4}$	D,S	
15	D. L. Garver	905	65	80	Dol	Sca	8				Dr	DH	$4\frac{1}{4}$	D,S	
16	Frank Cary	922	41	50	Dol	Sca					Dr	DH	$4\frac{1}{4}$		
17	Ed. Lemley	942	170	200	Dol	Sca					Dr	DH	$4\frac{1}{4}$	D	
18	Eli Yutzy	940	190	200	Dol	Sca					Dr	DH		S	
19	Barntrigger	942	71	167	Dol	Sca					Dr	DW	$4\frac{1}{4}$	D,S	
20	Mrs. Robert Winston	952	132	148	Dol	Sca	15				Dr	DE	$4\frac{1}{4}$	D	
21	Mrs. Mary Roby	950	93	112	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D	
22L	A. H. Converse	945	54	115	Dol	Sca	19	3- 4-49			Dr	DH	$4\frac{1}{4}$	D	
23	Webster Sherwood	941	80	104	Dol	Sca	14				Dr	DE	$4\frac{1}{4}$	S	
24	Mary Nolan	915	50	65	Dol	Sca					Dr	DH	$4\frac{1}{4}$	D	
25	William Horch	925	40	117	Dol	Sca	10				Dr	DE	$4\frac{1}{4}$	D,S	
26	Eli Yutzy	908	2	30	Dol	Sca	8				Dr	DH	$4\frac{1}{4}$	D,S	Water analysis in table 7.
27	Unknown	898	33		Dol	Sca					Dr				
28	Chas. F. McCarthy	921	70	90	Dol	Sca					Dr	DH	$4\frac{1}{4}$		
29	Beach Chandler	924	97	122	Dol	Sca					Dr	DH	$4\frac{1}{4}$		
30	John B. Yoder	948	170	179	Dol	Sca					Dr	DH	$4\frac{1}{4}$	S	
31	W. B. Kilgore	954	70	80	Dol	Sca	9				Dr	DW	$4\frac{1}{4}$	S	
32L	Eli Yutzy	948	237	278	Dol	Sca			20		Dr	DE	$4\frac{1}{4}$	D,S	
33	L. W. Price	956	80	110	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D	
34	John Price	971	73	97	Dol	Sca	15				Dr	DH	$4\frac{1}{4}$	D	
35	Neil Beachy	967	125	145	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
36	Levi J. Gingerich	971	85	96	Dol	Sca	14				Dr	DH	$4\frac{1}{4}$	D,S	
37	D. J. Miller	975	100	125	Dol	Sca	15				Dr	DH	$4\frac{1}{4}$	S	
38	O. E. Miller	976	79	95	Dol	Sca	14				Dr	DH	$4\frac{1}{4}$	D,S	
39	Jonas E. Beachy	976	80	90	Dol	Sca	10				Dr	DH	$4\frac{1}{4}$	D,S	
40	J. W. Miller	976	70	85	Dol	Sca	14				Dr	DH	$4\frac{1}{4}$	D	Also has stock well about 130 feet deep.
41	W. J. Dyer	977	80	92	Dol	Sca	10				Dr	DG	$4\frac{1}{4}$	S	
42	W. J. Dyer	977	85	97	Dol	Sca	11				Dr	DE	$4\frac{1}{4}$	D	
43	John Byerly	981	120	150	Dol	Sca					Dr	DH	$4\frac{1}{4}$	S	
44	Ben J. Miller	978	170	220	Dol	Sca	20				Dr	DE	$4\frac{1}{4}$	D,S	
45	Lewis Thomas	979	102	200	Dol	Sca	14	1947			Dr	DE	$4\frac{1}{4}$	D,S	
46	H. B. Yoder	973	150	175	Dol	Sca	11				Dr	DH	$4\frac{1}{4}$	D	
47	Ben Yoder	972	150	202	Dol	Sca	12				Dr	DH	$4\frac{1}{4}$	D,S	
48		971	107	108	Dol	Sca					Dr				
49	Tom Arnold	965	144	163	Dol	Sca	15				Dr	DE	$4\frac{1}{4}$	D,S	
50	Ella Beach	952	170	210	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
51	Harry High	954	190	235	Dol	Sca	15				Dr	DW	$4\frac{1}{4}$	S	
52	Roy Wilson	961		138	G						Dr	DH	$4\frac{1}{4}$	S	
53	Irma Harbage	958	260	347	Dol	Sca	33				Dr	DE	$4\frac{1}{4}$	D,S	
54	Frank Chandler	942	60	64	Dol	Sca	11				Dr	DW	$4\frac{1}{4}$	S	
55	L. G. Young	921	83	96	Dol	Sca	16				Dr	DE	$4\frac{1}{4}$	D,S	
56	Maurice Schiderer	922		68	G		19				Dr	DH	$4\frac{1}{4}$	D	
57	Andrew Yutzy	932	68	122	Dol	Sca	16				Dr	DE	4	D,S	
58	Lee Chandler	900	23	70	Dol	Sca					Dr	DE	$4\frac{1}{4}$		
59L	John W. Price	956		57	G		6	7-23-49	20	8	Dr	SE	4	S	
60L	W. H. Hainer	962		49	G		30	12- 1-49	10		Dr		$4\frac{1}{4}$	S	
61L	Eli Troyer	973	82	82	S		12	10- -49	15		Dr		$4\frac{1}{4}$	D	
62L	Betty Morgan	950		61	G		14	12-20-49			Dr	DE	4	D	
63L	Jonathan Alder School	950	69	102	Dol	Sca	5	2-10-56	100	4	Dr	DE	5	P	
DARBY TOWNSHIP															
100	Elford Rausch	975	55	65	Dol	Sca	20				Dr	DE	$4\frac{1}{4}$	D,S	
101	Killen Burger	972	45	90	Dol	Sca	10				Dr	DE	$4\frac{1}{4}$	D	
102	N. L. Troyer	970	50	96	Dol	Sca	11				Dr	DE	$4\frac{1}{4}$	D	
103	Dan Hostetler	951	70	110	Dol	Sca	14				Dr	DH	$4\frac{1}{4}$	D,S	
104	Charles F. Miller	941	73	105	Dol	Sca	18				Dr	DE	$4\frac{1}{4}$	D,S	
105L	Harry Minick	933		31	G		18	3- 2-49			Dr	SE	$4\frac{1}{4}$	D	
106	Village of Plain City	925	126	402	Ls	Sn	3	1944			Dr	TE	12	P	Av. pumpage from wells 106 & 107 was about 200,000 gal. per day in 1956. Water analysis in table 7.
107	Village of Plain City	925	100	377	Ls	Sn	3	1944			Dr	SE	8	P	
108	James Miller	924	90	100	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
109	Andrew Grace	930	90	100	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D	
110	George Shover	945	140	150	Dol	Sca	15				Dr	DE	$4\frac{1}{4}$	D,S	
111	Frank Cary	952	89	125	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
112	Walter Latham	950	60	100	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D	
113L	Clyde Purdum	950	52	93	Dol	Sca	15	6- 6-49	25		Dr	DH	$4\frac{1}{4}$	D	
114L	Robert Patterson	946	64	96	Dol	Sca	16	6-20-49	17		Dr	DH	$4\frac{1}{4}$	D,S	
115	Rodney Cary	951	176	196	Dol	Sca					Dr	DH	$4\frac{1}{4}$	D	
116	Elton Debolt	947	180	200	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D,S	
117	Elmer George	947	180	190	Dol	Sca					Dr	DH	$4\frac{1}{4}$	D,S	
118	Daniel Helmuth	921	70	90	Dol	Sca	10				Dr	DW	$4\frac{1}{4}$	D	
119	Frank Grace	930	65	80	Dol	Sca	10				Dr	DH	$4\frac{1}{4}$	D	

Table 8. RECORDS OF WELLS AND TEST HOLES IN MADISON COUNTY, OHIO (continued)

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
DARBY TOWNSHIP (continued)															
120	Vernon Yutzy	930	100	125	Dol	Sca	22				Dr	DH	4¼	D,S	
121	William Rogers	918	90	125	Dol	Sca	12				Dr	DH	4¼	D,S	
122	William Rogers	920	80	125	Dol	Sca	14				Dr	DH	4¼	D	
123	Leroy Miller	930	80	125	Dol	Sca	20				Dr	DE	4¼	D,S	
124	Holycross	938	80	85	Dol	Sca	17				Dr	DE	4¼	D,S	
125	Lester Hostetler	943	80	95	Dol	Sca	15				Dr	DE	4¼	D,S	
126	Howard S. Faust	946	40	85	Dol	Sca	25				Dr	DE	4¼	D,S	
127	Mrs. D. M. Hostetler	948	110	130	Dol	Sca	17				Dr	DE	4¼	D,S	
128	A. F. Miller	951	100	130	Dol	Sca	7				Dr	DH	4¼	D,S	
129	A. A. Miller	951	90	128	Dol	Sca	10				Dr	DH	4¼	D,S	
130	J. M. Lapp	955	80	115	Dol	Sca	20				Dr	DH	4¼	D,S	
131	Mrs. Kramer	956	70	108	Dol	Sca	18				Dr	DH	4¼	D,S	
132	Mrs. D. M. Hostetler	962	30	94	Dol	Sca					Dr	DH	4¼	D	
133	Alvin Kramer	971	25	84	Dol	Sca	17				Dr	DH	4¼	D,S	
134	D. L. Garver	970	45	115	Dol	Sca					Dr	DH	4¼	D,S	
135	Eli C. Beachy	972	60	75	Dol	Sca	9				Dr	DH	4¼	D,S	
136	Mrs. Herschberger	972	65	85	Dol	Sca	10				Dr	DH	4¼	D,S	
137	Chris Gingerich	970	75	95	Dol	Sca	11				Dr	DH	4¼	D,S	
138	Worthington	972	40	120	Dol	Sca	15				Dr	DE	4¼	D,S	
139	Eli E. Beachy	977	45	100	Dol	Sca	28				Dr	DH	4¼	D,S	
140L	Emerson Morgridge	978	38	82	Dol	Sca	12	11-22-48			Dr	DH	4¼	D	
141	Ralph C. Yutzy	978	65	95	Dol	Sca					Dr	DH	4¼	D,S	
142	Lombard School	978	90	125	Dol	Sca	15				Dr	DH	4¼	P	
143	Dean Richmond	979	70	120	Dol	Sca	12				Dr	DH	4¼	D,S	
144	Mrs. H. C. Temple	981	60	112	Dol	Sca	9				Dr	DE	4¼	D,S	
145	Dr. J. M. Morse	982	62	110	Dol	Sca					Dr	DH	4¼	D	
146	J. E. Yutzy	972	80	88	Dol	Sca	14								
147	Walter Florence	975	120	160	Dol	Sca	22				Dr	DH	4¼	S	
148	Walter Florence	975	90	110	Dol	Sca	10				Dr	DH	4¼	D,S	
149	Jean Mengert	981	90	100	Dol	Sca	12				Dr	DE	4¼	D,S	
150	Walter Florence	979	86	95	Dol	Sca	14				Dr	DH	4¼	D,S	
151	H. Morgridge	981	85	100	Dol	Sca	8				Dr	DE	4¼	D,S	
152	Anne Peters	980	90	105	Dol	Sca	12				Dr	DG	4¼	S	
153	W. J. Dyer	979	85	95	Dol	Sca	10				Dr	DE	4¼	D	
154L	Joe Rummel	941	90	107	Dol	Sca	22		12		Dr		4¼	D	
155L	Henry Dillinger	982	74	84	Dol	Sca					Dr		4¼	D	
156L	Stub Conklin	932		41	G		14				Dr	DH	4¼	D	
157L	George Jackson	932		47	G		15				Dr	DH	4¼	D	
DEER CREEK TOWNSHIP															
200	Orleton farms	1024	54	110	Dol	Sca	10				Dr	SE	4¼	S	
201	Orleton farms	1015	109	127	Dol	Sca	20				Dr	DE	4¼	S	
202	Orleton farms	1021	72	125	Dol	Sca	17				Dr	SE	4¼	D	
203	Orleton farms	1022	68	95	Dol	Sca	18				Dr	DH	4¼	D	
204	Orleton farms	1019		64	G		11				Dr	SE	4¼	D	
205	Orleton farms	1021	93	141	Dol	Sca	16				Dr	SE	4¼	S	
206	John Bridgeman	1000	77	193	Dol	Sca	27				Dr	DE	4¼	D	
207	Orleton farms	1020		48	G		16				Dr	SE	4¼	D	
208	Orleton farms	1021	90	92	Dol	Sca	18				Dr	SE	4¼	D	
209	Orleton farms	1025	68	120	Dol	Sca	18				Dr	SE	4¼	D	
210	Orleton farms	1028	109	141	Dol	Sca	18				Dr	SE	4¼	D	
211	Orleton farms	1040	158	208	Dol	Sca	20				Dr	SE	4¼	D	
212	Gwynne-Burr farms	1039	206	208	Dol	Sca	25				Dr	DE		S	
213	Gwynne-Burr farms	1027	132	167	Dol	Sca	25				Dr	SE	4¼	S	
214	Gwynne-Burr farms	1022	90	145	Dol	Sca	18				Dr	SE	4¼	D,S	
215	Gwynne-Burr farms	1021		57	G		15				Dr	DH	4¼	D	
216	George Nelson	1012		135	G						Dr	DG	4¼	S	
217	George Nelson	1004		100	G						Dr	DE	4¼	D	
218	Layh brothers	1006	107	167	Dol	Sca	18				Dr	DE	4¼	D	
219	Valance	1018		90	G		24				Dr	DG	4¼	S	
220L	George Jones	1015		119	G		24	8-12-48	8	27	Dr	DE	4¼	D,S	
221	Valance	1018		106	G		25				Dr	DH	4¼	D	
222	Mrs. McMurray	1022	122	150	Dol	Sca					Dr	DH	4¼	S	
223	Crabbe	1013		100	G		20				Dr	DH	4¼	S	
224	John Mentor	1018		120	G						Dr	DW	4¼	D,S	
225	Dean Richman	1020		165	G						Dr	DG	4¼	S	
226	Gwynne-Burr farms	1022		55	G						Dr		4¼		Well not in use.
227	Gwynne-Burr farms	1021		45	G		Flows				Dr	SE	4¼	D	Well drilled in 1901.
228	Gwynne-Burr farms	1022		65	S		25				Dr	DE	4¼	S	Very poor well.
229	Gwynne-Burr farms	1021		45	G		15				Dr	DE	4¼	D	
230	Gwynne-Burr farms	1025		50	G		20				Dr	DH	4¼	S	
231	J. L. Roberts	1029		194	G		Flows				Dr	None	4¼	D,S	Water piped to house and barn.
232	Lafayette School	1019	293	350	Ls	Sn					Dr	DE	5	P	
233L	M. L. Adams	1015		55	G		30				Dr	DE	4¼	D	
234L	James Estepp	1018		127	G						Dr	DH	4	D	
235L	Fettrows restaurant	1015	258	329	Dol	Sca					Dr	DE	6	P	
236	Howard Dorn	1005		104	G		25				Dr	DE	4¼	D	
237	Martin Miller	983		144	G						Dr	DE		D	Well at slaughter house.
238	Wood	985		100	G						Dr	DE	4¼	D	
239		990		350	S						Dr				Well not in use.
240L	R. S. Harbage	982	129	133	Dol	Sca	30	7-12-48	10		Dr	DE	4¼	D	
241	Frank Bennett	990	225	241	Dol	Sca	38				Dr	DH	4¼		
242	Chester Street	985		124	G		14				Dr	SE	4¼	D	
243		981		285							Dr				Well no good, finished in till.
244	S. A. Hoover	982	100	163	Dol	Sca					Dr	DE	5	D	
245	Mason Daily	982		125	G		25				Dr	DH	4¼	S	
246	Mt. Carmel Hospital	977		135	G		6				Dr	DE	4¼	S	
247L	B. L. Adair	970		63	G		15	6- 5-48	16		Dr	DW	4¼	S	
248	J. E. Sidner	999	196	210	Dol	Sca					Dr	DG	4¼	S	
249	J. E. Sidner	1001		120	G						Dr	DH	4¼	S	

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
DEER CREEK TOWNSHIP (continued)															
250	J. E. Sidner	1000		139	G						Dr	DH	4¼	D	
251L	R. Long	1004		132	S		92	4-25-48			Dr	DH	4¼	D	Well casing pulled back from 250 feet in till.
252	Mrs. Beach	1001	138	238	Dol	Sca	40				Dr	DE	4¼	D	
253	Miss Eagleton	1003		135	G						Dr	DH	4¼	S	
254	Mrs. Beach	1002		120	G		15				Dr	DE	4¼	D	
255	George Larkins	1000		54	G		Flows				Dr	DG	4¼	S	
256	L. M. Roudebush	995		93	G		Flows				Dr	SE	4¼	D	
257	Karl Burr	1010		164	G		19				Dr	DE	4¼	D,S	
258	Karl Burr	1005		178	G						Dr		4¼		Well not in use.
259	Karl Burr	1012		158	G						Dr	DG	4¼	S	
260	C. F. Cecil	1020		425	S		Flows				Dr		4		Casing perforated between 170 and 180 feet.
261	Loy Snider	1024		309	S						Dr	DE	4¼	S	
262	George Larkin	1029		108	G		25				Dr	DE	4¼	G	Water analysis in table 7.
263	Kisick	1062		96	G						Dr	DH	4¼	D	
264	Mrs. J. W. Ferguson	1055		145	G		10				Dr	SE	4¼	D,S	Has 10 dug wells on farm.
265L	Dorsey Reed	990	365	385	Ls	Sn	40	9-24-55	25		Dr	DE	4	D	Water analysis in table 7.
FAIRFIELD TOWNSHIP															
300	Mrs. W. B. Culp	985	145	160	Dol	Sca	45				Dr	DE	4¼	S	
301	E. P. Sidner	980	119	120	Dol	Sca	60				Dr	DE	4¼	D,S	
302	P. Stickle	938	100	111	Dol	Sca					Dr			D	
303	C. O. Keye	943	140	150	Dol	Sca					Dr	DE	4¼	D,S	
304	Lilly Chapel parsonage	977	180	207	Dol	Sca	45				Dr	DE	4¼	D	
305	J. E. Byers	985		85	G		37				Dr	DW	4¼	D,S	
306	Neil Hoppes	985	235	238	Dol	Sca	40				Dr	DW	4¼	S	
307	Neil Hoppes	985	123	144	Dol	Sca	40				Dr	DH	4¼	D	
308	G. L. Tomlinson	983	170	210	Dol	Sca	40				Dr	DE	4¼	D,S	
309	Garrett L. Elfrink	982		125	G		25				Dr	DE	4¼	D,S	
310	James Hume	982	200	204	Dol	Sca	40				Dr	DH	4¼	D,S	
311	Paul Dwyer	990	182	260	Dol	Sca					Dr	DE	4¼	D,S	
312	Tope	990		70	G		40				Dr	DH	4¼	D,S	
313	Paul Dwyer	990	179	210	Dol	Sca					Dr	DE	4¼	D,S	
314	Fairfield Twp. school	982		146	G		60				Dr	DE	4¼	P	
315	Abe McLaughlin	982		101	G		40				Dr	DE	4¼	D,S	
316	Eldon Jones	970	123	150	Dol	Sca					Dr	DE	4¼	D	
317L	Kenneth Adams	963		155	S		5	6-15-48	6	8	Dr	DE	4	D	
318L	Percy Rider	942	87	105	Dol	Sca	47	6-23-48			Dr	DG	5	S	
319	Robert Keye	960	155	158	Dol	Sca					Dr	DE	4¼	D,S	
320	Rogers estate	940		40	G		10				Dr	DH	4¼	D,S	
321L	Mrs. Minnie Graham	942		160	G		60	7- -49	5		Dr	DE	4	D	
322	L. Bricker	942		104	G		35				Dr	DH	4¼	S	
323	J. Anderson	958	123	160	Dol	Sca					Dr	DE	4¼	S	
324	J. Gligrow	961		83	G		23				Dr	DE	4¼	D	
325	Denecca	962	120	130	Dol	Sca					Dr	DH	4¼	S	
326	H. C. Wilson	961	119	156	Dol	Sca	50				Dr	DE	4	D	
327	Howard Markham	980		98	G						Dr	DH	4¼	D,S	
328	Mrs. E. L. Terman	981		120	G		18				Dr	DE	4¼	D	
329	E. O. Fitzgerald	980		111	G		40				Dr	DE	4¼	D,S	
330	C. G. Harsh	965		76	D		20				Dr	DE	4¼	D	
331	Jesse Kellough	982	158	165	Dol	Sca	25				Dr	DH	4¼	D	
332	Goodsin	980	69	90	Dol	Sca					Dr			D	
333L	Harold Bricker	962		99	G		20	10- -49	20		Dr	DE	4¼	D	
334	Henry Wilson	960	190	204	Dol	Sca					Dr	DH		D	
335L	Mrs. Mary Bricker	936	355	367	Dol	Sca					Dr		4		Test hole drilled Sept. 1953.
336L	Floyd Callaway	985	194	206	Dol	Sca	75	4-28-55	5	7	Dr	DE	4½	D	
JEFFERSON TOWNSHIP															
400	Warrington	981	160	250	Dol	Sca	15				Dr	SE	4¼	D	
401	McVay	991	125	250	Dol	Sca					Dr		4¼		Well not in use.
402	John Hanscel	990	125	265	Dol	Sca	12				Dr	DW	4¼	S	
403		950	144	168	Dol	Sca					Dr				
404	Ray Welsh	942	100	125	Dol	Sca					Dr	DE		D	
405	Frank Peene	915	110	130	Dol	Sca	16				Dr	DE	4¼	D,S	
406L	John Murray	941		65	G		14	5-21-49	20		Dr	DH	4¼	S	
407	McVay	970	140	250	Dol	Sca					Dr		4¼		
408	McVay	972	150	250	Dol	Sca					Dr		4¼		Well not in use.
409	R. H. Rotruck	977	294	336	Dol	Sca	14				Dr	DH	4¼	D	Water analysis in table 7.
410	H. J. Kauffman	977	287	315	Dol	Sca	20				Dr	DH	4¼	D	
411	Watson	979	230	300	Dol	Sca					Dr	DH	4¼	S	
412	Fred Simpson	977		227	G		8				Dr	DE	4¼	D	Casing pulled back to 60 feet.
413	Leroy Bradley	974	95	170	Dol	Sca					Dr	DE	4¼	D	
414	Leroy Bradley	974	230	250	Dol	Sca					Dr				Well not in use.
415	Oleh Braithwait	970	120	147	Dol	Sca					Dr	DE	4¼	D	
416	Oleh Braithwait	970	104	168	Dol	Sca					Dr	DE	4¼	D,S	
417L	Oleh Braithwait	962	138	159	Dol	Sca	47	10-15-49	20		Dr	DH	4	D	
418	Smith Olney	963	124	170	Dol	Sca					Dr	DE	4¼	D,S	
419	Ralph Parsons	963	170	200	Dol	Sca					Dr	DE	4¼	D,S	
420	Ralph Parsons	960	188	225	Dol	Sca					Dr	DH	4¼	S	
421	Ed Ball	945	139	150	Dol	Sca					Dr	DE	4¼	S	
422	Don Riebel	944	116	124	Dol	Sca					Dr	DE	4¼		
423L	W. A. Beedle	948	81	106	Dol	Sca	35	10-21-49	20	15	Dr	DH	4	S	
424	Robert Wilson	943		71	G		20				Dr	DE	4¼	D,S	
425	V. K. Hix	925		100	G		20				Dr	DH	4¼	D	
426	Lawrence Stanton	931	100	104	Dol	Sca	17				Dr	DH	4¼	D,S	
427	C. E. Carr	921		59	G		12				Dr	DH	4¼	D	Water analysis in table 7.
428L	Otto Deitch	918	110	127	Dol	Sca	33	6- 3-49	20		Dr	DE	4¼	D,S	
429L	Stokely Corporation	900	78	132	Dol	Sca	22	5-26-48	400		Dr	TE	8	I	Water analysis in table 7.

Table 8. RECORDS OF WELLS AND TEST HOLES IN MADISON COUNTY, OHIO (continued)

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water Level: Below land surface (feet)	Water Level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
JEFFERSON TOWNSHIP (continued)															
430	Vill. of West Jefferson	918	34	100?	Dol	Sca	15		150		Dr	SE	8	P	East well.
431	Vill. of West Jefferson	918	38	70?	Dol	Sca			150		Dr	SE	6	P	West well.
432	Ray Welsh	950	91	104	Dol	Sca					Dr	DG	4¼	S	
433	Richard Thomas	958	119	128	Dol	Sca					Dr	DE	4¼		
434	Sand and Gravel Co.	905	16	16							Dr				Test well, casing pulled.
435L	H. H. Tucker	980	132	139	Dol	Sca	60	5-20-48	16		Dr	DE	4	S	
436L	H. H. Tucker	975	125	146	Dol	Sca	60	5-14-48	16		Dr	DE	4	D	
437	R. J. Rae	965		125	G		12				Dr	DE	4¼	D	
438	K. E. Campbell	980		140	G						Dr		4¼		Well not in use.
439		980	130	167	Dol	Sca					Dr				
440L	William Collins	981	155	162	Dol	Sca	16	10-15-47	28		Dr	DH	4¼	D	
441	J. W. Houck	965	204	215	Dol	Sca					Dr	DE	4¼	D	
442L	Seibold	980	193	252	Dol	Sca	43	5-30-49	20	15	Dr	DE	4¼		
443	Bruce Little	990		33	G		30				Dr	DE	4¼	D,S	
444		982	4	400	S						Dr				
445	Mrs. Maddox	982	142	160	Dol	Sca					Dr	DH	4¼	S	
446	Ransom Salyer	960		101	G		30				Dr	DE	5	D	
447	Allen Silvers	935	63	95	Dol	Sca					Dr	DH	4¼	D	
448	Henry Alford	922	44	65	Dol	Sca	20				Dr	DE	4¼	D,S	
449	D. C. Powers	930	78	112	Dol	Sca	27				Dr	DE	4¼	D,S	
450	Dr. Van Buskirk	922	50	100	Dol	Sca	18				Dr	DE	4¼	S	
451	Mrs. Ruffing	900	33	76	Dol	Sca	18				Dr	DH	4¼	D	
452	L. F. Bradfield	950	100	123	Dol	Sca	30				Dr	DE	4¼	D,S	
453	Albert Gregg	985	100	150	Dol	Sca					Dr	DE	4¼	S	
454	Clarence Corbitt	985		30	G		20				Dug	DE	48	D,S	Water analysis in table 7.
455	Albert Engle	986		50	G		20				Dr	DE	4¼	D,S	
456	Charles Ruff	986	137	145	Dol	Sca	45				Dr	DE	4¼	D,S	
457	Cowling and Farrar	981	101		Dol	Sca	40				Dr	DE	4¼	S	
458L	Mrs. F. B. Thomas	980		123	G		45	12- 7-48	20		Dr	DE	4	D,S	
459L	Opekasit farms	953		38	G		10	7- 3-48			Dr		4¼	D	
460L	Alex Dombey	902		45	G		30	11-23-49			Dr		4	D	
461L	F. H. Andrix	860	3	53	Dol	Sca	7	3-17-50	10		Dr		4¼	D	
462L	Alex S. Dombey	900	50	72	Dol	Sca	6	3-24-50			Dr	DH	4	D	Note: Av. daily pumpage from wells 430 & 431 was about 150,000 gallons in 1956.
463L	Demsky	942	181	228	Dol	Sca	60	1- 4-50	15	73	Dr	DH	4	D	
464L	Allan Hance	901		164	G		14	7-29-54			Dr	DE	4¼	D	
465L	Battelle Mem. Inst.	913	103	138	Dol	Sca	40	8-13-54	250		Dr	DE	12	I	Water analysis in table 7.
MONROE TOWNSHIP															
500	W. T. Booth	1032	86	110	Dol	Sca	14				Dr	DH	4¼	D,S	
501	H. A. Smith	1023	80	103	Dol	Sca	7				Dr	SE	4¼	D,S	
502	Austin Burnham	1005	51	75	Dol	Sca	15				Dr	DE	4¼		
503	Clara Williams	1009	59	75	Dol	Sca	11				Dr	DH	4¼	S	
504L	Clara Williams	1005		53	G		10	5- 2-48	7		Dr	DH	4¼	D	
505	Jenny Finley	981	90	210	Dol	Sca	12				Dr	DE	4¼	D,S	
506	J. M. Morris	982	83	103	Dol	Sca	14				Dr	DE	4¼	D	
507	Whume & Mabe	981	71	78	Dol	Sca	11				Dr	DH	4¼	S	
508	Whume & Mabe	980	80	92	Dol	Sca	12				Dr	DH	4¼	D	
509	Edward Renner	979	50	65	Dol	Sca	12				Dr	DE	4¼	D	
510	Pence	995	69	90	Dol	Sca	20				Dr	DH	4¼	D,S	
511L	Paul Sanford	997		92	G		16	12- 8-49	16		Dr	SE	4¼	D	
512	Louis Becker	1030	55	61	Dol	Sca	17				Dr	SE	4¼	D	
513	Louis Becker	1030	55	65	Dol	Sca	20				Dr	DE	4¼	D	
514	Ida Beath	1025	60	70	Dol	Sca	15				Dr	SE	4¼	D,S	
515	Orleton farms	1012		58	G		18				Dr	SE	4¼	D,S	
516	Leach	1008	46	114	Dol	Sca	12				Dr	DE	4¼	D,S	
517	Orleton farms	1010	60	124	Dol	Sca	18				Dr	DH	4¼	D	
518L	Laule	1010		54	G		40	12-21-47			Dr	DE	4	D	
519	Littler	1009	100	120	Dol	Sca					Dr	DH	4¼		
520	Dr. Morris	1012	72	120	Dol	Sca	Flows				Dr	DH	4¼	D	
521	Mrs. Minnie Williams	975		78	G		8				Dr	DE	4¼	D,S	
522	Lester Tatman	975	140	182	Dol	Sca	40				Dr	DG	4¼	D,S	
523L	John Byer	976	102	164	Dol	Sca	19	10- 1-47	28		Dr	DG	4¼	S	
524	H. D. Troyer	983	179	250	Dol	Sca	20				Dr	DH	4¼	D,S	
525L	Erma Byerly	980	167	204	Dol	Sca	9	11-22-48			Dr	DE	4¼	D	
526	John Byerly	982	175	220	Dol	Sca					Dr	DH	4¼	S	
527	Ora Byerly	981	176	200	Dol	Sca	45				Dr	DW	4¼	D,S	
528	East-McKell farm	970	166	187	Dol	Sca					Dr	DW	4¼	D,S	
529	John Taylor	975		93	G						Dr		4¼		Well not in use.
530	West-McKell farm	992		100	G						Dr	DG	4¼	S	
531	Gwynne-Burr farm	992		115	G						Dr	DW	4¼	D,S	
532		1000	155	218	Dol	Sca					Dr				
533	Former schoolhouse	991		90	G						Dr	DH	4¼		Well not in use.
534L	Straley	992		66	G		20	1-31-50	8		Dr		4¼	D	
535L	John R. Littler	1005	135	165	Dol	Sca	45	5- 9-55	10	20	Dr	DE	4¼	D	
OAK RUN TOWNSHIP															
600	Mrs. J. F. Bell	1003		202	S						Dr	DE	4¼		Poor well, pumps sand.
601	Wilbur Humes	1003	186	200	Dol	Sca	35				Dr	DG	4¼	D,S	
602	McVay	970	176	206	Dol	Sca					Dr	DE	4¼	D,S	
603	Former schoolhouse	988		100	G						Dr	DE	4¼	D	
604	R. L. Shoaf	1001		50	S		13				Dr	SE	4¼	D,S	
605	S. G. Smith	1015	96	121	Dol	Sca	4				Dr	DE	4¼	D,S	
606	C. R. Shoaf	1014		30	G		9				Dr	SE	4¼	D	
607	John Funk	991		70	G		20				Dr	DE	4¼	D,S	
608	John Whiteside	990		58	G		16				Dr	DE	4½	D	
609	Mrs. Catherine Higgins	985		97	G		8				Dr	DE	4¼	D,S	
610	Earl Caldwell	985		90	G						Dr	DE	4¼	D	

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
OAK RUN TOWNSHIP (continued)															
611	Albert Carnes	975		60	G						Dr	DH	4	D	
612		960		121	G						Dr				
613	Mrs. Cary Hines	976	132	136	Dol	Sca	20				Dr	DE	4¼	D,S	
614	M. L. Rea	968	175+	1630							Dr				Well drilled for gas.
615	Pearl Wilson	972		198	G						Dr	DH	4¼	D	
616	Stanley Lucas	960		105	G		30				Dr	DH	4¼	D,S	
617	B. F. Beery	965		145	G		40				Dr	DE	4¼	S	
618	Earl Ray	955		125	G		25				Dr	DH	4	S	
619	B. F. Beery	956		135	G		25				Dr	DE	4	S	
620L	Clarence Garner	928		114	G		56	8- -49	6		Dr	DE	4¼	D	
621	Mrs. Andre Crotti	947		193	G						Dr	DE	4¼	S	
622L	Gwinn	980		35	G		14	8- -49	6		Dr	DH	4	D	
623L	John R. Patton	984	188	191	Dol	Sca					Dr		4		Test hole drilled Aug. 1953.
624L	Emmitt Morris	982	394	397	Ls	Sn					Dr		4		Test hole drilled Aug. 1952.
625L	Mrs. Rea Chenoweth	978	410	420	Ls	Sn					Dr		4		Test hole drilled June 1953.
626L	Mrs. Rea Chenoweth	972	235	245	Dol	Sca					Dr		4		Test hole drilled Aug. 1953.
627L	Mrs. Rea Chenoweth	950	185	190	Dol	Sca					Dr		4		Test hole drilled Aug. 1953.
PAINT TOWNSHIP															
700L	Roy Groves	1140		130	G		19				Dr	DE	4¼	D	
701	Walter Florence	1135	220	220	G						Dr	DE	4¼	S	
702	Agricultural Lands, Inc.	1140	235	239	Dol	Sca					Dr	DE	4¼	D,S	
703	Mrs. C. Seifret	1140	200	205	Dol	Sca					Dr		4¼		Well not in use.
704	Ray Gordon	1122	210	215	Dol	Sca					Dr	DE		D	
705	Clarence Hunter	1130	390	396	Ls	Sn					Dr	DE	4¼	D,S	
706	E. Porter	1140		195	G		32				Dr	DE		S	
707	W. Earles	1122	220	227	Dol	Sca					Dr	DH	4¼	D	
708	James Hunter	1122		132	G						Dr	DE	4¼	S	
709	F. Timble	1072		112	G						Dr				Well not in use.
710	Agricultural Lands, Inc.	1100	83	85	Dol	Sca	22				Dr				
711	Agricultural Lands, Inc.	1091	131	197	Dol	Sca	1				Dr			S	
712	Agricultural Lands, Inc.	1120	74	80	Dol	Sca	25				Dr			S	
713	Agricultural Lands, Inc.	1107		112	G						Dr	DE	4¼	D	
714	Clara Hornbeck	1095		130	G						Dr	SE	4¼	D	
715	William C. Moody	1030	100	135	Dol	Sca					Dr	DH	5	D	
716	Henry Lindsay	1052		93	G						Dr	DE		D	
717L	George Norris	1071		60	S		17	4- 2-48	35	4	Dr	DE	4¼	D	Casing perforated 67 to 69½ feet.
718	V. Jordan	1060		107	G		19				Dr	DE	4¼		
719		1068	163	322	Ls	Sn					Dr				
720	Mrs. Robert Morrison	1090		103	G		38				Dr	DE	4¼	D	
721L	Dean Richmond	1040		115	G		Flows	11-20-47	22		Dr	DH	4¼	S	
722L	John Buehl, Jr.	1082		88	G		19	4- 5-48	20	4	Dr	DE	4¼	D,S	Casing perforated 74 to 77 feet.
723L	John Buehl	1095		98	G		14	4- 9-48	40	2	Dr	DE	4½	D	Casing perforated 85 to 88 feet.
724	F. G. Smith	1043		110	G		12				Dr	DH	4¼	S	
725	Mrs. Proctor	1095	100	120	Dol	Sca					Dr	DH	4¼	S	
726L	Newport church	1068		84	G						Dr		4¼	P	
727L	Anne Lovely	1042	106	126	Dol	Sca	2		30	16	Dr	DH	4¼	D	
728L	Edgar Smith	1042		110	S		18	3-29-49	25	3	Dr	DH	4¼	D	
729L	Clara Hornbeck	1071		81	S		16		16	2	Dr	DH	4½	D	
730L	Arthur Clark	1120	210	245	Dol	Sca	80	9-17-55	5		Dr	DE	4½	D	
731L	A. H. Baughn	1070	126	195	Dol	Sca	40	10-23-55	10		Dr	DE	4½	D	
PIKE TOWNSHIP															
800	Kennedy	1005	30	80	Dol	Sca	12				Dr	DG	4¼	D	
801L	Charles Keller	1012	41	46	Dol	Sca	8	4-21-49	10	2	Dr		4¼	D	
802	Mrs. Matthews	1021		92	G						Dr	DH	4¼	D	
803L	F. Emanory	1005		39	G		12	5-13-49	20		Dr		4	D	
804	Alice Underwood	995	40	50	Dol	Sca					Dr	DH	4¼		
805	C. O. McCullough	1001	28	40	Dol	Sca					Dr	DE	4¼	D	
806	Dr. Goodyear	997	60	88	Dol	Sca	8				Dr	SE	4¼	D,S	
807	Norman Burns	999	22	38	Dol	Sca	7				Dr	SE	4¼	D,S	
808	Dr. Goodyear	996	40	48	Dol	Sca	5				Dr	SE	4¼	D	
809	J. G. Boerger	996	40	44	Dol	Sca	4				Dr	SE	4	D	
810	Emma Greenbaum	993	39	60	Dol	Sca	8				Dr	DE	4¼	D	
811	Fred Nichols	981	45	80	Dol	Sca	10				Dr	DH	4¼	S	
812	Clarence Bidwell	981	40	70	Dol	Sca	15				Dr	DH	4¼	S	
813	Walter Dellinger	975	40	80	Dol	Sca	20				Dr	DE	4¼	D,S	
814	Walter Thiergartner	982	55	100	Dol	Sca	23				Dr	DE	4¼	D,S	
815	Robert Arnold	982	47	75	Dol	Sca					Dr	DH	4¼	D	
816	Charles Keller	980	45	90	Dol	Sca	18				Dr	DH	4¼	D	
817	Charles Keller	981	40	85	Dol	Sca	20				Dr	DE	4¼	D,S	
818	Harold Nichols	978	75	150	Dol	Sca	15				Dr	DE	4¼	D,S	
819	Roy Yutzy	981	60	100	Dol	Sca					Dr	DE	4¼	D,S	
820	Lee Sidner	970	80	110	Dol	Sca	12				Dr	DH	4¼	D,S	
821	W. S. Leckie	985	60	92	Dol	Sca	15				Dr	DE	4¼	D,S	
822	Edith Adams	983	60	195	Dol	Sca	2				Dr	DH	4¼		
823L	F. M. Clemans	999		43	G		12	2-26-49	10		Dr	SE	4¼	D	
824	Carl Williams	1001	87	89	Dol	Sca	15				Dr	DH	4½	D	
825	Howard Hatcher	1010	119	130	Dol	Sca	14				Dr	DE	4¼	D	
826	Robert McCarty	1011		45	S		7	4-28-49			Dr	SE	4¼	D	
827	Cecil	1011	60	80	Dol	Sca	16				Dr	DH	4¼	D	
828	Eva G. Wing	1018	115	138	Dol	Sca	20				Dr	DH	4¼	S	
829	Dave Wing	1009	24	50	Dol	Sca	12				Dr	DH	4¼	D	
830	C. H. Murphy	1048	96	126	Dol	Sca					Dr	DH	4¼	D	
831	Vincent Burnham	1041	110	120	Dol	Sca					Dr	DE	4¼	D,S	
832	Vincent Burnham	1041	100	109	Dol	Sca					Dr	DH	4¼	D	
833L	F. M. Clemans	1029	203	210	Dol	Sca	22	10- 1-49	20	3	Dr		4¼	D	
834L	William E. Purgit	1042	144	145	Dol	Sca	40	7-27-49	8		Dr				
835L	Miss Bertha Guy	1020		52	G		12	11-12-49	10	5	Dr		4¼	D	

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
PLEASANT TOWNSHIP															
900	J. B. Anderson	939		85	G		45				Dr	DE	4¼	D	
901	J. B. Anderson	925		160	S						Dr		4¼		Well not in use.
902	Mrs. Andre Crotti	945	198	202	Dol	Sca	40				Dr	DE	4¼	D,S	
903	J. E. Bower	922		58	G		8				Dr	DE	4¼	D	
904	Cecil White	920		75	G		23				Dr	DE	4¼	D,S	
905	L. A. Thornton	932		90	G		20				Dr	DH	4¼	S	
906	Leo Deyo	930		25	G						Dr	DE	4	D,S	
907	Ralph Booth	922	34	50	Dol	Sca					Dr	DW	4¼	S	
908	Clyde Bandy	922		155	G		12				Dr	DH	4¼	D,S	
909	L. A. Thornton	925		98	G		25				Dr	DE	4¼	D,S	
910	Harold Wade	922		117	G						Dr	DE	4¼	D,S	
911	Darrell Jones	924		75	G						Dr	DE	4¼	D	
912	Mrs. W. E. Ewing	902	102	116	Dol	Sca					Dr	DE	4	D	
913	S. H. Anderson	922	117	120	Dol	Sca	15				Dr	SE	4¼	D	
914	Seymore Kious	924	155	160	Dol	Sca	30				Dr	DH	4¼	S	
915	Mary E. Neff	876	58	1858							Dr				Well drilled for gas.
916	N. H. Crabbe	880		130	G						Dr	DE	4¼	D	
917	Former schoolhouse	921	136	156	Dol	Sca					Dr				
918	Davis Smith	929	109	116	Dol	Sca					Dr	DH	4¼	D,S	
919L	Wayne Smith	936		127	G		80	10- -47	5	20	Dr	DH	5½	S	
920	John Day	923	78	110	Dol	Sca					Dr	DW	4¼	S	
921	Former schoolhouse	942		102	G						Dr	DH	4¼	S	
922	Dr. Lutz	930	87	132	Dol	Sca					Dr	DE	4¼	D,S	
923	Ohio Fuel Gas Co.	922	139	155	Dol	Sca					Dr	DE	8	I	
924	E. R. Jones	918	123	140	Dol	Sca					Dr	DH	4¼	D,S	
925	Harley Tracy	920	90	100	Dol	Sca	10				Dr	DE	4¼	S	
926	Former schoolhouse	915		95	G						Dr	DH	4¼	S	
927L	Byron Redman	934		73	G		25	6- -48	7		Dr	DE	4¼	D,S	
928L	Ray Butts	915		72	S		25	2-17-45	7	10	Dr	DE	4¼	D,S	
929	Charles Beal	910	102	200	Dol	Sca	20				Dr	DH	4¼	S	
930L	Edward Douglas	903		92	G		43	3- -45	8	23	Dr	DE	4¼	S	
931L	B. A. Schadel	918	83	164	Dol	Sca					Dr	DG	4¼	S	
932	Village of Mt. Sterling	900	85	276	Dol	Sca		1925	110		Dr	TE	10	P	Average daily pumpage from wells 932 & 933L was about 90,000 gpd in 1956. Water analysis in table 7.
933L	Village of Mt. Sterling	900	84	285	Dol	Sca	48	5-27-36	140		Dr	TE	8	P	
934	Fred Harness	850	54	64	Dol	Sca	8				Dr	DH	4¼	D	
935	A. S. Alkire	908	77	100	Dol	Sca					Dr	DH	4¼	D	
936	R. T. Alkire	895	96	104	Dol	Sca	32				Dr	DE	4¼	D	
937	Holtzmuller	860	69	75	Dol	Sca	4				Dr	DE	4¼	D	
938L	Pleasant Cemetery	880		25	G		12	4- -46	7		Dr	DH	4¼	P	Water analysis in table 7.
939		905	113	120	Dol	Sca					Dr		4¼		Well not in use.
940	Max A. Chenoweth	878		60	G		25				Dr		4		State and Federal observation well M-1.
942	Mrs. Porter Mills	923	73	79	Dol	Sca					Dr		4¼	D	
943L	R. H. Graham	885	239	250	Dol	Sca					Dr		4		Test hole, drilled Aug. 1952.
944L	Earl Anderson	941	293	300	Dol	Sca					Dr		4		Test hole, drilled Aug. 1953.
945L	Harmon Boss	936	283	291	Dol	Sca					Dr		4		Test hole, drilled Sept. 1953.
946	J. B. Anderson	880			G			10-15						P	Anderson spring; water analysis in table 7.
947L	Dr. F. A. Lutz	918	261	282	Dol	Sca	33	8-24-56	9		Dr	DE	55/8	D	
RANGE TOWNSHIP															
1000	F. Beauman	1020	135	139	Dol	Sca	14				Dr	DG	4¼	S	
1001	F. Beauman	1022	139	144	Dol	Sca	16				Dr	DG	4¼	S	
1002	F. Beauman	1021		120	G		5				Dr	DG	4¼	S	
1003	F. Beauman	1001		45	G		18				Dr	DE	4¼	D	
1004	Dr. Crearen	1001		104	G						Dr	DH	4¼	D,S	
1005	Isaiah Call	1012	119	136	Dol	Sca					Dr	DE	4¼	D,S	
1006	P. Follrod	1082		123	G						Dr	DE	4¼	D	
1007	Mrs. Proctor	1082	102	165	Dol	Sca					Dr	DE		D	Water analysis in table 7.
1008	Mrs. Proctor	1080	71	150	Dol	Sca					Dr	DE	4¼	D	
1009	Mrs. Proctor	1060	100	165	Dol	Sca					Dr	DH	4¼	S	
1010	Mrs. Proctor	1050	100	170	Dol	Sca					Dr	DH	4¼	S	
1011		1041	90	92	Dol	Sca					Dr				
1012	George Wickline	1040	70	72	Dol	Sca					Dr	DE	4¼	D	
1013		1040	120	137	Dol	Sca					Dr				
1014L	John Mantle	1022	137	144	Dol	Sca	Flows	3-20-48	50	10	Dr	SE	4¼	D,S	
1015	Miller	1002		65	G		20				Dr	DE	4¼	D	
1016	Ernest Anthony	975		85	G		30				Dr	DE	4¼	D,S	
1017	John Sullivan	970		78	G						Dr	DH	4¼	D,S	
1018	Roy Craig	985		87			14				Dr	DE	4¼	D,S	
1019	Roy Craig	995		38	G		10				Dr	SE	4¼	D	
1020	Goldsmith	1000	98	131	Dol	Sca					Dr	SE	4¼	D	
1021L	T. K. Emery	1025	74	114	Dol	Sca	21	3-15-48	20	2	Dr	DE	4¼	D,S	
1022	C. N. Nickell	1041	87	139	Dol	Sca	40				Dr	DE	4¼	D,S	
1023	Otto Straley	1042		85	G						Dr	DH	4¼	D	
1024	Mrs. Proctor	1080	70	150	Dol	Sca					Dr	DH	4¼	D	
1025		1074	75	79	Dol	Sca					Dr				
1026	Sam Robinson	1065	156	179	Dol	Sca					Dr	DE	4¼	D,S	
1027	G. A. Heath	1070	159	176	Dol	Sca	18				Dr	DE	4¼	D,S	
1028	Ralph Satterfield	1072	59	105	Dol	Sca	15				Dr	SE	5	D	
1029	Chester Gallagher	1022	136	141	Dol	Sca					Dr	DE	4¼	D,S	
1030	Roy Craig	975		60	G		15				Dr	DG	4¼	S	
1031	Albert Anderson	922	156		Dol	Sca					Dr			D	
1032	H. J. Dewey	940		70	G		8				Dr	DE	5	D,S	
1033	Elizabeth Lamson	930		103	G		10				Dr	SE	4¼	D,S	
1034	R. S. Reno	940		40	G		2	8-16-49			Dr	DH	5½	D	

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
RANGE TOWNSHIP (continued)															
1035	John Moats	945		137	G		15				Dr	DE	4¼	D,S	
1036	Will Shuler	981		55	G		9				Dr	DE	4¼	D,S	
1037	Woodstock farms	1000	102		Dol	Sca					Dr				
1038	E. J. Hinkleman	958		45	G						Dr	DG	4¼	S	
1039	E. J. Hinkleman	952		63	G						Dr	DE	4¼	S	
1040	Armour Chenoweth	966		124	G						Dr		4¼		Well not in use.
1041	Armour Chenoweth	965		62	S						Dr	DE	4¼	D,S	
1042	Robert Terhune	962		36	G		11				Dr	DE	4¼	D	
1043	Frank Sheppard	1001		80	G		16				Dr	DG	4¼	S	
1044	James Wagan	995		132	G						Dr	DE	4¼	D	
1045	May McClimens	1003	80	140	Dol	Sca	20				Dr	DE	4¼	D	
1046	Danville school	1010	90	129	Dol	Sca	30				Dr	DH	4¼	P	
1047	Leonard Hux	1001	80	91	Dol	Sca					Dr	DH	5½	D,S	
1048	Dan Tope	1005	81	82	Dol	Sca					Dr	DH	4¼	D	
1049	John Frederickson	1010	91	133	Dol	Sca					Dr	DH	4¼	D,S	
1050	John Donahue	1041		58	G		15				Dr	SE	4¼	D,S	
1051	Kenneth Dorn	1040	92	100	Dol	Sca					Dr	DE	4¼	D,S	
1052	A. R. Trehearne	1035	84	90	Dol	Sca	24				Dr	DE	4¼	D,S	
1053	W. S. Cowan	1065		117	G						Dr	DW	4¼	S	
1054	Joe Smith	1065		191	G						Dr	DE	4¼	D	
1055L	Cecil Ridenour	975		64	G		25	7-20-49	14	9	Dr	DE	5	D	
1056L	Ottes Strayley	1042		53	G		20	9-16-49	17	3	Dr			D	
1057L	John Moats	955		125	G						Dr		4¼		
1058L	Frank Jones	965	136	138	Dol	Sca					Dr		4¼	S	
1059L	Harold Friend	1065	73	165	Dol	Sca	10	3- 7-56	10	15	Dr	DE	6	D	
1060L	S. E. Robinson	1060	85	149	Dol	Sca	24	1-27-56	10		Dr	DE	4½	S	
1061L	Dr. Strine	970	194	200	Dol	Sca	21	12- 9-55	10		Dr	DE	4½	D,S	
SOMERFORD TOWNSHIP															
1100L	E. Carter	1046		24	G		11	12- 9-49	20	9	Dr	SE	4¼	D,S	
1101	William Calaway	1054		71	G		20				Dr	SE	4¼	D,S	
1102	B. C. Zimmerman	1060	200	205	Dol	Sca	17				Dr	SE	4¼	D,S	
1103	Jacob Fornof	1052	140	144	Dol	Sca					Dr	DE	4¼	D,S	
1104	James McNary	1062	160	170	Dol	Sca					Dr	DH	4¼	D	
1105	Jacob Fornof	1055	140	150	Dol	Sca					Dr	DE	4¼	D	
1106	Mrs. Alice Ackerman	1115		50	G		Flows				Dr	SE	4¼	D	
1107	Mrs. Alice Ackerman	1095		152	G		30				Dr	DG	4¼	S	
1108	Mrs. Alice Ackerman	1120		110	G		75				Dr	DE	4¼	D	
1109	Orleton farms	1040		66	G		15				Dr	DH	4¼		
1110	Orleton farms	1030	83	92	Dol	Sca	20				Dr	SE	4¼	D	
1111	William Stadler	1068	64	130	Dol	Sca	20				Dr	DE	4¼	D,S	
1112	Mrs. Edward Hackett	1080		90	G						Dr	DE	4¼	D	
1113	Mrs. Edward Hackett	1065		88	G		10				Dr	DC	4¼	S	
1114	Orleton farms	1031		90	G		4				Dr	SE	4¼	D	
1115	Orleton farms	1040		88	G		20				Dr	SE	4¼	D	
1116	William Daisch	1138		100	G						Dr	DH	4¼	D	
1117	Tradersville church	1120	63	90	Dol	Sca					Dr	DH	4¼	P	
1118	Marie Byers	1110	100	220	Dol	Sca	20				Dr	DE	4¼	D,S	
1119	George Wingate	1145		137	G		37				Dr	DE	4¼	D	
1120	G. D. Stroupe	1100		75	G		16				Dr	DE	4¼	D	Water analysis in table 7.
1121	Orleton farms	1035	125	140	Dol	Sca	18				Dr	SE	4¼	D	
1122	Del Fauber	1035	210	220	Dol	Sca	25				Dr	SE	4¼	D	
1123	Orleton farms	1049	204	210	Dol	Sca	26				Dr	DE	4¼	D	
1124	George Myers	1060	100	120	Dol	Sca					Dr	DH	4¼	S	
1125	Clara S. Houston	1120		168	G		40				Dr	DW	4¼	D,S	
1126	J. Houston	1060		120	G						Dr	DE	4¼	D	
1127	P. Gibson	1110		168	G		45				Dr	DH	4¼	D,S	
1128	Tom Huber	1100	112	120	Dol	Sca					Dr	DE	4¼	S	
1129	Heckma	1090		160	G						Dr	DE	4¼	S	
1130	Frank Woosley	1058		140	G		20				Dr	DE	4¼	D	
1131	Agricultural Lands, Inc.	1040		90	G		30				Dr	DE	4¼	D	
1132	Agricultural Lands, Inc.	1052	210	220	Dol	Sca	40				Dr	DG	4¼	S	
1133	Agricultural Lands, Inc.	1093	203	214	Dol	Sca					Dr	DE	4¼	D	
1134	P. Andricks	1095		108	G		43				Dr	DW	4¼	S	
1135	C. R. Gould	1100		110	G		6				Dr	DE	4¼	D	
1136L	Nellie Dunn	1175		75	G		30	4- 8-48			Dr	DH	4¼	D	
1137L	Carl Wiseman	1165		88	G		35	4- 8-48			Dr	DH	4¼	D	
1138L	Harry Bird (Motel)	1162		87	S		55	9-30-47			Dr	DE	4¼	P	
1139L	Myron Woods	1162		39	G		13	3-25-49			Dr	DE	5½	D	
1140	H. Myers	1142		64	G		40				Dr	DE	6	D,S	
1141	Perry Maples	1125		183	G						Dr	DH	4¼	D	
1142	Mrs. G. P. Overturf	1082		93	G		30				Dr	DE	4¼	D,S	
1143		1095		204	G						Dr			D	
1144	Ethel Williams	1095		140	G		41	4-25-49			Dr		4¼		
1145L	Frank Rainer	1095		102	S		36	4-12-49	14		Dr	DH	4	D	
1146	M. L. Sweet	1100		86	G		37				Dr	DE	4¼	D,S	
1147	Agricultural Lands, Inc.	1062	224	254	Dol	Sca	35				Dr	DE	4¼	D	
1148	B. C. Zimmerman	1175		83	G		20				Dr	DH	4¼	D	
1149L	Bradford	1122		80	G				20		Dr		4¼	D	
STOKES TOWNSHIP															
1200	E. Vallery	1122	150	160	Dol	Sca	40				Dr	DW	4¼	S	
1201	Pancake heirs	1098		146	G						Dr	DE	4¼	D	
1202	Selsor heirs	1085		148	G		70				Dr	DG	4¼	S	
1203	George Clemens	1075	131	150	Dol	Sca					Dr	DH	4¼	S	
1204	E. Vallery	1085	96	155	Dol	Sca	25				Dr	DW	4¼	S	
1205	Della Selsor	1080	105	115	Dol	Sca					Dr	DE	4¼	D	
1206	Della Selsor	1081	96	105	Dol	Sca					Dr	DE	4¼	S	
1207	Della Selsor	1080	110	120	Dol	Sca					Dr	DE	4¼	D,S	

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Water level: Below land surface (feet)	Water level: Date	Yield: Rate (g.p.m.)	Yield: Drawdown (feet)	Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
	STOKES TOWNSHIP (continued)														
1208	Ralph Pancake	1105	99	197	Dol	Sca					Dr	DE	4¼	D,S	
1209	P. Mallon	1095		118	G		Flows				Dr	DH	4¼	S	
1210	Pancake heirs	1103	140	149	Dol	Sca	2				Dr	DH		S	
1211	P. Mallon	1102	165	193	Dol	Sca	33				Dr	DW	4¼	S	
1212	P. Mallon	1101		118	G						Dr	DW	4¼	S	Water analysis in table 7.
1213	P. Mallon	1102	165	195	Dol	Sca					Dr	DW	4¼	S	
1214	Elmer Gahm	1122	182	185	Dol	Sca					Dr	DW		S	
1215	H. Riegel	1122	157	208	Ls	Sn					Dr	DE		D,S	
1216	W. W. Morris	1130	122	150	Dol	Sca					Dr	DE	4¼	S	
1217	Henry Sexton	1141	175	195	Dol	Sca					Dr		4¼		
1218	Agricultural Lands, Inc.	1118	204	213	Ls	Sn	21				Dr	DW	4¼	S	
1219	B. Bond	1120		169	G						Dr	DG	4¼	S	
1220	B. Bond	1122	150	155	Dol	Sca					Dr	DW	4¼	S	
1221	Brunskill	1115		170	G						Dr	DG	4¼	S	
1222	James McDorman	1117	184	190	Dol	Sca					Dr	DH	4¼	S	
1223	R. Slaughter	1098		128	G						Dr	DH	4¼	S	
1224	G. Eiser	1102	139	150	Dol	Sca					Dr	DE	4¼	D	
1225	G. Eiser	1099	90	110	Dol	Sca					Dr	DH	4¼	S	
1226	Selsor heirs	1081	100	133	Dol	Sca					Dr	SE	4¼	D	
1227	C. C. Tope	1072	70	98	Dol	Sca	16				Dr	DG	4¼	S	
1228	C. C. Tope	1069	70	90	Dol	Sca					Dr	DW	4¼	S	
1229	H. Friend	1065	102	225	Dol	Sca					Dr	DE	4¼	D,S	
1230	G. Gossard	1070	90	175	Dol	Sca					Dr	DH	4¼	D	Owner complains of sulphur taste.
1231	Lore Irvin	1070	80	142	Dol	Sca	25				Dr	DE	4¼	S	
1232	R. Slaughter	1075	75	133	Dol	Sca					Dr	DE	4¼	D	
1233	R. Slaughter	1080	89	111	Dol	Sca	35				Dr	DE	4¼	S	
1234	C. Chiteside	1070	81	183	Dol	Sca					Dr	DH	4¼	D	
1235	Brigge	1075	90	132	Dol	Sca					Dr	DH	4¼	S	
1236	F. H. Smith	1082	60	100	Dol	Sca	28				Dr	DE	4¼	D	
1237	Fred Rihl	1082	75	104	Dol	Sca					Dr	DG	4¼	S	
1238	A. L. Torbit	1082	114	125	Dol	Sca					Dr		4¼		
1239	L. Mace	1098	80	150	Dol	Sca					Dr	DE	4¼	S	
1240	W. Ream	1100	82	135	Dol	Sca					Dr	DE	4¼	S	
1241	L. C. Titus	1095	82	107	Dol	Sca					Dr		4¼		
1242	Joe Clawson	1098	98	103	Dol	Sca					Dr		4¼		
1243	John S. Moon	1105		106	G						Dr		4¼		
1244	J. C. Clawson	1095	95	185	Dol	Sca					Dr	DH	4¼	S	
1245	Thomas school	1100	86	175	Dol	Sca					Dr		4¼		Well not in use.
1246	William Gordon	1118	147	174	Dol	Sca					Dr		4¼	D	
1247	South Solon Waterworks	1118	140?	179	Ls	Sn	60	2- -52	70		Dr	TE	8	P	Av. pumpage 30,000 gal. per day in 1956. Water analysis in table 7.
1248	Gene Fout	1125	153	200	Ls	Sn					Dr		4¼		Well not in use.
1249	South Solon school	1122	130	195	Ls	Sn					Dr	DE	6	P	
1250	Harrods drug store	1118	140		Ls	Sn					Dr	PH	5	D	
1251	Douglas Lucas	1102	96	105	Dol	Sca					Dr		4¼		
1252	Unknown	1104		185	S						Dr	DE	5½	D	
1253	Mrs. Smithwatson	1110	128	211	Ls	Sn	50				Dr	DE	4¼	D	
1254	Mrs. Smithwatson	1115	110	180	Ls	Sn					Dr	DH	4¼	S	
1255	Otis Core	1105		65	G						Dr	DH	4¼	D,S	
1256	Mrs. Garnet Lansing	1110	100	225	Ls	Sn	45				Dr	DE	4¼	D	
1257	Mrs. Garnet Lansing	1102	168	180	Ls	Sn	50				Dr	DH	4¼	S	Owner complains of sulphur taste.
1258	A. J. Brock	1110	54	136	Dol	Sca					Dr		4¼		
1259L	Joe Daugherty	1102	61	136	Dol	Sca	15	8-29-49	7	17	Dr		5½	D	
1260L	Sinclair Oil Co.	1115	176	204	Ls	Sn	25				Dr		4¼	P	
	UNION TOWNSHIP														
1300L	Robert Terry	1180		93	G		46	4- 8-48	10		Dr	DE	4¼	D,S	
1301L	F. Andrix	1182		107	G		54	4-12-49	10		Dr	DE	4¼	D,S	
1302	Paul Allen	1178	318	350	Dol	Sca					Dr	DE	4¼	D,S	
1303	Agricultural Lands, Inc.	1140		80	G						Dr	DE	4¼	S	
1304	Agricultural Lands, Inc.	1138		80	G						Dr	DE	4¼	S	
1305	Agricultural Lands, Inc.	1135		80	G						Dr	DE	4¼	S	
1306L	London Prison Farm	1107		305							Dr		8		Well no good, casing pulled.
1307L	London Prison Farm	1080		123	G		22	8-29-45	75	8	Dr	DE	6	S	
1308L	London Prison Farm	1081		48	S		25	8-11-45	50		Dr	DH	6	S	
1309	London Prison Farm	1083		110	G		28				Dr	DE	10	P	Four wells at this location, pumped by air lift. Water analysis in table 7.
1310	London Prison Farm	1081		520	S						Dr		10		
1311	J. C. Brandeburg	1062	324	350	Ls	Sn					Dr	DE	5	D,S	
1312L	London Prison Farm	1055		64	G		18				Dr	DH	6	S	
1313	Merick	1063	333	350	Ls	Sn	40				Dr	DE	4¼	D	
1314	London Prison Farm	1082		122	G		Flows				Dr	DE	8	S,I	
1315L	D. L. Mirick	1059		413	S						Dr		4¼		Well no good, casing pulled.
1316	London Prison Farm	1081		140	G		30				Dr	DE	6	D	
1317	London Prison Farm	1102		110	G		20				Dr	DG	6	S	
1318	Downing heirs	1082	157	180	Dol	Sca					Dr	DE	4¼	D,S	
1319	London Prison Farm	1100		160	G		40				Dr	DH	6	D	
1320	London Prison Farm	1080		162	G		45				Dr	DH	6	S	
1321	Jake Rhoades	1118		119	G		7				Dr		4¼	D	
1322	Leroy Roudebush	1120		130	G		15				Dr	DE	4¼	D	Also has 15 g.p.m. for stock.
1323	Sam Johnson	1110		137	S						Dr		4¼		Well not in use.
1324L	State highway garage	1073		120	G		20				Dr	DE	4	P	
1325	Charles Winkel	1050		89	G		2				Dr	SE	4¼	D	
1326	W. Cawley	1050		120	G		12				Dr	DE	4¼	D,S	
1327	K. Snyder	1041		96	G						Dr	DE	4		
1328L	London Water Co.	1035	177	200	Dol	Sca	40				Dr				Test well, casing pulled.
1329		1035	155	1585							Dr				Well drilled for oil or gas.
1330	Dr. W. C. Hackett	1040		106	G						Dr	DE	4¼	D	
1331	Armstrong Products Co.	1045		75	G		26				Dr	TE	5	I	Av. pumpage 50,000 gal. per day.

Well number	Owner or Name	Elevation at well (feet above sea level)	Depth to bedrock (feet)	Depth of well (feet)	Principal water-bearing bed		Water level		Yield		Type of well	Type of pump	Diameter of well (inches)	Use	Remarks
					Character of material	Geologic horizon	Below land surface (feet)	Date	Rate (g.p.m.)	Drawdown (feet)					
UNION TOWNSHIP (continued)															
1332	Madison Tile Co.	1045	225	250	Dol	Sca	60				Dr	TE	6	I	
1333	Shively Hotel	1045		117	G		10				Dr	DE	$4\frac{1}{4}$	P	
1334	George Pfeil	1040	220	250	Dol	Sca	27				Dr	DE	$4\frac{1}{4}$	D	
1335L	Grace Williams	1040	300	385	Ls	Sn	20	4-14-48	7	44	Dr	DE	3	D	Water analysis in table 7.
1336	Oscar Reeves	1018	258	267	Dol	Sca	30				Dr	DE	$4\frac{1}{4}$	D	
1337	Oscar Reeves	1018		125	G		25				Dr	DE	$4\frac{1}{4}$	S	
1338	E. P. Spesmaker	1020		69	G						Dr	DE	$4\frac{1}{4}$	D,S	
1339	W. B. Small	1020		128	G						Dr	DH	$4\frac{1}{4}$	D,S	
1340	E. P. Spesmaker	1005		129	G		15				Dr	SE	$4\frac{1}{4}$	D,S	
1341L	Earl McLeoid	978	157	180	Dol	Sca	34	6-14-49	18		Dr		$4\frac{1}{4}$	D	
1342L	Harry Stites	985	149	153	Dol	Sca					Dr	DH	4	D	
1343	R. E. Oberlin	985	159	165	Dol	Sca					Dr	DE	$4\frac{1}{4}$	D	
1344	Harry Turvy	982		143	G		22				Dr	DE	$4\frac{1}{4}$	S	
1345	Robert Plymell	965	139	150	Dol	Sca	25				Dr	DE	$4\frac{1}{4}$	D,S	
1346	Jones and Plymell	975		103	G		19				Dr	DH	$4\frac{1}{4}$	D	
1347	London Oil and Gas Co.	975	151	1921							Dr		8		Well drilled for oil or gas.
1348	Mrs. Irene Smith	1018		93	G		40				Dr	DH	$4\frac{1}{4}$	D	
1349	Edward Lanigan	1030		100	G		28				Dr	DE	$4\frac{1}{4}$	D,S	
1350	Madison rural school	1042	167	276	Dol	Sca					Dr	DE	$4\frac{1}{4}$	P	
1351	Ridenour	1040	135		Dol	Sca					Dr			D	
1352	Boyd	1055	168	184	Dol	Sca					Dr	DH	$4\frac{1}{4}$	D,S	
1353	Lester Gordon	1035	147	175	Dol	Sca					Dr		$4\frac{1}{4}$		Well not in use.
1354	Lester Gordon	1027		93	G		12				Dr	DH	$4\frac{1}{4}$	D,S	
1355	Moony	1037	119	127	Dol	Sca	Flows				Dr		5	D	
1356	Ira Earne	1008		58	G		15				Dr	DE	$4\frac{1}{4}$	D	
1357L	London Waterworks	1035		82	G		19				Dr	TE	24	P	
1358L	London Waterworks	1035		173	G		2	5-11-44	400		Dr	TE	26	P	
1359L	Joe Baker	1002		109	G		36	9-10-49	16		Dr		4	D	
1360L	C. Rinehart	1020	51	82	Dol	Sca	12	3-15-50	40	5	Dr	DH	$4\frac{1}{4}$	D	
1361L	London Prison Farm	1080		201	G		23	10-25-50	200	41	Dr	TE	12	P	Water analysis in table 7.
1362L	London Prison Farm	1086	530	540	Sn	Or					Dr		4		Test hole, drilled Aug. 1953.
1363L	Robert Terry	1160		305	G		90		18	14	Dr	DE	$4\frac{1}{4}$	D	
1364L	Lawrence Storts	1020	166	186	Dol	Sca	45	6-13-56	7		Dr	DE	$4\frac{1}{2}$	D	
1365L	Ina Foster	1060	259	263	Dol	Sca	45	1-27-56	10		Dr	DE	5 5/8	D	
1366L	Edna Sands	980	172	196	Dol	Sca	44	7-11-56	10		Dr	DE	$4\frac{1}{2}$	D	
1367L	London Prison Farm	1080		201							Dr		6		Test hole drilled Feb. 1957.
1368L	London Prison Farm	1060		200	G		14	2-26-57			Dr		8		Test hole drilled Feb. 1957.
1369L	London Prison Farm	1102		258	S&G		58	5-20-57	210	19	Dr	DG	6		Test hole drilled May 1957. Water analysis in table 7.
1370L	London Water Co.	1038		168	S&G		6-19	1957	300	10-20	Dr	DE	12	P	In 1957 used one week per month. Av. daily pumpage was 424,000 gal. in 1956. Water analysis in table 7.
1371L	London Water Co.	1038		172	S&G		5-12	1957	300	75-100	Dr	DE	12	P	

MAP SHOWING

PRINCIPAL SOURCES OF GROUND WATER IN MADISON COUNTY, OHIO AND APPROXIMATE CONTOURS ON THE BEDROCK SURFACE

BY S. E. NORRIS

ALTITUDE IN FEET ABOVE SEA LEVEL

BEDROCK CONTOUR INTERVAL 50 FEET

TOPOGRAPHY FROM THE U. S. GEOLOGICAL SURVEY TOPOGRAPHIC MAPS OF THE MECHANICSBURG, MILFORD CENTER, DUBLIN, SOUTH CHARLESTON, LONDON, WEST COLUMBUS, OCTA, MT. STERLING, AND ERA QUADRANGLES. CONTOUR INTERVAL 10 AND 20 FEET.

SCALE IN MILES

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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER
1959

BULLETIN 33 PLATE I

EXPLANATION

Sand and gravel valley-train deposits underlying the larger streams may yield up to 500 gpm to wells. Ground-water supplies of 1 to 2 mgd may be available from groups of wells replenished by stream infiltration. Where the valley-train deposits are thin and relatively unproductive, wells may be drilled to deeper aquifers.

Sand and gravel deposits overlain by till yield 300 to 500 gpm to some wells. Ground-water supplies of 0.5 to 1 mgd have been developed at London and the London Prison Farm. Wells drilled below the buried sand and gravel deposits may obtain water from the limestone and dolomite bedrocks, except in areas underlain by the Teays Valley and its principal tributaries.

Limestone and dolomite bedrocks of Silurian age yield as much as 400 gpm, or even more, from zones of relatively high permeability. Ground-water supplies of 0.1 to 0.5 mgd have been developed at Plain City, West Jefferson, and Mount Sterling. Water supplies for home and farm use are generally available from wells drilled into the top few feet of these rocks.

Sand and gravel beds of small extent, interbedded in till. Water supplies generally adequate for home or farm use; the better wells may yield up to 50 gpm. Wells drilled deeper than 200 to 300 feet in the buried Teays Valley and its tributaries may encounter thick deposits of clay, silt, and fine sand.

—900—

Approximate contours of equal elevation on the bedrock surface. Approximate depth to bedrock may be calculated by subtracting the elevation of the bedrock from the ground-surface elevation.

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Well or test hole drilled into bedrock.

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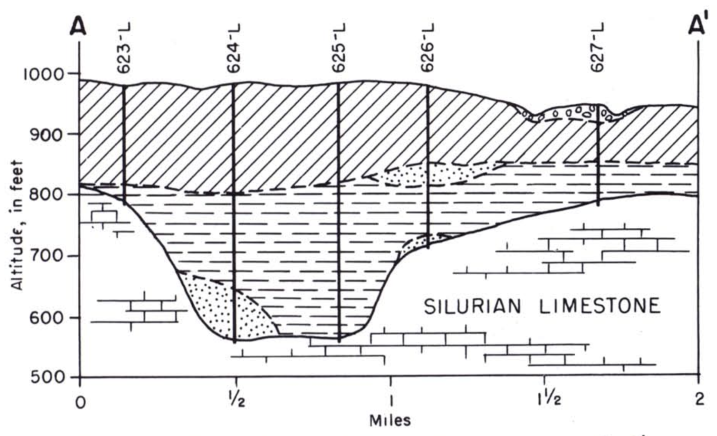
Well or test hole in sand and gravel deposits. (Numbers refer to data listed in table 8. Letter "L" after number refers to log shown on Figure 12. Number underlined refers to water analysis shown in table 7.)

Spring

▲

Surface exposure of consolidated rocks.

Arrows indicate the direction of flow of the preglacial Teays River and its tributaries.



Cross section of buried Teays Valley at line A-A'

EXPLANATION

GRAVEL CLAY TILL SAND OR SILT