THIRTY-EIGHTH ANNUAL REPORT

OF

Department of Geology and Natural Resources

INDIANA

EDWARD BARRETT
State Geologist

1913

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1914

LIST OF ASSISTANTS.

E. J. Quinn.....Field Assistant
C. H. Orahood.....Field Assistant
H. N. Coryell.....Field Assistant
R. S. Hesler.....Field Assistant
E. J. Grimes.....Field Assistant
Floyd E. Wright.....State Supervisor of Natural Gas
Margaret M. Kirby.....Stenographer and Clerk
W. V. Moss.....Custodian and Messenger

THE STATE OF INDIANA.

EXECUTIVE DEPARTMENT,

July 10, 1914.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,

July 30, 1914.

No financial statement.

W. H. O'BRIEN,

Auditor of State.

JULY 31, 1914.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

B. B. JOHNSON,

Secretary to the Governor.

AUGUST 1, 1914.

Filed in the office of the Secretary of the State of Indiana.

L. G. ELLINGHAM,

Secretary of State.

Received the within report and delivered to the printer August 3, 1914.

ED D. DONNELL,

Clerk Printing Board.

TABLE OF CONTENTS.

STATE OF INDIANA,
DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.
INDIANAPOLIS, IND., July 10, 1914.

Samuel M. Ralston, Governor of Indiana:

MY DEAR SIR—I submit to you today, in accordance with the law, the manuscript of the Thirty-eighth Annual Report of the Department of Geology and Natural Resources.

Due to the co-operative contract under which the Department is working with the U. S. Bureau of Soils in a soil survey of the State, the submission of this report was delayed several weeks awaiting the inspection of the Soils Correlating Committee of the U. S. Bureau. Owing to the volume of work before it, this committee could not complete its work on the Indiana soils until a few days ago. Through the courtesy of Milton Whitney, Chief of Bureau of Soils, the inspection work was hurried to completion and our farmers will get the benefit this year of the work done in 1913 under the co-operative contract.

During the period which I have had to wait for the work of the U. S. Soils Committee, I have been gathering data on the Sullivan, Indiana, Oil Field, and the data on that field was brought down to the present time, and the information contained in this report will doubtless be found useful to the sixty or seventy-five drillers and operators now engaged in Sullivan County.

With the hope that the manuscript herewith submitted will meet your approval, and that the State Printing Board will order its early publication, I am Very respectfully,

EDWARD BARRETT,
State Geologist.


AREA
COVERED
BY
SOIL SURVEY
U.S SURVEY
STATE SUR
INDIANA
Showing the
General Types
Glacial boundary
and mordines after
F Leverett
LAKE
PORTER
STARKE
PULASKI
FULTON
CASS
MIAMI
WABASH
WHITLEY
ELKHART
LAGRANGE
STEUBEN
DE KALB
ADAMS
BENTON
CARROLL
HOWARD
CLINTON
WARREN
FOUNTAIN
JAY
ORANGE

INTRODUCTION.

By Edward Barrett.

The importance of a detailed soil survey becomes more apparent as the years go by. When the population of the country was sparse and the soils in their virgin fertility the production of grain and other farm products was far in excess of the population. In recent years this condition has been reversed. Production has not kept pace with population. In addition to this are other conditions that have influenced the farming interests of the country. Prominent among these are the following:

(1) The drift of the country population toward the cities.

(2) A lack of intelligent cultural methods among the majority of the farmers.

(3) Wide and indiscriminate use of fertilizers.

(4) Neglect of crop rotation.

(5) Lack of leguminous crops.

An analysis in detail of the above five points would require a long chapter—possibly a volume. Suffice it to say here that farmers are waking up to the necessity for attention along these lines.

In accordance with the above conclusions, the soil investigations were continued during the year 1913 in Delaware County by Mr. L. A. Hurst, of the U. S. Bureau of Soils, and Mr. E. J. Grimes, of the Indiana Department of Geology. The fact that these men had direct charge of the field work is sufficient guarantee that the work would be well done. These men went carefully over every section of Delaware County, and their map and descriptions are among the very best thus far issued.

The work in Hendricks County was in charge of Mr. W. E. Tharp, of the U. S. Bureau of Soils, and Mr. Edward J. Quinn, of the State Department. These two men spent about five months in Hendricks County, and there is scarcely a farm in the county they did not traverse.

After the completion of the survey of Hendricks County, Mr. Edward J. Quinn was transferred to Blackford County, and, assisted by Mr. Robert H. Peacock, the soil survey of that county was completed before cold weather, Mr. Quinn giving the work his usual careful and conscientious attention.

The soil work in Vermillion County was in charge of Mr. H. N. Coryell, a senior student of the State University. The farmers of that county bear testimony of the industrious and careful work of Mr. Coryell, whose report appears in another part of this volume.

The soils of Parke County were carefully gone over by Mr. Harold Orahood, a graduate student of the State University. In addition to a clear and comprehensive report on the soils, Mr. Orahood was able to pay particular attention to the geology of Parke County, and in his work he located and recommended a number of shale and limestone deposits for future development by citizens of that county or interested investors from other places.

The State Geologist, early in his administration, saw the importance of basing the geology of the State on a contour or topographic map. In the absence of surveys of this kind by the State Department, the work was begun on an area known as the Bloomington Quadrangle, comprising in the most part Monroe County. The field work was in charge of Dr. J. W. Beede, of Bloomington, assisted by a corps of advanced students in geology. It is the purpose of the State Geologist to continue this work during the year 1914, and the results of these investigations will be published in the annual report of the Department of Geology for the year 1914.

The investigation of the various kinds of sands in the State was continued intermittently by the State Geologist during the year 1913. The results of these investigations are published in another part of this report, though want of time and means precludes publishing a report on any of the sands except those suitable for glass making. The State Geologist will continue the investigations of molding and sawing sands during the coming year.

The annual report for the year 1913 closes with the report of the State Supervisor of Natural Gas, Mr. Floyd E. Wright. Mr. Wright took charge of the work September 1, 1913, and has given commendable attention to every phase of the work. There has been a largely increased activity in the oil and gas fields of the State, particularly in Sullivan County, where the second best field in the State is being developed, though at the present writing the field is but twelve months old. The production at this writing (July 1) is about 3,500 barrels of oil per day, and there are from forty to fifty rigs at work in the county. A preliminary report on the Sullivan field appears on pages 9 to 40.

Sullivan County Oil Field.

By Edward Barrett.

Fifteen years ago, the people of Indiana generally believed that Trenton rock was the only gas and oil producing formation in the State. The large production of both gas and oil during the fifteen years following 1889 in the old Trenton rock field led to a period of marvelous industrial and commercial activity in that portion of the State, and this activity heightened the belief that the Trenton was the only rock worth exploiting for oil and gas.

So long as these conditions prevailed, little systematic or determined effort was made by drillers and operators to find gas or oil in other parts of the State, or in formations other than the Trenton. As soon, however, as the Trenton production began to decline, and the industries of the Trenton field began to be threatened with a shortage of fuel, exploitation for gas and oil took on more intelligent, exact, and even more scientific methods. The fact had become generally known that Trenton rock in the oil field was at a depth of about one thousand feet, and this fact formed the basis for work.

Then exploitation began in other parts of the State and in other formations than the Trenton, drillers and operators sought information as to stratagraphic and structural relations of formations, sea level datum, and the geologic conditions governing the accumulation of gas and oil.

For more than a quarter of a century it had been an established fact that the following conditions governing the accumulation of gas and oil must exist:

1. A porous reservoir (formation) to hold the gas and oil.
2. An impervious cover (usually shale) above to hold gas or oil.
3. An anticline, dome, or pool as a reservoir.
4. A force, or pressure, behind the oil or gas to force them into the reservoir, or out of it through the drill hole or well.

After the decline of gas and oil in the old Trenton field, the four conditions mentioned above were sought with renewed emphasis in new fields, such as Princeton, Oakland City, Lyons, and later Sullivan County.

Although sufficient data have not been gathered to establish the existence of anticlines or even domes in the above mentioned fields, there is no doubt of the existence of the first, second and fourth conditions enumerated above. It is possible for oil or gas to exist in a formation without an anticline or dome, but it is not possible for it to exist without (1) a porous reservoir, and (2) an impervious cover, and (3) pressure behind the oil and gas.

Since the oil and gas in the Sullivan field occur in pools of the Huron limestone and sandstone, the above conditions of accumulation, confinement and pressure must exist.

Areally the Sullivan County, Indiana, oil and gas field is wholly within the Pennsylvania system or Carboniferous system of rocks. Sullivan County lies on the extreme eastern margin of the great interior coal basin, which extends throughout southwestern Indiana, eastern Kentucky and southern Illinois.

The oil and gas are doubtless found in the Huron formation, which consists of limestones and sandstones. The Huron is the topmost member of the Mississippi system of rocks, and lies just below the Mansfield sandstone, the basal member of the Carboniferous or coal measures. The oil and gas in the Princeton field and the Oakland City field to the south are doubtless from the same formation.

The Huron of Indiana is correlated with the Kirkwood sand of Lawrence County, Illinois. According to the Illinois Geological Survey, the Kirkwood sand is the most widespread producing horizon in Illinois, as well as in Lawrence County. The Kirkwood sand in Illinois "shows excellent initial production and long continued yield, and is the most reliable of all sands." It is barely possible that some of the oil and gas of Sullivan County comes from the lower portion of the Mansfield sandstone.

It is a well-known fact by drillers, operators and geologists that in the absence of anticlines or domes for the accumulation of oil and gas that such accumulation occurs in pools, and it seems that this is the prevailing condition in the Sullivan field. By pools, we do not mean recesses or caverns filled with oil, in the limestone or sandstone. The expression is used simply to express variation in the structure of a formation. Oil and gas occupy space like any other matter. There are variations in the structure of limestone and sandstone, some being of a fine, close-grained character, and others being of the loose and friable character. In other words, the spaces or interstices among the particles in some

sandstones and limestones are larger than others. Hence the accumulation of oil or gas would be in the portions of the formation where the spaces between the particles of sand were the largest. Little or no oil or gas would accumulate in the close-grained portion, and this part of the formation might form in a manner a partition between different pools. If the driller puts down a well that strikes one of these pools, the chances are that oil or gas will be found. If the drill happens to strike between the pools in the close-grained part of the formation, a dry hole will be the result. These so-called pools may vary in size and form according to the structure of the formation in which they occur.

The State Geologist at the present writing, in the absence of sufficient data to establish an anticline or any portion of an anticline in Sullivan County, believes that the oil and gas occur as described above.

From the time of the earliest activity in oil and gas in other parts of the State, more or less prospecting and wildcatting was done in Sullivan County, but it was not until the middle of the year 1913 that wells of sufficient production were found in the county to justify liberal prices for leases and liberal investment in oil properties.

In October, 1913, the State Geologist with two assistants ran a line of levels from the north end of Sullivan County southward through the productive territory, almost to the south boundary of the county. Many operators have taken advantage of the levels thus run to estimate the probable depth of pay sand in territory on either side of the line. The Department of Geology never before had undertaken work of this kind, so far as the writer has any knowledge. In the Twenty-fifth Annual Report of the Department of Geology, the following statements are made concerning the importance of surface levels, pages 485 and 486. The statements made are applied to the Trenton rock in the old oil and gas field, but they are equally true of the pay sand in Sullivan County.

"*Necessity of Accurate Surface Levels.*—Where a bore for petroleum has resulted in a good producing well, the level of the surface of the Trenton rock below tide should be carefully ascertained. This can be done only by running a transit level from the nearest point where the surface level is known, usually on a railway, to the surface of the bore. By subtracting the surface level of the bore from the depth at which Trenton limestone is first

struck, the surface level of the latter will be obtained. In but few places in the State is Trenton found above sea level. Where so found the depth to Trenton will be less than the surface level of the bore, and should be subtracted accordingly.

"The location of the first dozen or more wells in any area a mile or two square must of necessity be largely a matter of guess work, but if the surface level of the Trenton in each bore, productive or dry, be carefully ascertained, the trend of the anticline and the approximate limits of the field or pool can be soon determined. Too much guesswork concerning the surface level of the spot on which the well is located has been done in the past. In a broken country it is difficult for any man to guess approximately at the relative levels of two points a quarter of a mile apart, and the new level should always be ascertained with instruments. Of course the surface level of the bore has nothing to do with the absolute height or surface level of the Trenton, or the absence or presence of the petroleum, but it has a great deal to do with the accurate determination of the surface level of the Trenton, and therefore with the location of future wells. If a few thousand dollars had been spent in Indiana in past days in the careful determination of surface levels, it would have saved a few hundred thousand which have been sunk in dry holes."

The altitude indicated by a bench mark located at the northwest corner of the court house yard Sullivan, Indiana, by the U. S. Geological Survey was taken as the initial datum. From this altitude a transit level was run to a point at the southeast corner of Turman Township, elevation 531.09. This altitude was taken as the datum for the line of elevations running north to the northern boundary of Sullivan County and south to the southern boundary. Few if any of the producing wells of Sullivan County are less than 600 feet deep; therefore the productive sand is below sea level. Other altitudes established are as follows, running north from the above mentioned point:

Stone at intersection of S. Graysville road with N. and S. township line at base of gatepost on S. side of road. Post marked I. G. S. (Indiana Geological Survey) 537.68 Stone. Section 30, Hamilton Township, S. W. corner.

B. M. 1 miles from B. M. No. N. 3. Oak tree W. of S. W. corner red barn E. side of road. Marked I. G. S. 520.91. Section 19, Hamilton Township, S. W. corner.

Corner fence post on township fence line N. side of N. Grays-

ville road marked with nails I. G. S. 518.85. Sec. 18, Hamilton Township, S. W. corner.

Stone 3 rods 3 feet N. of section stone on township line in line with E. and W. fence line to the E. 500 feet. Sec. and S. L. stones between two locust trees. Marked I. G. S. 525.63. Sec. 10, Hamilton Township, N. W. corner.

Section stone N. W. corner Sec. 7. S. side of fence on south side of road on G. W. Osborne's farm. Marked I. G. S. 529.24. N. W. corner Sec. 7, Hamilton Township.

Beech tree blazed on E. side, N. W. corner of Hamilton Township and of W. T. Dix farm. S. side of E. and W. road. Marked I. G. S. 483.34. N. W. corner Sec. 6, Hamilton Township.

Corner fence post N. side of E. and W. road, W. side of N. and S. township line road. Marked on E. side of post I. G. S. 518.87. S. E. corner Sec. 25, Fairbanks Township.

Maple tree 15 feet E. of N. E. corner of iron bridge on township line road and Turman Creek. Tree blazed on W. side I. G. S. 478.28. S. W. corner Sec. 19, Curry Township.

Fence post 15 feet W. of Sec. stone W. side of township line road. Marked I. G. S. 526.07. N. E. corner Sec. 24, Fairbanks Township.

Fence post at N. W. corner Sec. 18 Curry Township. S. side of E. and W. North boundary road of Sec. 18 and on E. side of township line road. Marked I. G. S. 532.15. N. W. corner Sec. 18, Curry Township.

Levels from S. E. corner of Turman Township south to county line along township fence line.

Brown pebble in concrete base of and on N. W. side of corner fence post at intersection of S. line of Sec. 1, Gill Township and township line. Post marked I. G. S. 527.70. S. E. corner Sec. 1, Gill township.

Concrete base on S. E. side of corner post at intersection of township line with S. line of Sec. 7, Hamilton Township, N. side of E. and W. road. Concrete marked I. G. S. 516.99. S. W. corner Sec. 7, Hamilton Township.

Stone at S. W. corner of Hamilton Township, 1 foot south of corner fence post N. side of road. Marked I. G. S. 501.46 S. W. corner Sec. 18, Hamilton Township.

Cedar post 9 feet W. of corner stone at S. E. corner of Section 24, Gill Township. Marked on S. E. side I. G. S. 480.82. S. E. corner Sec. 24, Gill Township.

Oak tree half way between ½ Sec. line E. and W. and N. Sec. line E. and W. of Sec. 31 and 400 feet E. of W. N. and S. Sec. line of Sec. 31, Gill Township. Tree 25 feet W. of S. W. corner of house. Marked I. G. S. 468.07. W. middle Sec. 31, Gill Township. Post end of N. and S. fence on S. side of dividing E. and W. road between Gill and Haddon townships, .25 mile E. of township line. Marked I. G. S. 468.07. N. W. quarter Sec. 6, Haddon Township.

Oak tree 45 feet S. of E. and W. road at point where it jogs N. road is E. and W. half section line of Sec. 12, Gill Township. Tree at intersection of ½ section line and township line. Tree blazed upon root on N. side. I. G. S. 443.72. E. center Sec. 12, Gill Township.

Cornerstone S. E. corner Sec. 13, Gill Township. E. side of E. and W. road at point of jog N. at township line. Marked 435.89 I. G. S. S. E. corner Sec. 13, Gill Township.

S. W. pier of bridge across Busseron Creek ½ mile S. of E. and W. township dividing line on S. side of Gill, dividing Gill and Haddon. Road across bridge is E. boundary of Sec. 26, Haddon Township. E. center Sec. 26, Haddon Township. Reading at top of pier: 427.45.

ELEVATIONS ON THE EVANSVILLE AND TERRE HAUTE RAILROAD IN SULLIVAN COUNTY, NORTH AND SOUTH OF SULLIVAN.

North.

Sullivan	539.0
Union Mine	512.0
Mildred Mine	516.0
Shelburn	541.0
Standard	559.0

South.

Sullivan	539.0
Paxton	489.0
Carlisle	482.0
Bellevue Mine	464.0

The elevations and bench marks established by the Indiana Geological Survey in 1913 mentioned above show a difference of approximately 100 feet in the surface elevation from the north end of the county to the south end. The difference in elevation along the Evansville and Terre Haute Railroad from the north

end of the county to the south is approximately 100 feet. These figures are important only in showing the surface slope of the county to the southwest but it is a strange coincidence that the pay sand along the line of levels established by the Indiana Geological Survey is found, as a rule, deeper as we go southward. Pay sand is found in Curry Township in the north at 560 feet; in Gill Township in the south it is found at 940 feet. These figures show a violent dip of the pay sands to the southwest.

This difference in depth at which pay sand is found in the north and south ends of the county can hardly be accounted for on the ground that the drill probably penetrated the sand to greater depth in the wells in the south end of the county than in the wells in the north end. The figures do not necessarily show that the wells are located on the slope of an anticline nor on the side of a dome. We have just as good reason to say that the figures show that the "pools" mentioned above are found at different depths.

Herewith, are submitted a list of well records showing varying depths of pay sand, and the different formations encountered in reaching it.

The principal operating companies are the Ohio Oil Co., W. T. Kennedy & Co., Henderson & Snyder, Riggs & Oliphant, Bays Bros., Hamilton Oil and Gas Co., E. R. T. Producing Co., James Crawford Co., T. Colt Co.

Record of well drilled on J. Hoesman farm, N. E. ¼ N. E. ¼, Sec. 20, Gill Township, Sullivan County. Drilled by John T. Hays, S. A. White and J. R. Riggs, and others, 1904:

PIPE RECORD.

10-inch drive pipe	78 feet
8¼-inch drive pipe	250 feet
6¼-inch drive pipe	610 feet

Coal	230 to 235 feet
Coal No. 7	285 to 290 feet
Gas sand	375 to 385 feet
Gas sand	470 to 475 feet
Salt water sand	540 to 560 feet
Salt water sand	630 to 650 feet
Shale	650 to 660 feet
Coal	660 to 663 feet
Shale	750 to 820 feet
Sand, showing oil	820 to 869 feet
Shale	869 to 900 feet
Salt water sand	900 to 905 feet

Total depth of hole, 905 feet.

Record of well drilled on J. Hoesman farm, N. E. corner S. E. ¼, Sec. 9, Gill Township, Sullivan County. Drilled by Fred Boden, 1906:

PIPE RECORD.

10-inch drive pipe	45 feet	
8¼-inch drive pipe	410 feet	
6¼-inch drive pipe	920 feet	
Coal	210 to	215 feet
Gas shale		460 feet
Salt water sand	595 to	630 feet
Oil and gas sand	745 to	760 feet
Shale	760 to	820 feet
Salt water sand	820 to	905 feet
Shale	905 to	1,100 feet
Sand	1,100 to	1,120 feet
Shale	1,120 to	1,202 feet

Total depth, 1,202 feet.

This well was ruined by shot and failure to get water cased off. Well showed to be about a ten-barrel well.

N. W. corner N. E. ¼, Sec. 8, Township 8 north, range 10 west, Turman Township. Drillings by Dodd Bridge:

Rock		26 feet
Shale	26 to	70 feet
Sand	70 to	80 feet
Shale	80 to	255 feet
Coal (5 feet of coal)	255 to	260 feet
Shale	260 to	305 feet
Coal	305 to	310 feet
Limestone	310 to	340 feet
Shale	340 to	510 feet
Sand	510 to	570 feet
Shale	570 to	585 feet
Sand (quick or water sand)	585 to	680 feet
Sand	680 to	690 feet
Shale	690 to	910 feet
Salt sand	910 to	960 feet
Shale	960 to	965 feet
Black sand	965 to	985 feet
White sand	985 to	1,090 feet
Shale	1,090 to	1,110 feet
St. Mary's sand or pay sand	1,110 to	1,130 feet
Black slate	1,130 to	1,140 feet
Blue sand	1,140 to	1,210 feet
Limestone	1,210 to	1,230 feet
Black slate	1,230 to	1,270 feet
Gray sand	1,270 to	1,290 feet
Limestone	1,290 to	1,460 feet
Brown oil sand	1,460 to	1,475 feet
Limestone	1,475 to	1,585 feet
Blue Lick sand	1,585 to	1,762 feet

Record of bore drilled on Simpson Edward's farm, N. ½ N. ½ S. W. ¼, Sec. 10, Gill Township, Sullivan County. Drilled by E. R. Riggs, 1911:

PIPE RECORD.

10-inch drive pipe	25 feet
8¼-inch drive pipe	360 feet
6¼-inch drive pipe	728 feet

Coal No. 8	90 to	93 feet
Coal No. 6	330 to	333 feet
Sand, some gas	470 to	555 feet
Sand, showing oil	500 to	515 feet
Shale	555 to	570 feet
Sandy, gritty shale	570 to	585 feet
Coal No. 3	585 to	590 feet
Shale	590 to	605 feet
Coal	605 to	610 feet
Shale	610 to	625 feet
Sandy shale	625 to	640 feet
Shale	640 to	670 feet
Salt water sand	670 to	690 feet
Shale	690 to	722 feet
Sand	722 to	726 feet
Shale	726 to	771 feet
Oil sand	771 to	780 feet
Shale	780 to	782 feet

Total depth, 782 feet.

Shot forty (40) quarts. Well started off at twenty (20) barrels per day. Now running two (2) barrels.

There are three producing wells on this farm and one dry hole.

Record of bore sunk on J. Hoesman farm, N. E. ¼ S. E. ¼, Sec. 9, Gill Township, Sullivan County. Drilled by E. R. Riggs, 1911:

PIPE RECORD.

10-inch drive pipe	28 feet
8¼-inch drive pipe	451 feet
6¼-inch drive pipe	720 feet

Drift	4 feet	
Loose sand and gravel	24 feet	28 feet
White shale	42 feet	70 feet
Sand, fresh water	35 feet	105 feet
Coal No. 8	2 feet	107 feet
Shale	93 feet	200 feet
Limestone	12 feet	212 feet
Shale	8 feet	220 feet
Limestone	8 feet	228 feet
Shale	32 feet	260 feet
Soft limestone	20 feet	280 feet
Shale	55 feet	335 feet
Coal No. 6	3 feet	338 feet

Shale	82 feet	420 feet
Coal No. 5	1 foot	421 feet
Shale	64 feet	485 feet
Sand, dry	7 feet	492 feet
Brown shale	128 feet	620 feet
Salt sand, water	10 feet	630 feet
Shale	40 feet	670 feet
Salt sand, water	25 feet	695 feet
Brown shale	72½ feet	767½ feet
Sand, broken, showing oil	14½ feet	782 feet
Shale	99 feet	791 feet
Shale	14 feet	805 feet

Total, 805 feet.

Shot twenty (20) quarts, well showing about two (2) barrels.

Record of well drilled on J. B. Kaufman farm, N. E. corner Sec. 16, Gill Township, Sullivan County. Drilled January, 1912, by E. R. Riggs:

PIPE RECORD.

10-inch drive pipe	45 feet
8¼-inch drive pipe	350 feet
6¼-inch drive pipe	740 feet

Coal No. 8	110 to 117 feet
Coal No. 6	340 to 346 feet
Gas sand	385 to 395 feet
Sand	475 to 495 feet
Shale	495 to 625 feet
Sand	625 to 645 feet
Shale	645 to 665 feet
Salt water sand	665 to 690 feet
Shale	690 to 770 feet
Dry sand	770 to 777 feet
Shale	777 to 822 feet
Sand showing oil	822 to 826 feet
Shale	826 to 830 feet
Sand showing oil	830 to 835 feet
Shale	835 to 837 feet
Sand showing oil	837 to 842 feet
Shale	842 to 844 feet
Salt water sand	844 to 851 feet

Total depth of well, 851 feet.

Possibly would have made five (5) barrel well with shot.

Record of well drilled on Anderson farm, S. E. corner Sec. 28, Gill Township, Sullivan County. Well drilled by Burton Bros. and E. R. Riggs, 1912:

PIPE RECORD.

10-inch drive pipe	65 feet
8¼-inch drive pipe	265 feet
6¼-inch drive pipe	730 feet

Gravel	65 feet
Coal	235 to 236 feet
Coal No. 7	285 to 290 feet
Coal No. 6	340 to 346 feet
Sand, 300,000 feet.	
Gas	350 to 362 feet
Shale	362 to 570 feet
Salt water sand	570 to 670 feet
Shale	670 to 695 feet
Coal	695 to 697 feet
Shale	697 to 720 feet
Lime	720 to 728 feet
Shale	728 to 760 feet
Sand, dry	760 to 790 feet
Black shale	790 to 864 feet
Lime	864 to 866 feet
Sand, dry	866 to 871 feet
Shale	871 to 874 feet
Dry sand	874 to 890 feet
Shale	890 to 935 feet
Sand, salt water	935 to 944 feet

Total depth of hole, 944 feet.

WELL No. 1.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 200 feet from E. line.

Contractor, W. T. Erdman.
Commenced drilling August 22, 1913.
Completed drilling August 30, 1913.
Casing, 565 feet of 6¼ inch.
Top sand, 612 feet.
Best oil, 620 feet.
Total depth, 630 feet.
First 24 hours production, 150 barrels.
Second 24 hours production, 125 barrels.

WELL No. 2.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 580 feet from S. line, 200 feet from E. line.

Contractor, S. V. Cawley.
Commenced drilling August 22, 1913.
Completed drilling August 29, 1913.
Casing, 560 feet of 6¼ inch.
Top sand, 606 feet.
Best oil, 615 feet.
Total depth, 625 feet.
First 24 hours production, 250 barrels.
Second 24 hours production, 200 barrels.

Record of bore drilled on Beard farm, N. E. corner S. E. ¼ N. W. ¼, Sec. 1, Turman Township, Sullivan County. Well No. 1 drilled by J. R. Riggs, E. R. Riggs, Fred F. Bays and Lee Bays, September, 1913:

PIPE RECORD.

10-inch drive pipe	25 feet
8¼-inch drive pipe	145 feet
6¼-inch drive pipe	505 feet
Coal No. 7	60 to 62 feet
Coal No. 6	120 to 126 feet
Coal	171 to 172 feet
Coal No. 4	262 to 266 feet
Sand	293 to 400 feet
1,000,000 feet gas	300 to 320 feet
Water	320 to 360 feet
Shale	400 to 450 feet
Coal No. 3	450 to 452 feet
Firestone	452 to 457 feet
Shale	457 to 483 feet
Coal	483 to 488 feet
Shale	488 to 502 feet
Lime	502 to 525 feet
Shale	525 to 549 feet
Hard sand	549 to 550 feet
Gas sand	550 to 560 feet

4,000,000 feet gas.
290-pound rock pressure.
Total depth, 560 feet.

This well is one-half (½) mile in advance to west of Shelburn pool.

No. 6 ranges 150 to 200 in pool and is 40 to 100 feet deeper, one to two miles away in every direction from pool.

Pay sand in majority of Shelburn pool weels is found from 595 to 650 feet.

WELL No. 4.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 660 feet from E. line.

Contractor, F. F. Williams.
Commenced drilling September 11, 1913.
Completed drilling September 20, 1913.
Casing, 560 feet of 6¼ inch.
Top sand, 607 feet.
Best oil, 615 feet.
Total depth, 629 feet.
First 24 hours production, 200 barrels.
Second 24 hours production, 150 barrels.

Record of well drilled on Sanders farm by the Hamilton Gas and Oil Company. Sec. 31, Hamilton Township, Sullivan County. No. 4 well completed September 24, 1913.

PIPE RECORD.

10-inch drive pipe	30 feet
8¼-inch drive pipe	300 feet
6¼-inch drive pipe	716 feet
Coal No. 6	260 feet
Sand showing oil	480 to 500 feet
First pay sand	743 to 751 feet
Second pay sand	661 to 671 feet

Shot each day with forty (40) quarts. Pumped ninety (90) barrels first twenty-four hours.

WELL No. 1.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 200 feet from N. line, 200 feet from E. line.

Contractor, Claude Hoover.
Commenced drilling September 21, 1913.
Completed drilling October 4, 1913.
Casing, 573 feet of 6¼ inch.
Top sand, 606 feet.
Best oil, 612 feet.
Total depth, 650½ feet.
First 24 hours production, 200 barrels.
Second 24 hours production, 45 barrels.

WELL No. 3.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 275 feet from E. line, 200 feet from N. line.

Contractor, W. T. Erdman.
Commenced drilling September 25, 1913.
Completed drilling October 9, 1913.
Casing, 560 feet of 6¼ inch.
Top sand, 611 feet.
Best oil, 615 feet.
Total depth, 637½ feet.
First 24 hours production, 200 barrels.
Second 24 hours production, 200 barrels.

WELL No. 5.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 200 feet from W. line.

Contractor, F. F. Williams.
Commenced drilling October 2, 1913.
Completed drilling October 15, 1913.
Casing, 560 feet of 6¼ inch.

Top sand, 610 feet.
Best oil, 620 feet.
Total depth, 660 feet.
First 24 hours production, 350 barrels.
Second 24 hours production, 200 barrels.

WELL No. 6.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 660 feet from S. line, 660 feet from E. line.

Contractor, F. F. Williams.
Commenced drilling October 9, 1913.
Completed drilling October 18, 1913.
Casing, 570 feet of 6¼ inch.
Top sand, 615 feet.
Best oil, 620 feet.
Total depth, 650 feet.
First 24 hours production, 350 barrels.
Second 24 hours production, 150 barrels.

WELL No. 4.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 1,120 feet from N. line, 200 feet from E. line.

Contractor, Fred Ward.
Commenced drilling October 16, 1913.
Completed drilling November 3, 1913.
Casing 606 feet of 6¼ inch.
Top sand, 610 feet.
Best oil, 643 feet.
Total depth, 676 feet.
First 24 hours production, 170 barrels.
Second 24 hours production, 85 barrels.

WELL No. 2.

Farm of M. J. Beard, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from E. line, 200 feet from S. line.

Contractor, Claude Hoover.
Commenced drilling October 10, 1913.
Completed drilling November 7, 1913.
Casing, 564 feet of 6¼ inch.
Top sand, 617 feet.
Best oil, 623 feet.
Total depth, 647 feet.
First 24 hours production, 210 barrels.
Second 24 hours production, 160 barrels.

WELL No. 7.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 660 feet from E. line, 200 feet from N. line.

Contractor, W. T. Erdman.
Commenced drilling October 22, 1913.
Completed drilling November 4, 1913.
Casing, 600 feet of 6¼ inch.
Top sand, 626 feet.
Best oil, 640 feet.
Total depth, 659 feet.
First 24 hours production, 200 barrels.
Second 24 hours production, 150 barrels.

WELL No. 8.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from N. line, 200 feet from W. line.

Contractor, F. F. Williams.
Commenced drilling October 25, 1913.
Completed drilling November 7, 1913.
Casing, 575 feet of 6¼ inch.
Top sand, 624 feet.
Best oil, 625 feet.
Total depth, 650 feet.
First 24 hours production, 185 barrels.
Second 24 hours production, 125 barrels.

WELL No. 1.

Farm of W. W. Harris, Sec. 1, Turman Township, Sullivan County, 200 feet from N. line, 200 feet from E. line.

Contractor, J. M. Huggins.
Commenced drilling November 5, 1913.
Completed drilling November 24, 1913.
Casing, 560 feet of 6½ inch.
Top sand, 656 feet.
Best oil, 668 feet.
Total depth, 733 feet.
First 24 hours production, 45 barrels.
Second 24 hours production, 15 barrels.

WELL No. 5.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 1,200 feet from N. line, 200 feet from E. line.

Contractor, F. F. Williams.
Commenced drilling November 12, 1913.
Completed drilling November 22, 1913.
Casing 556 feet of 6¼ inch.

Top sand, 608 feet.
Best oil, 675 feet.
Total depth, 705 feet.
First 24 hours production, 35 barrels.
Second 24 hours production, 20 barrels.

WELL No. 6.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 200 feet from E. line, 200 feet from S. line.

Contractor, Fred Ward.
Commenced drilling November 20, 1913.
Completed drilling December 5, 1913.
Casing, 583 feet of 6½ inch.
Top sand, 631 feet.
Best oil, 645 feet.
Total depth, 671 feet.
First 24 hours production, 75 barrels.
Second 24 hours production, 35 barrels.

WELL No. 2.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 200 feet from N. line, 200 feet from E. line.

Contractor, Fred Ward.
Commenced drilling December 11, 1913.
Completed drilling January 1, 1914.
Casing, 614 feet of 6¼ inch.
Top sand, 646 feet.
Best oil, 655 feet.
Total depth, 687 feet.
First 24 hours production, 150 barrels.
Second 24 hours production, 120 barrels.

WELL No. 1.

Farm of C. E. Merrill, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 200 feet from W. line.

Contractor, H. Heim.
Commenced drilling December 31, 1913.
Completed drilling January 9, 1914.
Casing, 566 feet of 6½ inch.
Top sand, 663 feet.
Best oil, 670 feet.
Total depth, 678 feet.
First 24 hours production, 70 barrels.
Second 24 hours production, 50 barrels.

WELL No. 7.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 200 feet from E. line, 970 feet from S. line.

Contractor, F. F. Williams.
Commenced drilling December 10, 1913.
Completed drilling January 5, 1914.
Casing, 568 feet of 6¼ inch.
Top sand, 630 feet.
Best oil, 631 feet.
Total depth, 673 feet.
First 24 hours production, 110 barrels.
Second 24 hours production, 80 barrels.

WELL No. 2.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 1,120 feet from S. line, 200 feet from W. line.

Contractor, Lawrence Henderhan.
Commenced drilling December 13, 1913.
Completed drilling January 7, 1914.
Casing, 105 feet of 6¼ inch.
Top sand, 632 feet.
Best oil, 632 feet.
Total depth, 676 feet.
First 24 hours production, 80 barrels.
Second 24 hours production, 60 barrels.

WELL No. 1.

Farm of S. A. Merrill, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from N. line, 200 feet from W. line.

Contractor, Sam Shearard.
Commenced drilling January 26, 1914.
Completed drilling March 6, 1914.
Casing, 592 feet of 6¼ inch.
Six feet coal at 205 feet.
Three feet coal at 320 feet.
Two feet coal at 540 feet.
Top sand, 709 feet.
Best oil, 709 feet.
Total depth, 718½ feet.
First 24 hours production, 50 barrels.
Second 24 hours production, 30 barrels.

WELL No. 5.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 125 feet from E. line, 386 feet from N. line.

Contractor, Fred Ward.
Commenced drilling January 30, 1914.

Completed drilling February 11, 1914.
Casing, 580½ feet of 6¼ inch.
Five feet of coal at 150 feet.
Five feet of coal at 315 feet.
Three feet of coal at 540 feet.
Top sand, 637 feet.
Best oil, 639 feet.
Total depth, 679 feet.
First 24 hours production, 160 barrels.
Second 24 hours production, 145 barrels.

WELL No. 4.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 660 feet from N. line, 200 feet from E. line.

Contractor, Fred Ward.
Commenced drilling January 14, 1914.
Completed drilling January 23, 1914.
Casing, 575 feet of 6¼ inch.
Two feet of coal at 150 feet.
Three feet of coal at 195 feet.
Five feet of coal at 315 feet.
Five feet of coal at 430 feet.
Three feet of coal at 510 feet.
Top sand, 638 feet.
Best oil, 638 feet.
Total depth, 679 feet.
First 24 hours production, 140 barrels.
Second 24 hours production, 120 barrels.

WELL No. 9.

Farm of Josephine Dix, Sec. 1, Turman Township, Sullivan County, 553 feet from S. line, 195 feet from E. line.

Contractor, F. F. Williams.
Commenced drilling January 20, 1914.
Completed drilling February 3, 1914.
Casing, 575 feet of 6¼ inch.
Five feet coal at 225 feet.
Five feet coal at 460 feet.
Four feet coal at 565 feet.
Top sand, 626 feet.
Best oil, 626 feet.
Total depth, 640 feet.
First 24 hours production, 125 barrels.
Second 24 hours production, 80 barrels.

WELL No. 2.

Farm of C. E. Merrill, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 510 feet from W. line.

Contractor, H. Heim & Co.
Commenced drilling March 2, 1914.
Completed drilling March 19, 1914.
Casing, 595 feet of 6¼ inch.
Top sand, 660 feet.
Best oil, 665 feet.
Total depth, 680 feet.
First 24 hours production, 130 barrels.
Second 24 hours production, 120 barrels.

WELL No. 1.

Farm of H. H. Burton, Sec. 28, Turman Township, Sullivan County, 365 feet from E. line, 200 feet from S. line.

Contractor, H. H. Adkins.
Commenced drilling January 15, 1914.
Completed drilling January 28, 1914.
Casing, 720 feet of 6½ inch.
Top sand, 800 feet.
Best oil, 818 feet.
Total depth, 837 feet.
First 24 hours production, 75 barrels.
Second 24 hours production, 25 barrrels.

WELL No. 6.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 200 feet from E. line, 200 feet from S. line.

Contractor, Frank Breech.
Commenced drilling February 27, 1914.
Completed drilling March 6, 1914.
Casing, 544 feet of 6¼ inch.
Four feet coal at 110 feet.
Five feet coal at 205 feet.
Six feet coal at 520 feet.
Top sand, 640 feet.
Best oil, 640 feet.
Total depth, 691½ feet.
First 24 hours production, 200 barrels.
Second 24 hours production, 175 barrels.

WELL No. 7.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 460 feet from S. line, 200 feet from W. line.

Contractor, Frank Branderberry.
Commenced drilling February 26, 1914.
Completed drilling March 2, 1914.
Casing, 560 feet of 6¼ inch.
Top sand, 630 feet.
Best oil, 635 feet.
Total depth, 683 feet.
First 24 hours production, 80 barrels.
Second 24 hours production, 60 barrels.

WELL No. 8.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 200 feet from N. line, 1,120 feet from E. line.

Contractor, Jesse Huggins.
Commenced drilling February 24, 1914.
Completed drilling March 4, 1914.
Casing, 545 feet of 6¼ inch.
Top sand, 648 feet.
Best oil, 648 feet.
Total depth, 683 feet.
First 24 hours production, 40 barrels.
Second 24 hours production, 35 barrels.

WELL No. 2.

Farm of Emma Scott, Sec. 36, Turman Township, Sullivan County, 200 feet from N. line, 710 feet from E. line.

Contractor, Smith and Williams.
Commenced drilling February 14, 1914.
Completed drilling March 4, 1914.
Casing, 700 feet of 6¼ inch.
Coal 95 to 100 feet.
Coal 285 to 290 feet.
Coal 330 to 335 feet.
Coal 440 to 445 feet.
Coal 560 to 565 feet.
Coal 680 to 684 feet.
Top sand, 754 feet.
Best oil, 660 feet.
Total depth, 794 feet.
First 24 hours production, 85 barrels.
Second 24 hours production, 72 barrels.

WELL No. 4.

Farm of Alex Raley, Sec. 33, Turman Township, Sullivan County, 155 feet from E. line, 1,085 feet from S. line.

Contractor, F. E. Branderberry.
Commenced drilling February 26, 1914.
Completed drilling March 9, 1914.
Casing, 719 feet of 6¼ inch.
Coal 85 to 90 feet.
Coal 270 to 275 feet.
Coal 330 to 334 feet.
Coal 580 to 585 feet.
Coal 629 to 635 feet.
Top sand, 737 feet.
Best oil, 740 feet.
Total depth, 761 feet.
First 24 hours production, 95 barrels.
Second 24 hours production, 50 barrels.

WELL No. 9.

Farm of H. Heim, Sec. 36, Fairbanks Township, Sullivan County, 660 feet from S. line, 200 feet from W. line.

Contractor, F. F. Williams.
Commenced drilling March 12, 1914.
Completed drilling March 22, 1914.
Casing, 580 feet of 6¼ inch.
Five feet coal at 180 feet.
Five feet coal at 440 feet.
Three feet coal at 500 feet.
Top sand, 450 feet.
Best oil, 618 feet.
Total depth, 650 feet.
First 24 hours production, 60 barrels.
Second 24 hours production, 50 barrels.

WELL No. 3.

Farm of Emma Scott, Sec. 36, Turman Township, Sullivan County, 200 feet from N. line, 1,120 feet from E. line.

Contractors, Smith & Williams.
Commenced drilling March 11, 1914.
Completed drilling March 21, 1914.
Casing, 730 feet of 6¼ inch.
Coal 110 to 115 feet.
Coal 280 to 285 feet.
Coal 340 to 346 feet.
Coal 580 to 586 feet.
Top sand, 768 feet.
Best oil, 775 feet.
Total depth, 790 feet.
First 24 hours production, 75 barrels.
Second 24 hours production, 50 barrels.

WELL No. 4.

Farm of J. V. Merrill, Sec. 35, Fairbanks Township, Sullivan County, 200 feet from E. line, 1,080 feet from S. line.

Contractor, Lawrence Henderhan.
Commenced drilling March 12, 1914.
Completed drilling, March 23, 1914.
Casing, 596 feet of 6¼ inch.
Coal 70 to 73 feet.
Coal 175 to 180 feet.
Coal 225 to 228 feet.
Top sand, 658 feet.
Best oil, 660 feet.
Total depth, 670 feet.
First 24 hours production, 125 barrels.
Second 24 hours production, 120 barrels.

WELL No. 10.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 660 feet from E. line, 200 feet from S. line.

Contractor, Frank Breech.
Commenced drilling, March 14, 1914.
Completed drilling March 25, 1914.
Casing, 608 feet of 6¼ inch.
Coal 110 to 113 feet.
Coal 150 to 154 feet.
Coal 280 to 287 feet.
Coal 512 to 521 feet.
Top sand, 645 feet.
Best oil, 650 feet.
Total depth, 690 feet.
First 24 hours production, 40 barrels.
Second 24 hours production, 30 barrels.

WELL No. 3.

Farm of C. E. Merrill, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from S. line, 810 feet from W. line.

Contractor, Heim Drilling Company.
Commenced drilling March 26, 1914.
Completed drilling April 17, 1914.
Casing, 610 feet of 6¼ inch.
Coal 175 to 180 feet.
Coal 226 to 230 feet.
Coal 425 to 427 feet
Top sand, 661 feet.
Best oil, 661 feet.
Total depth, 685 feet.
First 24 hours production, 60 barrels.
Second 24 hours production, 50 barrels.

WELL No. 8.

Farm of Alex. Raley, Sec. 33, Turman Township, Sullivan County, 1,685 feet from S. line, 600 feet from W. line.

Contractor, F. E. Branderberry.
Commenced drilling March 24, 1914.
Completed drilling April 2, 1914.
Casing, 720 feet of 6¼ inch.
Coal 36 to 365 feet.
Coal 600 to 605 feet.
Coal 635 to 640 feet.
Top sand, 767 feet.
Best oil, 768 feet.
Total depth, 784 feet.
First 24 hours production, 100 barrels.
Second 24 hours production, 80 barrels.

WELL No. 4.

Farm of Emma Scott, Sec. 36, Turman Township, Sullivan County, 660 feet from N. line, 660 feet from E. line.

Contractor, H. H. Greenlee.
Commenced drilling April 14, 1914.
Completed drilling April 23, 1914.
Casing, 725 feet of 6¼ inch.
Coal 110 to 115 feet.
Coal 282 to 287 feet.
Coal 342 to 348 feet.
Coal 582 to 588 feet.
Top sand, 763 feet.
Best oil, 775 feet.
Total depth, 787 feet.
First 24 hours production, 70 barrels.
Second 24 hours production, 40 barrels.

WELL No. 5.

Farm of M. J. Beard, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from E. line, 660 feet from S. line.

Contractor, F. F. Williams.
Commenced drilling March 30, 1914.
Completed drilling April 15, 1914.
Casing, 592 feet of 6¼ inch.
Coal 215 to 220 feet.
Coal 310 to 314 feet.
Coal 450 to 455 feet.
Top sand, 629 feet.
Best oil, 629 feet.
Total depth, 668 feet.
First 24 hours production, 60 barrels.
Second 24 hours production, 50 barrels.

WELL No. 2.

Farm of E. T. Osborne, Sec. 1, Turman Township, Sullivan County, 200 feet from N. line, 660 feet from E. line.

Contractor, F. E. Branderberry.
Commenced drilling April 8, 1914.
Completed drilling April 15, 1914.
Casing, 589 feet of 6¼ inch.
Coal 172 to 178 feet.
Coal 300 to 305 feet.
Coal 460 to 465 feet.
Top sand, 665 feet.
Best oil, 666 feet.
Total depth, 742 feet.
First 24 hours production, 40 barrels.
Second 24 hours production, 25 barrels.

WELL No. 5.

Farm of J. V. Merrill, Sec. 35, Fairbanks Township, Sullivan County, 200 feet from E. line, 660 feet from S. line.

Contractor, Lawrence Henderhan.
Commenced drilling March 30, 1914.
Completed drilling, April 10, 1914.
Casing, 590 feet of 6¼ inch.
Coal 70 to 74 feet.
Coal 170 to 175 feet.
Top sand, 645 feet.
Best oil, 645 feet.
Total depth, 666 feet.
First 24 hours production, 140 barrels.
Second 24 hours production, 140 barrels.

WELL No. 1.

Farm of William Strain, Sec. 9, Turman Township, Sullivan County, 200 feet from N. line, 200 feet from W. line.

Contractor, C. C. Kirk.
Commenced drilling April 17, 1914.
Completed drilling April 27, 1914.
Casing, 642 feet of 6¼ inch.
Coal 180 to 183 feet.
Coal 475 to 480 feet.
Top sand, 680 feet.
Best oil, 683 feet.
Total depth, 708 feet.
First 24 hours production, 60 barrels.
Second 24 hours production, 50 barrels.

WELL No. 9.

Farm of Alex. Raley, Sec. 33, Turman Township, Sullivan County, 1,075 feet from S. line, 210 feet from W. line.

Contractor, F. E. Branderberry.
Commenced drilling April 15, 1914.
Completed drilling April 23, 1914.
Casing, 715 feet of 6¼ inch.
Coal 300 to 306 feet.
Coal 360 to 366 feet.
Coal 385 to 390 feet.
Coal 642 to 648 feet.
Top sand, 772 feet.
Best oil, 774 feet.
Total depth, 792 feet.
First 24 hours production, 90 barrels.
Second 24 hours production, 75 barrels.

WELL No. 11.

Farm of F. J. Harris, Sec. 1, Turman Township, Sullivan County, 660 feet from E. line, 660 feet from S. line.

Contractor, Frank Breech.
Commenced drilling March 29, 1914.
Completed drilling April 15, 1914.
Casing, 586 feet of 6¼ inch.
Coal 145 to 150 feet.
Coal 395 to 400 feet.
Coal 415 to 418 feet.
Top sand, 638 feet.
Best oil, 638 feet.
Total depth, 686 feet.
First 24 hours production, 60 barrels.
Second 24 hours production, 50 barrels.

WELL No. 7.

Farm of J. V. Merrill, Sec. 35, Fairbanks Township, Sullivan County, 660 feet from E. line, 660 feet from S. line.

Contractor, Lawrence Henderhan.
Commenced drilling April 22, 1914.
Completed drilling April 29, 1914.
Casing, 592 feet of 6¼ inch.
Coal 220 to 225 feet.
Coal 435 to 437 feet.
Coal 550 to 553 feet.
Top sand, 645 feet.
Best oil, 645 to 664 feet.
Total depth, 677 feet.
First 24 hours production, 160 barrels.
Second 24 hours production, 150 barrels.

WELL No. 4.

Farm of Wyatt Dix, Sec. 36, Fairbanks Township, Sullivan County, 200 feet from N. line, 200 feet from E. line.

Contractor, F. F. Williams.
Commenced drilling April 18, 1914.
Completed drilling May 5, 1914.
Casng, 679 feet of 6¼ inch.
Coal 220 to 225 feet.
Coal 310 to 315 feet.
Coal 495 to 497 feet.
Top sand, 681 feet.
Best oil, 681 feet.
Total depth, 711 feet.
First 24 hours production, 20 barrels.
Second 24 hours production.

WELL No. 3.

Farm of E. T. Osborne, Sec. 1, Turman Township, Sullivan County, 660 feet from S. line, 200 feet from W. line.

Contractor, F. E. Branderberry.
Commenced drilling April 25, 1914.
Completed drilling May 5, 1914.
Casing, 570 feet 6¼ inch.
Coal 130 to 135 feet.
Coal 305 to 310 feet.
Coal 470 to 475 feet.
Top sand 622 feet.
Best oil, 622 to 627 feet.
Total depth, 697 feet.
First 24 hours production, 20 barrels.
Second 24 hours production, 20 barrels.

WELL No. 3.

Farm of J. T. Alkire, Sec. 1, Turman Township, Sullivan County, 660 feet from E. line, 200 feet from N. line.

Contractor, Jesse Huggins.
Commenced drilling April 26, 1914.
Completed drilling May 5, 1914.
Casing, 570 feet of 6¼ inch.
Coal 120 to 125 feet.
Coal 160 to 163 feet.
Coal 450 to 453 feet.
Coal 550 to 557 feet.
Top sand, 670 feet.
Best oil, 675 to 685 feet.
Total depth, 694 feet.
First 24 hours production, 20 barrels.
Second 24 hours production, 17 barrels.

The so-called "pools" of Sullivan County are named and located as follows:

Shelburn pool, three miles west of the town of Shelburn.
Jamison pool, two and one-half miles west of Sullivan.
Denny pool, five miles west of Sullivan.
Rinkston pool, four miles southwest of Shelburn.

These are the principal oil-producing areas of Sullivan County, and the total daily production June 1st was 3,500 barrels. Between forty and fifty drilling outfits were drilling in Sullivan County at the above date. A total of 400 wells had been drilled in the fourteen months preceding June 1, 1914, of which 225 are producers of from 5 to 250 barrels each, 165 dry holes, and 10 gas producers.

First producing oil well in the county was drilled by the Hamilton Gas and Oil Co. of Sullivan, Indiana, on the W. C. Jamison farm, Section 31, Hamilton Township, in April, 1906.

POSSIBLE DANGERS FROM OIL AND GAS WELLS IN COAL MEASURES.

It is only within the last year that the State of Indiana has been brought face to face with the problem set forth in the above heading. Hitherto oil and gas exploitations have been in areas in Indiana far removed from her coal measure rocks.

The old Trenton rock field of the State is at least forty miles east of the eastern margin of the productive coal area of the State.

Shallow, small producing, and short-lived oil and gas wells have been drilled in the Niagara rocks of southeastern Indiana, and the Genesee and Corniferous nearby, but these are farther removed from the coal measures than the old Trenton field.

A small field, known in Indiana as the Oakland City field, lying well on the southeastern margin of the coal fields, and covering an area of about thirty-five or forty square miles, has been developed in the past five years, but as few coal seams were penetrated in drilling, the problem of danger has never demanded public attention. Again, the great Phoenix oil well located in the center of the city of Terre Haute, Indiana, and the greatest producing well ever struck in Indiana, penetrated the coal measures, but as subsequent drilling in the vicinity resulted in dry holes, the attending dangers of drilling in the Carboniferous never attracted public attention. But within the last twelve months oil and gas development has been in progress in Sullivan County, Indiana, com-

prising an area of some four or five hundred square miles and lying wholly within the coal measures. Public attention is now fixed on the possible dangers to mine operations from the presence of drill holes. The anxiety, if I may use the term, is intensified by the fact that the laws of the State hitherto made concerning the plugging or sealing of wells related almost entirely to the question of the *waste* of *gas* from abandoned wells, that is, wells from which the owners expected to draw the pipe to use elsewhere, or to sell. Incidentally the law protects the fresh water supply of a community from contamination by the salt water from oil and gas wells. The law in Indiana relating to the sealing of oil and gas wells, and based wholly on the propositions of *waste* and *contamination* is not adequate to meet the present contingency. The section of the law relating to those two results reads as follows:

> "Section 1. Be it enacted by the General Assembly of the State of Indiana, That before the casing shall be drawn from any well drilled into gas or oil-bearing rock for the purpose of abandoning the same, it shall be the duty of any person, firm or corporation having the custody of such well, or having charge of removing the casing therefrom for the purpose of abandoning the same, at the time of such abandonment, to properly and securely stop and plug each of said wells so abandoned in the following manner: Such hole shall first be solidly filled from the bottom thereof to a point at least twenty-five (25) feet above such gas or oil-bearing rock with sand, gravel or pulverized rock, on the top of which filling shall be seated a dry pine wood plug not less than two (2) feet long and having a diameter of one-fourth of an inch less than the inside diameter of the casing in such well; above such wooden plug such well shall be solidly filled for at least twenty-five (25) feet with the above mentioned filling material; immediately above this shall be seated another wooden plug of the same kind and size as above provided, and such well shall again be solidly filled for at least twenty-five (25) feet above said second plug with such filling material. After the casing has been drawn from such well there shall immediately be seated at the point in said well where such casing was seated a cast-iron ball, the diameter of which ball shall be greater than that of the hole below the point where such casing was seated, and above such ball such well shall again be solidly

filled with the above mentioned filling material for a distance of fifty (50) feet."

This law and manner of sealing oil and gas wells is inadequate for conditions in the productive coal measures of Indiana. A law should be formulated based on the following relations between coal mines and oil and gas wells:

1. Protection to open coal workings.
2. Protection to inaccessible spaces.
3. Pillars, or coal that may be left as pillars.
4. Protection to future mining operations.

The dangers attending the drilling of oil and gas wells through workable coal seams may be enumerated as follows:

1. Loss of human life.
   (a) By suffocating gases.
   (b) By explosion.
2. Destruction of property.
   (a) The mine itself.
   (b) Machinery and improvements.
3. Depreciation of coal property on account of proximity to oil or gas wells.

It is well known that the most common form of accident in coal mines is by the explosion of gases accumulated in the mine. Four-fifths of the mine accidents in Indiana are due to this cause, and there will be added danger and increased loss of life and property if protection is not afforded mine operations from possible leakage of gas from oil or gas wells. So far as I know there have been no accidents or explosions as yet in Indiana from this cause. Within the last year more than five hundred wells have been driven in Indiana through workable coal seams.

Dr. R. R. Hice of Pennsylvania says of this same condition in Pennsylvania:

> "It would seem that a great mine disaster directly due to some improperly operated or protected well is needed to arouse public sentiment and cause the enactment of laws which will probably be more drastic than is demanded, and this fact is recognized by some of the more advanced and broader operators."

At a meeting of coal operators, oil and gas operators, coal mine inspectors and state geologists, held in Pittsburgh, Pa., last February, the formation of a law regulating the location, drilling, operating and abandonment of oil and gas wells, especially those passing through workable coal beds, was carefully considered. It is not necessary to enumerate the mine accidents reported at this conference, due directly or indirectly to wells. It does not seem probable that all such accidents were reported. The greatest reported loss of life due to an explosion from a leaking gas well was 29, and many others were reported where the attending loss of life was from two to a half dozen.

The center of activity in oil and gas drilling in Indiana today is within our productive coal measures area. With the increased demand for oil, the drilling of wells will continue. "In June of this year, according to the Oil City Derrick, west of the Mississippi in the Mid-Continent and Texas and Louisiana fields 2,327 wells; in July, 2,342 wells, and in August 2,381 wells were completed. East of the Mississippi in July 1,067 and in August 1,109 wells were finished, and at the end of August 513 wells were in process of drilling. This makes a total of nearly 10,000 wells for the Mid-Continent territory. When we consider that we have no record of the location of any of these wells now drilling, of those in operation, or of the many thousands which have been abandoned, we must all agree that the business is one that has been allowed to take care of itself. Under such conditions, it is not necessary to say anything regarding the necessity of regulation and inspection if we are to prevent the reckless destruction of producing territory by irresponsible operators; to prevent damage to mines and loss of life through improper locating and wrong methods of drilling and casing new wells and improper plugging of old ones, and to prevent the unnecessary pollution of surface waters."

At the Pittsburgh conference there was naturally some differences in opinion as to how far such laws should reach. Some coal men seemed to think that absolutely no well should be allowed to be drilled through any bed of coal which might at any time be mineable, while on the other hand some oil operators seemed to think any regulation whatever was an interference with their right to carry on their own business. Naturally these extreme ideas were not urged to any extent in the meeting; but they existed. It was generally recognized, however, that the coal and oil and gas represented distinct and separate estates, each of which was pos-

sessed of certain rights, and each under the burden of certain restrictions as regard to the other.

The results of the deliberations at the Pittsburgh conference are summed up briefly by Dr. Hice as follows:

"1. Accurate and formal location and recording of wells.
"2. Co-operation of the several parties interested to obtain a safe location.
"3. Designation of effective methods of casing and protecting wells through coal beds.
"4. Formal abandonment of wells.
"5. Safe methods of plugging wells.
"6. Adequate inspection."

There is a law on our statute books that compels the operator of each coal mine to make a map of such mine, the principal requirements of which are as follows:

1. An accurate plan of the workings in minute detail.

2. A copy of the map shall be put in the hands of the State Mine Inspector, and a copy be kept at the office of the mine for inspection by anyone interested.

3. The map shall be revised and extended the first day of May and the first day of September of each year, so as to include all extensions in the workings.

4. All expenses in connection with such map shall be paid by the operator.

5. In event of failure of operator to make such map, the State Mine Inspector shall make a survey and map, and the expense of the same shall be a lien on the mine property.

It would seem that this law compelling the mapping of coal mines is adequate for all practical purposes.

There is no law in Indiana compelling oil or gas operators to make maps of the areas they are developing, or the location of proposed wells. The principal protection afforded the people are the records made in the report of the State Geologist as to the geographical location of oil and gas wells. That a law compelling the mapping of oil and gas territory and the exact location of all drillings by operators is needed in Indiana goes without saying. The details of the manner of sealing or plugging oil or gas wells drilled through workable coal seams is yet to be worked out.

The general plan is as follows:

1. That the drill hole shall penetrate the rock thirty feet below the lowest coal seams.

2. That the drill hole shall be from one to three inches larger in diameter than the outer casing, and this space shall be filled with cement.

3. That there shall be several casings of different sizes with spaces between, some of which are to be filled with cement.

4. That one of such spaces shall be open to permit the exit of accumulated gas at the top.

5. That these casings shall be surmounted by a top to prevent the influx of surface water.

That a cone of cement shall protect the casing when extended through an open working.

If it shall be found to be impossible to pass a law embodying the best of the above suggestions, then there is but one thing left to do, and that is, when a well is to be abandoned, fill it from bottom to top with cement.

In concluding his report on the Pittsburgh conference, Dr. Hice says:

"It is certain that changes will be made in the suggested regulations before enacted into a law in any State, but that it is important, and of increasing importance, to every State where oil and gas is or may be produced is without question. It will entail a very considerable expense upon the industry, but less relatively than is forced upon the coal interests by the laws regulating the mining of coal. The industry is a large one, and the necessity for conserving it is becoming daily more apparent, and the expense to the State will be many times returned in the taxes paid by the business. It will be due, however, to the friends of conservation, to those who want to see our resources used, but used intelligently, and desire to prevent the present waste and loss of life, to see that some such legislation is passed. It will be their duty to reconcile the divergent views of the opposed interests, to point out to them that such regulations mean not loss, but gain, that will secure the passage of the required laws by the several legislative bodies in the states concerned."

Glass Sands of Indiana--Industries.

By Edward Barrett.

It is not the purpose of the following article to discuss the question of the glass industries of Indiana, but rather to indicate the possibilities of the State in the matter of the raw materials that enter into the manufacture of ordinary glass products. The bulk of the glass manufacturies of the State is ordinary kinds for household purposes and ordinary construction. Indiana has abundance of good sands, both of glacial and sedimentary varieties, to furnish the bulk of materials for the manufacture of the kinds of glass mentioned above. It also has limestone of the purest variety to supply the necessary fluxing element. In the discussion of the essentials of a good glass sand or sandstone, we necessarily keep in mind the one great formation that furnishes the major part of the silica element in the manufacture of glass.

The most common impurities in any glass sand, particularly if it is sandstone, are oxide of iron and alumina. A short description of the methods of ridding the glass sand of these impurities is given under proper heads in another part of this paper. The questions of the per cent. of silica and the size of the particles also deserve and receive attention under proper heads.

Glass Sand Deposits.

It was stated above that the glass sand deposits or formations in Indiana are mainly of two kinds—sedimentary and glacial. The most important sedimentary deposit for glass purposes is the Mansfield sandstone, which is the basal member of the Pennsylvania system of rocks in Indiana. Down to very recent years this formation was known principally because it furnished the key to a study of the Carboniferous and Subcarboniferous systems.

The Mansfield sandstone outcrops in an area from the Ohio River in Perry County in a direction west of north to Benton County, influencing profoundly the topography of all of the counties between the ones mentioned above. The outcrops appear in bold cliffs along the stream courses. The massive and castellated form of the stone is due to the fact that after exposure and cemen-

tation by oxide of iron the sandstone resists weathering agencies. The exposures of the Mansfield where streams have cut part way through it are the most massive of any formation in Indiana. Examples of this may be seen at Williamsport, Warren County, where Fall Creek has cut its way through the sandstone to a depth of 75 to 100 feet on its way to the Wabash River. The head of the ravine formed by this creek ends abruptly in a massive outcrop of Mansfield sandstone over which the stream falls in a beautiful cataract a distance of 50 feet. A quarter of a mile to the east of the falls Mansfield sandstone was quarried for building purposes for many years, but owing to the many uses of cement

Base of facing of Mansfield Sandstone of Loogootee Glass Sand Company, one mile east of Loogootee, Indiana.

as foundation and structural material the quarries ceased operation a few years ago.

Three miles south of Attica, in Fountain County, the Attica Glass Sand Company has been operating a mining and washing plant for a number of years, drawing their supply of glass sand from an outcrop of a sandstone on Big Shawnee Creek.

In Parke County, prominent outcrops of the Mansfield occur on Sugar Creek and Raccoon Creek.

In Putnam County, prominent outcrops are found on the bluff of Big Walnut Creek, in the southwestern portion of the county.

In Clay County, bold exposures occur on the west bank of Croys Creek, about three and a half miles southeast of Brazil, and on Eel River in the eastern part of the county.

Many exposures occur in Owen County on the bluffs on either side of White River and some of its smaller tributaries within the county.

In Greene County there is a perfect network of exposures in stream valleys, large and small.

Probably the most massive and striking exposures of the Mansfield sandstone occur along the bluffs of the White River in Martin County. Just north of the city of Shoals, on the west bank of White River, the Mansfield exposes in the castlelike rock known as the "Pinnacle."

All of the northeast part of Dubois County has numerous exposures, particularly in the vicinity of Dubois and Jasper.

Continuing on down through western Crawford and Perry counties this formation is exposed in all of the upper portions of the bluffs in stream valleys.

There is scarcely an exposure mentioned above in any one of the counties but what the Mansfield would be suitable for glass sand purposes, particularly in making glass of the utility kind. There is a feature of the Mansfield exposures in Indiana which is particularly important. There is scarcely an important exposure of this formation but what the base of such exposure lies above drainage, thus enhancing the convenience and easiness in quarrying.

The area of exposure mentioned above is also crossed by at least seventeen important railroad lines, as follows, beginning at the north:

1. Cleveland, Cincinnati, Chicago and St. Louis.
2. Lake Erie and Western.
3. Wabash (main line).
4. Wabash (branch line).
5. Toledo, St. Louis and Western.
6. Cleveland, Cincinnati, Chicago and St. Louis (Peoria div).
7. Cincinnati, Hamilton and Dayton.
8. Vandalia (Logansport Division).
9. Cleveland,Cincinnati, Chicago & St. Louis (St. Louis div).
10. Vandalia (St. Louis Division).
11. Evansville and Indianapolis.
12. Monon (Wallace Branch).
13. Vandalia (Vincennes Division).
14. Illinois Central (Indianapolis Southern).
15. Chicago and Southeastern (Southern Indiana).

16. Baltimore and Ohio Southwestern.
17. Southern.

Many of the outcroppings are also in close proximity to a number of short branch lines of several of the above railroads. To make transportation doubly complete, the Monon Railroad from Chicago to Louisville follows the outcrop of this important formation almost its entire distance from Lafayette to the Ohio River.

No formation in Indiana is in closer proximity to the streams of the State. All of the important streams of the State have cut their way through its outcrops, and scores of tributary streams furnish abundant water supply for mining and washing purposes, and many of the streams furnish abundant water power for the operation of machinery. A number of firms have taken advantage of these transportation and water facilities and have established plants for mining and preparing this sandstone for market. These plants and work they are doing are mentioned in another part of this paper.

The Mansfield sandstone, lying as it does at the base of the coal measures, is convenient to a fuel supply from the coal fields which lie along its entire margin on the west. In many places seams of coal of workable thickness extend in tongues well into the Mansfield area.

Qualities of Mansfield Sandstone.

Texture.—Samples gathered from most of the above points show that this sandstone varies greatly in texture, possessing every variation from a coarse conglomerate to a fine-grained sandstone. In many places the Mansfield consists of a pebbly strata, made up of a multitude of quartz pebbles; again it consists of a coarse conglomerate; and again a coarse sandstone, and the cementing element in all of these varieties is usually ferric oxide.

Color.—The natural color of the Mansfield when first laid down was white, very much like coarse granulated sugar; but oxidation has changed the color to shades of yellow, brown and red, and variations of these colors.

Thickness.—The Mansfield is probably the most massive formation in Indiana in its structure, often showing faces from 25 to 75 feet.

Workability.—The formation on first opening or quarrying is rather friable, and in many places could be torn down by hydraulic force. In other places quarrying could be done with a common

hand pick while still others require powder blasting. At present the stone is quarried in Indiana principally by the blasting process.

With an inexhaustible supply of the Mansfield formation in Indiana, comparing well in chemical analysis with the glass sands of Illinois, Missouri and Kansas, and having in close proximity those facilities, viz., fuel, water and transportation, the writer knows of no good reason why there should not some day in the near future be a line of glass industries either for shipping or manufacturing, or both, extending all the way from the Wabash River at Attica to the Ohio River at Cannelton.

In this preliminary investigation of the glass sands and glass sand facilities of Indiana, the State Geologist visited many of the Mansfield exposures.

COXVILLE.

Prominent among these is the deposit at Coxville, Parke County, where the Acme Glass Sand Company is mining a sandstone which for many years past was known as Mansfield but later geological research has placed at a later age than the Mansfield. This deposit is located at the village of Coxville, about eighteen miles northeast of the city of Terre Haute, on a bluff of Raccoon Creek, where the sandstone shows a face of about 40 feet. Of this deposit the U. S. Geological Survey speaks as follows:

"The beds are massive, lie nearly horizontal, and are covered by a few inches to nearly 10 feet of drift clay containing bowlders and gravel. This sand is rather soft, of medium-sized, angular grains, and the mass ranges from white to light brown in color. Close inspection shows that certain beds are speckled with iron-oxide spots the size of a pin head, so closely spaced that thirty or more spots appear in a square inch of surface. The sand is slightly micaceous and the bed contains occasional clay streaks. When crushed and dried the average sand has a light yellowish-brown color, due to impurities, a large proportion of which might be removed if the product were washed. The process of treatment is simple. After the customary drilling and shooting down, the broken rock and loose sand is loaded into the mill by a steel bucket a cable conveyer and dumped directly into a Blake jaw crusher. The material then passes through one set each of corrugated rolls and smooth rolls and is thus separated into its individual grains. A belt conveyer, elevator and chute, in the order given, carry the sand to a rotary drier burning coke. From the drier the sand may

be delivered directly to cars or stored in bins. The capacity of this mill is about 250 tons a day. The quarry is fairly well situated with respect to transportation facilities, having direct connections with the Chicago and Eastern Illinois Railroad, and switching connections at Rosedale with the Vandalia line. The market for this sand consists chiefly of glass works in the State that make beer bottles. Some of these works are at Terre Haute. Without washing the sand is not satisfactory for flint and window glass. It is, however, in great demand for furnace use."

Analysis of the Coxville glass sand may be seen in table of analyses in this paper.

Sand storage and drying bins of Loogootee Glass Sand Company one mile east of Loogootee, Indiana.

GREENCASTLE.

About five miles southwest of Greencastle, Putnam County, at Fern, the Mansfield exposes along a small stream leading to Big Walnut Creek. The exposure is really in a bluff of that stream. Here the Root Glass Company of Terre Haute has installed a quarrying and crushing plant for utilizing this sandstone. The sandstone here is of a typical, massive variety and shows a face of at least 40 feet. The crushing plant is built within a few feet of the quarry and a spur from the St. Louis Division of the Big Four Railroad supplies transportation. The major portion of the output of the plant is used in the company's glass plant at Terre Haute, though a number of cars are shipped each month to other

glass factories in Indiana and Illinois. The quality of the sandstone has proved to be very satisfactory to the companies using it. The plant has a capacity of at least one hundred tons a day.

BRAZIL.

On the west bank of Croys Creek, a branch of Eel River, about three miles and a half southeast of Brazil, there occurs a number of massive exposures of the Mansfield sandstone, the principal ones of which are on the farm of Dr. J. D. Sourwine of Brazil. The writer visited these exposures in his investigations and took samples therefrom, the chemical analyses of which are given in another part of this paper.

The State Geologist has no hesitancy in saying that the Mansfield sandstone at the above point on Croys Creek is of a quality for the successful manufacture of utility glassware.

ATTICA.

In all of the valleys of the small streams about Attica, as well as the Wabash River itself, there are exposures of Mansfield sandstone suitable for glass making purposes. The deposits of Mansfield sandstone on Big Shawnee Creek, three and a half miles south of Attica, and on Fall Creek, at Williamsport, and several points on the Wabash River bluffs near Fountain, are all suitable for the making of plain glass products. Analyses of samples from these places show from 95 to 97 per cent. silica, and a small per cent. of oxide of iron and alumina, the latter two being the most prominent discoloring elements in the Mansfield.

WOLCOTT.

The Mansfield deposit near the town of Wolcott seems to be rather isolated, most of the surrounding country being heavily glaciated. But at this point, however, there is only a stripping of some six or eight feet. The quarry lies just south of the Logansport and Effner Division of the Vandalia Railroad and is reached by a short spur from this road. The quarry was operated for a number of years by the American Window Glass Company. The sandstone here is of very loose structure and could easily be reduced by a hydraulic jet.

Analyses made by the American Window Glass Company of

samples from this deposit show the following percents of silica, alumina and oxide of iron:

	No. 1	No. 2	No. 3	No. 4
Silica (SiO_2)	99.990	99.714	99.659	99.579
Alumina (Al_2O_3)	.008	.280	.310	.350
Iron oxide (Fe_2O_3)	trace	.066	.011	.021

According to E. F. Burchard, of the U. S. Geological Survey, this sand is suitable for the following purposes:

"No. 1 is suitable for the very highest grades of glassware and flint glass. Nos. 2 and 3 are suitable for tableware, plate glass, chimneys, prescription ware, etc., and No. 4 is used for window glass."

LOOGOOTEE.

The most important sand plant in southern Indiana at present is that of the Loogootee Glass Sand Company. This company operates a quarry of Mansfield sandstone about a mile and a half east of Loogootee on the Baltimore and Ohio Southwestern Railroad. The capacity of the plant for crushing, washing and drying the sand is about twenty cars of thirty tons each a month. A part of the output is used by Graham Brothers, who operate a glass factory in the town of Loogootee. Some of the prepared sand is sent to Evansville, but the larger portion of the output goes to Louisville, Kentucky. The quarry at present shows a face of 40 feet. The writer was informed by O. H. Gernest, superintendent of the plant, that test bores show that the Mansfield sandstone at this quarry is at least 100 feet thick. The exposed parts of the deposit are strongly colored by oxide of iron, colors varying from yellow into dark brown and dark cherry red. The sandstone is broken down by the use of dynamite. The Jeffrey crusher into which the sandstone is fed is located in the bottom of the quarry. After crushing, the sand is elevated by means of a belt conveyer into the washing bins, where the larger part of the impurities are washed from it by means of a hydraulic jet. The clean sand is re-elevated to the drying bins, and after being dried by means of steam pipes and coils is loaded into the cars. A considerable per cent. of the Mansfield from this quarry is a coarse quartz conglomerate. Much of this is separated from the raw material before being put through the crusher.

SHOALS.

In the vicinity of Shoals, there are many massive exposures of the Mansfield sandstone, which in appearance and quality do not vary much from the same formation farther north, the principal difference being the amount of ferric oxide with which the sandstone is impregnated. This is particularly true of the face of the exposures. After a few feet of the face of the deposit is broken away the iron stain grows less and a sand is produced which, by proper washing, would grade alongside of the Loogootee sand, five miles to the west.

JASPER.

In the vicinity of Jasper, Dubois County, and on the line of the French Lick Branch of the Southern Railroad, many exposures of Mansfield sandstone occur, which in appearance and texture is similar to the Shoals and Loogootee sands, and doubtless could be used in several varieties of common glass.

MICHIGAN CITY.

Probably the best known and largest deposit of loose or drifted sand is the well-known ridge of sand on the lake front at Michigan City. This accumulation of sand is probably the result of the combined action of the lake and winds. The huge ridge of glistening sand is known locally as the "Devil's Slide." There is an inexhaustible amount of sand in this ridge because the ridge is continually renewed by sand washing up from the lake and then moved by the wind and forming this huge dune.

Several of the glass sand industries of the State use this sand in the manufacture of glass products. Notable among these is the well-known firm of Ball Bros. of Muncie, Indiana, manufacturers of jars. This company has been using the sand from Lake Michigan for about twenty-five years and it has proved very satisfactory. This sand has the advantage of freedom from the usual impurities which accompany indurated deposits, for the reason that it comes ready washed from the lake. Ball Bros. use about 150 tons of this sand per day. Their products are shipped to all parts of the world. The Michigan City sand is also used in foundry work in making cores, particularly by the Chandler-Taylor Company of Indianapolis.

DePAUW.

Near the town of DePauw, twenty-three miles west of New Albany, occur a number of deposits of loose sand, which in former years was used in glass making. For many years, sands from deposits near New Albany were used in the DePauw Glass Works in the manufacture of glass products. These sands probably belong to what is known geologically as the Ohio River sands.

The Root Glass Company of Terre Haute, which operates the American Glass Sand plant at Fern, west of Greencastle, operates its Terre Haute plant exclusively on plain bottles and carbonated water bottles. The output of the plant is between 300,000 and 350,000 gross of bottles, which is very close to its capacity.

The Root Glass Company was started in the fall of 1901 and has gradually increased its capacity up to the present time. Shipments of its products are made over the entire United States, also to Canada, Old Mexico, Cuba and South America.

PROPORTION BY WEIGHT OF COMPONENTS OF GLASS.

The U. S. Geological Survey presents the following table on the general proportions by weight of the various components of glass:

Component.	*Plate Glass.*	*Window Glass.*	*Green Bottle.*	*Lead Flint.*	*Lime Flint.*
Sand (SiO_2)	100	100	100	100	100
Salt cake (Na_2SO_4)	.....	42	38	.....	.....
Soda ash (Na_2CO_3)	36	...	...	.....	36
Limestone ($CaCO_3$)	24	40	34	.....	.....
Carbon (C)	.75	6	5	.....	.....
Arsenic (As_2O_3)	1	2	...	.15	.02
Slaked lime ($Ca(OH)_2$)	.....	...	...	.....	12
Potash (K_2CO_3)	.....	...	...	34	.....
Red lead ($2PbO+PbO_2$)	.....	...	...	48	.....
Niter ($NaNO_3$)	.....	...	...	6	1
Manganese (MnO_2)	.....	...	...	.06	6.66
Antimony (Sb)	.....	...	...	.02	.23

"Sand is therefore the major constituent of glass, constituting from 52 to 65 per cent. of the mass of the original mixture, or from 60 to 75 per cent. of the finished product after melting has driven off carbon dioxide, sulphur dioxide, and other volatile materials. To the sand is due the absence of color (according to its purity), the transparency, brilliancy and hardness of glass. In other words, the quality of the glass depends largely on the quality of the sand.

For the finest flint ware, such as optical and cut glass, 'water whiteness,' absolute transparency, great brilliance and uniform density are required, and only the purest sand can be employed, since slight impurities, especially small quantities of iron, tend to destroy these effects. For plate and window glass, which are commonly pale green, absolute purity is not so essential, but generally the sand should not carry more than two-tenths per cent. of ferric oxide. Green and amber glass for bottles, jars and rough structural work can be made from sand relatively high in impurities. An excess of the chief impurity, iron, is usually avoided in the quarries by a careful selection of the whitest sand, although the

Storage and loading bins of Loogootee Glass Sand Company, one mile east of Loogootee, Indiana.

whitest sand is not invariably the purest. Repeated washing tends to remove the iron. Magnetic separators also have been resorted to, especially when the iron is present in the form of magnetite. Clay materials are objectionable because they cloud the glass. Washing helps to remove them, since they occur usually in a very finely divided state. Magnesia, which is more apt to be introduced into glass materials through limestone than through sand, is troublesome because it renders the batch less fusible. If the sand is derived from indurated sandstone the latter should be friable or easily crushed. In examining sand, in order to ascertain its value for glass-making purposes, inspection with a magnifying glass is the best preliminary test. The following points should be observed: The sand should be nearly white in color; it should be of

medium fineness (passing a 20 to 50 mesh horizontal sieve); the grains should be uniform in size, even, and angular, or, less preferably, they may be rounded. A simple chemical test may be employed by heating the sand in a dilute acid. Effervescence indicates the presence of lime; loss of color shows the presence of clay impurities. Iron in the most minute quantity may be detected by dissolving sand in hydrofluoric acid and adding potassium ferrocyanide, which produces a blue precipitate if iron is present. Complete quantitative analyses as well as a furnace test should be made as a final determination of the character of a prospective glass sand. The impression has long prevailed, especially among writers on the subject of glass making, that round-grained sands are at a decided disadvantage in comparison with the sharp, angular variety. Practice seems to disagree with this idea, at least in the case of the Mississippi Valley plants, where smooth, rounded sand is successfully used for all ordinary varieties of glass and for some fine flint ware. As a rule, no very close check is kept on materials by manufacturers of the ordinary commercial grades of glass. Results are watched with care, however, and experience with certain materials usually determines their use or rejection. Sand uniformly finer than one-sixtieth inch is said to 'burn out' in the batch and not to produce as much glass per unit of weight as does coarser sand. In a mixture of coarse and fine sand the finer sand is liable to settle to the bottom of the batch, thus preventing an even mixture of the materials and producing in consequence a glass uneven in texture."

ANALYSES OF GLASS SANDS OF INDIANA.

Location of Deposit.	Owner.	Authority.	Silica (SiO_2), Per Cent.	Alumina (Al_2O_3), Per Cent.	Ferric Oxide (Fe_2O_3), Per Cent.	Calcium Oxide (lime), (CaO), Per Cent.	Magnesium Oxide (MgO), Per Cent.	Loss by Ignition (mostly water and organic matter), Per Cent.	Other Minerals.	Total.	Remarks.
Clark County— Jeffersonville	Newport Sand Bank Co., Newport, Ky.	Laboratory, Cincinnati College of Pharmacy, Cincinnati, Ohio.	94.00	5.00	1.00	None.	None.	.....	.....	100.00	Fine-grained molding sand.
Floyd County— New Albany	Ditto	Ditto	92.00	1.50	5.00	Trace.	.....	.....	.....	98.50	Fine light-colored molding sand.
Fountain County— Attica	Western Silica Co., Danville, Ill.	State Geologist of Indiana	98.84	.38	.10	.....	.03	.32	Titanium oxide (TiO_2), Trace.	99.67	.....
Hancock County— Maxwell	E. L. Dobbins, Greenfield	.....	85.00	.....	.....	.50	13.50	.....	Loam, 1 per cent.	100.00	.....
Jackson County— Brownstown	Newport Sand Bank Co., Newport, Ky.	Cincinnati College of Pharmacy, Cincinnati, Ohio.	92.00	6.50	1.00	.....	.50	.....	.....	100.00	Coarse red molding sand
Laporte County— Michigan City	Pinkston Sand Co	.....	91.98	4.44	.56	2.20	Trace.	.72	Loss, 10 per cent.	100.00	Molding sand, grinding sand.
Martin County— Loogootee	Loogootee Glass Sand Co	J. F. Elson, New Albany	97.78	1.13	.10	.06	.....	.....	.....	99.07	Glass sand, selected sample
Ditto	Ditto	Operator, report of State Geologist.	96.26	2.50	.92	.....	.16	.....	Potassium and sodium oxides (K_2O) and (Na_2O) 0.13%.	99.97	Glass sand, crude.
Parke County— Coxville (near Rosedale)	Acme Glass Sand Co., Terre Haute.	W. A. Noyes, Rose Polytechnic Institute, Terre Haute.	98.61	.74	.22	.12	Trace.	.32	.....	100.01	Glass sand, unwashed.
Clay County— Brazil	Dr. Sourwine	W. M. Blanchard, Chemist, Laboratory De Pauw University, Greencastle, Indiana.	96.52	2.69	.18	.19	.06	.70	.....	100.34	.....
Ditto	Ditto	Ditto	95.41	2.79	.40	.19	.17	.80	.....	99.76	.....
Ditto	Ditto	Ditto	94.88	3.05	.66	.32	.07	.93	.....	99.91	.....
Ditto	Ditto	Ditto	98.00	.61	.32	.10	.08	.36	Sulphuric Anhydride (SO_4) .13%.	99.60	.....
Ditto	Ditto	Ditto	93.69	2.68	1.05	.51	.08	1.05	Ditto, .14% Soda (Na_2O), 50%.	99.70	.....

We cannot do better than to include in this discussion the following from U. S. Geological Survey Bulletin No. 313:

Preparation of Glass Sand.

"The method of treatment of glass sand depends on the character of the deposit and on its position. The materials used for glass sand in central United States are mainly bedded sandstones, and a complete process of preparation includes quarrying, breaking, crushing, and grinding into component grains, screening, washing, draining, drying, and final screening to various sizes. Some beds of sandstone are so loose and friable that they can be reduced by a strong hydraulic jet; some producers dispense with the operation of washing their sand, others do not dry it. It has been shown that washing improves the quality of sand of the highest grade. It is mistaken economy to neglect this important phase of treatment on account of the expense of installing washers, for the price of sand, and often its use or rejection, is affected by the small percentage of impurity that may be washed away. Two methods of washing are followed. One method involves several sets of bins, into which sand and water are elevated or pumped so that the sand settles quickly while the finer impurities are washed away; the other employs a crude, open-top pug mill, in which rotating "augers" or screws move the sand up inclined troughs, rolling it over and over so that by attrition it is freed from a large portion of its impurities and stain, and the impurities are then readily removed by a stream or water playing down the troughs.

"Drying is effected by three general types of apparatus: (1) Rotary cylinders, through which the sand passes against a draft of flame and hot gas; (2) a stationary roaster, and (3) coils of steam pipes. The first method involves the greatest initial cost, but is by far the most rapid and efficient.

"Sand that passes a 60-mesh sieve or one of smaller mesh is regarded as fine grained that which passes 30- and 40-mesh sieves is regarded as medium grained, and that which is retained by 30- or 20-mesh sieves or sieves of coarser mesh is considered coarse grained. The divisions have been made the basis for classifying, according to their grain, the various sands mentioned in the following notes."

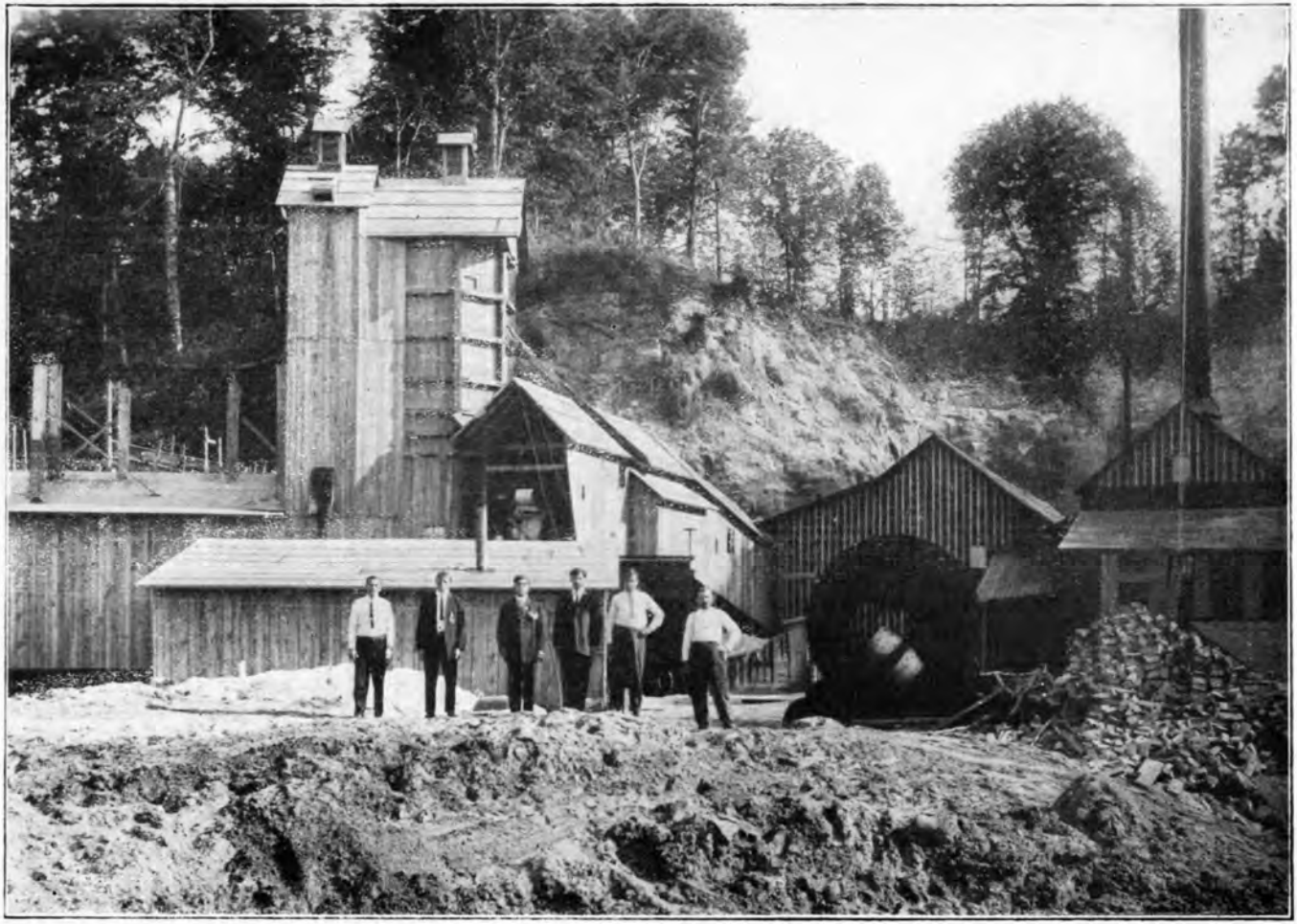
Indiana Limestone as an Ingredient For Glass Making.

Lying to the east of the Mansfield sandstone area geographically and below it geologically are Indiana's purest and best limestones, viz., the Mitchell and the Bedford or Oolitic. The outcrops of these two limestone formations run almost parallel with the Mansfield throughout its entire length, and always within a fraction of a mile to a few miles distant. Their drainage systems are the same, and railroad facilities the same.

The Mitchell and Bedford limestones contain from 95 to 98 per cent pure calcium carbonate and a small per cent of silica and a mere trace of impurities harmful to glass products. The greatest number of plants in operation in Indiana for the crushing and grinding of these limestones is in the area mentioned above.

The superiority of these limestones as a glass ingredient is because of their freedom from iron oxide, the most common impurity encountered in the manufacture of glass. Clay and iron sulphide are two other impurities met with in the manufacture of glass, and the Mitchell and Bedford limestones are singularly free from these, as a rule containing a mere trace. The opinion prevails that impurities usually come to the batch from the sand or sandstone used in the manufacture of glass. Frequently, however, the impurities come from the limestone used in the batch. Therefore, careful and frequent analyses of the limestone ingredient should be made, so that limestone containing any considerable per cent of the above impurities should be rejected.

The preparation of limestone as a glass ingredient consists in reducing or grinding the limestone to an almost impalpable powder, in which condition it is easily mixed with the sand and other ingredients. Below are given four chemical analyses of Bedford Oolitic limestone. These analyses were made by Dr. Noyes for the Twenty-First Annual Report of this Department. Also we give below four chemical analyses of Mitchell limestone by Noyes and Smith, as given in the Thirtieth Annual Report of the Department of Geology.



American Glass Sand Company's plant for mining, crushing and washing Mansfield sandstone, four miles southwest of Green-

ANALYSES OF BEDFORD OOLITIC LIMESTONE FROM SOUTHERN INDIANA.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$)	Ferric Oxide (Fe_2O_3).	Insoluble Residue (Silica, etc.).	Total.
Bedford Stone Quarry, Lawrence County	98.27	.84	.15	.64	99.90
Hunter Bros. Quarry, Monroe County	98.11	.92	.16	.86	100.05
Romona Oolitic Stone Co., Owen County	97.90	.65	.18	1.26	99.99
Twin Creek Stone Co., Washington County	98.16	.97	.15	.76	100.04

ANALYSES OF MITCHELL LIMESTONE FROM SOUTHERN INDIANA.

Source of Sample.	Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Ferric Oxide and Alumina (Fe_2O_3 + Al_2O_3).	Insoluble Residue (Silica, etc.).	Total.
Oolite from Eichel Quarry, Milltown, Ind.	98.91	.63	.15	.48	100.17
Gray stone from Mitchell Lime Quarry, Mitchell, Ind.	96.65	1.20	.27	1.57	99.69
Gray stone from south of Harrodsburg, Ind.	97.64	....	.32	.82	98.74
Gray stone from land of J. B. Lyne, Monroe County	99.04	....	.09	.80	99.92

These analyses clearly sustain the reputation of the Bedford and Mitchell limestone as carriers of a high per cent of calcium carbonate and unusual freedom from impurities.

General Aspects of Glass-Sand Industry.

"The consumption of glass sand has been rapidly increasing for many years, and it is probable that it will continue to do so indefinitely. Vast resources of the material are in sight. The uses for glass are now so varied and extensive that it may well be classed with iron and cement in its importance under present conditions. Glass sand in situ possesses relatively little intrinsic value. The market value is due to the labor cost of extraction and preparation.

"The factors on which a deposit of sand depends for its possible value for glass making are (1) chemical composition, (2) physical character, (3) amount available, (4) location with respect to fuel supplies, (5) conditions of quarrying or mining, (6) location with respect to transportation routes, and (7) location with respect to markets.

"A deposit so thin as 20 feet should have an areal extent of at least 20 acres of good sand in sight to warrant the erection of a mill and trackage. Most deposits are thicker than 20 feet, but it would be safer to have a much higher ratio between areal extent and thickness than the minimum given. Where ledges of sand require stripping of overlying limestone, the limestone may in certain cases be of such purity that it also could be used for glass making; if this is not the case other uses should be sought for it as a by-product. In regard to fuel, every plant turning out glass sand in quantity sufficient to net a profit must be equipped with power for moving the sand and drying it, and in most cases with equipment for cleaning as well. The margin of profit is at present so low that the cost of preparation can not reasonably stand freight charges on coal for more than 50 miles. Natural gas would be a suitable fuel, especially in the operation of rotary driers. In respect to transportation routes, the general principle 'the more available the better' is applicable. Aside from the necessity of securing fair and uniform freight rates experience has shown, especially where the dependence is on only one railroad for transportation, that shortness of cars at certain seasons may seriously handicap a plant in its shipments and lead to cancellation of many orders. In respect to markets, it must be considered that sand is for its value one of the bulkiest products, and therefore one whose cost to the consumer is greatly influenced by distance. At the same time the question of permanence of these markets must be considered.

"Some of the large sand properties, together with their mills, represent an outlay of about $75,000, a sum that requires good business judgment for its investment and subsequent careful management in order to keep it paying adequate interest. Strong competition in the Middle States has forced prices down very low at present, and competition in the form of the small producer who leases a sand bank and works out by hand and team all the choice sand within convenient distance and then abandons the quarry, having figured only daily wages to himself as profits, has resulted in some embarrassment to the larger companies."

According to statistics compiled by the U. S. Geological Survey, the quantity of glass sand produced in the United States and the value thereof for the ten years—1902 to 1911 inclusive—was as follows;

QUANTITY AND VALUE OF GLASS SAND PRODUCED IN THE UNITED STATES, 1902-1911, IN SHORT TONS.

Years.	*Quantity.*	*Value.*
1902	943,135	$807,797
1903	823,044	855,828
1904	858,719	796,492
1905	1,060,334	1,107,730
1906	1,089,430	1,208,788
1907	1,187,296	1,250,067
1908	1,093,553	1,134,599
1909	1,104,000	1,163,375
1910	1,461,089	1,516,711
1911	1,538,666	1,543,733

It will be seen from these figures that the production of glass sand in 1911 was 77,577 tons more than in 1910, and the value in 1911 was $27,022 in excess of 1910. The price per ton in 1911, however, was approximately $1.00 per ton, as against $1.04 per ton in 1910.

Soil Survey of Blackford County.

By E. J. Quinn and R. H. Peacock, of the Indiana Department of Geology.

Blackford County, the fourth smallest county in Indiana, lies east of the north central part of the State, about 55 miles northeast of Indianapolis and 21 miles west of the Ohio state line. It is bounded on the north by Wells County, on the east by Jay County, on the west by Grant County, and on the south by Delaware County.

The county is approximately 13 miles square, making a total acreage of 107,520. There are four civil townships in the county —Washington, Licking, Harrison and Jackson.

Hartford City, with a population of over 6,000, is the county seat.

Montpelier, the next largest town in the county, with a population of 4,392, is situated near the north county line in Harrison Township. Roll, Mollie, Trenton and Millgrove are small villages found in the county.

The topography of the territory under consideration is quite uniformly level except in the southwest and northeast portions, where it becomes irregular and more undulating. There are no prominent hills or elevations. The general elevation is about 800 feet above sea level. From railroad profiles it is found that the elevation at the L. E. & W. depot at Hartford City is 895 feet, and at the same railroad depot at Montpelier, 869 feet.

The Salamonie River and Lick Creek are the principal drainage lines in the county. The water shed or divide between these two systems extends in a southeast-northwest direction through the central part of the county, dividing the portion drained by each about equally. The Salamonie, which rises in Jay County to the east, cuts the eastern line of Blackford about three miles south of the northeast corner and flows in a northwesterly direction, leaving the county north of the town of Montpelier. Big Lick Creek, which also has its head in Jay County, enters the county north of Dunkirk, and flowing northwest unites south of Hartford City with Little Lick Creek, a small stream heading in the low-lying areas in the northern part of Jackson Township. The stream from the

confluence of these two creeks is known as Lick Creek and flows southwest through Licking Township, leaving the township in Section 6, finally reaching the Mississinewa River in Delaware County.

There are a number of open ditches throughout the county which were constructed to drain the marsh land and low areas. Many of these ditches are now being tiled and covered, thus avoiding much waste which formerly prevailed, and allowing the land to be cultivated.

The roads of the county are well improved with gravel or limestone. Good gravel deposits extend from Hartford City southwest along Lick Creek, while other good pits are found near Montpelier. Limestone as a road metal is being used more extensively now than formerly, and great quantities are being quarried for this purpose from the deposit of Niagara limestone at Montpelier.

Educational facilities are excellent, the county being supplied with several good accredited high schools and consolidated grade schools. A means of conveyance is furnished to those children living at a distance from the school, the burden of the expense of the upkeep of such conveyance being borne by the township.

The county is traversed by two railroads and one interurban line. The L. E. & W. Railroad crosses the county from north to south and the C. C. C. & St. L. Railroad from east to west, both of these roads passing through Hartford City. The Ft. Wayne and Northern Indiana Traction line parallels the L. E. & W. through the county, passing through both Hartford City and Montpelier.

Blackford County was organized in 1839. The territory before this time was part of Jay and Delaware counties. The name Blackford was given in honor of Hon. Isaac Blackford, one of the first judges of the Supreme Court of the State of Indiana. The original settlers came principally from Pennsylvania, Ohio and New York. In 1840 the population was 1,226; in 1900, 17,213.

For a number of years gas and oil were a great source of income to this county, but of late the supply of these products has decreased and agriculture is once more the chief source from which the county derives its prosperity.

CLIMATE.

There is no Weather Bureau Station in this county, but the following data taken from the records of the Marion station in Grant nty answers for this area.

TOTAL MONTHLY PRECIPITATION FOR YEARS 1911, 1912 AND 1913.

YEAR.	*Jan.*	*Feb.*	*Mch.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
1911	3.87	1.55	1.83	4.16	.99	4.76	1.07	5.08	6.34	4.07	3.71	3.39
Annual for year 40.82.												
1912	2.19	2.43	4.09	4.66	3.84	1.45	3.26	4.88	4.37	2.02	1.80	1.09
Annual for year 36.08.												
1913	7.51	1.62	10.31	3.33	3.78	.88	5.75	3.27	2.03	2.92	2.59	.47
Annual for year 44.46.												

Maximum temperature for year 1911 was 102° on July 2.
Maximum temperature for year 1912 was 96° on September 2.
Minimum temperature for year 1911 was 0° on January 5.
Minimum temperature for year 1912 was 18° on January 13.
The last killing frost in spring 1911 was May 5.
The last killing frost in spring 1912 was April 23.
The first killing frost in fall 1911 was October 24.
The first killing frost in fall 1912 was September 27.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first settlements to be made in this county were in the southwestern part of Licking Township, along Lick Creek. The first entry of lands was made by Benj. Reasoner in the year 1831. The northern part of the county was not so readily settled because of the wet and marshy lands. The greater part of the southern half of the county was heavily timbered, and in order to quickly clear the land huge piles of fine black walnut, white, red and burr oak and shellbark hickory were rolled together and burned.

The agricultural history of Blackford is similar to that of other counties in the State. Primitive culture with rude, home-made tools and implements was carried on for years, to be replaced with the advent of the railroad and the introduction of machinery by more modern methods. Large tracts of good land went for years without any attempt being made to drain them of the standing water with which they were covered. With the introduction of better drainage conditions, the low marsh lands of Polk's Prairie, Petit Prairie and the Cranberry Marsh were reclaimed and put under cultivation. Thousands of acres of the best land in this county have been thus reclaimed within only comparatively recent years.

The crops grown are the same that were produced in the early days of the county, although the acreage and yield have changed considerably. In the year 1900, the acreage of corn in the county was 26,153 with a production of 1,137,950 bushels, or an average of 43.5 bushels per acre; in 1911 the number of acres devoted to the

crop was 22,345 with a yield of 895,090 bushels, or an average of 40.06 bushels per acre. In 1900 the acreage of wheat was 14,040, with a yield of 183,330 bushels, or 13.05 bushels per acre; in 1911 there was 3,882 acres with an average of 14.42 bushels per acre. The acreage of oats has increased in the last few years; only 3,873 acres were given to oats in 1900, with an average yield of 31.04 bushels, compared with an acreage of 11,635 and an average yield of 30.14 bushels per acre in 1911. The average yield of hay per acre is about 1¼ tons. Alfalfa is being grown to some extent, about 42 acres being devoted to this hay crop in 1911. Clover does fairly well in this county; over 8,000 tons of clover hay were produced in 1910; in 1911 the yield was a little over 2,000 tons.

Commercial fertilizers are used to some extent, especially for wheat on the lighter colored soils. Without doubt the thing to be recommended for the Miami series in this county is ground limestone, as much of these lighter colored soils are sour and acid. The darker colored soils of the Clyde series frequently show an acid reaction, but lime concretions and nodules are found in the subsoil and can often be reached by deep plowing. It has been found that fertilizers containing phosphoric acid and potash give best results on the Clyde silty clay loam, while a complete fertilizer gives best returns on the Miami silt loam. Good management in regard to rotation of crops, the turning under of green manurial crops in order to maintain sufficient organic matter, and a liberal application of ground limestone once every five or six years should be sufficient to keep up the fertility of any of the land found in the county.

Blackford County is among the most prosperous counties in the State. There is practically no waste land and the soils, which are all of glacial origin, are inherently fertile. The farms are well fenced and improved, with the farm buildings in good condition. Rural free delivery and telephone communication reach every part of the county.

The average size of farms is 98.5 acres. The valuation of farm lands in the county is $3,196,950. Land sells at from $125 to $250 an acre, depending on the improvements, nearness to the towns, and amount of black land.

SOILS.

The soils of Blackford County are all of glacial origin and were transported here during the Wisconsin stage of glaciation.

The depth of the drift varies from 10 to 150 feet, the greater depth being found in the southern part of the county.

Five different types of soil were recognized in the area, these types being determined by their origin, texture, color and structure. The higher uplands and morainic hills consist mostly of the Miami series, while the soils of the depressions and black lands along the small creeks are included in the Clyde series. Alluvium is a name given to those varied deposits along Lick Creek and the Salamonie River. Muck is another type, and comprises the peaty deposits formed by the accumulation of organic remains.

Excepting the areas mapped as Miami loam, the Muck areas and the sandy portion of the alluvium, the soils of the county are heavy and contain high percentages of silt and clay. There are no stones of any size to interfere with cultivation, and very little surface gravel except on the morainic hills along Lick Creek.

Miami Silt Loam.

The surface soil of the Miami silt loam consists of a grayish to yellowish silt loam, 8 to 12 inches deep, underlain with a darker, more granular and crumbly material having a higher percentage of clay. At 24 inches to 26 inches the sand and gravel become more abundant and the material assumes a gritty clay loam texture. The depth of the surface soil is variable, as erosion often thins out the silty covering of the more prominent ridges and elevations, while the material thus eroded is in time transported and deposited in the valleys and on the more gradual slopes, making the accumulation in such places much heavier and the subsoil considerably deeper than is ordinarily found on the more level lands.

The material which goes to make up the type has been derived from the glacial till of the Wisconsin drift. The thin covering of fine silty material which has been deposited over the coarser soil, although primarily of glacial origin, is believed to be an aeolian deposit, or what is commonly known in geology as loess. It is this thin covering, averaging 8 to 12 inches in depth, that is usually considered as the surface soil. The line of demarcation between the surface and subsoil is well marked, the characteristic color and texture being well defined.

The topography of the type varies from gently rolling to level. Because of the slight relief and the close and heavy nature of the soil, natural drainage is not well established. Tile drainage has been found very beneficial and much of this is being done. Many

of the large open ditches which were constructed to drain the black lands furnish a good outlet for laterals in the surrounding uplands.

Although crop yields are often not as high as on other types of soil found in the county, with proper management the average yields amount to about the same. Corn on an average produces about 30 to 40 bushels per acre; wheat 15 to 20 bushels, and oats 20 to 30 bushels. Where the land is fertilized, greater returns than these are secured. Wheat seems to respond more readily to commercial fertilizers than any of the other crops. On account of the lack of organic matter, large quantities of manure should be applied and green manurial crops turned under. Lime should be added to counteract the acidity, as well as to improve the mechanical condition of those parts of the type which are flat and poorly drained.

The rotation usually followed is corn, wheat and clover. Timothy is grown to some extent, and is of good quality. A few patches of alfalfa are to be seen on the type, and where careful preparation of the soil had been made before seeding, good stands were secured. This soil is well adapted to fruit, especially to small fruits such as berries, etc. Although the type was formerly covered with a growth of hardwood, such as maple, white oak, etc., very little standing timber now remains.

This land sells at $125 to $200 per acre. The cash rent usually asked is $6 to $8 per acre but much of the land is leased on the share basis. The rental terms are usually that the tenant furnish the seed grain, except clover seed, and deliver one-half of the products to granary, mow or market.

MECHANICAL ANALYSIS OF MIAMI SILT LOAM.

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt and Clay, Per Cent.
S. E. ¼, S. W. ¼ Sec. 14, Washington Township	Soil	2.36	1.86	7.03	7.33	10.06	71.33
	Subsoil	1.86	2.70	13.60	14.70	9.00	58.13

Miami Loam.

This type of soil is not very extensive. The largest area is found bordering Lick Creek in Licking Township. The surface soil is generally a brownish loam or sandy loam 8 to 10 inches deep, grading into a heavier material at 15 to 36 inches. The subsoil often contains considerable gravel and small stones. Gravel pits are frequently found within the boundaries of the type.

The topography is rolling and undulating. In Section 6 of Licking Township a small level terrace has been included in this type although the material is much coarser than the typical Miami loam. There are also places along Lick Creek where the slopes of the uplands are quite steep and where erosion has carried the greater part of the light silt and clay away and left the coarser material exposed. Such places are too small in extent to map and have been included in the general type.

This soil is used for the growing of all general crops. Corn, wheat, oats, alfalfa and timothy all make fair yields, but the average is not as high as for that of the black lands or the Miami silt loam. Because of the comparatively light structure and coarse texture, crops mature several days sooner on this land than on the heavier types. On the more sandy areas, especially where deposits of gravel underlie the type, crops often suffer from drought.

Few farms are made up of this type alone. The price of such land would average about the same as that of the Miami silt loam.

MECHANICAL ANALYSIS OF MIAMI LOAM.

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt and Clay, Per Cent.
S. E. ¼, N. W. ¼, Sec. 22 Licking Township	Soil	1.20	.80	6.60	2.66	9.66	80.00
	Subsoil	11.40	4.33	22.50	22.96	9.10	29.69

Clyde Silty Clay Loam.

The Clyde silty clay loam consists of a silty clay loam, black in color and containing a high percentage of organic matter. The first 10 inches, which is the average depth of the surface soil, contains less clay than the subsoil and is much darker in color. From

10 to 30 inches the material is a stiff, dark gray mottled clay loam. The soil is heavy, and when wet is stiff and plastic and difficult to work. Very few stones or pebbles are found on the surface or in the subsoil. Lime nodules are frequently encountered below 6 or 8 inches.

The surface of the type is level and represents low flat areas that were formerly poorly drained.

The type occurs in all parts of the county. The larger areas, however, are found in Harrison and Washington Townships and along Big Lick Creek in Jackson Township. Numerous irregular strips that were too small to indicate on the soil map have been ignored and included in the type with which they were associated.

The Clyde silty clay loam is the best agricultural land in the county, and is especially adapted to corn. Corn yields 40 to 80 bushels per acre. Oats and wheat do well and alfalfa has been found to make an excellent growth where the land was well drained.

Very little fertilizer is used. With good management the fertility of the soil can be easily maintained. Probably no other soil in the county will stand the continual cropping and still produce such good yields. Corn has been grown for six or eight years without any rotation and fair yields still obtain.

As has been mentioned elsewhere, the subsoil often contains lime which can be reached by deep plowing, but where this is not the case an application of this amendment will be necessary. From 10 to 20 bushels per acre every few years should correct the trouble.

The price of this type of soil ranges from $125 to $250 an acre, depending upon location and improvements.

MECHANICAL ANALYSIS OF CLYDE SILTY CLAY LOAM.

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt and Clay, Per Cent.
S. W. ¼, S. W. ¼, Sec. 30 Harrison Township	Soil	.00	.00	.30	.31	1.50	94.93
	Subsoil	.00	.00	.13	.20	2.30	96.70

Alluvium.

This type of soil is so variable in structure and texture that no definite description can be given of the type as a whole. Ordinarily, however, the surface and subsoil to at least 36 inches consist of a dark brown loam or sandy loam containing a high percentage of organic matter. In the immediate vicinity of the uplands where the silt and clay have been washed from the slopes and deposited in the lower levels, the material is much heavier, approaching a silt loam.

Corn is the principal crop grown on the alluvial soil of the county. The yield on this soil is often as high as 60 or 70 bushels. Some portions of this type are poorly drained, and of little agricultural value at present, except for pasture land.

This type is of such limited extent that no great importance is placed on it.

MECHANICAL ANALYSIS OF ALLUVIUM.

Location.	Description.	Fine Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt and Clay, Per Cent.
N. E. ¼, S. W. ¼, Harrison Township	Soil	.56	.43	3.76	20.05	33.56	40.16
	Subsoil	3.50	2.33	12.50	22.33	33.89	23.33

Muck.

The Muck soils of Blackford County consist of black or dark brown decayed organic matter mixed with more or less mineral material such as clay, silt and fine sand. The type occurs in basin-like depressions, somewhat lower than the surrounding upland, and represents the remains of decayed pond vegetation. For years such localities were covered with stagnant water in which reeds, rushes and wild grasses thrived. Where complete decomposition has taken place the plant forms are entirely destroyed, but often peaty deposits are found where the fibrous character is yet discernible.

The depth of this soil is usually more than 36 inches, or greater than the length of the soil auger. In the larger areas or toward the center of the smaller ones, the material is often a number of

feet in depth. The underlying material consists of a bluish or grayish clay, often times containing considerable marl or carbonate of lime.

The county contains numerous tracts of this kind of soil, ranging in size from a few acres to hundreds of acres in extent. The largest areas are to be found northeast of Hartford City, in Sections 2, 3, 4, 7, etc., Jackson Township, and five miles north of this city in Sections 17 and 24 Washington Township. Smaller areas are found in all parts of the county closely associated with the Clyde silty clay loam.

The surface features of the Muck are practically level. When well drained, as most of the areas are, the type is devoted to corn, grass, potatoes and truck. Good yields are usually obtained except in a very dry year when the light material is quite susceptible to drought.

The price asked for the Muck land is about the same as that for the heavier types in the county.

SUMMARY.

Blackford County comprises 168 square miles. It is situated east of the north central part of the State. The county is one of the smallest in Indiana. The topography varies from level to undulating. There is practically no waste land in the county and except for a few small tracts of timber land and a small area of poorly drained land along the creeks, all is under cultivation.

The climatic conditions are favorable for growing all the crops of this latitude. The principal crops grown are corn, wheat, oats, hay and potatoes. Special crops, such as tomatoes, cabbage, onions, etc., are grown for the local market.

Transportation facilities are good. There are two railroads and one interurban line passing through the county. The wagon roads are in good condition, many of them being graded with crushed stone.

Besides being a good agricultural county, there are several industries in the territory. Hartford City, the county seat, and Montpelier, the next largest town, support numerous factories, among which the most important are glass factories, paper mills, a steel plant, brick and tile works, etc.

There are five types of soil found in the county. The Miami silt loam and the Clyde silty clay loam occupy the most extensive areas. Hundreds of acres of Muck are also found. The Miami

loam is small in extent and represents the eroded land along the streams and a few morainic hills south of Hartford City. The Alluvium is a minor type found bordering Lick Creek and the Salamonie River. The soils of this county are fertile, and with proper management and care their fertility can be maintained. With adequate drainage, attention to rotation of crops, and, in certain cases, fertilization, there is no question as to the carrying on of permanent agriculture in all parts of the area.

It is very hard to suggest just what fertilizers are required for any type of soil described in this report. Even a chemical analysis will not answer fully for a given type as a whole. Careful study and experiments carried on by the farmer himself should disclose whether his particular soil is deficient in any of the elements required for plant growth. It might be said, however, that all the land in Blackford County would be greatly benefited by an application of slaked lime or ground limestone. Numerous tests made both on the light colored clay lands and the black lands of the depressions and bottoms show that the soil is oftentimes decidedly acid and sour.

LETTER OF TRANSMITTAL.

DEPARTMENT OF GEOLOGY, BLOOMINGTON, IND.,
February 5, 1914.

Mr. Edward Barrett, State Geologist, Indianapolis, Ind.:

DEAR SIR—I have the honor to submit herewith my report of the Soil Survey of Vermillion County, based upon the field work of 1913. Supplemental papers and photographic views give added detail to various phases of the industries of the county, though the principal feature of the work deals with the soil classification and differentiation.

The writer was assisted by Mr. Ralph Hesler, student of Indiana University, and Mr. E. J. Quinn, of Notre Dame University, to whom he gives his appreciation.

Very respectfully submitted

H. N. CORYELL, A. S. S. S.

Soil Survey of Vermillion County.

By H. N. Coryell, Assistant State Geologist.

LOCATION AND DESCRIPTION.

Vermillion County lies on the west bank of the Wabash River thirty miles north of Terre Haute. The Illinois State line forms its west boundary. At no point is this county over ten miles wide nor less than five. It is one of the longest counties of the State and contains approximately 252 square miles.

Topographical features divide the county into three distinct regions: first, the alluvial soils and river bottom; second, the rolling lands; third, the prairies. The first of these is a narrow strip of land that follows the general meanderings of the river. At Clinton it is only a mile wide but gradually widens northward and again returns to the river just north of Hillsdale. Two miles south of Newport the bottom land is one and a half miles wide and retains that width northward to Little Vermillion River. North of this river it widens to two and a half miles. At Dickason the alluvial soils are three and a quarter miles wide and are known locally as the Black Sand Prairie. One mile north of Perryville the terraces end. In the remaining sections northward the alluvial soil consists of only the river bottom deposits of a quarter of a mile or so in width. The Sioux, Wabash and Muck series constitute the soils of the first district and their description will be given in following papers.

The second district lies to the west and adjacent to the first. It consists of the hilly and rolling land. This is spoken of as the upland soils, consisting of the Miami and Carrington series. The forests of Vermillion County grew principally upon these rolling uplands, of which a few wood lots remain, that barely give us more than an idea of the species of trees that composed these early forests.

The third region lies to the west of the second and is not continuous throughout the county from north to south. In fact there are only two districts that make up this division; one lying about Dana in Helt Township and the other about Gessie in Highland Township. These are the prairie regions of Vermillion County,

being the eastern limits of two of the lobes of the Illinois prairie, or Chicago prairie that project into Indiana. Here are located the prize farming lands. Of these three the second has received the least attention, and having been deprived of its forest covering by use and waste so completely, precipitation, that usually finds its way into the soil and flows out into springs, now runs off and becomes an active agent of soil erosion. On steep slopes, gullies, and deep narrow ravines are evidences of the great work that it is able to do. The soil with the available plant food is removed and reclamation becomes a very difficult task. The springs are more intermittent than several years ago and often cease to flow during the summer months. The rougher portions are being turned into blue grass pastures, or, as in a few limited areas the owners have planted vineyards that prove good investments. This vegetative protection conserves moisture, decreases erosion, and assists in restoring the soil to a more fertile state.

POPULATION.

Very few counties have shown so great an increase in the number of its people within the last three or four years as the county of Vermillion, especially the southern townships of Clinton. The following table gives an idea of the rapid increase due to the extensive development of the coal mines and the influx of capital from Chicago for like purposes:

TABLE.	*1913 estimates.*	*1910*	*1900*	*1890*
Clinton Township and cities....	14,000	9,391	5,193	3,609
Clinton City.....	10,000	6,229	2,918	1,365
Fairview	700	630	....	....
Bunsen	750	....	....	....
Rhodes	150	....	....	....
Needmore	50	....	....	....
Centenary	450	....	....	....
Jacksonville	150	....	....	....
Geneva	130	....	....	....
Helt Township and towns.....	4,000	3,543	3,799	3,474
Dana	900	748	893	495
Summit Grove	50	....	....	....
Hillsdale	425	....	....	....
Highland	40	....	....	....
Alta	75	....	....	....
St. Bernice	275	....	....	....
Jones	150	....	....	....
Scissorville	20	....	....	....
Toronto	50	....	....	....

TABLE.	*1913 estimates.*	*1910*	*1900*	*1890*
Vermillion Township and towns.	2,000	1,974	2,089	2,175
Newport	750	732	610	551
Quakers	30	....	....	....
Eugene Township and towns....	2,250	2,112	2,038	1,664
Cayuga	1,000	911	832	....
Eugene	300	....	....	....
Highland Township and towns..	2,100	1,845	2,133	2,232
Perrysville	600	....	....	....
Gessie	250	....	....	....
Rileysburg	30	....	....	....
Vermillion County	24,550	18,865	15,252	13,154

CLINTON CITY.

Clinton, named in honor of the early governor of New York, DeWitt Clinton, was laid out in 1824 by William Harris, who was at that time a resident of Martin County, Indiana; however, the records at Newport show that Clinton was platted and recorded by Lewis P. Rogers on January 8, 1829. This was probably a corrected and legal platting of the original town.

At first the growth of the town was very slow and during the civil war was a mere village. The railroad gave it new impetus and from that time (1868) it has steadily grown to its present size (10,000), based upon stable industries and natural resources. Aside from the mining element, the population is largely American. The former have settled principally in a portion of Clinton known as Italy, and people of that nationality own and operate practically all of the business institutions upon the plan of the progressive American system.

As a residence town Clinton is busily engaged in paving its streets, building walks and erecting new homes. This growing town is not only a desirable place to live, but in a few years it will be a beautiful location. The school system is equal to any in the State and the newly erected buildings furnish ample and modern accommodations. Facilities for developing parks, gardens and a beautiful water front lay at the city's command and no doubt will be taken into account in due time.

The commercial interests may be listed as the extensive coal mining, the agricultural trade and clay industries. These will be discussed at length under separate topics elsewhere. Other industries, as machine shops, shirt factories, flouring mills, ice plants, and many smaller business institutions insure Clinton a steady growth.

Mining Camps.

Throughout the township of Clinton are many mining camps. These have been laid out as small villages and are inhabited for the most part by mixed nationalities. Rhodes, Bunsen, Centenary, Klondike and Jacksonville are among the busy camps. Their people find work in the mines that are sunken close by. The population of these villages fluctuates with the immediate operation of the mines that caused their growth. During a slack season the laborers must shift to other mines and then return during the busy seasons.

Shale outcrops north of Cayuga along Big Vermillion River. The exposure at this place has a depth of 15 feet.

Summit Grove.

Summit Grove is a small village situated on the Chicago and Eastern Illinois Railroad about four miles north of Clinton. It has a population of about fifty. A splendid gravel pit is located here and gravel shipments are the principal local commerce except during the autumn, at which time Summit Grove is a shipping point for the farm crops of wheat, corn and oats.

Hillsdale.

Hillsdale has a population of 425. It is located in the eastern part of Helt township at the junction points of the Chicago and Eastern Illinois, and Cincinnati, Hamilton and Dayton railroads.

It has a splendid view to the east over the Wabash bottom land. It is a beautifully located village upon the Wabash bluffs.

The clay works give ample employment to the people of this town and often it is necessary to employ laborers from other places.

Hillsdale is electrically lighted, the power being furnished by the clay company.

Alta, Highland and West Montezuma.

Alta is really a part of Hillsdale. It is located only a short distance south of the latter town and depends upon it for retail shops and stores.

Highland lies north of Hillsdale. It is a small town, and formerly was an important stage station on the road from Lafayette to Terre Haute. At present it is a small residence village, using the railway station of West Montezuma for all commerce and travel. The latter station is only a flag stop for the Chicago and Eastern Illinois Railroad.

Dana.

Dana is located in the best farming district of Vermillion County, being surrounded by level prairie land which produces splendid farm crops of all kinds; corn, oats, clover and wheat are the chief ones. Dana makes a splendid market for the immediate vicinity, though grain elevators are located on the Southern Indiana Railroad, one being just a mile west of Dana, and another two miles south of the first. Thus, ample facilities are afforded the farmer to dispose of his products through the Chicago markets over the Southern Indiana railroad, and through the Indianapolis markets over the Cincinnati, Hamilton and Dayton railroad. The agricultural products are taken up more thoroughly under the soil-type topic.

This town with its 900 population is beautifully planned and makes a most desirable home. It operates its own lighting system, with night service only. The streets are of macadam and in addition are kept oiled during the summer season. Every lot is fronted by practically new cement walks, and uniform rows of shade trees, namely the maple species, give additional beauty to the street and property.

The school system is good, though the building is not fully modern. The business institutions are principally retail shops. The ice plant, elevators, feed mills and electric plant, give work to the laboring class, while the greater number of inhabitants have farms lying near, which furnish a source of income.

Toronto.

Toronto, or "Bono," three miles south of Dana, is one of the early county towns which has ceased growing because of the lack of a railroad. Nevertheless it is in a good locality and furnishes the people a ready access for provisional supplies. A splendid commissioned township high school is located at this place, built upon the consolidated type, and gives great advantage to the young people of the community for a thorough high school education.

Toronto has a population of fifty, most of its people being farmers, either owners or renters.

St. Bernice and Jones.

St. Bernice is located in the southwest part of Helt Township and has a population of about 150. Just east of this place is the older portion called Jones, or Jonestown. It is the older location, and was the only town in this part of the township until the Southern Indiana Railroad was built. The new part is located near the railroad and is now the commercial center for the two.

The elevator and lumber yards are the largest industries.

Newport.

This town lies upon the southern end of the Newport-Engene Terrace and south of Little Vermillion River. It is the county seat and has a population of about 800 which proves to be a busy and enterprising people. In 1913 its first brick street was built, extending from the railroad to the business section. The court house and grounds add to the beauty of the town. The southern part of the corporation lies upon the upland hills and in this part is the well-known "Newport Hill." Newport's chief industry is the extensive clay works of William Dee, a Chicago capitalist. Grain elevators, lumber and coal yards, and sawmills give work to the laboring people. This town is well lighted with night service of electricity from Cayuga.

Cayuga.

Cayuga, formerly Engene Station, has at present a population of more than 1,000. It is a young town and is busily engaged in building permanent improvements. Its industries are a flouring mill and grain elevator, brick works and electric light plant.

Eugene.

Eugene is but another example of how a railroad may kill or make a town. The Toledo, Chicago and Eastern Railroad built its line a little to the south of this village and there started up Cayuga.

In 1887 Eugene had a population of about 500 and its present population is placed at 300. The terrace here is a sandy soil, good for gardening. Good water lies only 18 to 25 feet below the surface. The principal business establishments have moved away, either to Cayuga or some other railroad town. Formerly the milldam north of Engene in the Vermillion River gave power for one of the busiest mills of its day. Engene was an early river port.

Perrysville.

Perrysvile, formerly the largest town in Vermillion County and one of the best early trade centers, is still the largest town of the northern township. It is located upon the terrace bluffs of the Wabash, which at this place approach the bank of the river.

The early trade of Perrysville was drawn for miles overland, as this village was one of the most enterprising river trading posts. Though the town has been improved by the modern methods of street and walk-building, yet, historically it remains an interesting place, where the quaint styles of architecture can be seen in its older buildings both for homes and shops.

Its present business institutions are principally retail shops. A good flouring mill and elevators furnish adequate markets for the crops. The school system is one of the best and includes the graded, common studies and high school work. The principal interest of the major portion of the inhabitants is in the farm lands, either owning them or controlling interests of cultivation and cropping.

Gessie.

Gessie is a village three miles northwest of Perryville, and located on the Chicago and Eastern Illinois Railroad. It has a population of about 250. This town is surrounded by splendid prairie land, that produces the best of farm crops. Gessie furnishes a good local market, and is able to offer the best prices, since over the Chicago and Eastern Illinois Railroad the Chicago markets can be reached within a few hours.

Rileysburg.

This town lies two miles northwest of Gessie and is a local grain market and trading center. It depends upon the good farming land which surrounds it for its commercial life. The Chicago and Eastern Illinois Railroad gives it ready access to the Chicago markets.

It has a population of about 30, most of its people being employed upon the farms or in occupations that are directly connected with farm operations.

Transportation Facilities.

Pioneer Days.—Before the construction of the Wabash canal and the railroads, or even before wagon roads had been provided the Wabash valley was the center of attraction and the Wabash River was the only means of transportation of products and supplies. The towns and villages along this river were thus made the centers of trade. All the adjoining region to the east in Indiana and to the west in Illinois was compelled to bring its produce to the Wabash River for transportation to New Orleans and other southern markets.

At first numerous flatboats of various sizes were loaded with pork, hogs, beef, cattle, corn, wheat, oats and hay and sent southward. Several hundred boats were often sent out of Big Vermillion River from Eugene and Danville in a single season, and often twenty to forty would pass Eugene in a single day during the spring months. The down-river trips were filled with attraction that lured the adventurous youth into the occupation of flatboat commerce. Clinton, Eugene and Perryville were the home of the early captains and each could relate thrilling experiences with the southern Indians and "Murrell's Gang."

The first steamboat made its appearance on the Wabash in 1820, and it was a great and much-talked-of event, creating much public excitement. The flatboats disappeared from the streams and the steamers became a common sight.

In a few years wagon roads were constructed and improved, leading from the river ports to the important settlements farther inland. This was followed by the building of the present railroads which furnish adequate facilities to better markets in the east, west, north and south.

Chicago and Eastern Illinois Railroad.—This railroad was the first to be completed in Vermillion County, being built in 1868-70.

The undertaking gave universal satisfaction to the people, though not to some of the villages along its line. It crossed the Wabash River at Clinton and followed it northward to Perryville, thence northwestward to Danville and Chicago. Being constructed in the interest of the Danville and Terre Haute trade, the local towns were not taken into account and from some of them it was located a mile or more away. Clinton received new life, but many of the smaller towns a short distance from the railroad suffered greatly. Eugene is an example of this sudden change of commercial development. Cayuga (Eugene Station) receives the trade and produce usually brought to Eugene, and now the former has become a thriving in-

Topography of the terraces south of Cayuga. At this place they are over three miles wide.

corporated town. The principal stations along the railroad line are, from the south to north, Clinton, Summit Grove, Hillsdale, Newport, Cayuga, Perrysville, Gessie and Rileysburg. Furnished coaches and adequate accommodations are made for long distance traveling. The local trains give good service to the small stations, making all stops mentioned above

The C. C. C. and St. Louis Railroad.—This railroad under the name of the Wabash was built in 1851-52, but it can scarcely be counted of any great benefit to Vermillion County as one of its railroads. It crosses the extreme northern sections of Highland Township, but makes no regular stops. Less than three miles of main track are in Vermillion County.

Cincinnati, Hamilton and Dayton Railroad.—This railway system crosses the county in the northern part of Helt Township and makes station stops at the junction of the Southern Indiana Railway, Dana, and Hillsdale. Nine and one-half miles of track lie in Vermillion County.

The above company operated this road until the summer of 1912, when it was taken over by the Baltimore and Ohio system.

The Cincinnati, Hamilton and Dayton Railroad is a direct line east to Indianapolis and west to Decatur, Illinois, and places the splendid farming region about Dana and the clay works at Hillsdale in easy access to eastern and western markets.

Toledo, St. Louis and Western Railroad.—This railroad is perhaps better known as the "Cloverleaf." It crosses the county in the southern part of Eugene Township and has eight and one-half miles of main track in the county. The junction of the "Cloverleaf" with the Chicago and Eastern Illinois Railroad is at Cayuga, which is the only station stop. The bridge over the Wabash is the longest on this road, having five spans of one hundred sixty feet each. In the western part of the county the steel trestle work over Vermillion River is a masterful structure, and one of the new improvements.

Southern Indiana Railroad.—The Southern Indiana, or Chicago, Terre Haute and Southeastern, is known as the "Walsh Road." It was built largely through the capital furnished by that noted capitalist of Chicago, John R. Walsh.

This line of railroad, in its course from Chicago to the great coal fields of Indiana runs through Danville and Terre Haute, and en route, it traverses the western part of Vermillion County, with a few stations, including Quakers, West Dana, St. Bernice, Scissorville and Jacksonville. It was projected and completed about 1905. It transports immense quantities of coal and grain. Seventeen miles of track are in this county.

All other railroads have good systems of passenger service throughout their entire lines, but only one train daily carries passengers over this road and it runs only between West Dana, the junction of the Cincinnati, Hamilton and Dayton with the Southern Indiana, and Terre Haute.

Terre Haute, Indianapolis and Eastern Traction Company.—The northern terminus of this electric system is at Clinton. Every hour during the day interurban cars run between Terre Haute and Clinton, making connections with the cars leaving for Indianapolis, Sullivan, and Paris, Illinois. This gives excellent and inexpensive

passenger service. The best modern equipments are used on the limited service. The local accommodations are superior to many short line "runs". The electric railroad handles a great deal of the merchant freight for Clinton, especially that of the fruit and grocery dealers.

The Coal Mining Industry.

This is one of the greatest sources of revenue to the citizens of Vermillion County. The output is prolific and the revenues are large to the operators and people in general, yet the zenith of its development has not fully been reached in every territory. The five mining companies are operating seventeen separate mines and employing more than fifteen hundred men. One of the largest and most thoroughly modern collieries in the United States is located near Clinton, the Bunsen Coal Company, a subsidiary of the United States Steel Corporation. More than three and one-half million dollars are invested in this one plant for mining soft coal. Every modern safety appliance is used for the protection of its employes, while at work in the entries and rooms. The surface accommodations of bath rooms, dressing rooms, etc. are furnished in order to make the mining business enjoyable to everyone. The grounds are planned and cared for like a park. The buildings are of steel and cement. Many other machine mines at present are also equipped with all improved inventions and are able to increase the output immensely.

The table below shows the production of coal in Vermillion County as contrasted with the other great coal-bearing counties of Indiana in 1910. Accompanying the items of production this table also shows the wages paid.

County.	*Tons Mined in 1910.*	*Wages Paid in 1910.*
Sullivan	4,339,173	$3,703,122
Vigo	4,116,981	3,612,856
Greene	3,241,690	2,332,927
Vermillion	1,676,281	1,446,481
Knox	1,045,868	720,091
Clay	948,402	1,064,757
Parke	727,727	780,260
Warrick	701,390	559,108
Pike	599,952	485,978
Vanderburgh	369,987	295,534
Gibson	285,101	235,286
Daviess	72,692	70,986
Total	18,125,244	$15,527,390

The Norton Creek coal mines were among the first opened. They were developed and operated in the early eighties (1884). The company was incorporated under the Wisconsin laws but managed by local parties, Mr. C. P. Walker of Clinton being superintendent. The incorporation included a number of tenant houses, a general mercantile establishment and the mines. This was the beginning of the mining camp now known as Geneva. These mines at present are not operated and many of the buildings are empty.

The following table gives the names of the owners, the geological number of the different coal seams worked, the thickness of the seams, and the depth of the overlaying strata of the Vermillion County mines that are in operation.

Owner.	Name of Mine.	No. Geol. Strata.	Thickness of Seam.	Depth of Overlying Strata.	Railroad Transportation.
Clinton Coal Co.	Crown Hill No. 1	5	4 ft. 10 in.	165 feet.	C. & E. I.
Clinton Coal Co.	Crown Hill No. 2	5	4 ft. 10 in.	155 feet.	C. & E. I.
Clinton Coal Co.	Crown Hill No. 3	3	6 ft.	345 feet.	C. & E. I.
Clinton Coal Co.	Crown Hill No. 4	4	4 ft. 6 in.	249 feet.	C. & E. I.
Clinton Coal Co.	Crown Hill No. 5	5	5 ft.	182 feet.	S. I.
Clinton Coal Co.	Crown Hill No. 6	5	4 ft. 6 in.	190 feet.	S. I.
Oak Hill Coal Co.	Oak Hill No. 1	3	6 ft. 2 in.	353 feet.	C. & E. I.
Oak Hill Coal Co.	Oak Hill No. 2	5	4 ft. 8 in.	149 feet.	C. & E. I.
Oak Hill Coal Co.	Oak Hill No. 5	4	4 ft. 6 in.	.....	C. & E. I.
Oak Hill Coal Co.	Oak Hill No. 8	4	4 ft. 9 in.	.....	C. & E. I.
Oak Hill Coal Co.	Buckeye No. 3	3	7 ft.	300 feet.	C. & E. I.
Oak Hill Coal Co.	Buckeye No. 4	5	5 ft. 4 in.	.....	C. & E. I.
Whitcomb Coal Co.	.....	5	5 ft.	.....	Wagon mine
Bunsen Coal Co.	Universal No. 4	4	4 ft. 10 in.	236 feet.	C. & E. I.
Bunsen Coal Co.	Universal No. 5	5	4 ft. 11 in.	165 feet.	C. & E. I.
Shirkey Coal Co.	Twin Mines No. 1	6	4 ft. 8 in.	.....	S. I.
Shirkey Coal Co.	Twin Mines No. 2	5	5 ft.	.....	S. I.

The following table gives the analysis of 100 pounds of Indiana coal on the basis of combustion.

	Combustible Matter (Pounds)	
Fixed carbon		43.
Volatile carbon	18.	
Available hydrogen	3.3	
Total combustible volatile matter		21.3
Sulphur		3.
Total combustible matter		67.3

		Non-combustible (Pounds)	
Ash		11.4	
Nitrogen	1.1		
Oxygen of water of constitution in gas	7.3		
Hydrogen of water of constitution in gas	.9		
Total inert volatile matter		9.3	
Oxygen in "moisture"	10.7		
Hydrogen in "moisture"	1.3		
Total "moisture"		12.	
Total non-combustible			32.7
Total coal			100.

Outcrops of coal are found around Perrysville and in wells west of that place. The Minshall coal outcrops along Coal Branch in Secs. 21 and 27, T. 18 N., R. 10 W., about five and one-half miles southwest of Perrysville. It is badly split up by partings and in 1913 only two drift mines were in operation. It outcrops again along Vermillion River just a short distance above Eugene, where it has been worked on both sides of the river.

Southwest of Cayuga one mile, coal has been mined at a depth of 80 feet. Along Little Vermillion River the strata of coal lies above the bed of the stream. Wagon mines are in operation in the bluff district one and three-fourths miles southeast of Newport. At Hillsdale it is met with in drillings. An old shaft one mile west of Dana passed through an eleven-foot vein at a depth of about 100 feet. The mine was abandoned. It was necessary to timber the entire roof since the overlying clay formation was not strong enough to furnish a workable roof. In Clinton Township the majority are shaft mines, working seams 3, 4 and 5. Though coal beds are found in nearly all parts of the county, mining is developed on an extensive scale only in the southern part.

Iron Mining.

Iron mining began in Vermillion County in 1839 and continued until 1893. When the hematite beds of Missouri, Tennessee and Georgia were opened it became unprofitable to work the bog iron ore and now none of the fourteen blast furnaces are in operation.

Clay Works of Vermillion County.

It is along the bluffs that border the river terraces that the largest and most available deposits of clay are exposed. The bluffs approach the river closely at Hillsdale and Newport and give added advantages for commercial development. The close proximity of the railway to the clay beds furnishes the necessary transportation facilities. Numerous plants for utilizing these deposits have been built along the bluffs, forming a line of clay-working establishments extending in Vermillion County from Clinton to Cayuga.

The plant farthest south is the Clinton Brick Company, which erected a large factory in 1893 for the manufacturing of vitrified brick from the shales, one and one-half miles northwest of Clinton. The plant now lies at the border of the incorporation of the city and utilizes the clay from the bluffs that lie only a few hundred yards west of the plant. At present this company is specializing in paving brick of excellent quality.

Just south of Hillsdale is a second large clay plant. It is operated by people of Parke County and works an exposure of shales and drift clays of over 100 feet exposure.

The third is situated in a ravine west of the station of West Montezuma, and works a section of very high quality. At the time of opening the section contained:

1. Soil and drift, 5 to 7 feet.
2. Sandstone, 2 to 10 feet.
3. Light gray arenaceous shale, 1 to 6 feet.
4. Coal, 3 to 5 feet, 6 inches.
5. Fire clay, 3 to 4 feet.
6. Blue to drab argillaceous shale, 25 to 30 feet.
7. Concretionary iron carbonate, two banks, 6 inches.
8. Black fissile shale, 2 to 3 feet.
9. Coal, 1 foot.
10. Fire clay (white silicious), 5 to 7 feet.
11. Blue and drab argillaceous shale, 42 feet.
12. Black fissile shale, 2 feet.
13. Coal, 1 foot and 8 inches.
14. Fire clay, 8 feet.

The workable clays of the above section aggregated 90 feet and the coal furnished suitable fuel. At present the section has changed in respect to the items numbered 1, 7, 9, 11 and 13. However, in its entirety the development has given a clear quality of

workable materials and a proof of a permanent supply for many years.

Lying only a short distance north of the latter plant is another. It is situated near the station of Worthy. In many respects in regard to location and supply of material this last plant is quite similar to the one near West Montezuma.

Mr. Dee of Chicago owns and operates the plant at Newport. This is one of the largest plants of the county which specializes in drain tile. The clay beds at this exposure are:

1. Soil and drift, 4 to 10 feet.
2. Arenaceous and fire clay shale, 25 to 40 feet. (The base is not exposed.)

The last plant of the line is situated one-half mile south and three-fourths mile west of Cayuga. The clay used is found 70 to 100 yards from the dry pans, and is hauled into the sheds by tram cars.

The section here is as follows:

1. Soil drift clay, 2 feet.
2. Shaly sandstone, 5 feet.
3. Drab arenaceous shale, 5 feet, 6 inches.
4. Blue arenaceous shale, 7 feet.
5. Fire clay (bottom concealed), 6 feet.

The clay tests chemically to be of low refractory power and burns into a buff front brick of handsome appearance.

The above is the most available deposits of commercial clays of Vermillion County. However, at other places along the Chicago and Eastern Illinois Railroad, the shale is mined and shipped to some point where it is utilized in manufacturing fire clay goods for refractory purposes in the construction of furnaces, crucibles, flues, and where heat resistance is sought.

Agricultural Interests.

Vermillion County has 90 to 95 per cent. of its area in farms and the major portion of this is tillable soil. The hilly portion comprises about 18 per cent. of the farms. It should be kept under permanent vegetation to prevent the erosion. The average value per acre ranges between $50 and $75. The prices of the separate types are given along with their description. The following table gives a few interesting facts for 1910:

Corn.—Acres, 44,934; bushels, 1,739,274.
Oats.—Acres, 18,857; bushels, 598,964.
Wheat.—Acres, 12,242; bushels, 238,455.
Clover Seed.—Bushels, 316.
Potatoes.—Acres, 361; bushels, 34,508.
Timothy.—Acres, 7,364; tons, 9,179.
Clover.—Acres, 1,534; tons, 1,730.

Alfalfa is being tried in several sections of the county, but the writer does not feel that the experimental stage is over and nothing definite could be given as to its permanency as an addi-

Topography of the Miami gravel-loam type. One mile west of Clinton.

tional crop for Vermillion County. Several small plots are doing well, but they are young, being only one or two years old. The dry season of 1913 was a severe test on the recently seeded tracts. However there is little doubt but that a portion of the county could be inoculated and grow thrifty crops of this plant.

Corn, oats, wheat and clover are the leading crops and they are spoken of in connection with the soil types.

Climate and Crop Notes.

The growing season in Vermillion County is amply long for the maturing of all staple crops of the temperate climate. The winters are seldom severe nor are the summers intensely hot. These ex-

treme ranges are shown in the following chart. The information for the chart was gathered at the United States Bureau Station of Climatology, located at Rockville, which is a short distance east of this county, but has, however, practically the same climatical changes.

ROCKVILLE.

Months.	Length Of Record.							
	Mean Monthly Precipitation, 22 Years.	Mean Temperature, Fahrenheit, 22 Years.	Maximum Temperature, F., 22 Years.	Minimum Temperature, F., 22 Years.	Average Snow Fall, 20 Years.	Average Number of Days with .01 Inch Precipitation, 21 Yrs.	Average Date Killing Frost, 16 Years.	Date of Killing Frost, 16 Years.
January	2.5	28	69	-15	4.5	8		
February	2.4	28.6	69	-22	4.8	8		
March	3.6	40.4	85	-3	3.6	10		
April	3.4	52.4	88	19	.2	10	Last in Spring April 27.	
May	4.21	62.4	96	28	Trace.	12	Latest in Spring, May 28.	
June	4.15	71.2	100	34	0	11		
July	3.25	74.8	104	43	0	9		
August	2.88	73.0	101	40	0	7		
September	2.92	67.3	103	26	0	6		Earliest in autumn, Sept. 13.
October	2.27	54.6	92	18	Trace.	7	First in autumn, Oct. 7.	
November	3.50	41.8	75	2	.7	8		
December	2.56	32.1	76	-12	2.4	8		
Annual	37.68	52.2	104	-22	16.2	104		

The western part of the county, notwithstanding its narrowness, has a greater variation of temperature than the eastern. This is affected by the proximity of the Chicago prairie, over which the winds, coming from the west, may pass without much deflection. Then also the Wabash River has a tendency to equalize the temperature ranges of the valley country in the eastern portion.

Abundant precipitation falls during the spring and summer months to insure adequate moisture for the seeding and growing seasons.

In reference to corn the seeding is done in the early part of the month of May, the definiteness of time being governed by the variability of the season changes and the moisture condition. The growing season extends over the summer months. The crop matures in the month of September.

Winter wheat is usually sown from the 10th to the 20th of Sep-

tember. However, wheat that has been sown in October generally gets sufficient growth. The land sown in wheat should be visited by a killing frost a few weeks after the wheat comes through the ground in order to insure its safety of becoming infected with the "fly" or other noxious insects.

Oats are sown upon "corn stubble" field or "fallow" ground as soon as the freeze is out of the ground and it becomes sufficiently dry to work. The exact date for this seeding ranges greatly, due principally to the amount of moisture and late freezes. Usually, however, the fields are prepared and seeded during the first weeks of April and occasionally during the last of March.

The harvesting of the wheat and oats follow each other in succession during the month of July.

Drainage.—The drainage of Vermillion County is made very simple since the Wabash forms the eastern boundary. No point of Vermillion County is more than 10 miles from this river. All principal streams flow to the southeastward and empty into the Wabash. The larger streams named from north to south are as follows: Spring Creek, Vermillion River, Little Vermillion River, Norton Creek, Brouilette Creek. Vermillion River was used for power during the early days, being employed in turning a water wheel at an old mill which formerly stood near where the Eugene bridge now spans that stream.

The first and second divisions of the county according to the topographical features, spoken of in a former paper in this report, are well drained. The latter is seldom tiled, being the rolling Miami series, and constituting the previously forested area of the county. The level portions of the upland should be drained artificially, which would assist in removing the sourness of these soils.

In the prairie districts artificial drainage must be depended upon altogether. The surface is flat with a gentle slope to the southwest. Artificial open ditches drain the lower portions and tile drains lead from these. These prairie soils should be well drained to prevent stagnation of the water in the soil and produce a condition that is commonly known as "alkaline." In Vermillion County only a very small area is affected thus, which can be corrected by drainage alone. For the most part the prairies are well improved and owned by people who know that improvements and care of the soil are good investments.

The Liming of Soils.—The recognition of the agricultural value of certain forms of lime is not new. It has been used for soil im-

provement since the beginning of agricultural history. In England, Germany, France and other European countries the application of lime in various forms has been and still is used extensively. Lime together with some phosphate usually causes a complete change in the poorest of soils, so that for a time cultivated crops do well. The early lime fertilizers were the native deposits of chalk or marl, though very finely ground limestone or thoroughly air-slacked lime are more available and are practically identical to the first two so far as the calcium carbonate is concerned as a constituent. It makes no difference what form of limestone is applied to the soil the subsequent benefit during the following months or years is due to the same slacked lime or calcium carbonate.

These facts alone favor the use of good natural limestone ground to a fine flour.

The burnt lime or caustic lime stimulates the soil, destroys its texture and eats away the available foods of the soil by chemical action. The crops following such an application of fertilizer may be better than the previous ones, yet the depletion of the soil does not approve of such stimulation and eventually the production becomes unprofitable and the soil practically barren. The action of burnt lime, or quick lime upon one's hand is sufficiently familiar to all and shows its method of attack upon organic substances in the soil.

For further enrichment of the soil, it is necessary that the legume is grown. These, cowpeas, soybean, clover, alfalfa and vetch will not grow well upon acid soils. Lime is very desirable to sweeten the sour soils and to assist the growth of the root-tubercle bacteria. Farm manure or other fertilizers will make it possible for the legume plants to grow, but the development of the bacteria is retarded because of the acid soil.

The effects of liming land are due to two distinct chemical properties: first, to its basic property in neutralizing the acidity of the soil and making it possible to grow plants whose roots are the homes of nitrogen-gathering bacteria and bring the nitrogen from the air into an available form of plant food; second, to its caustic properties, lime decomposes and destroys the humus and liberates and reduces the stock of plant food stored in the soil. The last effect of lime upon soils may be used to an advantage upon peaty deposits in order to hasten the process of decay, but yet in such reaction of caustic lime the nitrogenous plant foods are liberated and escape from the soil.

The following experiment shows the different reports of different kinds of lime.

The experimental field was on a farm tilled for seventy-five years with careless management.

	Produce in Eleven Years.		
Kinds of Lime Used	Corn (bu.) 4 crops.	Wheat (bu.) 3 crops.	Hays (tons) 4 crops.
None	98	32	2.6
Quick lime from stone	128	32	3.09
Quick lime from shells	129	34	3.82
Lime as ground shells	148	42	3.97
Lime as shell marl or well slacked lime or powdered limestone	145	43	4.29

In the case of using limestone the magnesium limestone should be discarded. The magnesium carbonate contained in such stone proves injurious to the roots of plants. A method of differentiating it from the purer limestone may be made by noting the fact that it is heavier than the limestone and will not effervesce vigorously when cold hydrochloric (muratic) acid is dropped upon its surface. On the contrary pure calcium carbonate decomposes vigorously when an acid is applied.

The frequency with which liming should be practiced depends, among other things, upon the character of the soil and the rate of application, the number of years involved, in the rotation practiced, the plants grown and their order of succession. As a general rule, it may be stated that from one-half to one and one-half tons of lime per acre every five or six years is sufficient. Applications of two or three tons may, however, be advisable in case of very acid soils which are to be seeded down and to remain in grass for several years. The practice of applying small amounts of lime at somewhat frequent intervals is being generally accepted as preferable to the use of large amounts at rare intervals.

Lime in the form of carbonate of lime (limestone) or marl can be applied in the spring or at any season of the year, but the autumn is always the safest time to apply the caustic or slacked lime. It is generally considered best to apply the lime to the soil immediately after plowing, and harrow in thoroughly. Lime which is already slacked may be spread upon the soil directly from wagons or by the use of a lime spreader or fertilizer attachment. Burnt (quick) lime should be well slacked before spread upon the soil

Gas-house lime, if used at all, should be weathered for some time in the open air before it is incorporated with the soil. The sulphur compounds which it contains are injurious to plants.

Lime alone should not be depended upon to maintain the fertility of the soil, for all of the ingredients which plants need must be present in the soil to insure the profitable production of crops.

Late Crops.—On nearly all farms every year are a few acres of spare ground that can be profitably planted in some late crop. Several good crops for late feed can be planted from the first to the middle of July if there is ground to spare and everything is in

One of Vermillion County's modern country homes. Private water-supply lake for the general farm use, and home conveniences.

readiness when spare times comes for the work. One advantage in the late crop is that the weather is warm and favorable for rapid growth and early maturity.

One of the good late crops that can be planted in midsummer is cowpeas, which may go into the ground any time from the first weeks of June till the last weeks of July. The crop planted in midsummer with favorable soil conditions will mature in from eight to ten weeks, and be ready for harvest and storage before frost. Millet may be planted either with the cowpeas or separately, maturing in about the same length of time. Land intended for fall seeding of wheat, rye or grass may be planted in cowpeas in the middle of the summer, and the seed or grain drilled in the field as soon as the

crop of peas is harvested. This will save one plowing and the extra working of the soil for fall seeding.

Standard maturing or large sweet corn, also early maturing varieties of standard field corn, can be planted in midsummer and make the best of fodder for late fall feeding. If frost is late much good sound corn will be secured. A few acres of this late corn will produce enough good fodder for a large number of animals for several weeks, thus saving hay and grain in storage. It can be planted and tended with scarcely missing the time.

Sorghum and Kaffir corn are other good crops for mid or late summer planting. On good ground these crops grow wonderfully fast after once making a start and they will yield immense amounts of succulent green fodder for fall and early winter feeding. Both are excellent drought-resisting crops, yet they grow extremely fast and thick under the stimulus of the late summer or early fall rains.

Of the taller growing plants, as a rule, the best general results will be secured by planting the spare ground in sweet corn in the middle of the summer. In the planting of a few acres of sweet corn or some variety of very early maturing field corn, the regular corn crop may be saved for later feeding or for marketing. Corn has now risen to such good prices that it is well to save this valuable crop as much as possible for marketing some of the grain for cash, unless plenty of animals are kept on the farm to consume it. The late planted sweet corn for home use will make practically as much good feed as the early planted standard field corn, acre for acre, and in this way will be of as much value as the early corn. Sweet corn, using all the plant when just past the roasting ear stage, makes the best kind of feed and with it stock will do well.

Where one has either a large or small patch of early potatoes, early maturing corn may be planted between the rows at the last cultivation of the potatoes and the crop will mature for good home feeding before frost. If the potato field is clean and the vines do not cover all the ground between the rows the corn will come up and grow very fast with scarcely any cultivation. If the potatoes are dug and marketed early the corn may be cultivated to advantage after the potatoes are out of the way.

Vetch.—Along with cowpeas and soybeans, another legume that is attracting considerable attention just now is vetch. This plant has been known and cultivated in the old world from time immemorial, and for the last few years has been grown in various parts of this country.

There are two varieties among the cultivated forms, the summer and winter types. The former is sown in the spring and harvested late in the summer, while the latter being perfectly hardy, is usually sown in the fall and harvested the summer following. The latter variety is as hardy and cold-resisting as wheat or rye, with which it is usually sown, and affords pasturage during the winter and early spring when nothing else is available. Even during the heavy snows of our northern winters, the green tops project above the snow and are greedily eaten by all kinds of stock.

The various experiment stations throughout the country have been experimenting with this plant for several years and recommend the winter variety for sowing with rye as a pasture and soiling crop, and as a green manuring crop, to plow under the following spring.

As a soil renovator, the plant has few equals, since it will grow on the poorest of soils, preventing washing and leaching during the rainy seasons, and makes a rank growth to plow under in the spring.

The vetch belongs to the same family of plants as the pea and clover, resembling the former in its habits of growth and general appearance. It grows about three feet high ordinarily, although occasionally on good soil it reaches a height of five or six feet. Some plants have been found growing with oats and field peas in central Indiana recently, fully five feet in length.

The seeds or peas are smaller than the field peas and are black in color, resembling somewhat the seed of sweet peas.

It makes an excellent hay when grown with wheat or rye to hold the plant up, but its rank growth and vining habits unfit it for a hay crop when grown alone. Probably its greatest value will be found as a pasture crop with rye and as a green manure crop to plow under to add humus to the soil.

The greatest drawback at present is the scarcity and high price of the seed, but a small plot will furnish enough seed for several acres, and when more generally grown this difficulty will be overcome.

The Michigan Experiment Station reports a considerable acreage grown in that State and in every case the plant withstood the winters perfectly and furnished abundant winter and spring pasturage.

The time has come when legumes of some kind must be grown, not only for pasturage and hay, but for the beneficial effects on the

soil, and winter vetch is one that will fit in perfectly with the small plots of rye sown every year, and will assist in maintaining soil fertility and return a profit at the same time.

We cannot always continue to take from the soil, unless we put something back into the soil from which to draw. Fertility is limited, and like a bank account, it must be replenished or a time will come when our drafts will not be honored. For this purpose legumes must and will be grown.

SOILS.

MIAMI SERIES.

The soils known as the Miami series consist of three types; namely, Miami Silt Loam, Miami Gravelly Loam and Miami Loam. They comprise the upland soils and in Vermillion County the forest lands. Often phases of these series are locally known as "sugar tree land," and in the virgin state is a productive soil. The general color ranges from a pale gray to dark gray and the texture of the surface is fine powdery silt to a loamy silt with coarse gravel. The Miami soils are the best blue grass lands of Vermillion County. The level portions make splendid farms, producing profitable crops of wheat, corn and oats. The quality of the Miami types of soil for fruit raising cannot be excelled by any other type of soil in the county. A number of large orchards and vineyards show what possibilities these types offer the horticulturist.

The areas of the Miami Series are given in the following table:

MIAMI SERIES.

Types.	*Areas.*
Miami Silt Loam	75 square miles
Miami Gravelly Loam	55 square miles
Miami Loam	3 square miles
Total of Miami Series	133 square miles

MIAMI SILT LOAM.

As found in Vermillion County the surface soil of the Miami silt loam to the depth of 8 to 12 inches consists of a grayish to yellowish brown silt loam. This is underlaid by a yellowish silty clay loam to a depth of 18 to 20 inches, where a yellowish brown gritty clay loam is encountered, to dark plastic clay. The soil and subsoil have a dense, close structure, as well as a fine texture.

In the southern part of the county the soil is not quite so silty as elsewhere; the subsoil is somewhat heavier and contains more clay than the type as a whole.

In the central township where the individual tracts are large the soil is very floury in appearance, being very silty and of a whitish color. These areas are rather low in organic matter and less productive than the same types farther north in this county. The Miami silt loam is an easier soil to cultivate than the clay loams and can be worked under a wider range of moisture conditions. Cultivation when wet causes some baking and clodding, and of

One of Vermillion County's big springs improved for public service. A favorite spot on the Perrysville-Covington road.

course this should be avoided as much as possible. The physical character of this soil is such that good mulch can be kept on the surface by judicious cultivation and a very loose and mellow seed bed secured. The Miami silt loam is one of the most extensive and important types in the county. It extends from the northern to the southern boundary in isolated tracts associated with other types of the Miami series. The topography varies from level to gently undulating. In places it is rolling and especially near the division of this type with the more hilly Miami gravel-loam. On the more rolling portions a sod of some grass or clover should be maintained to prevent or at least decrease the surface wash and possibilities of gullying. Fall plowing for spring tillage is inadvisable, as the

surface then puddles and makes the preparation of a seed bed almost impossible without replowing. Also leaching of the soil by the percolating water of the winter rains, and the possibilities of gullying are greatly increased. The rains during the seeding season cause a compact crusting upon the surface which often prevents a good stand of intertillage crops even when the proper care has been taken in all other preparatory necessities.

The fine structure and texture of the Miami silt loam makes under drainage inadequate. The narrow land dead furrows are used as shallow surface drainage ditches. Artificial drainage of numerous tiled ditches paralleling each other only a few yards apart would give immediate evidence that the soil had been benefited by the removal of the stagnant underground water that contains a great per cent of the soluble acid constituent of the soil, and give means for better aeration. Liming the land is an immediate remedy for "sour soils"; however, it does not increase measurably the needed plant food. The calcium would be added in excess and react with the acid to transform perhaps the hydrogen into available compounds though the much needed potash and phosphorous elements would be lacking in sufficient abundance.

The removal of the excess ground water would lengthen the period of cultivation and give opportunity for more thorough tillage methods, and consequently better control the moisture conditions in time of drought as well as in times of excessive rainfall. The original forest of beech, oak, hickory, maple, walnut, etc., have been mostly cut away and leaving the type "cleared" for cultivation. The Miami silt loam is especially adapted to the production of hay, yielding from one to two and one-half tons per acre. The best yielding fields are sown in a mixture of clover and timothy. After the meadow has been cut over from two to four seasons the sod should be harrowed and reseeded without plowing, or a rotation of crops to corn and clover would be beneficial to the soil, rolling the meadows in the early spring as soon as the ground is firm enough to enter upon with the necessary tools.

Even though this soil cannot be called a "corn soil" in its natural state, excellent crops of this grain have been produced upon the more improved portions. The average yield, however, is not over 30 to 40 bushels to the acre. Oats usually yield about 40 bushels per acre. The better managed portions of the Miami silt loam yield from 60 to 80 bushels of corn, oats from 40 to 50 bushels, and hay seldom less than two tons per acre,

The farming practices upon this soil are not as good as they should be. More organic matter should be introduced into the soil either by green manuring or by utilizing the refuse of the stables. This would improve the soil as to its ability to hold moisture and make the structure easier to manage in preparing for seeding.

Careful restriction of the soil to those crops for which it is adapted will also tend to make farming upon it safer and more profitable. The value of this type ranges from $30 to $60 an acre in the poorer condition to $75 to $100 for the well improved portion.

The following is the table showing the mechanical analysis of the Miami silt loam.

MIAMI SILT LOAM FROM SECTION 21, T. 19 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-10	1.2	5.4	11.4	13.4	18.5	31.4	18.7
Subsoil	10-30	2.4	7.1	14.3	15.5	11.5	24.6	24.6

Miami Gravel Loam.

The Miami gravel loam as found in Vermillion County is subject to considerable variation. The greater part of it occurs in Clinton and Eugene townships and differs in composition, according to the contiguity of large areas of the Miami silt loam type from which the soil of the former receives the surface wash, and any lodgment would locally cause noticeable variation in the composition chemically and physically. The most extensive areas of this type are a light brown to yellow gravel loam containing a great amount of silt. The clay constituent of the soil is heavy wherever it becomes thin and the coarse gravelly subsoil contains a heavy per cent of clay even to such an extent that it is used in the clay works along with the Merom shales upon which it lies.

The underlying shales have but little to do in influencing the chemical variation of the Miami gravel loam. The clay industries are located along the eastern bluff line of this type where the shales often outcrop in ravines and steep hillsides. Some difficulty is experienced in cultivating where the gravel is too close to the surface or where the topography is too rough and broken. The gravelly nature of the subsoil makes the type somewhat unretentive of moisture. The clays of the soil produce a firm crust that increases

the amount of "run off" to such an extent that gullying is a characteristic feature of this type.

The areas of the Miami gravel loam in Vermillion County are in the forest district spoken of in a former part of this paper. The heavier phase occurs in the central part of the county, closely associated with the Miami silt loam, and the lighter phase in the southern part in the coal fields. The attention paid to the coal production greatly tends to the neglect of the agriculture development. The coal proves far more remunerative than the soil, but encouragement should be given to the development of the latter in order to gain the greatest income possible.

The Miami gravel loam is splendidly adapted to fruit raising. Orchards, if not extensive, should be found on every farm as an additional source of food and income. The orchards grow well upon the slopes too steep for advantageous tilling. Vineyards are found in the southern part of the county growing upon this type of soil. "Mulching" and stable manure are used in protecting the roots of the vines in winter and it also serves to invigorate the growth in the spring. Other fertilizers are scarcely ever used. Clover makes the best orchard sod where it is possible to get it started. The steepness of the slopes and the readiness of the soil to wash makes the seeding difficult.

Where large areas of this hillocky land is owned by one farmer it is profitably given over to the production of pasturage for cattle and sheep. The number of sheep in the county is limited to a few flocks. On dairying farms the Miami gravel loam is used for permanent pastures. The price of the land ranges from $20 to $50 an acre. The following table gives the mechanical analysis of the Miami gravel loam:

MIAMI GRAVEL LOAM, FROM SECTION 16, T. 14 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0–6	0.0	0.0	6.9	9.0	17.4	28.9	37.8
Subsoil	6–30	3.6	3.7	10.3	22.4	19.5	10.5	40.0

Miami Loam.

The surface soil of the Miami clay loam consists of a brownish-gray silty loam or silty clay loam 8 to 10 inches deep, underlaid

by a yellowish brown clay, which at 24 inches grades into a stiff, tenaceous chocolate-brown gravelly clay. The depth of the surface soil is variable, as erosion has removed from some of the higher elevations the silty covering which has accumulated on the lower slopes to a considerable depth. The surface of the Miami loam is more silty in the southern deposits than elsewhere. There are also a few shallow beds of gravel found in portions of this type.

The Miami loam has a rolling to hilly topography and is used principally for pasture and woodland. However, the leveler tracts respond readily to tillage and produce good yields of corn and truck crops.

The Miami loam is derived largely from the weathering of glacial till, and the surface wash from the higher phases of the Miami series. Though it appears along streams adjacent to the Genesee series, it is derived directly from the glacial debris instead of alluvial deposition, yet a portion may be the product of high water sedimentation. In many places one might suppose that the Miami loam occupied a second or third terrace; however, the deviation disproves this classification, and allying it to the silt loam types of the same glacial and loessial deposition.

MARSHALL SERIES.

In the type list on the map the next series shown is the Marshall. This one is composed of two types, namely, the Marshall black clay loam, and the Marshall silt loam. These two types are found in the prairie districts of the county about Dana in Helt Township and in the northwestern part of Highland Township. The best farm lands of the county are composed of these soils. Corn, wheat, oats and clover are the principal crops.

The topography is gently rolling to flat and also in the absence of native trees the area has a typical prairie appearence.

The area of this series is shown by the following table:

MARSHALL SERIES.

Types.	*Areas.*
Marshall Black Clay Loam	26 square miles
Marshall Silt Loam	12 square miles
Total of Marshall series	38 square miles

Marshall Black Clay Loam.

The Marshall black clay loam of Vermillion County makes up the greater portion of the prairie region about Dana and Gessie.

This is a dark brown to black loam, 10 to 14 inches deep and rests on lighter colored subsoil mottled with yellow streaks and spots of iron stains. The deep subsoil consists of a clay mixed with some sand and gravel. Glacier boulders are found occasionally. The type occupies a gently undulating to rolling country and covers a wide area in the prairie region.

While extensive areas of this type are well drained there are other areas where depressions unfit it for cultivation without arti-

The terraces in the foreground. The upland bluff line at the horizon. One-half mile west of Perrysville.

ficial drainages. Southwest of Dana the type lies in a depressed area and is drained by a shallow open ditch. North and west of Dana the Marshall black clay loam lies so flat that drainage is very difficult, though the artificial drainage employed removes without much delay the excess of water. A few bogs, ponds and swampy depressions remain yet to be drained. Notwithstanding the above difficulties, the methods of improvement of tillage and drainage have made this type one of the best farming districts of Vermillion County. In fact the prairie district is the prize farming region of the county. Wheat, oats, corn and clover are the principal crops.

The corn yields from 65 to 100 bushels per acre; the oats from

40 to 60 bushels, and wheat from 15 to 30 bushels. The maximum and minimum amounts are controlled by the method of tillage and previous care that has been given to the land. Though the land has not been more than a score and a half years under tillage many fields that have received no crop rotation are showing signs of decrease in production. In endeavoring to turn every product of the fields into money the tillers of the soil, many times disinterested in the future of the farms, have robbed the soil of every vestige that was salable. The soil is limited in fertility especially in a few important plant foods, as phosphorus and potassium, and these with o her organic producing elements must be returned to the soil. The best extensive method of returning the majority of these foods is by crop rotation in which a legume plays an important part. The legume assits rapidly to bring the soil to a better condition, especially when the plant is used for green manuring as well as the benefit derived from its roots. This method takes several years to reach the maximum of fertility desired but the movement for the best is permanent. With fertilizers the progress is more rapid; it works as a stimulant as well as adding available food to the soil. A little commercial fertilizer must be added to replace the lost foods that have been taken from the soil by the plants. These would be principally potash and phosphates. If, however, the full utilization is made of the solid and liquid manures of the stables, scarcely any fertilizer at all need be used on such soils as we have in the Marshall black clay loam. The soil is not sour to an injurious extent, but liming would benefit the soil if added in the form described under that head in this paper.

The value of the Marshall black clay loam ranges from $125 to $200 per acre. The improvement in regard to the buildings and fences are excellent. The region stands first in the county in reference to its beautiful country homes and ample storage barns.

The following table gives the mechanical analysis of the Marshall black clay loam:

MARSHALL BLACK LOAM, FROM SECTION 35, T. 16 N., R. 10 W.

Description.	Depth, Inches.	Gravel, Per Cent	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-12	.....	3.1	10.4	18.4	19.7	27.8	20.6
Subsoil	12-30	5.4	4.3	15.6	15.2	17.6	20.4	21.3

Marshall Silt Loam.

Marshall silt loam is found along with the Marshall black loam and possesses some of the general characteristics of the latter.

The type consists of a dark brown silt loam rich in organic matter. It ranges in depth from 10 to 15 inches. The subsoil is a light colored, mottled, silty loam or silty clay.

The drainage is usually good, but artificial drainage cannot be dispensed with altogether in order to get the best results. The topography is level to rolling and appears as broad low hillocks upon the Marshall black clay loam type. The subsoil, retaining moisture well, assists in resisting droughts to a marked degree.

The Marshall silt loam is without doubt one of the most important corn soils in the county. Oats are an important crop, always making splendid yields notwithstanding the variations in weather conditions. In other districts it has proven a valuable soil for the production of alfalfa and sugar beets, and is well adapted to late crops of pears and apples for winter market. Pastures of clover or bluegrass make good "runs" for beef or dairy cattle, and in a few localities it is used for that purpose.

The Marshall silt loam is a soil well adapted to intensive farming. Vegetables for fall and winter market are grown and many other canning products, as tomatoes and sweet corn, yield successfully.

The soil covering, as it does approximately two-fifths of the area of Vermillion County, has been an active figure in bringing about the splendid improvements of that district.

The valuation of the Marshall silt loam ranges from $100 to $200 per acre.

The following is the table showing the mechanical analysis of the Marshall silt loam:

MARSHALL SILT LOAM, FROM SECTION 35, T. 16 N., R. 10 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-12	3.6	1.8	6.1	15.1	25.2	30.8	17.4
Subsoil	12-30	1.6	3.1	4.5	18.2	21.4	27.1	25.1

WABASH SERIES.

The first bottom lands of the Wabash River are classed as the Wabash series. The two types that come under it are the Wabash fine sandy loam and the Wabash loam. Both are river deposits and lie below the high waters of the river. These floods usually come annually, but seldom cover the whole area. The silt deposits during this time tend greatly to enrich the bottom lands so that the continual cropping of corn has but little effect upon the apparent fertility of the soil. Corn and oats are the principal crops upon these types and the former does exceedingly well. The high waters of the spring season do not permit the sowing of winter crops of wheat. The flood either covers or kills the wheat and in places washes it away. The oats are used as a nurse crop for clover, wherever the bottom is not subject to direct wash. Clover grows splendidly upon the Wabash series if not too sandy and subject to too frequent overflow.

The following table gives the area of the Wabash series:

WABASH SERIES.

Types.	*Areas.*
Wabash Fine Sandy Loam	10 square miles
Wabash Loam	11 square miles
Total of Wabash Series	21 square miles

Wabash Fine Sandy Loam.

The Wabash fine sandy loam is a type of the first bottom land along the Wabash River. It extends in a narrow strip along the entire eastern border of the county. It lies adjacent to the river as is shown by the legion of small circles which is used as the differentiative feature upon the map.

It is a light-brown fine sandy loam 10 to 20 inches deep and containing a good proportion of clean fine sand. The subsoil is brownish yellow sand containing only a small per cent of clay and a great amount of coarse sand. This furnishes splendid underdrainage. The entire type is subject to overflow. Artificial drainage is seldom used, since the tiles soon fill with the sandy loam and are useless as underground watercourses. Corn is practically the only crop save small tracts used for trucking in the raising of melons, sweet potatoes and cabbage.

The annual inundation furnishes a new covering of silt soil which acts as a fertilizer and gives the Wabash fine sandy loam almost a permanent fertility.

The more sandy portions suffer from drouth during the weeks of slight rainfall. The corn if "earing" at such a time yields only a stinted ear and ripens or dies early.

The value of this soil ranges between $60 and $100 an acre.

The following table shows the mechanical analysis of the Wabash fine sandy loam.

WABASH FINE SANDY LOAM, FROM SECTION 10, T. 14 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-16	0.5	2.2	4.1	15.9	55.7	8.8	12.8
Subsoil	16-36	3.1	6.1	8.7	15.8	47.1	8.2	11.0

Wabash Loam.

The Wabash loam consists of a dark-brown to a black sandy loam of rather coarse texture and extends to the depth of 10 to 14 inches. The subsoil is similar in color to the soil save being a shade lighter because a slight deficiency in organic material. Farther back from the Wabash fine silt loam the Wabash loam has a lighter appearance.

This type lies adjacent to the Wabash fine sandy loam and is almost continuous throughout the extent of the county. The terrace approaches closely to the river at Clinton, Worthy and Perrysville for its formation. In those places the Sioux series and the Wabash fine sandy loam lie adjacent.

The Wabash loam is one of the best bottom lands for corn, raising from 60 to 80 bushels per acre.

The type is covered by the overflow partly if not wholly sometime during every year. This makes it unprofitable to try winter crops as great portions of them would be buried in silt or washed away.

In the lower portions of this type where the water of inundation remains longer than elsewhere, tile drainage is advisable though in every case it would not be profitable, as the outlet of artificial ditches would necessarily cross the Wabash fine sandy loam, at which place the fine sand would soon obstruct the openings and make the labor of tiling useless. Very little of any fertilizer has been used upon this soil. The higher places respond readily to barnyard manure and in those places alone will the full benefit of it be derived as the overflowing water that covers the lower

portions will carry with it a great deal of the available plant food given the ground by the addition of the manure.

The value of the Wabash loam ranges from $75 to $125 per acre. The following is a table showing the mechanical analysis of the Wabash loam:

WABASH LOAM, FROM SECTION 10, T. 17 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0–14	.....	2.6	6.6	10.2	19.7	35.8	25.1
Subsoil	0–30	1.4	3.7	11.2	20.4	30.6	32.6	30.1

Coloma Sands.

The area of Coloma sands in Vermillion County is very limited, being only about one square mile. The greatest area is located Sec. 28, N. W. of Eugene and has a rolling topography. The soil is a sandy loam of grayish color containing a heavy per cent of silt loam. The subsoil is of a more reddish yellow, heavy sandy loam of coarser quality. In cuts along a road traversing this type of soil, that had been recently graveled, is exposed a layer of heavy plastic bowlder clay that contains a great amount of gravel and locally merges into gravel substratum. This lower substratum assists in the underdrainage, and in occasions of a few weeks of slight rainfall is even a detriment to the crop yield. This soil is moderately well suited to sugar beets and other trucking crops. Corn, oats, wheat and potatoes give fair yields, especially during a year of regular precipitation. Green manuring should be practiced in order to maintain a proper supply of organic matter. Clover of the deep rooted alfalfa species will be difficult to start upon such a soil; nevertheless, it is proving a good crop when once the spike root reaches to the stratum of permanent moisture. This soil lacks sufficient phosphorus, potassium and nitrogenous compounds, which have been removed more speedily from this soil because of its loose texture and hillocky topography.

Waverly Loam.

The Waverly loam is limited to about one square mile and occurs as first bottom lands along the smaller streams, near the point where they enter the bottom lands of the Wabash River. It

contains some organic substance but not sufficient to give it a black color. In many places it has been leached to a pale whitish soil and apparently has the character of a "water logged" soil. The soil is principally alluvial and often of great depths. It is often quite difficult to determine the division between the soil and subsoil. In color they are alike, and the latter contains more clay and fine gravel than the former. The soil depth ranges from 6 to 8 inches; however, it is not unusual to find areas much deeper. In the subsoil local strata of gravel are found.

Trees that thrive in a wet soil cover this type, namely, the sycamore, willow, soft-maple, water beech, etc. The topography is level, though a portion is somewhat slightly rolling. Open ditches are provided for adequate drainage. Some parts are subject to overflows during the rainy season.

When this type is thoroughly drained and protected from overflows it proves to be a good corn, wheat and forage land. Good meadows occasionally are found upon the higher portions of this type. Truck cropping with cabbage and onions does well, but this soil is not well adapted to tomato raising for canning purposes. The dry rot attacks the tomato before ripening and the blight stunts the plant, preventing it from blossoming.

The Waverly is a sour soil, and deficient in organic foods. Considerable ditching and tile drainage is the first practical step in its improvement, and the good results become evident the first year. Crop rotation with legumes proves an advantage as well as yielding abundant forage. Soils upon which this is not done become unprofitable for the standard crops and relapse back into the marshy stage because of neglect. Well improved areas of this soil produce 30 to 50 bushels of corn; 15 to 20 bushels of wheat and 1 to 1½ tons of timothy per acre. It is well worth while to give it the needed attention.

Genesee Sandy Loam.

The soil of the Genesee sandy loam is found along the entire length of the smaller streams of the county. It consists of about 20 square miles though no part of this type is more than one-half mile wide at any place.

The soil is a light brown soil 6 to 12 inches deep. The subsoil consists of a yellow silt in which are found appreciable amounts of fine sand and gravel. The surface is a humus, easily tilled and can be worked into a fine seed bed. The soil is friable, seldom

crusting after a rain. This type is one of the most important soils for an upland farm. It furnishes a splendid tract that can be used for corn two years out of every three and yet maintain a reasonable fertility. Clover and oats make good crops to com-

Mine tipples of Crown Hill No. 1 (in foreground) and No. 3 (in background). No 3 is one of the best equipped mines of the county.

plete the rotation circle with the corn. The greater areas of the Genesee sandy loam lie along the Big and Little Vermillion rivers. In these portions of the county especially is this soil valuable as a corn soil.

The topography is uniformly level, as would be expected from its formation being laid down by the streams. In places the drain-

age is very poor, and standing water does damage to the tillage crops. Artificial drainage should be used as much as possible; however, the outlets for such drainage are not open at all times of the year.

The Genesee loam are first bottom soils and composed of reworked glacial till. The periodic inundations of the small streams assist in building up this type and giving it additional supplies of organic material. The matter of cultivation is made more difficult by the reason of the overflows, as they act as a carrier of weed seeds and also deposit a fine silty film over the surface, which gives them a splendid bed for germination. Thus the task of keeping the corn clean is often an arduous task. Because of the frequent flooding timothy has become a paying crop, principally because it is not so easily damaged by the overflows that bury it only for a few hours. Nevertheless, when the danger of the high waters can be avoided standard crops such as corn, wheat and oats yield extremely well, and also special crops of sweet-corn, beans, peas, tomatoes and beats for canning can be successfully grown.

The value of this soil ranges from $50 to $100 per acre according to its location and to the amount that lies together.

The following table shows the results of the mechanical analysis of the Genesee sandy loam:

GENESEE SANDY LOAM, FROM SECTION 26, T. 17 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-14	0.0	1.8	10.0	20.1	30.4	16.7	11.0
Subsoil	14-36	1.4	2.1	14.9	19.0	22.9	25.0	10.7

Genesee Loam.

The Genesee loam of Vermillion County lies in the valleys of the smaller streams. The entire area is very limited and of not much consequence to the agricultural development of the county. One square mile would include all of the isolated tracts.

This soil is a dark brown loam or silt loam 8 to 16 inches deep underlain by a gray or drab mottled clay loam. This soil, like all alluvial deposits, is stratified, being laid down by water. The soil is relatively uniform and shows a great persistency in maintaining

its own fertility. It is composed of particles which are light and consequently deposited in the more quiet waters farthest from the stream current.

All tracts mapped were formerly timbered with elm, soft-maple and other trees thriving in moist soils, but are now cleared and used either for tillage crops, meadows or pastures.

Corn yields from 40 to 60 bushels per acre; oats, from 30 to 60; and hay, from 1 to 3 tons per acre. Onions, cabbage and other truck crops do well upon this type.

The small tracts in Vermillion County furnish a limited advantage for intensive farming. The soil will react for commercial fertilizer but it is better to furnish the needed plant food by the green manuring, legume culture and clovers where possible. Some potash and phosphoric fertilizer even then could be used beneficially especially on that portion of the type lying above the overflow of the streams. Some organic material is transported to this soil by the overflow and from the inwash of the uplands.

The following is the table showing the mechanical analysis of the Genesee loam:

GENESEE LOAM, FROM SECTION 26, T. 17 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-14	2.7	3.7	2.6	10.9	21.6	37.5	21.0
Subsoil	14-30	5.4	5.7	3.5	12.8	17.9	25.6	29.1

Muck.

In depressed areas or otherwise uneven topography there are in many places areas that were once occupied by lakes of small size and are now outlined principally by the character of their deposits. Organic accumulations of various stages of decay make up the surface soil. It is usually an organic mold that has a tendency to retain a great amount of water during a rainy season but being of such coarse texture the surface will become dry at depths that do injury to the roots of growing plants. Thus, in either wet or dry seasons, this soil produces only very moderate crop yields. Wherever uniform drainage can be made and the excess of plant mold oxidized to a finer soil the muck soils produce good yields of special crops, such as cabbage, onions, celery and other truck crops.

Muck soils are usually deficient in available potassium or potash.

Vermillion County has only a few small tracts of soil of this type, being principally near the Wabash River and along the border of the prairie land west and north of Perryville. In all there is one square mile and some of this can be improved so as to make the best of land for intensive agriculture.

MUCK TAKEN FROM SECTION 7, T. 19 N., R. 9 W.

Description.	Depth, Inches.	Gravel and Organic Matter, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-14	6.4	15.0	6.8	19.6	30.1	21.3	10.2
Subsoil	14-36	10.4	10.7	9.2	15.1	30.7	20.0	11.8

Carrington Black Clay Loam.

The Carrington black clay loam type consists of isolated, irregular areas located in the promiscuously arranged depressions of the Miami series division. It is a black clay soil, very high in organic matter, and is underlain by a dark gray mottled subsoil. The soil and subsoil are of glacial till in addition to the organic loam that has been added to the soil by swamp plant, due to the insufficient drainage which gave them opportunity for a rank growth. The many years of constant accumulation of the plant remaining gave the soil its dark color and fertile quality. Decaying plants liberate to the soil the necessary plant-food for a vigorous vegetation. These types of soil make some of the best productive agricultural lands. When well drained it becomes one of the best corn soils, though because of its perviousness it has not proven a good soil for winter wheat or rye. The soil on freezing has a tendency to be torn apart by the vertical ice crystallization which plays havoc to the roots of the seedling. This has caused the tillage crops of this type to be limited to corn.

Clover does well and produces a very rank growth. Oats grow so rapidly that lodging is caused by the winds.

The Carrington soils yield readily to the seeding preparations; a quality that proves a great advantage to its proficiency. Grasses, as timothy or blue grass, make profitable returns. Some of the best upland meadows are found upon the Carrington black clay loam.

The type is easily differentiated by its dark to black color as seen in the spring of the year and its rank growth of vegetation.

Confusion in Vermillion County, however, may be made with the Marshall series which are found in the prairie region.

The Carrington was formerly a timbered soil, which will assist in its identification. The soils about it are timber-bearing also.

Up to the present time the Carrington soil has given the farmer very little thought concerning its limited fertility; however, many have noticed that the yields of a few years ago were of a better quality and larger than the present. As this has not advanced far, the legumes and clovers will prolong almost indefinitely the present yields, especially by the occasional addition of some phosphate and potash fertilizer.

The Vermillion County area covers nearly five square miles.

SIOUX SERIES.

In the eastern part of Vermillion County are the most beautifully defined terraces. These second bottoms are from 20 to 30 feet above the first bottom land; the division being marked by a distinct bluff throughout the whole extent of the terraces in the county. The western boundary of the series is just as well defined by a distinct bluff line of the rolling uplands (Miami series).

Thus one of the best marked types is outlined even to the untrained eye as a beautiful formation of one massive remain of the work of the glacier drifts. The old bed of the ancient river that drained the melting glacier had a much wider bed through which it meandered than the present stream. The heavy load of sediment of gravel and sand was deposited within this bed, forming the terraces of deep gravel subsoil and sandy soil of the present day. The present first bottom land of the Wabash is therefore very recent deposits geologically made by the streams which has cut down a valley within the gravel deposits. This gives us a brief explanation of the bluff lines that form the east and west boundaries of this type.

Local names are given to different areas of this terrace, according to its geographical location or some peculiar characteristic, as Walnut Mound, Helts, Newport and Sand. These are given in order from the southern to northern portions. The Sioux series is divided into four types shown by different legendary markings and described under the names Sioux Sandy Loam, Sioux Sandy Gravelly Loam, Sioux Loam and Sioux Fine Sandy Loam.

The area of the types and series is given in the following table:

SIOUX SERIES.

Types.	*Areas.*
Sioux Sandy Loam	10 square miles
Sioux Sandy Gravelly Loam	5 square miles
Sioux Loam	4 square miles
Sioux Fine Sandy Loam	6 square miles
Total Sioux Series	25 square miles

Sioux Sandy Loam.

The Sioux sandy loam is a brown coarse to medium sandy loam from 10 to 24 inches deep, containing a great amount of organic material. The color becomes lighter with depth.

The subsoil over wide areas consists of almost pure waterworn gravel which is found at an average depth of 30 inches. The subsoil, however, varies considerably, and the gravel is frequently bedded in a matrix of sandy loam, silty sand or sand. This type makes up the greater portion of the Vermillion County terraces, appearing as it does under various local names.

The topography is undulating to gently rolling and is even too well drained where the gravelly subsoil rises near the surface. The crops show the effect of the scanty rainfall upon this soil more than any described previously. This, however, fits this type especially for early short seasoned crops. It would make a splendid soil for early intensive farming. Yet, because of the rather equal distribution of the rainfall throughout the entire growing season corn produces favorable yields. Hay, alfalfa and oats are uncertain depending altogether upon the moisture conditions. As an average year corn yields from 40 to 60 bushels, oats from 30 to 50 bushels, and wheat from 10 to 20 bushels. The value of the Sioux sandy loam ranges from $80 to $150 per acre.

The following table shows the mechanical analysis of the Sioux sandy loam.

SIOUX SANDY LOAM, FROM SECTION 22, T. 14 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-14	1.1	0.5	30.1	20.0	20.4	15.6	12.4
Subsoil	14-30	5.2	4.1	19.7	26.2	13.7	20.2	10.9

Sioux Sandy Gravelly Loam.

The Sioux sandy gravelly loam consists of about 12 inches of dark brown to black loamy sand or light sandy loam, containing a few small gravel and a considerable amount of organic matter. The sand content is made up of all grades from fine to coarse sand or small gravel, but the medium sand predominates.

The subsoil is composed of layers of gravel and coarse sand which often occur in strata of uniform thickness. The gravel particles vary in size from coarse sand to small cobbles several inches in diameter and the interstial material consists of various grades of sand.

Many commercial gravel banks are opened in this type both along roads that have been paved with the finer gravel and along the Chicago and Eastern Illinois Railroad. However, the largest pit belonging to the Chicago and Eastern Illinois is one of finer gravel opened in the Sioux sand loam type at Dickason.

During a rainy season the Sioux sandy gravelly loam produces good yields, but if a difficiency of rainfall occurs during the growing season or even during the ripening period the crops show the result of lack of moisture.

The crops upon this type are uncertain and give profitable yields only during a moist season.

The value of the land based upon the raising of early maturing crops ranges from $60 to $100 per acre.

Deep rooted plants, as alfalfa or alsike clover, make good permanent pastures and assist in the industry of dairying. In this the soil has proven valuable; however, the seeding is rather difficult. Small tracts of melons are grown upon the soil and the quality produced is excellent.

The following table gives the mechanical analysis of the Sioux sandy gravelly loam:

SIOUX SANDY GRAVELLY LOAM, FROM SECTION 16, T. 18 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0–10	0.0	1.2	3.3	15.5	41.5	15.0	22.6
Subsoil	10–30	4.5	2.4	5.1	11.7	40.3	15.8	20.2

Sioux Loam.

The Sioux loam consists of a brown slightly sandy loam about 18 inches deep. The surface is friable, easily worked, free from stones and coarse gravel.

The subsoil has a depth varying between 20 and 40 inches and consisting of a brownish-yellow loam. This is underlain by a reddish gravelly loam overlying a bed of gravel. The type constitutes the higher terraces and has a level topography. As a general rule in Vermillion County this soil is used for general farm purposes; however, it would prove a favorable type for tillage crops for canning purposes. The area of the county is rather limited, the largest tract being a few miles southwest of Perrysville.

Corn is a favorable crop on this type and produces a good yield. Oats and wheat yield profitably. Small tracts of timothy meadow give a desirable quality of hay, yielding from one and one-half to two tons per acre. This soil is valued at $100 per acre and most of the type in the county is owned by farmers who have made the best of improvements upon it, in regard to buildings and fencing.

The following table shows the mechanical analysis of the Sioux loam:

SIOUX LOAM, FROM SECTION 18, T. 18 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-14	0.2	1.6	5.3	21.1	27.0	33.5	14.3
Subsoil	14-30	0.3	2.4	3.6	10.4	21.1	24.0	10.1

Sioux Fine Sandy Loam.

The Sioux fine sandy loam is composed of a dark-grey or black fine sandy loam soil from 10 to 15 inches deep, containing a relatively high percentage of organic matter. The subsoil is a fine to medium sandy loam of a light brown color. At from 3 to 8 feet below the surface the material changes to sand and gravel. The topography is generally level. This soil occupies the river terraces along with the three previous types and is a good soil for trucking. Tracts of timothy and clover, or blue grass furnished favorable pastures for dairying or beef cattle.

This is also desirable soil for wheat, corn and oats. It is easily prepared for seeding, and is unusually free from excessive growth of weeds.

Small plots of alfalfa are doing well but are not of sufficient age to insure permanency; still there is every advantage in the character of the soil and the location to prove a desirable type for this plant.

The valuation of the Sioux fine sandy loam varies from $80 to $125 per acre.

The following table shows the mechanical analysis of the Sioux fine sandy loam:

SIOUX FINE SANDY LOAM, FROM SECTION 20, T. 18 N., R. 9 W.

Description.	Depth, Inches.	Gravel, Per Cent.	Coarse Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt, Per Cent.	Clay, Per Cent.
Soil	0-12	6.8	4.1	11.6	33.1	13.0	34.7	11.6
Subsoil	12-30	2.0	3.3	12.2	34.6	15.0	21.1	9.8

EXPLANATIONS AND DIRECTIONS FOR THE USE OF THE SOIL MAP.

The soil map has been prepared with especial care and detail so that it may be used readily by anyone. The writer deems it necessary to give a detailed description and exemplary method of searching out and applying the information given. Any farm may be located and described with ease when once the method is understood. The "Legend" on the upper right hand corner should be studied in order to be able to distinguish the conventional signs for homes, churches, schoolhouses, soil divisions, mines, gravel pits, etc. Then, paying no attention to the soil-type identifications, it will be possible to find the home of the farm sought, being also guided by the direction from the nearest town, the roads and sections. For example, west of Highland two and one-half miles there is a road leading to the south, then west; a short distance from the road in Section 32, about the center of the north half there is a square dot that represents a farm home. This one is located in clear portion on the map. The soil type list gives the identification as "Miami Silt Loam." To the west of this house is another type represented by horizontal dash and dot alternately.

In the soil type list it is identified as the "Miami Silt Loam." This is usually rather rolling land.

Just north of the same house flows a little stream and the type that lies in that narrow bottom is represented by fine dots. In the list of types at the left it is named "Genesee Sandy Loam."

After all the types are found that cover the desired territory, then the descriptions of each should be read in the paper headed "Soil Types." Association of these descriptions to the land would indeed be excellent checks upon the information in this report. The scale of miles is given at the bottom of the map and will be a check upon the distance traversed.

Soil Survey of Parke County.

By HAROLD ORAHOOD, of the Indiana Department of Geology.

EARLY HISTORY OF PARKE COUNTY.

Ref. Atlas of Parke County 1874. By A. T. Andreas.

"Parke County was organized, by act of the Legislature, in 1821. It was named in honor of Benjamin Parke, the first member of Congress for the territory, and afterwards territorial judge. * * * The county contains about four hundred and forty square miles, with a population in 1870 of 18,195.

"*Early Settlement.*—The territory now embraced in Parke County began to be settled before the county was organized. It is not positively known who the first settler was, but we have obtained information reaching back nearly sixty years, and including 'old settlers' in nearly every part of the county.

"When the land was sold in the county, an Indian reservation was made, running up and down the Wabash River, from the mouth of Sugar Creek to the mouth of Big Raccoon, and about seven miles in width. Reserve Township now embraces most of the territory. It was all sold with other lands, except what Christmas Dazney, a noted half-breed, inherited near Armiesburg, where he lived as one of the first settlers of that locality.

"The Friends, or Quakers, settled in Penn Township, in about 1825. The settlement increased afterwards, becoming quite numerous. The Friends have a large church and high school at Bloomingdale, the latter under the care of Prof. B. C. Hobbs, who made it a superior school for the education of boys.

"The primitive condition of Parke County at that time (about 1821) may be inferred from the fact that his (Pearly Mitchell) nearest neighbor was four miles away; deer, wolves and bears were plenty, and several bands of the Miami and Kickapoo Indians were still in the neighborhood, and the whole population of Parke County did not exceed one hundred persons."

Parke County is located in the western part of the State. It is bounded on the north by Fountain and Montgomery counties, on the east by Putnam and Montgomery, south by Clay and Vigo, and on the west by the Wabash River. The civil townships are

thirteen in number, and are Liberty, Sugar Creek, Howard, Reserve, Penn, Washington, Green, Wabash, Adams, Union, Florida, Raccoon and Jackson.

Geology and Physiography.

1898. G. H. Ashley, 23d Ann. Rep. Dept. of Geol. and Nat. Resources. Chap. XIX. Parke County. Page 297.

¶424. Section 1. *Drainage and Topography.*—"Parke County abounds in large streams. The Wabash River, flowing along the western border, receives in this county the waters of Coal Creek, Sugar Creek and Raccoon Creek. The latter two streams rise well to the east of this area and carry an abundance of water. All along the eastern side of the Wabash the bottom lands tend to have a width of one or two miles, back of which rise the bluffs from 100 to 250 feet high. Sugar Creek appears to be flowing through a post-glacial channel, as far as the mouth of Rush Creek, its immediate valley being usually narrow and often hemmed in by cliffs of sandstone, yielding many excellent exposures of the coal measure rocks, and affording some of the most picturesque scenery of the State. Its principal tributaries from the north are Rush Creek and Sugar Mill Creek. The latter valley is somewhat of the type of Sugar Creek; the former is thought to have been possibly the preglacial channel of Sugar Creek, and its banks show little but glacial deposits of sand, clay and gravel. From the south side the principal tributary is Roaring Creek, which, in the lower part of its course, winds through a narrow, rocky ravine. Many of the smaller tributaries of Sugar Creek are, over the lower part of their courses, inclosed in rocky gorges with perpendicular or overhanging walls, these gorges being often from 50 to 100 feet deep and sometimes of a less width at the top than their depth, as at Turkey Run.

"Raccoon Creek and its principal tributary, Little Raccoon Creek, occupy their preglacial channels as far as Rosedale, above which point they have broad bottoms and yield but few exposures. These broad bottoms from Rosedale pass southwest into Vigo County, showing the former course of the stream. At present it turns northward at Rosedale and flows nearly parallel, though in an opposite direction, from the Wabash River, emptying into that river at the old mouth of Leatherwood Creek. This part of the channel is comparatively narrow and the side ravines yield numerous exposures, but it appears to have been a channel of

some kind in preglacial times, judging from the fine deposits of gravel exposed along its banks. The principal tributaries are Leatherwood, Rocky Run, Iron Creek, Little Raccoon, with its tributaries, Wiesner's Branch, Williams' Creek and Sand Creek—Stronger's Branch, Rocky Fork, Troutman's Branch and many smaller tributaries.

"As may be judged from the roads shown on the map, the surface of Parke County is much broken, especially in the eastern part, where the divides tend to become sharp-crested ridges. There are, however, all over the county, small, scattered patches of the level land so characteristic of the visit of the glacier."

¶ 427. "Section 2. *Surface Geology.*—Parke County is entirely within the drift-covered area, though as a rule not as deeply buried as the counties to the north. The drift may be said to range between 25 and 75 feet, averaging nearer the former and occasionally running over the latter up to probably 150 feet. Probably the principal reason for the comparative thinness of the drift in this county is the presence of many large streams. These large streams, by cutting deeply, greatly lower the main drainage level, below what it would be with only small streams present. This gives a greater fall to the tributary streams and results in a much more rapid erosion. Away from the influence of these larger streams the conditions are much as in the flat areas of the surrounding counties, and the drift is still often 100 feet or over deep. A terminal moraine crosses the county from east to west across the southern end, producing hummocky topography and unusual depth of drift wherever the erosion has left it undisturbed. Some preglacial channels are found, but not many. Mention of these is made in the detailed description."

¶ 428. "Coxville Sandstone (Merom?).—In the earlier reports much was made of a number of 'conglomerate' (Mansfield sandstone) ridges, supposed to cross the county from east to west, dividing it into a number of bays or basins in which the upper coals were laid down. It was found that what were taken to be ridges of Mansfield sandstone are the sandstone fillings of a deep and broad erosion channel or system of channels carved out of the upper measures. Not only are channels cut down through the measures, but there appears to have been extensive though shallow erosion for some distance on either side of the immediate channel, also filled with sandstone. This erosion has profoundly influenced the amount of workable coal in the county. The filling is best

exposed in section on the northeastern side of Raccoon Creek at Coxville. As yet, it has not been possible to accurately set the time at which this erosion took place and to which the sandstone now filling these ancient valleys was laid down. The evidence points to either a short time after the laying down of Coal VI or to a time entirely subsequent to the deposition of the coal measures proper, or at a time corresponding with the laying down of the Merom sandstone of Sullivan County. The latter theory is considered as best sustained."

¶ 430. *Lower Carboniferous.*—"The Lower Carboniferous underlies the coal measures of the whole county and outcrops in the northeastern part and in the stream valleys over a still larger area. The rocks appear to be the Mitchell to Harrodsburg limestone and the Knobstone, the latter predominating to the north."

¶492. *Coal Measures on Sugar Creek.*—" * * * The coal of this district is very irregular, due apparently to this being in the path of the old Coxville carboniferous river, met with at Silverwood. Not enough detailed work was done to settle this question definitely, but from what was noted we were led to surmise that the old river channel crossed Sugar Creek at Rockville. The resemblance of the sandstone filling to the Mansfield sandstone exposed both up and down the creek and the failure to find just the data needed renders this opinion somewhat doubtful. There is, however, some outside data that tends to confirm that theory; principally, that this old filled channel is plainly exposed at Silverwood, and the appearance of certain sandstones in Sec. 5 of this township (17 N., R. 8 W.) indicate that the channel was not very far away. Evidence of it are next met to the southeast along the middle course of Roaring Creek and in the region of Sand Creek. Rockville is in the line between these places and is moreover the only place along Sugar Creek where such a crossing appears to have taken place. * * *"

¶ 494. *Up Rush Creek.*—"No coal was seen along Rush Creek, whose bluffs generally show only drift, suggesting, as said above, that Sugar Creek may have formerly followed this channel from Kingman. * * *"

¶543. *Location, Etc.*—"This township (14 N., R. 8 W.) is nearly in the southwestern corner of the county and corresponds to the eastern two-thirds of Florida of the civic townships. The southeastern and eastern part of the township is characterized by the broad, level bottoms of Raccoon and Little Raccoon creeks;

this is continued northward as a somewhat narrower valley down Raccoon Creek across the center of the township. The V-shaped area north of the junction of the two creeks is cut up by Iron and Wiesner creeks into three broad rolling divides and two narrow valleys. West of Raccoon Creek is a high, flat tableland, from which rise the hummocks of the terminal moraine that crosses here."

(T. C. Hopkins, 20th Ann. Rep. Dept. of Geol. and Nat. Resources. Pp. 262-263.)

Turkey Run and Vicinity.—"Along Sugar Creek, between the mouth of Sugar Mill Creek and Turkey Run, sandstone outcrops in a number of places, but it is of inferior quality for building purposes. Through the south part of Sec. 28 (17 N., 7 W.) are some bold bluffs of Mansfield sandstone, which contain much iron oxide and false bedding.

"Turkey Run has cut a narrow, winding channel through the Mansfield sandstone 40 to 60 feet deep, with nearly perpendicular and, in places, overhanging bluffs on either side. The stone is yellow and gray in color and contains numerous streaks and patches of iron oxide. While stone for heavy masonry might be obtained here, it is doubtful if first-class building stone could be obtained in paying quantities. The same is true of the stone along Sugar Creek, between Turkey Run and Rocky Hollow, in a less degree, as in some places along the north side of the creek there are patches of considerable extent which appear to be free from the iron blotches. Mr. Hooghkerk reports that in drilling the well at the Turkey Run Hotel the drill passed through:

Gravel and sand	31 feet
Sandstone (Mansfield)	30 feet
Limestone	2 feet
Sandstone, white, fine-grained (Riverside)	30 feet
Total	93 feet

"The limestone is supposed to be Lower Carboniferous and the sandstone overlying it the Mansfield standstone.

"The sandstone in the vicinity of Turkey Run has been deeply scored by the glacier, the sand that has been scraped off being distributed over the region to the south. Glacial striæ bearing south, 37 degrees east, are clearly shown in two places: one about a quarter mile east of the hotel, the other more than half a mile east. This glacial action has scraped off all the disintegrated material

from the top of the sandstone, if any such ever existed, and the fine state of preservation of the striæ shows that there has been no disintegration of the stone at these points since that date, probably several thousand years ago, surely a strong proof of the durability of the stone.

"*Rocky Hollow.*—Rocky Hollow, which lies mostly in the northwest quarter of Sec. 27 (17 N., 7 W.), is a deep, narrow gorge cut into the massive Mansfield sandstone. The walls are so high and precipitous that the gorge can be entered only at the mouth and at the head of a few of the terminal ravines, many of which are cut down so abruptly at the terminus as to be practically inaccessible. No part of the gorge can be traversed except in time of low water. While much of the stone along the bluffs is crossbedded and ferruginous, in a number of places it is free from imperfections and would furnish good buff and gray building stone, should it ever be made accessible to transportation. This deep, winding, rocky gorge, with its precipitous, overhanging, moss-grown walls, is a romantic spot and attracts a great many tourists during the summer months. * * *"

SOILS.

Knox Fine Sand.

This type of soil has a topography comparable to a region occupied by sand dunes. The conspicuous features are the well rounded hillocks and ridges along with the depressions or basins. The dune-like surface along with the porous soil results in a drainage that is extreme. Crops are often affected by deficient moisture in the soil.

The Knox fine sand is made up chiefly of loose, unconnected, relatively fine sand. The organic matter present is usually small The subsoil at a depth of ten to twelve inches is a light brown to yellow sand. Often pockets of extremely loose and incoherent grayish sand are found in the subsoil. The color of the soil varies, in places it is light brown, again it is yellow, this being determined by the amount of organic matter present.

The Knox fine sand is found bordering the Wabash River and on the uplands adjacent first bottoms. There are three regions in which the Knox fine sand is typically developed. In Liberty Township, about Howard, the type occupies uplands. The region is cut in two by Coal Creek, but the sand appears again west of

Waterman and extends to the river bridge at the junction of Fountain and Parke counties.

There are a few springs near the top of one ridge, the water of which stands within four or five feet of the surface during the driest part of summer. In places only a few yards distant from a good shallow well, water can not be reached even at great depths.

In Reserve Township an area of Knox fine sand extends from Montezuma north, being in total length nearly two miles, with an average width of one-half mile. The city of Montezuma is situated on the southern end of this terrace-like formation.

In Wabash Township, extending from the channel of Big Raccoon almost to the Florida Township line, is a long ridge of regular outline. This ridge, although occupying the position of the Knox fine sand, is not typically developed. The undulatory topography is absent and more organic matter present. The slope to the east is gentle, reaching the lowest point about the position of the old canal, from which is rises gradually to the foot of the hills marking the eastern bank of the old river channel.

The third area in which the Knox fine sand is typically developed is north of Lyford, in Florida Township. It is an irregular area about two miles long with an average width of one-half mile. During the flood in the spring of 1913 only the highest points of this area remained above water.

The sand at present is by no means at rest. A strong wind blowing over a dry field unprotected by vegetation, drives the sand before it in sheets, as rain before the variable gusts during a storm. The distant observer might conclude that the wind is carrying dust particles only, but once in the path of the storm one will decide that there are small grains of sand being hurled through the air at terrific speed, as they beat upon the hands and face like so many little pellets of ice, during a storm of sleet.

The side of the stream upon which sand is deposited is determined by the direction of the prevailing winds. Indiana being in the region of the prevailing westerlies, sand is deposited on the eastern banks of streams. With this tangible evidence at hand, one readily concludes, as stated in other reports, that this type of soil is the result of drifting sand by wind action and the origin of this sand the valley of the Wabash River.

When the water of the Wabash River rises to a level with the bottoms of the depressions, water begins to rise in them, and as the water in the river continues to rise, the water in the basins rises.

This indicates the porosity of the sand near the base of the area. Since this is true, the inference is that there is not only a river of moving water in the visible channel, but another less voluminous, moving, however, on either side of the larger one, through the coarser sands toward the uplands. This great underground reservoir, storing away large quantities of water, holding it in reserve from the mighty visible river of water, tends to prevent devastating floods. It returns its water gradually as the water in the river is lowered. This reservoir of unseen water serves to keep the river in normal flood longer as the water returns slowly from these sandy hills. Thus these porous banks are the governors whose tendency is to maintain a normal stream.

Small patches of timber, in which scarlet oak predominates, are scattered over the area. Fruit and truck farming are well adapted to this type of soil. Melons, rye and corn are the principal crops grown. Alfalfa is being successfully grown in parts of the area.

Knox Sand.

The Knox sand occupies a small area in the extreme southern part of the county in the vicinity of Rosedale. The topography is rolling, made up of low rounded hills and ridges.

The soil to a depth of twelve to sixteen inches varies from a brown to a light brown, slightly loamy. The subsoil to a depth of thirty-six inches is an orange-colored sand of about the same texture of the top soil. In structure the subsoil is looser and more incoherent than the top soil. The tops of the ridges contain less organic matter, and a very slight difference exists between the soil and subsoil. In the depressions the soil is darker in color and more loamy, yielding better crops than on the ridges. The sand consists largely of rounded quartz grains. It is of glacial origin, having been reworked by the action of wind and water.

The porosity of this type of soil causes crops to suffer in dry seasons, because of its incapacity to retain moisture. The soil must be supplied freely with barnyard manure or anything that will increase the organic matter in the soil. Corn, wheat and oats produce moderate yields. Hairy vetch of the winter variety is being tried on this type of soil south of Rosedale. Alfalfa should be grown in the depressions where the roots of the plant could reach sufficient moisture.

Carrington Silt Loam.

Only a small area of this type large enough to separate was encountered in Parke County. Small patches formerly occupied by ponds are scattered throughout the Knox silt loam area, but not of sufficient size to separate. In Sugar Creek Township an irregular area consisting of four or five hundred acres, east of Grange Corner, is the only area of Carrington silt loam mapped.

The area was in early times a swamp but now it is well drained. Good yields of corn, hay and other crops are harvested. The ground is too "strong" for oats, it producing a rank growth of straw and the danger of its falling badly before harvest time is encountered. The soil consists of a dark brown to black silt loam. The top soil varies in depth from ten to twelve inches. At this depth the soil changes to a drab-colored subsoil mottled with yellow, the clay content increasing with depth. This type occupies relatively flat areas, natural drainage being poor.

The soil consists of material derived from glacial till mixed with a large quantity of organic matter. Corn yields forty-five to sixty bushels an acre, depending upon the season as well as upon methods of agriculture. When scientific methods of agriculture are followed the result is inevitably shown in the resulting harvest.

The price of land is not so high as would be expected of this type of soil. The reason is not far to seek, as marketing facilities are not good, the area being distant from any railroad accommodations. Land sells for $125 to $135 an acre. Good gravel roads connect this area with the neighboring towns.

Knox Silt Loam.

The Knox silt loam represents the prevailing type of soil in Parke County. The type consists of a light brown or dark gray to a white silt loam. When wet the soil changes to a dull gray. Iron concretions are often apparent on the surface and through the soil. Small areas of this nature are found throughout the area of the Knox silt loam. These iron concretions are noticed more readily in fields that have been plowed and rolled, after heavy rains. They are more conspicuous in wheat fields after being exposed to the freezing of winter and the heavy rains of spring.

Another peculiarity of this class of soils is that in breaking, the plowshare is constantly grating as if passing over small pebbles, but an examination of the bottom of the furrow will show numerous stripes made by the plow in crushing the little nodules of iron.

The grayish color of the soil in which these iron concretions are found is due to the fact that the iron, the coloring matter of the soil, is locked up in this "turkey gravel" or "buckshot," as the concretions are locally known. They are always associated with the light colored soils and one that is poorly drained. The soil is compact, has good absorbent capacity, and though it is seldom covered with water more than a few days at a time, is saturated during most of the winter and spring months. This condition favors the formation of concretions. Thus with the iron oxides formed in these nodules the coloring matter has been withdrawn from the soil, leaving an ashy gray color.

If this quality of soil is well underdrained so as to relieve it of its saturated condition, and give the air thorough access to the soil, these iron pellets will in a few years dissolve and the iron will again become the coloring matter of the soil. The soil will then take on the proper brownish tint that it should have to be a valuable, productive soil.

The soil with the nodules is not in favor with the farmers, it being designated a "cold, sour" soil, which describes its qualities well.

Thorough drainage and use of ground limestone one and a half to two tons to the acre every three or four years will with its high absorbent properties become a very productive soil, one that will be durable and retentive of manures. The native forest trees were beech, oak, hickory and elm. When cultivated under good moisture conditions the soil is loose and easily kept in flour-like condition, but when plowed wet clods of great size and hardness will be formed and are pulverized with difficulty.

In some localities farmers say they are injured more by too much than by scanty rainfall. By deep plowing and intensive, shallow cultivation, good yields of grain are harvested. The surface of the Knox silt loam is loose, with a "flour-like" feel, but a few inches below the surface it becomes compact, puddles easily and runs together. With this difficulty to contend with farmers should be very cautious in regard to working the ground wet. Deep plowing should be practiced. The depth should vary from year to year to avoid the formation of "plowsole," an artificial hard pan.

Reference: "Soils," by Hilgard, p. 186.

"*Plowsole:* An artificial hard pan is very commonly formed under the practice of plowing to the same depth for many consecutive years. The consolidated layer thus created by the action of

the plow (hence known as plowsole) acts precisely like a natural hardpan, and is sometimes the cause of the formation of a cemented subsoil crust simulating the natural product. This is most apt to occur in clayey lands and greatly increases the difficulty of working them, while detracting materially from the higher productiveness commonly attributed to them as compared with sandy lands. Of course it is perfectly easy to prevent this trouble by plowing to different depths in consecutive years and running a subsoil plow from time to time. In this case, also, lime will generally be very useful and be found to aid materially in the disintegration of the "plowsole."

In action the common mouldboard plow is that of a wedge driven through the soil, which separates and overturns the soil above the share while it puddles and compacts the bottom of the furrow over which it slides into a mass, if it is a clay soil, which in a few years becomes almost impervious to water. This layer is impenetrable to the roots of most crops. Sweet clover is very effective in breaking up this hard layer, making waterways and paths for roots weaker in penetrating power.

The primal fertility of the soil without proper crop rotation or the addition of a fertilizer is soon depleted, becoming sterile in a few years. The general condition of soils is now improving under more scientific management. The time is past forever when farmers will continue one field year after year in the same crop. Soils that were unproductive in the memory of many are now yielding abundant crops. Land is being restored from reckless agriculture, to something like its pristine condition, through a proper system of tillage, in which deep plowing and rotation of crops find a prominent place. The example set by the native vegetation should be followed by man as closely as possible. The deep roots bring the mineral substances from the deeper portions of the earth and, by process of decay of the growing vegetation, it is deposited in the upper soil.

In many places at a depth of ten to twelve inches there is encountered a layer of tough clay mottled with light yellow iron stains. This layer is four or five inches thick, below which there is a clay of paler yellow containing more silt, the moisture content being high. This layer must be broken up in order that the moisture can rise and supply the growing vegetation in times of extended drought. Sweet clover will prove a very valuable crop in breaking up this layer, as the strong roots penetrate this hard soil.

The soil auger should be used by every farmer. The subsoil should receive as much attention as the topsoil. If there is a layer beneath the topsoil the farmer should know it and every effort to break it up should be put forth.

Dynamiting is practiced in some localities to break up this hard layer.

Meadow Land.

All lands along smaller streams where little tillable soil is found has been classified as Meadow land. There are a variety of soils represented in this classification. There may be small areas of Wabash silt loam or Wabash gravelly loam and others, but the areas are so small they have all been mapped together. Most of the lowlands along the streams are in pasture and small timber. A great amount of the area is subject to seasonal overflow, being worthless for anything except pasture.

Sioux Sandy Loam and Loam.

The second terrace of the Wabash Valley is in most places very sandy, underlain by coarse gravel at a depth of 16 to 18 inches. In other places the finer sand extends much deeper. The area varies in width from one-half to two miles. The eastern boundary of this area marks the eastern banks of the channel of the old Wabash River. The western boundary of the area is marked by an enormous gravel terrace which extends the full length of the county along the eastern side of the Wabash. It is not continuous throughout, but intermittent, as the area is cut by the channels of a few streams. The surface is rather irregular. The ridges of Knox fine sand appear in places along its western limits. In places the area is very level for great distances. The soils of the area vary considerably in character. In places it is sandy, changing to darker colored soil in which the organic content is high. In some of the lower parts of the area the natural drainage was poor, but artificial drainage has converted the former marshes and swamps into productive fields.

In regions where the sandy loam is typically developed the soil is from brown to black in color, a medium sandy loam, from 10 to 24 inches in depth, containing considerable amount of organic matter. The color lightens with depth. Gravel is found beneath practically the entire area. Extensive gravel pits are worked along the terrace and a great amount of gravel for road material and

railroad ballast is taken from this area. The supply of gravel is almost inexhaustible. The Sioux loam area is usually level and less sand and more silt and clay are found in the soil. The subsoil is of a loamy character to a depth of 24 to 48 inches, where gravel is usually encountered. Drainage conditions are good at present. In places where only a thin coating of soil covers the gravel subdrainage is excessive and crops suffer from drought. When the gravel is covered by three or four feet of soil, moisture is retained and better crops are grown in dry seasons. Corn yields from forty-five to seventy-five bushels an acre. It is an excellent soil for truck farming and fruit growing.

Ancient Soils.

(From 12th Ann. Rept. of Director U. S. Geol. Survey, Part 1, pp. 321-322. By N. S. Shaler.)

"Although the soil-coating of the earth is in a certain way an ephemeral structure and is commonly subjected to immediate destruction where it is affected by the action of the waves, by glacial wearing, or by other violent accidents, some parts of this detrital coating in certain times and places have by chance been preserved to us from a remote geologic past. The first clearly recognizable deposits of this nature are found in the rocks of the Carboniferous age, where, indeed, they plentifully occur; beneath each bed of coal we commonly discover a layer of material which was the soil in which began to grow the plants from whose remains the coal bed was formed. So as far as these coal-producing plants were rooted forms they generally drew their sustenance from these ancient soils. We can still in many instances trace their roots, and occasionally we find the tree, fern or other plant to which they belong standing erect amid the swamp deposits which accumulated about it, and which now appears as coal. These soils of the Coal Measures differ from those now existing on the upland parts of the earth in certain important ways; they are generally of less thickness than are those of today which have been formed under similar conditions, and contain a rather smaller proportion of organic matter. These peculiarities are probably due to the fact that in the olden time there were few kinds of plants which had strong roots, and thus there was less opportunity for vegetable matter to become commingled with the earth.

"The most peculiar feature of these ancient soils consists in the fact that they usually lack those materials, such as potash and

soda, which are a conspicuous and a necessary element in the greater part of the soils of the present time. The general absence of such material has led to the occasional use of these ancient deposits as fire clay, *i. e.*, materials which will endure without melting the high temperature to which they are exposed in furnaces. In any ordinary soil a white heat will cause the siliceous element of the deposit to melt, for the reason that the lime, potash, or soda which it contains will combine with the silica when the mass is greatly heated, thus forming a glass or cinder. It is not likely that the present condition of the Carboniferous soils is that which they exhibited when plants first began to grow upon them; at that time they may have had the usual share of alkaline substances; but the very conditions which made these soils the seat of swamps secured the surface on which they lay from wearing downward in the manner common in ordinary districts, and so prevented the constant renewal from the underlying rock of the materials removed by vegetation. The result was that in time the earth below the swamp accumulation was deprived of the matter which could be removed through the action of plant roots. So far as these plants by their conditions of growth could take up soluble minerals of the soil, they removed them, storing the matter in their stems and leaves. When the plants decayed their waste fell into the peaty accumulation and gradually the mineral matter became leached out and conveyed away to the sea. As there was no means of restoring plant food, the soil gradually lost the power of contributing to the growth of plants. Thus while in the case of ordinary upland soils the process of decay in the underlying rock continually adds to the fertility, while the waste of vegetation is constantly returned to the earth, in most of these swamps of the Carboniferous time, on the contrary, all the conditions serve to pauperize the layer. Owing to various causes, however, some of which are to be noted hereafter, the soils beneath our modern swamps do not in the same complete manner undergo the process of exhaustion."

"It is probable that the progressive removal of the soil matter from beneath the swamps of the Carboniferous period had much influence on the development of the peaty material which in time became converted into coal. The larger part of their Carbonaceous materal was formed from the waste of plants which required a certain amount of mineral matter for their support. This the plants had to obtain through their roots. After the swamp at-

tained a certain thickness, the continual leaching away of these substances would gradually limit the growth of the plants which tenanted the morass, and finally the growth might be entirely arrested by lack of such material to support the vegetation."

MECHANICAL ANALYSIS OF SOILS.

Locality.	Description.	Fine Gravel, Per Cent.	Course Sand, Per Cent.	Medium Sand, Per Cent.	Fine Sand, Per Cent.	Very Fine Sand, Per Cent.	Silt and Clay, Per Cent.	Clay, Per Cent.
Knox Sand. South of Nigger Lake, Prairie, E. Rosedale	Soil	.....	.....	8.1	28.4	29.2	32.4	.....
	Subsoil	.36	.06	2.4	33.3	34.0	28.9	.....
Knox Silt Loam. Mile and a half South of Kingman	Soil	.....	.....	.9	7.6	12.8	77.4	.....
	Subsoil	4.8	1.8	2.9	5.7	11.5	72.7	.....
Knox Fine Sand. At Howard	Soil	.....	.03	.33	15.5	76.5	6.7	.....
	Subsoil	.....	.....	.3	12.7	81.1	5.0	.....
Sioux Sandy Loam. Between Montezuma and Armiesburg	Soil	1.1	.96	9.6	21.7	16.8	45.0	.....
	Subsoil	36.8	5.4	20.1	13.5	9.1	12.4	.....
Carrington Silt Loam. East of Grange Corner two miles	Soil	.3	.....	.4	6.2	4.4	86.2	.....
	Subsoil	.....	.....	.1	4.6	21.6	72.7	.....
Wabash Silt Loam. One-half mile Southwest of Howard	Subsoil	.....	.....	.....	.....	18.0	81.1	.....
	Soil	.....	.....	.5	2.1	2.3	94.7	.....
Wabash Gravelly Loam. East of Rockville, west of pumping station Small area.	Subsoil	9.8	.7	6.0	20.5	22.2	38.2	.....
	Soil	7.0	1.1	5.46	19.5	31.0	34.3	.....
Knox Silt Loam. West of Grange Corner, 2¼ miles	Soil	.....	.1	.7	2.1	26.1	70.2	.....
	Subsoil	.....	.....	5.5	15.9	17.3	60.0	.....

Wabash Township.

A variety of soils are found in this township, as a glance at the map will show. The bottom lands of the Wabash River and Big Raccoon Creek are very productive. The second terrace of the Sioux sandy loam produces enormous crops of corn, wheat and other crops. The soil is loose and easily worked. The uplands are of the Knox silt loam soil. The hills about Mecca contain a great deal of sand, indicating a moraine. Streams flowing out from the front of the glacier are responsible for these sand deposits. Mecca is the only town in the area. Mecca drain and sewer tile made from the deposits of shale and clay at this place are favorably known in several states. Excellent clay and shale deposits are being worked on either side of Big Raccoon at Mecca. At one time a great part of this township was an Indian reservation.

Southeast of Montezuma, about one and a half miles, on the north side of Big Raccoon Creek, a small group of houses marks the position occupied by the army of Gen. W. H. Harrison in the fall of 1811. The army remained here long enough that a small

village started. The site was afterward called Armiesburg, since the army had encamped here. General Harrison was on his way to quell Tecumseh's outbreak, which ended in the battle of Tippecanoe, November 7, 1811. General Harrison had marched from Vincennes along the eastern side of the Wabash, crossed Big Raccoon and camped. From here he marched west, crossed the Wabash and continued his march on that side of the river. He left the old Indian trail he was following, which led through dense forests in many places, as he feared an ambuscade. The other trail, the one he followed, was through more open country.

Adams Township.

This township is centrally located, has the largest city, which is also the county seat. The upland soil is of the Knox silt loam type; the bottom along Little Raccoon is the Wabash silt loam. Northwest of Rockville a short distance there is a small area that is darker, in color approaching the Carrington silt loam type, but the area was not large enough to separate.

The State Tuberculosis Sanitarium is located in this township, three and one-half miles east of Rockville. The grounds and buildings are sanitary in every respect and every help possible is afforded the patients for a speedy and permanent cure. The rules of the institution are very strict and are rigidly enforced. The patients who will not obey the rules of the institution are requested to leave at once. Rest, pure air and wholesome food are the essentials sought in the cure. Medical treatment is given when the patient is in need of it. Regularity of habits, especially rest and sleep, are encouraged, in fact required by the rules of the organization. Spitting upon the grounds and about the buildings by sufferers of tuberculosis is punishable by dismissal. Great good is being accomplished by the Indiana State Tuberculosis Hospital.

Parke County poor farm is located in the northwest portion of the township.

Ref. Atlas of Parke County, 1874. By A. T. Andreas:

"Rockville was laid out in the fall of 1823, and became the permanent county seat of Parke County in 1824. Previous to that courts had been held in Rosedale and Armiesburg. The donors of the land on which Rockville is situated were the first settlers of the town. The circumstance of a large number of rocks of the bowlder description lying on the site, gave it the name of Rock-

ville. It is said that the name was dedicated by breaking a bottle of whisky on one of those bowlders. Be that as it may, the article was not prohibited in those days, nor was there any conscientious scruples about taking a 'dram.' It was a common civility to friends and visitors to set out the decanter or bottle and invite them to help themselves.

"Andrew Ray built the first house, which was a log cabin, situated on the public square. It was a place of entertainment for all land hunters in this section of the county. He also built and opened the first tavern in the place, in 1824.

"Being an inland town, some eight miles from the Wabash River, and accessible only by bad, muddy roads, the growth of Rockville was quite slow for many years, as was the surrounding country."

Rockville today has a population of nearly 2,000. Many fine residences and business houses show that energy and push are the characteristics of its citizens.

Washington Township.

The major part of this township is composed of the Knox silt loam type of soil typically developed, especially in the vicinity of Marshall. When natural drainage is good, not excessive, the soil is friable, loose and open textured, soft and flour-like to the touch; few if any iron concretions on the surface. The lowlands south of Judson furnish fields of corn, wheat and hay in abundance. Glacial bowlders are scattered over the surface of the land between Judson and Guion, west of the railroad and on the uplands.

One mile north of Marshall the water from a weak spring has been piped to a cement trough at the side of the road. In regions where springs abound more attention should be given to furnishing the public highway with these conveniences. The public appreciates these seemingly little things. The township should furnish the cement without hesitation and the remainder of the work would no doubt be gladly supplied by men living near the spring to be improved.

West of Marshall three-fourths of a mile, there is a depression in the land presenting very much the appearance of an old valley. Its outlet apparently was to the southwest by way of Leatherwood. Some black soil near the center of the area indicates that it was swampy for a long time. At the north small tributaries to Roaring Creek have cut through the higher rim. One explanation for

its presence is that during the glacial period a mass of ice was buried here and after the retreat of the glacier the mass of ice melted leaving the surface of the land lower here than in the immediate vicinity. This would account for the area being a lake and swamp for a long time. During that time decayed vegetable matter accumulated, which resulted in giving the soil the dark color. When the area was drained by encroaching streams it was in condition for habitation by man. The C., H. & D. Railroad passes through this depression. From the rim of the area the depression has the appearance of an old wide valley to a stream, but on entering it the observer finds there is no stream present. The basin is probably of glacial origin rather than the result of stream action, as one would conclude at first consideration. Basins of this kind are common in moranic areas.

Sugar Creek Township.

In this township the Carrington silt loam type of soil is typically developed. The area is not of great extent, but the only area large enough to separate. The price of land is not as high here as it is in other places where this type of soil is represented. This can be easily accounted for since the area is so distant from railroad accommodations. Land sells at from $100 to $125 an acre. The area is located east of Grange Corner, in the northeast corner of the area.

Much of the land in this township is rough and cut up by tributaries to Sugar Creek. It is good land for pasture if cared for properly. Land slips are abundant and are evidence that removing forest growth encourages land erosion. Something must be done to hold the soil in place or it will be wasted away by stream action. An attempt should be made to get a sod covering to the soil that is now exposed and where gullies are now starting. Sweet clover holds tenaciously the soil within its grasp, as its root system is enormous. This plant promises to be the great redeemer of waste lands. It stops gullying and enriches the soil. Sweet clover should find a welcome place especially on every hilly, rolling or wornout farm.

A little bottom land is found along Sugar Mill Creek and Greens Creek. Coal banks in sections eight and nine furnish coal for local consumption. The coal is of good quality, burning to a fine ash, producing no clinkers, but giving a large amount of heat. Along the southern boundary of the township many glacial bowl-

ders are scattered over the surface. Several good gravel pits are found also in the southern part of the township.

Grange Corner is the only town in the township.

Liberty Township.

In this area is found a modification of the Knox silt loam. It is whiter in color, more compact, and iron concretions are found on the surface and scattered through the soil. These present in a soil indicate need of drainage and aeration. With proper drainage and with air in the soil these pellets of iron will disintegrate, mix with the soil and give it a darker color. It will then be a typically developed Knox silt loam. The area has been mapped in as Knox silt loam, since it is a modification of this type. The Wabash silt loam of this area is very productive. Corn is the principal crop grown. It is seldom that a crop is lost by high water. The first terrace or bottom land is for the greater part owned by large landowners and rented to tenants. Grain rent is the method usually practised.

In ordinary seasons raising a crop of corn in the river bottoms is not a difficult task. The ground is listed, followed by the planter. When the corn is up large enough to cultivate, sometimes the ordinary cultivator is used; again, the sled disc cultivator is used to push into the furrow a little of the dirt of the ridge at each side of the row. This covers all weeds starting to grow. This method of cultivation predominates.

The dune-like ridges of sand appear in this township on the uplands, bordering first bottoms. At Howard water stands in wells within four or five feet of the surface in wells seven or eight feet in depth. Those who live in this community say that some places wells may be dug very deep but no water is found. In other places at six or eight feet abundance of water is found. This is explained in this way: In some places at a depth of a few feet a layer of hard blue clay that is impervious to water is encountered. It even comes to the surface in places. It is lenticular in shape, with the convex side down, very much as if a huge saucer was set deep in the sand, its rim extending to the surface in places. This saucer-shaped layer of impervious clay holds the water, furnishing wells in this area with plenty of water. Wells then outside of this area must reach great depths to find water.

East of Howard there is an elongated hill occupied by the Ephlin Cemetery. There is also another smaller mound east of

this one that may deserve comment, on the west bank of Mill Creek. Some have attempted to trace their origin to the work of Indians or the Mound Builders. This is not necessary at all, for a little study will convince the observer that they were once a part of the uplands to the west, as they have the same structure. The meandering Mill Creek has cut away that which is valley now and these knolls were points encircled by the crooked stream. When the stream completed its crookedness to that point that the channel cut through its bank the oxbow was left, the mound was left and the stream had a straighter channel. Since the stream abandoned the oxbow to the west of the graveyard, soil has washed from the uplands and from the ridge until to the untrained eye no remains of a former stream channel is present. The other knoll has been separated in a similar manner.

Coal Creek and Mill Creek have worn their channels through these sand ridges. Some small, rich, black spots or depressions, once ponds, north of Tangier and probably in other sections of the county, now drained and farmed, have been a source of discontent with many farmers. Farmers call them alkali spots. The best treatment for these areas is underdrainage, and the application of barnyard manure, straw, cornstalks, or any other rough material.

About one mile west and one-fourth mile north on the section line in a deep ravine a layer of glacial pebbles are exposed. They appear immediately above a layer of hard blue clay. This condition can be traced up the ravine for quite a distance, when it finally disappears beneath the hill. The mass of glacial till above this layer is twenty to twenty-five feet thick. The coarse mass of glacial bowlders are in a layer of one and one-half to two feet thick, with huge bowlders scattered here and there in the ravine. One large, massive limestone bowlder, coarse, blue and fossiliferous, was found associated with the others of igneous origin. It contains about two cubic yards. Many of the rocks are deeply striated.

About a mile south of the Coal Creek bridge, at Waterman, there is an exposure of shale along a small ravine, very fossiliferous.

Penn Township.

In many ways this is a very interesting township. Much attention is given to dairy and truck farming. It boasts of having within its boundary one of the largest, if not the largest dairy barns in the county. The barn is located one-half mile west of

Annapolis. Silos are conspicuous features in this township. In fact silos are getting a place on every farm where progressive agriculture is practiced. Farmers who now have one silo, as their business allows build another. When once a farmer knows the value of a silo by actual experience he is silo promoter ever after.

One farmer in the northwest part of the area made good use of the water from a spring that flows through a bottom field. In the middle of summer when the soil is dry he makes irrigation ditches that carry the water to various parts of the field. First the stream is allowed to flow through one main stream and its divisions to one part of the field, then transferred to another main trench and its division to another part of the field. Thus the stream is swung back and forth in this manner, keeping all parts of the field supplied with moisture. The changes were made every two or three days. The corn showed clearly the effect of this treatment. This unique plan of conserving the natural resources should be made use of by others. The spring that furnished the water for this project flows, as shown by actual weir measurements, a head of water one and three-eighths inches deep and three inches wide, or at a rate of fourteen and one-half gallons a minute. This in twenty-four hours would be 662.5 barrels. A small concrete dam at the end of the hollow could be erected at small cost, then the entire field could be watered. There are probably other conditions in the county that could be handled in like manner.

On the south side of Rockport bridge, west of the place where once stood the Rockport mill, a small spring finds its way to the surface, on the south side of the road. It crosses beneath the road and loses itself in the sandy bottom land below. It flows 13.7 barrels a day during the driest summer. This would be an excellent place for a public watering place. A concrete trough here would mean much to the locality and be a great convenience to the traveling public. It is located on one of the main roads of the county, and if possible should be improved. If the material was furnished by the township the remainder of the work would be gladly donated by men living near this place.

A gravel pit containing material above the average quality for road purposes is located on the farm of Mr. Morgan, one mile east of Rockport bridge. It contains calcium carbonate in great quantities which act as a cementing material. It binds the gravel together with such force that masses of great size must be thrown aside because they cannot be crumbled. These bowlders of cement-

ed gravel are evidence of the cementing power of the calcium carbonate present. When gravel from this pit is used upon the road it seems to set, forming a hard and resistant road, one that packs quickly and stays solid through the dry summer season. It does not pick up, forming "chuck holes," as the ordinary gravel road.

One change in water courses is plainly in evidence in this township immediately southwest of Bloomingdale. The old channel of Leatherwood was southwest from Bloomingdale, through Rocky Run, down past Coloma, then west, receiving the waters of the present Leatherwood at a point no great distance from its confluence with Big Raccoon Creek. The change has been brought about by stream piracy. In Section 22, what is now the channel of Leatherwood was once only a tributary to what is now the lower course of present Leatherwood. When this condition existed the head waters of Leatherwood from Bloomingdale flowed through the shorter and older channel by way of Rocky run. But the tributary in Section 22 lengthened and deepened very rapidly until it intersected the old channel, diverting the head waters of Rocky Run. The upper course of the beheaded stream filled, forming a lake or pond. Later Rocky Run cut the lower rim lower, as it slowly deepened its channel, draining the area. Probably old Leatherwood's water had become sluggish and slow, wearing its channel very little, while the pirate stream was active, with swifter current and greater power to deepen its channel. The bed of this stream being more easily eroded. The tributary then on reaching old Leatherwood diverted the head waters through its new and present course.

Bloomingdale, located on the C., H. & D. Railroad, is the principal town of this area. It has a canning factory that uses great quantities of corn and tomatoes. A large clay factory that makes a variety of earthenware is situated immediately west of Bloomingdale. The clay used by this plant is unexcelled any place in the State. Several carloads of clay are shipped from here each year.

Coke Oven Hollow, two and one-half miles west of Annapolis, has been famous for years for its fine quality of potter's clay. The plant at Bloomingdale gets its supply from this pit.

Bloomingdale Academy, one of the oldest institutions of learning in Parke County, is located at Bloomingdale.

The prevailing soil type of this township is the Knox silt loam. The extreme northern portion is very rough and broken, being cut

up by Sugar Creek and its tributaries. In the uplands bordering Sugar Creek are small patches of sand here and there, changing to gravel in places. A mass of bowlders of glacial origin, northeast of Annapolis about three miles, immediately above the Cox Ford bridge, show the position of a moraine.

The great number of silos already in use and the still greater number being erected in this as well as in many other parts of the county are evidence of thrift, enterprise and progress of the Parke County farmers.

Raccoon Township.

This township lies wholly within the Valley of the Raccoons. The wide fertile flood plains of Big Raccoon Creek produce abundant crops of corn and wheat. Alluvial flood plains in recent years do not receive the fertility and richness of deposits as in former years. The uplands have been stripped of their richness by years of erosion until now, although the weathering continues, no fertile soil is left to be carried to the larger streams and be deposited as alluvium. But as scientific methods of agriculture are practiced and the original fertility of the land is approached, alluvial plains will also increase in fertility.

The hills in many parts of the township contain great quantities of gravel of good quality. A water power mill is located at Bridgeton.

Florida Township.

This township contains within its boundaries the valleys of three of the four largest water courses of the county, the Wabash, Big Raccoon, and its principal tributary, Little Raccoon, besides numerous tributaries to these streams.

The wide terraces along the Wabash in places reach a width of two miles. A mammoth gravel terrace extends south from Lyford to the county line. The terrace is the first above the alluvial flood plain of the Wabash. Much of the gravel is consumed for local road building, while still greater quantities are shipped to other places. The old canal parallels this gravel terrace.

Three railroads cross the township, giving its inhabitants good shipping facilities for farm products, as well as the products of the mine and pit, for great quantities of coal, shale and gravel are sent out. Finished products of clay and shale in the form of brick and tile, both drain and sewer, are shipped out of the county.

A lake occupied a large area east of Rosedale in early times. It was called "Nigger Leg Lake" in honor of an old Indian chief, "Nigger Leg," whose tribe occupied the region about the time the first white settlers came to this section of the country. It is reported that at the east side of the lake was the Indians' burying ground. From the gravel pit, said to be the burying ground, many human bones have been unearthed by men hauling gravel from the pit. The pit contains some good gravel for road material.

There is a story current concerning the origin of the lake that during the ice invasion a mammoth cake of ice was buried very deep here and that part of the ice yet remains. The ice that remains buried is still melting and is the source of the water flowing from the lake.

"Nigger Leg Lake" was in early times the best fishing grounds in the community. The lake is no doubt the remnant of Raccoon's former channel. It is now being drained by open ditches. Though it was the driest part of the summer when visited, large quantities of water were leaving it by way of the open ditches. Farm crops are gradually encroaching upon the area once occupied by the large body of water. Only a few years will elapse before the whole area will be producing abundant crops of corn, wheat and oats. The area is now called "Nigger Leg Prairie," and is partially covered with wild grass. The southeast part of the area is soft and quaking. The soil is black, in places muck. The soil auger could easily be thrust four feet into the soil with one hand. This does not represent the depth of the soil, only the length of the auger.

Immediately to the southwest of the lake the Knox sand sets in. To the north the lake gradually passes into the Raccoon bottoms.

North of Jessup a small area of second bottoms is found, but was mapped as first bottom, the area being small and the soil being very much like the other.

Rosedale is the principal city of this township, with a population of 1,166.

The area in the Wabash River bottom, mapped Knox fine sand, is adapted to melons and truck farming. During the high waters of the spring of 1913 only a very small portion of the highest points of this ridge were above water. The houses are situated on the highest points of this ridge, but even then some dwellers were forced to move in boats to their neighbors' as the water encroached dangerously near the buildings. All the lower ground to the east

of this ridge to the uplands, a distance of a mile, was covered by water to enormous depths.

A field of hairy vetch, winter variety, was sown in the fall of 1913 south of Rosedale. It should be watched by farmers living on this type of soil, as it is in need of organic matter. The plowing under of green crops and the addition of barnyard manure will add materially to the productivity of the soil.

Reserve Township.

The township contains some of the richest alluvial soils that the Wabash River enriches throughout its course. The Wabash silt loam of Liberty Township changes in Reserve almost to the Wabash fine sandy loam. This is due wholly, probably, to one factor. Sugar Creek enters the wide Wabash Valley immediately north of West Union, in the northern part of the township. When the Wabash is within its natural bed, Sugar Creek follows its ordinary course to the river, but in times of flood, when the waters of the Wabash cover the first terrace, the channel of Sugar Creek is shortened from one-half to three-fourths of a mile. The swift current of Sugar Creek entering this great mass of water in the lowlands, is checked, being forced to give up part of its load. The heavier or coarser material is deposited near its channel. The finer material carried in suspension will be deflected by the waters of the Wabash and carried southward down its course. As the water of the bottoms are quieter than in the main current, this material will be deposited, giving the area a layer of sand, silt and clay.

The channel of Sugar Creek, in Parke County, to the mouth of Rush Creek, has been worn very deep in massive sandstone. The tributaries to Sugar Creek flow through glacial deposits carrying gravel, pebbles and bowlders, besides silt, sand and clay. These are the tools the stream uses in cutting its bed wider and deeper in the massive sandstone. This accounts for the great load of sand carried by Sugar Creek on reaching the Wabash. Only a part of the sand and silt lodges on the immediate lowlands, greater quantities being carried long distances before being deposited.

The second terrace, of the Sioux sandy loam type, has a width of two miles in places before the upland is reached. The second terrace road from the county line on the south, to West Union, is one the traveler will long remember. Looking down over the lowlands toward the river the traveler will see green fields of pasture

and growing crops. The glistening rails of steel of the railway, keeping pace with the traveler, the haze in the distance, make up a scene so entrancing that one with any romance in his life will ponder, dream, awake and exclaim, beautiful!

Montezuma is situated on the Wabash River on the edge of a river terrace. The uplands to the east, being nearly one and one-half miles, mark the eastern boundary of the old Wabash River channel. Montezuma has a population of 1,537.

Reserve Township has two railroads, the Chicago & Eastern Illinois and the Cincinnati, Hamilton & Dayton. Great quantities of gravel are loaded and shipped from near the junction of the two roads east of Montezuma.

Along Rush Creek, about one-half mile north of the C. & E. I. Railroad bridge across Sugar Creek, a blue, fossiliferous limestone is exposed. Outcrops along the creek show a thickness of seven or eight feet of the limestone. The stone would make excellent road material and at the same time produce a good quality of limestone for fertilizing purposes. The limestone is covered only by a thin layer of soil and in much of the area soil is entirely absent. Shipping facilities are first-class, for the area is immediately along the C. & E. I. Railroad. The area of this description covers forty to sixty acres. Great quantities of the stone would be consumed in the immediate locality, as there is not only a need of limestone as a fertilizer here but a large demand for it. As valuable as the stone is and as much need as it is on the soil of the county this region should be worked.

Howard Township.

Howard Township lies almost wholly within the Sugar Creek drainage basin. It is located in the northeast corner of the county, joining Fountain County on the north and Montgomery County on the east. Except in the extreme south and southeast portion the area is rough and broken. Blackberries of fine quality grow wild. A great amount of the area that is rough is covered with a heavy growth of underbrush; a few scattered trees of medium size remain, the majority of the native trees have been removed. Surface erosion is held in check by the heavy undergrowth. Should this be removed, land slips and gullying would work havoc among the hills. But some of the land should be cleared enough that blue grass could get a hold on the soil and also furnish pasture. In this way some returns could be got from land at present almost profit-

less. Sweet clover of the white blossom variety could be sown in the more open places to check the gullying, enrich the sterile soil and furnish excellent pasture.

Two miles west of Byron, on Kellar's Branch, there is a small knoll probably thirty feet high. It has steep slopes on the east and south slopes, but the other sides are such that the summit could easily be reached by a team and wagon. Large granite and sandstone bowlders partly buried in the soil occupy the steep slopes. The main body of the knoll is made up of gravel, sand and loam; the sand predominates. Some think it an Indian mound and contemplate searching the interior for Indian relics. Kellar's Branch flows on the east and south sides only a short distance away. Its presence here is only the result of stream meander. It has been given the name of Potato Hill.

The soil in the southern portion of the township is of the Knox silt loam type. With proper methods of cultivation good yields of corn, wheat and other farm products are harvested. More clover should be grown. Limestone is needed to sweeten the soil and give it a looser texture.

In the northeast portion of the township, along Sugar Creek, is the remains of what was once a favorite summer resort, known as Pleasant View. It is very favorably surrounded by scenery so characteristic of Sugar Creek. Refreshing springs of cold, clear water, gorges, deep and narrow; high cliffs of shale and sandstone, the old mill, fine shade, and rest grounds are some of the things so attractive about these grounds. Thousands of people visited this romantic spot each year. There was plenty of water for swimming and bathing. Immediately below the dam was a deep hole for those who wished to do deep diving. A pontoon bridge across the quiet waters above the dam made the eastern shore easily accessible. Much amusement accompanied each crossing, as the bridge rocked to and fro, up and down, as each company of young people crossed and returned.

With a concrete dam across the creek at the place the old log dam formerly occupied, cabins to replace those gone, fountains erected, and other attractions, this place could be made second to none in this section of the State.

Turkey Run is one of the most attractive summer resorts at present in this section of the country. It is visited annually by thousands of pleasure seekers. Some come to spend one day, and some to spend weeks. The camping grounds are favorably located,

with plenty of water, shade and swings. The mammoth giants of the forest, the poplar trees, scattered here and there, are worth seeing, even though there were no other attractions there. From these, the younger generation may get an idea of the enormity of trees that made up the primitive forests of this country. Rocky Hollow, as the name indicates, is a rocky hollow, and more, it is a series of hollows. Small tributaries to Sugar Creek flow through narrow gorges, wide amphitheaters, and deep canyons cut through solid walls of sandstone. Jumbled masses of rock that have fallen into the valleys, dripping waters from the ledges, noisy streams rushing down their narrow channels, make the scene enchanting. The Hollow is on the north side of the creek, the Run on the south side of the creek. The two are connected by a small suspension bridge. Many automobile parties from Danville, Ill., and various other distant cities visit Turkey Run each season.

The broken area of this township as well as others in the rougher areas is of the Knox silt loam type. In places where the top soil is not protected, erosion has removed much of the top soil, leaving the subsoil exposed. At first notice one would classify this soil in some other soil group. As the larger stream channels are approached the natural fertility of the soil decreases. But with proper tillage, selection of seed and correct crop rotation, the land produces abundantly. Sweet clover or some other legume is important in regaining this class of land. The root crop of sweet clover is immense, and it stops washing of gullies. Land sown to sweet clover improves rapidly because the roots die every two years, adding humus to the soil.

Green Township.

Some very rich soil is found in this township. In the northeast portion of the area some black soil occupies depressions that were once swamp lands. Underground drainage has converted this region into productive fields. The area was mapped as Knox silt loam, there not being sufficient black soil to separate. Southeast of Parkeville two and one-half miles there is another area in which natural drainage is poor and some black soil is found. It has the appearance of Carrington silt loam, but areas were too small to separate.

Some limestone in this township is very suitable for fertilizer. When ground and applied to the fields at the rate of one and one-half to two tons to the acre a forward step in the restoration of

the natural fertility of the soil has been made. Two railroads cross the township, giving the farmers good markets for their grain and livestock. Little Raccoon with its tributaries drains most of the area.

Union Township.

The best farming land in Union Township is situated in the northwest portion. The farms about Bellmore are of the Knox silt loam type. Farms are improved and well kept. The central part of the township is rough, being cut up by Big Raccoon Creek and its tributaries from either side. Outcrops of sandstone and limestone are found along the main stream and adjacent regions where the tributaries have cut deep enough to expose them. The limestone has been quarried some for road material, giving very satisfactory results. The stone contains iron pyrites, commonly called fool's gold, for so many times has it been mistaken for gold. In the limestone that has been exposed to weathering for some time the softer parts have been worn away and left the hard resistant pyrites standing out, and has much the appearance of a rosette. The small cubes of pale brass yellow that make up the group were responsible at these local quarries for much controversy.

The bottom lands along Big Raccoon Creek are not wide but very fertile and productive. Ferndale, Bellmore, Hollandsburg, and a part of Portland Mills make up the little towns of this township.

Jackson Township.

Jackson township is situated in the southeast corner of the county. The southwestern portion of the area is level to rolling. The soil is a light gray to ashy white color, easily worked when in proper condition. Much of the land needs draining, as in moderately wet years crops suffer greatly from this cause. Knox silt loam is the prevailing type.

Big Raccoon Creek and Rocky Ford with their tributaries have cut the northern half of the township into numerous valleys, leaving it in a very rough condition. One problem the farmer of this region is confronted with is the rescue of this land from the ravenous work of streams. As the forests are cleared away erosion gets a better chance to work, gullies are developed and grow to enormous size in a relatively short time. The hills should be covered with sod to prevent waste. A heavy sod of bluegrass will prevent washing. Sweet clover is an excellent soil preserver, as

the root system is enormous. It stops the gullies from forming, checks those already started, furnishing excellent pasture all the while.

Mansfield, a little village situated on the west bank of Big Raccoon Creek, is of interest because the famous Mansfield sandstone is typically developed here and received its name from the little town. Considerable gravel of good quality is found in the bed of the creek just below the mill. The uplands along Big Raccoon contain some good gravel. The tributaries during flood erode the adjacent hills, bringing in a large amount of gravel, depositing it in the bed of Raccoon. Much sandstone outcrops along Raccoon and its tributaries in this township. The quarry just north of Mansfield when in operation shipped great amounts of this stone.

The soil of this township needs a good dressing of limestone. The land has been depleted of its original store of its acid neutralizing qualities, and an attempt to restore this condition is sought in the use of ground limestone. The bacteria of clover will not thrive well in an acid soil. Without a legume in the crop rotation the soil will fail in a short time to produce other crops. Sweet clover as a soil builder is unexcelled. The sweet clover plant grows wild along the public highways in many places. Until recently sweet clover has been termed a weed. But recent study and experiments with the plant shows it to be a very valuable weed.

In rolling to hilly areas where erosion is cutting and wasting the fields with gullies there is no better holder of soil than sweet clover. It grows and thrives well where no other plant would grow, at the same time stopping the waste of the land. In regions where there is a tendency of the soil to drift sweet clover holds it in place.

Many farms are going to ruin through sheer indolence. The owner, instead of being wideawake, using methods of economy and good management, is content to follow ancestral methods of farming. Inhabitants of the soil, of this class, feed fodder of stunted growth, grown upon a soil sour and clammy, to a degenerate class of horses and cattle, in a little, old, open, rickety, dilapidated barn. An invasion of this territory by men of scientific methods of farming is needed. Only by intelligent, scientific management can these practically worn out soils be reclaimed. By application of limestone, one or two tons to the acre, growing of legumes, as sweet clover, red clover, vetch (winter variety), and alfalfa. By deep

plowing and proper tillage, with protection against further gullying, these farms may be restored partially at least to their virgin fertility.

Sweet clover for best results should be sown in the spring with a bushel to a bushel and a half of oats, using about twenty pounds of sweet clover seed.

Some advantages of sweet clover over alfalfa are: cattle and sheep do not bloat on sweet clover; sweet clover is a biennial. The root system is immense, spreading wide and deep. Its roots die every two years, the roots form openings into the subsoil enriching it with humus and leaving nitrogen in the surface soil. Alfalfa roots do not die until the field is plowed, killing the plants. Enough seed shatters from sweet clover to keep a stand from year to year.

The white variety makes the best hay and pasture. Sweet clover is worth as much ton for ton as bran to feed dairy cows. In winter sweet clover hay is fed to hogs. Stock must learn to like sweet clover. When once a liking for sweet clover is created no further trouble about stock eating it is encountered. Experts claim sweet clover is higher in protein, ash and fat than alfalfa. It adds more organic matter to the soil because its roots die every other year. It is a better nitrogen gatherer than alfalfa and has a higher feeding value pound for pound.

A small plot of ground consisting of about one acre will furnish sufficient pasture for eighteen or twenty hogs. It should not be pastured too young. At least ten to twelve weeks should elapse after sowing before pasturing is begun. Hogs will not fatten much on sweet clover alone, but bone and muscle growth are fostered. With half rations of corn, hogs fatten rapidly pasturing on sweet clover.

Seed is difficult to buy at seed houses, as they ask enormous prices for it. It can usually be found growing along the roadside in the neighborhood.

As a soil builder sweet clover is unexcelled. Its roots penetrate the hardest soil.

BUREAU OF SOILS—MILTON WHITNEY, Chief
In Cooperation with the State of Indiana, Department of Geology
EDWARD BARRETT, STATE GEOLOGIST

SOIL SURVEY

OF

HENDRICKS COUNTY, INDIANA

BY

W. E. THARP, OF THE BUREAU OF SOILS, AND
E. J. QUINN, OF THE INDIANA STATE DEPARTMENT OF GEOLOGY

1913

Soil Survey of Hendricks County, Indiana.

By W. E. Tharp and E. J. Quinn.

DESCRIPTION OF THE AREA.

Hendricks County is situated in the central part of Indiana. It is bounded on the north by Boone, on the east by Marion, on the south by Morgan, and on the west by Putnam and Montgomery counties. It embraces about 420 square miles.

The area as a whole is a somewhat uneven plain with a general inclination toward the south. The elevation above sea level ranges from 800 to 900 feet for most of the region, with a few points rising to about 1,000 feet. Throughout the northeastern part of the county and in the west central portion the characteristic topography, except in the immediate vicinity of the creeks, is a succession of slight swells and low, broad divides usually without very definite trend and more or less uneven with regard to relative elevation. The depressions vary from mere swales a few rods across, to very irregularly extended flats involving several hundred acres. A few of the largest areas are several miles in length and expand in places to more than a mile in width, but in the northern part of the county such large bodies of low land are exceptional. Instead there are more frequent, although slight variations in relative elevation, but these differences are accentuated by the light gray shades of the higher ground in their strong contrast with the black color of the soils in the depressions.

In the southern part of the county the relief is much more pronounced. The National Road between Plainfield and Stilesville crosses several high divides that decline in long undulatory slopes to the wide valleys of Mill and Mud creeks. To the south of this highway the country generally slopes to the south and the local differences in elevation are generally greater than further north along the Pennsylvania and Big Four Railways. Except in the immediate vicinity of the drainage lines there is very little land on which the heaviest farm machinery can not be used with ease. In many places the comparatively mild contours of the uplands prevail to the very crest of the bluffs overlooking the valleys of the White Lick creeks. Occasionally hilly land extends some dis-

tance back, or the tributaries are bordered by very short, steep slopes.

Between New Winchester and Coatesville much of the surface has very slight relief, and there are frequent flats or slightly depressed areas, but these seldom include more than 10 or 20 acres. The largest body of level land in the county is that embraced by the several branches of Kamp's Run. This tract is somewhat lower than the uplands to the west and south and much inferior in elevation to the high morainic ridge to the northeast. The latter extends from below Danville nearly to North Salem, rising about 100 feet above most of the country to the east. The western slopes are very mild, but those on the eastern side are more pronounced. Near Danville the lower parts of the divide are cut by many short ravines, and hilly to broken land occurs in many places.

Throughout the northern part of the county there are numerous local elevations rising from 10 to 40 feet above the general level of the surrounding county. They vary from small mounds of less than one acre to ridges a fraction of a mile in length. From Danville southwest to the county line there also are many of these isolated elevations. Some of those along East Mill Creek are essentially gravel mounds with a veneer of loam, but those near Stilesville are broad ridges not entirely distinct from the other topographic features of that section.

The northern and northeastern part of the county which has such poor natural drainage is the southern extension of that great area of central Indiana, which is characterized by similarly immature development of its minor drainage systems. In this county artificial mains and the installation of hundreds of miles of tile drains has remedied the natural deficiencies so far as agricultural interests are concerned.

In the southern half of the county the drainage is much better developed. This is due in the main to the greater differences in elevation compared with the surface of the northern townships, and to the longer periods the streams have been actively eroding their valleys. The White Lick creeks and Ader Branch have trough-shaped valleys from one-eighth to one-half mile in width. Their floors are comparatively flat while the sides in most instances are nearly vertical bluffs from 20 to 50 feet in height. The abrupt declinities are most striking features of the landscape along the above mentioned streams and also on the lower Eel River, where there are bluffs upwards of 100 feet in height. The

small tributaries of these creeks usually have U-shaped valleys along their lower courses while the upper parts have relatively wider strips of alluvium bounded by low banks. In most cases the extreme heads of all these drainage lines have their origin in the structural depression of the uplands where little or no erosion has yet been accomplished. This, of course, is most noticeable in those branches that rise in the northern part of the county, but is also true of the majority of the small drainage lines in other sections of the area.

Mud Creek Valley is a broad depression with poor natural drainage until the present channel had been artificially opened. Since this was done the moderately high gradient has resulted in the widening and deepening of the main channel so it affords a good outlet for the numerous laterals that have been constructed.

The Mill Creek valleys are comparatively wide but consist in large part of low terraces. The recent alluvium is limited to narrow strips seldom more than one-fourth mile in width. These valleys and that of Mud Creek have no such bluffs or abrupt slopes on either side as occur along the other streams. The long upland slopes merge so gradually into the lowlands that no definite boundary can be drawn between them.

The terraces on the White Lick creeks and lower Eel River are nearly level benches 20 to 50 feet above the bottom lands. Their outer margins are sharp, stony declivities but on the upland sides the transition to the latter both with respect to topography and character of soil is very gradual.

The larger creeks maintain their flow the entire year. Many of the smaller ones are perennial, being fed by tile drains and numerous artificial ditches. Along all the bluffs, particularly those facing the south, springs are of very common occurrence and the quality of the water excellent. Near New Winchester, Amo and Clayton there are a number of flowing wells. In the valleys and in most of the larger areas of Clyde soils potable water is usually found at less than 15 feet. On the uplands the depth of dug wells ranges from 20 to 50 feet, and the supply is generally sufficient for all farm purposes. In recent years many driven wells have been sunk from 90 to 150 feet and an apparently inexhaustible supply is thus obtained.

All of this area was originally covered with a heavy forest. Exception must be made of a few small tracts in the larger bodies of black lands in the north central townships. These so-called

"prairies" were really marshy lands not yet sufficiently free from water to admit of cottonwood, willow, elm, or other moisture enduring species to establish themselves. The timber now remaining consists mostly of scattering trees in pastures, along highways and the groves around farm buildings. It is probable that less than 10 per cent of the area has escaped the plow. Practically all is included on well improved farms, the untillable portions having been utilized for pasture to such an extent that very little undergrowth or young timber of any kind now remains.

The price of farm land has advanced very rapidly the last 10 years. The best improved lands now range in price from $125 to $150 per acre, even larger prices being readily obtained for small tracts near the electric lines or close to towns.

The total value of all farm lands (Census of 1910) was $21,735,044; of buildings, $3,852,155. This is an increase of about 100 per cent compared with the returns of 1900.

The average size of farms is about 91 acres. There are a few individual holdings of more than 500 acres, but large estates are not common. The majority of farms include from 80 to 160 acres, with a good many of 40 acres, and even smaller ones near the towns. About 30 per cent of these farms are operated by tenants. The rates of rent now obtaining vary considerably, but are generally being advanced. Some farms rent for one-half of all grain and hay produced, others two-fifths of the grain crop and cash payments for grass land. All cash rental for farms consisting chiefly of Clyde soils is about $8 per acre; of land less desirable for corn $6 to $8 is the usual rental price.

The county is crossed from east to west by four steam roads and two electric lines. Danville, the county seat, is also connected with Indianapolis by an electric railway.

The public roads are good, and rural delivery of mails is made daily to almost every farmhouse.

The average rainfall for each of the spring and summer months is sufficient to cause good yields of grain and grass, but the precipitation for the corresponding month in those seasons when there was a marked deficiency, is too low to meet the requirements of most crops. There are comparatively few years in which at some period of the growing season there is not a shortage of rainfall, and consequent decrease in yields of one or more crops. For this reason the necessity of conserving moisture, and the means of so doing is discussed at some length in the type descriptions. In

this respect, however, conditions in this area do not differ materially from those of adjacent counties.

The average date of the last killing frost in the spring is April 16, of the first in the autumn, October 19. The earliest in recent years was September 21, and the latest, May 21.

AGRICULTURE.

The government survey of the lands in this county was made in 1819, and the first group of settlers located on lower White Lick Creek in 1820. Owing to the better natural drainage of the lands in the southern part, and to the completion of the National Road in 1830, through this section, its development was much more rapid than that of the northern part of the area. As late as 1830, it is stated there were not more than fifty persons within the present limits of Union, Middle, Brown and Lincoln townships. The drainage of the larger areas of Clyde soils in these townships was not generally effective until about 1880, and at a little later date the flat lands on Mud Creek and lower Mill Creek were reclaimed. These drainage systems have been extended until practically all the lands are tillable.

Corn, wheat, oats, clover and timothy are the principal crops, and no other products have ever received any considerable attention. The general trend of agriculture is indicated by the following table taken from the U. S. Census returns:

U. S. CENSUS.

(Acreage and Yields of Principal Crops for Census Years 1880-1890-1900 and 1910.)

	Corn.		Wheat.		Oats.		Clover.	
	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.	Acreage.	Yield.
1880	54,114	2,016,351 Av. 37.+	31,523	553,506 Av. 18	4,699	138,917	.....	703 –
1890	50,637	1,642,054 Av. 32.+	32,956	376,831 Av. 11	10,178	259,872 Av. 25+	.....	5,676 tons
1900	63,282	2,770,000 Av. 44.+	44,115	507,180 Av. 12	3,499	105,160 Av. 30+	14,981	20,519 tons
1910	76,085	3,125,343 Av. 41.+	26,614	363,548 Av. 14	17,522	467,480 Av. 25	2,935	3,452 tons

	Alfalfa.		Tomatoes.	
	Acreage.	Yield.	Acreage.	Yield.
1910	119	276 tons.	193	1,033 tons.
1911	.....	.....	596	3,114 tons.

Few farmers consider wheat in itself a profitable crop, and while the average returns from oats are somewhat better, neither of these grains would be grown as extensively as at present were it not for the opportunity thus afforded of seeding ground to clover and timothy. On all types except the Genesee and the darkest colored phases of the Clyde soils a frequent change to clover is recognized as indispensable in the maintenance of fertility, or from the more common view point, as essential to the profitable production of corn. The increasing demand for this grain is stimulating interest in every means that promises greater yields, especially on the light colored soils. The crop rotation practiced is planned chiefly with regard to requirements of corn although commercial fertilizers are used on both this crop and wheat. The consumption of manufactured fertilizers is increasing very rapidly in recent years.

NOTE.—Expenditures for fertilizers, from U. S. Census—

1879	$1,217
1889	680
1900	14,710
1910	21,160

The grades of goods most commonly used have about the following proportions of the three essential elements: Nitrogen 1 to 2%; potash 4 to 8%, usually the lower figure rather than the higher; while nearly all carry from 8 to 10 of phosphoric acid. In most instances from 100 to 200 pounds per acre are applied, and a material increase in yield of corn and wheat are reported. It is also stated that the quality of the latter is generally improved. On the so-called "chaffy" lands, potash is being very generally used when such ground is planted to corn, and this substance invariably improves both the yield and quality of grain.

The demand for more or less specific information relative to commercial fertilizers increases as their use becomes more common. In a report of this kind it is quite out of the question to go into detail regarding commercial fertilizers. As yet no extensive or continued field experiments have been made on the more important types and in the absence of such experimental work no very specific directions can be made regarding the most profitable combinations of the several elements for each crop. Some of the principal underlying fertilizer practice and the application to local conditions may be outlined.

The Clyde soils are so well supplied with humus that in average seasons and under fair conditions of tillage the available nitrogen seems ample for corn and wheat. The addition of further supplies as in a complete fertilizer which may contain from 1 to 2% is not necessary or at least is doubtless unprofitable. Changes to clover, especially on the lighter phases or those so long in cultivation that the color is preceptibly lighter than the normal and there is a tendency to clod, is beneficial chiefly in improvement of the physical conditions. It is also true that the incorporation of brown humus, or that which results from decay of green vegetation or manure greatly improves the light brown phases of this type with regard to requirements of most crops.

The Miami soils are so generally deficient in humus that the available nitrogen supply is low. The physical condition of the silt loam, especially of the heavier phases, is often unfavorable to the development of nitrates in the soil or to the release of mineral elements in the subsoil. The application of a complete fertilizer temporarily remedies this deficiency, so to speak, and enables a crop to start off promptly and make an early growth that may be of greater advantage throughout the remainder of the season. With corn the same result would be secured by drainage, tillage and addition of rather liberal amounts of manure or of some legume plowed under. There would be not only a direct and immediate increase of plant food, but the ability of the soil to endure extremes of wet or dry weather, would be immeasurably improved.

With regard to wheat an increase of nitrogen and improvement of physical conditions may not so nearly meet requirements as in the case of corn. The very general increase in yield and improvement in quality following applications of fertilizers evidently indicates some particular need of this crop not fully met by the Miami soils even under most favorable conditions of season and tillage.

In general no method of increasing the nitrogen supply is superior to, or even equals, the methodic rotation of crops in which clover or some legume has an important place. On most farms, the manure supply is limited and no very marked increase in the future seems probable.

As indicated in Chapter IV, the origin and mineralogical composition of the soil forming materials leaves little or no doubt as to their comparative richness in potash. The potash supply of all except possibly the limited areas of mucky soils and very light

sandy types is practically inexhaustible. So far as this problem concerns the farmer it is a question of rendering this element available through drainage, tillage and presence of organic matter in the soil.

With regard to phosphorous, the above observations do not apply quite so well because this element does not exist in loessial or glacial soils in such amounts as does the potash. But the total amount as measured by crop requirements is adequate for many years of tillage, and no "deficiency" or "exhaustion" exists as is assumed by many farmers. This is plainly shown by chemical examination of the dominant soil type of this region and is also supported by field observations. On the light colored soils the limit to crop yields is usually some physical factor, as unfavorable seasons or poor condition of the soil, but in a larger way it seems to be determined chiefly by nitrogen supply. Where this element is restored by clover growing the yields of corn, clover and timothy are comparable with those on the black soils. In both cases, and all these soils are closely related with regard to character of mineral constituents, there is little indication of crops being cut short by lack of fertility. As previously stated the limit is most frequently determined by the water supply or some other physical condition of soil, that precludes as heavy a growth or as full a development of the plants as would otherwise be possible.

Since most of the brands of fertilizer used in recent years are high in phosphorous and this application in moderate amounts usually gave increased yields of corn and wheat it seems that this element may be profitably supplied in some form. In the complete fertilizer it is the acidulated form that is obtained. In a few instances "floats," or finely ground phosphate rock has been applied to the Miami soils but sufficient time has not yet elapsed for results to be apparent. In this form phosphorous became available slowly, or during a term or years succeeding its application.

In general the most practical crop rotation for this section consists of corn, followed by wheat or oats, and the ground seeded to clover to remain two years. The clover ought to keep up the nitrogen supply, and it will do so if a sufficient proportion of the two years' growth is returned to the soil. On the light colored soils one crop ought to be turned under, and considering the profit a good crop of corn assures there is little doubt of the practicability of so utilizing a part of the clover growth. The present

NOTE—See Circular 155, Ind. State Ex. Station.

practice usually results in most of the crop above ground being removed from the land.

Since the presence of organic matter renders more of the mineral elements of fertility available than occurs under otherwise similar conditions an increase of the humus supply is practically an increase in all the essential mineral constituents. This fact should be kept in mind in comparing crop returns on the Miami and Clyde soils, for the abundance of organic remains in the latter is the chief difference between the two types.

The lime requirements of the soils have been discussed in the type description.

The keeping of live stock has such a direct bearing upon the maintenance of fertility that the number of farm animals in this county may be of interest.

According to Indiana Department of Statistics the number for 1912 is as follows:

Horses and colts, 8,635; mules, 1,412; cattle, all kinds, 14,197; hogs, 40,407; sheep, 11,745.

With regard to production of manure ten hogs or sheep are counted as the equivalent of one horse or cow, this means that it is about one animal to seven acres of improved farm land. Even if all manure produced were returned to the land without loss, the amount would not be much in excess of one ton per acre per year. The method of handling on many farms is very wasteful. In the villages the accumulation at livery barns is usually donated or sold at a nominal price to any one who will haul this away.

Dairying has become a very important industry in the county since the shipment of milk to Indianapolis is facilitated by the several electric lines crossing the county. Compared with other Indiana counties this one ranks high in the number of cattle annually fattened. Eel River Township enjoys the distinction of producing more fat cattle than any other township in the State.

Bluegrass and white clover form practically all the grass in the permanent pastures. Most of the land devoted to this purpose is the Miami loam, but the silt loam also forms much of the woodland pasture and very frequently it is the heavy phase, the soil being notably acid and markedly deficient in lime. An application of several tons of ground limestone would immeasurably benefit such pastures, for both the blue grass and clover are lime loving plants and thrive best when this mineral is abundant. But not much attention is given the pastures either in the way of fertiliza-

tion or mowing of weeds. The small ragweed infests much of the upland pastures and meadows and some of the bottom lands are hardly less free in the fall from various rank growing species.

In the last few years alfalfa growing has commanded considerable interest and small fields, experimental in many instances, are quite numerous. As a rather general estimate of relative adaptability of several types as indicated by these fields the Miami loam ranks first, the Clyde soils second, and the Miami silt loam third. The heaviest yield observed was an a well drained Clyde silty clay loam. Ideal conditions are found in those phases where lime nodules occur in the subsoil and the water table is within 6 to 8 feet of the surface. Good stands have been established on the best drained Genesee types. On the Miami loam a calcareous substratum is usually found at less depth than under either of the other upland types and this is a factor of much significance in alfalfa culture.

Any soil type well adapted to corn should be suitable for alfalfa with additional requirements of lime and inoculation. Since sweet clover has so generally spread along the road and railway line, the soil in places requires no artificial introduction of the necessary bacteria, but it is well to scatter dirt from sweet clover patches over the ground at about the time the seed is sown. Lime at the rate of from 4 to 6 tons per acre is necessary in most instances and an absolute requirement on the Miami silt loam which is invariably acid. July and August seeding seems to be safer than spring sowing. The land should be plowed early and frequently disked to destroy all weeds.

Not much attention has been given to trucking of any kind except production of tomatoes for canning purposes. The acreage varies much from year to year and the annual returns are also extremely variable. The price in recent years has been about $9 per ton with yield of from less than 1 ton to about 10 tons per acre, the latter being a normal production. The Miami silt loam and loam are said to produce a firmer fruit than the Clyde soils.

Strawberries are grown, in a few instances, in patches of one or two acres, and the local demand readily takes all the production. It would seem that this industry could be made very profitable near one of the electric lines which afford almost hourly service to the city of Indianapolis.

There is no doubt of the adaptability of this section to produce

apples on a commercial scale. The Miami loam in particular affords excellent sites for orchards and all except possibly the heaviest phase of the Miami silt loam may be considered well suited to this fruit. The present orchards, in many instances, consists of old trees that have not received much attention in any way whatever. With such care as pruning, spraying and cultivation as is given in fruit producing sections commercial orchards here would be equally profitable. There is little present demand for summer and fall varieties but this is partially due to lack of sufficient quantity by any one grower to assure commission men of a dependable supply. The winter varieties are the Ben Davis, Genet, Jonathan and other equally desirable kinds. The quality, through failure to spray, is usually very inferior.

SOILS.

Throughout the county the prevailing surface material is a silt or silty clay, having an average depth of about 3 feet. In the extreme western and northwestern parts of the area it is somewhat deeper while in the southern portion the thickness of the silty deposit is generally less than 2 feet.

This superficial stratum overlies glacial material known geologically as early Wisconsin drift. This till, at least in the southern part of the county, rests upon the Knobstone shales, which are exposed in a number of places along White Lick Creek. In but few places on the uplands is the depth to rock less than 50 feet. As a rule it is greatly in excess of this estimate, so that neither the shales nor glacial material older than the Wisconsin has entered into the soils to any appreciable extent.

For a few feet below its contact with the overlying silty clay the till, especially on hillsides, is usually a reddish brown granular clay with more or less sand and stony material. The brown coloration is due to the higher degree of oxidation of the iron content in this upper portion compared with that below. The latter is a very light brown, or pale yellowish-brown mixture of silt and clay with enough sand to render it rather porous and friable. Weathered exposures are usually very crumbly, and in fresh excavations it may be very fine or compact, but the material never approaches an impervious condition. Its physical structure generally admits of relatively free circulation of air and water throughout the mass. This is also favored by the presence of much coarse material varying in size from gravel to small stones. Large

boulders are not of common occurrence in the drift. Most of this rock consists of well rounded fragments of quartz, close grained granites and other hard resistant species. Pieces of shales, sandstone and other weak rock seldom occur in any considerable numbers, but at a depth of 6 to 8 feet below the surface limestone fragments are relatively numerous and from this depth downward the till is so calcareous as to respond freely to hydrochloric acid.

In the valley of Mud Creek stratified sand and gravel are found a few feet below the surface and evidently extend to a great depth. Similar conditions prevail on Mill Creek above Stilesville, indicating in these places pre-glacial valleys, deeply filled with outwash material. In some of the flat areas of black lands in the northern part of the county water laid gravel occurs at a depth of a few feet, but such deposits are not so commonly found as in Boone County.

While the glacial material has entered to some extent into the composition of all the types the dominant ones owe their origin to the silty clay, or loess. This thin but almost unbroken deposit is found everywhere except in the creek valleys and in the larger depressions of the uplands where local erosion and redeposition have modified its original condition to a greater or less extent. On the steeper slopes it has also suffered partial removal or lost its identity by admixture with the underlying till. Elsewhere the contact between loess, for such it evidently is, and the boulder clay is well defined, and the two deposits have distinct physical characteristics.

To a depth of about a foot a representative section of loess consists chiefly of silt, or the grade of soil particles between clay and very fine sand. The latter is the next highest component, but there is not usually enough coarser sand to materially effect the physical properties. The percentage of clay is usually too low to impart a marked degree of plasticity or render the material sticky when wet, or very hard if dry. In general this silt surface layer is characterized by extreme friability and a degree of porosity highly favorable to desirable moisture conditions and consequent ease of tilth.

Between the depths of 12 and 30 inches, although these limits are subject to more or less modification by topographic position, the loess has a higher content of clay. Its structure is more compact than that of the upper layer and internal drainage and aeration are less effective. This is indicated by the mottled coloration usually observable in this stratum. Beyond a doubt the retentive

nature of this silty clay would be more noticeable in its effect upon average moisture conditions, were it not for the relatively open glacial material immediately below. The latter tends to induce underdrainage and favor deeper and freer circulation of air than would be the case if the tight silt-clay had a greater depth. The average conditions in this respect are expressed by the normal phases of the Miami silt loam, which is the dominant upland type in this region.

Where the loess has a somewhat greater depth a phase of this type has been developed characterized by reluctant drainage and deficient aeration. It is indicated on the soil map as the heavy phase of the Miami silt loam. Extreme conditions of this kind are locally termed "clay spots," but may be found in all phases of the silt loam.

On the other hand where the loess is shallow and there has been more or less admixture of coarse material from the underlying till, relatively free underdrainage and aeration has resulted. Consequently there has been a more complete oxidation of the iron content and brown and yellow are the characteristic colors throughout the soil section. Such modifications of the silty material often have the texture of a loam, and areas where these conditions generally prevail have been mapped as Miami loam. Two quite distinct phases are recognizable. On developed or comparatively steep erosional slopes near drainage lines, while another occurs on the mound-like morainic elevations that are so conspicuous in some sections.

The surface soil of these types is generally very light colored. There is but little humus in any form and practically none of the black carbonaceous vegetal remains that characterizes the Clyde soils. All the Miami type was originally forested, and such a covering, on well drained soils, never results in such accumulations of organic matter in the surface soil as follows a long continued occupation by herbaceous vegetation or prairie grasses.

It is also probable that the light color of the surface soils, where no organic matter is present, indicates a degree of leaching, considerably greater than has occurred in the material at a little greater depth. This suggests a lower content of mineral elements of fertility in the surface soil. With respect to lime this is true, and doubtless is applicable in some measure to the other less soluble but equally important constituents. Under favorable physical conditions all of these types respond so well to tillage and addition of

organic matter as to indicate that the silty clay or loess, as a whole, is comparatively rich in mineral plant food.

In the depressions of the uplands conditions originally were favorable for the preservation of organic remains and in practically all such situations the Clyde soils were developed. While most of the black lands were heavily forested when the first settlers entered the county it is probable that most of the dark carbonaceous material that renders them so valuable agriculturally is a heritage from that comparatively recent period when all these tracts were marshy prairies. Most of the humus is vegetable matter in that form it assumes when decomposition takes place under water or when air is partially excluded. As an active element of fertility it is of inferior value to the brown humus which results from the decay of animal and plant remains in the first few inches of a well-drained soil.

The mineral constituents of the black soils consist chiefly of the silty clay either in practically its original position, as in the case of small local depressions, or of such material derived by surface wash from adjoining higher grounds. In the assorting process that thus resulted very fine silt and clay were generally first deposited in these shallow lakes and ponds and the final filling, largely accomplish by accumulation of plant remains. Thus the subsoils of the larger areas are usually stiff, silty clays inclined to be somewhat impervious. The condition in many instances is relieved by occurrence of gravel immediately beneath the clay, or more frequently of the relatively open till at a depth of a few feet below the present surface.

In some instances the proportion of organic matter on the surface is so high that a mucky or "chaffy" soil is found. Such conditions as well as the few limited areas of true muck are less common in this area than in the counties to the north. In a course of time all these will change to soils of normal structure.

The development of these types has been so largely a function of topography that a relief map would show the approximate location and extent of the individual areas of each type. On the uplands the Miami silt loam and Clyde silty clay loam are so closely associated that this actual representation by this means would require a map with about 1 foot contour interval. In this section very slight differences in elevation, if associated with obstructed drainage, have given rise to pronounced modifications in the organic matter content and in many instances to the texture of the soil and subsoil.

The alluvial lands consist of reworked material of local origin. In the White Lick drainage a silty or fine sandy loam is the prevailing surface soil while coarse sand enters largely into the composition of the lower subsoil. There has been a slight development of terraces along these streams but they are of such comparatively recent origin that the materials have not suffered much modification by weathering, differential drainage, or addition of organic matter.

The high terraces on the larger streams are distinct from those just mentioned. They are much older, certainly pre-loessial, for the silt-clay stratum forms the surface material in all places except where removed by recent erosion, as on the marginal slopes, and flanks of ravines.

On Mill Creek and its several branches a silt loam is the prevailing type, due perhaps to the wider valleys of that stream and to its lesser gradient compared with the White Lick creeks. The source of material of the former stream is chiefly the surface silt or loess, while the alluvium of the White Lick creeks contains much glacial debris on account of the deeper valleys the main streams and the principal tributaries have carved into the drift.

In all instances the alluvial soil of the larger streams is characterized by absence of organic matter and a consequent lighter color than prevails in a soil better supplied with humus. The color is a pronounced brown, suggestive of exceptionally uniform oxidation and distribution of the ferruginous matter. Owing to their structure and to the elevation above the stream channel the drainage throughout is generally good. This, in the absence of organic matter, favors the development of the uniformly brown color. The failure to accumulate humus may be ascribed to the same cause as that operative on the Miami type; that is, to the originally heavy forest cover in conjunction with the effective drainage.

Miami Silt Loam.

The Miami silt loam is the light colored soil commonly called "clay land," or "white land" by farmers. It is the dominant type throughout the county, forming 70 per cent of the total area.

To a depth of 8 or 10 inches the soil is composed chiefly of silt and very fine sand. There is usually a little medium sand present and scattering pebbles and small stones are frequently found on the surface. Cultivated ground, if dry, has an ashy gray color, but under usual moisture conditions very light brownish gray is

the characteristic tint. The friable porous clods crush easily to a fine earth in which there is but a slight tendency to granulation, or the "crumb structure," observable in the black soils. This is due to the low content of organic matter. Even in virgin soils there is very little humus below 4 or 5 inches.

The subsurface soil is usually a gray or mottled gray and yellowish brown silt loam that at 10 to 15 inches changes to a stiff, compact silty clay loam. To a depth of 25 or 30 inches it offers considerable resistance to penetration by any implement and is not usually so permeable to air and moisture as is desirable. While somewhat crumbly on drying it has rather close structure with but slight development of granulation. This condition is modified in some measure by occurrence of coarse sand grains and occasional small pebbles. Where these form an appreciable proportion of the material brown and yellow tints prevail without much grayish mottling, but this latter coloration is characteristic of all the heavier phases of the subsoil.

Below 30 inches the proportion of sand and gravel rapidly increases, this stratum varying from a coarse loam to sandy clay. It is much more open and permeable than the silty clay overlying it. The available moisture content is usually much higher, often sufficient to render the material sticky or plastic when the surface soil is quite dry. The color is generally reddish or yellowish brown. Iron concretions are not commonly found in the lower subsoil but are more numerous in the surface and middle soil.

The Miami silt loam has this characteristic structure: a gray silt loam surface with mottled silty clay subsoil that at less than 40 inches changes to a sandy or gravelly material. The depth at which the latter occurs and the relative thickness of the soil and middle subsoil sections is somewhat variable, but not to such an extent as to materially modify the general physical properties of the type. These variations usually have a rather definite relationship to local topography. The soil and subsoil are of least thickness on slopes and deepest where the surface is nearly level or but gently inclined. On the latter the gravelly substratum may be at a greater depth than 40 inches, while on convex slopes of moderately high gradient it may be within 12 or 18 inches of the surface. In the latter case the soil is generally more sandy and has a brown color. Such phases are essentially the Miami loam and have been so mapped if large enough to show on the scale used. In depressions the soil has more than the average amount of humus, and if

the natural drainage was poor the type passes into the Clyde silty clay loam. There are innumerable gradations of this character not practicable to indicate on the map.

Certain regional variations in the average thickness of the silt-clay layer are recognizable. It is of greater depth in the western townships than in the central ones, and is considerably thinner in the southern part of the area than in the northern portion. South of Plainfield and Cartersburg most of the Miami silt loam has sandy or gravelly material at less than 25 inches. Heavy phases and "clay spots" are of rare occurrence in this section of the area.

All of this type was formerly covered with a mixed growth of deciduous trees. On the heavier phases beech, ash, hickory, white oak and elm were more common than on the lighter textured phases. On the latter, sugar maple, poplar, walnut and red oak formed a large proportion of the forest. There seems to have been less tendency on this type toward the dominance of certain species than on the Clyde soils.

With the exception of the limited acreage in woods pasture all this type is now cultivated. Large boulders are of rather common occurrence in some sections, but neither they nor small stones are numerous enough to interfere with cultivation.

The usual yields of corn on this type are below rather than above 40 bushels. Ground that has been sown to clover and fields in which there are numerous swales where the soil has more than the average amount of humus often produce 50 to 60 bushels. The latter estimates indicate the possibilities of the type instead of present actual returns. The deficiency in organic matter is chief cause of the comparative low average yields, but the close nature of the subsoil renders the type very susceptible to irregularities of rainfall, a factor of great importance in most seasons.

The yields of oats are more generally affected by seasonal extremes than if the soil were somewhat richer in organic matter. In 1912 when the precipitation was ample the average returns were about 50 bushels, but in 1913 dry weather prevailed during May and June, and much of the oat crop was hardly worth harvesting. Wheat sometimes yields 25 or 30 bushels, but the usual returns range from 10 to 20.

After a stand is secured, timothy and clover do well on even the heaviest phases of the type. The production of hay is less than on the Clyde soils, but the quality is good. Considering the fact that all the surface soil is markedly acid it is somewhat remarkable that clover does so well. The free lime in the substratum at

4 to 5 feet below the surface doubtless compensated for the deficiency in the soil and subsoil.

All of the Miami silt loam stands in need of more humus and better internal drainage. The first is so obvious as to hardly need mention, but the relationship between organic matter and the nitrogen supply as well as its effect upon availability of other elements of fertility are discussed in the chapter on agriculture.

Tile drains immeasurably improve the physical condition of the type. They should be lain in rather than below the heavy subsoil and the distance apart in the heavy phases should be not less than 6 or 8 rods, and closer would be advantageous in many instances. Tiles not only remove excess water but induce a freer circulation of air than usually takes place in such tight subsoils. This material is particularly in need of better aeration especially where mottling is conspicuous, or bluish gray clay is found in the lower subsoil. Under natural conditions much of the plant food in the subsoil is unavailable through frequent saturation and lack of oxidation.

Where drains have been installed farmers state that the cost is soon returned in increased yields of grain.

Lime is needed in the soil to correct the acidity. From 2 to 4 tons per acre would be beneficial in all cases but greater amounts would not be amiss. Liming and occasional crops of mammoth clover turned under with the drainage improvement outlined in the preceding paragraph, would render this type far less susceptible to wet and dry weather, and also reduce the apparent need of fertilizers. The latter requirements are taken up in the chapter on Agriculture.

The present price of farms consisting largely of this type ranges from $125 to $150 per acre. The rental value is usually one-half of grain raised or if cash is paid the price ranges from $5 to $7 per acre.

The mechanical analyses of representative samples of this type gave the following results:

Heavy Subsoil Phase.—Where the surface is nearly level and the silt-clay, or loess, has a depth of 30 or 40 inches a heavy phase of the Miami silt loam is usually found. The surface soil is generally very light colored if dry, and more sticky and inclined to puddle when wet than are the normal developments of this type. The deficiency in organic matter and lack of granular structure is very apparent in the soil.

The upper subsoil is generally characterized by much mottling

and the lower portion is more compact as to sometimes be designated by farmers as "hard pan." It is not impervious, however, although at about 40 inches a layer of tenacious, bluish gray clay is sometimes found which is even less permeable than the silty clay loam above it.

The most pronounced developments of this phase are the "clay spots" that occur in practically all the larger areas of Miami silt loam. Fortunately they are not very numerous and the average size is usually less than one acre.

In the extreme western part of the county where the loess has more the average thickness and the surface relief is slight a heavy phase is of common occurrence. The "clay spot" condition obtains chiefly on these local flats where both surface and underdrainage are decidedly poor. In many instances much of the adjacent upland is but little better in this respect, so that the heavy phase generally prevails. The areas so indicated are but approximate representations of this phase because no sharp line can be drawn between it and normal developments of the silt loam. A slight slope toward a drainage line or local elevation suffices in most instances to prevent the sluggish drainage which is the chief factor in the development of the "beech tree" land, as this is locally termed.

The suggestions concerning drainage of the Miami silt loam are particularly applicable to this phase.

Low Phase.—This phase of the Miami silt loam is represented by numerous low lying areas in Mud Creek Valley. Some of them are islands of gray soil in the large tracts of black land, on the lower course of this stream, Post oak flats, some of these were formerly termed on account of prevailing timber. The areas near its source are mostly depressed extensions of upland slopes having but slight elevation above the adjoining alluvial or semi-alluvial lands. While the distinction between this phase and the normal development of the type is chiefly topographic the drainage conditions thus induced have in most instances modified the soil materials and affected the agricultural value.

The soil is a silt loam, similar to that of the uplands, but it usually has very light color, and in many instances a peculiar lifeless, ashy gray appearance not suggestive of a high degree of fertility. There is marked absence of granulation and even where there is some medium sand present, as is often the case, the soil is more inclined to pack after rains, than most of the type on the

uplands. The organic matter content is low and the sharp contrast in this respect with the adjoining black lands is often marked.

The subsoil is a mottled gray and yellow silt loam or silty clay loam. The aeration and drainage are usually poor, or at least not effective to as great a depth as in the higher lying phases. The lower subsoil is generally a sandy material but instead of reddish grown tints some shade of light yellow or bluish gray is not uncommon. In some of the isolated areas in the Clyde loam the deep subsoil is a yellowish fine sandy loam.

Under natural conditions the average level of the ground water was pretty close to the surface of much of these low areas, but since the adjacent land has been drained it has fallen to a depth of several feet. The general condition is improving but the tight subsoil yields rather slowly to effects of better underdrainage. Otherwise the gray and pale yellow coloration would tend to a reddish brown.

Most areas of this phase are especially in need of more complete drainage systems. Wherever the surface soil has an ashy gray color a compact subsoil will be found and this should be opened up by tiles which will give better results than open ditches. With improved drainage it is highly probable that the soil would assume a better physical condition, but liberal applications of lime and incorporation of vegetable matter would insure most effective and permanent change in this respect and greatly increase the available fertility. Under natural conditions or where but little artificial drainage has been secured, the yields of grain are very dependent upon weather conditions during crop growth.

The general increase in the depth of the silty surface stratum that covers all the uplands of this region becomes quite apparent in the west tier of townships of Hendricks County. From New Winchester southward this condition finds expression in the heavy phase of the Miami silt loam. North of Eel River where the surface relief is much more pronounced than in the vicinity of New Winchester the silty upland soils resemble the Miami silt loam, which has an extensive development in the counties west of Hendricks. The areas in the county indicated as Miami silt loam are essentially a broad transition with many local variations according to topography between the true type and the Miami silt loam. It consists of the same kind of material and has about the same agricultural value as the latter. The chief difference is in the depth to boulder clay. This is seldom less than 35 or 40 inches—except

on comparatively steep hillsides—and sometimes is as much as 4 or 5 feet. Owing to the more pronounced surface inequalities compared with the topography of most of the Miami silt loam, and also to the evidently slight increase in sand, this deeper silt usually has a brownish color instead of gray and yellowish mottlings. This is not everywhere the case, but most of the areas mapped as Miami silt loam have as good aeration and as effective subdrainage as the normal phases of the Miami.

The surface soils of these types—as represented in this area—are practically identical. In each case similar conditions with respect to topographic position and drainage have given rise to like coloration, organic matter content and general agricultural values.

The subsoil of the Miami silt loam is usually a grayish or slightly mottled silt to a depth of 10 to 15 inches. Below this, it changes to a more compact silty clay loam. Light brown or buff is the more common coloration but in places gray and yellow mottlings prevails, especially in the lower subsoil. The reddish-brown gravelly till is usually found between the depth of 30 and 40 inches but on the level areas there may not be much change in character of material within 50 inches of the surface.

Along the zone of contact there is usually a higher moisture content than in the middle or upper subsoil. A foot or two below this reddish-brown material the till is more or less calcareous. The surface soil is usually acid.

The crop adaptations and tillage requirements of the type are so nearly identical with those of the Miami silt loam that no separate discussion is necessary.

Clyde Silty Clay Loam.

The soil of this type is a black silty clay loam. The content of organic matter is high, imparting a rather open, friable structure very apparent in well-tilled ground. Below the plow line the proportion of clay is usually higher and the material is more compact. Occasionally it is so dense that it is termed "gumbo," but as a rule it is a very firm black silty clay in which the tendency to break into coarsely cubical granules is well defined. There is not usually so many coarse sand grains or as many small pebbles in this sublayer as in the surface soil.

Below 15 inches the color is much lighter. It is dull brown or drab, often with some brownish iron stains, but the mottling is not usually very pronounced. This material, generally a silty clay,

has a somewhat granular structure, but at a little greater depth it changes to light gray and is very sticky and tenacious if wet. This lower subsoil is not impervious, for as a rule silt particles form a large proportion of the material, and even if no sand is present dried samples show a considerable degree of porosity.

Areas of this type surrounded by the Miami soil usually have a sub-stratum of glacial material. In many instances it may be reached at 40 inches, and the lower part of the 3-foot soil section is a yellow or grayish mottled material with more or less sand. Many of the areas along small streams are underlain by gravel. In such instances the soil contains more sand and scattering pebbles are found on the surface. Practically all of the Clyde soils in Mud Creek Valley have a substratum of loose gravel at from 5 to 10 feet below the surface.

In the type as a whole there is much variation in the amount of organic matter. As a rule it is highest in the soil of the large tracts and lowest in the small, ill-defined areas surrounded by the Miami silt loam, but local differences are often quite pronounced. In innumerable instances the lowest part of an area has a soil containing so much organic matter that it is loose, or almost "chaffy," as the semi-mucky spots are called, while the marginal portions of the area have a firm, silty soil containing no more humus than necessary to insure good physical conditions.

Practically all of the Clyde soils east of White Lick Creek and south of the Cincinnati, Hamilton and Dayton Railroad have but a moderate amount of organic matter. A large proportion of each area is usually silty loam, smooth and friable rather than granular. "Chaffy" conditions never occur in these phases. The subsoils are generally silty clay loams in which aeration and internal drainage are effective to considerable depth, as indicated by the prevalence of brown and yellow coloration.

The areas on the west side of Mud Creek Valley have soils high in proportion of silt. In places the humus content is rather low and the surface appearance of the soil suggests a long period of effective drainage.

In general the organic content is highest in the soils of the northern half of the county, and lowest, or at least more variable, in the southern part.

On Plum Creek, a small tributary of Mill Creek, an exceptionally heavy phase of the Clyde silt loam is found. It is in part, at least, of alluvial origin, the material evidently having been de-

posited by floods from Mill Creek. The surface soil varies from a dark brown silty clay loam to a black, granular clay. The subsoil is a black or drab clay containing some gravel and coarse sand, but usually very sticky and tenacious when saturated. Below 30 inches is somewhat lighter colored and streaked with yellowish iron stains. At about 40 inches below the surface, sandy clay or coarse sandy material of variable structure is found.

The surface soil is well supplied with organic matter—black carbonaceous material—that imparts a loose, crumbly structure, highly favorable to a good condition of tilth. The upper portion of the subsoil is also more or less granular and this structure also prevails in most instances to a depth of 2 feet or more. This insures good aeration to this depth, which in the central part of the area is but little above the usual water table. On the outer margin of this area the surface soil is of lighter texture, having been modified by washings of silt from the adjacent uplands.

This soil has practically the same crop adaptations as the heavier phases of the type elsewhere.

The smaller areas are local depressions in the uplands and the larger ones valleys of present streams or sites of former lakes. In all cases obstructed drainage and conditions arising therefrom have been the chief factors in the development of the type.

The organic matter consists almost entirely of black, carbonaceous material in the form that vegetable debris assumes if its decomposition takes place under water. As an element of fertility it is probably less valuable than organic material in the process of decay in a normal soil, which forms brown humus. But this abundant black humus imparts excellent physical conditions to what would otherwise be heavy clayey soils, and to its presence must be attributed their present high agricultural value.

The Clyde silty clay loam is preeminently the corn soil of this area. The yields are from 50 bushels per acre upward to 80 or 90. The highest average returns are secured from those areas where a water-bearing substratum is found at 3 or 4 feet. If the surface is well drained these phases are but little affected by extremes of precipitation. On the small areas surrounded by the Miami silt loam and including more or less transitional phases between the types, seasonal variations are more noticeable, but the average returns of all crops are exceptionally good.

The occasional spots where the excessive amount of humus in the surface soil gives rise to "chaffy" conditions will improve in

course of time. Washing from the higher ground will tend to correct this trouble. Deep plowing has the same effect. The places where the upper subsoil is a very stiff clay would be benefited by deep fall plowing which by exposure of this clay to the atmosphere gives rise to a finely granular condition and admits of more or less admixture with the coarser organic remains of the surface soil.

Wheat yields are sometimes 30 bushels per acre, but this is much above the average. In seasons of heavy rainfall oats are liable to grow so rank as to lodge badly. In 1913 when but little rain fell in May and June, much better yields were obtained on this type than in 1912, when there was abundant precipitation in the corresponding months.

Clover and timothy make exceptionally heavy yields on this soil. There is usually but little difficulty in securing a stand or maintaining it as long as desired. The soil is not acid, or rarely so, according to the litmus paper test. In some instances the lower subsoil will react to hydrochloric acid, but lime concretions and limestone fragments are numerous in the substratum at less than 5 or 6 feet, where the latter is not exceptionally gravelly. In the latter case the subsoil evidently contains enough lime to meet requirements of all ordinary crops.

Well-drained locations are suitable for alfalfa. Where a very smooth light-colored clay is found at less than 30 inches the average level at which the ground water stands should be ascertained. In such places the drainage may be insufficient for alfalfa. Most of the silty phases that have tile drains or even an open ditch nearby are safe with respect to moisture conditions. Fields that produce good corn and clover and which have water-bearing gravel at about 6 feet are admirably adapted to alfalfa. The soil would be benefited by lime, and inoculation may be necessary.

Commercial fertilizers are not generally used on this soil, practically none are needed. It is probable that no profitable increase in yields could be secured above those obtainable by means of better tillage and the use of legumes. This statement does not apply to the "chaffy" spots where liberal treatment with potassium in some form is so beneficial to corn.

Under continued cultivation there is a noticeable tendency toward reduction of the original organic matter content. Farmers state that some ground that has long been in cultivation now requires more labor to keep it in good tilth. The most practicable

means is turning under of clover. This is practised to a considerable extent on the black soils but in no such measure as to compensate for the steady drains occasioned by the almost continuous cropping to corn.

The present price of this land unimproved except by artificial drainage is generally above $100.00 per acre. Well improved and desirably located farms consisting chiefly of this type command from $150.00 to $200.00 per acre. The rental value is in the neighborhood of $7.00 or $8.00 per acre.

Clyde Loam.

The soil of the Clyde loam to a depth of about 6 inches varies from a moderately heavy black loam to a sandy loam. There is a rather high percentage of clay present so that the material when wet is slightly sticky and the tendency to form friable clods is very observable in cultivated fields. They crush easily and the fine earth is "crumbly," or granular. This desirable structure is due in large measure to the high content of humus, practically all of which is in the form of finely-divided carbonaceous material.

Between the depths of 6 and 15 inches the subsoil is usually a stiff bluish-drab or black clay loam. It contains some sand and gravel and the property of granulation is not lacking but this part of the subsoil is much more compact than the surface soil. In a few places it is so hard to turn with the plow that farmers call it "gumbo."

The lower subsoil is usually a clay or clay loam but contains a good deal of coarse sand and gravel. A light bluish color indicative of rather poor aeration prevails in some places, but most of this subsoil is a dull brown or some shade of yellow with numerous dark-brown iron stains.

Thirty to 40 inches below the surface sand and gravel form a large proportion of the material, and at a depth of 5 or 6 feet in most places the top of what is evidently a deep water-bearing gravel bed is reached.

This description applies to most of the large area on the lower part of Mud Creek Valley. The areas further up the stream and those joining the Clyde silty clay loam are not so sandy.

Practically all has been reclaimed within the last 30 years, or since the channel of Mud Creek has been deepened. The original timber consisted chiefly of elm, ash, hickory and white oak.

The average yields of corn are high. Seventy-five to 90 bushels

per acre are not uncommonly gathered on well tilled ground. The returns from wheat, clover and timothy are comparable with those of corn. The friable easily-tilled soil and excellent moisture conditions of the subsoil and stratum just below render the type almost drought proof, while the drainage is now efficient.

The present price of land is about $125 per acre. Farms, with good buildings, consisting wholly or in part of this type command a higher price.

A heavier phase of this loam is found on the low Mill Creek terraces associated with the Fox silt loam. The soil is a loam or silty loam to a depth of 8 or 10 inches. The proportion of sand is not so high as in the Mud Creek soil, but there are usually more pebbles and very small stones on the surface. The organic matter content is sufficiently high to impart a good black color and insure a crumbly structure to the surface soil.

The subsurface layer is a rather heavy clay loam that with increase of depth has considerable sharp, coarse sand and more or less gravel. The color ranges from bluish-drab to various shades of brown or yellow. The drainage is good since the main streams in this section have channels much below the level of this soil and loose sand and gravel form the substratum. It is found at varying depths but in many places is not more than 5 feet below the surface.

All of this phase is very desirable farm land. It may not have quite so high a degree of available fertility as the areas on Mud Creek but the crop yields are nearly as high in normal seasons.

Miami Loam.

The Miami loam is a rather broad type embracing the soils found in the rougher parts of the uplands. The topography varies from local elevations with their usually moderate gradients to more hilly lands along the streams where shallow ravines and bluffy escarpments are very common features. Under such conditions uniformity in the texture and structure of the soils is not to be expected. There is considerable variation in this respect, most apparent in the majority of instances when local differences in surface configuration are compared. The soil and subsoil of the material found on steep slopes is usually coarser textured and more open than that on the crests of ridges or where the land is but slightly rolling. In a broad way, however, the agricultural value of the land in any one section near the larger streams does

not differ greatly from that in another area of corresponding size similarly located. The same statement holds true with regard to those developments of the type found on the structural elevations, or morainic hills, of the upland. Locally there may be considerable difference in character of the soil in a ten-acre field, but in comparing areas of much larger size one with another, the average value is about the same.

The difference with regard to topographic position gives rise to two quite distinct phases although the line between them can not be drawn very closely. The surface soil on the slopes along the drainage lines is usually coarser textured and presents more variable subsoil conditions than the phase developed on the ridges and morainic mounds. The latter have a more silty soil and a heavier subsoil, and are usually less stony, although there are many exceptions to the last statement.

The soil of the slope phase—as that near the streams has been termed—is usually a light brown, or grayish-brown soil in which fine sand and silt are the chief components. It varies texturally from silty loam to a fine sandy loam. Coarser material in the form of pebbles and small stones is usually present but not to such an extent as to interfere with cultivation.

The upper subsoil is generally a silty loam moderately compact but possessing good capillarity. Brown or yellowish-brown tints are the characteristic colors but in the heavier phases of this section there may be some grayish mottling. The lower subsoil is brown or dull reddish-brown loam with more or less coarse sand and small gravel. This lower part of the subsoil as well as the material below is usually glacial debris with the relatively high degree of oxidation of the iron content that characterizes the upper part of the boulder clay. In many places the material is a silty clay with a coarse blocky structure. The color in such instances is a dull chocolate or may be obscurely mottled with very dark reddish-brown iron stains.

In practically all instances both soil and subsoil have good internal drainage and the aeration is relatively free and effective to a depth of several feet. The structure induces good capillarity, and as the substratum of glacial material usually has a high moisture content the soil seldom becomes very dry. It is this property, combined with good drainage, that enables this phase to endure seasonal extremes so well. Crops seldom suffer from excessive rainfall nor are they so soon affected by dry weather as on the Miami silt loam.

Compared with the last-named type the slope phase of the loam includes a larger proportion of glacial material. Limestone fragments are sometimes found within the 3-foot soil section, and calcareous material occurs at slightly greater depths. The soil is not generally very acid, although there are numerous exceptions, usually in spots where the silty character is most pronounced.

This phase includes those lands which owe their surface inequalities chiefly to erosion. With the exception of the bluffs along the larger creeks and the ravines extending back into the uplands practically all of the surface is tillable.

A phase of the Miami loam is found on the isolated mounds, low ridges, and larger areas of rolling to very moderately hilly land that form divides between some of the local drainage systems. In general the topography is milder than that of the slope phase. There are no stony bluffs and very few slopes on which heavy implements cannot be used conveniently.

The soil is not quite so clearly differentiated from the Miami silt loam as is that of the slope phase. It is more silty and the depth to the sandy or gravelly part of the subsoil is usually greater —averaging more than 18 inches. The soil materials are practically the same in each phase—a silty stratum overlying glacial materials. The former has lost more or less of the finer constituent through surface wash with consequent reduction in original thickness and an increase in the relative proportion of the coarser particles. On the crests of the local elevations and on steeper hillsides the surface soil is a fine textured loam or a fine sandy loam. Where the inclination is less or the slopes very long the soil is a silt loam but usually carries some coarse sand, while gravel and small stones are more or less numerous.

On account of the comparatively open structure of the soil and shallow depth at which the coarse glacial material occurs the entire soil section has good internal drainage and aeration. The iron content has been pretty well oxidized and light brown to reddish brown are the prevailing colors. The chief exceptions in this respect occur on level spots and the lower flanks of ridges where the silty material has much more than the average depth. Such spots are essentially a heavy phase of the Miami silt loam.

The largest area of this phase is found on the morainic divide between Danville and North Salem. There are also areas of less extent in the southern and western parts of the county.

On Eel River for a mile or more above the west county line the

bluffs and steep hillsides rise 100 feet or more above the stream. A number of small branches from the north have cut deep ravines, so that in this locality some very broken land is formed but the individual areas of such ground, however, are generally small. The soil is mostly a stony or gravelly loam of little value except for pasture. Along Eel River the Knobstone shales are exposed and influence the lower slopes to some extent, but elsewhere the soils are glacial material.

The limited areas near Danville are a very rough phase of the Miami loam, as are several small tracts in the extreme northeastern part of the county.

The miles of steep slopes on each side of the valleys of the White Lick creeks, having in most instances an inclination greater than 45 degrees, are essentially this type of soil. They would have been so indicated, but their representation on a map of this scale is impracticable. Where the vertical height exceeds 25 or 30 feet these bluffs have been indicated by hachures.

The very small areas shown in so many places are mounds rising from 10 to 50 feet above the general level of the country near them. In the northern part of the county most of these small elevations have a moderately heavy loam soil that on the lower flanks grades to the Miami silt loam. The areas between Amo and Stilesville are prominent ridges with sandy loam surface soils underlain at a few feet by gravel. Some of these areas are inclined to be droughty.

All of this type is locally called "sugar tree land" by farmers. This name, which is also applied to the lightest and best drained phases of the Miami silt loam, indicates the prevailing timber growth. The few remaining "sugar camps" are generally open groves on ground too rough to be easily farmed.

The high agricultural value is due to the excellent drainage and aeration that practically all of it enjoys. It endures seasonal extremes well. As previously stated, the glacial material, excepting gravel beds, generally maintains a high content of available moisture. In most of this type the upper limit, so to speak, of this soil water supply is generally within two feet of the surface. The texture of the overlying material is usually very favorable to capillarity, and to the easy penetration of roots of growing crops. The elements of fertility are thus continually available without those interruptions due to saturation in soil types where the internal drainage is sluggish, or on the other hand, the texture so coarse that the deep subsoil water is cut off.

It is also probable that the total amounts of the essential mineral elements are higher in the three-foot soil section of the average phase of this type than in the corresponding depth of the level upland soils. In the latter case the leached surface materials have not been removed, or but slightly reduced in original thickness, while on the hilly lands erosion constantly tends to bring the comparatively fresh, unweathered rock debris within the zone occupied by roots of growing plants. This is certainly the case with respect to the lime in the boulder clay and must apply in some measure to other elements. The surface soil, however, is acid but not strongly so except in the heaviest phases.

The low content of organic matter is doubtless the limiting element in production of corn, and to a less marked degree of other crops. The average yields of corn may be placed above forty bushels per acre; wheat does well compared with returns on other types, and oats not so liable to be affected by unfavorable seasonal conditions as on either the Clyde soils or Miami silt loam. Some excellent stands of alfalfa have been established on each phase of this type, while clover is ordinarily secured without much trouble.

Fox Sandy Loam.

This type comprises the coarse-textured soils on the low terraces of the larger valleys. Most of these second bottoms lie well above the flood limits and the drainage otherwise is good. In most instances the outer margin is a gentle sloop or a slight acclivity rising a few feet above the average level of the more recent alluvial deposits between it and the stream. The surface of the larger areas is nearly level, or has a very moderate gradient from the foot of the adjoining uplands and toward the down stream side. The small areas have the more uneven surfaces and also the greater variation in texture of the soils.

These low terraces consist for the most part of reworked glacial material deposited by the stream when its channel was at a higher level than at present. Along the foot of the uplands, in many instances, the material has been derived largely from adjacent slopes, or laid down by transient floods from the small tributaries.

Throughout most of the larger areas the surface soil is a rather coarse sandy loam with enough interstitial material to cause very friable clods to form if plowed when wet. There is usually but little humus except in local depressions. The surface color is dull gray to brown, due to weathering, but the mineral particles almost

invariably have a coating of iron oxide that gives the fresh soil a pronounced brown color.

The subsoil to a depth of about 30 inches—although there is much variation in this respect—contains much more silt and clay than the surface soil. It is usually a reddish-brown loam or clay loam with more or less sand and gravel and frequently many small stones. The lower subsoil is a gravelly clay that with slight increase of depth generally changes to gravel or sand.

On slight elevations and along the marginal slopes the soil is usually a rather light sandy loam and the subsoil is very gravelly, or frequently a loose brown sand. Such spots are droughty and crops thereon soon show the effect of dry weather.

As the uplands are approached the surface becomes heavier and the subsoil has no gravelly stratum immediately below it. If present, the latter is at a considerable depth. In sags and former semi-marshy spots at the foot of the slopes the soil is frequently a black, silty loam, but such areas are small and not of frequent occurrence. But in many instances there is an exceptional amount of yellow iron oxide at certain depths in the subsoil, suggestive of deposits of bog iron.

With some exceptions there is a sufficient depth of fine textured material to hold enough moisture to meet the requirements of crops, but any prolonged drought is likely to test the endurance of this type. It is not quite so safe in this respect as the Genessee fine sandy loam or most of the uplands types. The water table, as indicated by wells, is from 10 to 15 feet below the surface, but the presence of a gravelly substratum may, and undoubtedly does, in many places, prevent capillary connection between this source of supply and the surface soil.

Some successful stands of alfalfa have been established on this soil. Clover also does well. In both cases it is probable that the roots reach water. The soil is not acid, and on the heavier phases near the hills there is more or less direct deposition of washing from slopes where the calcareous till is exposed.

In normal seasons corn yields from 40 to 60 bushels. There would be marked increase if more frequent changes to clover were made. This type is usually treated as an alluvial soil, but most of it receives no periodic additions of silt from floods. The deficiency in humus is not such a serious matter as in the upland types, but the fertility could be increased by plowing under more vegetable matter.

Several of the areas on White Lick Creek near Avon are terraces much older than those just described. They have greater elevation and most of the material forming them is glacial rather than alluvial. The soils are heavier than those on the low terraces of the same stream. In most instances the surface soil is a brown silty loam with considerable sand and gravel and the subsoil is a yellowish silt loam. The drainage is good and the general agricultural value is similar to that of the Miami loam. The slopes are very similar to the rougher portions of the latter type, but the level surface suggests terrace structure and these areas have been included with the Fox soils.

Fox Silt Loam.

The soil to a depth of about 6 inches is a moderately dark gray silt loam. It usually contains enough medium and fine sand to impart a decidedly gritty feel to hand sample and materially increases its friability. Some gravel and small stones are usually present, but large boulders are of rare occurrence. The organic matter content is low and in most instances does not affect the color below the plow line. In local depressions the humus may be more abundant and if so the soil to a depth of a foot or more is quite dark and slightly granular. The latter property is almost entirely lacking in the normal phases of the type.

To a depth of about 15 inches the subsoil is a crumbly silt loam or silty clay loam rather compact but containing some coarse sand and well rounded gravel. The lower subsoil is usually a reddish or yellowish-brown clay loam with so much gravel that it is difficult to penetrate with a soil auger below 25 or 30 inches. In places the material is a sticky sandy clay. Where stratified gravel is found at a depth of a few feet the lower part of the 3-foot soil section is usually a reddish-brown clay of pronounced granular structure. But unconsolidated sand and gravel is not found at such shallow depths in many places. The substratum, as the uplands are approached, is glacial material that evidently does not contain a great deal more coarse debris than the till underlying the upland soils, but it is sufficiently open to admit of comparatively free underdrainage, and there is seldom any indication of poor aeration. Farmers state that this land is in condition for tillage after heavy rains much sooner than the Miami soils.

This description is applicable to the large areas on White Lick Creek. The surface is nearly level except for occasional ravines extending back some distance from the bluffy margins overlooking the valleys. These slopes are too steep to admit of cultivation, but the soil thereon is a gravelly loam that is by no means droughty or unproductive.

The small areas of this type along the middle course of White Lick Creek have not so great an elevation as the larger ones. This is also true of some terrace soils on Eel River near North Salem that are included with this type. In all such instances the surface is more or less uneven and a relatively larger proportion of the entire area is involved in the marginal slopes. The soil is more sandy than that of the higher terraces and the subsoil is quite variable in texture. The agricultural value of such phases is about the same as that of the Miami loam.

The areas of Fox loam north of North Salem are not more than 15 or 20 feet above the stream levels. Those south of the town lie 50 feet or more above the valleys and the general difference in elevation rapidly increases toward the southeast. None of these areas are very sharply differentiated from the adjoining Miami silt loam. The long easy slopes of the latter merge almost imperceptibly into the level surface of the terraces, and there is hardly greater difference in the general character of the underlying glacial deposits. The Fox soils usually contain the higher percentage of sand, are a little darker colored, and the subsoil is seldom quite so heavy or has the mottling characteristic of the Miami silt loam. The surface material is the silt, or loess, that gives rise to the Miami silt loam and is not essentially different in mineralogical composition or general physical properties.

The suggestions concerning the maintenance of fertility on the Miami silt loam apply almost equally well to these heavy phases of the Fox soils. They are deficient in humus and in some places need drainage to render them less susceptible to excess of rainfall. But as previously stated, most of the type has good underdrainage.

Wheat does well on this type, and the average yields according to farmers is somewhat above that of other upland types. The adaptability to clover, timothy, corn and oats compares closely with the Miami loam, but the level surface renders tillage easier and there are not such local differences in the surface soil.

A phase of the Fox silt loam is the principal soil type on the low, broad second bottoms of Mill Creek. The valley of the east

fork below Pecksburg is more than a mile in breadth and all except the narrow flood plain—seldom exceeding a quarter mile across—consists of level bench lands from 5 to 20 feet above the first bottom. Above Stilesville terraces of greater or less extent occur on each of the branches of Mill Creek. The surface of each is very slightly undulating, or may have a perceptible inclination from the foot of the upland slope toward the stream and also down the valley. The surface drainage is good and is supplemented by the generally coarse structure of the underlying materials.

The latter throughout most of the valley of the east fork is gravel, or very gravelly till. The low, isolated hills in this locality have gravelly centers and on the level land adjoining them similar material is usually found at from 5 to 10 feet. At the head of this valley the gravel beds if present seem to be deeper, for the general structure of the soils is more like that of the upland types. The areas above Pecksburg are separated from Miami silt loam chiefly on account of level topography. On the bench lands north and northwest of Stilesville the substratum is a boulder clay.

In general the soil on these low terraces is somewhat darker colored than that of the high terraces. It contains more sand and usually scattering pebbles and a few stones are present, often in considerable numbers, along the margin near the stream. In places there is enough organic matter to darken the surface, but as a rule the humus content is low. A slightly ashy gray color often prevails and there is no crumbliness to soil in such instances. These ashy phases as well as very light-colored silty soils near the upland slopes need artificial drainage. The subsoil is often a mottled gray and yellow silty clay quite close and heavy to a depth of several feet. Most of the phase has an acid soil and lime fragments are not seen except in deeper exposures of the heavier phase of the till.

Genesee Sandy Loam.

In each of the larger valleys there has been some development of coarse-textured soils on the first bottoms. As a rule the individual areas are limited to the immediate vicinity of the channels, or to the debouchure of a tributary valley. In the latter case the soil materials include more silt and clay and also stones than in the former. In all instances there has been considerable assortment of materials so that uniformity in texture and structure are not to be found over any considerable development of the type.

On White Lick Creek, between Brownsburg and Plainfield, most of the alluvium indicated as Genesee sandy loam ranges from a brown loamy sand to moderately heavy sandy loam. In depressions there is enough fine material to such depth that the soil is a silty loam, but heavy phases constitute much of the total area. The subsoil is usually a sand or very open material of some kind. Much of the surface is overflowed each spring but a part of these areas are not inundated except by unusually high water, and in no case are the lands covered for any length of time. The high gradient of the streams and the strip of lower ground that immediately borders it in so many places prevents any prolonged occurrence of a flood stage. This is practically true of all the larger creeks in the county.

South of Plainfield the sandy loam near the Meadow is generally a coarse brown sand with enough interstitial material to give most of it some agricultural value. Farther from the stream, where the line between it and the fine sandy loam has been drawn, the soil is a sandy loam of variable depth and texture. All this part is cultivated but somewhat susceptible to dry weather. Small areas near the foot of the bluffs are generally a loam with brownish sandy clay subsoil of sufficient depth to retain moisture fairly well. Most of the latter lie above all liability of overflow from the main stream, and are not usually injured by water from the tributaries.

Most of this sandy soil is regularly cultivated to corn and the yields are satisfactory. Wheat does not do so well except on the heaviest phases. Clover and blue grass usually show effects of dry weather on the light sandy knolls and other places where the subsoil fails to afford capillary moisture during protracted dry periods.

Genesee Fine Sandy Loam.

The surface soil of this type ranges from a light, fine, sandy loam to a silt loam. Silt and fine sand are the chief constituents, with a rather variable proportion of coarser particles. Gravel and small stones occur sparingly in most places, but are never abundant. The color is a pronounced shade of brown. Each soil grain seems to be uniformly coated with brown oxide of iron and there is seldom enough vegetable matter present to materially modify this dull ocherous tint.

No definite line may be drawn between soil and subsoil. The latter consists of the same kind of materials, although at a depth of 6 or 8 inches a little heavier and more compact zone is usually en-

countered which may prevail to a depth of 20 or 30 inches below the surface. The lower subsoil is much coarser textured, consisting in most instances of fine sand that with increase in depth rapidly changes to coarser sand with but little interstitial material. Five or six feet below the surface gravel is usually found.

In general the depth of the soil body, that is, the stratum of material having sufficiently close structure to retain moisture well, may be placed at about 30 inches. It is thinnest and also more sandy as a rule near the stream channel and gradually thickens and is heavier in texture as the foot of the bluffs are approached. In the latter locations, in the widest parts of the valleys the depth to the substratum of coarse sand or gravel may be several feet.

Practically all this superficial stratum consists of reworked material of local origin. It is probable that the silty surface covering of the hills has contributed the greater part. It is a comparatively recent deposit, although general overflows are not now of frequent occurrence, except in the narrower parts of the valleys. In the spring of 1913, however, nearly all of this type was inundated; also in 1875, when exceptional floods covered all the alluvial soils.

Near the channels of the main streams and more especially below the entrance of tributaries into the valleys the surface is often overflowed for a few hours at a time, but with these exceptions injury from high waters is not usually very frequent or extensive. In nearly all of the larger areas the surface elevation above the channel, or of the meadow, where the latter is developed, ranges from 3 or 4 feet to as much as 10 or 15 feet near the outer margin of the valley.

In all of the widest portions of the White Lick valleys this fine sandy loam is the prevailing type. On the Mill Creek branches and also on Eel River the texture of the alluvium is more variable, ranging from a moderately heavy silt loam to a sandy loam, but much of it corresponds fairly well with this type and has been so indicated on the map On the small branches the type is of course quite variable.

Notwithstanding its deficiency in humus practically all this soil has a high degree of available fertility. This is due chiefly to its physical structure. The soil yields very easily to tillage and with a minimum of labor may be kept in excellent tilth. The subsoil is sufficiently open to admit of deep penetration of water while it also has good capillarity and is seldom lacking in moisture. Much

of this supply doubtless comes from the permanent water table which is seldom more than a few feet below the surface. In some places a thin stratum of coarse sand at 30 or 40 inches may cut off capillary connection between the subsoil and the permanent supply below, but this structure is not of common occurrence except on slight local elevations or near the stream channel.

The average yield of corn on this type may be placed at about forty bushels. On the heavier phases, especially the depressions along the foot of the bluff, a much higher yield is generally secured. This is also true of fields where corn follows clover, but there is less of this legume grown on this bottom land than is desirable for the maintenance of as high a degree of fertility as the type is capable of attaining.

Oats usually do well and excellent yields of wheat are secured, but owing to possible injury by winter or early spring floods the latter grain is not generally sown. The higher portions of this land are suitable for alfalfa and some good stands have been established. While the soil is not acid, liming would probably be advantageous and organic matter in some form ought to be added.

The narrow strips on the small branches are more frequently used for pasture than for cultivated crops. Blue grass usually makes a more continuous growth than on the upland soils, especially where the moisture content is above the average, as is frequently the case at the foot of the stony slope.

Genesee Silt Loam.

To a depth of 8 or 10 inches the soil of the Genesee silt loam is a light brown or dark grayish-brown silt loam. It rarely contains much coarse material of any kind except perhaps some scattering pebbles on the surface. The percentage of organic matter is low, but owing to the predominance of silt and very fine sand the soil is friable and but little inclined to become cloddy or compact.

The subsoil is a moderately heavy silt loam to a depth of about 30 inches, where it usually changes to a fine sandy loam that with further increase of depth is a sand or light-textured material of some kind. In the lower part of the subsoil mottled rusty-brown and reddish-brown spots occur, but in the upper subsoil the coloration is uniformly a pronounced brown, indicating the equitable moisture conditions that usually prevail.

This is the dominant type on the first bottoms of Mill Creek and its principal branches. The surface is generally level, with fewer

local inequalities than on the fine sandy loam. The average elevation above the stream channel of the area north of Stilesville is from 5 to 10 feet, so that general overflows are not frequent. The general surface drainage is effective and has been supplemented by open ditches.

On each of the branches of Mill Creek the Genesee silt loam is the prevailing type. Lighter variations occur near the channel and occasionally in the wider parts of the valleys, but practically all phases have a high content of silt and are valuable agricultural lands.

Corn is the principal crop to which this type is devoted. Other crops do well and excellent stands of clover are easily established. As stated in the description of the fine sandy loam, the fertility is due largely to good structure and unfailing moisture supply.

The small areas in West White Lick Valley are silty loams corresponding in the main with the larger developments on Mill Creek. The small areas below Plainfield are rather heavy silt loam with enough organic matter to give the soil a dark color. They owe their differentiation from the adjoining fine sandy loam to depositions of silty material from back waters of high floods. The natural drainage in most instances is poor owing to low position and more or less seepage from the bluffs.

Muck.

In only a few places are there such accumulations of vegetable debris that true muck has formed. In Section 15, Township 17 N., R. 1 W., several small areas of shallow muck occur. The depth seldom exceeds 12 inches, and there is considerable earthy matter mixed with the vegetable remains. It forms a black, spongy soil, grading to a very black, waxy clay, that extends to a depth of 15 or 20 inches. The lower part of the subsoil in many instances is a rather soft silty clay that contains so much carbonate of lime that it effervesces when tested with hydrochloric acid. Where the muck is not so deep, or is little more than a very light "chaffy" soil, the lower subsoil is a yellow clay without unusual content of lime.

These areas indicated, as well as other small ones not shown on the map, are associated with the Clyde soils and produce nearly as much corn and clover per acre as the latter. In most cases potash has been most profitably used with the former crop.

Occasional small accumulations of muck—owing their origin to

seepage from the hillsides—are found at the foot of the bluffs on the lower course of White Lick Creek. Most of them are mapped with the adjoining soil type on account of small extent and comparative shallowness of mucky material.

Meadow.

The very recent alluvial deposits of the larger streams and the narrow strips of low land along the small branches have been mapped as Meadow. The character of these soils, their drainage conditions and value agriculturally vary so much that no definite classification is practicable.

On the comparatively level uplands of the western part of the county many of the minor drainage lines have throughout most of their courses flat bottoms varying from a few rods to one hundred yards or more in width. The soil of these little valleys, which in many cases are bounded on each side by a low bank or sharp acclivity of several feet, is usually a brown silty loam that toward the head of the branch merges into the Clyde soils. While subject to frequent overflows the drainage at other times is sufficient to admit of a good growth of blue grass or even permit of cultivation. Occasional patches may be so wet that only coarse wild grasses thrive on them, but these are exceptional.

In the northern part of the county the small branches after leaving the areas of black land have cut rather deep narrow courses without much ground subject to overflow until the valleys of the creeks are reached. There is little of this low land which cannot be referred to either the Clyde or Genesee types. There is not much Meadow on the streams in the southern part of the area.

Along the middle course of White Lick Creek and to a less extent on the west fork of that stream the channel is bordered by a strip of sand ground lying from 5 to 10 feet below the adjoining bottom land. It is generally covered with willows, sycamore, and other water-loving trees and bushes. Below Plainfield the areas indicated as Meadow include many sand and gravel bars, for here the stream is rapidly deepening and widening its channel.

In nearly all instances the actual width of the strips of low land is somewhat exaggerated. Where none are shown on the creeks the tillable ground usually extends well up to the banks of the streams.

SUMMARY.

Hendricks County is located in the central part of Indiana, and has an area of 420 square miles. Most of the surface of the northern and western townships is undulating to very gently rolling. In the central and southern part of the county the relief is stronger but with the exception of low bluffs along White Lick Creek practically all the land is easily tillable. The valley of the above mentioned streams and the tributaries are comparatively narrow and bounded by short, abrupt slopes. This is also true of the lower course of the Eel River, but the valleys of the Mill Creek branches and of Mud Creek are much wider and the adjoining uplands rise in long, gradual slopes.

The average size of farms is about 90 acres. Corn, oats, winter wheat, clover and timothy are the principal crops of grain. From almost every farm more or less live stock is annually marketed. Hogs are the most important of the latter products, but cattle feeding is practiced to an extent that places the county among the leading ones in this vicinity of the State. Dairying is becoming an important business, but truck and fruit growing are of subordinate interest.

Throughout the entire area the principal soil-forming material is a surface layer of silty clay, or loess, ranging from 2 to 3 feet in thickness. It overlies a deep deposit of boulder clay whose physical and mineralogical features exert much influence upon the soils.

Whenever the silty clay stratum has about the average depth and the natural drainage is good the Miami silt loam has been developed. It is characterized by light color of the surface soil and rather heavy subsoil. Wheat, oats and timothy do well on this type, but the acidity and deficiency in humus renders it somewhat less suitable for clover and corn than the Miami loam.

The latter, on account of coarser texture and more rolling surface, has somewhat better internal drainage and is not quite so susceptible to seasonal extremes as the silt loam.

In each type several phases are recognizable, chiefly differences in topography, drainage and depth to the underlying till.

The Clyde soils are the black lands found in all the depressions of the uplands and in valleys wherever the natural drainage was poor. They have a high content of organic matter and since artificially drained are exceedingly productive. Associated with these soils are limited areas of mucky, or as locally termed, "chaffy lands."

The strictly alluvial soils are mostly brown silty or fine sandy loams. They consist of material derived locally from the loess and glacial deposits. Owing to the depth of the present stream channels and to the generally sandy nature of the substratum, the drainage of these soils is good. Practically all are under cultivation and highly esteemed for general farming. The three types recognized have been correlated with the Genesee series.

The limited area of second bottoms have soils very similar to the Genesee sandy loam, but since they lie above overflow they have been termed Fox sandy loam.

The high terraces found on each of the large creeks consist of glacial material and have a silty surface stratum so that the soils are almost identical with the Miami type. Then differentiation is chiefly on account of level surface and physiographic position.

BUREAU OF SOILS—MILTON WHITNEY, Chief
In Cooperation with the State of Indiana, Department of Geology
EDWARD BARRETT, STATE GEOLOGIST

SOIL SURVEY

OF

DELAWARE COUNTY, INDIANA

BY

LEWIS A. HURST, OF THE U. S. BUREAU OF SOILS, AND
E. J. GRIMES, OF THE INDIANA DEPARTMENT OF GEOLOGY

1913

Soil Survey of Delaware County, Indiana.

By Lewis A. Hurst, of the U. S. Bureau of Soils, and E. J. Grimes, of the Indiana Department of Geology.

DESCRIPTION OF THE AREA.

Delaware County, comprising an area of 399 square miles, or approximately 255,360 acres, is situated in the east-central part of Indiana, in the second tier of counties from the Ohio state line. The county is rectangular in outline, 19 miles from east to west and 21 from north to south. Grant and Blackford counties bound it on the north, Jay and Randolph on the east, Henry on the south and Madison on the west.

The surface is level to slightly undulating, except near stream courses, where erosion has rendered it more broken and in places even hilly, or where moraines exist. The descent to the stream courses is often abrupt or precipitous. The banks along the larger streams generally rise in two distinct terraces to the broken country, which merges rapidly into the broad level plain. Numerous old filled-in valleys in the area indicate that the preglacial topography was much more irregular than that of the present time. The most prominent of such valleys is one east of New Burlington, crossing Perry Township near the center and connecting with White River, and another lying parallel to the Granville Pike northeast of Muncie, known as "Muncie Prairie." The greatest surface relief is found in the northeast and southeast portions, particularly near Prairie and Stony creeks in Perry Township and Easley's Creek in Nile Township. Scattered throughout the county are many morainic knolls and ridges which frequently rise to an elevation of several feet above the general surface adjacent. A number of kames or rounded hills of gravel and sand are to be seen in the county, the most important ones being found between Muncie and Granville and between Muncie and Smithfield. There are several in and about Muncie, but much of the gravel has been removed from them. A prominent chain of asars, or long, narrow ridges of sand and gravel, extends from a point two miles east of Granville to a short distance northeast of Muncie. Its elevation is about 30 feet above the general surface. The watershed between

White and Mississinewa rivers present the largest expanse of level till plain, and it is in this section that the greatest acreage of "black land" occurs. The watershed between Buck and Bell creeks is also rather level, with but little relief except as the stream is appoached. The better drained uplands are seldom more than a few feet above the depressions in which the darker soils are found.

The average altitude is between 900 and 1,000 feet above sea level. The general slope of the surface is from east to west.

A heavy mantle of glacial drift of the late Wisconsin ice sheet covers the entire area, the depth of which is conjectured as ranging from 50 to 250 feet. The surface clays are either yellow where thoroughly oxidized or gray where oxidation has not taken place. A bluish or gray color characterizes the clays beneath the surface. The first water-bearing gravel is reached at depths varying from 10 to 60 feet.

No rock outcrops occur in the area, but it is in places sufficiently near the surface to be quarried, the largest quarries being located in the vicinity of Muncie and Yorktown.

The Mississinewa and White river with their tributaries drain the county, the Mississinewa, having as its chief tributaries Easley's, Half Way, Pike and Campbell creeks, receives the dainage of the northern one-third. White River drains the remainder, Prairie, Buck, Mud and Bell creeks being the largest tributaries. Kilbuck Creek flows into the White River in Madison County. A noticeable feature of several of the tributaries of these two rivers is that they parallel the rivers for a number of miles short distances apart. Pike Creek parallels the Mississinewa River for several miles before flowing into it; Mud, Buck and Kilbuck creeks also parallel White River for a number of miles. There are indications that Mud Creek was an original channel of White River, or was at least a prong of that river, for in times of high water a portion of the overflow from White River floods through this valley. Most of the waters of Mud Creek Valley flow west into White River near Yorktown, but less than a mile of the valley sends its waters east into this river near Muncie. A similar condition exists in a more or less distinct valley tributary to Kilbuck Creek, which discharges most of its waters west into White River through Kilbuck Creek, but also contributes waters for a mile or more to the Mississinewa. However, there is evidence in this case that flood waters pass through the valley from one river to the other.

The natural drainage is fairly well established except in the

central and northwestern sections, and the entire county presents sufficient surface relief to insure thorough drainage of all the land if the natural drainage is supplemented by artificial. The channels of almost all the smaller streams have been straightened and deepened by dredging throughout their entire length, and recently the question of straightening and deepening the channels of White and Missisinewa rivers has been agitated. In the last few years many of the open drains have been converted into underground or "blind" ditches by the use of tiling, and fields thus dissected are now even and unbroken. Many thousands of dollars have been spent by private and community enterprises to establish the excellent system of drainage which now obtains throughout the county. Tile drainage of individual farms has been practiced so extensively that almost no land remains not available for agriculture, though an even more thorough and systematic drainage is required to secure the highest efficiency of the various soil types.

The Delaware tribe of Indians, from whom the county received its name, were the first inhabitants, but the first permanent settlement made by white men was along the banks of White River in 1820. County government was granted in 1827. The earliest settlements of the area, Smithfield, Muncie, the county seat—formerly known as Muncietown—Yorktown and New Burlington, are situated along the course of White River and the old state road. The earliest settlers came chiefly from the states to the east and from Kentucky.

The population has grown steadily since the organization of the county in 1827. In 1860 the census recorded a population of 15,753. According to the 1910 census there are now 51,414 people in the county. Of this number about 40,000 live in Muncie and the other towns and villages of the area, the remaining population being distributed rather evenly over the rural sections.

Muncie, the county seat and largest town in the county, is situated on White River in Center Township, a little south of the center of the county, and 55 miles northeast of Indianapolis. It is not only the center of a rich agricultural region, but is the intersecting point of four steam roads and the terminus of two steam and five trolley lines. It is also the site of many important manufactories, including the largest glass fruit jar factory in the world, steel bridge works, piano factory, automobile factory, wire fence factory, silver plate works, several canning factories and numerous small manufacturing interests. The population, including suburbs, is approximately 35,000. It is the sixth largest city

in the State and modern in every respect. Muncie Normal Institute, which has an annual enrollment of more than a thousand students, is located in Normal City, a suburb. Muncie is the leading market and trading center of the county.

Eaton, Albany, Gaston, Selma and Yorktown are other important towns in the county. They are shipping centers for the rich agricultural territory surrounding them and also have some manufacturing interests. The greatest impetus in the growth of these towns came in 1884 upon the discovery of natural gas. Eaton is the pioneer gas town of Indiana. At the present time the supply of gas is very much depleted and is used by the farmers chiefly for domestic purposes. A portion of it also is used in the smaller towns and villages as well as in Muncie, but the greater part of the gas now consumed in Muncie is piped from West Virginia fields. Since the depletion of the gas supply a few of the towns have lost a part of their manufacturing interests and the population has declined to some extent. Every town in the county and all but four villages are situated on either railroad or trolley lines and many of them on both. In the vicinity of Selma a rather extensive oil field has been developed and is gradually being enlarged.

The first railroad in the county was the Big Four, built in 1852-53 from Indianapolis through Muncie. At the present time the county possesses a most excellent railroad system. Six steam roads and five trolley lines make transportation and shipping facilities adequate for all needs. The Lake Erie and Western Railroad enters near the center of the west boundary and leaves not far from the northeast corner; the Chesapeake and Ohio traverses the area from northwest to southeast; the Logansport and Muncie division of the Pennsylvania system enters near Wheeling and terminates at Muncie; the Big Four enters near the southwest corner and leaves not far from the center of the eastern boundary; the Ft. Wayne, Cincinnati and Louisville Railroad has an almost due north and south course through the center of the county; the Central Indiana Railroad enters near the same point as the Big Four and has a northeast direction to Muncie, its terminus. Traction lines affording both freight and express accommodations parallel the Big Four and the Ft. Wayne, Cincinnati and Louisville railroads throughout their course in the county, and a traction line also parallels the Lake Erie and Western Railroad from Muncie to Albany.

The first improved roads were constructed under the toll pike

system, which connected the principal towns usually by the shortest route and centered at the county seat. Such were the Centennial, Granville, Center, Wheeling, Bethel, Jackson Street, Yorktown, Middletown, Newcastle, Macedonia, New Burlington, Smithfield and Selma pikes. Within the last twenty-five years these toll roads have been opened by the county to the public and supplemented by an excellent sectionized public road system, so that now every farmer is within easy access to market. There are very few miles of unimproved roads, most of them being surfaced with gravel and in excellent condition. Unlimited quantities of gravel are available for constructing and repairing the roads. In recent years many macadamized roads have been built. Several of the main highways leading out from Muncie have been paved with vitrified brick for a distance of one to three miles into the country. Modern steel bridges span the various streams of the county.

Telephone lines and rural mail routes connect all parts of the county. Excellent churches and schools are accessible to every section. The county has been a pioneer in the movement for consolidation of schools. Outside of the cities and towns there are nine or ten township high schools and there is an annual expenditure of about $185,000 on the school systems, exclusive of cities and towns.

The average annual temperature of the county is 50.8 degrees F., the absolute maximum 102 F. and the absolute minimum .24 F. The maximum and minimum temperatures quoted are ordinarily of short duration. High temperatures are not uncommon in July, August and September, but rarely continue long unless accompanied by extremely dry weather. The annual snowfall is 29.3 inches. In extreme winters snow may remain several weeks, or even months. Zero weather occurs, though periods of such low temperatures seldom last long. Ordinarily the ground remains frozen only a few weeks and a thaw is expected in February or March.

The county rarely suffers from extreme drought or excessive moisture conditions, since precipitation is rather uniformly distributed through the year. The greatest rainfall occurs during May and June.

The length of the growing season is about five and one-half months, the average date of the first killing frost in autumn and the last in the spring being October 10th and April 25th, respectively. The earliest recorded date of a killing frost in autumn is September 6th and the latest in spring May 21st.

AGRICULTURE.

The first white settlers who came in 1820 to the region now known as Delaware County found it a dense forest of hardwoods, broken only by an occasional open swampy prairie. Natural advantages caused them to stake their claims along the larger stream courses. The streams afforded access to outside markets by raft or flatboat and furnished power for mills, including those used for marketing the lumber, while the bottom lands, enriched annually by stream overflow, offered easy and profitable farming. Because of its adaptability to bottom land soils, corn became the main crop. Large yields were also obtained when the uplands in the vicinity of the rivers were first cleared, these having in general better natural drainage than the more remote uplands. The first settlements made in the county were along the west fork of White River, near the present towns of Smithfield, Muncie and New Burlington.

A considerable section of the county was originally poorly drained and in its natural condition unfit for agriculture. A relatively large proportion of the land was, however, well suited to farming. The cost of installing artificial drainage in the so-called "black lands" and in many cases the lack of adequate drain outlets prevented the use of these soils by the early settlers, but they have since been made the richest and most valuable lands of the county by the deepening, straightening and widening of the natural drainage ways by ditching and dredging. Many thousands of dollars have been expended by private and community enterprises to reclaim the black lands and bottom lands along the more shallow streams. The first method employed in artificial drainage was the construction of open ditches, but in recent years they have been converted into blind ditches by tile drains.

The county's greatest wealth has always consisted of its fertile fields. The native timber was cut off when the revenue obtained from the sale of it was a trifle compared with the present value of such lumber. Some large steel, glass and other manufacturing interests flourished in the county seat and principal towns of the area upon the discovery of gas in the early eighties, though many of them have since ceased operations. The construction of railroad and traction lines which have opened up ready access to the larger markets have been an important factor in the development of the agricultural resources of the county.

Corn, wheat, oats, rye, flax and potatoes were among the early

crops grown in the area. Hay was cut from the open prairie. Corn has always been the leading crop of the area and it is the aim of most of the farmers to further increase the production of this grain. In some cases this has led to a depletion of the fertility of the soil, but the more progressive farm operators have avoided it by efficient methods of crop rotation. The acreage of this crop has steadily increased from 52,061 acres in 1880 to 71,706 in 1910, with a corresponding increase in production of 1,528,876 bushels in 1890 to 3,135,530 bushels in 1910. The largest yields are obtained from the Clyde and Genesee soils, which produce approximately twice as much as the lighter colored clay soils (Miami). They are rated among the best corn soils in the State, and yields of 70 to 80 bushels per acre are not uncommon. The yields from the clay or Miami soils can generally be increased through better cultural methods, including fertilization and seed selection. Barnyard manure is the chief fertilizer for corn, little commercial fertilizer being used. Crop rotation, green manuring, subsoiling, deeper plowing, winter cover crops are the best methods of maintaining the fertility of the soil, but these may be supplemented to advantage by fertilizers.

Experiments with ground limestone have shown that an application of two or more tons to the acre upon clover sod, especially upon the lighter colored soils, will when turned under with the sod increase the yields of corn. The effect of such an application will be even more apparent in the wheat and clover crops which follows the corn. Similar results have been obtained by subsoiling the clay lands or deepening the soil bed without turning too much raw material to the surface. A gradual deepening of the soil is generally recognized as beneficial. Too often the ground is plowed to the same depth year after year so that a form of hardpan is produced which greatly retards the free circulation of air and moisture. The relative percentage of phosphoric acid and potash required to properly fertilize the different grades of land varies with the local conditions, but in general the lighter colored soils yield better returns from the use of phosphoric acid, while the black lands are lacking in potash. Proper rotation of crops will maintain the nitrogen supply. For the black lands a fertilizer of ten parts of phosphoric acid and five of potash or eight parts of phosphoric acid and four of potash is recommended. This soil usually contains sufficient nitrogen but is deficient in the other two elements of plant food. The best way to apply phosphoric

acid is to mix acid phosphate with barnyard manure at the rate of thirty pounds of the former to a ton of the latter and spread at the rate of eight tons to the acre. This should be applied to timothy or clover sod and turned under in the spring.

An important factor in increasing the yields of corn is the selection of the variety best suited to the soil on which the crop is to be grown. Too often no attention is given to this matter or to the testing of seed corn. The seed to produce the best results should be strong in vitality and the kernels graded to uniform sizes, in order to drop from the planter evenly. The best varieties to grow on the different kinds of soil should be worked out by the farmers themselves. The seed corn selected from the clay land should be planted on the clay lands, so far as practicable, and that selected from the black lands should also be kept for the black lands, selecting from experience the varieties best adapted to each grade of land. Well-selected home-grown seeds are generally preferable to any other on any soil. Attention to these methods will materially increase the quality and yields from these lands.

The use of the check drill in planting corn permits the crop to be cultivated both ways and hoeing is not often required. In general three to four cultivations are given to the crop, though five are not infrequent. Riding cultivators are used almost exclusively. The use of power corn cutters has also reduced the labor of harvesting this crop. In the last few years a large per cent of the corn has been cut and stored for ensilage. The practice is being rapidly extended as the value of silo feeding becomes better understood. The planting of cowpeas and soybeans in the corn should be practiced more extensively. The advantage of having a legume growth in connection with corn can readily be appreciated, as it adds nitrogen and organic matter to the soil. Ensilage is frequently prepared from corn and peas thus grown together. The keeping qualities are probably not so good, however, as it is when corn alone is used.

The acreage and yield of wheat in Delaware County in 1910 was 14,766 acres and 190,963 bushels respectively. Wheat is recognized as not a paying crop commercially but its value as a nurse crop for clover warrants its continued cultivation. The lighter colored Miami soils of the area show the greater adaptability to this crop. The application of two or more tons of finely ground limestone to the acre will be even more beneficial to the wheat than to the corn. The limestone should be applied to the wheat ground

prior to seeding. The increased yields from subsoiling will also be noted, which should be repeated in three to five year periods. Too much attention cannot be given to the selection of suitable varieties of wheat for the soil, as well as a proper grading of the seed. Rotation, fertilization, treatment of seed for disease, and the combating of insects require careful attention to insure the largest returns from this crop. The Purdue Experiment Station recommends the use of 300 pounds per acre of a fertilizer analyzing two per cent. of nitrogen, eight per cent. of available phosphoric acid, and two per cent. of potash. This can be applied at the time of seeding by using a drill with fertilizer attachment. When clover has been turned under for corn and the latter is followed by wheat an application of 50 to 100 pounds of nitrate of soda is generally advisable, which can best be applied as a top dressing in spring. Where barnyard manure is used the most profitable results are secured when it is turned under with the clover sod preceding the planting of corn.

Although oats are not generally considered a paying crop, this grain fits in well with the customary rotation and is especially valued for its straw, which, when fed for hay in conjunction with ensilage, makes excellent roughage for stock. The acreage in oats in 1910 was 25,205 with a production of 678,661 bushels. The average, however, is usually 30 to 40 bushels per acre. Yields of 50 to 60 bushels are not uncommon. Oats are usually sown with an endgate attachment at the rate of two and one-half to three bushels per acre. Cowpeas and soybeans are being tried by many of the farmers as a substitute for oats.

Delaware County is not rated as a potato-growing county, but the number of acres devoted to this staple in 1910 was 1,927 with a yield of 150,162 bushels, or about 78 bushels per acre.

With the increased demand for canned tomatoes the cultivation of this crop is gradually being extended. The crop fits well into a system of rotation and when properly handled gives twice the profit per acre of a corn crop. Many growers are netting a profit of $70 to $100 per acre where proper cultural methods are employed. More attention should be given to the breeding of earlier varieties and to methods of maturing the crop before it is killed by frost. The selection of profitable varieties is also often overlooked. It is recommended that 500 or more pounds of fertilizer containing two per cent of nitrogen, ten per cent of available phosphoric acid and six per cent of potash be used as a working

basis for fertilizing the tomatoes. This formula must be varied to meet the requirements of local conditions. It is suggested that sulphate of potash rather than muriate of potash be used. From the 890 acres planted in 1911 to tomatoes 4,886 tons were harvested.

The growing of English peas offers another source of revenue to the farmer. A crop of this character is profitable not only from the sale of the peas but because of its value as a nitrogen-storing agent to the soil. It is especially beneficial preceding the sowing of alfalfa, since it aids in the inoculation of the soil for the later crop. It is also beneficial to clover.

The number of acres in clover in 1910 was 2,885 with a yield of 3,365 tons, or a little more than a ton to the acre. The small acreage sown to this crop accounts largely for the low percentage of humus in the clay lands. Clover is not generally included in the rotation of crops, or if so it is turned under without being cut for hay, a practice which was not observed during the course of the survey. It was observed, however, that both the hay and seed crops were removed. The cutting of the second crop for seed robs the soil of much valuable humus. The acreage of timothy is being rapidly reduced as its soil-robbing properties become more generally known.

The growing of alfalfa is receiving more attention each year, but its value as a feed is evidently not fully realized or it would be more extensively cultivated. This crop is especially well adapted to the second bottom lands or high terraces on account of their porous subsoils, but with proper preparation it can be grown successfully on almost any soil in the county except muck. Aside from its value as a money crop its value as a nitrogen-storing agent should recommend its culture, especially upon the lighter colored Miami soils which are low in humus. It is advisable that alfalfa be sown not later than August 10th, for unless it makes sufficient growth to withstand freezing it is liable to winter-kill. It may, however, be sown as early as the latter part of April. When sown on wheat land it is possible to get the seed in between July 15th and August 10th. To succeed with alfalfa it is necessary that the land be well drained, that it be limed, that it be thoroughly inoculated, and that it be well prepared and free from weeds. It is sometimes necessary to re-seed the crop the second and even the third year, and for this purpose about six pounds of seed to the acre is recommended. Too often the crop is neglected after the first stages of development and the fields become "spotted" and

weedy, a result which has a tendency to retard rather than encourage the growing of alfalfa.

Fruit growing has been made a profitable industry in a few cases where proper attention has been given to spraying, pruning, etc., but in general the orchards are neglected. Many of the older orchards are infested with diseases and insect pests which spread to the more recent plantings. The present tendency is to plant too large orchards to which sufficient attention is not given, while smaller orchards well sprayed and pruned would yield more profitable results. State inspection and modern methods of control are needed to make fruit culture a paying industry. The more rolling type of Miami silt loam and the Miami loam are particularly well adapted to the growing of fruit.

The farmers of Delaware County who cultivate their own farms usually practice some form of crop rotation. The three-year rotation of corn, wheat and clover is most commonly employed. This requires sowing wheat in the corn either before it is cut or in the stubble among the shocks. In either case the seeding is unsatisfactory and a good stand is rarely secured. To overcome this difficulty a four-year rotation of corn, soybeans, wheat and clover is recommended. The use of rye as a winter cover crop between the corn and soybeans would be an additional soil enricher. In planning a crop rotation the purpose in view should be: 1st, to get larger yields and profits directly or indirectly; 2d, to distribute the work more evenly throughout the year; 3d, to give a more certain and regular income than is possible with a one-crop system; 4th, to maintain, or better to increase, the fertility of the soil; 5th, to reduce to a minimum the injury from weeds, insect pests, and diseases that so often accompany shiftless methods of farming. Small grains, hay, and cultivated crops are the three main crops to be considered in a scheme of rotation. It is thus a question requiring more study of individual problems than lies within the province of the soil survey. However, every system of rotation should include one or more legumes as a soil enricher.

The county is a stock-feeding rather than a stock-raising area. Cattle are imported from the western states, fattened on the farm produce and then put upon the market. However, this practice has not been so profitable in the last few years on account of the scarcity of range cattle in the West.

The dairying industry is confined to supplying the local markets of the area, but the excellent shipping advantages warrant its extension to markets outside the county.

The price of land in Delaware County has kept pace with the advance in other sections and but little, if any, of it can be bought for less than $125 to $150 per acre. Well improved farm lands frequently sell for $200 to $225 an acre. The high price of land is due in part to the fact that the more prosperous farmers are satisfied with their holdings and refuse to sell unless offered a price commensurate with the advantages afforded by a highly developed county such as this.

The average farm wages range from $20 to $25 per month with board, lodging, washing, and feed for driving horse furnished, or in the case of a married man, house, feed for horse, cow, etc., are furnished. Harvest hands and extra laborers receive from $1.50 to $2.50 per day. The manufacturing and public works in Muncie offering shorter working hours and the various attractions of city life have drawn heavily upon the labor of the county, and desirable farm labor is scarce. Those who operate a farm of 160 to 240 acres seldom employ more than one regular helper, the work being done largely by the owner and his family.

SOILS.

Glacial till left upon the recession of the ice sheet at the close of the late Wisconsin epoch covers the entire county to a depth of 50 to 200 feet. It is a heterogeneous mass consisting chiefly of clay intermingled with sand, gravel and silt. The material of the drift varies with the character of the rocks over which the glacier passed, granite, gneiss, limestone, sandstone and shale from the Lake Superior region being intermixed and ground up with it. Niagara limestone underlies the glacial deposits throughout the county but no rock outcrop occurs, though in a few places it is near enough to the surface to be quarried.

The glacial till is the source of the upland soils of the area. The alluvial soils or bottom lands are stream-deposited material formed chiefly of wash from the upland soils. On account of their depth the underlying rocks have had little part in the formation of the soils of Delaware County, though they may have contributed to the ice-ground mantle covering the uplands from which the various types are derived.

The various agencies of weathering, water, air, etc., have been at work upon the glacial deposition of drift or debris to form the present soils. The drift material to a depth of 10 to 15 feet is a very light brown to pale yellow or grayish mixture of clay, fine

sand, and silt, carrying a large proportion of gravel and small stones. The latter consist largely of granite, schistose, gneissic and limestone fragments. The limestone fragments are more conspicuous below five to six feet. Artificial exposures of the till usually weather to a loose, friable, silty to fine sandy loam or loam. It is generally calcareous and responds readily to the action of HCL. In many cases this material is supplemented with beds of gravel, particularly along the stream courses. The upper portion of the glacial till to an average depth of 22 to 24 inches consists of a uniform silt or silty clay layer which from its mechanical composition and general appearance is strongly suggestive of a loess. It is possible to attribute the regularity in depth of this silty mantle to the freezing and thawing of the soil, the depth to which the soil is pulverized by such action being fairly uniform. The covering is for the most part light colored, due to a lack of organic matter and is quite uniform in texture. These upland soils are known locally as "clay lands."

Because of the formation of ponds, marshes, and small lakes by the advance and recession of the ice sheet a certain per cent of the area was always in a semi-swampy condition until drained artificially. These ponds and lakes have been filled up gradually by the decay of the native vegetation which invaded them, or were gradually silted up through the deposition of fine materials washed in from the adjacent uplands. These areas constitute the "black" lands of the county. As the silting-up process continued the timber growth gradually encroached upon the open prairies so that only the deeper ponds and lakes remained unforested.

Five series of soils were mapped in the county, the Miami, Clyde, Rodman, Fox and Genesee. An undifferentiated type of muck and peat was also encountered.

The Miami series is the most extensive and widely distributed. It consists of two types, the Miami silt loam and Miami loam, the former occurring in three phases, level, undulating, and rolling. The differences are due chiefly to surface configuration. The level and undulating grade into each other so imperceptibly that no boundaries were ascribed to them. The more rolling phase of the type was mapped but not with arbitrary boundaries. The level phase is the predominating soil throughout the central and eastern portions of the State. The rolling phase is more often found in the vicinity of stream courses where the agencies of erosion are more active. The Miami loam is of more or less morainic origin

and is confined largely to a single body in the southwestern part of Liberty Township, though a few isolated areas are found elsewhere. These types are derived from glacial till and are characterized by their light brown to brown surfaces.

The Clyde series, including the loam and silty clay loam types, also occupy the uplands and are of glacial till origin. They differ from the Miami in having black soils and in occupying poorly drained areas, favoring the accumulations of organic matter. The Clyde silty clay loam includes the greater proportion of the "black land" series while the loam type occupies only a few rather small scattered areas which were originally open, swampy prairies. The adjacent uplands have contributed some washed-in soil material to these depressions.

The Rodman silt loam is confined to a chain of asars lying northeast of Muncie. This type together with the Miami and Clyde soils constitute the upland soils of the county.

The first bottom lands subject to overflow were included in two types of the Genesee series, the loam and silty clay loam. They represent brown-colored alluvial material washed from the uplands by stream overflow. The loam is confined almost entirely to the bottom lands along the larger streams which are more sandy owing to the wash from the silty upland soils and also from exposure of the coarser substratum. The silty clay loam occurs along the smaller streams where drainage has been more sluggish and the bottom lands are silty. The Genesee silty clay loam type grades so imperceptibly into the Clyde silty clay loam that often no definite boundaries between them can be determined. The origin of the two is frequently very similar, the Genesee being developed along the smaller streams which often occupy old filled-in valleys while the Clyde originates in shallow basins or depressions.

Fox loam represents the second bottoms or terraces built up by overflow waters when the streams were flowing at higher levels than at present. The Fox loam differs from the Clyde silty clay loam in having a lighter color as well as a lighter texture, and in occupying better drained situations.

Muck and peat represent the accumulations of organic matter in lakelets and ponds in various stages of decomposition. Their extent is limited to a few small areas, the largest of which is Big Prairie in Washington Township.

Miami Silt Loam, Flat Phase.

The surface soil of the Miami silt loam—flat phase—to an average depth of about 8 inches is a compact silt loam of a gray to yellowish-gray color when dry, or of a darker gray or brown color when moist. Below 8 inches and to a depth of 15 or 18 inches the texture passes from a silt loam to a silty clay loam and the color becomes a mottled gray and brown. Below 18 to 20 inches a rather stiff yellowish-brown to dark brown mottled silty clay is encountered and at 24 to 30 inches this grades into a similarly colored friable silty to sandy clay, bowlder clay. The substratum below 3 to 4 feet is an intermixture in varying proportions of clay, sand and gravel of a lighter brown to grayish color.

The Miami silt loam, flat phase, is the most widely distributed and extensive soil type in Delaware County, as it is in all of central Indiana. It occupies the greater proportion of the better drained uplands and ranges in topography from level or undulating to rolling or hilly. So far as practicable the latter conditions were mapped separately as a rolling phase of the type. Two other phases, the level and undulating, are distinguished by local variations but they pass into each other so gradually as to make it impracticable to separate them. The two phases may be distinguished in the field by the description. The term "clay" land is applied locally to this soil to distinguish it from the "black land." The term thus applied probably has reference to the tendency of the soil to clod or run together, as its texture is that of a silt loam and not a clay. The tendency of the soil mass to adhere is due chiefly to the lack of sufficient humus but is also due in part to the fact that it is plowed when too wet.

The surface of the type throughout the area is a fairly uniform silt loam, the local differences being chiefly that of drainage, surface configuration, and color. Where the surface is more undulating the texture is slightly coarser, darker in color, or more brownish, and less coherent. A few chert, granite, limestone, and quartz pebbles are encountered in the soil profile particularly below 24 to 30 inches, or upon the surface where erosion has carried away the finer soil particles. The occurrence of bowlders was not infrequent when the land was first put under cultivation but on account of the introduction of labor-saving machinery, which necessitated their removal, only a few remain. They have been appropriated largely for building purposes.

The level phase of this type is characterized by an even surface

and an ash-gray or leached color. The subsoil is distinguished by its gray mottling, denser structure, and cold, clammy nature, as if waterlogged, a condition which is indicative of its poor natural drainage. It generally occurs closely associated with the Clyde silty clay loam and is seldom elevated more than a few inches above the level of that type. Areas of this phase of the type too small to be shown on the map were included with the "black lands." Small areas of the Clyde silty clay loam were also included with this phase of the Miami silt loam. Owing to its low situation and poor natural drainage it has been necessary to install artificial drainage on this phase in order to obtain the best results. The use of subsoil plows and lime to render the subsurface soil more open and porous is recommended. Numerous tests with litmus paper gave a decided acid reaction, a condition which can be corrected largely by the use of lime. Since the soil is already deficient in humus lime had probably best be applied in the form of finely ground limestone. Liberal applications of barnyard manure, commercial phosphates, and the turning under of large quantities of vegetable matter under proper conditions will tend to balance the chemical and physical requirements. This soil is generally less productive than the undulating phase of the type, and is sometimes referred to as "poor, thin land." The occurrence of this phase of the type is confined chiefly to the western half of the county, interspersed with the more extensive areas of the Clyde silty clay loam.

The Miami silt loam is found in all parts of the county, and is the predominating type, but the largest acreage occurs in the eastern half, where the undulating and rolling phases are most extensively developed. This is due to the better natural drainage of that section. The level phase of the type always occupies the broader watersheds where the natural drainage is least developed. As the drainage courses are approached there is usually a gradual shading off in color from the ash-gray of the level phase to the brown or yellowish-gray of the more undulating type, or the dark brown color of the rolling phase bordering the stream courses. In the early settlement of the county the pioneers naturally showed a preference for this type because of its better drained condition, the black lands being in a semi-swampy condition and in many cases having no apparent drainage outlets. When first brought under cultivation the type was rich in organic matter and much more productive than at the present time, as is shown by the greatly reduced yields of wheat, a crop to which this soil is well adapted.

Continued cultivation without recourse to proper methods of crop rotation has greatly reduced the natural store of humus, and to this depletion of organic matter is due the light color or leached appearance of the soil and its tendency to run together when wet, and clod.

The extent of this type in any particular field can usually be distinguished from that of the black soils not only by the lighter color but also by the more vigorous growth of the latter type in the early development of the crops, especially corn, oats and hay. With the exception of wheat the average yields of crops on the Miami silt loam are but little more than half that obtained from the Clyde silty clay loam. However, the better quality of grain produced on the Miami soils tends to counterbalance the larger yields of the black lands. The type is well adapted to wheat and the best soil in the county for that crop.

In order to force the crops in season this type is often plowed in the early spring when too wet. The result is that heavy clods are formed which are not reduced to proper tilth by subsequent cultivation and the physical and structural condition of the soil thus modified affects its productivity. Fall plowing has been recommended to offset this condition and to aid in storing moisture. A winter cover crop will help to correct this tendency of the soil to clod and should always be sown upon this type. The wheat crop should be estimated not only by the actual yields obtained but also by its value as a winter cover crop. The turning under of rye after it has served as a winter cover crop has proven successful in keeping the soil loose and moist. Where tests were made this soil, as stated before, showed a decided acid reaction, indicating the need of lime. Subsoiling, supplemented with deeper plowing each year, and liberal applications of ground limestone are recommended to improve the condition of this type and increase the yields. These tend to correct the sour condition of the soil by the more thorough aeration thus brought about. The turning under of such crops as clover, cowpeas, Canada field peas, soybeans, rye and oats stubble, will all tend to improve the physical condition of the soil as well as furnish a store of food supply for the plants.

Potatoes, tomatoes, beans, peas, sugar corn, and small fruits grown upon this soil are firmer and less subject to decay than the same crops grown upon the black lands, but the yields are seldom so large. Owing to the smaller yields on the Miami soils preference is usually given the Clyde silty clay loam when tomatoes are

grown for canning purposes. This soil is better adapted to fruit growing than the darker soils, but for such purposes the rolling phase of the type is preferred.

The original forest growth consisted of beech, black walnut, white oak, yellow poplar, red oak, shell bark hickory, red bud, wild plum, flowering dogwood, etc.

Although this type is never valued so highly as the black lands, some of the best improved farms in the county are located on it. Land values range from $125 to $200 per acre. Where modern methods of culture are used the returns from this soil are being increased, the crops being more certain than upon the Clyde soils.

Miami Silt Loam.

The surface soil of the rolling phase of the Miami silt loam to an average depth of 10 inches is a brown or yellowish-brown loose, mellow silt loam grading into a heavier silt loam and clay loam. Below 15 to 18 inches a dark brown heavy silt clay is encountered which in turn is underlain at 20 to 24 inches by a more friable silty to sandy bowlder clay. Below 3 to 4 feet the substratum materials are more heterogeneous, being a mass of clay, sand, gravel, and rock fragments. In the vicinity of stream courses pockets of stratified sand and gravel are frequently encountered in the lower substratum.

The surface soil is usually slightly coarser in texture than its associated type, the undulating phase of the Miami silt loam. The color is also darker, due to better drainage with higher oxidation and aeration of the soil and subsoil. Where the type occurs on the knolls and ridges the surface is somewhat sandy. Such areas are usually of only an acre or two in extent. Where erosion is excessive along the steeper embankments varying amounts of gravel and other course materials are found, the finer materials having been carried to lower levels by the excess surface drainage. The bowlder clay is not infrequently exposed where the slopes have been deeply gullied. The gravelly areas are confined to narrow strips along the steeper slopes approaching the deeply dissected stream valleys, or upon the narrow morainic ridges and sharper knolls.

The boundaries between this type and the Rodman silty loam were drawn largely from the character of the substrata, which was determined by borings with the auger and by the cross sections in gravel pits. Where this type merges into the Miami silt loam the boundaries are not definite ones.

Practically all of the type can be cultivated with labor-saving machinery, but if more attention were given to contour plowing the tendency of the soil to wash could be greatly checked. So far as practicable this phase of the Miami silt loam should be allowed to remain in pasture a greater portion of the time. When it is cultivated the plowing should be deep so that more of the surface water will be absorbed, and the run-off with its attendant erosion be lessened.

This type is usually found bordering the stream courses. It is most extensively developed in the northeastern and southeastern parts of the county. A high table land occurs in the vicinity of Cross Roads, in the southeastern part of the county, which is similar in color to this soil.

The type is well suited to wheat and fair yields are obtained, but as a rule the yields of corn are low. It is probably the best fruit soil in the county owing to the better aeration of the soil and subsoil. Apples and pears have better keeping quality and are more highly flavored than those grown upon the heavier soils. Where orchards are planted for commercial purposes and on a large scale a soil of this character should be considered.

Miami Loam.

The Miami loam is of morainic origin and is undulating to slightly rolling in its surface configuration. The surface soil to an average depth of 12 to 15 inches is a brown to slightly reddish-brown silty to fine sandy loam, or light loam. The subsoil is a yellowish-brown or slightly reddish-brown heavy sandy loam or a friable silty to fine sandy clay. The line of demarcation between the soil and subsoil is not sharply drawn but is rather a shading off in color and texture from one to the other. The tendency is for the soil to become lighter with depth, or more yellow.

This type is confined chiefly to an area of one square mile in Liberty Township and includes parts of Sections 19, 20, 29, and 30, T. 20, R. 11. Smaller areas are found in Section 30, T. 22, R. 11, and in Section 8, T. 19, R. 11.

The type is cultivated to the usual farm crops without reference to any one crop or crops to which it is best adapted. Because of its loose, friable structure it admits of a free circulation of air and moisture, responds readily to the use of fertilizers, and is easy to till. Unlike the Miami silt loam it does not run together or bake. A soil of this character warms up rapidly and is especially well

adapted to trucking purposes. Small fruits, potatoes, melons, cucumbers, and root crops of all kinds should yield better returns from this soil than can be obtained from the usual farm crops. It should also be well adapted to alfalfa if limed. The soil is deficient in phosphoric acid, which is required to produce the maximum yields, especially if wheat is one of the crops grown upon it.

This type along with the Miami silt loam is valued at $150 to $175 per acre when well improved.

Rodman Silt Loam.

The surface soil of the Rodman silt loam to an average depth of 8 to 10 inches is a brown silty loam grading into a darker brown silty to sandy clay. This is underlaid at 30 to 36 inches by a sandy, gravelly loam. Below four to five feet stratified layers of sand and gravel are sometimes encountered. These gravel deposits, however, seem to be confined to pockets rather than underlying the entire esker or kame in which they occur. The extent of the deposits could not be determined by borings with the three-foot auger but prospectors for gravel have found such conditions to exist.

The type is for the most part confined to a broken ridge or chain of eskers with a general northeast-southwest course across the county, starting from a point about two miles northeast of Muncie. The average elevation above the surrounding country is from 20 to 30 feet.

The soil varies somewhat with the topographic features. Where the slope is gradual the surface is a fairly uniform light silt loam, but where the descent is more rapid the underlying sandy material is often exposed, in which case the resultant soil is a sandy to gravelly loam. However, the lighter material is seldom of more than a few acres in extent in a single body.

This type is cultivated along with the Miami silt loam to the same crops. Owing to its well-drained condition it is well suited to fruit culture. Some of the largest gravel pits in the county have been opened in the ridges included with this type and its use for this purpose will probably continue until the supply of gravel is exhausted. The pits thus established ruin the land for cultivation but the revenue from the gravel greatly offsets its value for agricultural purposes.

A morainic phase of the Miami series, indicated on the map as 9M, is very similar to the Rodman loam and suggests its correlation with this type.

Clyde Silty Clay Loam.

The surface soil of the Clyde silty clay loam to an average depth of 8 or 9 inches is a dark brown to grayish-black heavy silt loam or silty clay loam. The subsoil is first a bluish-black silty clay and then grades into a drab to slate-blue heavy plastic clay. The color gradually lightens with depth to about 18 to 20 inches where a gray and drab, brown-mottled, stiff, rather impervious clay is encountered. Below 30 to 36 inches this heavy material is underlain by a more friable, silty to fine sandy clay of a light gray color and highly stained with iron, or the latter material may consist of a low grade of marl or quicksand, both of which are deeply stained with iron. Where this type occupies old partially filled-in glacial channels the lower substratum is composed largely of coarse sand and gravel. These filled-in valleys have been the chief source of the gravel supply for those counties in which no moranic ridges occur.

The Clyde silty clay loam comprises the greater part of the so-called "black land" of the county. The term applies to the dark surface soil which was in part formed from the decay of the native vegetation while these areas were in a semi-swampy condition. The content of organic matter determines largely the depth of color of the soil. The lower situations favoring the accumulation of vegetable matter are naturally darker than the better drained portions where the type gradually shades off into the lighter color of the upland soils. This deepening of the color toward the lower level is due to the movement of the surface waters in that direction carrying in suspension the finely divided soil particles and organic matter from the adjacent uplands, and also to the fact that originally the water remained longer in the lower depressions and supported a more luxuriant native growth of aquatic sedges and grasses which on decomposing added to the store of organic matter. The amount of organic matter present also affects the chemical and physical properties of the soil by giving it an extra store of nitrogen and increasing its ability to assimilate moisture. It also counteracts the tendency of the soil to run together and permits it to mellow more readily, making cultivation easier.

The Clyde silty clay loam occupies the swampy and poorly drained depressions of the late Wisconsin glaciation and is largely residual from materials composing that formation. It was originally covered with water throughout a greater portion of the year, but with the installation of open and tile drainage the surface waters are now removed almost as rapidly as they fall. Practically

all of the type is under cultivation and constitutes some of the richest lands in the county. The relative value of farm property is frequently rated by the number of acres of black land which it contains. It was one of the last types to be brought under cultivation owing to its lack of natural drainage outlets. Open ditches were at first installed but these have gradually been replaced in recent years by underground or tile drains which permit the cultivation of the land formerly occupied by the open ditches, and also make it possible to cultivate the type in larger bodies.

The boundary between the Clyde silty clay loam and its associated type, the Miami silt loam, is usually not definite, the transition from one to the other being gradual. This intermediate condition may be classed as a lighter phase of the "black lands." It constitutes one of the best soils in the area. It is particularly well adapted to the growing of tomatoes and produces heavy yields. However, the keeping properties of this crop are better when grown on the lighter-colored Miami soils.

The type occupies irregular shaped depressions which occur widely distributed throughout the area are found most typically developed in the northwestern part of the county. The largest unbroken areas occur in the vicinity of Gaston in Washington and Harrison townships. It is also rather extensively developed in Hamilton and the southern part of Union townships. The type is fairly uniformly distributed in the southwestern portion of the county and is least developed in the northeastern and southeastern portions. It occurs as low-lying or depressed areas among the uplands and forms the main background of the soil map upon which the Miami silt loam stands out in slightly more relief.

The Clyde silty clay loam is rated as one of the best corn soils in the State and yields of 60 to 70 bushels per acre are frequently obtained. Oats yield 50 to 60 bushels an acre, but in wet seasons this crop lodges badly with considerable loss except when it is cut and used for hay. The part that becomes lodged is valuable as a green manure when turned back into the soil. Alsike and red top clover and timothy produce from one and a half to two tons of hay per acre. Experiments on this soil have demonstrated that the yields of corn and oats can be greatly increased by the use of a potash fertilizer. When commercial fertilizers are used a mixture of 8 per cent phosphoric acid and 8 to 10 per cent of potash is recommended. Nitrogen is not generally needed for this soil but where it is deficient it should be supplied by legumes grown in the usual crop rotation.

With proper draining and liming of the soil alfalfa can be grown successfully on this type. The yields will be larger than that upon the lighter colored soils but the quality will not be so good and more time will be required to cure it properly.

The native forest growth upon the Clyde silty clay loam consisted of swamp white oak, pin oak, white elm, silver maple, burr oak, black ash, green ash, prickly ash, and some of the characteristic plants of smaller growth were the button bush, spice bush, and wild rose.

Clyde Loam.

The Clyde loam differs from the Clyde silty clay loam largely in its content of organic matter. Its occurrence as low-lying wet prairies in its virgin state is another distinguishing feature.

The surface soil of the Clyde loam to an average depth of 9 or 10 inches is a black, mucky silt loam or heavy loam. The high content of organic matter not only contributes to the fertility and friable, mucky nature of the surface soil but to it is also due its dark color. However the amount of organic matter in the soil is not sufficient to justify its classification as Muck.

The subsoil of the Clyde loam is a heavy black to bluish-black silty clay loam which grades below 10 to 12 inches into a slaty blue to grayish silty clay and this in turn into a mottled brown, drab and gray rather stiff, plastic clay. At a depth of 30 to 36 inches a friable silty to fine sandy clay or low grade marl is encountered which is generally light gray in color, deeply stained with brown iron stains. As the depth increases the content of fine sand or other coarser materials generally increases, and in some cases a wet, loose fine sand, similar to quicksand, forms the basic material of the lower substratum.

The Clyde loam type never supported a growth of timber and the pioneers always referred to it as "prairie land," a term usually applied to all treeless soils whether well drained or low-lying areas. The native growth included a variety of sedges, grasses, cattails, flags, button bush, and willows. The better drained portions supported a heavy mantle of native prairie grasses which was the chief source of hay for the early settlers. Its use for pasture and hay was the only value attached to this type of land until within recent years, when adequate drainage has been established and the land put under cultivation. The annual decay of this native prairie vegetation imparted to the Clyde loam its high content of organic matter. It is frequently referred to as "made land," a term which

is more applicable to the type Muck and Peat. "Chaffy land" is also a name given to the looser, deeper phases of the type which more nearly resemble Muck. The "chaffy" condition is more noticeable when the type is first put under cultivation following its reclamation by artificial drainage. Corn planted upon the chaffy areas makes a vigorous growth in the early stages of development but usually turns yellow or "burns" before maturity. This condition may frequently be corrected by the free use of barnyard manure, deeper plowing and more thorough cultivation in order to aerate and sweeten the soil as much as possible. The use of commercial fertilizers containing potash and phosphoric acid in the proportion of about two parts of the former to one of the latter has generally proven profitable in the increased yields from this type.

The largest single body of the Clyde loam is found in Sections 29, 30, 31, T. 22, N. Range 9 E. The next largest body forms the outer border of Big Prairie in Sections 16 and 21 of the same township. Smaller areas are found throughout the county, including portions of the valleys occupied by Prairie Creek in Perry Township and Muncie Prairie in Hamilton Township. This type usually occurs closely associated with the Clyde silty clay loam, or Muck.

This type is rich in natural fertility, particularly humus, but the best results have been obtained from the use of barnyard manure and commercial fertilizers, as previously suggested. The soil is more often deficient in phosphoric acid and potash, especially the latter. Potash fertilizers on corn and oats have proven profitable through increased yields. Ground limestone is recommended as beneficial, though the large amount of humus present in the soil would permit the use of lime in the more soluble forms.

It is only within recent years that satisfactory yields have been obtained from this soil since it occupied old filled-in valleys and shallow lakes or ponds and had no natural drainage outlets. But with the establishment of artificial drainage practically all of the type has been brought under cultivation. Corn is the chief crop. Oats produce a rank growth and are liable to lodge. This tendency may be overcome to some extent by sowing the oats thicker than is generally practiced upon the lighter colored soils.

Fox Loam.

The soil of the Fox loam to an average depth of 12 inches is a brown to slightly reddish brown light silty loam, or loam, grading

into a yellowish-brown silty clay loam. Below 18 to 20 inches the subsoil is a brown friable silty to sandy clay, with a variable intermixture of coarse sand and gravel. The content of coarser material increases with depth. Below 30 to 36 inches a sandy gravelly loam is generally encountered which in turn is underlain by stratified layers of sand and gravel. The surface soil is subject to local variations including small areas of sandy loam or gravelly sandy loam which were too small to be mapped separately.

The Fox loam is generally referred to as second bottom land although it may occupy both second and third terraces. The term "sugar tree flats," is sometimes applied to it, but the terraces are generally quite narrow in this county so that the term is not so applicable as in Hamilton, Marion, and other counties where the Fox loam spreads out over considerable areas. The boundary between the first bottoms and the terraces is usually more distinct in this area than that between the latter and the uplands. Only in a few instances was a bluff line found marking the latter condition. But it is not infrequent to find a high, steep bluff marking the descent to the streams where no terraces intervene.

The Fox loam differs from the Miami soils in the darker color and coarser texture of its surface and the position it occupies upon the terraces along the larger stream courses. The soil of the former type contains less silt and the subsoil a much larger percentage of gravel than either of the Miami soil types except the Miami loam. The open, porus nature of the subsoil permits a free movement of moisture. For this reason it warms up more quickly and the crops make a more rapid growth. It is an easy soil to cultivate and a mellow seed-bed is readily obtained.

The type is confined largely to the terraces along White River in the southern and Mississinewa River in the northern parts of the county. The largest bodies are situated in the vicinity of Albany and Eaton along the Mississinewa River and Muncie and Smithfield along the White River. Other smaller bodies occur intermittently along these streams. A number of small bodies were also mapped in the valley previously mentioned as occupied by Prairie Creek in the vicinity of New Burlington. The Fox loam is probably of alluvial origin, having been deposited when the streams along which it occurs were flowing at a higher level than at present.

This type is especially well adapted to alfalfa and in other sections of the State good yields are usually obtained, particularly where lime is liberally applied. This soil is also well adapted to

potatoes, tomatoes, peas, beans, etc., and where markets are accessible profitable returns can be had from these crops.

The predominting timber growth was hard maple, from which fact the type receives its local name of "sugar-tree flats." Other hardwood growths included black walnut, beech, white oak, etc.

This type along with the first bottom lands is valued at $150 to $200 an acre.

Genesee Loam.

The surface soil of the Genesee loam to a depth of 12 to 15 inches is a medium to dark-brown loam or silty loam except in the immediate vicinity of the streams, where it is generally sandy, the latter material being deposited by the swifter currents which transport the coarser particles. The subsoil is quite variable in texture and structure but is similar in color to the overlying materials. The substratum materials are not infrequently of the same general character as the surface soil but the tendency is for the texture to become lighter with depth or more sandy, sometimes being underlaid with a loose medium to fine sand or gravel below 24 to 30 inches. Owing to the uneven distribution of the alluvial materials the type is subject to local variations. Where the currents are swifter at times of overflow, which occurs where the first bottoms are narrow, the alluvial materials thus deposited are more sandy than that deposited in the outlying bends where the waters are less active. In the latter case the resultant soil is a silt loam or heavy loam somewhat darker in color than the coarser-textured phase of the type.

The Genesee loam is subject to frequent overflow and the constant additions of alluvium aid in the maintenance of its fertility, but the crop yields have shown a gradual decline since the land was first cleared and drained. This condition is due largely to the tendency to cultivate corn to the exclusion of other crops. Some form of rotation should be followed as with other soils and the use of some legume such as cowpeas, soybeans, etc., in the corn is recommended as a soil enricher. Where this soil is lighter in texture and well drained it is one of the best trucking soils in the county. It responds readily to the use of barnyard manure and commercial fertilizers and is easy to cultivate. It is especially well adapted to root crops, cucumbers, cantaloupes, etc. The overflows seldom come at a season of the year to interfere seriously with the use of this soil for trucking purposes.

The Genesee loam is confined almost entirely to the first bottom lands along the Mississinewa and White rivers. The largest expanse of the type is found southwest of Yorktown, covering parts of Sections 20, 21, 29, 31 and 33, T. 20, R. 9. The next largest is found in the vicinity of Eaton in Sections 23, 25, 26, T. 22, R. 10. Another area of considerable extent occurs just south of Albany. The type occurs continuously throughout the course of the two rivers in varying widths. The areas mentioned are those in which the valleys reach their maximum widths.

The Genesee loam, as stated above, is an alluvial soil composed of reworked materials from the upland glacial soils that have been redeposited by the streams along which it occurs, and the surface is generally level. The greater portion of the type is under cultivation and but little of the native timber remains standing. However, enough remains to designate the character of the original forest growth—silver maple, white elm, buckeye, red oak, sycamore, and hickory. The areas not under cultivation have been cleared of underbrush and are used for pasture. Where this soil was low-lying and poorly drained, ditches have been constructed to carry off the excess water. The open structure of the soil and subsoil permits the ready percolation of the surface waters so that the soil dries out rapidly after floods.

Genesee Silty Clay Loam.

The Genesee silty clay loam occurs as first bottom lands along the smaller stream courses, being most extensively developed along Kilbuck, Jake, Bell, Buck, Stony, Prairie, and Easley's creeks, which form the principal tributaries of the Mississinewa and White rivers. It occurs in narrow strips seldom exceeding one-fourth to one-third of a mile in width. The largest area occurs along Kilbuck Creek in the northwestern part of the county.

The surface soil to an average depth of 8 to 10 inches is a medium to dark-brown heavy silt loam or silty clay loam, which grades into a darker brown, almost black, silty clay, and this in turn into a drab to slate-blue stiff plastic clay mottled with dark-brown or reddish-brown iron stains. The stains may in part be due to the decay of roots from the native vegetation which have penetrated the subsoil. The color of the substratum becomes lighter with depth. Where this type merges into the Clyde silty clay loam the boundary between them cannot be definitely fixed as the characteristics of the one blend into the other. When the type occurs in

old partially filled-in valleys its origin is somewhat similar to the Clyde silty clay loam where the latter type occupies ponded areas and elongated depressions. Along Stony Creek in Perry Township the surface soil is more loamy, being similar to the Genesee loam, though the subsoil is quite heavy.

The Genesee silty clay loam is for the most part formed of reworked glacial till deposited by the streams along which it occurs, or is composed of wash from the adjacent uplands. The dark color of the soil is due to the accumulation of organic matter from decayed vegetation since these bottom lands were low and semi-swampy until adequate drainage was established by dredging. Narrow strips of sandy material are sometimes encountered adjacent to the stream but the limited extent of these areas did not warrant their separation. They should be correlated with the Genesee loam. The heavier materials were deposited in the lower situations.

Most of the streams along which this type occurs have been straightened and deepened by dredging and practically all the land is under cultivation which was formerly poorly drained. Some of the largest yields of corn in the county have been obtained from this type. It is subject to overflow but the floods generally come at the season preceding the planting of the crop. Yields of 70 to 80 bushels per acre are not uncommon and the average is between 50 and 60 bushels. Heavy yields of oats are obtained where they do not lodge and the full crop can be harvested. It is also one of the best grass soils of the county and yields of one and a half to two tons are obtained.

When the seasons are favorable a good tilth is obtained with this soil but too often when the spring planting has been delayed by unfavorable weather conditions the soil is turned up wet and forms large, compact clods which cannot be broken down readily by subsequent cultivation. Thus haste to get the crop in frequently impairs the physical condition of the soil for even more than one season. Owing to the profitable returns from corn grown upon this soil the tendency is to grow it continuously, and rotation is practiced only to a limited extent. Although the fertility is maintained in part from the constant additions of alluvium the yields from this soil will decline unless rotation is practiced. The soil is generally deficient in potash and experiments have demonstrated that the yields can be considerably increased when potash fertilizers are used. When this type is well drained heavy yields of tomatoes are obtained.

The original forest growth consisted of silver maple, white elm, swamp white oak, burr oak, pin oak, black ash, cotton wood, and other hardwoods.

Muck.

This type includes the two organic soils, Muck and Peat, which are alike in origin but are distinguished from each other by the state of decomposition of the vegetable matter of which they are composed. The term "made land" is frequently applied to this type since it was built up from the remains of cat-tails, rushes, sedges, grasses, etc., which originally occupied and filled up the shallow lakes and ponds in which Muck and Peat now occur. The Muck is of a dark brown to black color while the Peat is lighter brown and is more fibrous, or consists of a less decomposed mass of vegetable matter than Muck. The depth of this material varies from several feet near the center of the area to only a few inches at the margin. There is but little change in color with depth, but the deeper material is usually in a less advanced stage of decomposition. This surface material is generally underlain by a bluish-black, stiff, plastic clay which grades into a similarly textured clay of a drab to gray color, mottled with brown. In some places a highly decomposed impure marl is encountered in the lower depths of the subsoil or substratum.

The Peat was included with the Muck since it usually occurs in too small areas to be mapped separately, though the two types show a distinct agricultural difference where they are typically developed. Muck has a very much greater value for general farming or trucking purposes. Peat is usually found near the center of the bodies where the accumulations of organic matter have been more recent and has not undergone as thorough decay, though it sometimes occurs in spots throughout the area.

The largest single body of this type occurs in Sections 16 and 21, T. 22, R. 9 (Washington Township), and is known locally as "Big Prairie." The next largest area occurs in Section 33, T. 20, R. 9. Other smaller bodies are found in Sections 4, 9, 16, and 17, T. 19, R. 9; Sections 2, 3, 11 and 12, T. 19, R. 11; Sections 29 and 30, T. 20, R. 9; Sections 1, 2, 17, and 18, T. 21, R. 9, and Sections 22, 27, 34 and 36, T. 22, R. 9.

The native grasses which grew luxuriantly upon the Muck lands were the chief source of hay for the early settlers and were used almost exclusively for hay and pasture until recent years, when they have been reclaimed by artificial drainage. The drainage was

poor owing to the nearness to the surface of the water table. Dredged outlets have since made it possible to drain these areas. At first large open ditches were constructed and these supplemented by smaller underground tile drains. Open ditches constructed along the margin of the swampy areas to intercept the drainage from the adjacent uplands will aid further in the reclamation of these lands.

The greater part of the Muck areas have been brought under cultivation, being used chiefly for corn, although considerable timothy and oats are also grown. The latter crop is not so successful as on other soils, since it makes a rank growth and lodges badly. Timothy and alsike clover do well and are easily seeded, but the two should be grown in combination to get the best results.

Crops grown upon Muck are more susceptible to injury from frost, which settles in the lower situations. It is often necessary to make one or more replantings of corn to obtain a stand, and early frosts sometimes prevent this crop from maturing.

This type is especially well adapted to celery, and its culture should be extended. Onions, cabbage, Irish potatoes, beets, turnips, cauliflower, and other garden crops also do well. The returns in northern Indiana and adjoining States from celery and other truck crops far exceed the returns from the general farm crops. The value of the land has greatly increased since being properly drained and put under cultivation.

Experiments with potash salts and phosphoric fertilizers have usually been profitable from the increased yields obtained. The tendency of the crops to "burn" on this soil can be largely corrected through the use of potash as well as from liberal applications of barnyard manure. Lime judiciously applied is also beneficial.

This land is valued at from $100 to $150 per acre.

SUMMARY.

Delaware County is situated in the east-central part of Indiana and has an area of 399 square miles or approximately 255,360 acres.

The surface varies from level to undulating and in some places broken. The central and western portions of the county are comparatively level with slightly broken areas in the vicinity of stream courses. The greatest relief is found in the northeastern and southeastern portions near Granville and New Burlington, respectively. The average elevation above sea level is between 900 and 1,000 feet.

Mississinewa and White rivers and their tributaries drain the area. The Mississinewa receives the drainage of the northern one-third, while White River drains the remainder.

The first settlement in the county was made along the banks of White River in 1820. County government was granted in 1827.

The population of the county is 51,414, of which about 11,000 is rural.

Muncie, the county seat and sixth largest city in the State, is situated on White River near the center of the county. The population is about 35,000. It has a number of important manufacturing interests. Albany, Eaton, Gaston, and Selma are important towns of the area.

An excellent system of free pikes, which were originally toll pikes, and sectionized gravel roads characterize the entire county. There are only a few miles of unimproved roads.

Six steam roads and five trolley lines afford excellent transportation facilities.

The prosperity of the county is due chiefly to its productive soils though there are also a number of important manufacturing industries, including the largest glass fruit jar factory in the world, several manufactories of automobile parts, bridge works, wire fence factory, etc.

The area is highly developed and enjoys the advantages of good homes, towns, schools, churches, excellent roads, telephone lines, electric interurban lines, and rural mail delivery.

The climate is not subject to very great extremes of heat or cold. The mean temperature for the winter months is 29.1 degrees Fahrenheit, for the summer, 71.5 degrees. The average rainfall is about 39 inches, and well distributed throughout the year. The growing season is about five and one-half months.

The leading crop of the area is corn, the average yield being about 40 to 45 bushels. Wheat, oats, and hay are also grown in considerable quantities though the combined acreage of wheat and oats does not equal that of the corn. Corn is cut and stored for ensilage, which furnishes green food for stock in winter. Cowpeas are also being grown and used for this purpose. The growing of tomatoes, peas, beans, etc., for the canning industry is profitable and promises to become more general.

Much of the farm produce is fed to live stock. Cattle from the States farther west are brought in and kept long enough to be fattened for market.

No dairying is done except that required to supply the local

markets. With the excellent shipping facilities at hand this industry could very profitably be extended to outside markets.

Trucking forms a rather important agricultural feature of the county. The products are grown for canning purposes and to supply the local needs of Muncie and the towns of the area.

Prices of land range from $100 to 225 per acre.

Five series of soils were recognized and mapped in the county—the Miami, Clyde and Rodman, which occur upon the uplands, and the Fox and Genesee, which are found upon the bottoms and terraces. The so-called "clay" lands were included in the Miami series, while the greater part of the "black" lands was classified with the Clyde.

The upland soils are derived directly from glacial till of the late Wisconsin stage. They have undergone local changes which give rise to the various types. The bottom lands are derived from reworked and redeposited materials which represent wash from the uplands.

Of the Miami series two types were mapped, the silt loam and loam. The former, including the rolling phase, is the most extensive and widely distributed in the area. The Miami loam occupies morainic ridges. The Miami soils are best adapted to wheat and fruit growing.

The Clyde silty clay loam is the predominating type of that series. Only a small acreage of the Clyde loam, the only other type of this series developed in the county, was mapped. The Clyde soils are especially well adapted to corn. Good yields of oats and hay are also obtained.

The Fox loam occupies the greater proportion of the higher terraces. This soil is well adapted to alfalfa.

Of the Genesee series two types were mapped, the silty clay loam and loam. The loam is the predominating type of the series and occurs chiefly along White and Mississinewa rivers. The Genesee soils are best suited to corn. Oats and hay also produce good yields.

The Rodman silt loam represents the only member of that series mapped in the county. It occupies eskers and kames principally in the east-central part of the county.

The undifferentiated soil, Muck, is of very limited extent in the area.

The agriculture of the area is in a highly developed and prosperous condition. Scientific farming is practiced to some extent, but much can be done to increase crop yields by more careful study of the individual soil types and their crop adaptability.

OFFICE SUPERVISOR OF NATURAL GAS,
FORTVILLE, IND., December 31, 1913.

Hon. Edward Barrett, State Geologist, Indianapolis, Ind.:

Dear Sir—I am sending you today the manuscript of the Annual Report for the 38th Annual Report of the Department of Geology.

Thanking you for the valuable suggestions and assistance I have received from you, I am

Very truly yours,

FLOYD E. WRIGHT,
State Supervisor of Natural Gas.

Annual Report of State Supervisor of Natural Gas.

Our present gas laws were enacted to protect the gas and oil interests in the Trenton fields of Indiana, as little was known of the geology of the other fields at that time, consequently the laws are inadequate to cover all conditions in other parts of the State, especially in the Oakland City, Princeton and Sullivan County fields, where the oil and gas are produced from the Mansfield sandstone and the upper strata of the Huron group.

The purpose of casing and plugging gas and oil wells in the manner described on page 234 of the 1909 Acts of Indiana, is to prevent the fresh water contained in the upper strata of rock from flowing into the gas or oil bearing strata, also to prevent the salt water of the gas or oil bearing strata from rising and contaminating the fresh water of the upper strata. The damage done by allowing fresh water to flow into the gas or oil bearing strata is due to the fact that the fresh water comes from the strata near the surface, and usually in a quantity that will keep the hole filled up to the fresh water level, thus making a pressure at the bottom of the hole equal to the weight of the column of water, and as the rock is more or less porous, the water under pressure finds its way all over the immediate field and drives back the gas and oil and oversupplies the rock with water.

The above mentioned laws cover all conditions necessary to protect the gas and oil in the Trenton fields, but in some parts of the State fresh water is entirely absent and salt water is obtained near the surface, and as the damage to the oil or gas strata from water of the upper strata is due to the pressure created, and not any particular kind of water, the above mentioned laws do not protect that part of the State where fresh water is absent.

In the Princeton, Oakland City and Sullivan County fields, where the drill passes through productive coal measures and the oil and gas are produced from the Mansfield sandstone and the different strata of the Huron group of sandstones and shales, in a great many places there are no fresh water strata passed through, and the salt water strata are reached very near the surface and the salt water is present in nearly all the rock, to near the bottom of

the well. In most cases the salt water has sufficient pressure to flow over the top of the well. In such cases the salt water flows into the small fresh water streams, which in some locations are the only source of stock water. Also, the salt water will rise to the level of the commercial veins of coal and flood it so that it makes it very hard to profitably remove the coal.

The Indiana laws requires mine operators to record the location of the mines and extensions at short intervals. For the protection of mine operators the law should require oil and gas operators to record the exact location of oil and gas wells drilled in the part of the State containing coal, so that a small block surrounding the well could be left undisturbed, thus preventing the flooding of the coal mines.

In some parts of the State the impervious layer of shale overlying the gas or oil bearing strata is only one to two feet in thickness. The manner of plugging prescribed by the plugging laws requires that the hole be filled with the filling material to a point twenty-five feet above the top of the gas or oil bearing rock, at which point there shall be placed the first dry pine plug, on top of which is placed twenty-five feet more of filling material and another pine plug and another twenty-five feet of filling material, the theory being that when used in the Trenton field, where immediately overlying Trenton rock there is about two-hundred feet of hard, impervious shale, the pine plug swells enough to shut up the hole, where in other fields if the usual manner of plugging be followed the pine plugs are set in what is most likely to be a porous stratum of sand or limestone, practically leaving the hole open.

I will suggest the following amendments: That in other than Trenton fields the regularly prescribed manner be used in plugging the top gas or oil bearing stratum, except that the first pine plug be placed immediately above the gas or oil bearing stratum and that where more than one gas or oil bearing strata are drilled through or penetrated, the hole below the top stratum shall be plugged in the usual manner and a pine plug set immediately above each gas or oil bearing stratum. That one bag of Portland cement be mixed with the twenty-five feet of filling material placed on top of the pine plug set immediately above the top gas or oil bearing strata. That whenever a salt water bearing stratum be penetrated or drilled through it shall be plugged the same as a gas or oil bearing stratum, or while the well is maintained shall be cased and shut in so that the salt water cannot reach the fresh water strata or overflow at the top.

That in all drillings for gas or oil the person or persons drilling same shall record with the county recorder of the county in which such drilling is done and report to the State Supervisor of Natural Gas, the exact location, the different strata of rock penetrated and passed through with the depth at which each is reached, together with the thickness of the same, stating what each stratum produced.

The gas laws of Indiana provide a penalty for their enforcement, which is one great means of enforcing the laws, but the benefit which comes out of the enforcement is limited, as it only prevents the violator from repeating the same offense, while it leaves the damage done by any particular offense standing; in other words, punishing the offender does not right the wrong already done.

There should be, in addition to the penalty to the laws, a provision making the offender liable civilly, providing damage to the injured, or, when possible, repairing the injury done.

The oil of Sullivan County is produced from the Mansfield sandstone and the upper strata of the Huron group, at a depth of from seven to eight hundred feet.

The field at present is confined to pools, three miles west of Shelburn, Ind., and three miles west of Sullivan, Ind., in addition to which are a few light wells scattered over the west side of the county, but so far no pools of any note have been developed other than the above mentioned.

There have been a few old wells in the Trenton field near Albany, Ind., drilled deeper, and in which a second pay of oil was reached at about three hundred and seventy-five feet in Trenton rock.

The Oakland City and Princeton fields on January 1, 1913, were producing from 264 wells 770 barrels daily, and on January 1, 1914, the same fields were producing from 242 wells 395 barrels daily.

In the Sullivan County field on January 1, 1914, 76 wells were producing 1,750 barrels daily.

Indiana produced 970,000 barrels of oil in the year of 1913.

The average pressure of the gas wells of Indiana is 81.8 pounds.

The average price per thousand feet at which natural gas is sold in Indiana is 30.6 cents.

There were 1,205 abandoned wells plugged in Indiana during the year 1913.

GENERAL INDEX.