THE

LAKES OF NORTHERN INDIANA

AND THEIR

ASSOCIATED MARL DEPOSITS.

BY W. S. BLATCHLEY AND GEO. H. ASHLEY.

INTRODUCTORY.

In the preparation of the present paper Dr. Ashley collected and partially wrote up the data on the marl deposits of the larger number of the lakes, and, with three exceptions, drew all of the accompanying maps. He also furnished a part of the data for the preliminary article on marl. Mr. Blatchley wrote the articles on "Lakes" and "Marl," and most of the matter pertaining to the individual lakes. He also edited and rewrote in part that portion of the marl data on these lakes collected by Dr. Ashley. Dr. J. T. Scovell, of Terre Haute, prepared most of the article on Lake Maxinkuckee and furnished the map of that lake. Mr. Hugh B. Holman, of Rochester, kindly made the survey and platted the map of Manitou Lake and Mr. George W. McCarter that of the Barbee Lakes, Kosciusko County.

The thanks of the authors are due to a large number of persons who kindly furnished information, and in other ways assisted in the collection of the data. Among those to whom special acknowledgments are due are Dr. Vernon Gould, of Rochester; Mr. J. P. Dolan, of Syracuse; Mr. George W. McCarter, of Warsaw; Capt. B. F. James, of North Webster; Mr. Frank Hay, of Winona, Starke County; Mr. Jacob Kellar, of North Judson; Mr. Walter Derr, of South Bend, and Mr. Earl E. Ramsey, of Muncie. Others are mentioned specifically in the body of the paper.

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LAKES.

The lakes of northern Indiana are the brightest gems in the corona of the State. They are the most beautiful and expressive features of the landscape in the region wherein they abound. Numbered by hundreds, they range in size from an area of half an acre up to five and a half square miles. With the fertile soil, the great beds of gravel, and the myriads of bowlders, large and small, they are to be classed as mementos of those mighty ice sheets which, in the misty past, covered the northern two-thirds of our State. Outside of the counties in which they occur but few of the citizens of Indiana know of their presence, their beauty, their value. Their origin, their fauna and flora, the causes of their gradual diminution in size and final extinction are likewise known to but few.

By the red man these lakes were more highly appreciated than by his more civilized Caucasian successor, for the reason that the Indian stood much nearer to wild nature than we. On the higher ridges overlooking the lakes he had his village sites. Over their placid waters he paddled his birchbark canoe, and from their depths he secured with spear and hook fishes sufficient to supply his needs, while mussels and the roots of the water lily added variety to his daily food. Wild fowl by myriads, in their migrating seasons, came and went, stopping to feed upon the lakes, thus offering him many a chance to test his marksmanship with bow and arrow, while the skins of the muskrat, otter and beaver which he trapped about the marshy margins furnished him protection against the cold. Thus it will be seen that his very existence depended oftentimes upon these living bodies of water. It is little wonder, therefore, that he remained in their vicinity until driven westward by the conquering white man, leaving only the signs of his feasts—vast piles of shells, bones, and pit-ovens—as reminders of his former presence.

Of the two classes of glacial lakes existing in the United States, viz., those with *rock* basins and those with *drift* basins, only the latter are found in Indiana. The original bottom of these is composed of an impervious clay, or mixture of clay and gravel, which is probably nowhere much less than 100 feet in thickness. Upon this bottom has been deposited, during the centuries which have elapsed since the lake was first formed, thick beds of muck, silt or marl. The cause and manner of this deposition will be noted farther along. Here it is only necessary to say that it began the day the lake came into existence, has been continuous since, and will go on until the lake becomes wholly extinct. In other words, the water of all these glacial lakes was much deeper when they were first formed than now.

The lakes of Indiana all owe their origin to the irregular deposition of the drift brought in by the glaciers. The original hollows or lake basins are the counterparts and complements of the surrounding hills and knobs so characteristic of the terminal moraines of the retreating ice sheets. They occur only in the three northern tiers of counties of the State, and are found, for the most part, in the great interlobate moraines which lie between the former borders of the Michigan, Saginaw, and Erie ice lobes.

Morainic lakes are classified, according to the shape of their basins, into three divisions:

1. *"Kettle-hole" lakes* with round cauldron-shaped basins—usually of great depth. The size of the basins varies much, Bull's Eye Lake, two miles north of Valparaiso, Porter County, having an area of but one-half acre, with water 45 feet in depth, while Gage Lake, Steuben County, is one mile long by three-quarters of a mile in diameter, with a maximum depth of 70 feet. Other notable examples of the kettle-hole form, described in detail on subsequent pages, are Blue River Lake, Whitley County; Clear Lake, Steuben County and Pretty Lake, Lagrange County.

The origin or mode of formation of the kettle holes in which these lakes occur was for a long time a puzzle to geologists, but the study of existing glaciers has revealed the process. During the retreat of the glacier from the region where the kettle holes occur a great mass of ice was embedded in the debris where each kettle hole now exists. By its melting a cavity was left the shape and size of which depended upon the shape and size of the ice block and the amount of drift originally covering it. If the bottom and sides of the resulting kettle hole were of a porous nature it remained dry; but if they were of a stiff, impervious clay it in time became filled with water up to the level of the lowest point in its rim. If so located that the annual rain fall exceeded the evaporation, it became possessed of an outlet. Many examples of kettle-hole lakes without visible inlet or outlet are known. Among these, Walden Pond, near Concord, Massachusetts, made famous by the writings of Thoreau and Emerson, is perhaps most notable. There is usually drainage enough from the region around its basin to balance the loss by evaporation.

2. *Channel lakes,* or those with long narrow basins whose bottoms are very uneven, the water in places forming deep pools, in others being shallow. One of the best examples of such a lake in Indiana is Tippecanoe Lake, Kosciusko County, its basin being five miles long and in most places less than one-half mile wide. The irregularity of its bottom is shown by the variable depth of its waters, one of its pools being 121 feet deep, which is the greatest depth found in any Indiana lake. Other noteworthy examples are the long, shallow arm of Crooked Lake, Steuben County; also Long Lake, Lagrange County, and Shriner and Cedar lakes, Whitley County. All of these were formed by the erosion of the great streams which flowed from the retreating and melting glaciers. The morainic material dropped by the glacier was soft and loose, and the mighty stream rushing forth from the base of the melting ice ploughed its way through this with little opposition. As a result a broad and deep channel was left, whose mouth or lower end was afterward partially filled by sediment, thus damming back the water and forming the lake of to-day. A stream, variable in size, usually forms the outlet of these channel lakes and often connects several of them which occupy the same valley, thus forming a chain. For example, the Tippecanoe River flows through the lake of that name, above mentioned, and connects its three basins, James, Tippecanoe and Oswego, so that they practically form one body of water.

3. *"Irregular lakes,"* whose basins are very complex in outline, being branched, lobed and otherwise irregular. The bottom is also very uneven, deep pools of water alternating with shallow areas, without regard to order or regularity. The majority of the lakes in Indiana belong to this class, Lake Maxinkuckee, Lake Wawasee, Bass Lake and Lake James, Steuben County, being the largest and best examples. Each of these lakes was doubtless largely formed by the irregular heaping up of the drift about the area now included in its basin, leaving this the lowest land in the vicinity. The bottom and sides of this low area happened also to be composed of an impervious clay or other material into which the water did not sink. Many low basins were left by the retreating glacier which might

have become lakes had their bottoms not been of sand, gravel or other porous debris, which would not hold water. There is little doubt but that many of the lakes, bays, channels, etc., auxiliary to the main basins of the lakes of this group, were formed by erosion and other agencies at the time the surrounding drift was being dropped where it now rests.

A lake of small size, like those in Indiana, begins to die the moment it is born. In other words, its basin begins to fill with material other than water, and the process of final extinction is commenced. There are more beds of extinct lakes in northern Indiana to-day than there are existing ones. Their former basins are now the sites of extensive bogs or meadows underlain by 15 to 20 feet of muck and marl. All of the lakes now there are in various stages of existence or extinction.

The agencies which bring about the extinction of lakes are several in number. One is the *carrying in of debris or foreign matter by streams and springs.* The majority of the lakes are fed by great springs which well up from the bottom and so replace the water lost by evaporation. In the early history of the lakes the water brought in by these springs was so strongly charged with salts of lime that the resulting deposits of marl did far more to fill up the lake basins than any debris of surface erosion brought in by the streams. Those lakes which at present are fed mainly by streams are becoming shallow more rapidly than those fed by subaqueous springs, as the streams are much smaller than they were a score of years ago, and are each year lessening in size. The amount of debris annually carried into the lakes by streams and springs is very much less now than when the lakes were young. Then the surrounding material left by the glacier was not bound down and held in place by the roots of trees and other vegetation but was loose and readily eroded. The carbonate of lime and other materials in the surrounding high lands was then soft and easily soluble. It is probable that four-fifths of the marl now existing on the bottoms of the lakes was deposited there during the first half of their existence.

The *artificial drainage* carried on by man is a second important cause of the extinction of Indiana lakes. In order to reclaim a few hundred acres of adjacent marsh land a dredged ditch is put through it, which either taps the lake itself or allows its waters to slowly seep away; or it may be that the ditch drains the principal water supply of the lake and so causes the latter to lose by evaporation much more than it receives from without. Bruce Lake, Fulton County; High and Bear lakes, Noble County, and Loon Lake, Whitley County, are notable examples of former magnificent bodies of water, but now mere mud holes, and made so by the avaricious greed of man for more tillable land. Many others have lost half or more of their former water area by the same cause.

The *decrease of water supply* in the vicinity of lakes is another reason for their rapid extinction. This supply comes in the main, if not wholly, from the rainfall of the season which, soaking into the earth, finds its way through springs into the basins of the lakes, or is carried more immediately thereto by surface streams. The settlement of the regions about the lakes caused most of the timber to be cut away, and the land to become so drained that the water flows rapidly away instead of, as formerly, soaking into the ground and slowly seeping its way into underground currents, which finally emerged as springs about the rim of the lake or welled up from its bottom. For example, the outlet of Fish Lake, Steuben County, "was gauged in August, 1830, when its discharge was found to be much greater than in the year preceding and amounted to 18.64 cubic feet per second while the discharge into it on the same day from three small spring branches amounted to only 4.94 cubic feet per second. The supply, therefore, accruing from subterraneous sources was 13.70 cubic feet."* At present, especially in those lakes which have an outlet, the surplus water of a heavy rainfall is carried away at once, and the after seepage is often not sufficient to replace the loss by evaporation.

The most important cause of the extinction of lakes is, however, *the replacement of their water area by muck, formed by the decay of aquatic vegetation.* These muck beds are usually found upon the west and south shores of the main basins of the lakes, the east and north shores having their margins either of sand or mud, a condition due to the prevailing westerly and southerly winds, which create a stronger and more continuous breaking of the waves along the eastern and northern shores and so prevent the formation of muck. The bays and narrow channels are also more apt to be choked by vegetation and become filled with muck, on account of the limited extent to which their waters are exposed to wave action. In the words of Dr. Dryer, "the lakes are literally being filled with solidified air, the great bulk of the solid material which composes the plants being absorbed from the gaseous ocean above and consigned to the watery depths below."†

*Report of Howard Stansbury, U. S. Engineer, on the "Michigan and Wabash Canal," 1835, p. 15.

†Studies in Indiana Geography, p. 60.

A lake which has been raised by damming its outlet is more apt to have mucky margins than one which has been lowered, as the aquatic plants take root easily in the soil which lies beneath the newly acquired water area. Where muck meadows—former portions of the water area—border a lake the transition from the species of vegetation covering their surface to those growing in the water on the outer edge of the muck beds is a gradual one. In the water eight to 12 feet in depth, are pondweeds (*Potamogeton*), water shield (*Brasenia*), bladderwort (*Utricularia*), and water-millfoil (*Myriophyllum*). As the water decreases in depth, first the white water lilies (*Castalia*) and then the spatterdock or yellow water lily (*Nymphæa*), appear. With the latter are usually pickerel weed (*Pontederia*) and often the green arrow-arum (*Peltandra*). A little higher up and growing in the muck which reaches to or nearly to the surface of the water is usually a thick bed of cat-tails (*Typha*) and arrow-head (*Sagittaria*), while farther back are the sedges and grasses of a typical muck meadow. The most of the muck in the water is formed by the decay of the water lilies, especially the spatterdock, whose roots, stems and leaves are large and thick. The muck reaching nearly to the surface of the water is each season crowded still higher by the action of the ice, while the cat-tails, etc., growing upon it soon bring it wholly above the surface to form a part of the already existing meadow.

The water area of every lake in Indiana is thus being encroached upon by muck, some slowly and along only a small portion of their margins, others more rapidly and around most of their shores. The process is, however, slow if measured by the years of a man's life; the muck beds extending into the lake often only a few feet in a century. One of the best examples of the almost complete extinction of a lake by the decay of plants is that of Clear Lake, St. Joseph County, which, from a large, clear body of water, has been reduced to a mere accumulation of beds of muck, surrounding a pool of deep water. Another example is that of Cedar Lake, Steuben County, the former site of which—a square mile or more in area—is now a muck meadow. The water area of those lakes which have their bottoms mainly of marl or sand is much less subject to the encroachment of muck beds, since the aquatic plants growing therein are few in number and stunted in size. In the lakes with sand bottom the species of rushes (*Scirpus*) are often the only aquatic plants of note, while in several lakes whose bottom is composed wholly of marl, as Lime and Silver lakes, Steuben County, no vegetation at all is visible.

Like the lengths of the caves of southern Indiana, the depths of the northern Indiana lakes are greatly exaggerated by the surrounding inhabitants. According to their story, many of them "are bottomless" or have deep holes in which it is "impossible to find the bottom." Their attempts at sounding were probably made with an ordinary fishing line or the butt end of a cane pole. Mr. Stansbury, at the time of his survey in 1830, evidently took stock in the local stories regarding the depths of the lakes, as is shown by the following extract from his report above cited:* "The country around the summit level in Steuben County abounds in small lakes, from a half to two miles in length, either connected together in chains, or separate and alone, without any apparent inlet or outlet. They consist of the purest spring water, are full of the finest fish, and are of immense depth; in one of them, the bottom, as I have been informed, was sought in vain with a *line of 250 yards*." No one of the local residents who has such beliefs concerning the bottomless pools has ever brought up a Chinaman's queue on his fish hook, or a new species of fish from the central regions of the earth. In fact, the deepest water found in any lake in the State, and all of them have been carefully sounded, is 121 feet, in Tippecanoe Lake, Kosciusko County. Two or three others have water above 100 feet in depth, but in most of them the deepest pools are less than 70 feet. The following is the area and greatest depth of the five largest lakes in the State:

	Area in Square Miles.	*Maximum Depth.*
Lake Wawasee or Turkey Lake, Kosciusko County	5.66	68 feet.
Lake Maxinkuckee, Marshall County	2.97	89 feet.
Lake James, Steuben County	2.62	87 feet.
Bass Lake, Starke County	2.23	32 feet.
Tippecanoe Lake, Kosciusko County	1.61	121 feet.

In conclusion it may be said that all of the morainic lakes in Indiana are "geologically young, being confined to the very latest moraines of the glacial period. They are mere babes born yesterday and destined to die to-morrow. The present dominant race of men may pass away and leave these lakes still lying like bright jewels among the hills; but every one is doomed to final extinction.

'The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands,
Like clouds they shape themselves and go.'

* Page 14.

"But of all the features of the landscape, lakes are the most ephemeral. As long as they remain they will continue to contribute to the service and delight of man, by affording means for that relaxation and healthful pleasure which the conditions of modern life demand."*

MARL.

As stated in the paper on the Portland cement industry, the ingredients used in making that cement are some form of lime-carbonate and clay. In the majority of Portland cement works in the United States limestone is the form of lime-carbonate used. This must be crushed and ground fine before being utilized. In the Portland cement works now in operation in Ohio, Michigan and Indiana, *marl* is used as the carbonate of lime ingredient. With marl the expense of crushing and grinding the raw material is in part saved, and with care in choosing and mixing the marl and clay a good cement can be manufactured more cheaply than with limestone.

DEFINITION AND PROPERTIES.—Marl, or "merl," as it is commonly called in the country, is a soft, earthy material, composed principally of an amorphous form of carbonate of lime. Its color varies with the percentage of impurities which it contains. In the wet or damp state in which it occurs in lakes or marshes, it ranges from a milky-white through varying shades of brownish-yellow to a dark brown, which may finally grade over or merge into the overlying or adjacent muck. After exposure to the air a short time a wet marl that at first may seem almost white turns a bluish or drab color, on account of some chemical change which takes place. In drying the color of the marl tends to lighten again, but seldom gets beyond a light dove color, and is generally a decided drab, running from a light drab to a slate color. The purer forms, however, when dry, are white or slightly cream colored. The grains or particles composing the dry mass cohere very loosely and vary in size from coarsely granular to fine powder. They effervesce very freely and in time wholly disappear when a few drops of muriatic acid are applied, and in this way may be readily distinguished from any soft clay or mud, which effervesces or bubbles but slightly or not at all upon the application of acid. On dissolving the marl in acids small particles of vegetable and other organic and insoluble materials usually remain scattered throughout the solution.

* Dryer, Studies in Indiana Geography, 1897, p. 59.

Occurrence in Indiana.—Deposits of marl of sufficient size to justify the erection of cement factories occur in Indiana only in the three northern tiers of counties. Small deposits are found scattered here and there in other portions of the drift-covered area of the State, but none have been reported south of this glacial area. The reason for this is obvious and will be noted when we deal with the origin of the marl.

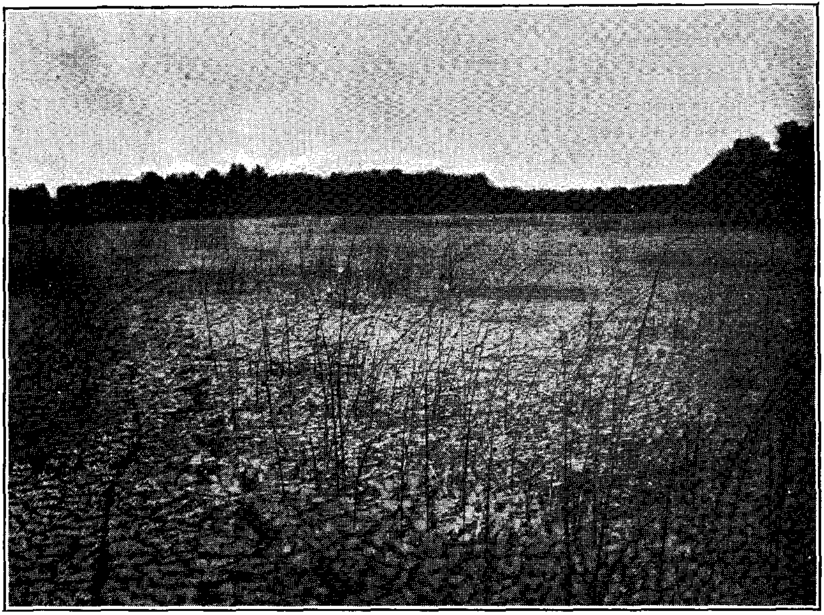
Except in a few instances where small deposits occur on hillsides, where they have been formed by the seeping waters of springs, all the beds of marl in Indiana are found either in existing or extinct lakes. Many of the deposits are found in marshes, now partly or wholly dry, but easily recognized as former lakes or ponds.

In hardness and consistency the marl as it occurs in lakes resembles somewhat soft butter. In some of the marsh deposits outside of the lakes it is firm enough to be cut out in blocks and handled with a shovel, but not easily because of its tendency to stick to the shovel. When piled up it tends to settle and spread slightly, though not usually to such an extent that it runs down to a level surface. Much of that found about the margins of lakes has the consistency of common mortar when ready for use. From the semi-solid condition found in marshes, it runs to the other extreme, where it becomes more like a thin pudding or thick soup. Some of the water deposits seem, in fact, to be only undergoing the process of deposition. From a boat it appears in such cases as though the water were only a few inches deep. But a very slight movement of the water is sufficient to either set the apparent bottom in wave-like motion, or to stir it up into a white cloud-like mass, which rises to the surface of the water. If allowed, however, it will quickly settle back to its old condition. An iron bar will sink rapidly of its own weight in such marl. In such a deposit it would seem as though the marl did not occupy over one-fourth of the space, the rest being water.

Usually the marl in the lakes forms a distinct body from the water, appearing like an ordinary lake bottom, except for its being whiter. An attempt to wade out into the water, however, at once shows the difference, for generally one sinks two or three feet at every step, and an oar put down from a boat is easily pushed its whole length into the marl, provided the latter is of sufficient depth. Where it is above water or at the surface in the marshes the marl can usually be crossed on foot, one not, as a rule, sinking more than six inches into it, and sometimes hardly at all, particularly if there has been some vegetation growing on it. In these places it is often quite difficult to force the iron rod its full length, 16 or more feet, into it,

PLATE 6.

a



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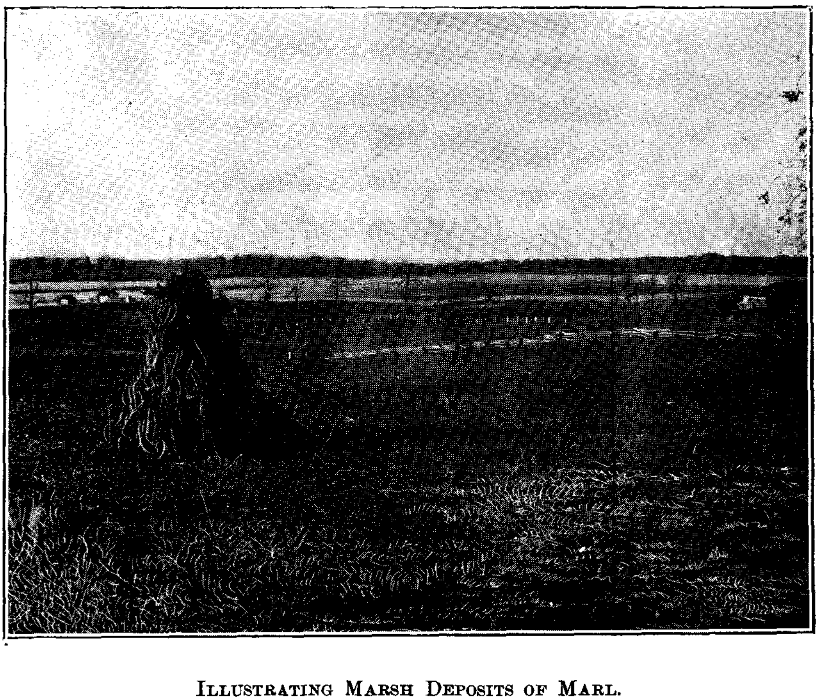

ILLUSTRATING MARSH DEPOSITS OF MARL.

(a) Deposit at Goose Lake, near Fish Lake, Laporte County, showing white marl surface, scant vegetation (bulrushes), and cracking due to drying. The footprints and bicycle track or withdraw it after being so forced in. Where the marl in a marsh is covered with muck or peat, its upper surface is level and wholly distinct from the lower surface of the overlying muck or peat. The marl, in other words, appears as a distinct stratum and does not merge irregularly into the overlying mass. When exposed, this marsh marl is usually whiter in color than that in lakes, though chemical analyses do not show it to be of greater purity. Like the more recent water deposits it has usually remains of shells scattered through it, the most common form being the fresh water univalve—*Helisoma trivolvis* Say. Where both muck and peat overlie the marsh marl, the peat lies next to the marl, the muck forming the surface layer. Sand or gravel underlies most of the marl deposits in Indiana, though in a few instances the rod struck a tough blue clay after passing through the bed of marl.

In size the marl deposits of Indiana run from a fraction of an acre to several hundred or a thousand or more acres. Lake Wawasee, including the arm known as Syracuse Lake, contains about 1,700 acres. Several deposits run over 800 acres, though in some cases this is not all commercially available. Areas of 100 to 200 acres are still more numerous, though the majority of the deposits run under 100 acres. This may be an under-estimate based largely on the fact that a large majority of the deposits examined showed less than 100 acres of shallow water marl or commercially available marl.

The thickness of the marl beds in Indiana varies from 0 to 45+ feet, a deposit of the latter thickness having been found in Turkey Lake, Lagrange County. Many deposits are everywhere less than 10 feet in thickness, but the majority exceed 16 feet in places and often over the major part of their areas. As 16 to 20 feet was the total length of the rod used on the lakes, the actual or maximum depth of the marl beds was often left unknown. Experience has shown that a testing rod 16 or 18 feet in length is as long as one man can readily handle in an open boat. Where greater lengths are used a platform is usually built over two boats and this being securely anchored, two or more men can make the tests. By such means, according to the map furnished of tests on Syracuse Lake, Kosciusko County, depths of 60 feet were reached with a maximum thickness of marl of 40 feet and bottom not reached. Depths of 25 to 30 feet or over were reported at several places. From our own experience it seems safe to say that a large majority of the deposits have a maximum depth of over 20 feet, even though the area of the deposit be quite limited.

Origin and Deposition of Marl.—The deposition of marl in the still water of lakes and ponds is, as yet, not fully understood by scientists. Several theories have been advanced, no one of which seems to fully account for the deposits as they actually occur. Since the remains of several existing species of shells are found in abundance in almost all of the marl beds, it was at first thought that the marl itself was derived from the remains of such shells. Such is at present the belief of most people who have made only a superficial examination of the marl deposits. An extended investigation soon shows that the immense size and thickness of the deposits precludes their origin from the remains of shells. A small portion of the marl is doubtless formed from the shells since these mollusca exist in numbers in all bodies of fresh water. Moreover, the shells are composed mainly of carbonate of lime, the same as is the marl. But the number of shells imbedded in the marl is not greater than would naturally exist in the waters of the lake at the time the marl was being deposited. As they died the majority of them were covered with the marl and were by it kept from being ground into fine powder by wave action. Some of them were doubtless so ground and their remains went to swell the bulk of the marl, but not more than one per cent. of the latter is, in our opinion, so derived. When the marl is exposed, numerous nearly entire fragile shells are found embedded in its mass. Should the marl beds, in the course of ages, become hardened into stone, such shells might become "fossils," and bear the same relation to the marl-stone as other fossils bear to the beds of limestone in which they occur. It is, of course, preposterous to think that any bed of limestone is wholly formed from the crushed remains of the same species of shells as those which have become fossilized in its midst, however abundant the latter may be. The same is true of the deposits of marl.

Since the marl occurs only in the drift-covered area of Indiana, and the larger beds are found in the vicinity of the thicker deposits of drift, there is evidently a close relation between the marl and the surrounding drift. A careful study of the marl leads to the belief that this relation is two-fold in nature. *First,* the lakes and ponds in which the marl is being and has been deposited occupy depressions formed by the irregular deposition of the drift. *Second,* the immediate source of the marl is the glacial clays which form so large a component part of the surrounding drift. These clays were transported to and deposited where they now lie by a great glacier or moving sea of ice which, thousands of years ago, was formed in the regions to the east and south of Hudson's Bay. The climate of those regions was, for a long period, similar to that of Greenland to-day, or even colder. The snow, ever falling, never melting, accumulated during hundreds of centuries in one vast field of enormous thickness. Near the bottom of this mass a plastic, porous sort of ice was gradually formed from the snow by the pressure from above. This ice mass or glacier took upon itself a slow, almost imperceptible, motion to the south and southwestward. As it moved thus onward great masses of partly decayed rock and clay from hillsides and jutting cliffs rolled down upon it and were carried on and on until, by the melting of their icy steed, they were dropped hundreds of miles from the parent ledge. Large, irregular masses of rock from the region in which the glacier was formed were either frozen into its nether portion or rolled along beneath it, and as the ice sheet moved they served as great stone drags, grinding down and smoothing off the hills and ridges and filling up the valleys, until the irregular, uneven surface of the old preglacial rocks was planed and polished. In this way all the beds of so-called "drift clays" were accumulated where they lie.

Transported and deposited as they were, it is no wonder that the majority of the drift clays are too impure for any use but the making of ordinary brick and drain tile, and oftentimes they contain too much lime even for this purpose, numerous analyses showing the presence of as high as 40 per cent. of calcareous material. This is due to the grinding up and mixing with the clays much of the soft surface limestones over which the glacier passed, as the erosion of that epoch not only removed and commingled the previously formed residual deposits, but planed away the country over a vast area to a greater depth than had been reached by any previous decay. These eroded limestones and the clays with which they were mixed were many of them ground into impalpable powder, and deposited as rock flour in the places where they now lie. They are rich, therefore, in finely divided limestone and other soft rock-forming minerals, many of which contain the components of marl.

Vast deposits of these glacial clays compose the hills and higher ground surrounding the lakes. Upon these deposits the rain of centuries has fallen, gathering unto itself before it reached the earth a part of the gaseous carbon di-oxide of the air. Rain water containing carbon di-oxide is a weak form of carbonic acid ($H_2O+CO_2=H_2CO_3$). This weak acid or acidulated water, wherever it comes in contact with limestone dissolves and holds in solution, up to a certain point, the carbonate of lime; the result being calcium bi-carbonate according to the following formula: $H_2CO_3+CaCO_3=$

$CaH_2(CO_3)_2$. Percolating through the deposits of glacial clays and limestone debris the rain water dissolves and becomes saturated with the carbonate of lime. It then flows onward underground until it issues forth in the form of a spring, either bubbling up from the bottom of the lake or flowing in from the side.

This spring water as it enters the lake is always colder than the waters of the lake itself. The bi-carbonate of lime is more soluble in cold water than in warm and a *part* of the dissolved material is therefore precipitated in the form of a fine powder soon after the cold stream enters the warmer, still water of the lake. Such precipitation of calcium carbonate from cold water as it becomes warm is seen every day in almost every household. The hard water heated in tea-kettles holds, while cold, a large quantity of bi-carbonate of lime in solution. As it becomes warm much, if not all of this, falls and forms a coating of lime upon the bottom of the kettle.

Again, if there is a large amount of carbon di-oxide in the percolating water, the percentage of carbonate of lime held in solution will be increased in proportion. As the spring water enters the lake and rises to the surface the pressure will be decreased and a part of the carbon di-oxide will escape, and so cause a precipitation of *another part* of the bi-carbonate of lime according to the following formula: $CaH_2(CO_3)_2—CO_2=CaCO_3+H_2O$.

Most if not all of the marl lakes examined in Indiana are fed by these subterranean or sub-aqueous springs, even though they have streams entering and leaving them. The larger deposits of marl in the lakes are found in close proximity to these springs and not along the direction of the current of water entering by inlet or leaving by outlet. In fact almost every lake which has a stream entering it has a large area of its bottom adjacent to the inlet covered with muck and silt from which much aquatic vegetation springs. A part of this muck and the most of the silt is brought in by the entering current, especially if the latter be in any way rapid. Where the inlet is sluggish and runs through a marshy area, more or less marl is often found along its bottom, quite a distance back from the lake. These facts do not bear out the following statement of a recent writer on the subject: "Theoretically, then, some, if not a great part of the dissolved matter, should be thrown down along the courses of the streams which connect the original outlets of the water from calcareous clays and lakes where marl occurs, and we should find the marl occurring in small deposits along these streams wherever there is slack water. Moreover, we should expect the waters of these springs and streams to show more or less milkiness on standing exposed to the normal pressure of the atmosphere at usual temperatures. Actually, however, none of these phenomena have been noted, and we infer that there is not a large amount of carbon dioxide, and not an approach to the saturation point for the calcium bi-carbonate, in the springs and streams feeding marly lakes."*

Mr. Davis evidently does not take into account the fact that most of the marl enters the lakes by means of hidden springs and not by the streams or inlets flowing above ground. The waters of the latter are mainly surface waters which are gathered from over a wide area. They have not percolated to any great extent deep beds of glacial clays and therefore, even if the amount of carbon di-oxide were great when the water fell upon the surface, the amount of carbonate of lime or marl material held in solution is small. Moreover, flowing as they do exposed to the air for long distances the carbon di-oxide will in great measure have escaped before the waters of the surface streams enter the lakes. Again, the amount of carbonate of lime held in solution by water, even where the latter is saturated with carbon di-oxide, is too small to show appreciable milkiness when standing. According to T. Sterry Hunt, water so saturated will not hold more than one part in one thousand of the carbonate of lime, and pure water only one part in thirty to fifty thousand.† For this reason the process of deposition of the marl in the lakes is necessarily a very slow one. It has been going on for hundreds of centuries, for the lakes and their surrounding beds of glacial debris have been in existence since the close of the glacial period. It was probably much more rapid in the past than at the present for the more soluble materials composing the glacial clays were doubtless first removed by the filtering waters. That the deposition is still going on is shown by the fact that many of the living organisms of the lakes, as shells and aquatic plants, are coated with the marl. All facts go to show that the beds of marl have been formed in much the same manner as have many of the beds of fine-grained limestone of paleozoic age. They are both sedimentary deposits, the principal difference being that the limestones are composed mainly of the remains of minute organisms which slowly fell in great masses to the bottom of the sea water, and were afterward covered with a different sediment and hardened by pressure and other forces. Given thousands of years and similar conditions, and the marl would also be changed into a somewhat similar limestone.

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*Chas. A. Davis, "The Natural History of Marl," Journal of Geology, VIII, 1900, p. 486.

†Chem. and Geol. Essays, p. 139.

Another factor which reduces the amount of carbon di-oxide in the entering waters and therefore causes a farther deposition of the marl, is undoubtedly the aquatic plants which grow in many of the marl-bearing lakes. Any one who studies the botany of such a lake soon notes that the stems of many of the submerged plants are encrusted with mineral matter, which, when removed and subjected to acids is easily shown to be carbonate of lime. "It is also easy for a casual observer to see that the deposit is not a true secretion of the plant, for it is purely external, and is easily rubbed off the outside of the plants in flakes, while the tissues beneath show no injury from being deprived of it, and again, the same species of plants in some sections of the country do not have any mineral matter upon them. The deposit is formed incidently by chemical precipitation upon the surface of the plants, probably only upon the green parts, and in performance of normal and usual processes of the plant organism.

All green plants, whether aquatic or terrestrial, take in the gas, carbon di-oxide, through their leaves and stems, and build the carbon atoms and part of the oxygen atoms of which the gas is composed into the new compounds of their own tissues, in the process releasing the remainder of the oxygen atoms." When the carbon di-oxide is removed from the surrounding water by the aquatic plants the carbonate of lime, held in solution on account of the presence of the gas, is precipitated. A part falls upon and encrusts the leaves and stems of the plants. Another part falls to the bottom and increases the thickness of the marl bed in which the plants have grown. When the plants die, their encrustation, as well as the organic matter in their bodies, is also added to the marl deposit.

The principal plants which thus aid in the deposition of marl in Indiana lakes are the different species of Stoneworts or Chara. They are easily recognized by "their jointed stems, which have at each joint a whorl of radiating branches, which are also jointed. In some species the stems and branches are covered with a thick coating of mineral matter, are almost white, and very brittle because of this covering. These plants not only grow near the surface of shallow water, where it is unoccupied by other plants, but in the deeper parts as well of our ponds and lakes, and, as they thrive where the light is feeble, they continue to grow throughout the year, although in winter they must grow less rapidly than in summer, because ice and snow on the surface of the lakes make less favorable light conditions."*

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* Davis, *loc. cit.*, p. 491.

However, not more than one-half of the marl lakes of this State possess the beds of Stonewort in any abundance. Again, the species of Chara are often found in lakes which contain no marl or in those portions of marl-bearing lakes remote from the marl itself. Where present in large quantity the stems of these plants, as they die and decay, add much organic matter to the marl and so cause it to be inferior in quality. In fact, all marl deposits covered with Chara are darker in color and show a smaller amount of carbonate of lime when analyzed than do those devoid of plant life. Some of the larger and thicker deposits of the whitest and purest marl in the State are found in Lime and James Lakes, Steuben County, and Tippecanoe and Dewart Lakes, Kosciusko County, where Chara and other plants are almost wholly absent, thus showing that the presence of plant life is not necessary to the deposition of the marl.

Another group of plants which evidently aid in the depositing of the marl are some of the lower forms of Algae. The cells of these are found in great numbers intermingled with the particles of marl in the encrustation on shells and in the concretions and pebbles of carbonate of lime found in James and neighboring lakes, Steuben County, and in Milford Lake, Kosciusko County.

SUMMARY.—From the foregoing statements we therefore conclude:

First.—That the marl deposits of Indiana have been formed in the still waters of lakes now in existence, or in former lakes, now extinct.

Second.—That the original source of the marl material is the glacial clay in the region surrounding the lakes.

Third.—That the deposition of the marl is caused by the loss of carbon di-oxide from the sub-aqueous spring waters which bear the marl material into the lakes.

Fourth.—That this loss of carbon di-oxide is, for the most part, caused in three ways, viz.:

(a) By the increase in temperature of the incoming spring water.
(b) By the decrease in pressure as the spring water rises to the surface of the lake.
(c) By the action of different aquatic plants in abstracting the carbon di-oxide for food.

RELATION OF MARL TO DEPTH OF WATER.—One of the most striking facts brought out in a detailed study of the marl deposits is the great irregularity in their occurrence. One part of a lake or marsh may contain a bed of marl 16 feet or more in thickness while in another part, 10 to 20 rods distant, it may be wholly lacking. This irregularity is doubtless largely due to the presence or absence of sub-aqueous springs. If they are absent in a lake and the latter is fed only by surface streams, there will be little or no marl found in its bed. One part of a lake may have a number of these springs welling up from the bottom or flowing in so as to enter the lake bed where the water is six feet or more in depth, and in other portions of the same lake they may be wholly absent. Under such conditions, if the lake be a large one, only that portion of its bed adjacent to the springs will likely be covered with marl. If it be small, the whole bottom may be covered, but the thickness of the deposit will be variable.

In the earlier Geological Reports of Indiana, the marl, when mentioned, was usually described as "composing the shore," or "bordering the lakes," or as "occurring around their margins," thus giving the impression that it was confined to the shallow-water area of the lake, or occurred only between the limits of high and low water. Recent tests, however, have shown marl to occur at probably all depths of water, and with often greater thickness of marl in deep water than in shallow. No data were obtained concerning the character of the bottom at depths of 100 feet or over. Perhaps the greatest depth at which we have data of the occurrence of marl is in Turkey or Wawasee Lake, Kosciusko County, where, in the plankton survey carried on by Mr. Chancey Juday, marl was found under all the deeper water up to 69 feet, the deepest point in the lake. Interpreting this in the light of our knowledge of shallower lakes it leads us to the conclusion that, as a rule, the marl occurs abundantly in the deeper water of all the lakes where it occurs at all. In a few of the lakes this rule did not appear to apply, for the marl found close to shore appeared to thin out in 10 to 15 feet of water. This was probably due to the fact that but few sub-aqueous springs entered such lakes and they only along the sides in the shallow water. It is possible a similar thinning out takes place in many other instances at depths too great for the fact to be observed with the facilities at our command. But in general the data seem to indicate not only a deepening of the marl toward deeper water but a more wide-spread distribution. Thus in many lakes the distribution of the marl close to shore is irregular so that perhaps not more than half of the three-foot water has marl under it, but in nearly every such case it was found that the eight or ten-foot water is almost all underlain with a thick deposit of marl. At present this deep water marl is considered unavailable for manufacturing cement, but there can be but little question that, as need arises, means will be devised for securing it with at least fair economy. It should be therefore taken into account in any calculation of the quantity of marl in a deposit.

In some cases the accumulation of marl has almost or quite filled up the lake. This is notably true in what are now marshes. In such cases it is evident that the marl is thickest at the points where the water was deepest when the marl began to deposit. In small lakes which have been recently drained, it is also found that the thickest beds of marl underlie those portions of the former lake over which the deepest water occurred.*

In any case it is evident that the thickness of the marl is limited by the depth of the sub-marl surface below the water surface. For this reason, even though accumulation is most rapid in the shallow water, the water surface, and hence the limit of accumulation, is more quickly reached, so that the slower accumulations in deeper water may continue until many times as thick as those in shallow water. In those cases where a lake becomes entirely filled up, the thickness of the marl at every point will be equal to the original depth of the water at every point, except as modified by changes in the water level. These conditions are frequently met with close to shore in unfilled lakes. Here, however, on account of wave action the surface of the marl seldom reaches the surface of the water except just at the shore line.

Marl islands, reaching almost or quite to the surface of the water, are often found in the deeper parts of the lakes. Sometimes there is a visible connection of marl under water, between these islands and the nearest shore. Again they are quite isolated from other beds of marl. In either case they are probably above and surrounding the orifice of a former, large sub-aqueous spring which bubbled up from the bottom of the lake.

Where the bed or basin of the lake is narrow and deep, it is manifest that the majority of the springs feeding it must enter from the sides. In such cases the larger and thicker deposits of marl naturally occur around the margin and it is probable that much of the marl after deposition is gradually carried down to fill up the deeper parts of the lake.

While complete detailed drillings of a number of the deposits would be desirable, we are fortunate in having one, that of Syracuse Lake, Kosciusko County. One of the most notable things shown by the detailed drilling in this lake is the tendency

*See detailed descriptions of deposits at Houghton Lake, Marshall County; Shallow Lake, Steuben County, etc.

towards filling up the hollows of the sub-marl surface. In several cases this has progressed until deep hollows have been filled up even with the marl over the higher ground on either side, so that no hint of the greater depth of the marl is given by the present depth of the water. From this we deduce that the deepest marl is probably found in places where the water was deepest when the marl began to be deposited; also that the present depth of the water may or may not be an indication of the greater or less depth of the marl. Where the lake had originally a uniform basin-shaped bottom it would generally be true that the deeper the water to-day the deeper the marl. But the bottom of most of the lakes examined was very irregular in shape, hence some of the deepest original depressions may have been so completely filled as to be in no wise indicated by the present depth of the water.

Finally it may be stated that the facts gathered go to show that most of the larger lakes possessing extensive deposits of marl are slowly filling up the lowest depressions, thus making the bottoms of the lakes more and more level. Should this process continue indefinitely it could but result in these lakes being filled level full, just as many of the smaller lakes of the State have been filled heretofore.

Size of a Workable Deposit.—In the Portland cement industry, a cubic yard of marsh marl, of the consistency of soft putty, is used in making two barrels of cement. Where the marl is dredged from a lake, and contains much water, this proportion is necessarily greater. Careful estimates go to show that an acre of marl three feet in thickness will make 10,000 barrels of cement. From this data the length of time necessary to exhaust any deposit can be readily computed. At the present time a factory with an output of 500 barrels of cement each 24 hours, is considered of only medium size. As the process is a continuous one, with no stop for Sundays or holidays, such a factory will use a bed of marl nine acres in area and six feet in thickness each year.

The following table gives approximately the length of time which deposits of varying area and thickness will last a factory whose output is 500 barrels of cement daily:

Area in Acres.	*Thickness in Feet.*	*Barrels of Cement.*	*Time.*
1	3	10,000	20 days.
1	6	20,000	40 days.
1	12	40,000	80 days.
1	18	60,000	120 days.
9	6	180,000	1 year.
40	12	1,600,000	8.9 years.
120	12	4,800,000	26.5 years.
135	12	5,400,000	30 years.
160	10	5,333,000	29.6 years.
200	10	6,666,000	36.5 years.
90	18	5,400,000	30 years.
270	6	5,400,000	30 years.

Since a modern cement factory with a capacity of 500 barrels daily costs in the neighborhood of $350,000, the company erecting it wish a deposit of marl in sight which will last, at least, 30 years. From the table we note that a deposit equal to 160 acres, 10 feet in thickness, will last almost 30 years, and such a deposit will, in this report, be termed a "workable deposit." It is needless to say that the great majority of deposits examined were too small to be workable except on a very small scale. The time may come when by improved processes the amount of capital necessary to manufacture the cement will be materially decreased. Small factories may then be erected and the lesser deposits utilized. Again, there is no doubt but that appliances will ere long be perfected for securing the marl from beneath all water 20 to 60 feet in depth. The amount of available marl will then be greatly increased, and a number of deposits not now considered workable will then be utilized.

USES OF MARL.—The marls found in Indiana can be used for the following purposes:

First.—As an ingredient in the manufacture of Portland cement.

Second.—As a fertilizer of soils.

Third.—As a means of improving the mechanical condition of clayey, sandy or peaty soils.

Fourth.—As a mineral food for poultry, furnishing them the necessary ingredient for shells of eggs.

Fifth.—As a polishing powder.

Sixth.—As a material for the manufacture of quicklime.

Seventh.—In the place of limestone in the manufacture of beet sugar.

These possible uses will be taken up in the order mentioned and briefly discussed.

First.—Its use *"As an ingredient in the manufacture of Portland cement"* has been fully discussed on preceding pages. Many farmers who have only 20 to 60 acres of marl have written to this Department asking for directions for making Portland cement, intending to use their deposit for this purpose. It will be evident, from what has been said, that it will not be practicable to utilize such small deposits for the manufacture of cement.

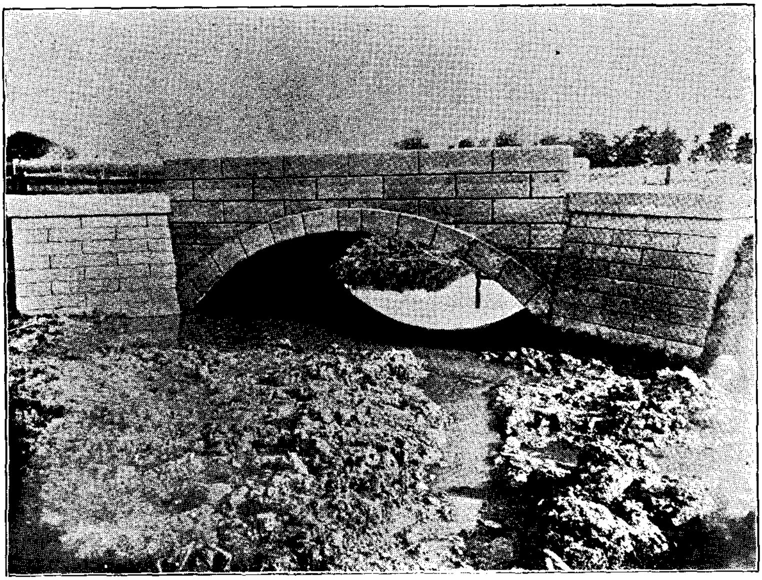
Second.—*"As a Fertilizer of Soils."* A fertilizer is any material which furnishes a necessary plant food to soils. It is well known that wheat or any cereal uses as food the following chemical elements, viz., carbon, hydrogen and oxygen, which are derived mainly from the air and water and which make up the greater bulk of the grain and stalk; and, in addition to these, nitrogen, sulphur, potash, soda, lime, magnesia, phosphoric acid, chlorine and silicon, which are important, yea absolutely necessary, constituents.

If any *one* of these is lacking in the soil, or is present in a form not available by the wheat roots, the plants will not flourish, and the soil will be worthless for wheat production. Such a soil may, in most cases, be made to produce a crop of grain by adding to it the constituent which is lacking, but if this can not be done except at a prohibitory cost, or one at which more fertile ground can be procured, the soil may be regarded as "worn out" or "barren."

Any compound containing in an available form the element or elements of plant food lacking in a soil, is a *fertilizer.* From the analyses of Indiana marls which will be given, it will be seen that their principal constituent is carbonate of lime. Other than it they contain but a small percentage of one or two of the important elements used as plant foods. Their value as fertilizers, therefore, depends almost wholly upon their lime component. Lime is one of the elements used as food by most plants, and it is therefore necessary to supply some compound containing it in case it is not found in sufficient quantity in the soil.

According to the German scientist, Dr. Maercker, a lime content in a soil of one per cent. is always sufficient; where one-half to one per cent. of lime is present, the application of lime fertilizers is occasionally beneficial, and always so, when only one-quarter to one-half per cent. of lime is present. When less than one-quarter of one per cent. of lime is found in the soil, liming is absolutely necessary. Generally speaking, we may say that the content of lime can not fall much below one-half of one per cent. in a light soil, and one per cent. in a heavy soil, without impairing the fertility of the soil.

PLATE 7.



Illustrating Uses of Portland Cement.

Highway Bridge, constructed of Portland Cement Concrete.

The great majority of Indiana soils are clayey, loamy or prairie soils, lying within the drift-covered area of the State, and, for the most part, containing a sufficient quantity of lime. The addition of marls to such soils would therefore be of little or no benefit. However, there are some large areas of light sandy soil in northern Indiana the fertility of which would undoubtedly be increased by a dressing of marl. Mucky soils, though usually containing a large percentage of lime, are often benefited by an application of marl or some other lime compound. The reason for this is that lime is present in these soils in combination with organic acids, as humates, ulmates, etc., which compounds can not supply plant food to crops until they are broken down and oxidized to inorganic materials. The effect of lime on marshy soils is partly in this direction, promoting the fermentation of vegetable matter and assisting in the decomposition of inert compounds so as to render them soluble in soil water and available as plant food, partly in the way of neutralizing free organic acids and of oxidizing poisonous iron compounds (ferrous salts) generally present in such soils.

An example of the beneficial results of marl on muck soil was noted on the land of F. M. Trissal, two miles northwest of North Judson, Starke County, in the summer of 1900. A field which a few years ago was part of an extensive marsh was being cultivated in corn. The surface was a loose black muck or semi-peat, two feet or more in thickness. Beneath this was a deposit of marl from two to six feet thick. In draining the field a ditch had been put down a foot or more into the marl and a quantity of the latter became mixed with the mucky soil when the ditch was refilled. On July 15th, the corn in three rows on either side of the ditch was fully twice the height of that in the remainder of the field, and it has since been learned that the yield of these rows was a third greater than that of the rows adjoining where the marl had not been mixed with the muck. Much of the mucky soil of northern Indiana is underlain with marl and the farmers owning such land could, at a small expense, bring about a mixture of the underlying marl and overlying muck. There is little doubt but that such a mixing would in the end prove highly remunerative. An account of the results of such mixing would, if properly compiled, also afford valuable data for those farmers and scientists who are interested in all important questions relating to commercial fertilizers.

Experience goes to show that good effects will follow the application of marls on land deficient in lime, but on account of the small amount of other plant food which they contain, their value is not sufficient to justify shipment for long distances. The marl must therefore be used near where it is found and the price which it will command will be governed by the law of supply and demand. In the vicinity of much of the light sandy soil of northern Indiana there is an abundant supply of good marl, and the price in this region will therefore be very reasonable.

As to the application of marl as a fertilizer, we can not do better than to quote the following from a paper by Mr. F. W. Woll;* "Where there is a probability that beneficial results may be obtained by applying marl on a soil, it should be done directly before sowing or planting time, or as a top-dressing on clover or on grass land, provided the marl at hand is in the form of a dry fine powder; if it is wet and putty-like, and dries to large hard lumps, the dressing should take place in the fall or early winter so that the winter and spring weather, with alternating frosts and thaws, may gradually reduce it to a pulverulent mass. In countries where liming or marling is frequently done, special machinery is used for the purpose of distributing the material evenly over the land, which is of importance. It is very likely that our common manure spreaders will do the work in a satisfactory manner.

"The crops most likely to be benefited by applications of marl are the legumes (clover, peas, beans), grass, potatoes, corn, and root crops. As in case of other fertilizers, a small quantity of marl placed in the row or the hill will go farther and give better results for crops planted or sown in this manner, than the same quantity scattered broadcast.

"Like all lime compounds, marl has a tendency to exhaust the soil if applied excessively and for a series of years, as it renders valuable fertilizing ingredients soluble and therefore subject to leakage. The old European saying that 'lime without manure, makes the father rich and the son poor,' is an expression of this fact. Unless we start with a soil well supplied with fertilizing ingredients, aside from the lime added, the effects of dressings of lime or marl alone will therefore be of temporary benefit, but a detriment in the end. To avoid this difficulty, barnyard manure, or complete artificial fertilizers should be applied at times on marled or limed land. The liming or marling, if done thoroughly, need not be repeated on the same land oftener than every sixth to eighth year.

"Marl may furthermore be used to advantage for making composts with muck, barnyard manure, and refuse fertilizing materials; its action in this case depends on the favorable effect which it exerts

*"The Marls of Wisconsin" in Bull. 51, Wisc. Agr. Exp. Stat., 1896, p. 14.

on the progress of the nitrification of inert organic nitrogen substances. Where marl is near at hand and easily accessible, farmers should not fail to make use of it for this purpose, and also to apply it directly in varying quantities on small pieces of their land, so as to obtain definite knowledge of what it will do under their conditions.

"In some of the potato-growing counties of our State (Wisconsin) where land plaster is used extensively for mixing with paris green, shell marl in a fine powder has been advocated as a substitute for plaster. Marl of this character is well adapted to this purpose on account of its mechanical condition, but it can not be considered as valuable as plaster as a fertilizer owing to the fact that the latter, being a sulphate, is able to bind the free ammonia and carbonate of ammonia of the air and soil, thus preventing the nitrogen which they contain from going to waste. Land plaster is also in other respects of greater value to growing crops than is any form of carbonate of lime."

Third.—The use of marl "*As a means of improving the mechanical condition of soils*" is a very important one, and is worthy of more general practice than it has received from farmers in the past. A soil may contain all the elements or ingredients necessary for the production of a certain crop and yet, on account of its mechanical condition—its extreme looseness or porosity, or its compactness—plants can not grow in it. By the application of certain materials, one of the best of which is carbonate of lime, these unfavorable physical properties of the soil are often modified or broken up, so that the plants can avail themselves of the store of fertility in the soil, and a good crop is the result.

Many clay soils, when wet by rains, are not porous enough to allow the water to pass through them with sufficient rapidity. As a consequence they become water-logged and the air which is necessary for the healthy growth of the plant roots is excluded. In time of drought such soils cake readily, thus forming large clods, and becoming more difficult to till and less adapted to the sustenance of the growing plant. Marl or some other compound of lime, when applied in sufficient quantity, will prevent this puddling or caking, thus allowing the water, air and heat to thoroughly permeate the soil. The texture of the soil will also become more suitable for the easy penetration of the roots and rootlets of the plants.

If to a loose sandy soil a sufficient quantity of marl be added, the sand grains will in time become more or less cemented together, thus lessening the large openings between the soil particles, and causing the better retention of heat and moisture.

Another way in which marl, or other compound of lime, improves the mechanical condition of soils is by its effect upon the action of microscopic organisms. "Many important changes are produced in the soil by organisms so small that they can only be observed by the aid of the most powerful microscopes. Some of the changes of this character in which lime plays an important part are the following:

"(1). The change of ammonia and of nitrogen in organic matter, such as blood, meat, fish, tankage, plants, etc., into nitrates, the form in which it is chiefly assimilated by most cultivated plants. This is known as the process of nitrification and is promoted by the presence of lime in soils.

"(2). The decomposition of organic matter in muck and other soils. In this process the production of carbonic acid is much accelerated by the use of lime. This carbonic acid in turn so acts upon the inert plant food of the soil as to make it more quickly available to plants. The indirect result, therefore, is to help the plant to draw more potash, phosphoric acid, etc., from the soil than would otherwise be possible.

"(3). The utilization of atmospheric nitrogen by certain of the leguminous plants (notably the clovers), particularly upon sour soils, is facilitated by the application of lime."*

Where marl is added to a soil for the purpose of furnishing the latter with lime for plant food, or as a fertilizer, the amount necessary will be much less than where it is applied to better the mechanical condition of the soil. In the former case a dressing of one to two tons per acre every six to eight years will generally prove sufficient. In the latter case as many as 25 to 40 tons per acre may be applied without harm. If the marl be spread out perfectly even over the surface a dressing of 40 tons per acre will form a layer about one-fourth of an inch thick.

Fourth.—"As a mineral food for poultry." Chemical analysis and experiments, together with reports from many practical poultry men, prove conclusively that the ordinary grain and green foods supplied to chickens and other fowls do not contain enough lime for the formation of egg shells. Several times as much lime as is ordinarily fed is necessary if good strong egg shells are to be produced. No form of lime is more convenient for this purpose than marl, its particles being in a state of fine division and easily assimilated as

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* H. J. Wheeler, Farmers' Bull. No. 77, U. S. Dept. Agr., 1898, p. 6.

shell-forming material. Several farmers in the vicinity of marl deposits in northern Indiana have tried it, hauling up a load two or three times a year and placing it where the fowls had free access to it. They report that the chickens lay much better during the winter season. It is probably better to keep the marl thus continually before the fowls, trusting to them to eat the amount necessary to supply lime, than to mix it with their other food. The judgment of the fowl can be relied upon to secure the amount required. Poultry supply houses could doubtless build up a good trade for marl for this purpose were they to give the matter proper attention.

Fifth.—"*As a polishing powder.*" Several different mineral products are used as "polishing powders," for scouring articles of silver, brass and other metals. Such a product, to be of value for this purpose, must be in a fine state of division and form an impalpable powder, free from grit or other similar impurities which might scratch the object to be polished. Beds of marl of this character, or which can readily be rendered suitable by grinding when dry, are of frequent occurrence in northern Indiana. On account of the limited demand for such powder it is not likely that the sale of marl for polishing purposes can ever become a source of much income to the owners of the deposits. The marl will, however, furnish an abundant supply of material for use in the kitchens of those homes adjacent to the beds.

Sixth.—"*As a material for the manufacture of quicklime.*" In the early settlement of northern Indiana much quicklime was made from marl. No one of the counties in which the principal marl deposits occur, have outcrops of limestone, and hence the marl was used, being burned in rude kilns erected for the purpose. Richard Owen, in his report on St. Joseph County, says: "Beneath the swamp-muck beds in the Kankakee marshes near South Bend, a shell marl, three to ten feet thick, is obtained, in which are large and abundant specimens, some well preserved, of shells belonging to the genera *physa, planorbis, cyclas* and *unio*. At many places this is dug and moulded into brick-shaped masses of considerable size, so as to be readily piled in a kiln, burnt and used for all purposes to which lime is usually applied, being an excellent quality and white color. An extensive manufacture of this kind is also carried on near the fine Catholic College of Notre Dame, beautifully situated a mile or two north of South Bend."*

Other localities where the marl lime was made, were near Rochester, Fulton County; Lime Lake, Steuben County; Albion, Noble

*Report of a Geological Reconnaisance of Indiana, 1859, p. 200.

County, and Silver Lake, Steuben County. The lime from the marl was snow-white in color, and very perishable owing to its fine mechanical condition. As much of the mortar made from the burned marl did not endure exposure to the weather (probably on account of too small an amount of sand being used in its composition) the use of marl as a lime material was discontinued when railways were constructed which brought in from Wabash, Delphi and Huntington a superior lime.

Since caustic lime or quicklime is the most concentrated form of lime which can be applied as a fertilizer, it might prove profitable to burn the marl into quicklime for that purpose. The manufacture of quicklime from the marl for use in mortar will, however, hardly be renewed, as the quality of the lime produced at the lime-burning cities along the Wabash, taken in connection with the present cheap and rapid means of transportation, will not justify its renewal.

Seventh.—The use of marl *"in the place of limestone in the manufacture of beet sugar"* has, as far as we can ascertain, not been practically tested, but we see no reason why the purer marls of northern Indiana could not be so used. From 2½ to 3 per cent. of lime is added to the juice of the beets as a purifying agent during the process of sugar manufacture. This lime is added to the juice after it has left the diffusion batteries and entered what are known as the carbonatation tanks. After the lime has been added carbonic acid gas is forced through the juice and the excess of lime is precipitated in the form of a carbonate, and carries down with it mechanically many of the impurities. This operation is terminated when the lime precipitate becomes granular and settles readily. At this point there still remains about a gram and a half of lime (CaO) per liter of juice. After having been passed through filter presses the juice is again treated while boiling hot, with ½ per cent. of lime, and carbonic acid is once more passed through it, until all the lime is precipitated. This second operation is termed the *saturation*, the former the first *carbonatation.*

In most beet sugar factories limestone is used, not only for the making of the lime mentioned above, but also in the making of the carbonic acid gas. Large areas of northwestern Indiana have, by practical tests, been proven in the highest degree suitable for the raising of sugar beets. An extensive factory will, in 1901, be erected at Shelby, Lake County, for making beet sugar, while several others will, in the next few years, doubtless be built in neighboring counties. Not an outcrop of limestone of sufficient purity occurs in or near any of the counties where these factories will be located, and such stone will have to be shipped long distances. Since the better marls found in this region contain at least 92 per cent. of carbonate of lime, it would seem that they are pure enough to take the place of the limestone. Care would have to be taken in their selection, and they would have to be briquetted, but even then the cost would, we believe, be less than that of limestone. The experiment is at least worthy of consideration by parties interested in beet sugar manufacture.

METHOD OF MAKING SURVEY.—The survey of the marl area was made between September first and December first, 1899, by Dr. Ashley and at intervals during the spring and summer of 1900 by Mr. Blatchley. It was planned to be only a reconnaisance, made for the purpose of determining in a general way where the workable deposits lay. Such details as may be given were obtained incidentally to the necessary examinations.

The work in the fall of 1899 was almost wholly on the lakes from a boat. The testing was done with a drill composed of $\frac{3}{4}$-inch gas pipe, in lengths of three feet, screwed together at the ends. To the lower joint of pipe was attached a $1\frac{1}{4}$-inch carpenter's auger. The total length of the drill was 16 feet. The purpose of the auger was to open a passage for the rod; break up the marl so as to facilitate the withdrawal of rod and to bring up specimens of the marl for examination. When, therefore, in the detailed description, it says the marl is over 16 feet, or in two feet of water is over 14 feet, it implies simply that the rod did not reach the bottom of the marl at a depth of 16 feet from the surface. The marl at such a point extends downward at least to 16 feet, and may extend down to 20 or 30 feet or even more. In the spring of 1900 the auger was lengthened to 25 feet in order that marsh deposits might be more thoroughly tested, and during that season 18 feet were usually used in work on the water.

As most of the lakes examined have a depth of from 30 to 100 feet over most of their area it follows that the examinations on water were confined to the usually narrow belt of shallow water close to shore or over bars, leaving in most cases the greater part of the lake's resources unknown. On the other hand, since practical cement men consider only the marl beneath 15 feet of water or less available with present appliances, it is evident that this deeper water area may, from the practical standpoint, be considered out of the question, and thus our examinations, limited as they were, covered the area of available deposits. For these reasons it is evident that with a given average depth of marl it is not so much the size of the lake that determines the size of the deposit commercially, as the size of the area of shallow water. Where it is possible to lower a lake or partly or wholly drain it, the available deposit may include everything out to where the water is 10 feet in depth, plus the possible amount of lowering. Many of the lakes, on account of the value of the adjacent real estate being dependent upon the maintenance of a high level, can not be economically lowered. Many have already reached the limit of lowering due to lack of fall in outlet or drainage ditch. Some can readily be lowered from three to ten feet. A few can, by expensive ditching, be completely drained.

In many instances, however, even where the lakes contain large deposits of marl and can be easily lowered, they are far more valuable to the public at large at their present level, than they would be, were their depths decreased and the deposit of marl made commercially available.

The work in the autumn of 1899 was carried on much more rapidly than that in 1900, and but little attention was given to the main features of the lakes themselves, the deposits of marl alone being considered. Usually two, and sometimes three or four deposits, often several miles apart, were examined in a day. As the season advanced much trouble was experienced in securing boats. The results of the investigation of that season are, therefore, in part crude and often irregular, some deposits being examined much more in detail than others. In 1900, with more time at command, the study of the deposits was made more in detail, and many interesting facts relative to the properties and deposition of the marl were secured.

LEGEND.

Figure 01 is explanatory of the details of the marl deposits as shown on the maps accompanying the descriptions of the lakes. The various shades and markings of black indicate a variability in the thickness and location of the marl and muck, as shown by the accompanying figure.

In general, black indicates workable marl, that is, marl having a thickness of over 10 feet and lying out of water or in shallow water, without muck cover. As the maps are all reduced to the same scale, a glance at any map suggests the relative amount of such marl in that deposit. Under the general rule that marl can not be profitably dredged at a depth of more than 15 feet, or removed from beneath more than three feet of muck, the black shows the amount of workable marl in each deposit, *without lowering the water level.* Many of the lakes can be lowered so as to render workable a part or all of the area which on the map appears as an unworkable deposit.

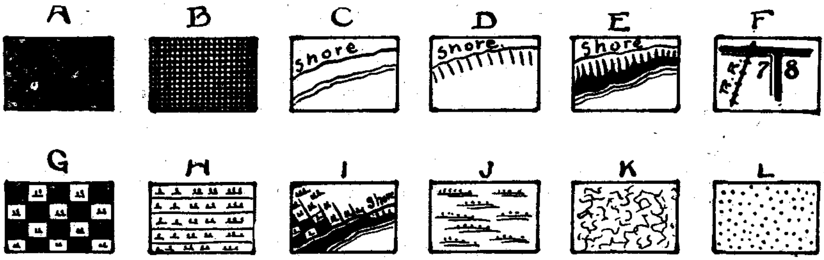


Fig. 01. Legend, Explanatory of Maps of Marl Deposits

A. Marl, dry, or in six feet or less of water, of which the bottom is over 16 feet deep. It thus, in all cases, represents marl over 10 feet deep. In lakes, the outer edge of solid black band, where shown, is supposed to represent the line of six-foot water. As a rule the distance from the shore to the six-foot line is exaggerated.

B. Marl, more than 10 and less than 16 feet thick; not overlain by muck.

C. Line or lines parallel to shore; marl in water over 6 feet deep; the bottom of marl being more than 16 feet below the water level.

D. Marl less than 10 to 16 feet deep. Lines at right angles to shore.

E. Sample map of overshore deposit, interpreted as follows: Marl sets in close to shore, increases in thickness toward the body of the lake, until at half way or a little more to the six-foot water line the bottom of the deposit is beyond reach of sixteen-foot auger, a condition that continues into deep water. The black band suggests the width of marl bed from where the deposit first extends more than 16 feet below water level to the six-foot water line. The lines outside of the black band indicate that marl is still found outside of the six-foot water line with bottom more than 16 feet below water level.

F. Section corner showing road, railroad and numbers designating sections.

G. Deposit, "dry," as in A, except that it has muck over it, the number of uprights in the open squares suggesting the number of feet the muck is thick (in this case, 2).

H. "Dry deposit" marl, less than 16 feet thick, overlain by muck—at left by muck averaging one foot thick; in middle, two feet thick; at right by muck three feet or more thick.

I. Sample map showing at the right a deposit similar to E; at left the marl extends out under shore, with muck overlying, a small area having only one foot of muck above more than 15 feet of marl.

J. Marsh, not explored.

K. Muck in cross sections.

L. Sandy ground, or sandy bottom of lake.

STEUBEN COUNTY.

References.—

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. Ind., p. 440.

1875.—Id., Seventh Ann. Rep. Geol. Surv. Ind., p. 491.

1891.—Dr. C. R. Dryer, Seventeenth Ann. Rep. Dept. Geol. & Nat. Reso. of Ind., p. 114.

1899.—Frank Leverett, Water Supply and Irrigation Papers of the U. S. Geol. Surv., No. 21, p. 27.

This county occupies the extreme northeastern corner of the State of Indiana. It is bounded on the north by Michigan, on the east by Michigan and Ohio, on the south by Dekalb County, Indiana, and on the west by Lagrange County. Its area is 311 square miles. The entire county, except a valley in the southeastern corner, is more than 900 feet above sea level, and it is estimated that more than one-half of the county is over 1,000 feet above, while occasional points rise to 1,150 feet. With the exception of Randolph County, its average height above sea level is probably greater than that of any other county in Indiana. This great elevation is not due to an elevated rock surface but to the heavy accumulations of drift which everywhere cover the underlying sedimentary rocks to a depth of 300 to 600 feet. The deposition of the drift has been in most parts of the county very uneven and has given rise to a remarkable group of rounded hills and irregular valleys, which has rendered the surface picturesque to a degree, hardly surpassed by any county of the State.

As yet the county is but fairly well supplied with transportation facilities. The Fort Wayne branch of the Lake Shore & Michigan Southern Railway enters the county near the middle of its southern boundary and runs through it in a northeasterly direction, leaving it at the station of Ray, three miles west of the northeastern corner. The Chicago division of the Wabash System runs east and west along the southern edge, crossing the L. S. & M. S. at Steubenville. This leaves a large area of the western and northwestern portions of the county distant 12 to 17 miles from a railway. Several electric lines have been proposed through this section, and one or more of them will doubtless be soon constructed.

Steuben is pre-eminently the ranking county of Indiana in the number and beauty of its lakes. They occupy the valleys and depressions due to the irregular deposition of the mantle of drift. Their great variety in size, depth and outline of shore render the region most delightful for a summer's outing, and the number of visitors annually attracted by their presence is constantly increasing. The waters of most of the lakes are very clear and pure. They are well stocked with the larger game and food fishes, thus furnishing an abundance of sport to visiting anglers and a plentiful supply of cheap and nutritious food to the permanent resident.

In the latest atlas of the county 57 lakes are named, but many of them are mere ponds or "Mud Lakes." Twenty-two of the larger ones were visited while gathering data for the present report. Six deposits of marl sufficient in area and thickness, and easily available under present conditions for cement making, were found in the county. Three additional deposits were of workable size but were mainly beneath deep water. Six of the deposits were found not to be of sufficient size to justify the investment of capital for their exploitation. In a number of instances the marl in or about two, three or four lakes was considered as one deposit, on account of their proximity, and is so treated in the pages which follow.

Finally it may be said that a number of the larger lakes of the county, although underlain with large deposits of marl, are of far more benefit to the community at large, as they exist to-day, than they would be were these deposits developed and used for cement making.

CLEAR LAKE.

Workable Deposit: Largely Under Deep Water.

Clear Lake lies principally in sections 19 and 20 (38 north, 15 east) Clear Lake Township, in the extreme northeastern corner of Indiana. Its northwestern point is about one and one-half miles from Ray, the nearest station on the Fort Wayne branch of the Lake Shore and Michigan Southern Railway.

The lake is broadly L-shaped with a large bay projecting from the southwest. The extreme length from east to west is over one and one-half miles, and from north to south over one mile, with a breadth in each of the arms of about one-half mile. The total area is 600 or more acres. The lake consists of three distinct basins which would become separate lakes if the water surface were lowered six or eight feet. This results from the presence of a broad bar extending from (D)* to (O) and (P).

* See the accompanying map.

It is evident that the low ridge at (D) which is rapidly being cut down, formerly extended south of west across the lake to the island and beyond; the island (F) being but a fragment spared in the planing down of the ridge by wave action. In November, 1899, a majority of the soundings across this bar gave a depth of three feet and none more than five feet on the crest of the bar. The shallow water around the lake is broad, the line of six-foot water running from 50 to 300 feet from shore, with an average of perhaps 150 feet. Outside of that the depth increases rapidly, so that at one point a depth of

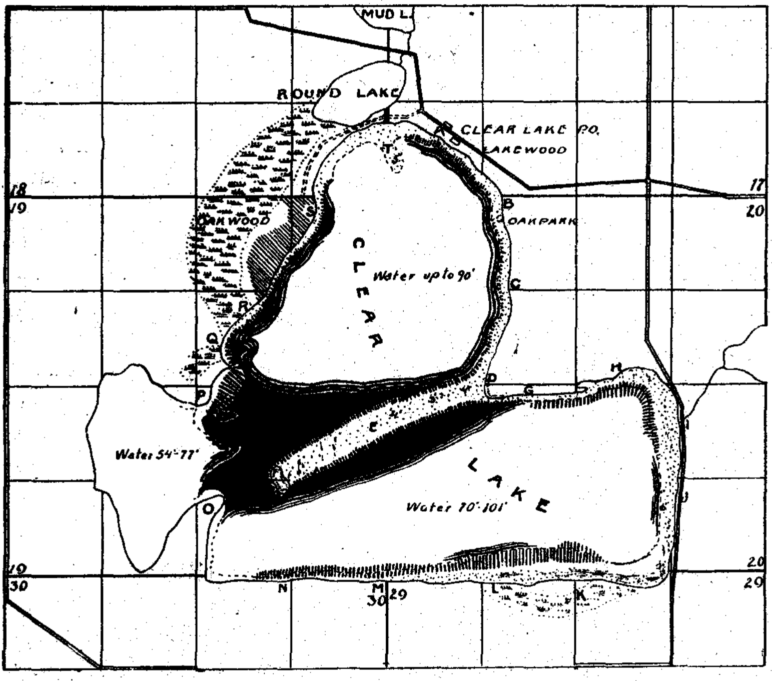


Fig. 1. Map of Clear Lake, Steuben County, Ind.

90 feet was found by Dr. Dryer within 10 rods of the bar. He reports a descent of 30 to 40 feet in five rods at several places, the average slope being not less than one foot in two. The south basin has a maximum depth near a line through the center of from 70 to 101 feet. The bay to the west gave depths of 54 to 77 feet. The north basin has an irregular bottom, and while of less average depth than the southern basin, gave 80 and 90 feet in places.

The fact that, except on the bar mentioned, no marl occurs in water with a depth of less than three or four feet, indicates that the surface of the lake is higher now than at some preceding period. On the other hand, the broad sandy beach at the eastern end indicates that it has also, for at least a short time, stood at a somewhat higher level than now.

Around most of the lake the banks slope up rather quickly to an elevation of a score or more of feet. The northwest shore is bordered by rather extensive marshes containing spring mounds and small elevated islands. There is also a small marsh near the southeastern corner of the lake. As a rule the shores of the lake are quite clean and free from vegetation. The yellow and white water lilies and pickerel weed occur in isolated patches in shallow water. The pond weeds and chara are of more frequent occurrence. The most conspicuous plant in the lake is the great bulrush, *Scirpus lacustris* L., which thinly covers the bars. The outlet of the lake is to the northward through a small stream which, after many meanderings, empties into the St. Joseph of the Maumee. Two large hotels on the north side of the lake, easily accessible from Ray station, furnish, during the summer, accommodations for visitors, and the place is rapidly growing into a resort for sportsmen, and all who seek clean, safe bathing, and ample boating and fishing grounds.

Marl.—As indicated on the map, the shallow water from (A) to (D) contains no marl. At (A) the marl is five feet deep where the water is four feet, and reaches about 10 feet at the six foot water line. Beyond that the bottom of the marl was not found, the water being 13 feet deep, at 200 feet from shore. Going toward (B) the marl on the six foot line runs under 10 feet and at (B) a fine blue clay replaces the marl in six feet of water. From (B) to (D) no marl was struck in three feet of water or less, and at one point four feet of water found no marl. At most points the marl reaches below 16 feet outside the six-foot water line. The bar running from (D) to (F) contained no marl on its crest as far as examined, the water thereon being from three to four feet deep. A little south of the crest the marl was over 12 feet deep in four feet of water and drillings in five feet of water at points along the south side found, everywhere, over 11 feet of marl.

At (G), in the southern basin, one foot of marl is found 100 feet out from shore in four feet of water, the bottom being hard nearer shore. At 150 feet out the water is eight feet deep and marl over eight feet thick. Going toward (H) the marl runs out in four feet of water at the same distance from shore. Six feet of water 200 feet from shore shows but four feet of marl. About the same conditions continue to (I). At (J) no marl is found in six feet of water, 150 feet from shore, but sets in and deepens rapidly beyond that. At (K) somewhat similar conditions prevail, but the marl does not appear to deepen quite so rapidly, only four feet being found beneath seven feet of water. Toward (L) the marl in seven feet of water deepens to more than nine feet at 400 feet out. The six-foot water line, which extends from about 200 feet to over 300 feet out, shows only three feet of marl, with none toward shore. Toward (M) and (N) the shallow water narrows so that at (N) five feet of water is found 50 feet from shore, with five feet of marl beneath. Between, as at (M), there is only three feet of marl in six feet of water.

Crossing the bar west of the high island (F) the water is mainly three feet deep, though running up to five feet in places. The marl is beyond reach of 16-foot drill all over this area until (P) is approached, where, in four feet of water, only seven feet of marl occurs and still less going north. The area between (P) and (D) was not explored in detail, so that the black shading north or northeast of the island is somewhat questionable. From (P) to (S) the six-foot water line is quite irregular, and where farthest from shore the marl was beyond reach of pole in four or five feet of water at all points tested. At (T) a long shoal projects from the north shore, but no marl was found on it, the bottom being blue clay like that at (B).

The area of marl in the lake is probably 400 acres or more. Of this about 80 acres, averaging 10+ feet in thickness, is beneath shallow water. The remainder is found beneath water 10 feet or more in depth.

CEDAR LAKE.

Not a Workable Deposit.

Two miles west of Clear Lake in sections 22 and 23 (38 north, 14 east), Fremont Township, and just east of the Ft. Wayne Branch of the Lake Shore & Michigan Southern Railway, is what was once called Cedar Lake. It has now been partly drained so that with the exception of a few lagoons its former area is a marsh. As far as examined, all across the north end near the railroad, this marsh was in the form of a floating meadow, barely, or not at all, sustaining one's weight and with water-muck below. Tests made in several places from the shore out 300 or more feet, or as far as seemed safe to go, showed no marl until a depth of over five feet of muck was reached, when marl began to appear. The points farthest out showed about five feet of watery muck and two feet of marl.

Since the lake area, as shown on the older maps, was 400 or more acres, it may be that quite a large area of marl exists near the center of the former lake, but even its proper testing is not, under the present conditions, possible.

LAKE GEORGE.

Large Deposit, Mostly Beneath Deep Water.

This lake lies partly in sections 14 and 15 (38 north, 13 east), Jamestown Township, Steuben County, and partly in Branch County, Michigan. It is about one and one-quarter miles in length by three-

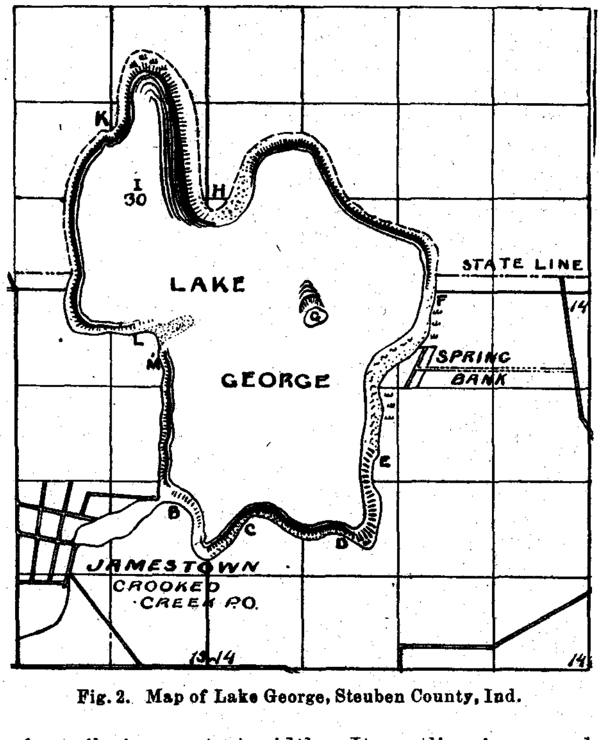


Fig. 2. Map of Lake George, Steuben County, Ind.

quarters of a mile in greatest width. Its outline is somewhat irregular, there being two bays on the north shore, one on the west and two on the south. Those on the north are much the larger and are formed by a long point of projecting land. The northwestern bay is the longer, while that on the northeast is the wider and contains the deeper water. The level of the lake was raised four feet in 1836 by the building of a mill-dam at its outlet, Crooked

Creek, near the southwestern corner. A good water-power mill, erected in 1862, is still in operation at this point.

Northeast of this mill, on the southwest shore of the lake, is a handsome grove now much frequented by picnic parties. East of this grove the banks are lower and the adjacent fields are cultivated. Along the southern third of the eastern shore there is a long, low wooded stretch of territory. North of this the eastern bank is high and sparingly wooded, forming an excellent site for cottages, of which quite a number have been erected at Spring Bank. In front of these the shore and bottom are of gravel, with many good-sized boulders intermingled. A fine spring, flowing 40 gallons or more per minute, runs into the lake from a height of 10 feet above the water level. Immediately north and south of Spring Bank a muck meadow, 10 to 20 rods in width, intervenes between the edge of the water and the margin of the wooded hills. This would indicate that the level of the lake was once at a sufficient height to cover the present meadow area. In the northwest corner of the northeastern bay a lagoon extends back in which there is much muck and aquatic vegetation, as spatterdock, cat-tails, etc. The long lobe of land extending into the lake from the north, has its eastern bank low, with stumps of trees out in three and four feet of water. The western bank is of gravel and rises eight feet above the water level. It is well wooded and offers fine sites for summer cottages. The northwestern bay extends about one-third of a mile north from the southern point of this lobe. Its shores are low with much aquatic vegetation along the margins. The same is true of the western shore of the lake. A long point, covered with rushes, puts out at (L) and forms the bay to the north.

On account of limited time no lines of detailed soundings were made. Dr. Dryer reports that "The main body of water was found to have nearly a uniform depth of from 50 to 60 feet, sinking to 80 feet a little south of the center, the depth being far in excess of what might be expected from the character of the shore."

Marl.—Around the south and west shores the area of shallow water marl is not wide. Opposite (B), 100 feet from shore in six-foot water, the marl was six feet thick. Two soundings, 150 and 250 feet from shore showed respectively 26 and 38 feet of water. Opposite (C), 75 feet out, the marl was beyond length of 18-foot auger in seven feet of water. Between (C) and (D), 150 to 200 feet from shore, the bottom of marl was reached but once in six-foot water, while three-foot water had gravel bottom beneath. The greater part of the southeastern bay is underlain with marl ranging up to 12+ feet in thickness. Opposite (E), 200 feet from shore, only five feet of marl occurs beneath six feet of water, but it deepens to beyond 11 feet in seven-foot water. Between (E) and (F) only a very tenacious blue mud occurs beneath six and seven feet of water. Near (G) one-third of the way across the lake, were several stakes, denoting fishing places, which were sunk into the marl—here 10+ feet thick beneath eight feet of water. Beyond (F) the marl sets in 200 feet from shore in five-foot water, but it is dark-colored or mucky. It gradually thickens and 150 yards out it is 11+ feet thick beneath seven feet of water. Southeast of the point (H) gravel bottom only is found in seven-foot water. Going westward one-third of the way across the northwest bay, a fine quality of marl was found 10+ feet in thickness at several points beneath eight-foot water. One-half way across near (I) the water was 30 feet in depth. One hundred yards north, a growth of rushes denotes another area of shallow water, but it was nowhere less than eight feet deep with 10+ feet of marl beneath. Opposite (K), 100 yards from shore, on the six-foot water-line, 12+ feet of good marl occurs. North of this muck sets in and covers much of the bottom of the shallow water area. Coming south between (K) and (L) 12+ feet of marl is found everywhere on the six-foot water-line. The rush-covered point at (L) is, however, composed of gravel, and no marl was found in eight-foot water, east or south of its extremity. Between (M) and (B) the marl sets in again and was everywhere found beyond reach of pole at the six-foot water-line.

From the above facts we judge that at least two-thirds of the original lake area is underlain with 12 feet or more of marl of a good quality. It seems to be lacking over part, at least, of the eastern third of the former water area. The deposit is not deemed available for cement making with the present facilities for securing marl beneath deep water.

HOG LAKE.

Workable Deposit, Partly Under Deep Water.

Hog Lake lies two miles west of the village of Jamestown and occupies part of section 17 (38 north, 13 east), Jamestown Township. Its northern border is about 50 rods south of the Michigan line. The water area of the lake was lowered about eight feet in 1896, by a ditch cut from it northward into Walters Lake, so that the present area covered by water is probably not over 70 acres. The immediate shores of the lake are, except on the east, everywhere low and marshy. On the south and west, the marshes gradually rise into higher, cultivated land. The eastern shore is, for the most part, composed of a gravelly ridge which a few rods back from the water's edge rises to a height of 15 or more feet. On the north a level marsh, 50 rods wide, separates Hog Lake from Walters Lake, the latter lying in Michigan just north of the State line. On the northwest is an extensive tamarack swamp. An island of five or six acres, thickly covered with tamarack, birch and alder, lies a little south of the center of the lake. Since the latter was drained the channel

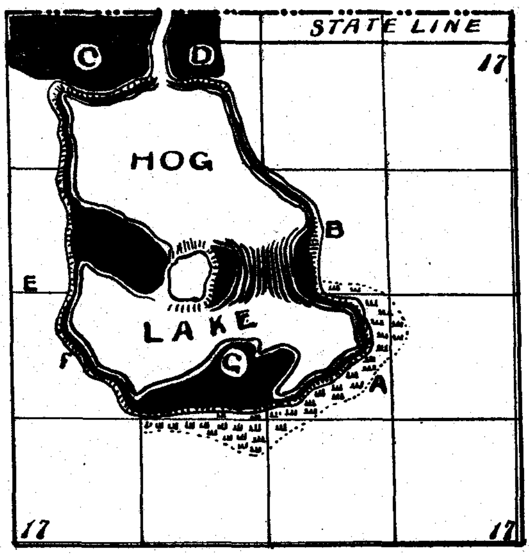


Fig. 3. Map of Hog Lake, Steuben County, Ind.

west of the island has become choked with vegetation, and a continuous marsh now exists between the island and main land. A long marshy point puts out from the south shore to the northeast, thus dividing the water, at present existing in the lake, into three lobes. Among the mollusca noted in Hog Lake were *Anodonta grandis* Say, *Unio luteolus* Lam., *Physa heterostropha* Say, *Campeloma decisum* Say and the *Helisomas trivolvis* and *bicarinata* Say.

The greatest depth of water found was north of the island where three soundings, 10 rods apart, showed respectively, 32, 35 and 33 feet. The southeast lobe of water runs up to 24 feet in depth, while no sounding in the southwest lobe showed over 15 feet.

MARL.—The area of shallow water along the east and north sides of the lake is not wide. A belt of rushes, *Scirpus lacustris* L. five to ten rods in width fringes these shores and wherever tested, in depths of four to six feet, the bottom of marl was not found with an 18-foot auger. The tests were usually made near the outer edge of the rushes where the bench of marl began to dip rapidly beneath deeper water. The water directly east of the island in the middle of the channel was but eight to 10 feet deep, and in it bottom of marl was nowhere reached. At only one point (B), opposite north end of the island on the east shore was bottom reached in three feet of water. Here, with 21-foot auger, the marl was found to be 16 feet thick, with gravel beneath. Along the north side, in two feet of water 75 feet from shore, the bottom of marl was reached at depths varying from 11 to 17 feet. Marl forms the surface of a large portion of the marsh, (C) and (D), between Hog and Walters lakes. At no place was it less than 14 feet thick and the large majority of tests showed more than 21 feet. On the west side of the drainage ditch, half way between the two lakes and five rods east of the border of tamarack, it was 16 feet thick beneath one foot of muck, but at the edge of the tamarack was not found. From the tests we judge that this marsh of 20 or more acres is underlain with marl of an average thickness of 18 or more feet. Walters Lake, 30 rods wide by 70 rods long, is said to be also wholly underlain with marl. Being in Michigan, it was not tested, except along its south shore, where the marl was 21+ feet in depth.

Along the eastern side of Hog Lake, north of the island, the marl was everywhere 18+ feet in depth in three-foot water. East of the lake and north of the half-section line, at (E), is a marsh of about 20 acres, over much of which the marl forms the surface. Seven bores were put down on this marsh which showed the marl at the water's edge to run from 15 to 21+ feet in thickness. Near the north end of the marsh, and 10 rods west of the lake's margin the marl was still 21+ feet, while within five rods of the western margin of the marsh it was eight to 12 feet deep. On the north side of the island, at the edge of the rushes, 75 feet from shore, the marl was 13 feet thick beneath two feet of water. It was 15 feet thick at several places along the south side of the island and at (F) on the west shore of the lake southwest of the island was 18+ feet in three feet of water. At (G) it had increased in thickness to 20+ feet and the larger part of the marsh and the shallow water area between (G) and (A) was underlain with a deposit 20 or more feet deep.

Taking into consideration the marl in and about Walters Lake, we have here a first-class workable deposit. The two lakes can, with little expense, be lowered so that the larger part of the marl now in water over 10 feet in depth, will become available. The only drawback to this deposit is its distance from transportation facilities, the nearest railway being seven miles to the eastward.

An analysis of an *average* sample of the Hog Lake marl showed its composition to be as follows:

Calcium carbonate	90.42
Magnesium carbonate	2.88
Alumina	.14
Ferric oxide	.28
Insoluble inorganic matter (silica, etc.)	.68
Organic matter	4.13
Total	98.53

The marl is thus proven to be of excellent quality. The percentage of organic matter is a little high, but this was probably due to the method of securing the samples. The organic matter is destroyed during the process of burning into cement, and the amount present, when less than six per cent. has, therefore, little or no effect.

LIME LAKE.

Workable Deposit.

Lime Lake lies about one mile northwest of Orland, in section 18 (38 north, 12 east), Mill Grove Township. In shape it is oval, and at present has but about 15 acres of water surface. The greatest depth is 26 feet, but most of the water is under 10 feet, and from a distance looks like milk on account of the reflection from the white marl at the bottom. The lake lies in a narrow valley between hills 30 or more feet in height. On the west is a marsh five to eight rods in width. On the north and south the marsh extends for a long distance up and down the valley. On the east the water reaches the base of a ridge of gravel. No vegetation, not even *Chara*, exists at present in the water. The outlet of the lake is a small stream which flows from Anderson Lake, 30 rods north of the State line, southward through Lime Lake and empties into Crooked Creek. The marsh land, mentioned below, lies on both sides of this stream.

Marl.—On the west, north and south sides of the lake at the water's edge, the marl is, with one exception, everywhere more than

25 feet thick. It also exceeds that depth in the marsh to the south of the lake as far as the road, beyond which it was not tested. At the extreme southeastern corner of the lake within 20 feet of the gravelly ridge, it was but six feet thick, with gravel beneath. Along the east side in three feet of water, 70 feet from shore, it was 18+ feet in thickness.

In the marsh to the north, which is over three-quarters of a mile in length and 20 to 30 rods in width, the marl comes to the surface in a number of places, and, five rods out from the foot of the bordering hills, was almost universally found to be more than 21 feet in thickness. In a few places it is overlain with muck one to two feet thick. The upper three or four feet of the marl beneath the muck

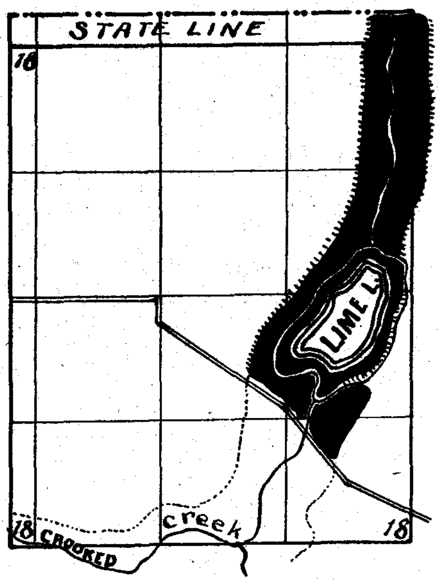


Fig. 4. Map of Lime Lake, Steuben County, Ind.

was here, as elsewhere, darker than that in the lake, on account of the sediment from the decaying grass and other muck-forming vegetation, soaking through it. Anderson Lake, north of the Michigan-Indiana line, is said to be somewhat larger than Lime Lake, and wholly underlain with marl which in places has been tested and found to be more than 35 feet thick. It was not visited by us.

The marl of Lime Lake is, in appearance, very white and pure. It was, in the early settlement of the country, burned for lime. Dr.

Dryer, who visited the lake in 1890, made a chemical analysis of a sample of the marl which showed its constituents to be as follows:*

Calcium carbonate	86.00
Magnesium carbonate	9.42
Iron carbonate	1.16
Silica	1.08
Organic matter	2.32
Total	99.98

The amount of magnesium carbonate found was in excess of that of any marl of which analysis has been made in the State, and it is very probable that a mistake was made in its computation. The other impurities are very few, and aside from the magnesium carbonate the anaylsis indicates a deposit of high grade.

Taking into consideration the acreage of marsh marl, above and below Lime Lake, and also the great average thickness of the bed, there is here a good workable deposit, which will doubtless become utilized whenever transportation facilities are secured.

SHALLOW, DEEP, LITTLE AND BEAVER-DAM LAKES.

Workable Deposit.

These four lakes are connected by a narrow stream and so form a chain which occupies a valley in the western half of sections 6 and 7 (37 north, 12 east), Jackson Township. They are about 12 miles east of the Grand Rapids & Indiana Railway, 11 miles west of the Fort Wayne Branch of the L. S. & M. S. Railway, and the same distance north of the Chicago Division of the Wabash Railway.

Beaver-Dam Lake, in the northwestern quarter of section 6, is one-half mile long by about 30 rods wide, and occupies a narrow valley between two parallel ridges. Its greatest depth is said to be 26 feet. Little Lake is nothing more than a large pond in the southwest quarter of the same section. Its water area is about six acres and its margins are thickly covered with rushes and other water-loving vegetation. These two lakes were not visited, but it was said by the residents of the vicinity, that their bottoms and margins were composed wholly of marl of great depth.

Deep Lake, in the northwest quarter of section 7, has a water area of about fifteen acres and a maximum depth of 28 feet. Its southern shore is less than 30 rods north of the northwestern corner of Shallow Lake. Its shores are low and surrounded by marsh.

*17th Ann. Rep. Ind. Geol. Surv., 1891, p. 124.

Shallow Lake lies near the center of section 7. It has been recently drained by a ditch running to the southwest, so that in September, 1900, its water area, of about 60 acres, was nowhere over two feet in depth, though one in wading was apt to sink deeper on account of the softness of the marl bottom. Its shores are low and surrounded by a wide marsh except on the east, where, 10 rods from the edge of the water, a gravel ridge rises 20 feet above the lake. From the side of this ridge, opposite the middle of the lake, two fine springs emerge about 10 rods apart. The larger of the two has a flow of at least 150 gallons per minute, and the other one-half as much. The only aquatic vegetation in the lake, other than scattered bunches of rushes, was about a half-acre of cat-tails, near the southern end of the eastern shore.

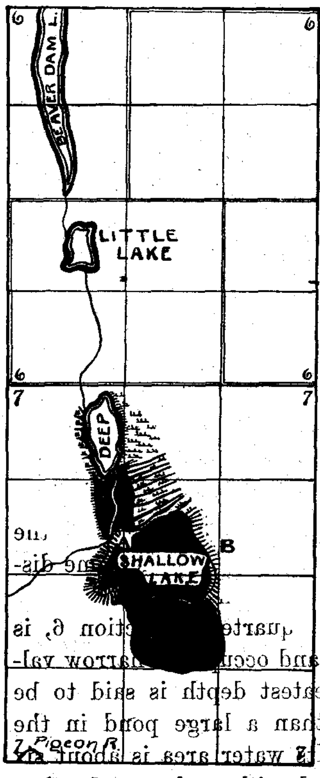


FIG. 5. Map of Shallow, Deep, Little, and Beaver Dam Lakes, Steuben County, Ind.

MARL.—On the north, west and south shores of Deep Lake, the marl at the edge of the water is everywhere more than 21 feet thick. The bottom shelves off rapidly into 10-foot water. The marsh on the west is but about 12 rods wide, and over most of it the muck is two feet deep and underlain with marl, which diminishes gradually in thickness from the edge of the lake to the margin of the hill. On the marsh, between Deep and Shallow lakes, the marl forms most of the surface and is 21+ feet in depth. At the northwest corner of Shallow Lake one bore was put down with a 25-foot auger which did not reach bottom of marl. At (A), thirty rods southwest and 50 feet from the former edge of the lake, it was 15 feet thick with gravel beneath. Along the entire west shore the marl was found to be 21+ feet, six to eight rods out from the former shore, but gradually diminishing to 13 feet at the old margin of the lake. On the south shore bottom was nowhere reached at 21 feet, and a number of tests showed that the greater part of the 30 acre marsh south of the lake is underlain with marl of an equal thickness. On the east side of

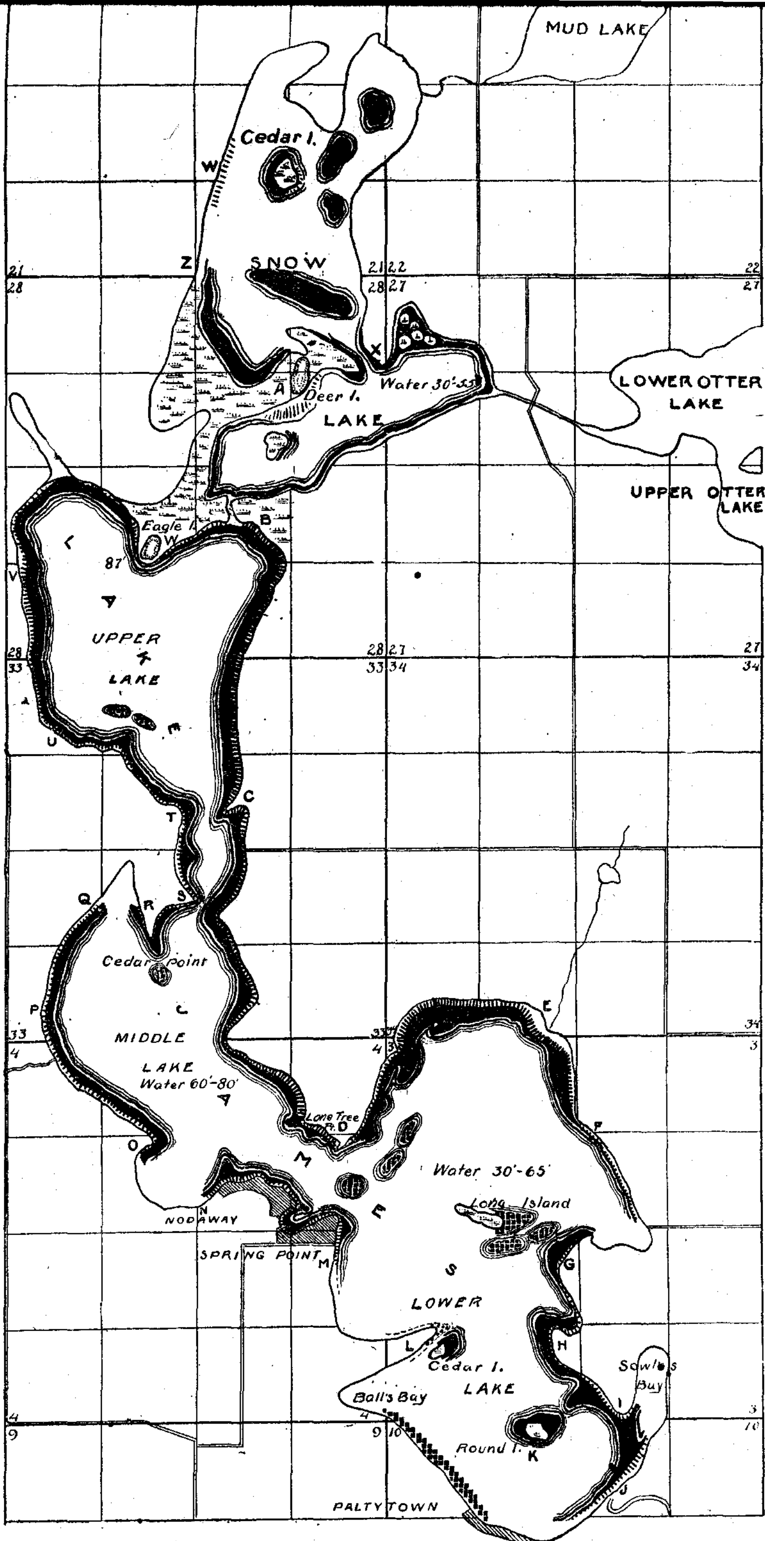


Fig. 6. Map of James Lake, Steuben County, Ind.

the lake, on account of the proximity of the gravel ridge, the marl is not so thick, being but nine feet at the margin of the former lake, and 15 feet six rods out from shore. Between the springs, at (B), and the lake, the marsh, 10 to 15 rods wide, is covered with a fine wire-grass and underlain with marl 15 feet or more in depth, while at the edge of the water it is 21+ feet. The marsh northeast of Shallow Lake and east of Deep Lake is 60 rods long by 40 wide, and covered with wire-grass. The surface is of muck two to six feet thick. The southern half is underlain with marl from four to 15 feet in thickness, but beneath the muck of the northern half only sand was found. Along the east margin of Deep Lake the marl was 21+ feet thick.

An analysis of an average sample of the marl from this deposit resulted as follows:

Calcium carbonate	93.29
Magnesium carbonate	2.67
Alumina	.04
Ferric oxide	.12
Insoluble inorganic matter (silica, etc.)	.47
Organic matter	1.56
Total	98.15

This shows the marl of Shallow Lake to contain the highest percentage of calcium carbonate of any deposit in the State, of which analysis was made. The acreage and thickness is sufficient to justify the investment of capital for the purpose of cement making, and there is little doubt but that the deposit will be so utilized in the future.

JAMES LAKE.

Two Workable Deposits; One Largely Under Deep Water.

Lake James lies in sections 21, 22, 27, 28, 33 and 34 (38 north, 13 east), and sections 3, 4 and 10 (37 north, 13 east), in Johnson and Pleasant townships. Its southern shore is three miles northwest of Angola, but the Fort Wayne Branch of the L. S. & M. S. Railway to the east can probably be reached in two miles. It is the third largest lake within the State, being exceeded only by Lake Wawasee, Kosciusko County and Lake Maxinkuckee, Marshall County. The total length of James Lake is nearly five miles and its average width about one-half mile. It covers an area of about 1,670 acres. In shape it is very irregular, lying mainly in a north and south line, but divided into five basins, separated from each other by narrow and often shallow channels.

The most southern basin, known as the "Lower Lake," is about one and one-quarter miles in length from north to south and three-quarters of a mile in extreme width, with a very irregular shore line, running back to form several prominent points and embayments, as Sowles, Ball's and other bays. The maximum depth of the Lower Lake is 65 feet. Half way between the southeast shore and Round Island the depth was 40 feet; 200 feet west of the island, it was but 18 feet, while 100 yards east of the cottages at Spring Point it was 32 feet. Three small islands, Long, Round and Cedar, project above the water and several shoals nearly reach the surface. These facts indicate that the bottom of the lake is very uneven. In like manner, the area of shallow water along the shore is quite irregular in places, as at (F) being very narrow, while from (D) to (E) and (G) to (J) it projects out in long and often broad points several hundred feet from shore, making the average width of shallow water over the stretches named, probably, 200 feet. The shores on the south side of this basin rise rather abruptly 30 or more feet and are heavily wooded with oak and hickory. Those on the east and northeast are much loftier, reaching a height, in places, of 100 or more feet. On the west, between Spring Point and Ball's Bay, the shores are much lower and the adjacent fields are, in part, cultivated.

The next basin north of Lower Lake is known as "Middle Lake." It is really the foot of the entire lake, as the outlet, Crooked Creek, flows from it into Jimerson Lake. This basin is separated from the preceding by a rather narrow strait between Lone Tree Point and Spring Point, in the center of which was formerly an island, now a shoal. Northwest of this shoal, near the point indicated by the letter (M) on the map, the water was 32 feet in depth; 100 yards farther northwest it was 56 feet; while a third sounding, the same distance north from the second, showed 63 feet. A fourth, 200 yards north from the third, and about the middle of this basin east and west, gave 72 feet, the greatest depth found in Middle Lake, though Dr. Dryer reports 80 feet as the maximum. The band of shallow water around this basin is narrow and as a rule quite regular. A small shoal exists just south of Cedar Point. Middle Lake is about a mile long by a third of a mile wide. The shores are more regular, though two bays or points put out from it. The hills on the east rise abruptly from the water, are heavily wooded, and 40 to 60 feet in height. To persons willing to climb, their crests contain many ideal sites for summer cottages. The shore at the northwest corner is low and marshy.

The remainder of the shore line slopes upward and backward into low wooded hills.

The third basin or "Upper Lake," is reached through a narrow channel with only two or three feet of water over the bar or spit of sand which puts out from the west shore. This basin is a mile long by three-quarters of a mile in greatest width. A depth of 87 feet of water, the "deepest sounding in the lake," is reported by Dr. Dryer to have been found a few rods west of Eagle Island, which forms part of the north shore of this basin. The greatest depth found by us was 78 feet.* The belt of shallow water in Upper Lake, particularly along the east side, is broader, ranging from 100 to 300 feet in width. The east shore, like that of the two basins to the south, is densely wooded, but the hills rise only about 30 feet. The west shore is of rounded hills of clay and gravel, bare of timber, and, near the northwest corner, sloping gradually upward to a height of 100 or more feet.

From the north of Upper Lake, an unbroken expanse of water formerly extended a mile and a half to the northeast. Now the encroachments of vegetation have nearly cut this off to form a separate lake, known as "*Snow Lake.*" This is also nearly divided into two separate basins. A channel, only about thirty feet wide and difficult to find, runs through the marsh to the east of Eagle Island, and admits the passage of a row-boat from Upper Lake to the south basin of Snow Lake, the longer axis of which extends northeast and southwest and is continuous on the east with the valley of Otter and Marsh lakes. This basin is three-quarters of a mile long by one-sixth of a mile wide and is separated from the much larger northern basin by a long marshy point from the northeast, and by Deer Island and a bar to the east of that island covered with a growth of rushes. Several soundings from west to east through the middle of the basin gave the following depths in feet: 78, 54, 40 and 36, the first and deepest being south of Deer Island. This island rises 40 feet above the water, contains an area of about three acres and is heavily wooded with oak and other timber, forming one of the prettiest spots about a lake which is far above the average in picturesque beauty. Deer Island, as well as Eagle Island, are now both connected with the main land by extensive marshy meadows. Along the south side of this basin the shallow water area is from 10 to 20 rods in width. At the inlet from Otter Lakes the valley is broad, it being evident that at one time the lower part of Snow

*This was near the point occupied by the letter "u" of "upper" on the accompanying map.

Lake extended east so as to include upper and lower Otter Lakes and Marsh Lake, the latter about two miles to the eastward.

The waterway at present connecting the North and South basins of Snow Lake is a channel about 10 rods wide between the marshy point at (X) and the extremity of the bar east of Deer Island. The North basin is very nearly a mile in length from north to south and not quite one-half mile in average width. A peninsula-like point of land juts into the water from the north shore, forming two bays, the eastern one of which is much the wider and receives Crooked Creek, the outlet of George and Mud lakes. A small island, less than an acre in area, and covered with wire-grass and cat-tails, rises three feet above the water about 40 rods south of the extremity of this peninsula. Betweeen the island and the west shore the water is 32 feet in depth. Twenty rods southwest of the island a shoal 10 rods wide, and thinly covered with rushes extends in a southeasterly direction almost across the lake basin. The water over this shoal is but 10 to 18 inches deep. West of the shoal two soundings gave respectively 48 and 36 feet of water. In the southwest bay, northeast of Deer Island, two additional soundings showed 33 feet and 52 feet; while on a north and south line across the lake, 20 rods east of Cedar Island, not over 32 feet of water was found. The east shore of this basin is wooded, but the hills slope back gradually and rise but 20 to 30 feet above the water. The shores of the northeast bay are, for the most part, low and marshy. The northwestern bay has a narrow muck meadow between the water and the adjoining hills. At several points northwest and west of Cedar Island, the muck banks rise abruptly three feet and more above the water. The greater part of the west shore is bordered with marsh, varying in width from 10 to 30 rods, and covered with wire-grass and other vegetation. Back of the marsh are steep, densely wooded hills, rising 150 feet or more above the level of the lake.

Except in a few localities, mollusca were not plentiful in James and Snow lakes. The only univalves taken were *Helisoma trivolvis* and *H. bicarinata* Say, which were common in shallow water near shore. One of the bivalves, *Margaritana marginata* Say, found in Snow Lake, is noteworthy in that this is the only lake in which it was seen. The specimens were plentiful just south of Cedar Island and were of large size. Other bivalves were *Unio luteolus* Lam., *Anodonta footiana* Lea, *A. grandis* Say, *A. salmonia* Lea, and *A. edentula* Say, all of which were seen in small numbers; *U. luteolus* being the most common and of very large size.

The waters of the lower and middle basins of Lake James are quite free from vegetation. In the channel connecting the Middle and Upper basins as well as along the east shore of the latter, the eel grass, *Vallisneria spiralis* L., grows in abundance, as do also several species of pond-weed (*Potamogeton*), and the two rushes, *Scirpus americanus* Pers. and *S. lacustris* L., the latter growing in water up to seven feet in depth. The newer portions of the marsh north and east of Eagle Island are covered with cat-tail, *Typha latifolia* L., while several species of marsh grasses and sedges thickly cover the older portions. The channel west of (B) runs between dense masses of spatterdock, *Nymphaea advena* Sol., broad-leaved arrowhead, *Sagittaria latifolia* Willd., and cat-tails. In the northeastern corner of the southern basin of Snow Lake the white water lily, *Castalia odorata*, and the spatterdock are both abundant. In the shallow water areas of the north basin, both along shore and over the shoal-like islands of marl which rise nearly to the surface, the eel grass and various species of *Potamogeton* grow in profusion. In fact Snow Lake contains as much aquatic vegetation within its bounds as do all the other basins of James Lake combined. In the words of Dr. Dryer: "The group of lakes, including James and its companions, furnish about ten miles of boating, every rod of which is rendered delightful by repeated surprises and a changing variety of picturesque scenes which rival on a smaller scale Lake George, the gem of the Adirondacks, and the famous Thousand Islands of the St. Lawrence. The region around it might be fitly characterized as the Alps of Indiana, and although alpine only in miniature, is worthy to attract more attention than it has yet received. It needs only to be better known to become a favorite resort for many who now travel hundreds of miles in search of the beautiful and the picturesque."*

MARL.—Around the Lower, Middle and Upper lakes at nearly every point examined marl was found, and in general deepened rapidly from shore, so that in no case was marl in four feet of water found to be less than 12 feet thick, and generally the bottom of the marl was not reached at 16 feet in two feet of water, and on the broad shallow bars not in one foot or six inches of water. Along much of the shore of the lake, particularly in the shallower water, the marl is markedly concretionary on top and often for three or four feet down. In places these concretions are like coarse grit, elsewhere they are like small gravel. Again they increase to a flattened diameter of several inches, and resemble geodes externally. The formation of these concretions and the incrusting of shells in this

*17th Ann. Rep. Ind. Geol. Surv., 1891, p. 123.

and other lakes has already been mentioned under the general heading of the "Deposition of Marl." This concretionary structure might easily be mistaken for gravel, for often the drill for the first three or four feet was forced through it with much difficulty. In places the encrusted shells are just scattered here and there on the bottom, but at other places, notably along the east shore of the bay north of Eagle Island, make quite a thick layer. Here also the pebbles of lime were thrown by wave action in windrows along the shore.

The width of the shallow water around the lake has already been described or is indicated on the map. At the mouth of a little branch from the northeast at (E) the marl is rather shallow, only four feet being found in three feet of water. The bar running from (I) to (J) across the mouth of Sowles Bay was thought to be hard bottom when tested, but the discovery a little later that a similar hard bottom was an unusual thickness of concretionary marl led to the theory that we had been in error and that the bar, like the rest of the shallow water, was deep marl. It is so mapped, though it was not retested. The shore from Paltrytown to Ball's Bay was not tested, but is reported to show a good breadth and thickness of marl. The marl off the point at (L) is shallow, three feet being found in six inches of water. At the east side of Cedar Island it was 14+ feet in two feet of water.

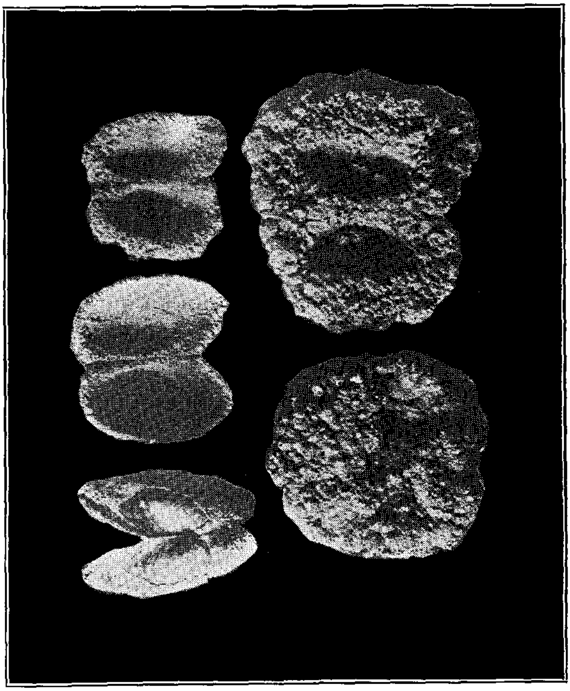
The tests for marl in September, 1900, were mostly on Snow Lake, and were made with an auger 18 or 21 feet in length. However, a few were made along the east shore of Upper Lake. These showed that between (C) and (B) the marl was everywhere 18+ feet in two and three feet of water. Southwest of (B) there is an area of 20 or more acres of this shallow-water marl. In the bay north of Eagle Island is one of the finest deposits in Upper Lake. In a number of places in one foot of water 10 feet from shore the marl was 18+ feet and of excellent quality. There is little doubt but that the greater part of the marsh area, 60 or more acres, to the east and northeast is similarly underlain.

An analysis of an *average* sample of the marl from the three lower basins of James Lake gave the following results:

Calcium carbonate	92.41
Magnesium carbonate	2.38
Calcium sulphate	.15
Ferric oxide	.29
Insoluble inorganic matter (silica, etc.)	1.16
Organic matter	1.97
Total	98.36

PLATE 8.

a



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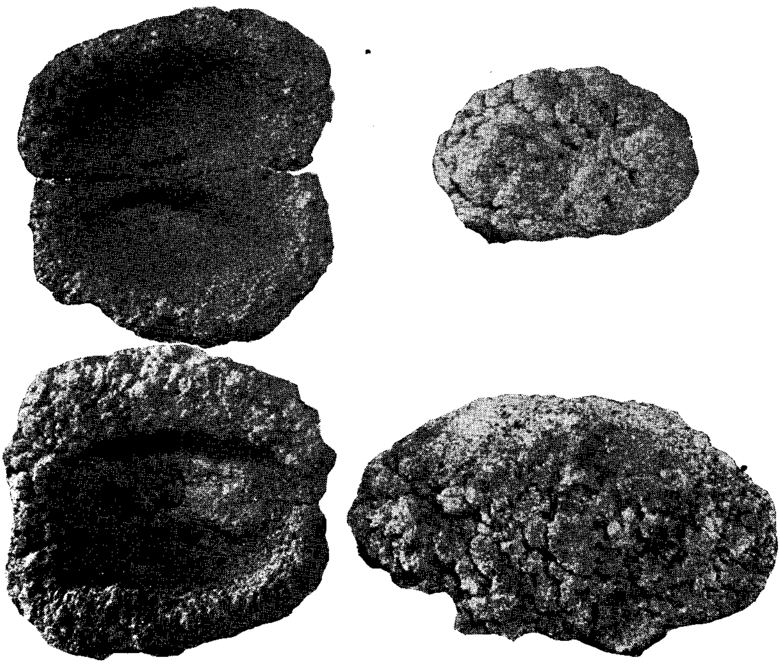


b

Illustrating Concretionary Forms of Marl, Found in James Lake.

(a) Showing gradual incrustation of shells of *Unios*.
(b) Showing nodular concretions caused by low type of freshwater alga growing in masses or

This analysis shows the marl to be of superior quality; the percentage of carbonate of lime being above the average. Dr. Levette states that "A heavy deposit of lime or 'marl' on the west margin of James Lake was, in the early settlement of that region, worked for lime for making mortar; the marl pits are still visible."* This fact is, in itself, a good evidence of its excellent quality, for only the purest deposits of marl were used by the early settlers for lime making.

It is estimated that there are at least 200 acres of marl 10 feet or more thick beneath less than six feet of water in the three lower basins of James Lake. It is, however, much strung out along the shore. The deep water of these basins is also very probably almost wholly underlain with a thick deposit. Due to the mill below and the large number of cottages along the lake, it is doubtful if its waters will ever be lowered. Indeed it is hoped that no endeavor will be made to lower them, for the lake is far more valuable to the citizens at large in its present condition than it would be were its water area diminished in an attempt to secure the marl beneath its depths.

The area of shallow water marl in Snow Lake is proportionally much larger than in the lower basins of James Lake. This is due to the fact that there are many shoals, or subaqueous islands, which rise to within a foot or 18 inches of the surface, and which are composed wholly of an excellent quality of marl 18+ feet in thickness. These shoals are scattered over the northern and eastern portions of the north basin.

Between Cedar Island and the northwest shore, the marl is everywhere present in shallow water, being 18+ feet in thickness in two feet of water. Where the muck banks rise perpendicularly from the water the marl is nine feet thick and underlain with gravel at the edge of the bank. That portion of Cedar Island below the level of the surrounding water is composed of marl 19+ feet in thickness on the western side, and eight to ten feet on the eastern. The long shoal, 10 rods or more in width, which reaches nearly across the lake basin, southwest of Cedar Island, is underlain with marl 18+ feet thick and very white in color. Between (Z) and the north end of Deer Island the shallow water area is from 5 to 25 rods in width; the bottom of marl in no place being reached with 18-foot pole. South of Deer Island, 100 feet from shore, the marl was 13 feet thick in two feet of water, with gravel beneath.

*Seventh Ann. Rep. Ind. Geol. Surv., 1875, p. 491.

At the western end of the south basin at the edge of the marsh, the marl was 18+ feet, 20 feet from shore in three feet of water. Along the southern shore of this basin the shallow water area, 10 to 20 feet in width, is all underlain with marl to beyond reach of 18-foot pole, except close to shore where the marl runs from five to 12 feet in thickness. In the northeast corner of the same basin, there is a large shallow water area, in which muck from one to two and a half feet thick overlies 14+ feet of marl. A similar area five to 10 rods in width is found along the south side of the long marshy point separating the two basins. At (X) there is 16+ feet of marl beneath two feet of water. The same thickness is found on the west side of the channel. On the east side of the north basin, the shallow water marl ranges in thickness from five to 16+ feet, except along the east shore of the bay which receives Crooked Creek, where it is largely replaced by muck.

Taking into consideration its great average thickness, the deposit of shallow water marl in Snow Lake alone is of workable size, and would fully justify the erection of a large Portland cement factory. The quality of the marl is also of the very best, fully equalling that of James Lake, an analysis of which is given above.

CROOKED LAKE.

Workable Deposit, Mostly Under Deep Water.

Crooked Lake lies in sections 6, 7, 8, 9, 16 and 17 (37 north, 13 east), Pleasant Township. It is about three miles northwest of Angola and somewhat less from the Fort Wayne Branch of the Lake Shore & Michigan Southern Railway. The lake was originally bottle or gourd shaped, but is now practically divided in two at the east side of section 7. The main part, or the part east of this, is divided into two lobes by a long point from the north. The part west of the road, in section 7, is really a long narrow neck nearly choked with vegetation. The total area of the lake is about 950 acres, of which the eastern lobe has about 400, the middle 225, the western 325 acres.

The eastern basin is nowhere deeper than 30 feet and contains much shallow water. From (C) on the east side a broad hammer-shaped bar extends out half way across the lake. The water here is nowhere more than two feet in depth, even on the part farthest out. Just west of it is a small island or shoal. From the west shore at (R) extends out a broad bar bending to the north. Over much of this the water is only six inches to one foot in depth. The point of land from the north is continued out some distance to the south in a long shoal. The shallow water belt from (A) to (B) is usually less than 100 feet in width.

In the middle basin there is a large area of shallow water just west of the end of the point from the north. At the western end the embayment (K M I H) is now nearly filled up, being practically shut off from the lake by a marl bar. The northwestern lobe is very shallow, in places being readily crossed by wading.

Though abrupt in places, the banks are neither as high nor as steep as those around much of the neighboring Lake James. In

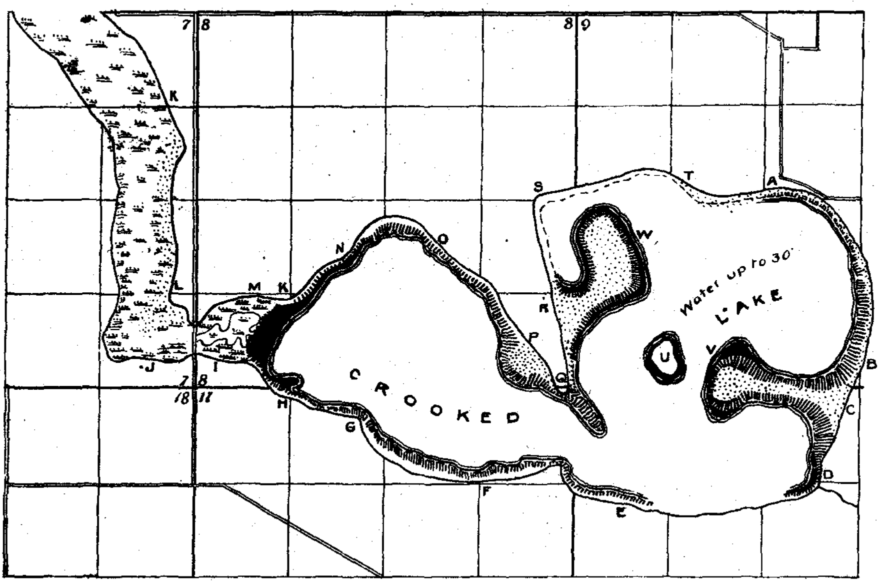


Fig. 7. Map of Crooked Lake, Steuben County, Ind.

places they rise from 50 to 70 feet above the water level of the lake. At several places along the east shore is a broad sandy beach very popular with bathers.

MARL.—From (A) to (B) the shore is sandy to a depth of one or two feet of water. At 25 feet from shore the water is three or four feet deep and the marl from one to five feet thick. Toward (A) there is usually some sand over the marl, often six inches or more, giving the impression that there is no marl present. The six-foot water line runs from 50 to 100 feet from shore and beyond it the drill at no point reached the bottom of the marl, indicating quite a rapid thickening of the deposit. The long point running out from (C) has no marl on its crest, but on the flanks of the point the marl rapidly thickens up. In the bay enclosed by the point on the south the water is shallow. Running west from a little south of (C) no marl is found in two feet of water. In three feet of water 75 feet from shore the marl is three feet thick. It is six feet thick from where the water is four feet deep to where it is over seven feet deep, but in nine feet of water several hundred feet from shore the bottom could not be reached with a 16-foot pole. At (D) the marl was over 13 feet deep in three feet of water quite close to shore. Due to the breaking of the drill the tests from (D) to (H) were made with only a nine-foot drill. Sand and gravel occur near the shore at (G) and there is only three feet of marl in four feet of water, but at all other points the bottom of the marl was not reached in three or four feet of water. From (H) to (K) is a marl beach with a channel cut through to the crest. The marl at every point tested was over 16 feet deep. West of this toward the road it appeared to be all marl but was too soft to wade, so was not tested. The southern end of the western basin at (J) is a floating meadow underlain with marl beyond reach of 16-foot pole. Only a short distance north there is hard bottom nearly if not quite clear across and tests between (L) and (K), made by wading, gave only hard bottom. From (M) to (N) the marl is variable. In places there are over 13 feet in three feet of water; in others, only one foot. At one point four feet of water has only seven feet of marl beneath. From (N) to (P) the marl is thinner, the bottom near shore being hard and at several places along the six foot water line the marl was only three feet deep with one foot of marl in four feet of water. In other places five feet of water showed from five to seven feet of marl. Marl is wanting over most of the broad shoal between (P) and (Q), but occurs around the edges, running from six to 10 feet deep in three to four feet of water. The subaqueous point running out from (Q) showed eight feet of marl with three feet of water. The center of the shoal (U) was not examined, but marl is probably not found there, as only nine feet of marl was found in four feet of water on the west side. The center of the bar from (R) to (W) shows no marl, but the marl deepens rapidly around it, so that the bottom is below 16 feet in three and four feet of water. From (A) to (T) the bottom is sand and boulders with no marl in 16 feet or less of water. At (T) marl sets in again, there being about six inches in four feet of water increasing to nine feet at the six-foot water line.

Dr. G. M. Levette, who visited Crooked Lake in 1875, made the following statement concerning the marl: "In this lake the deposition of lime (locally called 'marl'), from the water, by the action of light and vegetal growth, may be studied to advantage. The water is of crystal clearness, and objects on the bottom, under 10 or 15 feet of water, may be distinctly seen. Mussels (*Unionidæ*) are very abundant, and the posterior part of the shells, through which the breathing tubes project up into the water, are almost universally built up with a soft, pasty deposit of lime, varying in thickness from a half inch to an inch and a half, giving them the appearance of being much longer than they really are. This coating of lime excludes the light so completely that the epidermis beneath is a pale salmon hue, and without the rays and color markings peculiar to the species in running streams. The broken surfaces of stones, bits of wood, which, from partial decay, have sunk to the bottom, and the dead stalks of grass and weeds, are all coated with a film of lime. This incrustation appears to accumulate more rapidly in shallow water, where the sun's rays heat it more quickly and to a higher temperature than in deeper portions of the lake.

"A bottle of water was taken from this lake and sent to the laboratory at Indianapolis for analysis. It is clear and has a pleasant taste and is neutral to litmus paper. An imperial gallon (10 pounds) contains 10.5 grains of solid mineral matter, composed of

Bi-carbonate of lime	7.00 grains.
Iron, alumina and silica	2.10 grains.
Magnesia and undetermined	1.40 grains.
Total	10.50

"It contains no more mineral matter than is commonly present in river water and is not only a potable water in a most eminent degree, and may be drawn from the bottom with a temperature of 50 degrees, which is refreshingly cool without the addition of ice, but is likewise well suited for laundry purposes and for those branches of manufactures which require large quantities of water, such as the manufacture of fine writing paper, printing paper, etc."*

* 7th Ann. Rep. Geol. Surv. of Ind., 1875, pp. 490 and 40.

GAGE AND LIME LAKES.

Workable Deposit.

GAGE LAKE.

Lake Gage lies a short distance northeast of Crooked Lake, with which it is connected by Concord Creek. It occupies a part of section 35 (38 north, 12 east) and section 2 (37 north, 12 east), its eastern shore being about eight miles west of the Fort Wayne Branch of the L. S. & M. S. Railway.

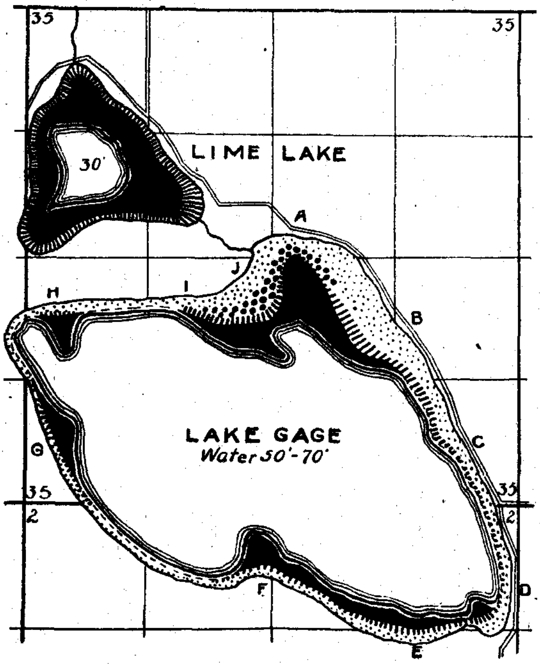


Fig. 8. Map of Gage and Lime Lakes, Steuben County, Ind.

This lake is heart-shaped and quite regular in outline. It has an area of about 350 acres and a diameter of one mile by three-quarters of a mile. The lake occupies a single deep and regular basin with a depth through the center of 50 to 70 feet. The area of shallow water is usually broad, being especially so at the north near the outlet. The general shape and position of the line of six foot water is shown on the map.

The lake ranks among the prettiest in the county, being clear and clean without adjoining marsh or much aquatic vegetation. On the east, hills of gravel rise 25 to 40 feet above the water. The other shores are less in height, are composed mainly of sand or gravel, and are less regular in outline. There is evidence that the lake is now higher than at some past time.

MARL.—The largest deposit of marl found was at (A). Going south from the shore the marl sets in about 50 feet out in about two feet of water. At 150 feet out the water is three feet deep and marl 10 feet in thickness. At twice that distance the water is four feet deep and marl beyond reach of 16 foot drill. The six foot water line is here nearly 1,000 feet out. Just west of this and 200 feet from shore the marl is only three feet deep in five feet of water. Going from (A) to (B) the belt lacking marl broadens from less than 50 feet to over 200, there being no marl at (B) in four feet or less of water. The line of six-foot water there becomes a belt 400 feet or more wide with the marl four feet deep on the inside and 10 feet or over on the outside. From (B) to (D) the belt of shallow water is narrow, usually not over 100 feet, but getting gradually deeper. There is no marl close to shore, and at only one point was it found in four feet of water. In seven feet of water the marl is usually over nine feet thick. From (E) to (F) the belt of shallow water is irregular but broad, extending out 400 or 500 feet from shore. Except in three feet or less of water, the marl was everywhere below reach of 16-foot drill. From (F) to (I) the shallow water is very narrow, except at (G) and (H). In places at 15 feet from shore in one or two feet of water no marl was found, while at 30 feet out in four feet of water the marl was over 12 feet thick. The marl is deep on the two points mentioned.

In appearance the marl of this lake was of a light dove color and unusually smooth and even. There is little doubt but that it underlies three-fourths of the water area of the lake.

LIME LAKE.

Lime Lake lies just northwest of Lake Gage in section 35. It is a small lake of about 50 acres and is said to be about 30 feet deep in the center. There is a broad bench of shallow water all around the lake, and its shores are low.

MARL.—Except close to shore all the tests made failed to reach the bottom of marl with the 16-foot drill. The deposit of shallow water marl in the two lakes is amply sufficient to justify the erection of a good-sized cement factory; the deficiency in acreage being counterbalanced by the greater average depth. The distance of transportation facilities is, at present, the greatest drawback, and deposits more favorably situated will doubtless be sooner developed.

FOX LAKE.

NOT A WORKABLE DEPOSIT.

Fox Lake lies a mile or less southwest of Angola in sections 27, 33 and 34 (37 north, 13 east), Pleasant Township. It is only about half a mile from the Fort Wayne Branch of the L. S. & M. S. Railway. The lake is three-quarters of a mile long by half a mile broad, with an area of about 150 acres. A long, low point from the north, near the west end, shuts off a small bay.

The deep water of the lake has a very uniform depth of more than 40 feet, with a maximum of 60 feet. The water is clear and cold, with clean shores and no marsh except at one point near the west end. A long point of shallow water extends out from (B) on the northeast shore of the lake. Along the part of the shore in sec-

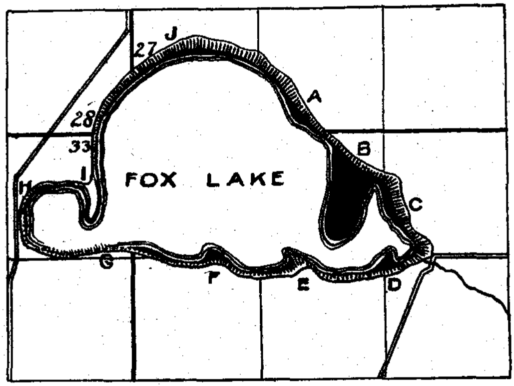


Fig. 9. Map of Fox Lake, Steuben County, Ind.

tions 28 and 33 the shallow water belt is narrow. Around the rest of the lake it is broader and more variable, there being several projecting submerged points on the south side. The shores are high and abrupt all around this lake except near the outlet, which flows southeasterly into Pigeon Creek.

MARL.—At (A) the marl is eight feet thick in four feet of water, and more than 10 feet thick in seven feet or over of water. Over the broad shallow bar running out from (B) the water is from one to four feet deep and the marl from nine feet to over 16 feet in thickness. At the eastern end of the lake the marl does not set in until the water reaches a depth of between one and two feet. In two feet of water the marl showed a depth of eight feet and in two and one-half feet of water, 75 feet from shore, was more than 14 feet. From (D) to (F) are several points on which the marl was over 16 feet thick except at (E) where the marl was found to be shallow on the crest of the point. From (G) to (I) the six-foot water line runs from 25 to 50 feet from shore, with marl to below drill at most points, but shallower at (G). There the marl was one foot thick at the shore and eight feet thick in seven feet of water. Around the long point, beneath two feet of water, the marl ran over 14 feet thick. At the north side of the lake the shallow water is broader, three feet of water at 200 feet from shore showing 11 feet of marl.

While the lake is largely underlain with marl, the acreage is not deemed sufficient to justify the outlay of capital for a cement factory, especially as much of the marl is at present beneath deep water.

PLEASANT AND LONG LAKES.

Not a Workable Deposit.

PLEASANT LAKE.

This lake is situated near the town of the same name, on the Fort Wayne Branch of the L. S. & M. S. Railway. It is in sections 14, 15, 22 and 23 (36 north, 13 east), Steuben Township. The lake is half a mile long by a quarter of a mile wide, with an area of about 75 acres. The basin is symmetrical, with a depth of 30 feet close to shore and 40 to 50 feet through the middle. The belt of shallow water, as a rule, is very narrow. The banks rise sharply all around, except at the outlet, to a height of 10 to 20 feet.

Marl.—In the northwest corner of the lake the drill found only muck, that in two feet of water being three feet deep, but running out before a depth of 13 feet of water is reached. Going south along the west shore the marl sets in and increases in depth. At (B) the marl is four feet deep in one foot of water and six feet deep in two feet of water. At (C) it is 10 feet deep in three feet of water, and in deeper water quickly extends to below 16 feet. Continuing toward (D) the marl becomes thin until at that point it is not over three feet thick in any depth of water up to 16 feet. At (E) only muck was found. The largest body of marl occurs in the embayment at (F), where drillings in from two to four feet of water failed to reach the bottom of the marl, four-foot water extending about 150 feet from shore. Toward (G) the marl is still over 10 feet thick on the six-foot water line, 50 feet from shore. At (H) four feet of water shows from two to 10 feet of marl. At (I) the marl is nine feet deep on the six-foot water line, 30 feet from shore, and just on the edge of deep water. Toward (K) the marl becomes shallow, being four feet deep in three feet of water at (J), 25 feet from shore; but at (K) only reaches a thickness of one foot in nine feet of water. At (L) four feet of mucky marl was found in seven feet of water.

The shallow water marl deposit in the lake is, from the tests, seen to be meager in size, while that supposed to be in deep water is not promising.

LONG LAKE.

Long Lake lies just northwest of Pleasant Lake village, close to the L. S. & M. S. Railway. It is in sections 15 and 16 (36 north, 13 east). The lake is a little over one mile long by one-quarter of a mile wide, much resembling in shape a willow leaf, and has an area of about 150 acres. In depth Long Lake varies from 25 to 40 feet. Except at the east end the belt of shallow water is rather narrow. The land around the lake is inclined to be marshy, and an extensive marsh stretches east and south from the eastern end of the water area. The water of the lake is of the rich amber color characteristic of Pigeon Creek, which flows through the lake, entering at a point west of the middle on the north side and flowing out at the western extremity.

MARL.—At the east end of the lake the bottom is of muck to beyond reach of pole at all depths of water from one to six feet. From (B) to (D) marl sets in, and while not far from (B) it reaches a thickness of 12 feet in two feet of water, it grows shallower to the west, finally running out between (D) and (E), where the bottom is of sand at all depths up to 16 feet. On the south side of the lake, marl shows from (F) to (H). It is of fair depth, the marl in three to four feet of water running from eight to 12 feet in thickness, while near (H) it was over 12 feet in four feet of water. The shallow water varies in width from 75 or less to 150 feet. A little east of (H) sandy bottom sets in and is found at all depths between (H) and (J), where the marsh begins.

The tests show that the area of shallow water marl in Long Lake is less than in Pretty Lake, and we are therefore led to believe that no workable deposit of marl occurs in the two lakes, even if that below deep water was largely available.

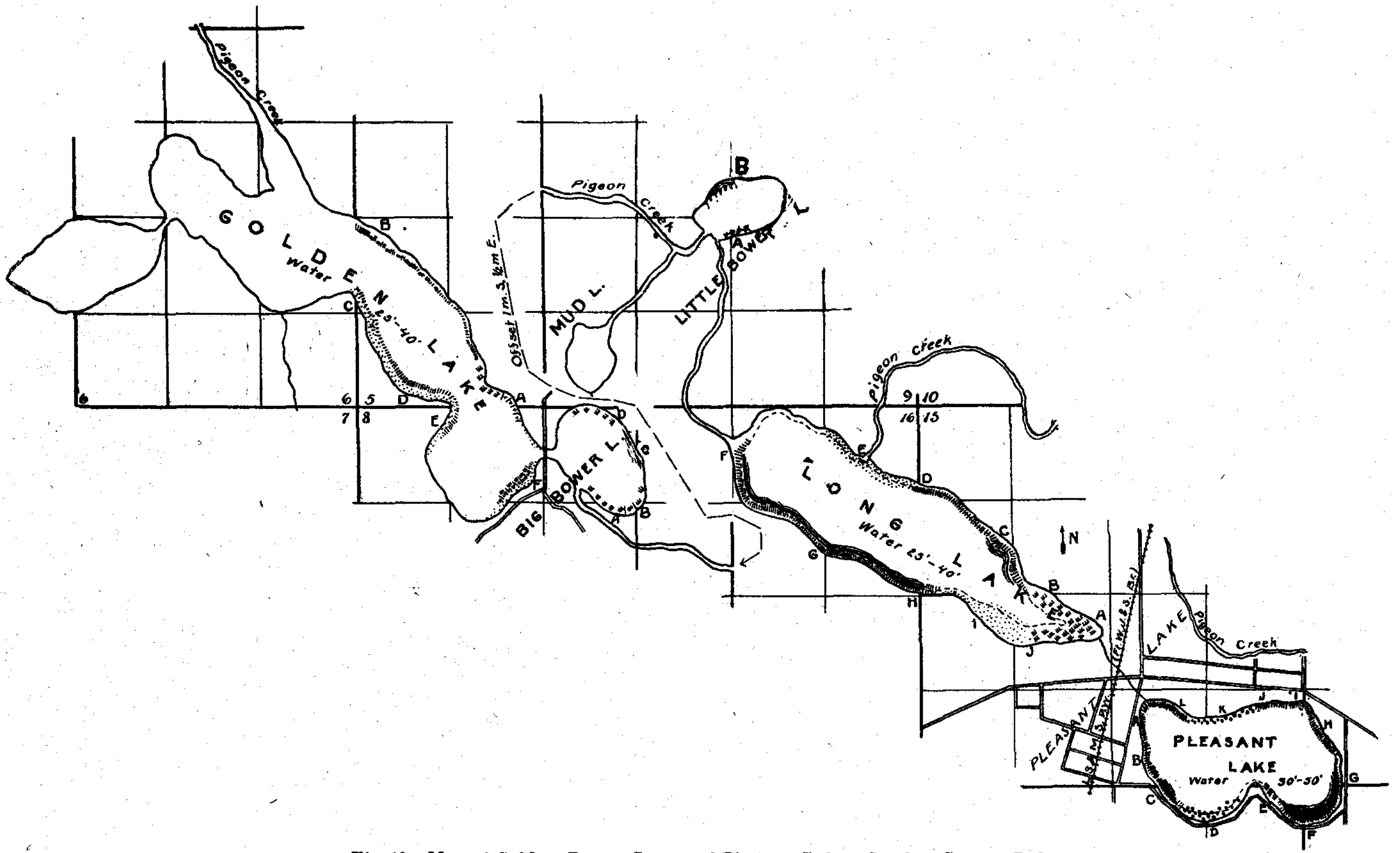


Fig. 10. Map of Golden, Bower, Long and Pleasant Lakes, Steuben County, Ind.

BOWER AND GOLDEN LAKES.

Not a Workable Deposit.

BIG AND LITTLE BOWER LAKES.

These are two small lakes or kettle holes filled with water, through which Pigeon Creek runs on its way from Long Lake to Golden Lake. The deep water of each sets in close to shore. Only muck was found on the south side of Little Bower. On the north side a little marl was found under six feet of muck. In Big Bower 13 feet of mucky marl was found in two feet of water at (C) and a little marl under 15 feet of muck at (B); otherwise only muck was found.

GOLDEN LAKE.

Golden Lake lies just northwest of Big Bower Lake, in sections 5, 6 and 8 (36 north, 13 east). It has a length of about one and one-half miles and a width of one-quarter of a mile. In shape it is a counterpart of Long Lake with a more irregular shore line. Its depth varies from 25 to 40 feet.

Marl.—On the north side a little marl was found, usually under several feet of muck. On the south side the bottom seems to be hard out to where the water is three or four feet deep. Then the marl sets in, but it is mucky and shallow. At (C) the marl is only three feet deep in seven feet of water. At (D) it is 11 feet deep in four feet of water. At (E) it has become shallow again and is approximately as at (C). At (F) the marl is five feet deep in four feet of water and seven feet deep in seven feet of water, but with muck on top. In water over 10 feet the bottom of marl could not be reached on the north side, but it was generally quite mucky. While there is doubtless a large area of deep water marl in the lake, it can never be used for cement making on account of its quality.

SILVER LAKE.

Workable Deposit.

Silver Lake lies four miles west of Angola, in sections 29, 30, 31 and 32 (37 north, 13 east), Pleasant Township. While only two and one-half miles in a straight line from the Fort Wayne Branch of the L. S. & M. S. Railway, it did not appear possible for a switch to be built via Fox Lake, but it must, instead, go from Pleasant Lake down Pigeon Creek by the side of Golden and Hog Back Lakes. Silver Lake is oval in shape, one mile long by three-quarters of a mile wide and with an area of about 300 acres. The marl deposit in this lake and adjacent to it extends up under a large marshy area to the north (probably 100 acres or more), including Mud Lake and a small lake in section 19.

The lake is rather shallow, the greatest depth being only 25 to 30 feet, while probably half of its area has a depth of six feet or less. Most of the shallow water is in the northeast part. Three island-like shoals, noted on the map, come nearly to the surface of the water.

The outlet starts from a little basin at (F) which is almost shut off from the main lake, and flows into Hog Back Lake, an enlargement

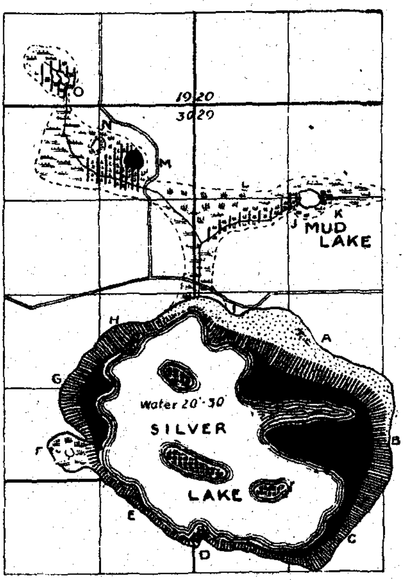


Fig. 11. Map of Silver Lake, Steuben County, Ind.

of Pigeon Creek. The shape of the marsh to the north is shown on the map. There is a small but high knoll in the arm of the marsh near (N).

The hills on the east side of the lake, though rising gently, attain a considerable height. The marsh land is shut in by rather steep hills. The shores west of the lake are not so high.

MARL.—Though small, this lake contains one of the best deposits of marl in Steuben County. It takes its name from the silvery reflection from the marl just below the water surface. The water has been lowered several feet, rendering the marl more noticeable.

In the northeast part of the lake, there is no marl near shore, but by the time two feet of water is reached the marl is four feet deep, and over 12 feet before four feet of water is reached. There are two extensive areas extending out from (A) and (B) with ten feet of water between them, also underlain with marl to below 16 feet.

Around the south side of the lake, the shallow water belt is narrow and the bottom of the marl was reached at most points at depths of from nine to 11 feet in two feet of water. On the west side the shallow water belt is broader, and except toward the northwest, has much marl over 14 feet deep in two feet of water.

Over most of the marsh to the north, as far as tested, the muck is too deep to permit the working of the marl. At (M), however, the marl comes to the surface over a small area and is over 16 feet deep. It was formerly worked here for lime, being cut out in blocks with a spade.

Just south of the knoll at (N) the muck is three feet or more thick, with seven feet of marl beneath. From (M) to (N) the depth of the muck increases until at (N) it is seven feet in thickness. Near the small pond at (O) the muck is seven feet deep, with marl below to over 16 feet. In the eastern arm of the marsh the least depth of muck was found just west of Mud Lake, where it was three feet with 10 feet of marl below. East of Mud Lake the muck is four feet or more thick, with marl below to over 16 feet.

An analysis of marl from this lake made by Dr. C. R. Dryer, showed its constituents to be as follows:*

Calcium carbonate	84.00
Magnesium carbonate	6.46
Ferrous carbonate	1.34
Silica and silicates	4.52
Organic matter	3.68
	100.00

Judging from the analysis, the sample taken by Dr. Dryer must have been secured from near the surface. From the general appearance of the marl we should judge that an average sample, taken from a dozen or more localities, some distance below the surface, would show a higher percentage of carbonate of lime and less magnesia and organic matter.

From the location cited, we judge that the sample of marl, whose analysis is given in the Report of the Indiana Geological Survey for 1878, p. 87, was taken from the western side of Silver Lake. Prof.

*17th Ann. Rep. Ind. Geol. Surv., 1891, p. 126.

Cox's statement regarding it is as follows: "The composition of a sample (marl) taken from the farm of G. W. Slocum, on section 30, T. 37, R. 13, in Steuben County, Indiana, is:

Moisture expelled at 212 degrees	8.00
Insoluble silicates	0.30
Alumina with traces of iron	1.50
Lime	45.36
Magnesia	3.42
Carbonic acid	41.50
Sulphuric acid	0.10
Phosphoric acid	0.38
	100.56

FISH LAKE.*

Not a Workable Deposit.

Fish Lake lies immediately north of the town of Hamilton, in sections 21, 22, 27, 28 and 33 (36 north, 14 east), Otsego Township. It is but one-half mile north of the Chicago Division of the Wabash Railway. The lake is nearly two miles long from north to south and just one and one-half miles wide from east to west. It is very irregular in shape, comprising a main body to the north with arms extending to the east and west, known as the Devil's Neck and Muskrat Bay, and to the south narrowing down to what is known as the Mill-pond, with a considerable body to the southwest almost shut off by South Island. The area, according to Col. J. M. Wilson, is 740 acres. The lake was formerly in three different bodies of water. In 1837 the outlet was filled in and the surface of the lake was thus raised nine feet, which united the three lakes into one body of water. The water power of this lake is utilized for milling purposes, and is at present controlled by the Fort Wayne Water Power Company. It has several islands, the largest, South Island, containing 13 acres, the others less than one acre each. The large island is covered with a growth of small oak.

The large basin forming the north part of the lake has a maximum depth of 68 feet, and a temperature in July of 70 to 75 degrees. In the narrow part of the lake in its middle the water is from two to 62 feet deep with an average of 40 feet. There is a small island a little northeast from the mouth of Muskrat Bay which is probably the southern end of a long bar. Northeast of this island, near the middle of the main lake, the depth was only 30 feet and the tem-

*This lake was visited in July, 1893, by Mr. Blatchley, while working for the U. S. Fish Commission, and again by Dr. Ashley in November, 1899. The most of the data relative to depth and temperature, and the list of fishes, were secured on the first visit.

perature of the water 57 degrees. The low temperature of the water at this point would indicate the presence of strong bottom springs.

A bay (Devil's Neck) extends from the northeast side of the main lake in a southeast direction. It has a length of three-quarters of a mile, and along its middle line a depth of 40 feet and a temperature of 67 degrees. Toward the shores the water gets shallower, with a corresponding increase in temperature. In 12-foot water the temperature was 70 degrees. The narrow channel leading to the Mill-

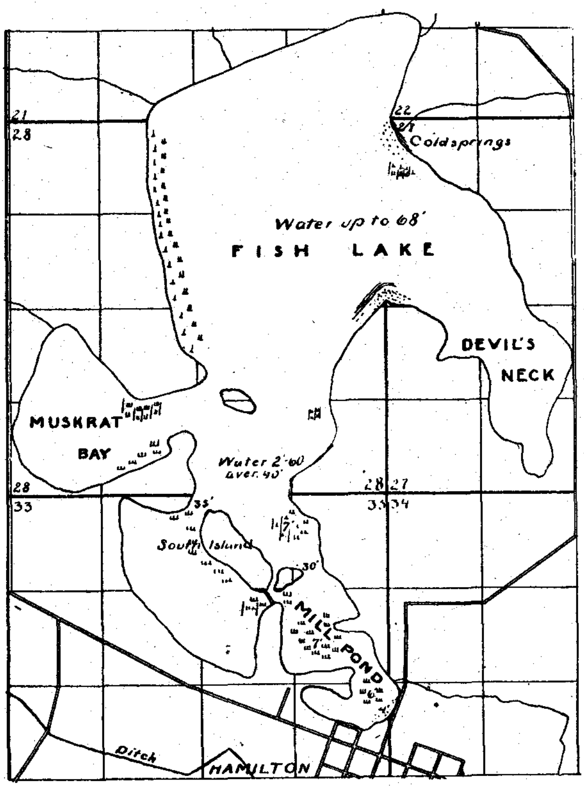


Fig. 12. Map of Fish Lake, Steuben County, Indiana.

pond is, in places, 30 feet deep, though only seven feet of water was found well out in the channel a little north of this. Tests in the Mill-pond showed a depth of water from four to nine feet, and the temperature of the water at this depth was 73 to 74 degrees. The temperature of the water immediately below the surface in all parts of Fish Lake was 78 degrees.

The shores of the main lake on its northwest and east sides are gravelly, with clean bottom, and the banks at either place are rather abrupt, with a height of from 10 to 20 feet, and are covered with woods. The remainder of the shores of the lake are more or less swampy, with several large patches of peat or muck, except along the large island, where the bottom is rather clean and solid. On the east side of the main lake are several strong springs. The water of these springs is charged with iron sulphate, and has a temperature of 49 degrees F.

Fish Lake receives its waters from several ditch-like tributaries, but chiefly from the springs along its shores and bottom. It empties its waters from the lower end of the Mill-pond into Fish Creek, of which it is the source, the latter stream flowing into the St. Joseph of the Maumee. The land around the lake is very uneven, being full of kettle holes and other depressions between conical and dome-shaped drift hills.

The water in Fish Lake is clear and well stocked with native game and food fish. The ringed perch (*Perca flavescens*), the blue gill (*Lepomis pallidus*), the common sunfish (*Lepomis gibbosus*), and the large-mouthed black bass (*Micropterus salmoides*) are among the most common food fishes. The following is a complete list of the fishes taken in the lake on July 19 and 20, 1893, by the party connected with the U. S. Fish Commission:

List of Fishes in Fish Lake.

1. *Lepisosteus osseus* (L.). Long-nosed Gar-pike.
2. *Ameiurus nebulosus* (Le S.). Bullhead.
3. *Catostomus nigricans* Le S. Hog Sucker.
4. *Moxostoma macrolepidotum duquesnei* (Le S.). Common Redhorse.
5. *Pimephales notatus* (Raf.). Blunt nosed Minnow.
6. *Notropis heterodon* (Cope). Northern Notropis.
7. *Notropis whipplei* (Girard). Silver-fin.
8. *Semotilus atromaculatus* (Mitchill). Creek Chub.
9. *Zygonectes notatus* (Raf.). Top Minnow.
10. *Lucius vermiculatus* (Le S.). Grass Pike.
11. *Labidesthes sicculus* Cope. Skipjack.
12. *Pomoxis sparoides* (Lacépède). Calico Bass.
13. *Chænobryttus gulosus* (Cuv. and Val.). Warmouth.
14. *Lepomis pallidus* (Mitchill). Bluegill.
15. *Lepomis gibbosus* (L.). Common Sunfish.
16. *Micropterus salmoides* (Lacépède). Large-mouthed Black Bass.
17. *Etheostoma nigrum* Raf. Johnny Darter.
18. *Etheostoma eos* (Jor. and Cope.). Sunrise Darter.
19. *Etheostoma microperca* Jor. and Gil. Least Darter.
20. *Perca flavescens* (Mitchill). Yellow Perch.

The Mill-pond and western side of Fish Lake are in places largely filled up with vegetable growth, the pond being covered with the white water lily *Castalia odorata* (Dryand). Dr. Dryer, who made careful observations in the summer season, reports that in the bays of the west shore the outer zone of vegetation begins at a depth of 10 feet with a band of Chara, Potamogeton and eel grass, *Vallisneria spiralis;* the latter peculiar to this lake. At a depth of five feet the white pond lilies, *Nymphæa,* flourish, the spatterdock or yellow lily, *Nuphar,* being scarce. At a depth of three feet rushes, smart-weed and cat-tails form a floating margin too thick to push a boat through. Above water level, on the solid mass of peat, a great variety of plants flourish, among which, besides grasses, small sedges and ferns, are the water hoarhound, *Lycopus europæus,* the clear-weed, *Pilea pumila,* the shrubby cinquefoil, *Potentilla fruticosa,* the willow herbs, *Epilobium coloratum* and *palustre,* the arrow-leaf, *Sagittaria variabilis,* the meadow cone-flower, *Rudbeckia hirta,* and the jewel-weed, *Impatiens fulva,* the latter covered with tangled orange skeins of the dodder, *Cuscata gronovii.* Besides these are also found the bedstraw, *Galium asprellum,* the marsh bellflower, *Campanula aparinoides,* the blazing star, *Liatris spicata,* the cardinal flower, *Lobelia cardinalis,* the swamp milkweed, *Asclepias incarnata* and the skull cap, *Scutellaria galericulata,* all conspicuous in August. In many places the strictly aquatic plants are absent, and the peat bed rises with a clean cut edge two feet above the water.

"The large area of Fish Lake, furnishing a broad expanse of water visible at one sweep of the eye, its irregular outline and prominent islands, its bold shores and encircling hills, and the beauty and profusion of its aquatic vegetation, form a combination of characters which render this lake one of the most interesting and attractive in the State. The village of Hamilton, at its south end, is clean and quiet, and furnishes such accommodations to the summer visitor as can not fail to make his stay enjoyable."*

MARL.—On account of the recent elevation of the water surface of this lake no marl need be looked for in less than seven or eight feet of water. Most of the drillings made in seven feet or less of water showed muck to below 16 feet. A little marl was found beneath six to eight feet of muck at the following localities: Near the south end of South Island; east of South Island; on the north side of the entrance to Muskrat Bay; just off from Cold Springs, and on the east shore opposite the mouth of Muskrat Bay. Marl without overlying muck was found around the point south of the mouth of

*17th Ann. Rep. Ind. Geol. Surv., 1891, p. 129.

Devil's Neck. The marl does not set in until seven feet of water is reached and then quickly deepens to beyond 16 feet. It was of a dark gray color. In the center of the channel east of South Island at least six feet of light brown marl was passed through beneath three feet of muck. On account of the conditions found to exist, no attempt was made to make a thorough test for the marl in the lake, as it is practically all beneath water too deep to allow the deposit to be worked.

LAGRANGE COUNTY.

REFERENCES.—

1859.—Richard Owen, Rep. of a Geol. Reconn. of Indiana, p. 198.

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. of Indiana, p. 444.

1893.—Dr. C. R. Dryer, Eighteenth Ann. Rep. Dept. Geol. & Nat. Resources of Indiana, p. 72.

1899.—Frank Leverett, Water Supply and Irrig. Papers, of the U. S. Geol. Survey, No. 21, p. 25.

On the northern border of the State and in the second tier of counties from its eastern boundary is Lagrange, which contains one of the most fertile sections of northern Indiana. It has an area of 393 square miles and lies between Elkhart and Steuben counties and north of Noble County.

The county is well supplied with railways. The Grand Rapids & Indiana crosses it from north to south near the center, passing through Lima, Lagrange and Wolcottville. The Chicago Division of the Wabash runs along its southern border, crossing the G. R. & I. at Wolcottville. The Goshen Branch of the Lake Shore & Michigan Southern crosses the northwestern corner, passing through Shipshewana and meeting the G. R. & I. at Sturgis, Michigan, six miles north of Lima. The elevation in feet above tide of the stations on the G. R. & I. Railway is as follows: Lagrange, 925; Lima, 886; Valentine, 967; Wolcottville, 949.

The elevation of the county is between 897 and 1,027 feet above tide, and the whole area is covered with drift from 100 to 200 feet or more in thickness, the bottom of which has rarely if ever been reached. "The general surface slopes gently to the north, except the lake region of Johnson Township, which is drained southward into the Elkhart River, the crest of the divide being near Valentine. It lies entirely upon the Saginaw side of the Saginaw-Erie interlobate moraine of Chamberlain, and contains no Erie drift, except, possibly, at the southeast corner. It is crossed by two terminal moraines of the Saginaw glacier, so that about one-half of the county presents a topography of a distinctly morainic character, but its outlines and distribution are so irregular as almost to defy description in words."*

The lakes of Lagrange County are not so numerous as those in Steuben County on the east or Noble on the south. About 40 occur which have been deemed worthy of name on the maps of the county heretofore issued. The total area of water in the county is about 4,000 acres, 1,500 of which are in Johnson Township. Twenty-two of the lakes were visited during the progress of the present survey and are briefly described on the pages which follow. Nine deposits of marl of workable size, i. e., containing an area of 160 or more acres and averaging 10 feet or more in thickness, were found in the county. These are either in single lakes or in groups of lakes the members of which are in adjoining sections. Of the nine, four are easily available for cement making under present conditions. The other five are, for the most part, found beneath water 10 feet or more in depth, and are therefore not available until appliances are invented for readily securing the marl from beneath such depth of water.

SHIPSHEWANA LAKE.

WORKABLE DEPOSIT; SECOND CLASS.

The eastern edge of this lake is about three-quarters of a mile west of the town of the same name. The lake lies in sections 4 and 9 (37 north, 8 east), Newbury Township. The Goshen and Michigan Branch of the Lake Shore & Michigan Southern Railway passes within one-quarter of a mile of its southeastern corner. The lake is about three-quarters of a mile in length from southeast to northwest by one-half mile in greatest width, and has a water area of 200 or more acres. The western half of the north shore and the west shore are bordered by extensive muck meadows. The east half of the north shore and the east side have wooded hills sloping gently back to a height of 30 to 50 feet. On the east these extend to the water's edge and furnish fine sites, as yet unutilized, for cottages. On the northeast the hills are separated from the lake by a strip of muck covered marsh five to 20 rods in width. On the south shore a marsh 20 rods in width and covered with wire-grass and other vegetation lies between the water's edge and the higher wooded slopes to the southward.

*Dryer, loc. cit., p. 73.

The lake is everywhere shallow, the greatest depth found being 14 feet, and the average depth not over eight feet, with probably half of its area less than six feet. Its waters contain much vegetation. On the east and north sides the principal growth is the giant rush, *Scirpus lacustris* L., which forms large beds, extending out into five and seven-foot water. On the west side the stems and leaves of spatterdock, *Nymphæa advena* Sol., and of the white water lily, *Castalia odorata* (Dryand), cover large areas of the water surface and by their decay are gradually replacing the water with muck. Several species of pondweed (*Potamogeton*) grow in all parts of the lake, their flowering parts reaching above the surface of eight to 10 feet of water, while their roots are buried in the muck and marl at the bottom. The water-shield, *Brasenia purpurea* (Michx.), with its curious flowers and floating peltate leaf is also a very common plant in most parts of the lake, while the ditch moss, *Philotria canadensis* (Michx.), covers a large portion of the lake's bottom. So much aquatic vegetation doubtless aids much in separating the marl-forming material from the water, but at the same time, the decay of the plants adds an undue percentage of organic matter to the slowly depositing marl and renders it dark in color.

MARL.—All along the east side the marl sets in about 50 feet from shore, the intervening strip of bottom being sand. In four foot water the marl was 10 feet thick, underlain with gravel. In all water over four feet, bottom of marl could not be reached with an 18-foot auger. Along the north side the marl was found closer to shore but was usually covered with a foot or less of muck out to 75 or 100 feet, where the muck disappeared. The tests nowhere found bottom of marl, except at a point 20 rods southwest of the northeast corner of the lake where, in three feet of water, the marl was nine feet thick, with gravel beneath. Twenty rods south of this point and the same distance from the east shore it was 15+ feet in three feet of water. A number of bores diagonally across the lake to the southwest corner gave 14+ feet of marl in four feet of water to within 10 rods of shore. Here, one-third the distance east from the west end of the lake, the drill touched gravel in four feet of water, showing the marl to be just 14 feet thick, the upper third dark, the lower portion of good quality. On the west side a bed of thick muck extends out 50 yards from shore, where it is gradually replaced by marl 14+ feet in five feet of water.

The marsh on the south shore showed muck four to six feet with gravel beneath. In the meadow on the north and west shores the muck was 18+ feet deep, with no indications of marl. Along the south shore to the eastward the marl was everywhere six to 10 feet thick in three feet of water, 10 rods from shore. In greater depth of water and farther from shore, bottom of marl was nowhere found.

From the tests made it is safe to say that 160 acres of the lake are underlain with marl which will average 10 feet or more in thickness. The upper third of the marl is in many places darker in color than the remainder. This is doubtless due to the larger percentage of organic matter derived from the decay of recent aquatic vegetation.

TWIN LAKES.

Large Deposit, Mostly Under Deep Water.

Twin Lakes are located two miles west of Lima, in sections 23, 26 and 27 (38 north, 9 east), Lima Township. They are about one-third of a mile east of Twin Lake Station on the Goshen & Michigan Branch of the Michigan Southern Railway, and two miles west of the Grand Rapids & Indiana Railway.

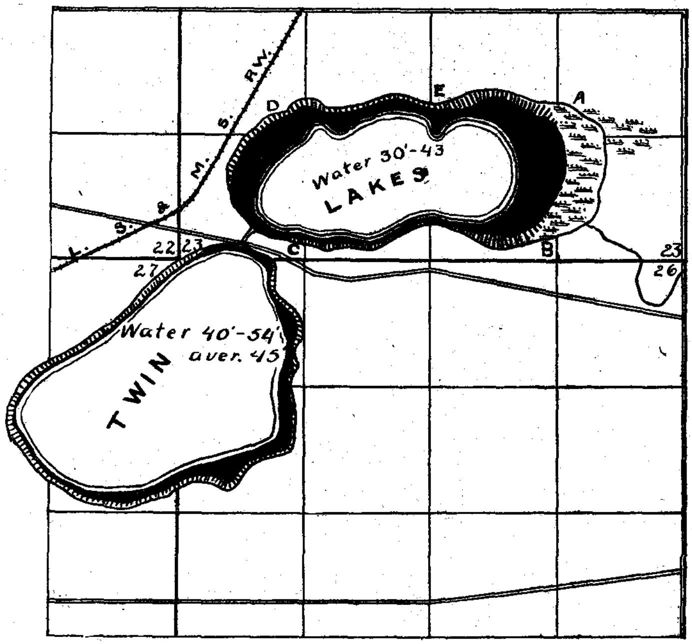


Fig. 13. Map of Twin Lakes, Lagrange County, Ind.

The upper lake is shaped somewhat like the bottom of a shoe and is about three-quarters of a mile long by one-fourth of a mile wide, with an area of nearly 160 acres. The lower lake is somewhat smaller and is roughly pear-shaped, with the narrow end to the west.

North Twin Lake has a depth of from 30 to 43 feet, with rather broad areas of shallow water in the east end and northwest corner, and much vegetation in the southwest corner. This, by its decay, is forming muck, thus gradually decreasing the water area of the lake from that direction. The banks of gravel and clay rise rather abruptly from 10 to 25 feet. The two lakes are not over 20 rods apart, with a wagon road running between them. The presence of marl and fragments of shells beneath the sand in the lowest part of the dividing ridge indicate that in a time not very remote the two lakes were one continuous sheet of water.

The bottom of South Twin Lake shelves off very abruptly along most of the north and west shores, 15 to 20 foot water being found in most places 75 feet from shore. Hills of drift rise abruptly 30 to 50 feet from the water's edge on the east and north shores, while at the west end is a muck meadow. On the south shore a strip of marsh separates the hills and water. The shallow area of the latter extends out 50 to 250 feet on the east and south, many rushes growing therein.

A row of soundings, taken 20 oar-strokes apart, from north to south along the eastern edge of the western third, showed the depth to be respectively 22, 32, 34, 36, 48, 40, 32 and 20 feet. A little east of the center, soundings from south to north gave 24, 36, 42, 48, 54, 46, 40 and 32 feet, 54 feet being the maximum depth found. The water of this lake is in hue a clear greenish blue and wholly free from visible vegetable organisms. In this respect it differs much from that of Shipshewana and other lakes in the region hereabouts. But little muck is found in the lake and that only along the shore of the meadow at the west end.

MARL.—The north lake has a large body of marl at the east end. The water here is very shallow and the marl everywhere tested extended to below 16 feet. There are also several acres of marsh at this end of the lake. Along the south side of the lake from (B) to (C) the shallow water belt is narrow, probably not averaging over 50 feet, though the marl shows a good depth except close to shore. Around the west end there is also considerable shallow water with deep marl. Along the north side it was estimated that the shallow water had an average width of 150 feet, with deep marl except close to shore. It was estimated that there are nearly 50 acres of shallow water in this lake, most of which was underlain by marl to below 16 feet. In appearance the marl seemed to be of very fine quality, being soft and smooth, and of a dove color.

In the south lake on the north side, marl of good quality was found all along the outer edge of the narrow shallow water area. In thickness it runs from eight to 14+ feet in four feet of water, thinning out to one foot at edge of shore. Numerous tests showed that the wider shallow water areas on the east and south sides are likewise underlain with a deposit 12+ feet in thickness in three to six feet of water. There is no doubt but that the marl exists beneath the entire deep water area of the lake. The quality is of the best, being, if anything, superior to that in the north lake. Altogether, the marl deposits of the two lakes are sufficient to furnish material for an unlimited number of years to any cement factory which might be erected, provided some means were devised for securing that beneath the deep water after the 75 or more acres in shallow water had become exhausted.

CEDAR, GRASS AND LIBEY LAKES, AND ADJOINING MARSHES.

Workable Deposit.

CEDAR LAKE.

Cedar Lake lies about three miles northeast of Lima in sections 21 and 22 (38 north, 10 east). It is two and a half miles east of the Grand Rapids & Indiana Railway.

This lake is nearly a mile long by one-half a mile or more broad. There is a small, nearly land-locked bay at the south end. The area is about 175 acres.

The lake is shallow, having a maximum depth of 24 feet with an average of not over 18 feet. On the south and east sides the banks rise abruptly 15 to 20 feet. A high point with a narrow neck projects out from the southeast corner. In 1832 this was fortified and called "Fort Donaldson." There is a small island a little north of the old fort.

Marl.—On the east side of the lake the marl is quite limited in amount, usually not setting in until some distance from shore and on the six foot water line running from 10 feet or over near (A) down to a few inches by the time the island is reached, with no marl just north of the island. South of the island the marl is shallow. In the embayment at the south end the marl runs from 10 feet to over 16 feet in depth, but is very mucky. All along the west shore there is a narrow belt where, in from four to six feet of water, the bottom of the marl was not reached at 16 feet. There is little doubt but that the deposit underlies the greater part of the water area, thinning out towards the east shore.

GRASS LAKE AND MARSH.

This lake and adjacent marsh lie just south of Cedar Lake, being partly in the same section, but mainly in section 27.

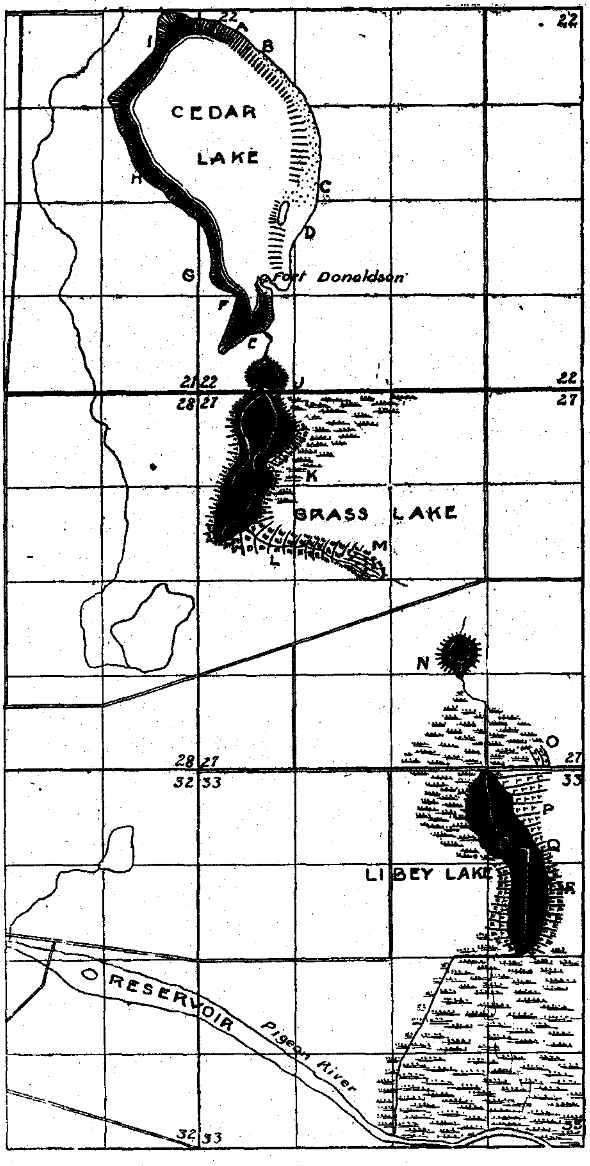


Fig. 14. Map of Cedar, Grass and Libey Lakes, Lagrange County, Ind.

The lake, as far as could be examined, seemed to be very shallow, appearing as though nearly filled up with marl. The marsh on the east side is rather extensive, running eastward from each end of the lake. On the west of the lake the bank is more abrupt.

MARL.—The deposit here covers probably 65 acres or more of exposed marl, 15 acres of which are in section 22. The lake occupies but a part of this area. The marl at all points tested was over 16 feet deep. On the north marsh back from the water it passes under the muck which in a short distance becomes over seven feet deep, or too deep to work.

Tests in the south prong of the marshes to the eastward showed that toward the head of that prong the muck thinned down to two or three feet, with the bottom of the marl not reached at 16 feet. Over how large an area of the marsh such conditions occurred could not be accurately determined.

LIBEY LAKE AND MARSH.

This deposit lies southeast of Grass Lake, in sections 27 and 33, where it occupies part of a considerable marsh. It is estimated that there are about 60 acres of this in section 33, where the marl is bare or covered by less than one foot of muck with marl over 16 feet deep.

The deposit at (N), in the northwest quarter of the southeast quarter of section 27, was estimated to contain 15 acres of deep marl. The thickness of the muck seemed to be irregular outside of the areas mentioned, occasionally, as at (O), being two feet or less thick with over 14 feet of marl underneath, and the next drilling, but a short distance away, perhaps showing six or seven feet of muck, so that it is difficult to say how much of that portion of the marsh overlain with muck contains workable marl. Libey Lake, which formerly covered the entire marsh, has now an area of only about an acre, having been reduced by artificial drainage.

Taking in connection with the 140 acres of marsh and shallow water marl in Grass and Libey lakes the deposit in Cedar Lake, the approximate area of which is unknown, it will be seen that we have here a good workable deposit for a cement factory of large capacity. From the extreme north end of Cedar Lake to the southern extremity of Libey Lake, the distance in a straight line is but little more than two and a half miles, so that with an electric tramway the three deposits could be easily worked from one plant, especially if the latter were situated near the center of the territory—say on the margin of Grass Lake.

GRASS AND FISH LAKES.

Workable Deposit.

GRASS LAKE.

This lake is now a dry or semi-dry, level marsh or marl plain. It lies in section 31 (37 north, 11 east), Springfield Township, about eight miles south of east of Lagrange. The lake, recently drained, had an area of about 100 acres. Over this the marl presents a bare surface, resembling in places the alkali plains of the west, more or less overgrown with bulrushes. At no point in this deposit was bottom reached with our 16-foot drill, and it is claimed that tests with long poles show it to have a depth of 30 feet or more over most of the area.

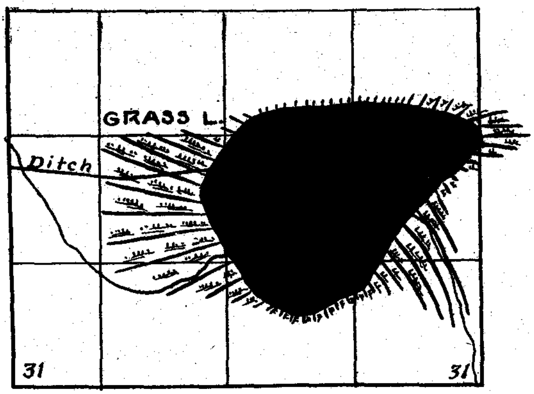


Fig. 15. Map of Grass Lake, Lagrange County, Ind.

This lake area is surrounded by a considerable original marsh area and it is reported that there is fully 100 acres of this that is underlain with deep marl with but little cover, making in all 200 acres, with a thickness of 16 feet or more. The marsh area was not examined or mapped. The area shown on the map is therefore only suggestive of the general position and shape of the marsh. It probably extends much farther west than shown.

This deposit is easily workable and is one of the largest in the county, lacking only railway facilities to make it a very valuable property. It is now owned by Chicago parties who secured it for a nominal sum, and who are expecting to develop it in the near future.

FISH LAKE.

This lake lies a mile and a half west of Grass Lake which, before draining, emptied into it. It has an area of about 140 acres, a maximum length of nearly three-quarters of a mile and a width of nearly one-third of a mile. At most points around the lake the marl extends back beneath the shore from a few yards to several rods, so that the depth at the water's edge is often from six to 15 feet or over. At most places it is not over 50 feet from the shore to the edge of deep water. Wherever the water is two feet or more deep the marl below reaches a depth of over 16 feet. At (F) the marl is shallower and at (C) the bottom is sandy for a short distance out. At (B) there is a broad bench of marl, amounting to several acres, which is 16+ feet in depth.

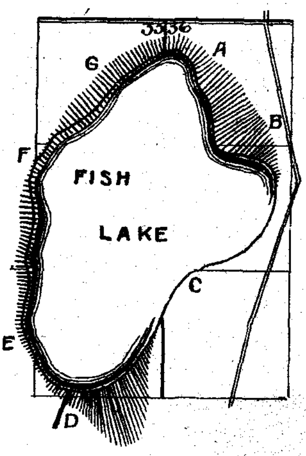


Fig. 16. Map of Fish Lake, Lagrange County, Ind.

It is possible that Fish Lake in itself contains enough marl to furnish material for a cement factory, but at present the greater part is beneath deep water and therefore not available. That portion along shore and beneath shallow water could be readily utilized in connection with the dry deposit at Grass Lake, provided there should be need for additional material.

TURKEY AND LITTLE TURKEY LAKES.

Workable Deposit, Owned and Utilized by the Wabash Portland Cement Company.

These lakes will be considered together, as they are not only close together but are at present owned by the same company and so may commercially be considered as one deposit. They lie in sections 1, 2, 11 and 12 (36 north, 11 east), Lagrange County, and sections 7 and 18 (36 north, 12 east), Steuben County. They were in 1899 connected by a switch, five miles in length, with the Chicago Division of the Wabash Railway at Helmer. The two new towns of Stroh and

Elmira, about one-half a mile apart, have sprung up near the cement works since their establishment. In October, 1900, they contained probably 50 houses.

The lakes have recently been lowered by the digging of a long ditch, materially reducing the size of their water areas, especially that of Little Turkey. The depth of water in Big Turkey Lake is re-

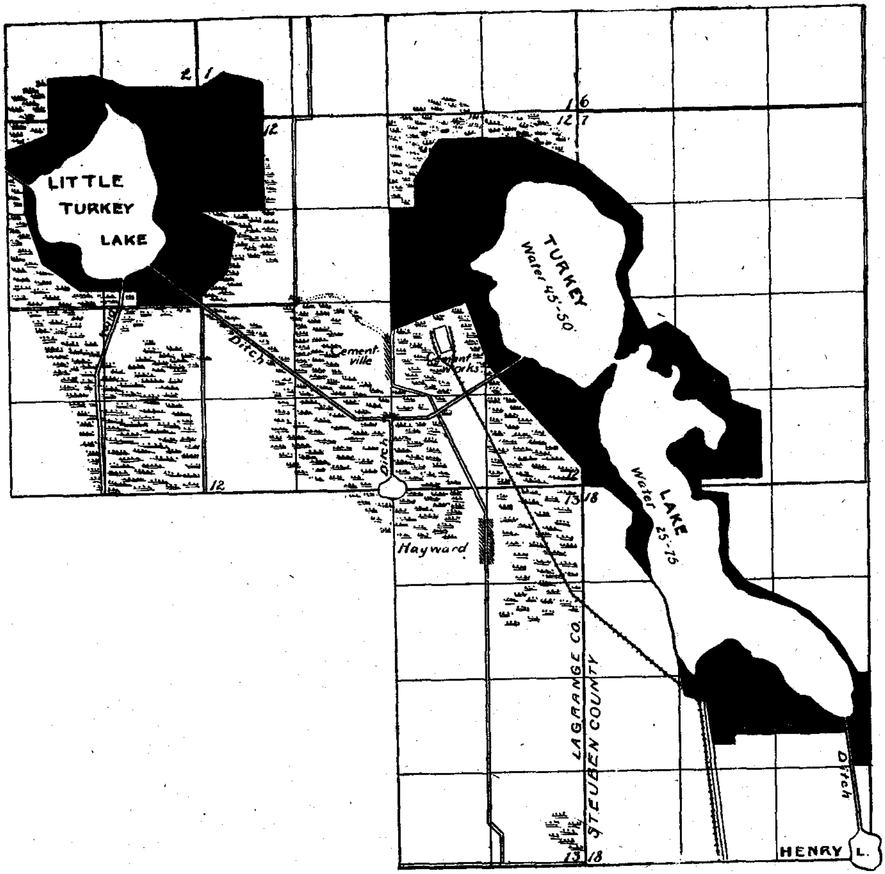


Fig. 17. Map of Turkey Lakes, Lagrange and Steuben Counties, Ind.

ported to be 45 to 50 feet in the northern lobe and 25 to 75 feet in the southern lobe. The banks are low on the west side of the lake but on the east side slope back irregularly to a height of 40 or 50 feet.

As shown on the map, the white space indicates the present water area. The black area outside shows the marsh and former lake area acquired by the company. The outside line of the black is said to have followed the line of 10 foot marl. This is copied from the company's survey sheet and shows a water area in Little Turkey Lake of about 75 acres, and land area outside, of 125 acres, or a total of 200 acres. Big Turkey Lake has a water area of about 250 acres and an equal amount of marl land around, or a total of 500 acres, making 700 acres for the deposits around and beneath the two lakes. Big Turkey Lake is over a mile and a half long by one-eighth to three-eighths of a mile wide and is divided nearly in two near the north end.

MARL.—It is claimed that the marl runs from a thickness of 10 feet on the edge of the area shaded black, to a maximum depth of 45 feet. It was not learned how much of the area was under water shallow enough to allow the marl beneath to be worked. In October, 1900, the marl was being secured from the border of the marsh, just north of the cement factory. The pit as exposed, showed muck one foot, marl nine feet.

The *average* of six analyses of marl from Big Turkey Lake, as furnished by Prof. W. R. Oglesbey, the chief chemist of the Wabash Portland Cement Co., was as follows:

Carbonate of lime ($CaCo_3$)	91.14
Magnesium oxide (MgO)	1.31
Alumina (Al_2O_3) and Ferric oxide (Fe_2O_3)	.86
Silica (SiO_2)	.85

The clay used in the making of the cement is hauled from a point about two miles northwest of the factory. It comes from a bed of drift clay, a section of which is as follows:

1. Sand	15 inches.
2. Clay	6 feet.
3. Clay mixed with pebbles	3+ feet.

The surface sand is stripped and the first six feet of clay is used, the remainder containing too many pebbles of lime and other minerals of drift origin to be available for cement making. The clay used is light brown, fine-grained and free from grit. It may be classed as exceedingly pure for a clay of glacial origin. An *average* of eight analyses of this clay kindly furnished by Prof. Oglesbey, was as follows:

Silica (SiO_2)	56.74
Alumina (Al_2O_3)	19.43
Ferric oxide (Fe_2O_3)	4.83
Lime (CaO)	7.27
Magnesia (MgO)	3.05
Loss on ignition	10.39
Total	101.71

LONG AND PRETTY LAKES.

Large Marl Deposit, Mostly Under Deep Water.

LONG LAKE.

Long Lake lies in a northwest and southeast direction in sections 22, 26 and 27 (36 north, 11 east), Milford Township. It is about one

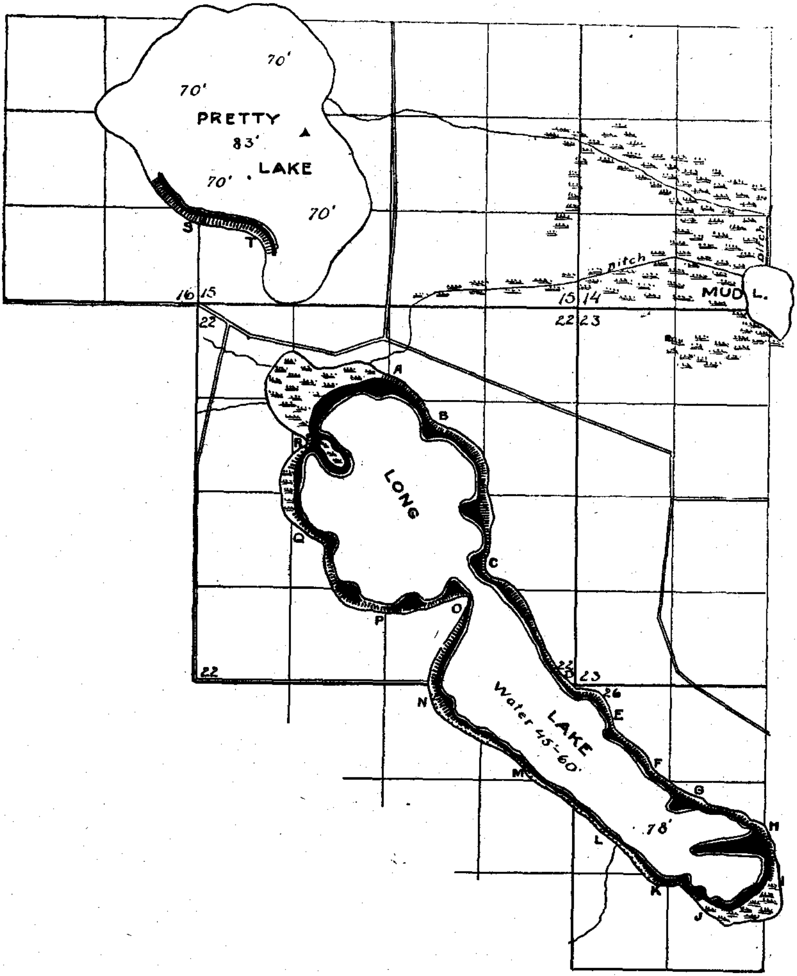


Fig. 18. Map of Pretty and Long Lakes, Lagrange County, Ind.

mile from the Chicago Division of the Wabash Railway. The lake is nearly two miles long by from one-quarter to one-half mile wide. A long point from the west side nearly divides it into two parts, giving it a striking resemblance to Big Turkey Lake, Lagrange County. The head and foot of the lake have been somewhat reduced by the encroachment of the marsh.

In the southern part of the lake the belt of shallow water is usually narrow with one unusually long point near the south end. In the north part of the lake the shallow water will average somewhat wider, due to the existence of several points extending out into the lake. The deep water runs from 45 to 60 feet, the deepest being 78 feet near the southern end. The banks around the lake are unusually steep and high.

MARL.—Judging from stumps and logs in the water around the margins of the lake it would appear to have been raised a little. Partly as a result the bottom is hard close to shore and in water under two feet deep. Generally, where the water has reached a depth of three feet the marl is found to be over ten feet deep and at most points over 16 feet deep. From (A) to (D) none of the drillings in two feet or over of water reached the bottom of the marl at 16 feet. At (D) the marl is shallower, being only nine feet deep in four feet of water, and is overlain by sand. At (E) it is deep and at (F) begins to get shallow again, so that at (G) it is only one foot thick in two and one-half feet of water, with six inches of sand over and seven feet deep in four feet of water with three inches of sand over. The marl is deep on the long bar running out from (H) and around the south end of the lake nearly to (L). From (L) to (N) the marl is shallower, being absent in two and three feet of water and only five or six feet deep on the six-foot water-line. Though one drilling showed only six feet of marl under seven feet of water, most of the tests in water of that depth or more did not reach the bottom of the marl at 16 feet. Between (N) and (O) the marl in two feet or more of water is over 14 feet deep. From (O) to (Q) the marl runs eight or nine feet deep in two feet of water near shore, but in two or three feet of water, on the points shown, extended to below reach of drill. Around the marshy island at (R) the marl is deep but inclined to be mucky and with usually a little muck on top. There is little doubt but that marl averaging over 10 feet in thickness underlies almost the entire deep water area of the lake.

PRETTY LAKE.

A lack of boat prevented the complete testing of this lake. It lies in sections 15 and 16 (36 north, 11 east), just northwest of Long Lake, from which it is separated by an elevated ridge about one-third of a mile in width. The lake is over three-quarters of a mile long by one-half a mile wide, with an area of more than 200 acres.

It is described as a very regular basin 83 feet deep in the center and shallowing gradually toward shore to 70 feet, then rising rapidly to the shallow water bench. The surrounding topography is much the same as that of Long Lake. Tests for marl were made by wading along the southwest shore. Thus at (T), in one foot of water 25 feet from shore, the marl is four feet deep and twice that depth in two feet of water at 40 feet from shore. In three feet of water at 60 feet from shore the marl is 11 feet deep and a little further out extends to below 16 feet. About the same results were obtained by tests at various other places along the south or southwest shore.

There is undoubtedly enough marl in the two lakes under consideration to justify the erection of a large cement factory, but until appliances are invented for securing the marl from beneath deep water it can not be utilized.

ADAMS AND EVE LAKES.

Large Marl Deposit, Mostly Under Deep Water.

ADAMS LAKE.

Adams Lake lies two miles northeast of Wolcottville, Lagrange County, in sections 23, 24, 25 and 26 (36 north, 10 east), Johnson Township. Its southern edge is a mile north of the Chicago Division of the Wabash Railway and its western edge a little over a mile east of the Grand Rapids & Indiana Railway.

The lake has a length of over one mile by a width of over a half-mile and an area of 320 acres. A long point, but slightly submerged, extends out from the northeast shore nearly cutting off the east end. This point had, when examined, only a few inches of water over it. The shore at most points runs out gently for 100 to 150 feet, to a depth of four to eight feet of water, then in a few feet descends rapidly to deep water. The deep water is said to run from 40 to 75 feet deep with 93 feet of water off from the long point mentioned. The shores of the lake are at most points elevated with a noticeably high hill at (G).

Marl.—A few inches of marl is often found close to shore, but usually it does not reach a thickness of three feet until 50 or 75 feet from shore, where the water is perhaps two feet deep. Where the water is three feet deep the marl is apt to run from five to ten feet deep. After reaching four feet of water the marl quickly thickens to over 10 or 12 feet. The conditions around the lake are fairly uniform and as given above. The long point has no marl on its crest, which is composed of sand and gravel, often quite coarse. The marl appears to be of good quality.

EVE LAKE.

This lake lies in section 24, just northeast of Adams Lake. It has an area of about 25 acres and a reported depth of 65 feet. Surrounding the lake is about 50 acres of marsh showing much bare marl. This, it is claimed, has been tested all over with a 15-foot pole without finding bottom except at the edges.

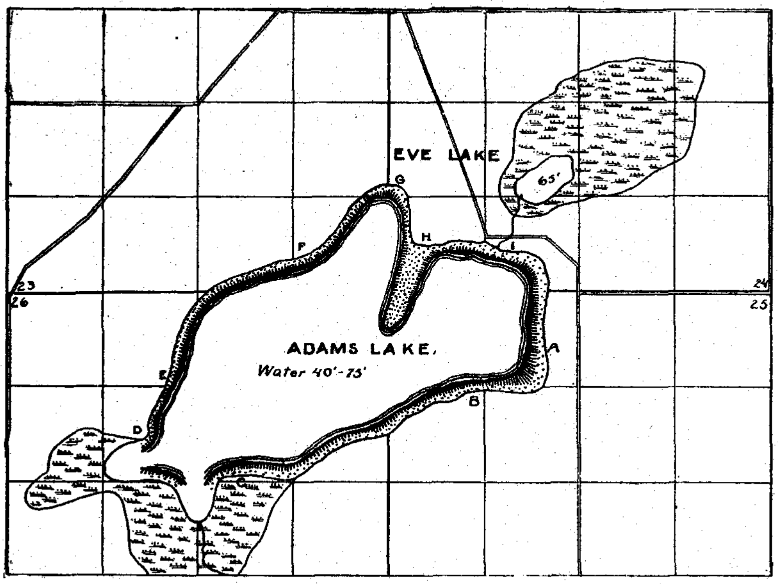


Fig. 19. Map of Adams and Eve Lakes, Lagrange County, Ind.

There is very probably an acreage and thickness of marl, beneath and around these two lakes, sufficient to furnish a large factory with cement material. The larger deposit in Adams Lake is, for the most part, however, covered with deep water, and is, therefore, not at present available.

OLIVER AND OLIN LAKES.

Large Marl Deposit, Mostly Under Deep Water.

These lakes, which are contiguous, lie in sections 17, 18, 19 and 20 (36 north, 10 east), Johnson Township. They are about a mile and a fourth west of the Grand Rapids and Indiana Railway, and two and a half miles northwest of Wolcottville. Oliver Lake is over a mile long from east to west and nearly a mile wide from north to south, with an area of about 600 acres. Olin Lake is more irregular in shape, with a length of one-half mile and a width of a quarter of a mile, covering probably less than 100 acres.

Oliver Lake has a broad expanse of shallow water in the northeastern part, but around the remainder of the lake the shallow water belt is comparatively narrow. There is a considerable shoal in

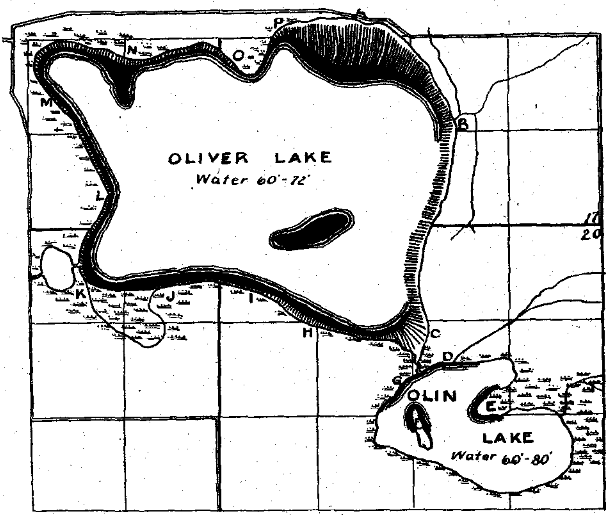


Fig. 20. Map of Oliver and Olin Lakes, Lagrange County, Ind.

the southeast part of the lake over which the water is from one to three feet deep. The deep water in the eastern half of the lake runs from 60 to 72 feet in depth.

The shallow water belt in Olin Lake is very narrow, being only a few yards in width at the most; when the bottom slopes down rapidly into deep water, which ranges up to 80 feet in depth.

Marl.—At (A) the shore is hard, but the marl sets in a short distance out, and though the water remains two feet deep for a long distance, the marl gradually increases from one foot to over 12 feet and in three feet of water extends to below 16 feet. Along the east side of the lake the marl is shallower, running up to eight feet in two feet of water in one place, but generally only showing five or six feet of marl in four feet of water. In seven feet or over of water the marl is deep. It is also deep on the shoal, and along the south side of the lake the bottom of the marl was not reached even in one and two feet of water. Along the western and northwestern side of the lake the conditions are practically the same. Though the shallow water belt is narrow the marl, even in two feet of water, reached to below the pole. All of the tests in Olin Lake found marl to below 16 feet.

The deposit of marl in the two lakes is sufficient to supply a large factory for many years, but the greater part of it is not at present available, on account of the depth of the overlying water.

NAUVOO LAKE.

Not a Workable Deposit.

This lake lies beside the Chicago Division of the Wabash Railway, about two miles east of Wolcottville. The tests for marl were limited to a line of drillings along the channel from the lake to the ice-house beside the railway. These were made about 100 yards apart, starting near the railway and extending to the lake. All of these showed muck varying in thickness from two to 16 feet, with the underlying marl from one foot to 14 feet in depth. The amount of muck was deemed too great to allow the working of the deposit.

WITMER, LONG, THIRD, DALLAS AND ATWOOD LAKES.

Large Marl Deposit, Mostly Under Deep Water.

As these lakes, except Atwood, are all openly connected, they will be treated as containing a single deposit. They lie west of Wolcottville, Lagrange County, in sections 29, 30, 31, 32 and 33 (36 north, 10 east); Johnson Township, and section 25 (36 north, 9 east), Clear Spring Township. Atwood and Witmer lakes are each but little over one-quarter of a mile from the Chicago Division of the Wabash Railway and Witmer Lake about a mile from the Grand Rapids & Indiana Railway.

Witmer Lake is an irregular oblong, a mile long by a quarter to a third of a mile wide. Long Lake is more like a wide, deep channel than a lake. It is a mile long by an eighth of a mile or less wide. Third Lake is an irregular body of water, a half mile wide from east to west and a little over that from north to south. The northern part narrows down to channel-like proportions, with Pickerel Bay projecting to the east. Dallas Lake has a length of about a mile

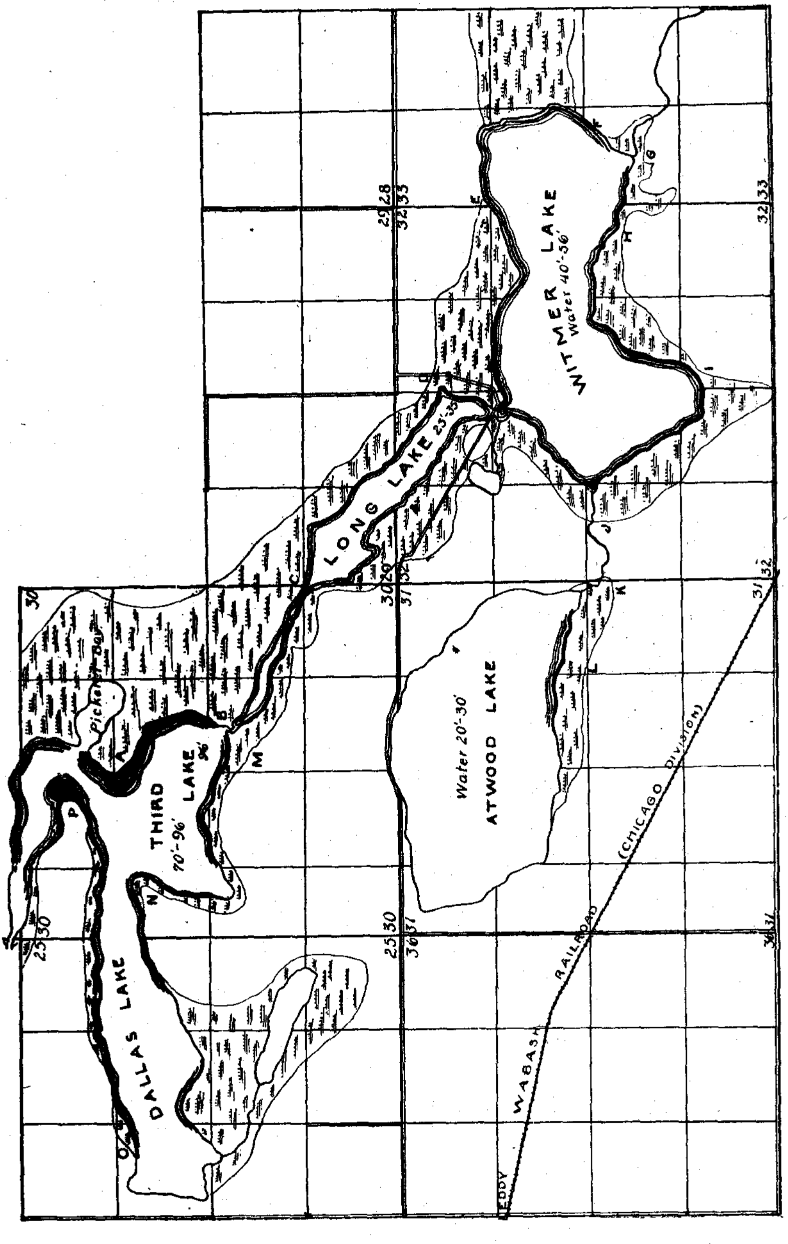


Fig. 21. Map of Atwood, Dallas, Third, Long and Witmer Lakes, Lagrange County, Ind.

and a width of a quarter of a mile or less. Atwood Lake is more regularly oval than the others with a length of over three quarters of a mile and width of nearly half a mile.

Though the hills surrounding these lakes are of only moderate height and usually separated from the lakes by a varying width of marsh, the lakes themselves have a good depth and, in the case of Third Lake, a surprising depth. Except a strip along the east side of Third Lake, the belt of shallow water around all of the lakes is very narrow, usually not more than a few yards or at most a few rods wide.

Witmer Lake has a depth of from 40 to 56 feet; Long Lake a depth of 25 to 35 feet. Third Lake showed a depth of 75 feet or more all over the deep water area with a maximum of 96 feet within 20 rods of the inlet. Atwood Lake is shallow, running from 20 to 30 feet. Around these lakes, somewhat as suggested on the accompanying map, is an extensive marsh area. Back of that the hills slope upward to moderate elevations. This chain of lakes forms the source of the northernmost branch of the Elkhart River, the upper course of which is characterized by passage through very extensive marshes, and lakes of considerable depth in the midst of them.

Marl.—With the exception of a small area of sandy bottom around the inlet of Witmer Lake, the shores of these lakes show marl at every point and except at a point near (E) on Witmer Lake and one on the north side of Long Lake, the marl extended to below reach of drill at every point tested. At the two points mentioned bottom was found at 15 feet. From the depth of the marl at the edge of the water it would appear evident that in many places it runs back under the marsh. Tests at one or two points showed that back from the water the marl quickly gets thinner while the overlying muck as rapidly thickens. The largest local deposit of marl was found on the east side of Third Lake at (A). At this point is a large area of shallow water, beneath which the marl is very light in color and comes within a few inches of the surface. In the sunlight this glitters with the white lustre of burnished silver, due to the milky color imparted to the water by the underlying marl. There is little doubt but that a large portion of the marsh east and south of Pickerel Bay is underlain with a thick deposit of marl, but the conditions were such that a detailed examination could not be made. Atwood Lake was only examined along part of the south side. The marsh here is, for the most part, a quaking meadow with a good depth of rather mucky marl below.

Judging from the thickness of the exposed or shallow water marl, around these lakes, the greater portion of their deep water area is underlain with a deposit of good depth. That at present available is mostly in Third Lake. On account of the excellent railway facilities and the quality of the marl, which appears of the best, the deposit will doubtless be developed as soon as appliances for utilizing the deep water marl can be used.

NOBLE COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 207.

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. of Ind., p. 447.

1875.—*Id.*, Seventh Ann. Rep. Geol. Surv. of Ind., pp. 487, 492.

1893.—Dr. C. R. Dryer, Seventeenth Ann. Rep. Ind. Dept. Geol. and Nat. Res., p. 17.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 31.

Noble County is in the second tier of counties south of Michigan and in the second tier east of Ohio. It is bounded on the north by Lagrange, on the east by Dekalb, on the south by Allen and Whitley, and on the west by Elkhart and Kosciusko counties. The county contains 417 square miles and lies between 868 and 1,018 feet above sea level, the lowest point being the Elkhart River on the western line of the county and the highest the summit in Wayne Township, three miles east of Kendallville. The following is the elevation in feet, above tide, of the more important railway stations in the county: Albion, 919; Avilla, 976; Avilla Summit (B. & O.), 1,007; Brimfield, 944; Cromwell, 930; Kendallville, 974; La Otto, 881; Ligonier, 885; Rome City, 933; Swan, 885; Wawaka, 895.

The county is well supplied with transportation facilities, being crossed by three railways and touched by two more. The Grand Rapids & Indiana passes north and south through the eastern part; the Baltimore & Ohio, east and west through the center, and the Lake Shore & Michigan Southern, east and west through the northern tier of townships. The Eel River Division of the Wabash crosses the extreme southeastern corner, and the Chicago Division of the same system touches the northern border for about three miles in Orange Township.

The surface of the entire county is thickly covered with drift, the known thickness of which ranges between 169 and 485 feet. The greater part of this drift covering belongs to the interlobate moraines of the Erie and Saginaw lobes. The Salamonie or Third Erie moraine crosses the southeastern corner of the county forming the surface of Swan and a small portion of that of Greene and Allen Townships. The Mississinewa or Fourth Erie moraine covers the townships of Greene, Jefferson, Allen, Orange and Wayne. The western part of the county is covered with the Saginaw Drift. On account of the intermingling or merging of debris from so many different glacial invasions, the surface of the county is extremely diversified. High rounded domes, hills and ridges alternate with deep valleys and level plains in rapid succession. Many of the depressions form water-tight basins, occupied by lakes either present or extinct. The latter far outnumber the former, the combined area of the marshes, which occupy the sites of former lakes being estimated at 15 per cent. of the total area of the county. Many of these marshes still retain a small pool of open water at the center, the last vestige of a once noble expanse of water, whose area has become gradually lessened by the encroachment of aquatic vegetation and by the dredged ditches of mankind.

The number of lakes still existing in the county probably exceeds 100, but the great majority of them might be termed "ponds," as they are less than 40 acres in extent. Nineteen, which contained an area of 150 or more acres each, were visited during our investigation of the marl deposits. A number of these were adjacent, the marl, if present, being termed as one deposit, even though beneath or surrounding two or three lakes. But four deposits were found in the county which were deemed workable under the present conditions of securing marl. Three others had a bed of sufficient area and thickness, but mostly beneath deep water. At the remainder the marl was not found in sufficient quantity to be available for the manufacture of cement.

TAMARACK LAKE.

Large Deposit, Mostly Under Deep Water.

This lake lies in section 6 (35 north, 11 east) and section 1 (35 north, 10 east), in Wayne and Orange Townships. It was formerly nearly a mile and three-quarters long with a long arm extending out from the northeastern side. By the removal of a dam and the ditching of the outlet it has been to a large degree lowered and reduced to a crescent-shaped body of water three-quarters of a mile long by less than a quarter of a mile wide. On account of this lowering, the water area is surrounded on all sides by marsh-land, the widest extent of which is on the south and east sides. The lake contains but little vegetation except at the margins, where *Chara*, rushes and spatterdock are, in places, abundant. The maximum depth of water found was 40 feet. Along the west and south sides it was almost, everywhere, 15 feet deep at a distance of 20 feet from shore.

MARL.—The present water area is probably wholly underlain with a thick deposit of marl as, except where the township line meets the south shore, the marl extends to below 16 feet at every point along the narrow, shallow water area. Only the marsh-land south and southeast of the lake between (A) and (B) was tested. Begin-

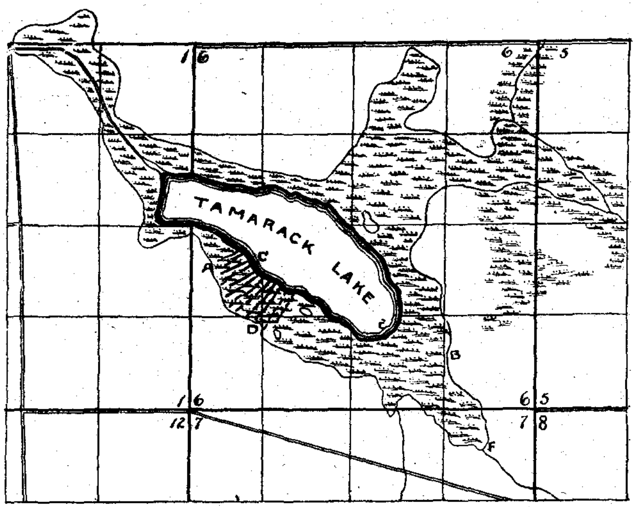


Fig. 23. Map of Tamarack Lake, Noble County, Ind.

ning at the water's edge opposite (C), four bores were put down, 10 rods apart, on a line to (D). These resulted as follows: (1) muck three feet, marl nine feet; (2) muck two feet, marl 11 feet; (3) muck six inches, marl 15 feet; (4) muck one foot, marl 12 feet. At the margin of the former water area, five rods south of number (4), the marl had wholly disappeared. Two bores, numbers (5) and (6), 10 rods apart, west of number (4), gave respectively nine and 10 feet of marl beneath one foot of muck. Twenty rods west of number (6), near (A), the muck had increased to four feet and the marl diminished to six feet in thickness. Twenty rods north 18 feet of muck only was found, and west of this to the township line no marl was found beneath 18 feet and more of muck. East of the quarter section line (C and D) the marl occurs 10 to 12 feet in depth for about 10 rods and is then gradually replaced by muck, so that not over 12 to 15 acres of this portion of the marsh are underlain with marl. A number of tests in the marsh, in a southeasterly direction to the end of the lake, found only small isolated patches of marl, the muck everywhere predominating. The same thing holds good of the 60 acres or more of marsh southeast of the lake (E to F), where but one or two of many bores, with 18-foot auger, showed marl.

While the deposit beneath the present water area, combined with that in the marsh, is doubtless large enough for cement making, the amount under *shallow* water and in the marsh is not sufficient to justify the erection of a factory at the present time.

SYLVAN LAKE.

Not a Workable Deposit.

This lake, more commonly known as "Rome City Reservoir," is wholly artificial, being formed in 1837 by a dam thrown across a small tributary of the Elkhart River, to create a feeder for the proposed Michigan and Erie Canal. It adjoins Rome City on the east and the G. R. & I. Railway runs along its western border. The lake is nearly three miles long by one-half a mile wide, with an area of 1,200 or more acres. Its depth runs from 17 to 30 feet and its outline is very irregular, with numerous points, bays and narrow channels. Several islands, prettily wooded with oak and other timber, dot its surface and furnish delightfully cool and shady retreats for picnic and boating parties. The "Island Park Assembly," an institution under the management of the Methodist Episcopal Church, holds here its regular summer sessions. The lake has several times been well stocked with fishes by the U. S. Fish Commission, and furnishes excellent sport for all interested in the pursuit of the finny tribe.

Marl.—*Being artificial, no marl occurs beneath its waters.* In many of the bays and inlets a deposit of muck is slowly accumulating by the decay of water-lilies, rushes and other aquatic vegetation.

In the report of this Department for 1875, Dr. Levette states that "In a bluff that formed the border of a lake now filled up by vegetation, about one mile north of Rome City, a ditch has exposed a deposit of marl or fresh water chalk several feet in thickness. Other heavy deposits were reported in the same neighborhood. In the absence of a better article, this might be burned and used for making mortar, but its chief value lies in its fertilizing properties when spread over the clay lands of the vicinity, after having been burned and slaked."

"An analysis of this marl showed the following composition in 100 parts:

Water at 212 degrees F	3.00
Carbonic acid and combined water	41.00
Insoluble silicates	.70
Oxide of iron	a trace.
Alumina	1.00
Lime	49.84
Magnesia	4.10
Sulphuric acid	.03
Phosphoric acid	.52
Total	100.19

"This chalk shows a remarkable degree of purity, the insoluble matter being less than one per cent., and it contains only a trace of iron. The discoloration is removed by ignition; it is pulverulent when dry and soft like mortar when first taken from the bank, and may be pressed into pencils and will mark like the common English chalk."*

LONG AND ROUND LAKES.

Large Deposit, Mostly Under Deep Water.

These lakes lie just north and northeast of Kendallville in sections 27 and 28 (35 north, 11 east), Wayne Township.

Long Lake is a mile long and has a width varying from a few rods toward the eastern end to one-quarter of a mile near the western end. Round Lake has been lowered several feet, thus materially reducing its water area. It is at present nearly three-quarters of a mile long by three-eighths of a mile wide and is almost divided in two by a point which projects out from its northwestern shore, and by a long island near its center.

The area around the basins of these lakes is high and rolling except for a marsh at the head of Round Lake and another at the foot of Long Lake. Around most of Long Lake and on the eastern side of Round Lake the banks rise abruptly from the water. The western side of the latter lake is at present occupied by an extensive marsh which covers at least one-third of the old lake area. Around both lakes the belt of shallow water is very narrow.

* Levette, loc. cit., pp. 493, 41.

MARL.—Long Lake showed marl to below 16-foot drill on the north side and at the west end, even where the water was only six inches or one foot deep. Along the south side of the lake the conditions vary greatly. At (M) the marl is over 15 feet deep close to shore in one foot of water. Going toward (L) it thins until it is only six feet thick in six feet of water; then deepens until it is 12 feet deep in one foot of water. Toward (K) the marl nearly runs out, and while here and there is a foot or two thick, in the main only sand and gravel is found out to 16 feet of water. The marl is deep but mucky in the bend at (J). Along the south side of the narrow neck of the lake no marl was found, but farther east at (H) it deepens rapidly so that as much as 12 feet of marl was found at the water's edge. Marl probably extends from one lake to the other.

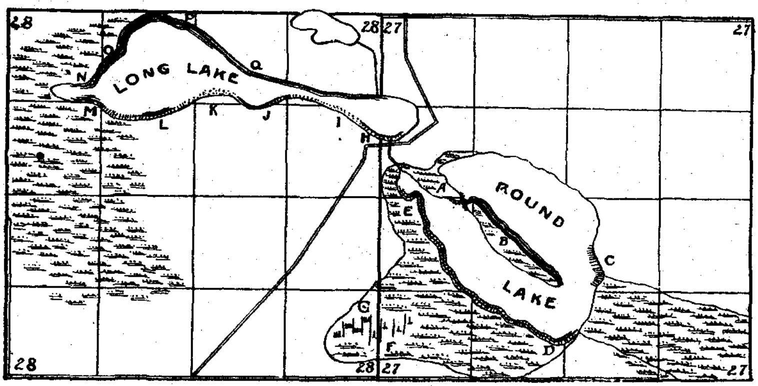


Fig. 23. Map of Long and Round Lakes, Noble County, Ind.

Tests on Round Lake along the south shore showed either 12 or 13 feet of marl at the water's edge with remarkable regularity. The same depth was found between the point and island. Along the north side of the island the marl is deeper, in most cases being over 16 feet thick and suggesting that the island is largely composed of marl. Tests made in the marsh at (F-G) showed from three feet to 12 feet of muck, underlain by from one to five feet of marl, the thickest marl coming under the thinnest muck. Doubtless still thicker marl underlies parts of this old lake bed, but circumstances prevented us from making a detailed test of its area.

From the results of tests made we feel safe in believing that the entire deep water area of the two lakes overlies a thick deposit of marl. The amount at present available is not, however, sufficient to term it a workable deposit.

WALDRON, JONES AND STEINBARGER LAKES.

WORKABLE DEPOSIT, PARTLY UNDER DEEP WATER.

This group of lakes lies about two miles west of Rome City in sections 7 and 18 (35 north, 10 east), and sections 12 and 13 (35 north, 9 east), Orange and Elkhart townships, and are tributary to the North Fork of the Elkhart River.

Jones Lake is nearly rectangular; is half a mile long by a quarter of a mile wide, with an area of about 100 acres. Waldron Lake is an irregular shaped body of water, more like an enlargement of the Elkhart River than a lake. Following its windings it has a length of

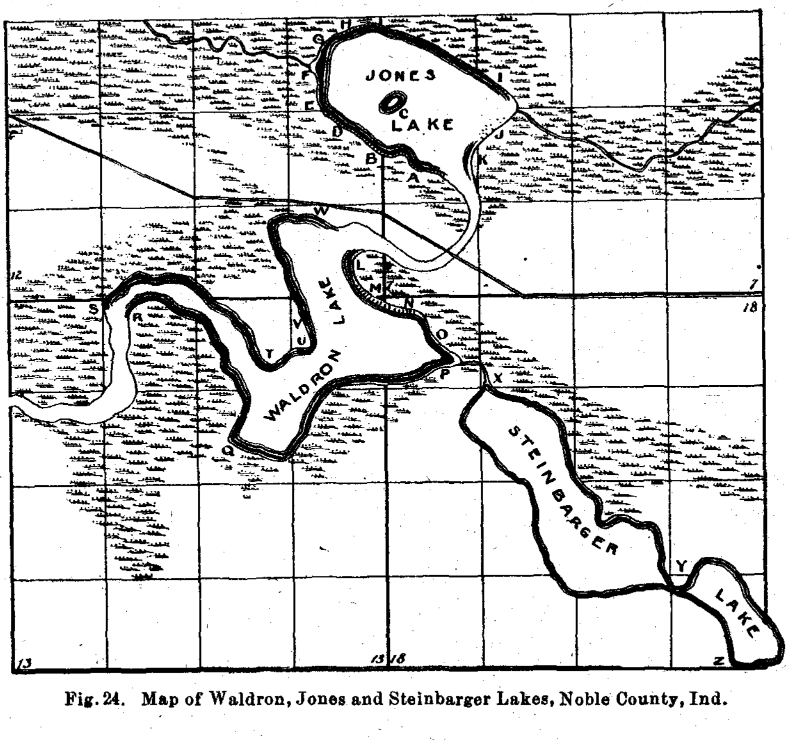


Fig. 24. Map of Waldron, Jones and Steinbarger Lakes, Noble County, Ind.

a mile or more with a width ranging from a few rods to a quarter of a mile. Toward the west it gradually narrows down to the proportions of a river. An open channel connects this lake with Jones Lake. Steinbarger Lake has a length of one mile and an average width of less than a quarter of a mile. A point from the north side near the southeast end nearly divides the lake into two unequal parts.

Except along the south side of Steinbarger, the immediate shores of these lakes are nearly everywhere flat and marshy. Back of these extensive marshes the land rises into rolling upland. As a rule the belt of shallow water is narrow, being especially so in Steinbarger Lake. Jones Lake has a maximum depth of 30 feet, and a small island rises a little west of the center. Waldron Lake averages 30 feet in depth with a maximum near the south end of 47 feet. Steinbarger Lake has about the same depth with a maximum, near the head, of 39 feet.

MARL.—In Jones Lake the marl ran to below 16 feet at nearly every point tested in water from one to 12 feet in depth. In places the marl gets shallow toward shore but generally it extends to below 16 feet in one foot or less of water, indicating that it tends to run back under the marsh. The island appeared to be all marl. In quality, the marl of this lake was usually dark and mucky, especially toward the northwestern corner, where it appeared to be more muck than marl.

In Waldron Lake the marl gets shallow toward shore at the east side at (M), in two feet of water running from four to seven feet in thickness. It is nine feet thick in three feet of water and then increases rapidly. At (U) on the north side the marl was only 10 feet thick, but at every other point tested it ran to over 16 feet. Time did not permit the testing of the extensive flats around the lake, but their appearance seemed to favor the idea that some marl would be found beneath them. The marl here appeared much whiter and more solid than in Jones Lake.

In Steinbarger Lake none of the tests found the bottom of the marl at 16 feet. The marl here was not as clean as in Waldron, and much softer, especially in the southeastern end.

The above three lakes are so closely connected as to form practically one deposit. A switch three miles in length would reach Waldron Lake, from either the L. S. & M. S or the G. R. & I railways, thus giving excellent transportation facilities, and there is no doubt but that the acreage and thickness of shallow-water marl now available in and around the lakes is large enough to warrant the investment of capital in its development for cement making.

SKINNER LAKE.

Not a Workable Deposit.

Skinner Lake lies about two miles east of Albion in sections 15 and 16 (34 north, 10 east), Jefferson Township.

The lake occupies a shallow basin 25 to 30 feet deep surrounded by low rolling land. It has an extreme length of nearly a mile and extreme width of half a mile, with an area of about 150 acres. The shores are low and devoid of points of interest.

Marl.—The distribution of marl on this lake is extremely irregular. At (A) is no marl, but muck to below 16 feet. Toward (B) marl sets in, being four feet deep in one foot of water but in deeper water is replaced with muck. Thus in four feet of water the muck is seven feet deep and a little further out is more than 16 feet in depth. The muck continues to 16 feet of water and beyond. At (C) the marl is six feet deep in one foot of water, four feet deep in four feet of water and has thinned out before eight feet of water is reached, where the bottom is hard. From (D) to (E) no marl was found. At (F) the marl is thick, the bottom not being reached in water eight feet or over deep. Going on to (G) it disappears and is replaced by muck which is over 14 feet deep in two feet of water, and bottom not reached farther out. At (H) a little marl appears below the muck. From (H) to (J) no marl was found, the muck being everywhere to below 16 feet. At (K) six feet and more of greenish marl was found under five feet of muck in five feet of water. Then for a distance the bottom is all sand at all depths within reach. At (M) in shallow water, marl appears below a considerable thickness of muck, but drillings in 10 feet or over of water showed only muck. At (N) the bottom is hard. From (O) to (P) the muck is deep. At (Q) the marl runs to below 16 feet at all depths of water but is mucky. At (R) there is a foot or two of mud and marl in water from one to five feet deep, but in deeper water the bottom is hard. From (S) to (T) the muck is thick.

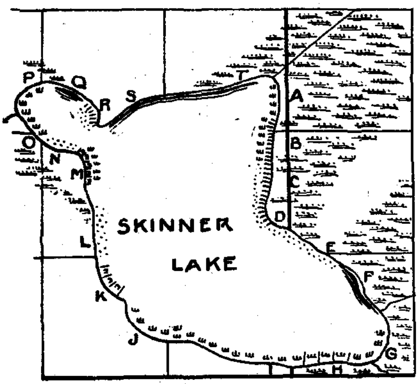


Fig. 25. Map of Skinner Lake, Noble County, Ind.

The tests showed that the marl is not sufficient in quantity or suitable in quality for cement making.

DIAMOND LAKE.

Large Deposit, Mostly Under Deep Water.

Diamond Lake lies in sections 31 and 32 (35 north, 9 east) and sections 5 and 6 (34 north, 9 east). It is two miles south of the L. S. & M. S. Railway and three miles north of the B. & O. Railway. The lake is five-eighths of a mile long by three-eighths of a mile wide and of a regular oval shape. On the south the country is rolling or flat but on the north rises one of the most abrupt ranges of hills occurring in the drift region of the State. In the words of Dr. Dryer:* "They are as rough and irregular a pile of gravel knobs as can be found in Indiana, rising 150 to 200 feet above the lake, with a southern descent almost too steep for a horse and wagon. The range is two and a half miles long east and west, and from one-half to three-fourths of a mile wide. It is completely isolated by the valley of the Elkhart on the east and north, and the valley of the lakes and their outlet on the south and west, and forms one of the most remarkable as well as conspicuous features of the region. The Diamond Lake hills stand like an Egyptian pyramid amid the ruins of an ancient city, a monument to show us what the Saginaw Glacier could do upon occasion."

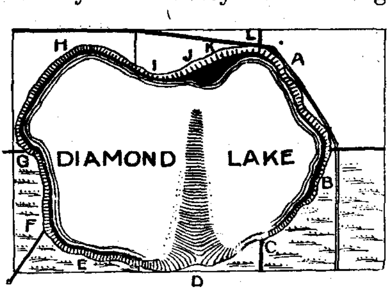


Fig. 26. Map of Diamond Lake, Noble County, Ind.

The depth of Diamond Lake is unusual for a lake of its size, averaging 50 feet, with a maximum of 82 feet. A long bar extends out from the south shore nearly across the lake. When visited in October, 1899, this had only a few inches of water over it. The shore at most points runs out gently for a way then descends rapidly to deep water. Although the Elkhart River is but one-half mile to the eastward with no elevation between, yet the outlet of Diamond Lake flows southwesterly into Eagle Lake and thence, by a small stream, cutting the highland, northward into the Elkhart near the town of Rochester.

Marl.—Around most of the lake the marl is deep, sometimes shallowing rapidly at the shore and sometimes running out beneath

* Loc. cit., p. 24.

the marsh bordering the shore, the latter condition being due to a recent lowering of the lake by ditching. Along the east side the shore is sandy, but in the water the marl quickly reaches a depth of 16 feet or over. At (A) the sand has washed down over the marl, making it appear as though absent. Thus in two feet of water is found six inches of sand, then 10 feet of marl. Toward (C) the marl gets more shallow again. On top of the long bar it runs from one foot to four feet in thickness, increasing to seven feet on the flanks where the water is five feet deep, then thinning down until it runs out in 12 feet of water and only hard bottom is found beyond. Toward (E) the marl gets thicker, being nine feet thick in six inches of water, 13 feet thick in two feet of water and below reach of drill in deeper water. Along the west end of the lake none of the tests in the water reached the bottom of the marl which here runs back from the water's edge. From (I) to (L) the marl is somewhat variable at similar depths, about half of the drillings failing to reach the bottom, while others found 12 feet or more.

On the whole the tests showed the presence of a large deposit of good marl, but as most of it is beneath 10 feet or more of water it is not, at present, available.

EAGLE LAKE.

Workable Deposit.

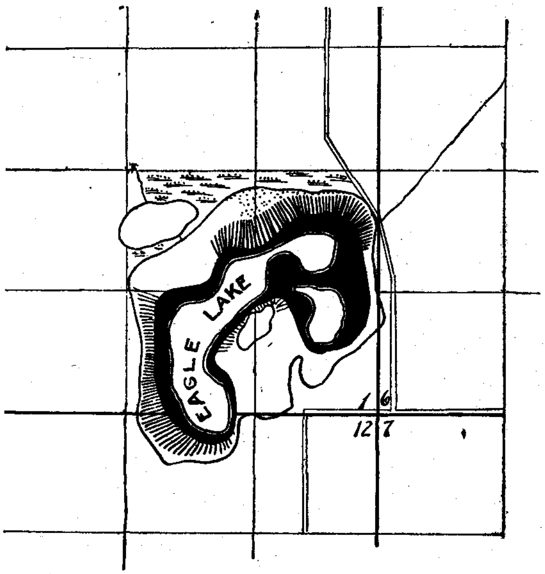


Fig. 27. Map of Eagle Lake, Noble County, Ind.

Eagle Lake lies a little southwest of Diamond Lake in section 6 (34 north, 9 east) and sections 1 and 12 (34 north, 8 east). It is two miles north of the B. & O. Railway and three miles south of the L. S. & M. S. Railway. The size of the lake has recently been much reduced by draining, so that the present water surface is comparatively small. It has a length of half a mile or more and a width of a few rods to one-eighth of a mile. The shores of the old lake basin on the north and west are low, while those on the south and east are abrupt. As already noted, the outlet flows northward into the Elkhart River.

MARL.—Though small, this lake is rich in marl. Except along the southwest shore none of the drillings in the water reached the bottom of the marl. Tests out on the shore indicated that while at places the marl extended back with gradually lessening depth to the old shore line, at other places it did not extend back more than half way. The marl appeared of good quality.

The total area underlain with marl in and around Eagle Lake is, at a low estimate, 200 acres, and its average depth is probably in excess of 20 feet. On account of its proximity to two important railways the deposit is an important one and in every way worthy of development for cement making purposes.

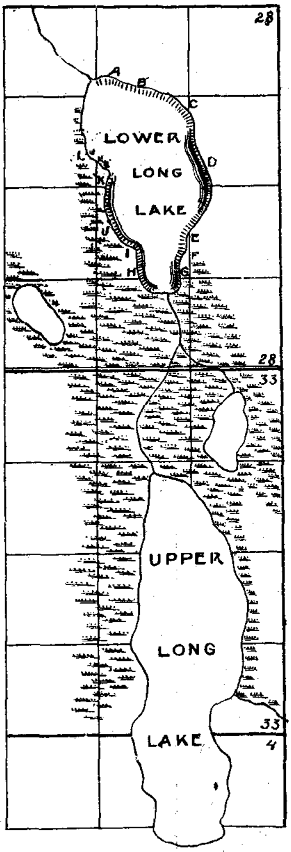


Fig. 28. Map of Upper and Lower Long Lakes, Noble County, Ind.

LONG LAKES.

NOT A WORKABLE DEPOSIT.

Long Lakes lie in sections 28 and 33 (34 north, 9 east) and section 4 (33 north, 9 east), York and Noble townships. Only the Lower Lake was examined.

This lake is less than three-quarters of a mile long by a little over a quarter of a mile wide. Upper Long Lake is one mile long by a quarter of a mile wide. The lakes lie in a narrow valley with high hills on either side, those east of the lake being especially rugged. As a rule the band of shallow water is narrow, in places the six-foot water line being within 10 or 15 feet from the shore. The outlet of the lakes is to the northward into Elkhart River.

MARL.—Marl was found at nearly every point around the shore, but at most points was comparatively shallow. Thus at (A) in one foot of water five feet from the shore the marl is six feet deep. At 10 feet from shore in four feet of water it is 11 feet deep, while at 15 feet from shore in six and a half feet of water it is only nine feet deep. Toward (B) the marl reaches a thickness of 11 feet in two feet of water, no marl showing in one foot of water as before. At (C) one foot of marl is found in one foot of water and five feet of marl in two feet of water, with the marl increasing in depth toward (D) where, in two feet of water it is over 14 feet thick but mucky. At (E) and (F) the marl is about three feet deep in one foot of water, five to five and a half feet in two feet of water, and eight feet deep in four feet of water. At (G) there is more muck than marl. At (H) and (I) the marl has a depth of nine feet in one foot of water and 13 feet in two feet of water, marl at bottom but muck on top. At (J) 10 feet of marl occurs in four feet of water, good at the bottom only. At (K) the marl is eight feet deep in six feet of water, while at (L) only muck is found. On the whole the quality of the marl does not appear to be very good and the quantity beneath shallow water is not sufficient for the purpose of cement making.

DEER LAKE.

WORKABLE DEPOSIT.

This is a small lake which occupies part of section 25 (34 north, 8 east), Sparta Township. It is distant one and one-half miles south of the B. & O. Railway. The lake is only a little over a quarter of a mile long and about the same in width, with low marshy ground in nearly every direction around its borders. It has been lowered materially in recent years, thus decreasing its water area.

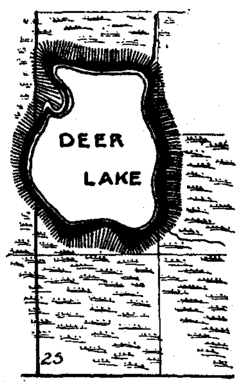


Fig. 29. Map of Deer Lake, Noble County, Ind.

MARL.—Though this lake is small the marl in its basin is above the average in thickness. Except in the northwest corner, all of the tests found marl to below 16 feet. Outside of the lake the marl extends back 75 or 100 feet. Thus at one point 50 feet back from the margin of the water the bare marl was 13 feet deep; 25 feet farther back it was only 3 feet deep, and ran wholly out within 100 feet from shore.

The marl appeared to be of good quality, and there is deemed to be a sufficient quantity for cement making, as the area of the bed is probably 130 acres and its average thickness 15 or more feet.

LONG AND SAND LAKES.

Not a Workable Deposit.

These are two out of eleven lakes which lie in a chain across northern Greene Township in sections 3, 4, 8, 9 and 10 (33 north, 10 east). These lakes are all small and occupy a narrow valley flanked with high hills on the north and south. Their outlet is to the southward into Blue River, a tributary of Eel River.

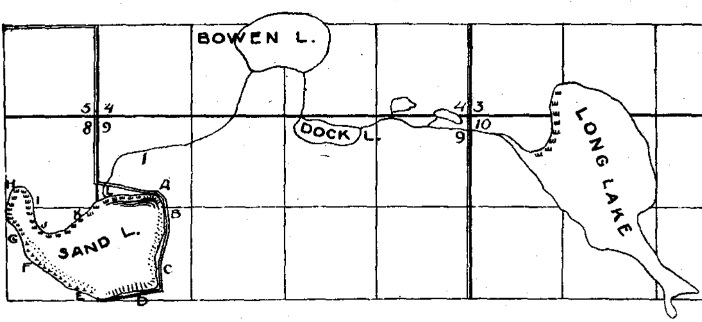


Fig. 30. Map of Sand and Long Lakes, Noble County, Ind.

Marl.—Long Lake, for lack of a boat, was only tested on the western side, where it revealed no marl at all. Sand Lake shows 10 feet of mucky marl in one foot of water at (A); but at (B) the marl has run out and there is only sandy bottom from (B) to (C). At (D) the marl is mucky and two feet deep in two feet of water; four feet deep in four feet of water, and at greater depths up to 16 feet, runs from three feet to zero in thickness. From (E) to (G) there is from one to three feet of muck in shallow water, or even out to 12 feet of water, but in 16 feet of water at every point the bottom is sandy. From (G) to (L) no marl is found, but everywhere the muck is deep, extending below drill in all tests. The amount of marl present is, therefore, too insignificant for further consideration.

MARL LAKE.

Thick Deposit of Doubtful Workable Size.

This is a small lake, east of Wolf Lake postoffice, in sections 10 and 11 (33 north, 9 east), Noble Township. It is about three-eighths by one-eighth mile in size and has an area of about 40 acres. It is largely surrounded by marsh land, beyond which the ground rises in rugged ridges.

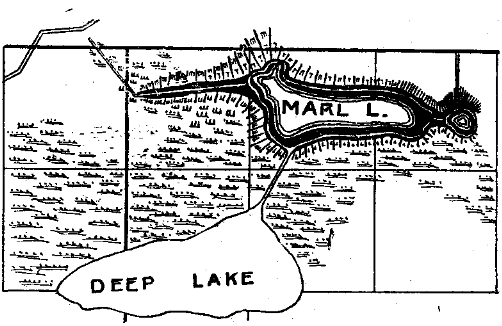


Fig. 31. Map of Marl Lake, Noble County, Ind.

Marl.—This lake seems to lack but little of being a solid marl bed. None of the tests in the lake with 16-foot drill reached the bottom of the marl, and around much of the shore the bare marl is exposed for 20 or 30 feet back, and extends still farther back, but with an ever increasing depth of muck over it. Up the ditch, at the west end of the lake, the marl is over 16 feet deep for a quarter of a mile; with from one to two feet of muck over it. Beyond that the marl is replaced with muck. At either side of the ditch the muck increases in thickness at the expense of the marl. There are several acres of marl additional in Little Marl Lake, just east of the other, and marl is reported as occurring extensively in the marshes in this neighborhood. While the acreage of marl in the lake and surrounding marshes is not large, its great depth renders it worthy of more detailed investigation than we could give it with the auger at our command.

Deep Lake, to the southwest of Marl Lake, has much aquatic vegetation around its margins. No boat was available for its exploration and the tests put down where it was possible to wade showed only muck.

BEAR AND HIGH LAKES.

Not a Workable Deposit.

These lakes are distant from one another about one-half a mile, and lie southwest of Wolf Lake postoffice, in sections 7, 8, 17 and 18 (33 north, 9 east) and section 13 (33 north, 8 east), Noble and Washington Townships.

BEAR LAKE.

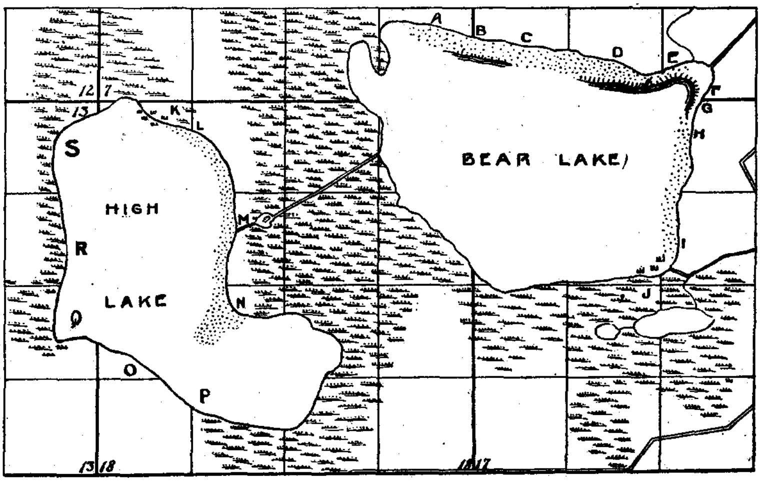


Fig. 32. Map of Bear and High Lakes, Noble County, Ind.

At the time of our visit in October, 1899, Bear Lake had a length of nearly a mile and a width of nearly three-quarters of a mile, with a water area of 320 acres. It was then a clean, compact body of water, with the banks of its north and east shores rising rather abruptly for 20 or more feet and then running back into a level or slightly rolling surface; while the south and west shores were bordered with extensive marshes, the area on the west between the two lakes being entirely a low marsh filled with dense aquatic vegetation. The water had a maximum depth of 50 and an average depth of perhaps 18 feet, the shallow water on all sides extending out well into the lake. In November, 1899, the lake was lowered six feet, thus destroying its natural beauty, by enlarging greatly the area of shallow water and causing great mud flats around its entire margin.

Marl.—Before the recent draining, Bear Lake had, for the most part, sandy and gravelly bottom in three feet or less of water. At (A) and (C) the bottom is clay instead of sand. In deeper water some marl was found. Thus at (B), in 10 feet of water, the marl is six feet deep. At (D) in five feet of water, there is sand six inches, over marl 10+ feet in thickness. Going toward (E) the marl was 11+ feet and overlain by one foot of sand in four feet of water. At (F) and (G) the marl extends to below 16 feet in water four to nine feet deep, but is mucky and poor. From (H) to (I) no marl was found. At (J) the bottom is muck to below 16 feet, and the same conditions prevailed along the south and west shores.

HIGH LAKE.

Before the recent dredging this was one of the prettiest lakes in Indiana. Along its eastern border was a natural ridge of sand and gravel, 30 to 50 feet wide, 15 to 20 high, and sparsely covered with fine oak and other trees, thus forming a beautiful site for camping parties and summer cottages. The waters of the lake were then clear and sparkling, well stocked with fish and mussels—a delightful resort for anglers and boating parties. Now all is changed. To gratify the caprice of a few men, who wished to enhance their acreage of land, a ditch was dredged through the gravel ridge and the marsh beyond, and "High Lake" was converted into a low mud-hole. The fish and bivalve shells are dead or dying. Rank weeds and aquatic rushes and cat-tails are rising over the marsh and sand bars which were formerly covered with clear, pure water. Mud and ooze, black, slimy, disgusting to the sense of sight and smell, is everywhere about the margins. Like hundreds of others of the fairer bodies of Indiana's inland waters, it has yielded forever its natural beauty to the devastating hand of man.

In 1893, Dr. Dryer wrote of High Lake as follows: "It is interesting from the fact that its basin seems to belong to a type hitherto undescribed in Indiana. The western half of section 7, Noble Township, is occupied by a series of sand ridges, perhaps 20 feet high, extending north and south. At the north end of High Lake they divide into two branches which follow the east and west shores respectively. Thus the lake basin lies between the arms of the Y in a space which is nearly closed up by a cross ridge along the south shore. These ridges are generally of moderate slope and from 20 to 40 feet above the lake, composed chiefly of sand; but at the point on the east side, where the outlet leaves the lake, the ridge is not more than three feet high and composed almost entirely of small, angular boulders. At this point it was first observed and was mistaken for a beach ridge. A few excavations in the higher part of the ridge show yellow sand intermingled with angular stones from the size of a man's fist to the size of his head. We evidently have here a specimen of the kames or eskers which are so numerous in other portions of the great morainic belt of North America."*

In its original condition the water area of High Lake was about one mile long by one-quarter to one-half a mile wide and with an area of 250 or more acres. The maximum depth of water was 30 feet. The bench of shallow water along the east side of the lake was very broad and near the bend in the lake extended out so that it was possible to wade fully one-third of the distance across. It is highly probable that High and Bear Lakes at one time formed one unbroken sheet of water, being connected around the south end of the sand ridge at (N).

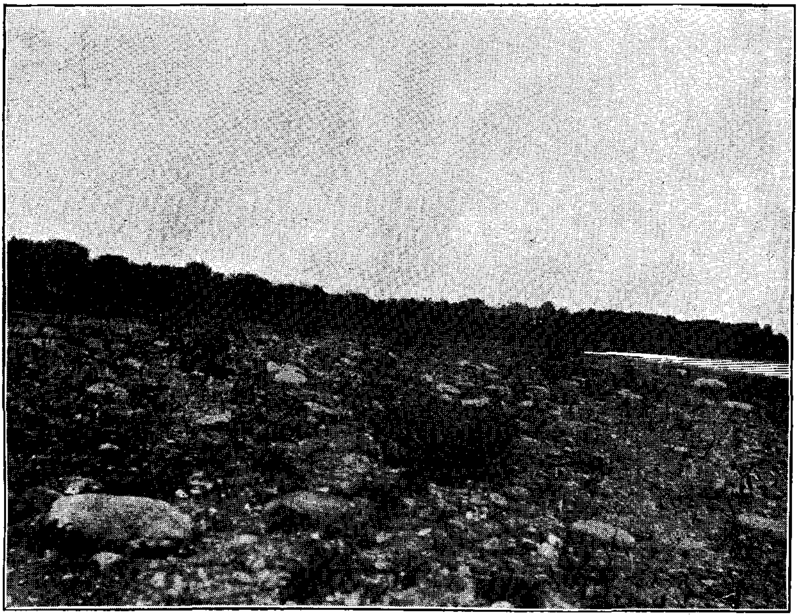
In October, 1900, no water above 22 feet in depth was found in what was left of the lake and three-fourths of the remaining water area was less than 12 feet deep, while it was everywhere thickly turbid with the sediment of decaying algæ and other organic matter. On the south side between (P) and (O) are wooded hills rising 25 to 40 feet above the former lake level. The water adjoining these hills has been reduced to a narrow morass, 20 rods wide, bordered on the north by the former bed of the lake, the surface of which is gravel and sand. A large portion of the former water area opposite the shore between (O) and (Q) has become a marsh covered with cat-tails. On the west shore between (R) and (S) a ridge of sand, 10 rods wide and thickly covered with boulders, has been brought to the surface. Over this were the scattered remains of many fishes and shells. One of the accompanying illustrations shows this ridge and gives a good idea of the nature of the former bottom of this portion of the lake.

MARL.—No trace of marl was found by any of the bores put down on High Lake. Along the entire eastern shore between (K) and (N) the bottom, for 250 and more feet out, was of sand before the lake was lowered. Much of this former sand bottom is now dry land. The southeastern lobe and the shallow water adjoining the entire southern and western shores is underlain with muck from 10 to 18+ feet in depth. A tamarack swamp occupies much of the former shore between (K) and the section corners. But little tillable land was reclaimed by the draining of High Lake and it would be far better to fill up the ditch and allow its basin to refill than to leave it as it is now, a pest-breeding spot of muck and mud.

* Loc. cit., p. 27.

PLATE 9.

a



b

Illustrating Results of Draining of High Lake, Noble County.

(a) Present beach on west side of lake, formerly covered with water; a portion of the kame or esker mentioned in text.

(b) Portion of esker island, and stretch of mud flat beyond; both formerly covered with water.

TIPPECANOE LAKE.

Not a Workable Deposit.

This, the largest lake in Noble County, lies in sections 28, 29, 32 and 33 (33 north, 9 east), in the extreme southern part of the county. It has a length of nearly one and one-half miles and a width of over one-half a mile. As a rule the shores seem to show rather broad areas of shallow water, the width from shore being, however, rather variable. The shores of the lake are low, except upon the south, where a wooded bluff rises 25 to 40 feet above the water level. This and adjoining lakes form the extreme head-waters of Tippecanoe River, one of the most picturesque streams of Indiana.

Dr. P. H. Kirsch reports* the following fishes as having been taken in the lake:

Lepisosteus osseus (L.). Common Gar-pike.
Ameiurus nebulosus (Le S.). Common Bullhead.
Pimephales notatus (Raf.). Blunt-nosed Minnow.
Coregonus artedi sisco (Jor.). Cisco.
Zygonectes notatus (Raf.). Top Minnow.
Lucius vermiculatus (Le S.). Grass Pike.
Chœnobryttus gulosus (Cuv. and Val.). War-mouth.
Lepomis pallidus (Mitch.). Blue-gill.
Micropterus salmoides (Lacépède). Large-mouthed Black Bass.
Perca flavescens (Mitch.). Ringed Perch; Yellow Perch.

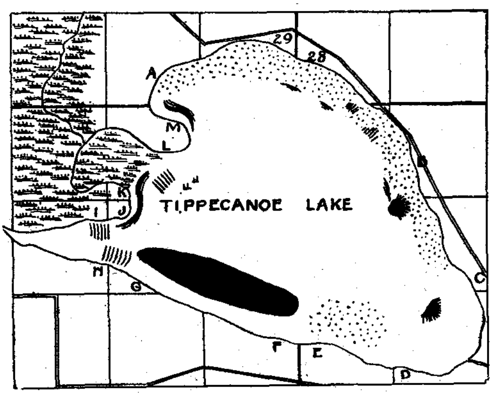


Fig. 33. Map of Tippecanoe Lake, Noble County, Ind.

Marl.—The marl deposits of Tippecanoe Lake are irregularly distributed. Along the east and northeast sides the shore tends to

*Bull. U. S. Fish Commission, 1894, p. 40.

show a hard sandy bottom of some width with marl in only a few places, and then generally in water eight or more feet deep. Off from (M) the marl extended below 16-foot drill in nine feet of water. Southeast of (L) beneath 12 feet of water only muck was found, though beneath eight feet of water near this eight feet of marl occurs. Off from (J) and (K) only muck having a depth of 13 feet and over occurs in shallow water, but out in seven to nine feet of water the bottom of marl could not be reached. Out from (H) the marl was thin, only four feet being found in seven feet of water. At the western end of the lake the water is shallow over a large area, running from three to 10 feet deep. Most of the drillings in this part of the lake found marl which in many cases extended to below 16 feet, but more often was less than eight feet thick. Along the western half of the south side there is a considerable area where the water is less than 10 feet deep and where all borings passed through marl to below 16 feet. Some marl was found in the southeast corner of the lake, but most of the drillings along the eastern end of the south side found a mud bottom. While the deeper waters of the lake are doubtless largely underlain with marl, the amount at present available in shallow water is too small to justify development.

WHITLEY COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 216.

1891.—Dr. C. R. Dryer, Seventeenth Ann. Rep. Ind. Dep. Geol. and Nat. Resources, p. 160.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 47.

1899.—E. B. Williamson, Proc. Ind. Acad. Sci., p. 151.

Whitley County is bounded on the north by Noble County, on the east by Allen, on the south by Huntington and Wabash and on the west by Wabash and Kosciusko counties. It contains 10 civil townships, nine of which correspond to the congressional townships and contain 36 square miles each; the other, Etna, in the northwest corner, having but 12 square miles—a total of 338 in the county. The county is crossed by three railways. The Pittsburgh, Fort Wayne & Chicago passes from northwest to southeast through the central portion; the Eel River Division of the Wabash, from northeast to southwest diagonally across the county, and the New York, Chicago & St. Louis (Nickel Plate), from east to west through the northern part of the southern tier of townships. The surface of the county lies between 787 and 948 feet above tide, the lowest point being near Collamer and the highest near Larwill. The elevation in feet above tide of the more important railway stations in the county is as follows: Churubusco, 887; Coesse, 850; Collamer, 787; Collins, 862; Columbia City, 838; Dunfee, 858; Larwill, 948; Peabody, 836; Taylors, 856; South Whitley, 813.

The entire area of the county is overlain with drift, the thickness of which is known in but two places, viz., at Columbia City, where it is 224 feet, and at Larwill, seven miles west, where it is 365 feet in thickness. That portion of the surface lying east and south of Eel River is flat or slightly rolling, being a part of the great level plain of east-central Indiana, though occasional knolls and ridges of drift, especially in Cleveland Township, give it some diversity. North and west of Eel River the surface is much more irregular and contains many deep, elongated valleys, with sharp, winding ridges intervening. The region drained by Blue River, comprising the northeastern third of the county, is less broken, but is still typically morainic in character.

The lakes of Whitley County are few in number and are found wholly in the northern tier of townships. Only eight have an area of more than 150 acres each. Of these seven were visited and are described in detail on the pages which follow. Five of the seven are largely underlain with marl, but only two of the deposits are deemed to be workable under present conditions. These two are distant from transportation facilities, so that some time must elapse before the marl will be utilized for cement making.

BLUE RIVER LAKE.

Large Deposit, Mostly Under Deep Water.

This lake lies two miles northwest of Churubusco, in sections 9, 10, 15 and 16 (32 north, 10 east), Smith Township. It is two miles or less from the Eel River Division of the Wabash Railway.

The lake is oblong in shape, narrower at the eastern end, about one and one-quarter miles long by one-half mile in average width, and has an area of about 420 acres. It has a very uniform depth of 40 to 55 feet. The area of shallow water is of medium width, rather broad on the east, south and west sides, and narrower on the north. The shores at most points are rather abrupt, the surrounding country being of a rolling type. The lake receives its waters from Upper Blue River, a small stream from Noble County, and from springs along the sides and bottom of the lake. The outlet, Blue River, a tributary of Eel River, is at the west end, and only a few rods from the entrance of the inlet above mentioned.

Blue River Lake is well stocked with game and food fishes, the large-mouthed black bass, blue-gill, ringed perch and calico bass being abundant. The following is a list of the fishes taken in the lake in 1892, by the State Fish Commissioner, Mr. P. H. Kirsch:

LIST OF FISHES KNOWN TO OCCUR IN BLUE RIVER LAKE.

1. *Lepisosteus osseus* (L.). Common Gar-pike.
2. *Amia calva* L. Dogfish.
3. *Ameiurus natalis* (Le S.). Yellow Cat.
4. *Ameiurus nebulosus* (Le S.). Common Bullhead.
5. *Minytrema melanops* (Raf.). Striped Sucker.
6. *Notropis anogenus* Forbes. Small-chinned Minnow.
7. *Notemigonus chrysoleucus* (Mitch.). Golden Shiner.
8. *Coregonus artedi sisco* (Jordan). Cisco.
9. *Zygonectes notatus* (Raf.). Top Minnow.
10. *Lucius vermiculatus* (Le S.). Grass Pike.
11. *Pomoxis sparoides* (Lacépède). Calico Bass.
12. *Chœnobryttus gulosus* (Cuv. and Valenc.). War-mouth.
13. *Lepomis cyanellus* Raf. Green Sunfish.
14. *Lepomis pallidus* (Mitch.). Blue-gill; Blue Sunfish.
15. *Lepomis gibbosus* (L.). Common Sunfish.
16. *Micropterus salmoides* (Lacépède). Large-mouthed Black Bass.
17. *Etheostoma eos* (Jor. and Cope.). Sunrise Darter.
18. *Etheostoma microperca* Jor. and Gilb. Least Darter.
19. *Perca flavescens* (Mitch.). Ringed Perch; Yellow Perch.

In his report on Whitley County, Dr. Dryer speaks of the mid-summer vegetation about the shores of this lake as follows: "Aquatic vegetation in great variety and profusion furnishes a botanist's paradise. The shores are nearly surrounded by a broad belt of plants arranged in distinct zones, according to the depth of the water. On approaching the shore the first zone appears at depths between eight and six feet, and consists of the water-shield, *Brasenia purpurea* (Michx.); pondweeds or *Potomogeton*, species with filiform leaves being very abundant; several kinds of bladderwort or *Utricularia* and water millfoil, *Myriophyllum.* At a depth of four feet the yellow pond lily, *Nuphar advena,* covers the water with its leaves, the spaces between being filled with a dense mass of *Chara* covered with a mantle of duckweed or *Lemna.* Here navigation becomes difficult. At a depth of three feet the pickerel-weed, *Pontederia* *cordata* L. appears with the water smartweed, *Polygonum amphibium*. At two feet the water passes gradually into a jungle of swamp loosestrife, *Decodon verticillatus* (L.); cat-tail, *Typha latifolia* L.; water-pepper, *Polygonum nodosum*; reed-grass, *Phragmites communis* Trin., and different species of willow, *Salix*, passable only by birds and reptiles. This lake is the only locality known to the writer in northeastern Indiana where the splendid American lotus, *Nelumbo lutea* (Willd.) occurs, and here it is as abundant as the white water lily, *Nymphæa odorata* Dryand. Its flowers are difficult to procure because they are gathered by numerous visitors as fast as they open, but the leaves, rolled up and rocking like a boat, or expanded into an orbicular shield twenty to thirty inches in diameter and flapping in the wind, present an interesting and attractive sight. The water of Blue River Lake in midsummer has the appearance of muddy coffee, and through the whole season teems with plant and animal life. Such a lake as this would repay a thorough and prolonged biological examination, and would furnish the naturalist with material enough for several years' study."*

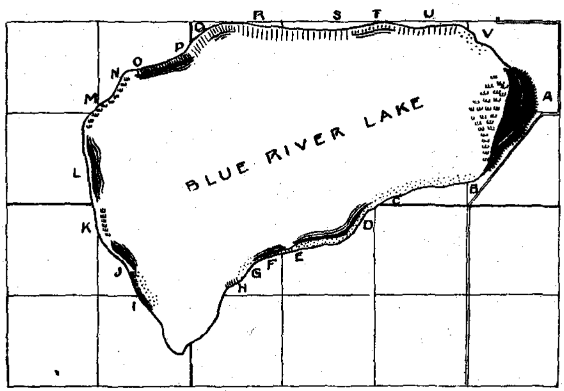


Fig. 34. Map of Blue River Lake, Whitley County, Ind.

Marl.—The distribution of the marl in Blue River Lake is very irregular. In places it extends back some distance from shore, while but a short distance away it is not found until deep water is reached. At (A) the bare marl extends back some distance from shore, 16 feet and more deep. Then it begins to be covered with sand, which increases in depth toward the bluff, the last drilling showing two feet of sand underlain by marl to below 16 feet. Out in the lake from shore, several tests in one foot or a little over of water showed over 15 feet of marl. In two feet of water the marl was only 11

* Loc. cit., p. 166.

feet deep with a blue mud bottom. Then the marl increases in depth again, but at the same time becomes mucky, and the tests in water from three to 16 feet deep showed only muck. How far the marl runs back under the bank can only be conjectured. At the east end of the south side of the lake, no marl was found, the bottom being sandy. Several attempts to find marl under the sand failed. From (D) to (E) the bottom is hard sand or blue mud for about 50 feet out from shore or in from five to eight feet of water, then for 25 feet, or in water from five to 15 feet deep, the marl is over 16 feet thick and of good quality. For a short distance, at (F), 25 feet from shore, the marl is beyond 16 feet deep in three feet of water. But diagonally out from this in six feet of water only blue mud is found. At (G) this mud bottom extends up to the shore, while at (H) the top of the mud is marly. At (I) the marl is one foot deep at the shore and the same out in one foot or a little over of water. In three feet of water and from there out the bottom is sandy. At (J) tests in water from two to five feet deep showed marl everywhere to below 16 feet. Just north of this only muck was struck, then the marl sets in again, the bottom not being reached in from one foot to seven feet of water. In the northwest corner of the lake only muck was found. Then from (O) to (P) the marl occurs again, running from one foot deep in six inches of water to beyond reach of drill at the six-foot water-line. East of this it is shallow again, only one foot of marl being found in four feet of water. From (R) to (V) the marl is variable, often being absent close to shore and in places is not over one foot thick in 10 feet of water; but generally the marl is of good depth in six to 10 feet of water.

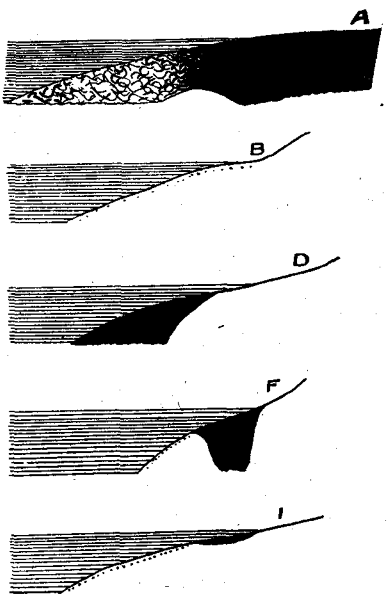


Fig. 35. Cross sections showing character of deposits at various points along shore of Blue River Lake, Whitley County, Ind.

The tests show that a large body of deep water marl occurs in the lake which may some day become available. The amount beneath shallow water is entirely too small to be of use at the present time.

ROUND, CEDAR AND SHRINER LAKES.

Not a Workable Deposit.

These lakes lie close together in sections 1, 2, 11 and 12 (32 north, 9 east), Thorn Creek Township. They are connected by natural or artificial channels and hence will be treated under one general heading. The railway nearest them is the Eel River Division of the Wabash, distant about three and one-half miles to the south-east.

ROUND LAKE.

This lake, which receives its waters from the other two and from the drainage of the neighboring woods and fields, has a length of seven-eighths of a mile and a maximum width of one-half a mile. Its shores on the north and east are rather thickly wooded and rise 20 to 30 feet above the water. The south shore is lower and bordered with cultivated fields. A long bay filled with aquatic vegetation extends out to the northwest. From it an artificial channel connects Round Lake with Shriner Lake. The inlet from Cedar Lake is through a marsh grown up with cat-tail flag, *Typha latifolia* L., button-bush, *Cephalanthus occidentalis* L., swamp loosestrife, *Decodon verticillatus* (L.), and a variety of other aquatic plants, with occasional stretches of open water. It enters the north side of Round Lake, while the outlet, Thorn Creek, a tributary of Blue River, leaves the south side. Thorn Creek has been dredged for some distance, thus materially lowering the water area of the lake. As a result, a number of long points project out under the water and there is a large area of shallow water in the western third of its basin. "Lowering the lake five feet more will fill it with sand bars or even reduce it to a number of ponds. An extensive tract near the head of Thorn Creek, which five years ago was a swamp, is now under cultivation. Among the farmers of the neighborhood the practice is common of planting artichoke among the spatterdock where the lowering of the lake has exposed the land. In the fall this is turned over to hogs and their persistent rooting in the soft earth pulverizes and dries the soil most effectually."*

In October, 1900, a series of soundings, about 10 rods apart, beginning at the eastern edge of shallow water on the west side and running east, a little south of the middle of the lake, showed the depth of the water to be respectively: 18, 12, 28, 25, 26, 32 and 17

* Williamson, loc. cit., p. 153.

feet. Another line running across from (M) to (C) gave 17, 22, 38, 48, 51, 54, 57 and 32 feet.

The vegetation about Round Lake is very rank. The spatterdock, *Nuphar advena* R. Bv., is very common, filling most of the bays and bordering the shores in many places. In the region of the second sounding, in the first series given above, a species of pondweed* was abundant, its fruiting head above the surface, its roots in the marl 12 feet below. Other species of pondweed are very common. Mr. C. C. Deam, of Bluffton, has found the reversed bladderwort, *Utricularia resupinata* Greene, growing along the western shore. The greater bladderwort, *U. vulgaris* L., is abundant, and eel grass, *Vallisneria spiralis* L., hornwort, *Ceratophyllum demersum* L., several species of water-millfoil, *Myriophyllum*, and the stiff white water crowfoot, *Batrachium tricophyllum* (Chaix.), cover the bottom of the more shallow portions of the lake.

The number of fishes in Round Lake is greater than in either of its neighbors, as is evinced by the following list of those taken in the three lakes in 1892 by Mr. Kirsch:

LIST OF FISHES KNOWN TO OCCUR IN ROUND, CEDAR AND SHRINER LAKES.†

1. *Lepisosteus osseus* (L.). Common Gar-pike.
2. *Ameiurus natalis* (Le S.). Yellow Cat.
3. *Ameiurus nebulosus* (Le S.). Common Bullhead.
4. *Catostomus teres* (Mitch.). Small-scaled Sucker; Black Sucker. Round Lake only.
5. *Erimyzon sucetta* (Lacépède). Chub Sucker; Sweet Sucker. Round Lake only.
6. *Minytrema melanops* (Raf.). Striped Sucker. Round Lake only.
7. *Pimephales notatus* (Raf.). Blunt-nosed Minnow.
8. *Notropis cayuga* Meek. Meek's Minnow.
9. *Notropis heterodon* (Cope). Variable-toothed Minnow.
10. *Notropis megalops* (Raf.). Common Shiner. Cedar and Round lakes.
11. *Hybopsis amblops* (Raf.). Silver Chub.
12. *Coregonus artedi sisco* (Jor.). Cisco. Shriner and Cedar lakes.
13. *Zygonectes notatus* (Raf.). Top Minnow. Shriner and Cedar lakes.

*This is the white-stemmed pondweed, *Potamogeton prælongus* Wulf. Another species very common in shallow water, where it formed thick beds on the bottom, was *P. robbinsii* Oakes. It grows but a foot or two high, and when the water is agitated the leaves spread out so that the whole plant resembles a fern. Both stem and leaves then wave gently to and fro in graceful motion.

† Where the species occurs in all three of the lakes no locality is given. Where in but one or two of them, they are mentioned specifically.

14. *Lucius vermiculatus* (Le S.). Grass Pike; Little Pickerel.
15. *Labidesthes sicculus* Cope. Brook Silverside; Smelt.
16. *Pomoxis sparoides* (Lacépède). Calico Bass.
17. *Chœnobryttus gulosus* (Cuv. and Valenc.). Warmouth.
18. *Lepomis cyanellus* Raf. Green Sunfish. Round Lake only.
19. *Lepomis pallidus* (Mitch.). Blue-gill; Blue Sunfish.
20. *Lepomis euryorus* McKay. Broad-eared Sunfish. Cedar and Shriner lakes.
21. *Lepomis heros* (Baird and Girard). Chain-sided Sunfish. Round Lake only.
22. *Lepomis gibbosus* (L). Common Sunfish.
23. *Micropterus salmoides* (Lacépède). Large-mouthed Black Bass.
24. *Etheostoma nigrum* (Raf.). Johnny Darter.
25. *Etheostoma eos* (Jor. and Cope.). Sunrise Darter.
26. *Etheostoma microperca* Jor. and Gilb. Least Darter. Round Lake only.
27. *Perca flavescens* (Mitch.) Ringed Perch; Yellow Perch.

MARL.—On the two bars indicated at (G) and (I) the water is shallow, a foot or less deep, and the marl from one to four feet in depth, while in two-and-a-half-foot water it thickens to seven feet. At the edge of deep water opposite (I) the marl had decreased to six feet and was underlain with a stiff, blue mud. In 12 feet of water it was six feet thick and underlain with gravel. Along the south shore between (J) and (K) the shallow water area, for the most part, overlies a good quality of marl 12+ feet in thickness. Near (M) in three feet of water it was 16+ feet thick but dark in color. At (A), across the lake, the same conditions exist, and at (B) there is too much muck to render the deposit of value. Good marl sets in again to the westward, and is everywhere 15+ feet thick in three feet of water. The shallow water area west of (C) widens greatly and is in most places, except within five rods of shore, underlain with marl below reach of 18-foot drill, though the water was seldom over 18 inches in depth. Close to shore the thickness of the marl is variable, running from three to 11 feet. The tests show that probably one-half of the area of the lake is underlain with marl. It is, however, variable in quality, much of that along the east end merging gradually into muck.

CEDAR LAKE.

This lake lies just northwest of Round Lake and empties into the latter through a broad, weedy channel. Cedar Lake is nearly divided into two unequal lobes, at the crossing of the north-south section line. The upper and larger lobe is about one mile long by one-quarter of a mile wide, with its main axis lying northwest and south-east. From its western side a short arm, now choked with vegetation, protrudes. The center of its basin shows a depth of water ranging from 45 to 79 feet. The lower lobe is but about one-third the size of the upper and is quite shallow. The shores of the entire lake are covered with underbrush, due to the fact that its level was raised by a dam at the same time that that of Shriner Lake was lowered. The shallow water area thus gained in the lower lobe is in part filled with muck and bears much aquatic vegetation, the spatterdock or yellow water lily being especially abundant. There are also many tree trunks and fallen limbs near the shore, which detract much from the original natural beauty of the lake.

MARL.—At most points around the lake the marl is shallow within the six-foot water line. Thus at (A) no marl is found in one or two feet of water, but in three feet or more of water the marl extends to below 16 feet. From (B) to (C) the marl is only six feet deep in seven feet of water, four feet in four feet of water, etc., the shallow water area being very narrow. From (D) to (E) the marl is deeper, being over 12 feet deep in four feet of water, and to below reach of drill at all depths beyond. From (E) to (G) some of the depths of marl found were as follows:

Water 4 feet—marl 8 inches to 3 feet.
Water 6 feet—marl 3 feet.
Water 7 feet—marl 7 feet.
Water 8 feet—marl 7 feet.

From (H) to (K) the marl is somewhat deeper, just about reaching 10 feet on the six-foot water line and extending below pole in all deeper water. At (L) only muck was found. Off the point at (M) the marl is over 15 feet deep in one foot of water at 75 feet from shore. From (N) to (P) in four and five feet of water, it runs from four to 10 feet in depth. Around most of the lake the area of shallow water is very narrow.

SHRINER LAKE.

This is one of the prettiest bodies of water in Indiana. Long and narrow, it lies like a priceless emerald of palest green, hidden and guarded by the surrounding hills. Its basin is in shape a deep trough or V, somewhat curved, one and one-quarter miles long by less than one-quarter mile wide in average width. In most places the water is shallow for only a few yards, or even feet from the shore line, when the bottom suddenly descends at a sharp angle to a depth, in some places, of 65 or more feet. A small stream, dry most of the year, enters the lake at its southwestern corner; but springs are almost the entire source of water supply, hence the clearness and purity of its depths. Back from the water line the shores rise in low bluffs, which are covered with oak, maple and beech timber. A few sycamores and cotton-woods grow near the water's edge. Around the northern lobe of the lake the shores have, for the most part, been cleared, and are cultivated in places, within 75 feet of the water's edge.

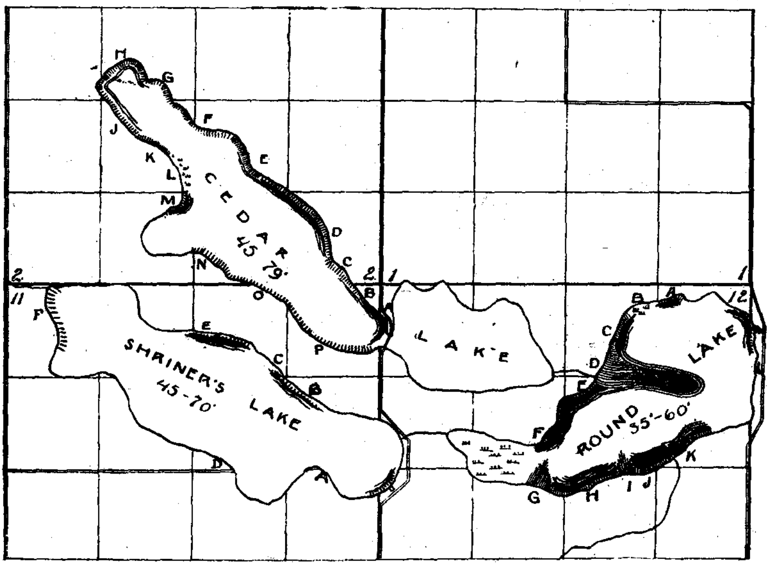


Fig. 36. Map of Cedar, Round and Shriner Lakes, Whitley County, Ind.

A number of soundings were taken in Shriner Lake on October 3d, 1900. In the southeast corner, at the boat landing, the water was six feet deep 20 feet from shore; 30 feet out it was 18 feet, and 100 feet out, 42 feet in depth. Forty rods west, on the south shore at (A), the shallow water area is less than 20 feet wide, then dips down at an angle greater than that of a steep house roof. The bottom, where it could be reached, was of a very tenacious blue mud, from which the auger, when sunk with difficulty about a foot, could hardly be removed. Ten feet from shore the water was eight feet deep. Three oar-strokes out it was 21 feet and 70 feet out was 32 feet. A line of soundings 50 feet apart from here across to (B) found the following depths: 45, 63, 65, 40, 27 and 8 feet, the last a boat's length from the north shore. Here the bottom was of marl six feet thick, with gravel beneath. At the bend, where the basin of the lake turns northward, a row of soundings from (C) to (D), 75 feet apart, resulted as follows: 48, 52, 50, 66, 60 and 34 feet. At this point the west shore is of gravel or sand, with but little vegetation. Sixty feet back from the water the wooded gravel hills rise 25 feet or more. Rowing 40 rods north along the gravelly west shore, another line, 10 oar-strokes apart, from east to west, showed 28, 51, 66, 62 and 26 feet. The shore on the east is here bordered by a marshy area, three to six rods wide, in which rushes, spatterdock and the green arrow-arum, *Peltandra virginica* (L.), flourish in profusion. The muck is here 12 feet deep in three-foot water, but at the water's edge the bottom is of a stiff blue mud. Just above this the lake narrows somewhat and then expands into a wider basin which comprises about one-quarter its area. Soundings near the center of this lobe showed the depth to range from 32 to 46 feet. Along the west shore of this basin the three-foot water line is underlain with 12 feet or more of muck, with gravel beneath.

In Shriner Lake and its neighbors, Round and Cedar lakes, are found growing in profusion many species of water-loving plants. Mr. C. C. Deam, of Bluffton, has taken there in August and September, the following species, all of which are aquatic, i. e., grow partly or wholly in the water:

LIST OF PLANTS GROWING IN ROUND, CEDAR AND SHRINER LAKES.

Typha latifolia L. Broad-leaved Cat-tail.
Potomogeton, four species. Pondweeds.
Sagittaria rigidi Pursh. Stiff Arrow-head.
Zizania aquatica L. Wild Rice.
Homalocenchrus oryzoides (L.). Rice Cut-grass.
Cyperus engelmanni Steud. Engelmann's Sedge.
Cyperus rivularis Kunth. River Sedge.
Dulichium arundinaceum (L.).
Eleocharis interstincta (Vahl.). Knotted Spike-rush.
Eleocharis mutata (L.). Quadrangular Spike-rush.
Scirpus americanus Pers. Chairmaker's Rush.
Scirpus atrovirens Muhl. Dark-green Bulrush.
Scirpus lacustris L. Great Bulrush; Mat Rush.
Scirpus lineatus Michx. Reddish Bulrush.
Rhynchospora glomerata (L.).
Cladium mariscoides (Muhl.). Twig-rush.
Carex lupuliformis Sartwell.

Carex comosa Boott. Bristly Sedge.
Eriocaulon septangulare With. Seven-angled Pipewort.
Pontederia cordata L. Pickerel-weed.
Juncus canadensis Gay. Canada Rush.
Rumex verticillatus L. Swamp Dock.
Polygonum incarnatum Ell. Slender Pink Smartweed.
Polygonum punctatum Ell. Water Smartweed.
Polygonum sagittatum L. Arrow-leaved Tear-thumb.
Brasenia purpurea (Michx.). Water-shield.
Nymphæa advena Soland. Large Yellow Pond Lily.
Castalia odorata (Dryand). White Water Lily.
Batrachium trichophyllum (Chaix.). Stiff White Water Crowfoot.
Decodon verticillatus (L.). Swamp Loosestrife.
Myriophyllum, one species. Water Millfoil.
Cicuta bulbifera L. Bulb-bearing Water-hemlock.
Cicuta maculata L. Water-hemlock.
Lycopus rubellus Moench. Water Hoarhound.
Mentha piperita L. Peppermint.
Gerardia paupercula (Gray). Small-flowered Gerardia.
Utricularia resupinata Greene. Reversed Bladderwort.
Utricularia vulgaris L. Greater Bladderwort.
Cephalanthus occidentalis L. Button-bush; Globe-flower.
Lobelia cardinalis L. Cardinal Flower.
Bidens beckii Torry. Water Marigold.
Bidens trichosperma (Michx.). Tall Tickseed Sunflower.

MARL.—On account of its deep shelving basin but little marl occurs around the margin of Shriner Lake. In the southeastern end near the boat landing there is a deposit six feet thick in two feet of water, and 12+ feet thick in six feet of water, but it is dark in color. Between (B) and (C) a better quality is found which is six feet thick in eight feet of water, but the bottom dips so rapidly that but little of it is available. Opposite (E), about half way the length of the east shore, there is an acre or two of shallow water, in which the marl is 15 feet thick in two-foot water and eight feet thick in one-foot water, with blue mud beneath. In the northwestern corner, at (F), there is a small area with marl bottom nine to 12 feet in thickness, in two to five feet of water. At all other points examined the bottom was of gravel, sand or muck.

There is, without doubt, quite an extensive deposit of marl beneath the deep water areas of Cedar and Round lakes, but that in Shriner Lake is evidently limited in extent. The deposit beneath the three lakes, considered as a whole, is not believed to be of sufficient importance to attract capital for cement making.

CROOKED LAKE.

WORKABLE DEPOSIT, PARTLY UNDER DEEP WATER.

The east end of Crooked Lake is only a little over a quarter of a mile from the west ends of Cedar and Shriner lakes, but is separated from them by the water-shed or divide between the basins of Eel and Tippecanoe rivers. This divide is a ridge about a fourth of a mile wide and 25 or 30 feet high. The lake lies in section 33 (33 north, 9 east), Noble Township, Noble County, and sections 3 and 4 (32 north, 9 east), Thorn Creek Township, Whitley County. It is

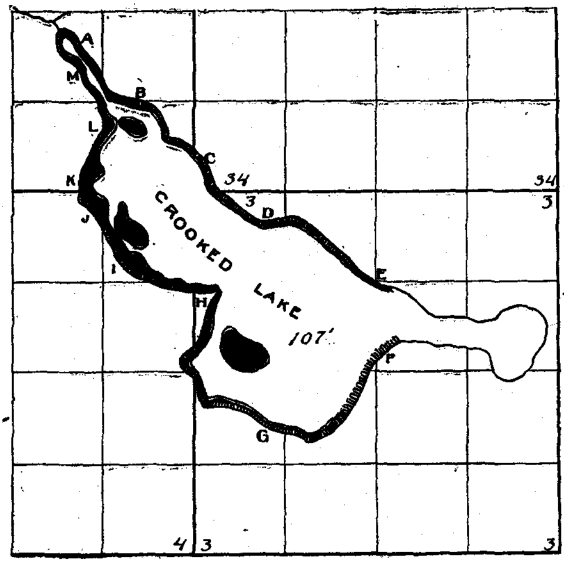


Fig. 37. Map of Crooked Lake, Whitley County, Ind.

very irregular in shape, as it grows very narrow at each end, while a prominent point from the southwest partly divides the main body into two irregular lobes. In size it is about one and one-quarter miles long with a width varying from a few rods to over half a mile, its main axis lying southeast and northwest.

The basin of Crooked Lake is very deep, a sounding of 107 feet having been taken near its center. Two submerged bars and a low island indicate a considerable area of fairly shallow water. The shallow water along the shore is generally narrow on the east side and around much of the eastern part of the main body of the lake. Along the western shore of the northwestern basin the shallow water bench is very irregular but with a good average breadth over the most of which the water is only a foot or less deep. The banks around the lake rise rather abruptly 20 to 30 feet, with rolling ground back from their crest.

The lake is well stocked with fish, among the larger of which may be mentioned the long-nosed gar-pike, cisco or lake herring, grass-pike, calico bass, blue-gill, large-mouthed black bass and ringed perch. The lake forms the headwaters of the Tippecanoe River which, by a very circuitous course, finds its way into the Wabash near Lafayette.

MARL.—Tests near the outlet of the lake at (A) showed three feet of marl in one foot of water, over 14 feet in two feet of water, and bottom not reached at greater depths. Toward (B) the marl in two feet of water ranged from eight to over 14 feet. The small shoal at the entrance to the western tongue has only about one foot of water over it and more than 15 feet of marl beneath. From (C) to (D) the marl is irregular, the three-foot water line varying from 20 to 100 feet from shore, and the marl from four feet to 13+ feet, the best being near the bend in shore, about half way between the two points. From (D) to (E) the shallow water is very narrow, in places the six-foot water line coming within 20 feet of shore. The marl runs from fair to good in thickness. At (F) the marl is four feet thick in four feet of water and five feet in eight feet of water, 100 feet from shore. Towards (G) the marl gets thicker, until 10 feet deep in two feet of water. On the shoal between (G) and (H) it extends to below 16 feet. At (H) the marl is mucky. From (H) to (M) the marl extends to below 16 feet at every point tested, including the island. Much of the shallow water area is broad and has only a foot or less of water over it, so that a large area of available marl is present along this shore. There is no doubt but that the greater part, if not all, of the deep water of this lake is underlain with a thick marl deposit. By lowering the water five to eight feet, a sufficient supply could be added to that already available to last a large cement factory for many years. We would not advise such a course, however, as under its present conditions, the lake is far more valuable to mankind at large than it would be were much of its present water area turned into mud flats. Then only a few manufacturers would derive a benefit from its marshy shores. Now the angler and the sportsman from far and wide can seek health and pleasure o'er its watery expanse.

LOON LAKE.

WORKABLE DEPOSIT, PARTLY UNDER DEEP WATER.

Two years ago this was one of the most beautiful sheets of water in northern Indiana. To-day it is a mud hole—a pond surrounded by wide margins of ill-smelling muck and marl. Then its clear waters rippled against the shelving banks almost at the very thresholds of the many summer cottages in the beautiful wooded grove on the south and east shores. Now a barren waste of gravelly or marly beach, 85 paces wide and in part o'ergrown with noisome weeds, intervenes between the cottages and the edge of the water, while the latter is not over two feet deep for 10 rods or more farther out. There are weeds enough on earth and places sufficient for their growth without changing a clear watery expense, like that formerly existing here, into a barren, weed producing waste. Yet the average human, who sees no beauty in such spots as was Loon Lake—who is possessed only of the desire to conquer and hold in thralldom more of the acres of our mother earth, goes on with his dredging and his ditching, and will so continue until all of nature's beauty spots are gone, and only dreary weed patches and cultivated fields remain.

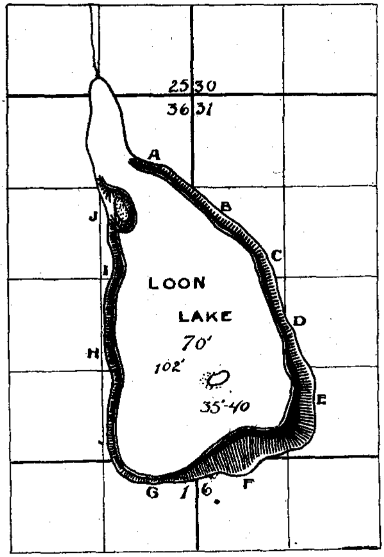


Fig. 38. Map of Loon Lake, Whitley County, Ind.

The basin of Loon Lake lies nine miles northwest of Columbia City, and is partly in Noble and partly in Whitley County. That portion in Noble County lies in section 31 (33 north, 9 east), Noble Township. That part in Whitley County lies in section 36 (33 north, 8 east), Etna Township; section 1 (32 north, 8 east), Troy Township, and section 6 (32 north, 9 east), Thorn Creek Township. It is roughly bottle-shaped with a short neck to the north and has a length northwest and southeast of one and one-eighth miles and a width of one-half mile. Before draining the water was very clear, so that objects at the bottom of 30-foot water could be plainly seen. The maximum depth was 102 feet, just northwest of a small but pretty island near the southern shore. Between this island and the shore to the south the deeper water ranged from 35 to 40 feet, while the main body of water north of the island had an average depth of 70 feet. The lake was fed by the overflow of Old and New lakes, each with an area of about 60 acres, and lying respectively one-half mile to the west and southwest. Numerous springs also welled up from its bottom, their waters adding to the clearness of its contents. Its outlet joined with those of Tippecanoe and Crooked lakes to form a tributary of the Tippecanoe River. Since draining, in the spring of 1900, the depth of water in Loon Lake has decreased 12 feet, leaving a wide margin of the basin bare, and greatly increasing the shallow water area.

The lake is well stocked with food and game fishes, the following 15 species having been taken in one-half day by Prof. P. H. Kirsch during his investigations in 1892:

LIST OF FISHES KNOWN TO OCCUR IN LOON LAKE.

1. *Lepisosteus osseus* (L.). Common Gar-pike.
2. *Ameiurus nebulosus* (Le S.). Common Bullhead.
3. *Pimephales notatus* (Raf.). Blunt-nosed Minnow.
4. *Notropis cayuga* Meek. Meek's Minnow.
5. *Notropis heterodon* Cope. Variable-toothed Minnow.
6. *Zygonectes notatus* (Raf.). Top Minnow.
7. *Lucius vermiculatus* (Le S.). Grass Pike.
8. *Labidesthes sicculus* Cope. Brook Silverside.
9. *Chænobryttus gulosus* (Cuv. and Valenc.). War-mouth.
10. *Lepomis pallidus* (Mitch.). Blue-gill; Blue Sunfish.
11. *Lepomis megalotus* (Raf.). Long-eared Sunfish.
12. *Lepomis gibbosus* (L.). Common Sunfish.
13. *Micropterus salmoides* (Lacépède). Large-mouthed Black Bass.
14. *Etheostoma caprodes* (Raf.). Log Perch; Hogfish.
15. *Perca flavescens* (Mitch.). Ringed Perch; Yellow Perch.

MARL.—The investigation of the marl resources of Loon Lake was made before the draining took place and the conditions then found are now greatly modified. From (A) to (D) the conditions are much the same; the marl, which is thin or wanting close to shore, rapidly increasing in depth until in four or five feet of water it extends to below 16 feet from the surface. The line of six-foot water runs from 75 feet to 100 feet from shore. Toward (E) the shallow water area gets broader, and tests near shore show sand over the marl. Thus at 30 feet from shore in two feet of water there is found one foot of sand and seven feet of marl. In three feet of water the marl is over 13 feet thick. Going toward (F) the marl is not so deep, drillings in three feet of water showing from three to 12 feet of marl, while one drilling in four feet of water showed only 10 feet. In deeper water the marl is beyond end of drill. The lake bottom around the island appears to be all gravel and a gravel bar covered with small boulders extends some distance west of the island. Along the west shore much the same conditions as on the east shore prevail, until toward the north end, where a sand and mud shoal occurs. A stop of less than a quarter of an hour was made on the south shore of the lake in October, 1900, while enroute to a station on the B. & O. Railway. There was no time for tests with auger. Along this shore the marl sets in and forms the surface of the drained area 120 feet out from the former margin. Over a wide area along the east shore it also forms the surface. The 120 or more acres in Old and New lakes, one-half mile distant, are reported to be wholly underlain with a good quality of marl. There is sufficient in the three lakes, or for that matter in Loon Lake alone, to attract the attention of capital for manufacturing purposes.

The quality of the Loon Lake marl, based upon chemical analysis, is fair only. In appearance it is white enough, and it is more than probable that samples carefully taken from below the surface with a spade will show better, as it is almost impossible to avoid mixing other substances with it when brought up from beneath water by the auger. An analysis of an average of a number of samples so obtained resulted as follows:

Analysis of Marl From Loon Lake.

Calcium carbonate ($CaCo_3$)	82.07
Magnesium carbonate ($MgCo_3$)	2.63
Calcium sulphate ($CaSo_4$)	.22
Ferric oxide (Fe_2O_3)	.42
Alumina (Al_2O_3)	.41
Insoluble inorganic matter (silica, etc.)	5.95
Organic matter	6.71
Total	98.41

CEDAR LAKE.

NOT A WORKABLE DEPOSIT.

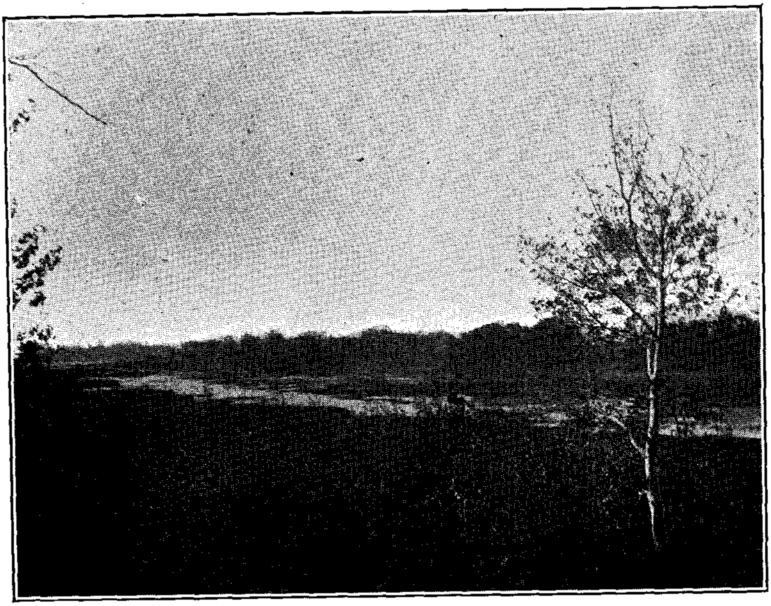
This lake lies in sections 10 and 11 (32 north, 8 east), Troy Township, about eight miles northwest of Columbia City and three miles southwest of Loon Lake. It occupies a valley 25 to 40 feet lower than the surrounding country. The original water area of about 150 acres has been lowered 10 feet by a ditch and water now covers only about 110 acres. For this reason the shallow water area around the margin is very narrow, and there are wide beaches of sand and muck which were formerly covered with water. The main body of the lake, comprising more than three-fourths of its southern area, is quadrangular in shape with narrow bays extending out some distance from the southeast and southwest corners. From the northeast corner of this main body the north shore runs 25 rods west, then turns north to form the narrow northern lobe of the lake which has its longer axis lying northwest and southeast.

On the south half of the east shore the gravelly beach rises gently into a level meadow about 25 rods wide, which intervenes between the lake and a wooded ridge. The shore is bordered with the rushes *Scirpus americanus* Pers. and *S. lacustris* L., but the bottom of the lake shelves off rapidly, 14 feet of water being found 50 feet from the margin. The northern half of the east shore is low and mucky, many soft maple trees (*Acer saccharinum* L.) fringing the woods which lie beyond. The north and northwest shores are bordered by an extensive morass, over which the elbow brush or button bush, *Cephalanthus occidentalis* L., the winter berry, *Ilex verticillata* (L.), the swamp loosestrife, *Decodon verticillatus* (L.), and several species of dwarf willows and other mud-loving shrubs, grow in such profusion that one can scarcely force his way among them. Beyond these shrubs is a large tamarack swamp. The margin of this portion of the lake is widely bordered with cat-tails and spatterdock, and the water evidently formerly covered a large area to the northwest. The west and south shores are, for the most part, low, with mucky margins. Only at one place, on the south side of a point of land which extends out from the north half of the west shore does a gravelly margin occur. Here numerous boulders cover the surface for some distance back from the water's edge.

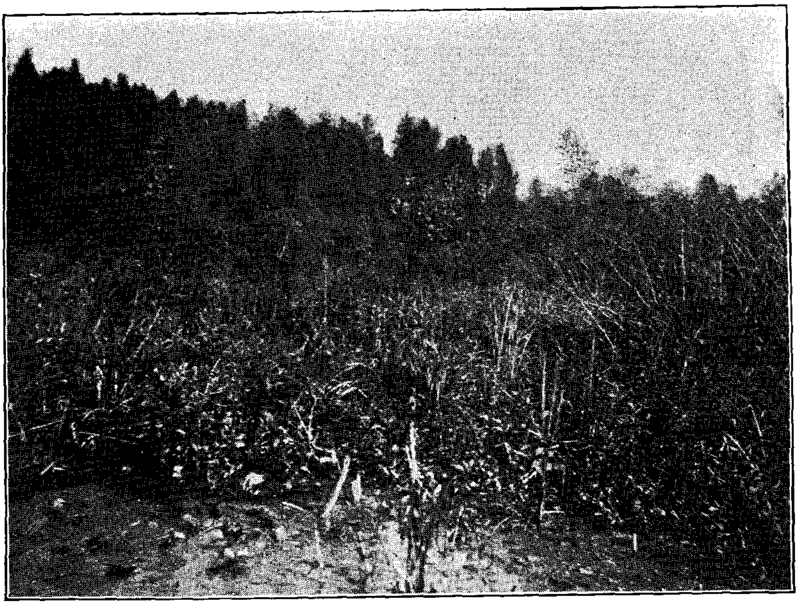
The water of Cedar Lake is turbid and contains enormous quantities of the lower forms of vegetable organisms. At places, especially over most of the northern lobe, the wake of the moving boat was bordered by a plainly visible line of green slime composed of

PLATE 10.

a



b



(a) Long arm of Crooked Lake, Steuben County, nearly choked with aquatic vegetation. (See page 84.)

(b) Showing dense character of vegetation growing on drained marsh north of West Cedar Lake, Whitley County. Tamarack grove in the background.

unicellular plants. A row of soundings about 10 rods apart, taken from east to west and 15 rods south of the north shore of the main body, showed the following depths: 12, 15, 24, 26 and 32 feet. Over the greater portion of the north lobe the depth ranges from 12 to 18 feet. A line of soundings from north to south, 25 oar-strokes apart, along the eastern margin of the western third of the main body of water found the depths to be respectively 25, 38, 44, 20, 24, 18 and 40 feet. Another line from west to east, along the northern margin of the southern third of the same body gave 40, 71, 81, 72 and 28 feet. Two soundings near the center gave 83 and 87 feet, the latter being the maximum depth found.

Besides the plants above mentioned the eel grass, *Vallisneria spiralis* L., the white water lily, *Castalia odorata* (Dryand), the three-squared rush, *Scirpus americanus* Pers., and the green arrow-arum, *Peltandra virginica* (L.), occur in the narrow shallow water area, around the main body of the lake, while the duckweeds, *Spirodela polyrhiza* (L.) and *Lemna minor* L., and the ditch-moss, *Philotria canadensis* (Michx.), flourish in profusion in the more shallow northern lobe. Muskrat houses were plentiful and their principal winter food—the fresh-water bivalves—were abundant in individuals but not in species, only *Anodonta grandis* Say, *Unio luteolus* Lamarck and *U. subrostratus* Say being found. Where the rats feed upon the thin shelled *Anodontas* one valve is always broken, but the valves of the thicker shelled *Unios* are left intact. How the animal opens them thus is, as yet, an unsolved problem.

The outlet of Cedar Lake leaves the southwest corner, and flows westward, uniting with that from Robinson Lake on the west line of the county, then northward into Ridinger Lake, Kosciusko County, and finally forms a tributary of the Tippecanoe River.

MARL.—But little marl was found in Cedar Lake. It is fed mainly by small streams which enter from the north, and by the drainage of the surrounding fields, hence the conditions for marl deposition are poor. Near the southeast corner a shallow water area 15 rods wide borders the south shore. Beneath this, in two to five feet of water, six feet of a fairly good quality of marl occurs beneath three feet of a mixture of muck and marl. The narrow shallow water area around the remainder of the lake was everywhere underlain with muck 12+ to 18+ feet in thickness according to the depth of the water, except at two points on the north half of the east shore where a poor quality of marl, 12 feet thick, occurs in four-foot water 75 feet from shore. The marl is here underlain with a stiff blue mud, which could not be penetrated with the auger.

ELKHART COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 198.

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. of Ind., p. 451.

1899.—Frank Leverett, Water Supply and Irrigation Papers, No. 21, U. S. Geol. Surv., p. 23.

This county is bounded on the north by the State of Michigan, on the east by Lagrange and Noble counties, on the south by Kosciusko, and on the west by Marshall and St. Joseph. It is quadrilateral in outline and contains an area of 465 square miles.

The county is well supplied with railways. Three divisions of the Lake Shore & Michigan Southern traverse its bounds, while the Michigan Division of the "Big Four" and the Chicago Division of the Wabash pass entirely through it, the former in a north and south direction, the latter east and west along the north border of the southern tier of townships. The Baltimore & Ohio also cuts across the southeastern corner.

The St. Joseph River enters the county from Michigan, about six miles west of the northeast corner and flows in a southwest course into St. Joseph County. At Elkhart it receives its principal tributary, the Elkhart River, which drains the southeastern portion of the county. Both the St. Joseph and the Elkhart are dammed in numerous places, and furnish cheap and excellent water power for many extensive factories, especially at Goshen and Elkhart.

In common with all the counties in which the lakes occur, the surface of Elkhart is wholly covered with drift, the thickness of which is known at three points, viz., Elkhart, Goshen and New Paris, where it is respectively 122, 162 and 90 feet. The surface of this drift is more level than in the counties to the east and south, an area of about 200 square miles in the northwestern and southeastern parts of the county being composed of extensive gravel plains. The uplands consist of till plains, with an area of 125 square miles, in the southwest part of the county, and of morainic belts, more broken, in the southern and western portions. The elevation in feet above tide of some of the more important railway stations in the county is as follows: Bristol, 783; Dunlaps, 747; Elkhart, 725 to 755; Goshen, 796; Millersburg, 885; New Paris, 813; Vistula, 808. The gravel plains in general are below the 800-foot level. The uplands are mainly between 800 and 900 feet above tide, though several of the higher points rise above 900 feet.

The lakes of Elkhart County are few in number and small in size, and are, with one or two minor exceptions, confined to the civil townships of Osolo and Washington, adjacent to the Michigan line.

SIMONTON, MUD AND COOLEY LAKES.

WORKABLE DEPOSIT.

The former beds of these lakes occupy parts of sections 13, 14, 15, 16 and 17 (38 north, 5 east), Osolo Township. They lie in an east and west line with their northern borders within one-half to three-fourths of a mile of the Michigan boundary. Simonton Lake is the only one of these which at present contains a large water area, the other two having been drained. On account of their proximity, the three are treated under one heading.

SIMONTON LAKE.

This lake lies about three miles north of Elkhart and not far from the Michigan line. Its longer axis is east and west and it has

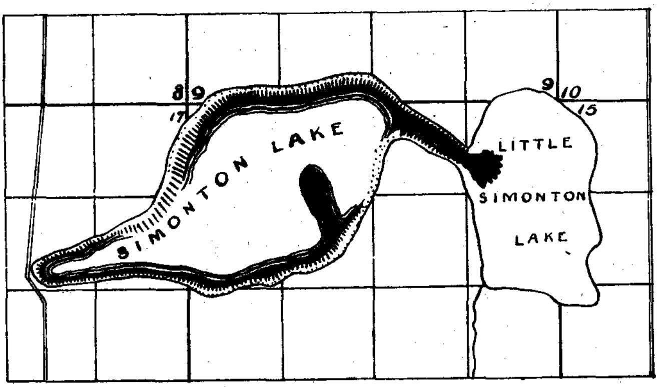


Fig. 39. Map of Simonton Lake, Elkhart County, Ind.

a length of one and one-half miles and width of over one-half mile. A large tongue of land from the south, jutting out a little east of the center, divides the lake into two unequal parts. When visited in the fall of 1899, the eastern or smaller of these was nearly dry, being in the condition of a marsh with open water channels too shallow for a boat. This part is sometimes known as "Little Simonton." The main body of the lake has shores with a fairly rapid descent. Some shallow water (four to five feet) exists just east of the center of the main part of the lake, but the greater part of its area runs from six to 15 feet in depth. The outlet flows southward into the St. Joseph River.

MARL.—Marl is found all around this lake except from the north end of the dividing tongue of land to the boathouse on the southwest corner. As a rule the marl runs out a short distance from the shore but quickly attains a good thickness, which is maintained out to deep water. Little Simonton Lake was in the main inaccessible; tests made in it as far as it could be entered from the west showed 16 feet of marl. In quality the marl appeared unusually white and good, and as tested by the drill it seemed much more firm than the average deposit.

MUD LAKE.

Before draining, the water area of this lake was about a mile long by three-quarters of a mile wide. The lake is now a vast marsh, the water area having been reduced to about 15 acres which is a mud hole, the water averaging about three feet in depth. In general the surface is muck, which varies in thickness from one to four feet. Peat was found in but two places, between the muck and marl. Marsh grasses of various kinds formed the prevailing vegetation. Around the border of the remaining water were many cat-tails and rushes. The remains of many large bivalve shells, mainly *Anodonta grandis* Say, were scattered about the surface. The shells of one or two species of *Planorbis* were also very abundant.

The outlet of Mud Lake formerly flowed south and united with that of Heaton Lake, which lies about one mile to the southeast, to form a tributary of the St. Joseph River.

COOLEY LAKE.

The greater portion of the former area of this lake is now a quagmire over which no man can pass in the summer season, for he can not push a boat through the cat-tails, spatterdock and other aquatic vegetation, and if he attempted to wade he would sink in many places up to his arm pits, if not deeper. Its western end is about one-third of a mile east of the former bed of Mud Lake, and its south side one-half mile north of Heaton Lake, into which its outlet formerly flowed. Between Mud and Cooley lakes there is a ridge of higher ground, part of which is covered with a dense growth of tamarack, swamp huckleberry, button bush and other marsh-loving trees and shrubs.

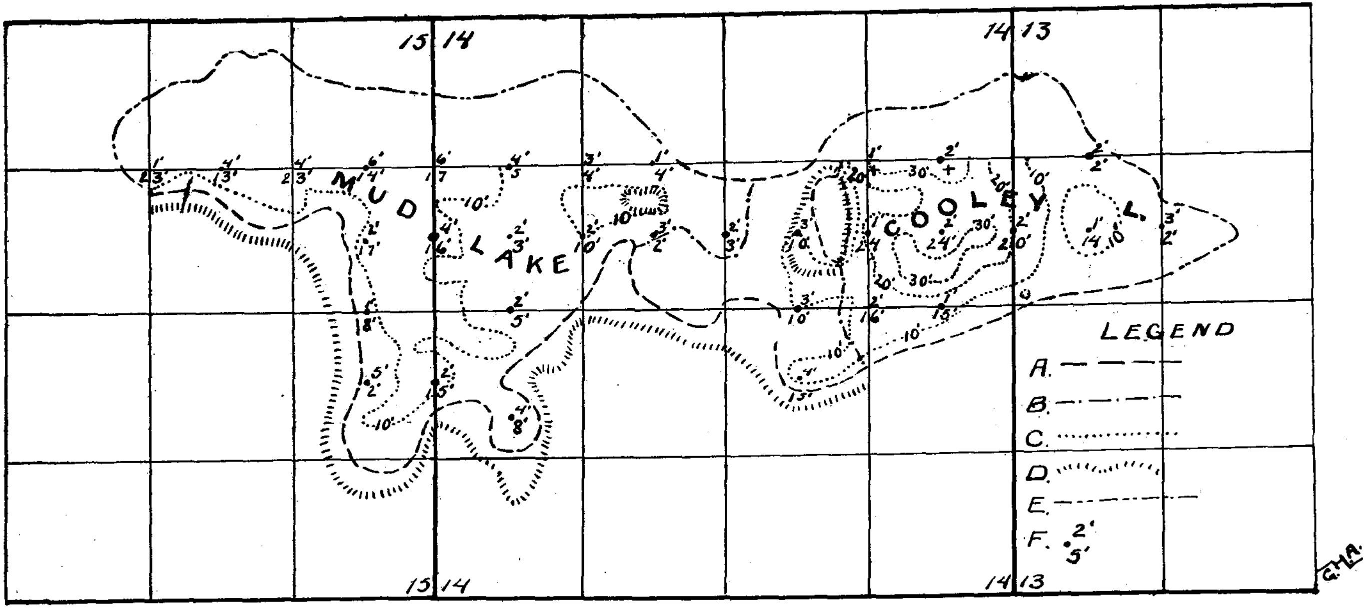


Fig. 40. Map Showing the Deposit at Mud and Cooley Lakes, Elkhart County, Ind.

LEGEND.

A. Approximate limits of marl.
B. Lines separating different qualities of marl.
C. 10-foot contours showing depth of marl.
D. Edge of flat land.
E. Approximate limits of marl in N. ¼ of sections.
F. Upper figure, depth of muck; lower, depth of marl.
A-D-F. From actual surveys made for the Goshen Portland Cement Co.
E. Based on county atlas.

MARL BENEATH MUD AND COOLEY LAKES.—The Goshen Portland Cement Co. has purchased most of the former area of Mud and Cooley lakes, and had an accurate survey made, and many test bores put down to show the thickness and distribution of the underlying marl. These tests were made 20 rods apart by digging a square hole through the muck to the surface of the marl and then taking the depth of the latter. The accompanying map shows in detail the results of these tests.

In July, 1900, Mr. Blatchley spent two days on the property and verified most of the tests made by the representative of the company. With the assistance of Mr. Josiah Replogle 72 bores were put down, mostly at intervals of 20 rods and near or in the holes made by the company. Of these 46 were on the former bed of Mud Lake and 26 around the margins of Cooley Lake. Of those on Mud Lake 14 showed a thickness of marl above 15 feet; 10 showed a thickness ranging from seven to 15 feet; 16 found marl between one and seven feet, while six found only muck.

Of the 26 bores around Cooley Lake, 14 found marl over 16 feet thick; in six the marl ranged from five to 15 feet, while in four it ran from one to five feet. But two bores showed no marl. Over a large portion of the northern half of Cooley Lake, the muck is too thick to justify the working of the underlying marl, if any be present.

All of the marl beneath Mud Lake is overlain by muck, the average thickness of which is about two feet, none of the bores showing over three feet. In Cooley Lake the average thickness of the muck over the marl is one and one-half feet. Wherever the muck ran over four feet, no marl was found beneath.

The marl in Mud Lake is whitish or light yellow in color, while that beneath Cooley Lake is bluish-gray when first uncovered. This difference in color is doubtless largely due to the dryer and more compact form of that beneath Mud Lake.

According to the careful estimate of the Osborn Engineering Co., who made the survey and tests for the present owners, there is 55,-115,400 cubic feet of the yellow marl beneath the former bed of Mud Lake; 16,380,500 cubic feet of grayish marl in the marshy interval between Mud and Cooley lakes, and 67,238,500 cubic feet of "blue marl" beneath Cooley Lake. This shows a total of 5,150,000 cubic yards. As each cubic yard will furnish carbonate of lime sufficient for two barrels of Portland cement, there is marl enough on the property owned by the Goshen company to supply a cement factory having an output of 1,000 barrels per day for 30 years or a 500-barrel-a-day factory for 60 years. This estimate does not take into consideration the marl underlying Simonton Lake, which can be made easily available by tramway from the site on which the company proposes to erect its factory.

An analysis of an average sample of the light yellow marl from Mud Lake, made by the Osborn Engineering Co., of Cleveland, O., and submitted to the Goshen Portland Cement Co., showed its composition to be as follows:

Calcium carbonate ($CaCo_3$)	82.89
Magnesium carbonate ($MgCo_3$)	2.04
Ferric oxide (Fe_2O_3) and alumina (Al_2O_3)	.64
Insoluble inorganic matter (silica, etc.)	7.94
Organic matter	3.67
Total	97.18

An analysis of the blue marl beneath Cooley Lake made by the same parties resulted as follows:

Calcium carbonate ($CaCo_3$)	88.21
Magnesium carbonate ($MgCo_3$)	4.78
Ferric oxide (Fe_2O_3) and alumina (Al_2O_3)	.88
Insoluble inorganic matter (silica, etc.)	1.42
Organic matter	2.58
Total	97.87

These analyses show a good quality of marl for cement making purposes. The yellow-white marl is lower in magnesium carbonate, and is probably better adapted for cement than the other.

HEATON LAKE.

NOT A WORKABLE DEPOSIT.

This lake occupies parts of sections 23 and 24 (38 north, 5 east), Osolo Township. It lies one-half mile southeast of the old bed of Cooley Lake and formerly received the overflow from that body of water. Heaton Lake was ditched about 1885 and its level lowered about five feet. Its outlet, in part artificial, empties into the St. Joseph River. The extreme length of its water area is now about three-quarters of a mile and its greatest width 80 rods. The shallow water along the shores is narrow, except on the west and northwest, where great masses of *Chara* nearly reach the surface and make the passage of a row boat very difficult. The maximum depth is 41 feet, though the greater portion is between 15 and 25 feet. The shores are everywhere low and in most places marshy for five rods back, when they rise gently; on the north and east into wooded slopes, on the south into cultivated fields or meadows. A vast marsh of cattails borders the west shore and continues along the outlet for some distance.

Among the fishermen of Elkhart, Heaton Lake is noted for its bass, which reach a weight of eight pounds; its pickerel, which are often caught up to 15 pounds, and its buffalo or red horse of equal or greater weight.

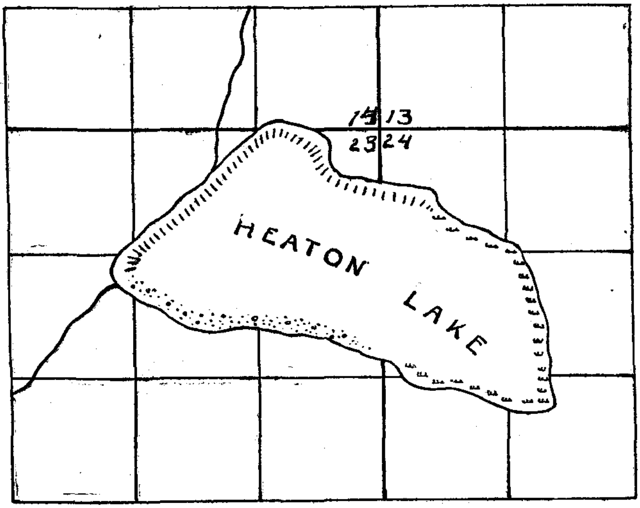


Fig. 1. Map of Heaton Lake, Elkhart County, Ind.

MARL.—But little marl occurs beneath the shallow water of the lake. The bottom of the entire eastern third is of muck beyond the reach of 18-foot auger in one to seven feet of water. Along the middle of the north shore beneath five to seven-foot water the marl is three to six feet thick. On the west shore, beneath the *Chara* above mentioned, the marl is but two feet in thickness with sand beneath. Along the western half of the south shore, the bottom is of gravel in most places, though two bores showed seven feet of a dark colored marl. It is probable that the deeper water is in part underlain with a thicker marl deposit, but there is not enough to attract capital for its development.

INDIANA AND LONG LAKES DEPOSIT.

WORKABLE.

This deposit occupies a semicircular chain of small lakes lying mainly in Michigan, but with their south ends extending into Indiana. Those portions of the deposit in Indiana are on the north edge of Elkhart County, a little west of north of Bristol. Only the parts in Indiana, or just over the line in Michigan were visited. This includes the deposit in Indiana Lake and in the flat stretch south of Long Lake. Baldwin, Coverdon and Long Lakes in Michigan were not examined.

INDIANA LAKE.

Indiana Lake lies in sections 8 and 9 (38 north, 6 east). Its area is estimated at 100 acres. Except over a small area on the east side of the lake, marl covers the bottom wherever tested. Along the west side the belt of shallow water is very narrow and everywhere showed marl to below reach of the drill. There is more shallow water at the south end of the lake, and a long tongue of similar water juts out from the east shore near the north end, where the marl is deep except close to the shore. In the northeast corner there are a few inches of sand over the marl which here runs from three feet deep on up.

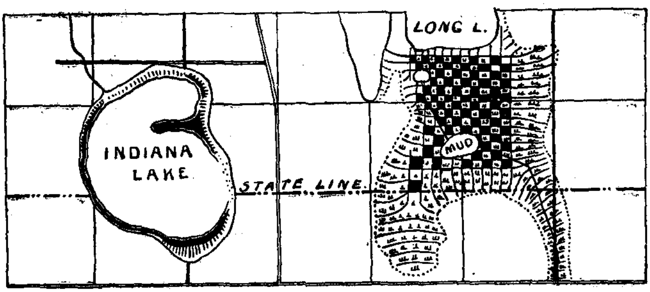


Fig. 42. Indiana Lake and Marl Deposit South of Long Lake.

A half mile east of Indiana Lake is a flat valley extending south from Long Lake. At the south end of this valley the marl is shallow, being but one or two feet deep. Toward the little basin known as Mud Lake it thickens up to over 24 feet, and apparently this or a greater depth is maintained northward to Long Lake. Over most of this area, the marl is overlain by muck, running from 0 to four feet in thickness. As a rule the muck is thin or wanting near the center of the valley and increases in thickness toward the edges. Its average thickness is not far from two and a half feet. There is about 130 acres of marl land in this valley south of Long Lake. The marl in this deposit appeared to be of excellent quality, that in Indiana Lake, especially, being very white. It was formerly burned for lime.

Including the deposits in and around Long, Baldwin and Coverdon lakes, there are reported to be 400 or more acres of marl land which will run over 15 feet in average thickness. The deposit is, therefore, one of the largest treated in this report, and on account of a large portion of it lying above or in shallow water, it can be readily and cheaply worked. The Monolith Portland Cement Company, with headquarters at Bristol, has already secured a major portion of this deposit and will soon erect near Bristol a large cement plant. A dam is being constructed across the St. Joseph River, which will utilize the 14-foot head of water and so obtain very cheap power, while the Lake Shore and Michigan Southern Railway, passing through Bristol, will furnish an excellent outlet for the manufactured product.

KOSCIUSKO COUNTY.

References.—

1859. Richard Owen, Geol. Reconn. of Ind., p. 208.

1875. G. M. Levette, Seventh Ann. Rep. Geol. Surv. of Ind., p. 483.

1899. Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv. No. 21, p. 35.

Kosciusko, one of the largest counties in Indiana, lies near the center of the second tier of counties south of the Michigan line. It is bounded on the north by Elkhart, on the east by Noble and Whitley, on the south by Wabash and Fulton, and on the west by Marshall and Fulton counties. Its total area is 521 square miles.

Three railways run entirely across the county, the Michigan Division of the Big Four north and south through its center; the Pittsburgh, Ft. Wayne and Chicago, and the New York, Chicago and St. Louis (Nickel Plate) east and west, the former through the center, the latter across the middle of the south half. In addition to these the Baltimore and Ohio cuts across the northeastern corner, while the Eel River Division of the Wabash just touches the southeastern corner.

The continental divide, separating the Mississippi and Great Lakes drainage systems, passes through the northern third of the county in a northeast-southwest direction. The streams and lakes in the northern tier of townships are, therefore, drained through tributaries of the St. Joseph River into Lake Michigan, while those of the remainder of the county are tributary to the Tippecanoe River, one of the main branches of the Wabash. The Tippecanoe enters the county from the east, a little north of the center and flows across in a westerly-southwesterly course. The streams of the extreme southern part drain into Eel River, also a tributary of the Wabash.

The entire surface of the county is covered with a heavy mantle of drift which is largely sand and gravel. The thickness of this is known only in the vicinity of Warsaw, the county seat, where two bores for gas wells showed it to be respectively 247 and 255 feet, while in a third, three miles west of Warsaw, it was 243 feet. The eastern and southern portions of the county are situated on the interlobate moraine of the Saginaw and Erie lobe, except the extreme southeastern portion, which is occupied by a moraine of the Erie lobe. The northwestern portion of the county, comprising about one-fourth its area, is occupied largely by gravel plains and by marshes. The general elevation of these plains is about 800 feet above tide. The moraine stands 920 feet or more in its higher portions.

The elevations in feet above tide of the principal railway stations in the county are as follows: Atwood, 821; Claypool, 887; Etna Green, 810; Leesburg, 865; Mentone, 838; Milford Junction, 843; Pierceton, 923; Sidney, 914; Silver Lake, 910; Syracuse, 862; Warsaw, 817 to 826.

The lakes of Kosciusko County are more than 40 in number. Of these more than 20 are too small to be given a name on the county map; while two, Turkey or Wawasee, and Tippecanoe, rank respectively first and fifth in size among those of the State. Fourteen of the larger ones were visited during our investigations, and in and about these, eight workable deposits of marl were found. These are fully described on the pages which follow.

TURKEY OR WAWASEE LAKE.

Large Workable Deposit.

This is the largest lake in Indiana, its water area, including that of Syracuse Lake, being 5.66 square miles.* That portion south of the Baltimore and Ohio Railway lies in sections 8, 9, 10, 11, 14, 15, 16, 17, 22, 23 and 24 (34 north, 7 east), Turkey Creek Township. Its northwest end is less than a mile from the town of Syracuse. The B. & O. Railway crosses the lake where it connects with Syracuse Lake and is but a short distance north of its shores at Pickwick Park, Oakland and Johnson's Bay.

"Turkey Lake is made up of two parts, connected by a channel. The channel is three-quarters of a mile in length and from 100 feet

*This data, as well as most of that which follows regarding the topography and physical features of Turkey Lake, is taken from a paper by Mr. D. C. Ridgley, published in the Proceedings of the Indiana Academy of Science for 1895. The data relative to the marl deposit was secured by Dr. Ashley in the fall of 1899.

to a half mile in width. Its depth varies from one to five feet. The part of the lake north of the channel is known as Syracuse Lake. The larger part, to the south and east of the channel, may be known as the main lake.

"The general trend of the lake is from southeast to northwest. Its greatest length is five and a half miles, and its greatest width at a right angle to its length is one and a half miles. The entire shore line is between 20 and 21 miles in length. No very prominent irregularities occur around Syracuse Lake, while in the main lake a number of evident indentations are to be found. The east end of the main lake is made up of three bays. Johnson's Bay, extending to the north, is one mile long and three-eighths of a mile wide. Ogden Point lies to the west of the entrance of this bay and Cedar Point to the east. The east end of the main lake is Crow's Bay, with Cedar Point on its north and Morrison's Island on its south. Jarrett's Bay extends to the southeast, with Morrison's Island to the east of its entrance and Clark's Point to the west. In the west end of the main lake is Conkling Bay, circular in form and with the surrounding marsh a half mile in diameter. It lies south of Conkling Hill. These are the most prominent indentations. Between the channel and Ogden Point, which are two and a quarter miles apart, the shore line curves gently northward three-quarters of a mile, forming Sunset Bay. Between Clark's Point and Black Stump Point, one and three-quarters miles to the northwest, the shore line bends southward one-third of a mile.

"The average depth of the lake, found by taking the average for the soundings at regular intervals of 300 feet along the lines of soundings, is 21 feet six inches in the main lake, 13 feet six inches in Syracuse Lake, and 20 feet five inches for the entire lake. The maximum depth found in the main lake is 68 feet seven inches, one-quarter of a mile from the southern extremity of Jarrett's Bay; 1,200 feet northeast of Vawter Park Hotel a depth of 66 feet five inches was found; three-quarters of a mile north and one-quarter of a mile west of the hotel the water is 60 feet deep; and a half mile northwest of Black Stump Point it is 63 feet three inches deep.

"An examination of the contour lines of the map shows that if we consider water having a depth of 30 feet or more as deep water, we have in the main lake four areas of deep water, varying greatly in size and connected with each other by channels.

"In Crow's Bay the greatest depth found was 49 feet nine inches. These waters enter the main body of the lake through a channel deeper than 30 feet, and 200 feet wide at its narrowest point. This channel flows across the mouth of Johnson's Bay, meeting a short arm deeper than 30 feet from that bay, and comes within 600 feet of the southeast extremity of Ogden Point. This channel continues less than 400 feet wide to a point two-thirds of a mile west of Ogden Point, where it joins the channel deeper than 30 feet from Jarrett's Bay. The deepest water in Jarrett's Bay is 68 feet seven inches, and the area deeper than 30 feet is one-fourth of a mile wide, extending north beyond the mouth of the bay and to within 700 feet of its southern shore. This 30-foot depth joins the main body of the lake a half mile north of Clark's Point, where the channel, 30 feet deep, is only 100 feet wide. Turning to the west, 1,000 feet northeast of the Vawter Park Hotel, this channel deepens to 66 feet five inches, and widens to half a mile directly north of the hotel. Here it meets the narrow channel 30 feet deep from Crow's Bay. The two channels merge into one and form an area of water from 30 to 66 feet in depth, one mile in length and with a maximum width of three-quarters of a mile. This area of deep water lies nearer the south shore, its center being one-third the distance from the south shore to the north shore. Near Black Stump Point the deep water narrows abruptly from the north, and 500 feet out from Black Stump Point its width is but 200 feet. West of Black Stump Point the deep water widens abruptly to the north to a width of a quarter of a mile, and deepens to 63 feet three inches. West of this the area of deep water narrows again and the water having a depth of 30 feet ends one-quarter of a mile southeast of the entrance to the channel between the main lake and Syracuse Lake.

"Between the deep channels from Crow's Bay and Jarrett's Bay the area having a depth less than 30 feet is one and a quarter miles long, 1,300 feet wide, and contains an area one mile long and 500 feet wide over which the water is less than 10 feet deep.

"If the level of the lake were lowered 30 feet there would remain four bodies of water connected by channels from 100 to 200 feet wide and less than 10 feet deep. These four bodies of water would be: (1) A small area in Crow's Bay with a maximum depth of 19 feet; (2) about one-half of Jarrett's Bay with a maximum depth of 38 feet; (3) the main body of the lake, its width decreased almost one-half and its maximum depth being 36 feet; (4) a small area northwest of Black Stump Point with a maximum depth of 33 feet. Lower the level of the lake 10 feet more, that is, 40 feet below its present level, and these four bodies of water would remain as separate lakes, the connecting channels now being dry.

"Great changes in the shore line will take place if the level of the lake be lowered to a much less extent. By observing the map it will be seen that a lowering of the level of the lake to the amount of 10 feet would move the shore line to the first contour line. This would leave one-half the bottom of Johnson's Bay dry land; it would move the shore line along Crow's and Jarrett's Bays from 400 to 1,000 feet into the lake. Clark's Point would extend 2,000 feet further north, and the distance between Clark's Point and Ogden Point would be reduced from 4,000 feet to 1,800 feet. The south shore line from Clark's to Conkling Bay would be moved northward distances varying from 250 feet at Iron Spring Point to 1,000 feet along the shore west of Black Stump Point. The north shore line from Ogden Point to the channel would be moved southward from 900 feet to 2,000 feet, and at one place—between Jones' Landing and Black Stump Point—4,000 feet, reducing the width of the lake at this place from one mile to 500 feet. The channel between the main lake and Syracuse Lake would be drained, and the greater part of Syracuse Lake would become dry land. Judging from the contour of the land the level of the lake has probably never been more than five feet below what it is at present.

The areas below which there is a certain depth of water have been estimated as follows:

Depth of Water.	*Area in Square Miles.*
1—10 feet	3.27777
10—20 feet	.59027
20—30 feet	.62500
30—40 feet	.45833
40—50 feet	.39583
50—60 feet	.22918
60—70 feet	.0694
Total	5.64576

"TOPOGRAPHY OF THE SHORE.—The shore of 20 miles is about equally divided between dry shores and marshy shores. The dry shores are composed of sand and gravel. Some are less than five feet high, but more often they are abrupt bluffs from 10 to 30 feet high, or hills which ascend rapidly to a height of 40 feet. The shore south of Turkey Creek, the outlet, is marshy, and these marshes extend along both sides of the channel between Syracuse Lake and the main lake. Pickwick Park is located on a gravelly shore less than 10 feet above the level of the lake. Between Pickwick Park and Eppert's is the Gordoniere Marsh extending northwest to the channel. The shore between Eppert's and Jones' is mainly marsh. From Jones' one-quarter of a mile east the shore is a bluff from 10 feet to 15 feet high. From this point almost to Wawasee the land near the shore is at present a dry marsh. The bluff at Wawasee is 15 feet high and extends along the shore 1,700 feet. This bluff extends back from shore 500 feet, where it joins the marsh which stretches along the shore to Ogden Island, and also to the east of Johnson's Bay. On the east side of Johnson's Bay are two bluffs, one reaching a height of 23 feet and extending from Cedar Point northwest one-quarter of a mile along the shore and having 500 feet for its greatest width; the other is 1,000 feet further to the northwest and is between 10 feet and 15 feet high, 700 feet long and 150 feet wide. Lying to the northeast of these bluffs and extending between them is an arm of the Johnson Marsh from 50 feet to 800 feet in width, which joins Crow's Bay just east of Cedar Point. From the northeast corner of Crow's Bay the bluffs extend south along the east end of the lake for half a mile. They are from 10 to 27 feet in height.

"The land on both sides of Turkey Creek, the inlet of the lake, is marshy. Lying to the north of the mouth of the creek this marsh is 400 feet wide and extends one-quarter of a mile north along the lake. This marsh is separated from the marsh along the east margin of Morrison's Island by a shallow channel of water. The west side of Morrison's Island is a bluff reaching a height of 21 feet. From Turkey Creek to Buttermilk Point the shore is skirted with marsh from 200 feet to 400 feet wide. Mineral Point is 200 feet from the lake and ascends abruptly from the marsh to a height of 25 feet. A half-mile south of Turkey Creek the lake is entered by Jarrett's Creek, which is the outlet of a chain of small lakes lying southeast of Jarrett's Bay. This stream flows through a marsh 400 feet wide, and all the small lakes are bordered by marsh land. The marsh along the lake ends at Buttermilk Point, and for a quarter of a mile the shore is dry and sandy. The land along this shore is not a perpendicular bluff, but rises rapidly from the lake to the south and reaches a height of 40 feet at a distance of 400 feet from the shore. The west side of Jarrett's Bay is skirted by a marsh from 150 feet to 1,000 feet wide. West of the marsh is a bluff from 10 to 15 feet high, continuous with the land south of the bluffs of Vawter Park. West from Clark's the south shore of the lake is a perpendicular bluff reaching a height of 29 feet in Vawter Park and extending west beyond the point where our survey of the summer ended. This bluff is cut by a ravine 50 feet wide at the Vawter Park Hotel and by a small stream entering the lake a quarter of a mile west of Vawter Park. The shore extending west to and around Black Stump Point is from five feet to 15 feet above the level of the lake. The high bluff from Clark's Point to Black Stump Point is by far the longest stretch of highland along the shore, being nearly two miles in length. Conkling Bay during the summer months contained an area of water about 300 feet in diameter and 20 feet deep, bordered by wide stretches of marsh containing a few small pools of very shallow water. To the north of Conkling Bay, Conkling Hill ascends rapidly to a height of 40 feet or more.

"Wherever there is a long stretch of shore bordered by marsh, there is no beach formed, but the muddy bottom of the lake merges into the mud of the marsh along the shore line. Along all the dry shores, and along the marshes of small extent lying between bluffs, the beach is composed of gravel and sand. These beaches along the bluffs are formed by erosion and deposit along the base of the bluffs. The sandy and gravelly beaches along marshes are found where the adjoining bottom of the lake is composed of sand and gravel. These beaches have most probably been formed by the action of ice.

"The lake freezes over and by expansion the ice is pushed up along the shore, carrying sand, gravel and stones with it. Numerous ice cracks form during the winter and fill with water. This water freezes and pushes the ice still further up the shore, carrying the beach-forming material still higher. These ice cracks are very numerous and may be as much as three inches wide. The amount of lateral pressure brought to bear on the shores by this means is very great, and beach ridges are begun and added to each year. The action of the ice in forming beaches along marshes is very great, while along bluffs it is small. In the first case no great resistance is met with in expansion, and the material for building the beach will be carried up to the full extent of the expansion of the ice, while along the bluffs the ice crowds against the shore and is itself broken at every expansion.

"INLET.—The only stream flowing into the lake and containing water throughout the year is Upper Turkey Creek, which enters the lake on the east side of Jarrett's Bay. During the summer months it is filled with an abundant growth of water vegetation, and is without any perceptible current. When the water is high the chain of small lakes lying to the southeast is drained into the large lake through Jarrett's Creek, entering Jarrett's Bay a half mile south of Turkey Creek. A small stream one-fourth of a mile west of Vawter Park, and another from the east side of Johnson's Bay, contribute water to the lake when the water is high, but not during the dry summer months. There are no springs around Syracuse Lake, but springs are found along the margin of the main lake wherever the shore rises 15 feet or more and extends across the country as elevated territory. These springs usually enter the lake near high-water mark. This gives springs along Crow's Bay, Mineral Point, the south and west sides of Jarrett's Bay, and along the south shore from Vawter Park one mile west. No springs are found along the bluffs at Jones', Wawasee, Cedar Point, Morrison's Island, or Conkling Hill, but in each case these highlands are narrow and surrounded by marsh or lowland. For a half-mile along Crow's Bay the bluff is more than 20 feet high. All along the foot of the bluff the water percolates from the gravel, and at places it flows from quite strong springs. At Mineral Point there are a number of strong springs. At Buttermilk Point and along the base of the bluffs west of Jarrett's Bay are also a number of springs. The margin of the lake from Vawter Park one mile west is very springy, but the flow of water is not so strong as along Crow's Bay. The waters from all these springs show traces of iron more or less strongly.

"Outlet.—The waters of the lake flow into Lower Turkey Creek through which they enter the Elkhart River near Goshen, Indiana; then through the Elkhart and St. Joseph rivers they reach Lake Michigan.

"Near the outlet of the lake the creek, during the summer, was about 20 feet wide and had an average depth of less than six inches. The volume of water discharged through the outlet was computed from measurements taken in the creek and the overflow of the mill race July 18, 1895. The outflow through the creek was 103 cubic feet, or 772½ gallons, per minute; through the mill race, 41 cubic feet, or 307½ gallons, per minute, making a total of 144 cubic feet, or 1,080 gallons, per minute. At the same time the volume of the creek a half-mile below was computed at 137½ cubic feet, or 1,031 gallons, per minute.

"By taking the outflow of the lake at 144 cubic feet per minute, finding the amount discharged in twenty-four hours, and computing the amount the level of the lake, with an area of five and a half square miles, would be lowered by such an outflow with no inflow, we find it to be .016 of an inch. At this rate it would require 62½ days to lower the lake one inch. In one year of 365 days, at the same rate, the level would be lowered 5.84 inches. The inflow during the summer months is almost entirely due to springs, and probably equals the outflow. The lowering of the level of the lake, during the summer months, seems to be due almost entirely to evaporation.

"CHANGES IN LEVEL.—The surface of Turkey Lake is 864 feet above tide, and 282 feet above the surface of Lake Michigan. Changes in the level of the lake have been due to three causes: Erosion, the dam which is built across Turkey Creek just below the outlet of the lake, and climatic conditions. Old beach formations give evidence that the level of the lake was formerly five or six feet higher than at present. By erosion the channel at the outlet was cut 10 feet below this ancient level, and the dam has raised the level of the lake five feet to its present level.

"The history of the dam as given by an old settler is as follows: A small dam was built in 1828, to which additions were made in 1831. This dam was washed out in 1833 and the present dam and mill race were begun in the same year. This raised the level of the lake so that timber stood in water five feet deep. Much of this timber remained uncut in 1840, and some was still standing as late as 1865.

"The fluctuations in the level of the lake are caused by climatic conditions, and vary with the inflow and outflow, rainfall and evaporation. The annual fluctuations are estimated to be about two and a half feet. The level of the lake is usually highest about May first, after the heavy spring rains, and lowest in August. The hydrographic basin is so small that at present but seven inches of water are removed from the surface by outflow, while 30 are removed by evaporation. The lake having a surface of 5.6 square miles, an increase of this surface by 7/30, or about one and one-third square miles, would be sufficient to allow all the water coming into the lake to be lost by evaporation except in wet seasons. The surface of the lake, therefore, can not have been very much higher than at present if the present precipitation and evaporation have been constant since the ice left this region."

MOLLUSCA OF TURKEY LAKE.

The following is a list of the mollusca from Turkey Lake as mentioned by Dr. R. E. Call in his various papers on Indiana mollusca:

UNIVALVES.

1. *Limnophysa palustris* Muller.
2. *Limnophysa caperata* Muller.
3. *Limnophysa humilis* Say.
4. *Physa ancillaria* Say.
5. *Helisoma trivolvis* Say.
6. *Campeloma decisum* Say.
7. *Campeloma rufum* Hald.
8. *Goniobasis pulchella* Anthony.

BIVALVES.

9. *Sphærium solidulum* Prime.
10. *Sphærium rhomboideum* Say.
11. *Pisidium rotundatum* Prime.
12. *Unio gibbosus* Barnes.
13. *Unio luteolus* Lam.
14. *Margaritana deltoidea* Lea.
15. *Anodonta grandis* Say.
16. *Anodonta subcylindracea* Lea.
17. *Anodonta footiana* Lea.

FISHES OF TURKEY LAKE.

The following lists of fishes and turtles known to occur in Turkey Lake are from papers by Dr. C. H. Eigenmann in the Proceedings of the Indiana Academy of Science for 1895:

FISHES KNOWN TO OCCUR IN TURKEY LAKE.

1. *Lepisosteus osseus* L. Common Gar-pike.
2. *Lepisosteus platystomus* Raf. Short-nosed Gar-pike
3. *Amia calva* L. Dog-fish.
4. *Amieurus natalis* LeS. Yellow Cat.
5. *Schilbeodes gyrinus* Mitch. Slender Mud Tom.
6. *Erimyzon sucetta oblongus* Mitch. Sweet Sucker.
7. *Pimephales notatus* Raf. Blunt-nosed Minnow.
8. *Notropis anogenus* Forbes. Small-chinned Minnow.
9. *Notropis bifrenatus* Cope. Two-bridled Minnow.
10. *Notropis heterodon* Cope. Variable-toothed Minnow
11. *Notropis microstomus* Raf. Small-mouthed Minnow.
12. *Notropis megalops* Raf. Common Shiner.
13. *Notemigonus chrysoleucus* Mitch. Golden Shiner.
14. *Fundulus diaphanus menona* Jor. and Cope. Top Minnow.
15. *Lucius vermiculatus* LeS. Little Pickerel.
16. *Labidesthes sicculus* Cope. Brook Silverside.
17. *Pomoxis sparoides* Lacépède. Calico Bass.
18. *Ambloplites rupestris* Raf. Rock Bass; Red Eye.
19. *Chænobryttus gulosus* Cuv. and Val. War-mouth.
20. *Lepomis cyanellus* Raf. Green Sunfish.
21. *Lepomis pallidus* Mitch. Blue Sunfish; Blue Gill.

22. *Lepomis gibbosus* L. Common Sunfish.
23. *Micropterus dolomieu* Lacépède. Small-mouthed Black Bass.
24. *Micropterus salmoides* Lacépède. Large-mouthed Black Bass.
25. *Etheostoma nigrum* Raf. Johnny Darter.
26. *Etheostoma caprodes* Raf. Log Perch.
27. *Etheostoma iowæ* Jor. and Meek. Iowa Darter.
28. *Etheostoma microperca* Jor. and Gil. Least Darter.
29. *Perca flavescens* Mitch. Yellow Perch.

Turtles of Turkey Lake.

"Turtles are at all times and everywhere abundant. They frequent especially the shallower portions of the lake. I present here simply a list with notes on their abundance and breeding habits.

1. Chelydra serpentina Linn. Snapping Turtle.

"This species is abundant in Turkey Lake, and reaches a larger size than any of the others. It is caught for the market. It is much shyer than the other species of turtles and is not frequently seen. It inhabits the shallower muddy parts of the lake, being abundant in the kettle and about Morrison's Island.

2. Trionyx spiniferus LeS. Soft-shelled Turtle.

"The soft-shelled turtle is very abundant. It is the second in size and is caught for the markets. Its round eggs are laid in the sand and gravel near the water's edge during June and July. On June 26 one was seen digging a nest in the gravel banks at Syracuse, and on the 27th we obtained eggs from five nests about Ogden Point and other places about the kettle. Other fresh nests were found July 9. The time of hatching was not determined. The number of eggs found in several nests was as follows: 9; 12; 17; 18; 27; 32.

3. Aromochelys odorata Bosc. Musk Turtle; Stink-pot.

"This species is abundant but not conspicuous. Individuals were oftenest seen the latter part of June and first part of July while laying their eggs. The eggs are laid in the rotten wood in the tops of stumps standing in the margin of the lake. The turtles were frequently found in the tops of these stumps, and some of their eggs wedged as far into the rotten wood as a finger could bore. Rotten logs removed some distance from the water are also favorable places for egg laying, and in a mucky place of small area at the edge of the lake 362 eggs were taken at one time. The number of eggs laid by one individual varies from four to seven, this number being usually in a cluster. At this rate about 60 turtles must have contributed to the nest of 362.

4. CHRYSEMYS MARGINATA Agassiz. Lady Turtle.

"This appears to be the most abundant turtle of the lake. How far its apparent abundance may be due to its habits I am unable to say. It is found floating or quietly paddling along, its head out of the water, but on nearer approach it always turns tail and seeks refuge in the abundant *Chara* fields or in other hiding places. The *Chara* fields are traversed by narrow paths and tunnels made by this turtle. The eggs are laid later in the summer and farther from the water than those of the other species. Many were leaving the water in late August; the eggs were found but once.

5. MALACLEMMYS GEOGRAPHICA Le S. Map Turtle.

"Next to *Chrysemys marginata*, the most abundant of the turtles. It goes also by the appropriate name of Housetop.

6. EMYS BLANDINGII Holbrook. Blanding's Tortoise.

"Found in moderate numbers in the lake and along the banks of Turkey Creek.

7. CLEMMYS GUTTATA Schneider. Speckled Tortoise.

"But two specimens were seen."

MARL.—Marl occurs in the open water just south of Buck Island but is replaced by muck under the swampy part of the channel. East of Conkling's Hill a large area of marl sets in, covering most of the southeast 40 of section 8 and the southwest 40 of section 9, though not running in close to shore. This area swings around the end of the deep water in this part of the lake and extends southeast along the shore to Black Stump Point. From the mouth of Conkling's Bay to the same point it extends in rather close to shore, often to within 50 feet, and deepens to over 16 feet in a few yards. Tests with a 24-foot auger in this area failed to find the bottom of the marl.

Between Black Stump Point and Vawter Park the marl sets in on the average about 100 yards from the shore and reaches a depth of over 16 feet in a few yards further, and from there out extends below reach of 16-foot pole into deep water.

The marl is distributed very unevenly over the broad shallow area off from Clark's, nearly half the tests showing hard bottom, while the others entered marl without reaching bottom, the water being from three to nine feet deep. Over the long shallow water bar between this and Ogden Point the marl is also irregularly distributed, though a considerable quantity is found here.

From Clark's to Buttermilk Point the marl is found almost if not quite continuously, though it sets in at variable distances from the shore. In the embayment between Buttermilk and Mineral Points the marl is shallow for some distance off shore but reaches a good depth in the center of the bay. Between Mineral Point and Morrison's Island only muck was found. Marl of good depth was found west of Morrison's Island off shore, but runs out southwest and north of the island, where only hard bottom was found. A small amount of marl was found in Crow's Bay, though none in shallow water or close to shore. Some marl was found just southeast of Cedar Point. Two thin beds of sand were passed through in testing here, the first at four feet and the second at seven feet. West of Cedar Point the bottom is hard out to a depth of from seven to nine feet of water, beyond which marl sets in. At the head of Johnson's Bay there is a good deposit of marl, thinning down to about 12 feet at the water's edge but extending half-way to the solid land before running out entirely. Along the sides of the bay the marl is less regular, often being mucky and in places only pure muck was encountered.

At Ogden Point there is a narrow belt of marl on the edge of deep water. From here to Oakland the broad belt of shallow water shows little or no marl. In places it is found on the edge of deep water or in slight depressions in the general level.

SYRACUSE LAKE.

Workable Deposit, Now Being Utilized by the Syracuse Portland Cement Company.

Syracuse Lake is the name given to the northern end of Turkey or Wawasee Lake, it being separated from the main body of the latter by a marsh and island, though rowboats can readily pass by a narrow channel from one to the other. It lies just east of the town of Syracuse on the B. & O. Railway and has a length of a mile and a quarter and a width of nearly three-quarters of a mile. The water area is at present 429¾ acres. A large factory has just been completed by the Syracuse Portland Cement Company for the utilization of the underlying marl.

The topography of the lake is indicated on the accompanying map.* The eastern and southern margins of the lake are shallow and a shallow water belt juts out from the southeast corner of the lake well to the center, giving from four to six feet of water there. Along the northern and western margins the water runs shallow close to shore but rapidly deepens to from 25 to 36 feet. The banks tend to be high along the north side with many sparsely wooded bluffs. Around the rest of the lake they are of moderate height or low. The southeastern corner tends to be marshy.

MARL.—Through the kindness of Mr. J. P. Dolan, of Syracuse, we are enabled to present the accompanying map of Syracuse Lake showing its marl resources as determined by an extended survey. Tests were made every 300 feet, along lines 300 feet apart.

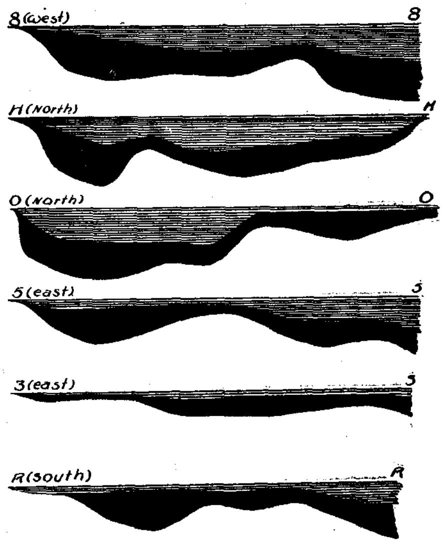


Fig. 44. Cross Sections of Lake and Marl, Syracuse Lake, Kosciusko County, Ind.

These tests show that the marl is inclined to be shallow, or lacking close to shore, a fact readily accounted for by the reason that the present lake surface has been artificially raised several feet. Figure 44 shows, by the width of the solid black bands, the depth of marl over the lake. In a general way this shows an area of deep marl under shallow water in the southeast part of the lake; marl of moderate depth (10 to 20 feet) over most of the rest of the south half of the lake; deep marl (15 to 40 feet or more) over most of the

*See map of Lake Wawasee, Syracuse Lake being included.

north half of the lake, in some cases the marl having depths of 30 to 35 feet within 300 feet from shore. Reference may be made to the accompanying map for the details concerning the deposit.

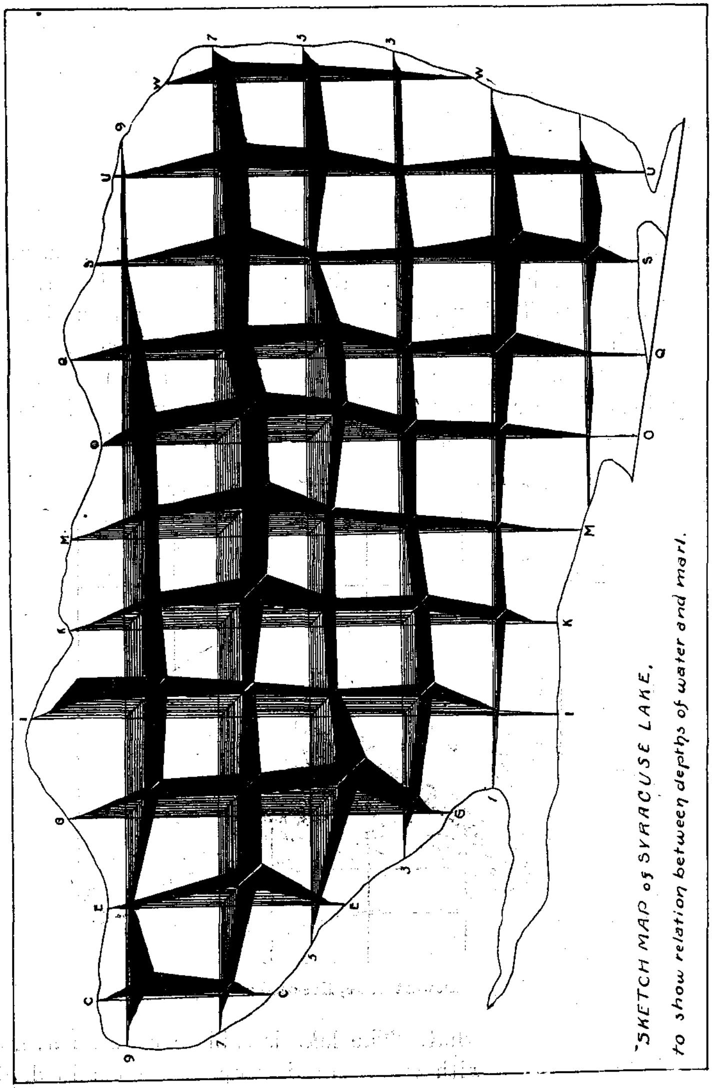


Fig. 45.

Analysis of the marl from Syracuse Lake, made by Prof. S. B. Newberry, of Sandusky, Ohio, resulted as follows:

Calcium carbonate ($CaCo_3$)	88.49 per cent.
Magnesium carbonate ($MgCo_3$)	2.71 per cent.
Iron oxide and alumina	1.21 per cent.
Calcium sulphate ($CaSo_4$)	1.58 per cent.
Insoluble	1.78 per cent.
Organic matter, etc	4.23 per cent.
Total	100.00

DEWART OR LINGLE LAKE.

Workable Deposit.

This lake lies about four miles southeast of Milford, in sections 25 and 36 (34 north, 6 east), Van Buren Township, and section 30 (34 north, 7 east), Turkey Creek Township. Its northern shore is three and a half miles a little west of south of the Baltimore & Ohio Railway at Syracuse. When visited in the autumn of 1899, it had recently been lowered, very much reducing its area and extent. The water area was estimated to be then over 300 acres, though

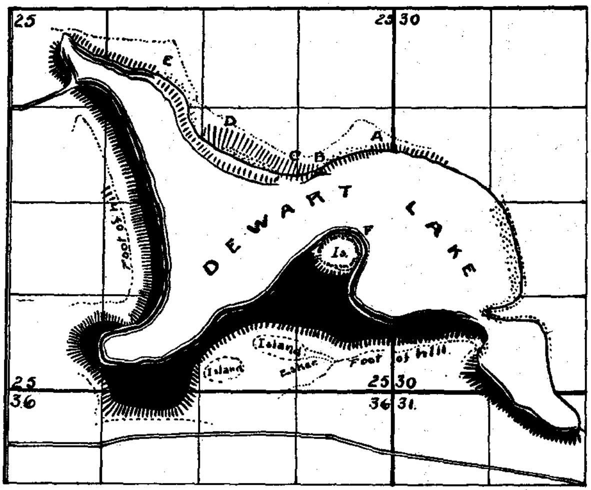


Fig. 46. Map of Dewart Lake, Kosciusko County, Ind.

originally nearly double that. The lake is said to have an average depth of about 30 feet with water running up to 60 feet in depth. A row of soundings, 25 oar strokes apart, on a line starting on the west shore and running east along the center of section 25, gave the following depths of water in feet: 20, 40, 48, 54, 56, 60, 58, 42, 38, 36, 42, 32, 32, 26, 22, 29, 27, 38, 24, 10. The outlet leaves the northwestern corner and flows northwesterly, passing through Milford or Wabee Lake, finally emptying into Turkey Creek. A wooded island with an area of about two acres rises in the east-central part of the lake. It is now, since the lake was lowered, connected by marsh with the south bank.

Around much of the lake is a belt of flat land flanked by rather abrupt banks. Along the east half of the north shore these banks rise into wooded hills 50 or more feet in height. A flat marshy area eight to 12 rods in width lies between the base of these hills and the water's edge. Toward the northwest this marshy area becomes from 20 to 40 rods wide. At the northwest corner it narrows again to 10 rods or less. Along the north half of the west shore the marsh area runs from five to 15 rods in width with a level area 10 feet higher, back of the marsh. The south half of the same shore has the marsh area narrower with low wooded banks coming close to the water. The marsh area on the south side is much more extensive, running back in places nearly 60 rods from the edge of the water. Above the level of this flat rise two small hills, the one farthest east being connected with the higher main land by a fine example of esker. This marshy flat on the south extends around the southeast corner of the lake and forms the south half of the east shore. The north half of the east shore has high wooded hills with their bases close to the water's edge, gravel banks intervening, the gravel forming the bottom of the lake 100 to 200 feet out from shore in 10 to 15 feet of water.

From the hills to the north the view over the lake is a pretty one, and before its level was lowered, was probably much more attractive. With the exception of rushes, the amount of aquatic vegetation in the present water area is limited. As a fishing resort the lake is noted, and many people, even in a region where lakes are abundant, seek its waters to try their luck in pursuit of the finny tribe.

MARL.—Near the southwest corner there is an unusually large stretch of bare marl of which no bottom could be found with 16-foot drill, until well outside the former shore line and but a short distance from the abrupt bank. An agent of the owners, The Indiana Portland Cement Company, claims that over much of this area it was impossible to reach bottom with a 28-foot auger. Within the old shore line the marl is bare, soft and of good quality. Outside the shore line it tends to be covered with muck reaching a maximum depth, as far as tested, of two and a half feet. It is said that the marl extends around the southeast side of the lake in a similar manner, underlying a large part of the flat belt; also that it underlies a large marsh south of the two islands and esker mentioned above, being underlain with more or less muck. The shallow water area along the north half of the east shore is underlain with gravel. At the boat house on the north shore, at (A), a short distance west of the north-south township line, the marl is 15 feet thick at the water's edge, and thins out gradually in the narrow marsh between there and the base of the hills, being seven feet thick, 50 feet back. Twenty rods west, and 200 feet out from shore in four-foot water, the marl was but one foot thick with gravel beneath. The low area northwest of the boat house widens in places to 20 rods and most of its surface is formed of gravel. Beneath all water up to five feet in depth opposite this gravel plain the marl runs from one to 10 feet in thickness. At (B), about 60 rods west of the boat house, marl begins to replace the gravel on the marsh north of the lake. At the water's edge the marl is 18+ feet thick, but back 10 rods it has thinned to six feet, and five rods farther back, to two feet.

West of this along shore the marl runs from 0 up to eight feet in two-foot water; while in two bores in five-foot water it was respectively 10 feet and one foot thick. There is not more than 12 to 15 acres of marsh marl north of the west half of the north shore, and over this the marl runs in thickness from two to 14 feet with an average of perhaps 10 feet. Between (C) and (D) a gravel ridge 20 rods wide lies between the main marsh area and the water. Out from (C) beneath five-foot water the marl was 10 feet thick with gravel beneath, while opposite (D) in six-foot water 150 feet out it was but one foot thick. Between (D) and (E) the shallow water area is underlain by marl running from nine feet thick in three-foot water to 14 feet in six-foot water with gravel beneath; the six-foot water line averaging about 150 feet out from shore. At (E), near the extreme northwest corner of the water area, the marl runs 15+ feet thick in three feet of water, 25 feet out from shore. Twenty-five rods southeast of this corner the water is 21 feet deep. Along most of the north half of the west shore the shallow water area is not more than 50 feet wide. The marl beneath water three feet and more deep was everywhere beyond the reach of auger. Over the narrow marsh area bordering this shore the marl runs from six to 15 feet in depth. There are perhaps 10 acres of this marsh. The south half of the west shore was not tested. At (F) on the north side of the island the marl was 17+ feet thick in one foot of water.

There is perhaps 40 acres of shallow water and marsh marl along the north and west sides of the lake. The greater portion of the present water area is over 10 feet in depth. The area of marsh marl on the south side is, however, of sufficient size and thickness to supply a factory for many years. The company owning the deposit propose to work it in connection with that of Milford Lake, connecting the two by an electric tramway, and locating the factory near the Michigan Division of the Big Four Railway just west of Milford Lake.

The quality of the marl in Dewart Lake appears good. That in the south marsh is better than that along the north and west shores. An analysis of a sample from the south marsh, made for the company by Mr. A. W. Burwell, of Cleveland, showed the following percentage composition:

Calcium carbonate ($CaCo_3$)	92.35
*Magnesium carbonate ($MgCo_3$)	3.54
Ferric oxide (Fe_2O_3) and alumina (Al_2O_3)	.53
Insoluble inorganic matter (silica, etc.)	2.00
Organic matter	2.12
Total	100.54

An analysis made by Dr. Noyes of an average sample collected by Mr. Blatchley along the north and east shores resulted as follows:

Calcium carbonate ($CaCo_3$)	84.24
Magnesium carbonate ($MgCo_3$)	2.85
Ferric oxide (Fe_2O_3)	.30
Alumina (Al_2O_3)	.18
Insoluble inorganic matter (silica, etc.)	4.52
Organic matter	5.02
Total	97.11

One is more likely to get foreign organic and inorganic matter mixed with a sample, when the latter is made up of many samples scraped off from the auger, than where the sample is taken carefully from one or two localities in a marsh deposit. An average of the above two analyses will, therefore, perhaps, show more justly the average composition of the entire Dewart Lake deposit. Such an average makes the percentage of carbonate of lime 88.29, which is about what the average Indiana marl will run.

*In the analysis furnished the company the magnesium oxide was given as 1.69. This is equal to 3.54 per cent. of magnesium carbonate, the form in which the magnesia really exists.

MILFORD OR WABEE LAKE.

Workable Deposit.

Milford Lake lies three-fourths of a mile southeast of the town of Milford in sections 16, 21 and 22 (34 north, 6 east). It is a little over a quarter of a mile from the Michigan Division of the Big Four Railway, and about two miles south from the B. & O. Railway. The lake has an area of about 175 acres and an extreme depth of 52 feet. A small and very pretty island occurs in the southeast part of the lake. Around the lake on the south, west and northwest is a considerable area of flat land much of which is well underlain by marl. In places on the north this land rises four to six feet above the present water level. The inlet is from Dewart Lake and enters the eastern end. The outlet leaves the northwest corner and flows northwesterly into Turkey Creek, a tributary of the Elkhart River.

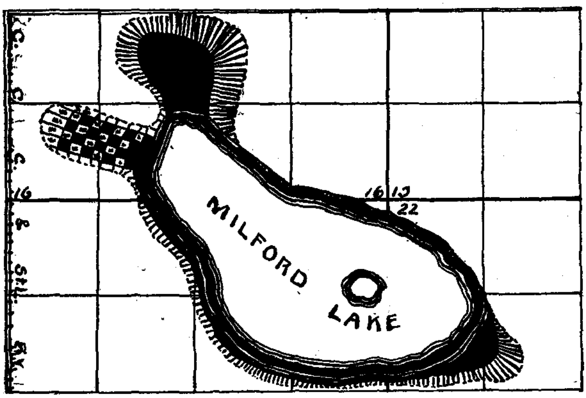


Fig. 47. Map of Milford Lake, Kosciusko County, Ind.

It is said that surveys show that by ditching the outlet it will be possible to largely drain the lake. Soundings along a line running east from the boat house at the west end, and taken at intervals of 25 oar strokes apart showed the following depths in feet: 15, 36, 42, 46, 48, 44. The water is blue and clear, and appears free from sediment or organic matter. Along the north shore, about 50 feet out, the bottom drops down rapidly. East of the island 250 feet, the water is 48 feet deep again. A belt of muck three to five rods wide fringes the shore on the eastern half of the north side. On the east end the rushes extend out 100 to 200 feet from shore. The bottom then shelves into deep water. On the southeast shore the muck banks rise five feet above the water, and the bottom is of sand 50 to 75 feet out from their base. The remaining portion of the south shore is bordered with a strip of marsh 20 to 40 rods wide and the shallow water area is about 15 rods in width, when the bottom shelves as in other places.

This lake and the surrounding marsh is owned by the Indiana Portland Cement Company of Detroit, which contemplates working the deposit of marl extensively in the near future in connection with that of Dewart Lake.

Marl.—In the mouth of the outlet the marl is 18+ feet thick beneath about eight inches of muck. In the south half of section 16 there is a large area of flat land underlain by marl. The marl runs out at the edge of this flat area but toward the lake thickens rapidly to beyond reach of drill. Except on the east side, all tests made with 18-foot drill around the lake and at the shore nowhere found the bottom of the marl. Beneath the muck banks on the north side of the lake the marl shows two to three feet above the water. On the east side the bottom is of muck for 100 to 200 feet from shore. Over the marl in the marshes outside of the lake there is usually a foot or two of muck, but at one or two places it is said to run up to a maximum of four feet. The marl everywhere appears to be very white with a distinctly granular grain. In places along the water's edge were many of the lime pebbles similar in appearance to those found in Lake James, Steuben County. These pebbles appear to have a concretionary structure, with often a bit of shell at the center.

TIPPECANOE LAKE.

Large Workable Deposit.

This is the second largest lake in Kosciusko County, and the fifth largest in Indiana. Its extreme length is about four and a half miles and its greatest width a little more than half a mile. It occupies parts of sections 6, 7, 8, 9, 16, 17 and 18 (33 north, 7 east) and sections 1, 11 and 12 (33 north, 6 east), Tippecanoe and Plain Townships. The general trend of the lake basin is from southeast to northwest, and the total water area is 1.61 square miles. The basin of the lake is divided into three parts. The most eastern, known as James Lake, has an area of about one-half square mile, and is connected with the much larger central basin by a channel about 200 yards long by 150 feet in width. The western basin—Oswego Lake—lies adjacent to the town of the same name, and has an area of only 30 acres.

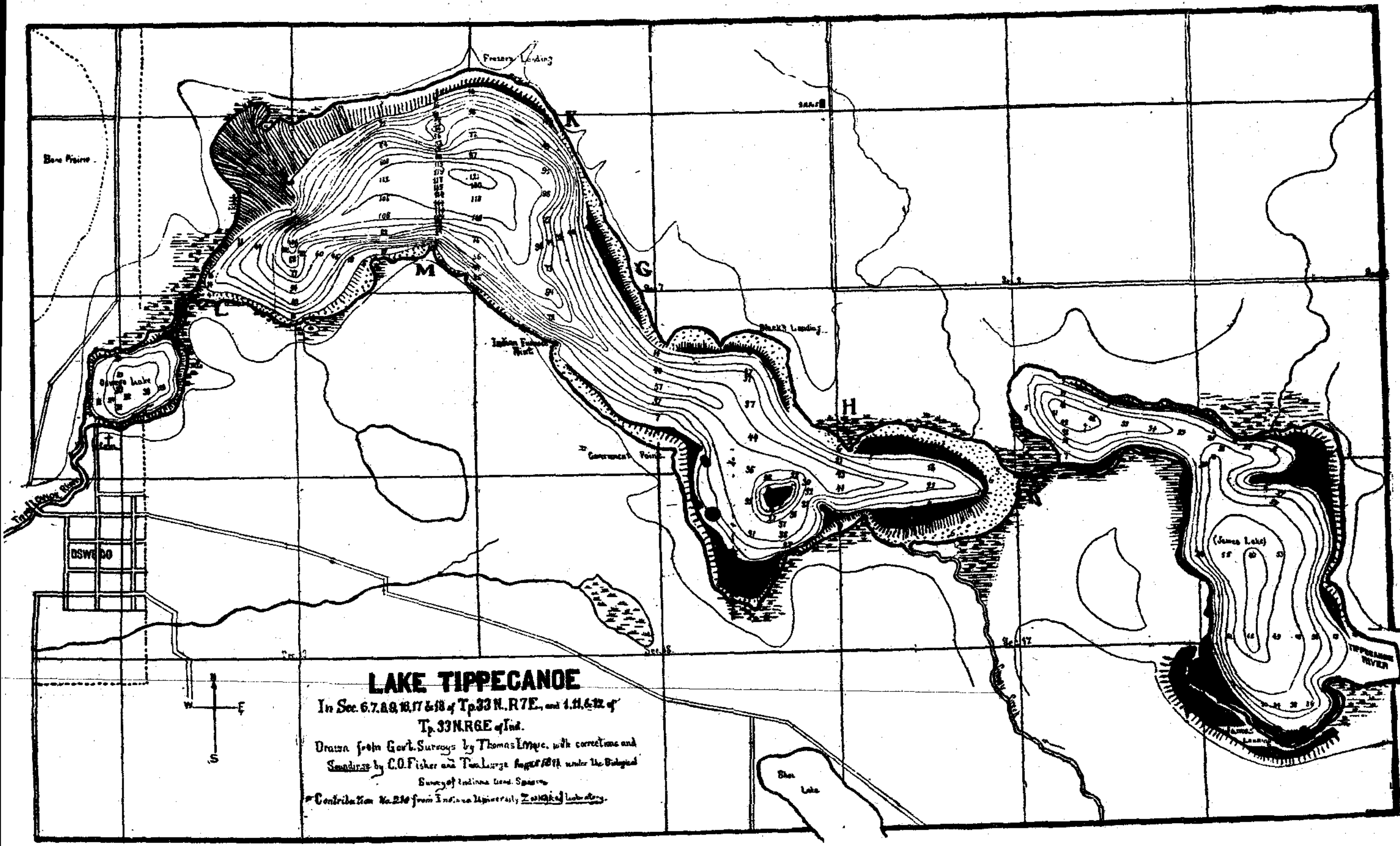


Fig. 48. Map of Tippecanoe Lake, Kosciusko County, Ind.

The lake receives two streams of importance. Tippecanoe River, after flowing through Webster Lake, a mile distant to the east, enters the eastern end of James' Basin and flows through the full length of the lake, leaving it at the western extremity of Oswego Basin. Grassy Creek, the outlet of the Barbee Lakes to the south, enters the middle basin near its extreme southwestern corner. Numerous springs also add to the waters of the lake, either by bubbling up from its bottom or entering near the rim of its basin. The water of the lake is said to vary in level more than four feet at different seasons of the year. The basin of the lake is but a widening of the channel of the Tippecanoe River and this doubtless causes a greater variation in the water level than would otherwise occur. On June 19th, 1900, the water was eight inches higher than on June 8th, while on the night of the 21st an extremely heavy local rain raised it five inches more.

Tippecanoe Lake enjoys the distinction of being the deepest of the Indiana lakes, a maximum depth of 121 feet having been found by Messrs. Large and Fisher near the center of the main basin. The greater part of James Lake is between 30 and 62 feet in depth. The contour lines of the accompanying map show the depths of the various portions of the basin.

This lake is, at present, more nearly in its natural state than any other of the larger lakes of Indiana. But few cottages are found along its shores. No damming or draining have in any way affected it. Its shore line of 12¾ miles is largely bordered by timber land. Especially is this true on the east and north shores, where the wooded bluffs rise in most places between 20 and 40 feet above the water level. Some fine sites for cottages are found on these bluffs, especially on those along the east shore of James Lake and south of Frazer's Landing on the same shore of the main lake. The shallow water area is not wide except on the north shore between Frazer's Landing and the channel opening into Oswego Basin; on the south shore between Government Point and the mouth of Grassy Creek, and around the easternmost bay of the main basin. Especially does the bottom of James Lake shelve off rapidly beneath deep water, the only shallow water areas of any size being opposite the inlet of Tippecanoe River and along the north side of the east shore. In the channels connecting the three basins the water runs from two to four feet in depth. The amount of marsh land around the lake is very limited in area and muck beds of large size occur only in the vicinity of the mouths of the two inlets and in Oswego Lake.

The waters of the two upper basins are remarkably free from aquatic vegetation, while those of Oswego Lake are full of it. In James Lake the muddy area opposite the entrance of the Tippecanoe River is prolific in pond-weeds *(Potamogeton)*,* bladderwort *(Utricularia)* and water-weed *(Philotria)*, while two or three species of rushes *(Scirpus)* occur in numbers, skirting the outer margin of the shallow water areas in other places. The channel between James and the main basin has only its middle third open, the shallow water along the sides being filled with dense masses of pond-weeds, spatterdock and white pond lilies, the root stalks of which are, in many instances, four or five inches in diameter and washed bare and shining. The Indians formerly used these stalks for food, roasting them in pits lined with boulders, the remains of many such pits being found about the lake, especially on the south shore near "Indian Furnace" Point. In Oswego Lake, waterweed, pondweeds, bladderwort, white water lilies, water-shield, duck-meat and many other aquatic plants flourish abundantly, while along the marshy margin are many muck-loving forms, as cat-tails, spatterdock, arrow-arum, pickerel-weed, etc. The decay of these plants is gradually forming muck and filling up this portion of the lake, so that it will be but a few years until it is a vast morass or muck meadow with the deeper channel of the Tippecanoe River passing through its center. The water area of the two main basins is being encroached upon only opposite the inlets and in a few places—as in the southwest corner of James Lake—along the borders of the marshes.

Mollusca of Tippecanoe Lake.

The molluscan fauna of Tippecanoe Lake is a rich one. This is due largely to the fact that the Tippecanoe River flows through the lake, as many thick-shelled *Unios* not usually found in lakes have been thereby introduced. The following is a list of the shells noted in the lake by the writer or mentioned as being found therein by Dr. Call in his numerous papers on Indiana mollusca. Careful collecting would doubtless bring to light many other species.

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*The species of pondweed taken in James Basin of Tippecanoe Lake have been identified since the description was in press, and are as follows: *Potamogeton natans* L.; *P. amplifolius* Tuckerm.; *P. heterophyllus* Schreb.; *P. lucens* L.; *P. foliosus niagarensis* (Tuckerm.); *P. pectinatus* L. and *P. friesii* Ruprecht.

UNIVALVES.

1. *Limnophysa palustris* Muller. Common.
2. *Physa gyrina* Say. Common.
3. *Planorbella campanulata* Say. Common.
4. *Helisoma trivolvis* Say. Common.
5. *Amnicola porata* Say. Frequent.
6. *Valvata tricarinata* Say. Scarce.
7. *Campeloma rufum* Hald. Frequent.
8. *Pleurocera subulare* Lea. Abundant.
9. *Geniobasis pulchella* Anthony. Abundant.

BIVALVES.

10. *Unio gibbosus* Barnes. Frequent.
11. *Unio phaseolus* Hildreth. Scarce.
12. *Unio iris* Lea. Common.
13. *Unio subrostratus* Say. Common.
14. *Unio fabalis* Lea. Common.
15. *Unio luteolus* Lam. Abundant.
16. *Unio multiradiatus* Lea. Scarce.
17. *Unio trigonus* Lea. Common.
18. *Anodonta edentula* Say. Frequent.
19. *Anodonta grandis* Say. Common.
20. *Anodonta footiana* Lea. Frequent.

FISHES OF TIPPECANOE LAKE.

The following 27 species of fishes were taken in Tippecanoe Lake by the students of the Indiana Biological Station at Wawasee Lake in the summer of 1895:*

1. *Polydon spathula* Walbaum.† Spoon-bill Cat.
2. *Lepisosteus osseus* L. Common Gar-pike.
3. *Amia calva* L Mud-fish; Dog-fish.
4. *Ameiurus natalis* Le S. Yellow Cat.
5. *Amieurus nebulosus* Le S. Common Bullhead.
6. *Ictiobus cyprinella* Cuv. and Val.‡ Common Buffalo Fish.

*This list is extracted from a general list of the fishes of the region by Dr. C. H. Eigenmann, in the Proceedings of the Indiana Academy of Science, 1895, p. 253.

†According to Capt. B. F. James, a specimen of this fish weighing 153 pounds has been taken in the lake.

‡This species is not given in Dr. Eigenmann's list, but Capt. James assures me that specimens of a buffalo fish, some of which weighed 90 pounds, have several times been taken.

7. *Erimyzon sucetta oblongus* Mitch. Sweet Sucker; Chub Sucker.
8. *Pimephales notatus* Raf. Blunt-nosed Minnow.
9. *Notropis heterodon* Cope. Variable-toothed Minnow.
10. *Notropis hudsonius* Clinton. Spawn-eater.
11. *Notropis megalops* Raf. Common Shiner.
12. *Notemigonus chrysoleucus* Mitch. Golden Shiner.
13. *Coregonus artedi sisco* Jor. Cisco.
14. *Zygonectes dispar* Agassiz Top Minnow.
15. *Lucius vermiculatus* Le S. Little Pickerel.
16. *Labidesthes sicculus* Cope. Brook Silverside.
17. *Ambloplites rupestris* Raf. Rock Bass; Red Eye.
18. *Chœnobryttus gulosus* Cuv. and Val. War-mouth.
19. *Lepomis pallidus* Mitch. Blue Gill.
20. *Lepomis gibbosus* L. Common Sunfish.
21. *Micropterus dolomieu* Lacépède. Small-mouthed Black Bass.
22. *Micropterus salmoides* Lacépède. Large mouthed Black Bass.
23. *Etheostoma nigrum* Raf. Johnny Darter.
24. *Etheostoma caprodes* Raf. Log Perch.
25. *Etheostoma aspro* Cope. and Jor. Black-sided Darter.
26. *Etheostoma iowæ* Jor. and Meek. Iowa Darter.
27. *Perca flavescens* Mitch. Yellow Perch.
28. *Roccus chrysops* Raf. White Bass.

The following species of turtles were observed while investigating the marl deposits. Three or four additional species undoubtedly occur:

Aspidonectes spinifer (Le S.). Common Soft-shelled Turtle.
Chelydra serpentina (L.). Common Snapping Turtle.
Aromochelys odoratus (Latreille). Musk Turtle; Stink-pot.
Malaclemmys geographicus (Le S.). Map Turtle.
Chrysemys marginata (Agassiz). Lady Turtle.

Several specimen of the lady turtle were found June 20th in a high, sandy cultivated field, 250 yards from any water. They were evidently seeking nesting places.

At present Tippecanoe Lake offers exceptional advantages to the fisherman in search of a quiet retreat. On its wooded bluffs he can pitch his tent with no fear of invading the privacy of some cottager. Over its deeper pools he can troll or cast for black bass, with the assurance that he will cause that gamy denizen to rise and strike; or alongside the weed-covered bars in water of medium depth he can, at times, pull in the blue-gill, cat-fish, ringed perch and war mouth as fast as he can bait the hook. If he tires of fishing and wishes exercise, he can row full nine miles up and down the lake itself, or, by pulling his boat up the weedy waters of Grassy Creek, can enter the Barbee lakes and add another eight miles to the rowing stretch. All in all, no better fishing and boating resort exists in Indiana than is found along this picturesque chain of lakes.

MARL.—The two larger basins of Tippecanoe Lake contain extensive deposits of marl of an excellent quality. Especially is this true of James Lake, which is everywhere, except over a small area in the extreme northwestern corner, underlain with a thick bed. At James' boat house on the south shore the marl is three feet thick in two feet of water, while 150 feet northwest it is 17+ feet thick in four feet of water. At the three-foot water line around the entire south and west sides it runs 15 or more feet thick, while in most places it is that thick at the margin of the marsh forming the shore, in less than one foot of water. The marsh area west of James' Landing comprises about 30 acres. At the edge, beneath one foot of muck, the marl is 20+ feet thick, while 175 feet back it is practically of the same thickness. The marsh east of the landing is of smaller size, and 70 feet back from shore the marl is 12 feet thick beneath three feet of muck and is underlain with gravel.

In the extreme southeast corner of James' Lake, opposite the Tippecanoe Inlet, muck replaces the marl over an area of 10 acres, but elsewhere the marl was 18+ feet beneath the three-foot water line. Along the south third of the east shore gravel or blue clay underlies the marl in the shallower water, the marl in places being 12 feet thick at the five-foot water line and 10 feet thick at the four-foot water line. Opposite the middle third of the east shore is a large area of shallow water marl which is everywhere, except close into shore, over 15 feet thick. In the extreme western end, north of the entrance to the channel leading into the main lake, the bottom is of gravel in all water less than six feet in depth.

In quality the marl of James Lake is above the average of Indiana marls. An analysis of an average sample by Dr. Noyes shows its chemical constituents to be as follows:

Calcium carbonate ($CaCo_3$)	90.67
Magnesium carbonate ($MgCo_3$)	2.42
Alumina (Al_2O_3)	.06
Ferric oxide (Fe_2O_3)	.26
Insoluble inorganic matter (silica, etc.)	2.48
Organic matter	2.87
Total	98.76

The middle of the channel connecting James Lake and the main basin of Tippecanoe Lake is underlain with marl 16+ feet in thickness, but along the sides, beneath the thick growth of spatterdock, muck only occurs. All water four feet deep and more in the large shallow water area immediately below the channel overlies marl 10 or more feet in thickness. Along the east shore, between the inlet and Wild Cat Point at (H), a number of bores found 17+ feet of marl beneath three to four feet of water 200 feet from shore. One hundred yards southeast of the Point, it was 20+ feet deep at the shore in six inches of water, but was rather dark in color. Between Wild Cat Point and Black's Landing the bottom close to shore, in one to three feet of water, is mostly of sand. The marl sets in a little farther out, beneath four-foot water, being two feet thick, while beneath six feet and more of water its bottom was everywhere beyond reach of 18-foot auger. Between Black's and the east-west township line at (G) the area of sand covered bottom is wider, but the marl is usually 10+ feet thick beneath at least half the water under eight feet deep. Just north of the township line, the bottom is of sand or blue sticky mud as far as (K) beneath all water less than six feet in depth, but in water 6+ feet deep, the bottom of the marl deposit was seldom reached. Below (K) marl sets in and varies from four to 11 feet in thickness at the six-foot water line until Frazer's Landing is reached. West of this landing, along the north shore, the marl thickens and is of better quality. At the three-foot water line 50 to 150 feet from shore it runs 10 to 14 feet in thickness with sand beneath, while at the six-foot line, 200 to 425 feet from shore, it was everywhere beyond reach of drill. Dog-Tail Bay, a wide stretch of shallow water at the northwest corner of the lake, is all underlain with a bed of marl 15+ feet thick. The channel opening into Oswego Lake has marl 14 feet thick along the full length of its bottom. In Oswego Lake the marl thins down to about an average of eight feet with muck two to four feet deep over most of it.

Passing back along the south and west shores of the main lake, we found the marl over most of the shallow water area between (L) and (M) to be thin and of poor quality. It runs from two to eight feet thick in four to six feet of water, while close to shore sand bottom only occurs. Between (M) and Indian Furnace Point, the bottom shelves abruptly into deep water and there is little if any available marl.

South of the Furnace Point the shallow water widens again, and the six-foot water line, as far as Government Point, is underlain with a 10+-foot bed of marl, which thins down to one foot or less before the shore is reached. From Government Point south nearly to the inlet of Grassy Creek is a shallow water area comprising 80 or more acres over which the marl is everywhere 17+ feet thick. Close in shore there is some muck above it, but in most places it is bare and of excellent quality. This is the largest shallow water deposit in the lake. For some distance on either side of Grassy Creek inlet there is a thick delta of muck which reaches out 200 or more feet into the lake. Beneath this muck the marl, however, occurs, and between the inlet and the channel at (P) it runs from six to 17+ feet thick beneath all water over four feet in depth, while in water less than four feet deep the marl deposit is variable, being in some places wholly lacking, in others one to five feet thick. The bed of Grassy Creek itself contains more or less marl, one bore, 300 yards above the mouth, showing 12+ feet in four feet of water.

An analysis of an average sample from the large deposit south of Government Point gave the following percentage composition:

Calcium carbonate ($CaCo_3$)	91.02
Magnesium carbonate ($MgCo_3$)	2.28
Alumina (Al_2O_3)	.—
Ferric oxide (Fe_2O_3)	0.29
Calcium sulphate ($CaSo_4$)	0.05
Insoluble inorganic matter (silica, etc.)	2.92
Organic matter	2.10
Total	98.66

From the tests made there is little doubt but that most of the deep water of the two main basins of Tippecanoe Lake is underlain with a thick bed of marl of a fine quality. The acreage of that now in shallow water is sufficient for the needs of a large cement factory for many years, but, with the exception of the large bed in the southwest part of the main lake, it is strung along a shore line of great length, thus lessening its availability. The distance from a railway is also a drawback for immediate development, the nearest line being the Michigan Division of the Big Four, five miles to the westward. It would be quite difficult to drain the lake so as to increase to much extent its shallow water area, and it is best that it is so, for its natural beauty is too great to be marred by drainage for the sake of a few thousand dollars, which might be obtained from the marl beds on its bottom.

WEBSTER OR BOYDSTON LAKE.

NOT A WORKABLE DEPOSIT.

This lake lies just east of the town of North Webster, in sections 10, 11, 12, 13 and 14 (33 north, 7 east), Tippecanoe Township. It is very irregular in outline and was formerly a group of two or three lakes, having a maximum depth of 35 feet, which occupied the areas enclosed by dotted lines on the accompanying map. In the early settlement of the country these lakes were surrounded by a marsh which

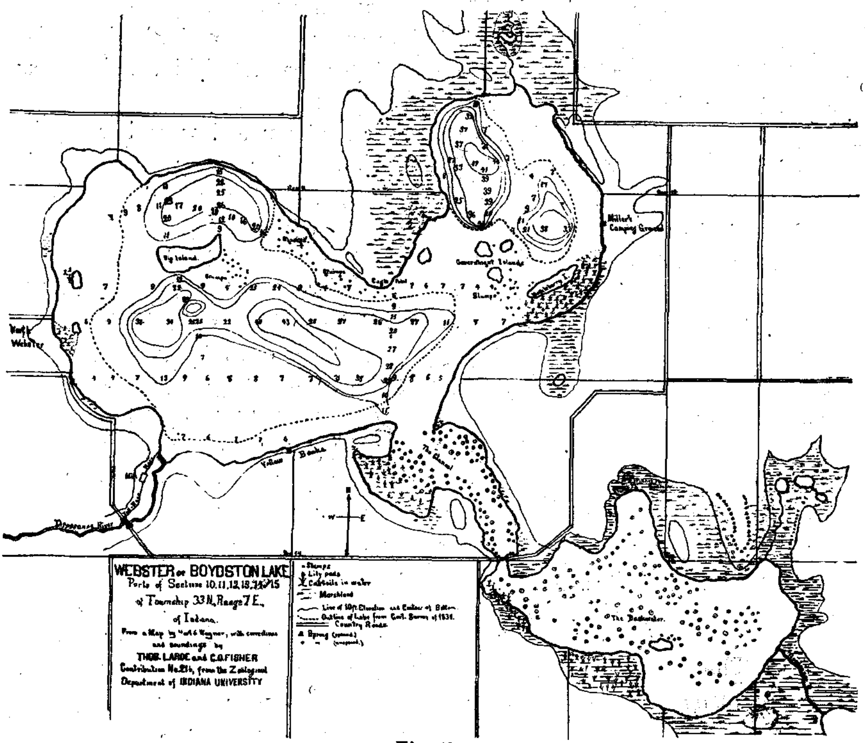


Fig. 49.

reached the margins of the present lake, and there is little doubt but that a natural lake of the same shape and area of the present partially artificial one, once existed here. About 1830 the outlet of the Tippecanoe, which flows through the lake, was dammed to secure water power for a grist mill. This raised the water seven feet, caused it to overflow the marsh of the former lake basin and unite into one body the two or three existing lakes. The "Backwater," shown on the map, was a low dry tract which by the overflow was covered with water two to three feet in depth.

At present Webster Lake is a very pretty body of water, with an area of 1.057 square miles, and a maximum depth of 43 feet. Seven islands, variable in size, rise above its surface and add to the picturesqueness of its scenery. The shores are varied in character. On the west they are composed of gravel banks 20 or more feet high which slope gently down to the water's edge. On the southwest, about the outlet of the Tippecanoe, they are low and marshy, On the south between the outlet and the channel leading to the "backwater," they rise, from a gravelly beach, 15 feet above the water and are prettily wooded with oak. This stretch is known as "Yellow Banks," and is a popular summer resort. Several cottages are already located and a number of fine sites exist for others.

East of the channel the shore is, for a distance, low and wooded, and the water adjacent to it in places contains many stumps and roots of trees which were cut after this portion was overflowed. At "Miller's," on the east side, is another fine cottage site which is partially occupied. On the northeast a strip of marsh land 20 or more rods wide borders the shore. It is in places a quaking bog—10 to 12 feet above the water level. The material composing the higher portions is a mixture of muck and marl thrown up by subterranean springs. The marsh area extends down along the west side of the northeast bay, but the west side of Eagle Point is higher, with gravelly beach and bottom, and many stumps in the shallow water adjoining. Between Big Island and the north shore is quite an area over which the water is from 15 to 25 feet in depth, while southeast of the same island is the deepest portion of the lake.

The more shallow waters of Webster Lake are full of immersed aquatic vegetation, pondweeds, bladderwort, millfoils, etc., being very abundant. The channel leading to the "back-water," as well as the large area of the latter, are literally filled with spatter-dock and white water lilies, while the rapidly forming muck beds about their margins produce rank growths of cat-tail flags, pickerel weed, arrow heads, etc., thus proving the statement previously made, that in a lake which has been raised by damming, aquatic plants flourish more luxuriantly than in one unmodified by man.

The number of species of fish in the lake is not great, but the individuals are numerous and grow to a large size owing to the abundance of plant food. The game fishes, bass, blue-gills, war-mouth and croppies, attract fishermen from long distances and their visits are always crowned with success. The following is a list of the fishes known to occur in the lake:*

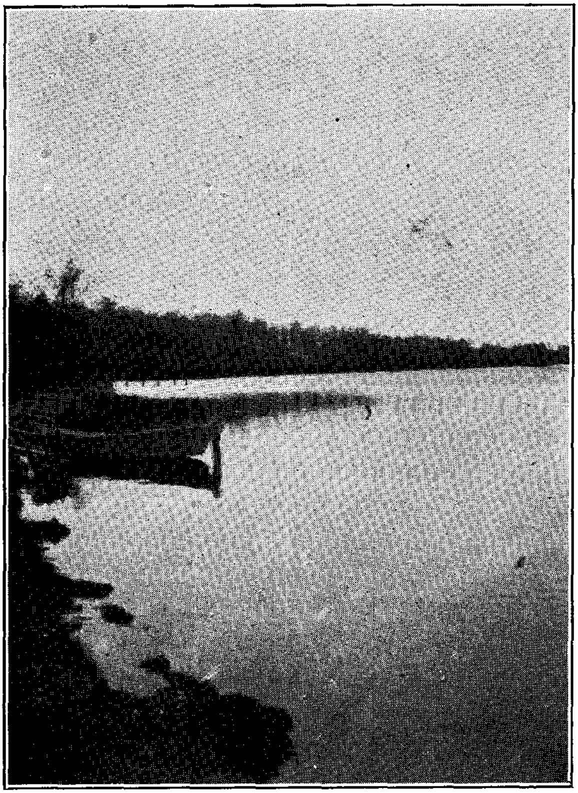
Amieurus natalis Le S. Yellow Cat.
Erimyzon sucetta oblongus Mitch. Chub Sucker; Sweet Sucker.
Pimephales notatus Raf. Blunt-nosed Minnow.
Notropis heterodon Cope. Variable-toothed Minnow.
Notropis megalops Raf. Common Shiner.
Hybopsis kentuckiensis Raf. Horny-head.
Semotilus atromaculatus Mitch. Horned Dace; Creek Chub.
Notemigonus chrysoleucus Mitch. Golden Shiner.
Zygonectes dispar Agassiz. Top Minnow.
Umbra limi Kirtland. Mud Minnow.
Lucius vermiculatus Le S. Little Pickerel.
Ambloplites rupestris Raf. Rock Bass; Red Eye.
Chœnobryttus gulosus Cuv. and Val. War-mouth.
Lepomis cyanellus Raf. Green Sunfish.
Lepomis pallidus Mitch. Blue Gill.
Lepomis gibbosus L. Common Sunfish.
Micropterus dolomieu Lacépède. Small-mouthed Black Bass.
Micropterus salmoides Lacépède. Large-mouthed Black Bass.
Etheostoma nigrum Raf. Johnny Darter.
Etheostoma caprodes Raf. Log Perch.
Etheostoma aspro Cope and Jor. Black-sided Darter.
Etheostoma flabellare Raf. Fan-tailed Darter.
Etheostoma iowœ Jor. and Meek. Iowa Darter.
Etheostoma cœruleum Storer. Rainbow Darter.
Perca flavescens Mitch. Yellow Perch.
Roccus chrysops Raf. White Bass.

MARL.—No marl worth mentioning occurs in shallow water in Webster Lake. Only two of many bores put down in water under 10 feet in depth disclosed marl. One in eight-foot water 250 yards from shore in the southwest part of the lake, found only a trace. The other, off Eagle Point in the same depth of water, found a deposit of dark colored marl six feet in thickness beneath three feet of muck. The deeper portions of the original lakes doubtless possess fair beds, but they are at present wholly unavailable.

* C. H. Eigenmann, Proc. Ind. Acad. Sci., 1895, p. 253.

PLATE 11.

a



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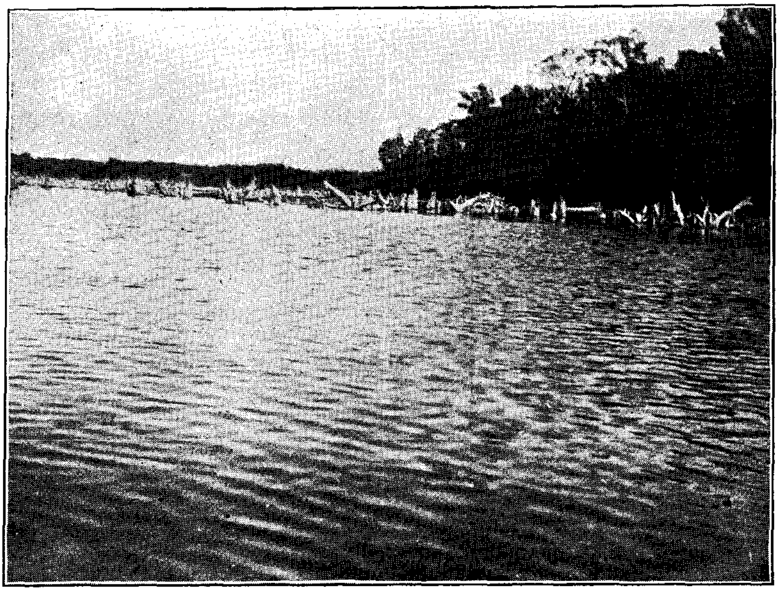

VIEWS OF WEBSTER LAKE, KOSCIUSKO COUNTY.

BARBEE LAKES.

Workable Deposit.

One of the prettiest groups or chains of lakes in Indiana is known collectively by the above name. They are six in number and occupy parts of sections 20, 21, 26, 27, 28 and 29 (33 north, 7 east), Tippecanoe Township. Their inlet, Grassy Creek, flowing northwest from Ridinger Lake, enters the extreme southern end of the largest of the group, Hammon Lake, and leaves, as their outlet, the northern extremity of the smallest, Mabie Lake. The accompanying map of the group, platted from a special survey by Geo. W. McCarter, of Warsaw, shows accurately the relation of the lakes one to another, their relative size, etc.

Where the public road crosses Grassy Creek, at the lower end of Mabie Lake, there was constructed, about 1840, a dam in order to secure power for a saw and grist mill, the latter being at Oswego, three miles northwest. To it an artificial water way or mill race 10 feet wide was constructed. This dam was washed out in February, 1857. During its existence, the waters of the lakes were five feet higher than now and Dan Kuhn and Hammon lakes formed one unbroken sheet of water.

Mabie Lake, the lowest and smallest of the group, is about 1,800 feet long by 750 feet wide and has an area of a little more than 30 acres. Its bottom is mostly of muck and shelves rapidly on all sides into 12 to 15-foot water, the maximum depth being 22 feet. The shores on the north, east and south are low and marshy, while on the west they rise 10 or more feet above the water.

Plew and Kuhn lakes occupy long and narrow parallel basins with a strip of high wooded ground, less than a quarter of a mile wide, intervening. The first named is the larger, being over three-quarters of a mile in extreme length by one-fifth of a mile in width. On the east and north the banks rise 15 or more feet, a narrow strip of marsh lying between their base and the water. The other shores are rather low and marshy. The greatest depth of water is 35 feet, while the area, less than 10 feet in depth, is small.

Irish Lake is the second in size of the group, being a little more than three-quarters of a mile long by one-half mile in greatest width. The greater part of the shore line is low and marshy. The central part of the north shore and the east half of the south shore are wooded and slope gently upward and backward from the water. At the southwest corner there is a large area of muck thickly covered with spatterdock and cat-tails. This extends back to form quite a bay.

Fifteen rods east of the west shore is an island about two acres in area. It is covered with stumps, rushes and cat-tail flags, and rises three feet above the water level. The shallow water area of Irish Lake is narrow, except along the east half of the north shore, where it extends out 200 yards or more into the lake. The greatest depth of water found was 32 feet. There is much *Chara* on the bottom along the north side, and many aquatic plants flourish luxuriantly in the muck beds about the island near the west shore.

Kuhn Lake, 180 rods long by 70 rods wide, is surrounded by low banks except on the north, where they rise gradually into the narrow ridge separating Kuhn from Plew Lake. Its maximum depth July, 1900, was 34 feet.

Hammon Lake is the largest of the group, its extreme length from northeast to southwest being just about a mile, while its greatest width is a little more than three-fifths of a mile. Its outline is quite irregular, a broad strip of land extending into its basin from the west. At Hammon's Park, on the northeast shore, wooded bluffs rise 40 or more feet a short distance back from the water's edge, otherwise the entire shore line is low and in most places marshy. There are several rather large areas of shallow water in different parts of the lake, but the greater portion of the water runs between 18 and 35 feet, while 42 feet was the maximum depth sounded. About the inlet of Grassy Creek, extensive beds of muck are slowly encroaching upon the water area. On their sub-aqueous portions pond-weeds, bladder-wort and other immersed plants flourish in profusion and, by their decay, add each year to the thickness of the slowly rising bottom. In this portion of the lake are also large numbers of water lilies, both white and yellow.

The ridge separating Dan Kuhn from Hammon Lake is about 200 feet wide and in its highest portion only three or four feet above the water level. It is covered with marsh grasses and sedges except about the old channel where dense thickets of cat-tail flags occur. This natural channel near the north end of the ridge is now choked with vegetation, but a new artificial one has been cut across farther south for the use of row boats. Dan Kuhn Lake is a little more than half a mile long by one-quarter of a mile in average width. It is the most shallow of all the lakes. The average depth is probably less than 12 feet, the maximum found being 19 feet.

The Barbee lakes are renowned as fishing resorts. The species occurring are practically the same as in Tippecanoe Lake. Irish Lake, especially, is noted for the number and size of the large-mouthed black bass which are found therein. Two club houses have been erected by disciples of Izaak Walton from Anderson, Indiana, and if their tales are to be relied upon, each season's catch is certainly phenomenal.

MARL.—A fine deposit of marl exists in Dan Kuhn and Hammon lakes. A large area along the west side of the former is covered with water from one to three feet deep beneath which no bore with 21-foot auger found the bottom of the bed of marl. Around the north and east shores there is 16+ feet everywhere beneath the four-foot water line, 150 feet out. Along the south shore in five-foot water the bed thins down to eight feet with sand beneath. The quality of the marl is excellent.

On the west and north sides of Hammon Lake between (A) and (B) the bottom of the marl bed could not be reached with an 18-foot drill in all water from the shore out 175 to 250 feet in the lake. From (B) to (C) sand was found next to shore beneath four to eight feet of marl in two to five feet of water, but at greater depths the bottom of the marl bed was beyond reach of drill. In the bay between (C) and (D) the shallow water area is extensive, reaching out 300 or more yards, and overlies marl 15+ feet in depth. Between (D) and the channel at (E) the bottom is of gravel for 75 feet out, when marl sets in, being 8+ feet thick at the eight-foot water line. From the channel nearly to the inlet, at (F), the marl is 14+ feet thick on the four-foot water line 75 to 100 feet from shore. On both sides of the inlet a thick deposit of muck covers the marl. Opposite (G) the marl appears free from muck, being 12+ feet thick at the six-foot water line 125 feet from shore. Out from (H) the bottom shelves down close to shore and in seven-foot water gravel underlies eight feet of marl. Adjoining the north side of the projecting strip of land at (I) is a large area of water only two to five feet deep, which is everywhere underlain with a marl bed 12+ feet in thickness. A similar shoal area is found opposite the channel leading to Kuhn Lake, but here the water is only six to 18 inches in depth while the marl is but six to 10 feet thick. Along shore, between (I) and (K), the marl was three to five feet thick at the water's edge and beyond reach of auger in three-foot water.

In Kuhn Lake shallow water occurs only along the margin, the four-foot line averaging about 75 feet out. The marl along the south shore is 14+ feet thick at this line, but on the north shore it averages only about 10 feet, with sand underlying. The quality is much inferior to that in the two lakes to the eastward, it being darker and, in places, gritty.

Along the north side of Irish Lake between (L) and (M) the shallow water is 200 yards wide and underlain with marl 16+ feet thick. At the shore there is usually one or two feet of muck over the marl. Between (M) and (N) the shore margin is of gravel or sand and the marl is only three feet thick at the six-foot water line, 150 feet out. A marsh of 20 or more acres borders the shore between (N) and (O). For 200 feet back this is composed wholly of a fine grade of marl 18+ feet thick. Then muck sets in, and at 250 feet is three feet thick above 10 feet of marl. Between (O) and (P) a similar marsh of marl extends back 200 to 275 feet, the marl running from 10 to 18+ feet thick, in many places bare, in others overlain with one to three feet of muck. Quite a body of shallow water marl also occurs around the island east of this marsh, but the bottom of the southwest bay is of muck only. Along the south shore gravel forms the bottom for 50 to 75 feet out, the marl averaging only about seven feet along the six-foot water line.

No marl was found in the shallow water of Mabie Lake, but in Plew Lake it occurs along the shore beneath all water three feet deep and over, the bottom of the bed being beyond reach of drill in all tests but one.

The greater portion of the bottom of this group of lakes is thus shown to be formed of a thick marl deposit. That in Dan Kuhn and the shallow portions of Hammon Lake is most available, and both in quantity and quality will well justify the investment of capital for its development. If necessary, the channels between the lakes could be easily enlarged so that the marl in and about Irish and Plew lakes could be transported in barges to a factory located near the larger deposits.

RIDINGER LAKE.

Large Deposit, Mostly Under Deep Water.

This lake occupies parts of sections 1 (32 north, 7 east) and 36 (33 north, 7 east), Washington and Tippecanoe townships. It lies in a long and rather narrow valley which trends almost due north and south. The total length of the water area, according to careful measurements made by County Surveyor McCarter, is 4,600 feet, while its width averages about one-third of a mile, the area being close to 300 acres.

The outline is quite regular, there being but two bays, one of about 10 acres in the southwest corner, the other much larger in the northeast. The inlet which enters on the south side is a stream which comes from Cedar and Robinson lakes, Whitley County, while the outlet is Grassy Creek, flowing from the northwest corner, north and then west into the larger of the Barbee lakes. A dredge ditch now being dug in Whitley County has been surveyed to the lake, and from it northward, which will lower its waters four or more feet and destroy much of its natural beauty.

At Weaver's Landing, near the middle of the west shore, there is a pretty bit of woodland sloping gradually down to the water's edge. The south half of the east shore slopes up from a gravelly beach into wooded hills, while the north half of the same shore bends rather abruptly to the east to form a wide bay, the shores of which are a willow-covered marsh, 10 rods or more wide. The north and south shores of the main lake are, for the most part, low and marshy, especially about the inlet and outlet. The greatest depth of water found was 45 feet near the center of the north half. The most of the water area is between 20 and 35 feet in depth.

MARL.—At Weaver's Landing the bottom for 50 feet out is of gravel, and shelves rapidly into deep water. Twenty rods south, in six-foot water 100 feet from shore, marl occurs 12+ feet in depth. Over the shallow water area of the southwest bay it runs about the same, except close in shore where it thins down to four feet or less. Along the west half of the south shore it is everywhere 14+ feet in four feet of water. The bottom is here covered with *Chara* and the marl is excellent in quality, the six-foot water line being about 125 feet from shore. One hundred yards west of the inlet the marl is 16+ feet thick in two feet of water. On either side of the mouth of the inlet there are large patches of spatterdock and white water lilies, beneath which muck only occurs to a depth of 14+ feet.

Along the south half of the east shore the bottom is of gravel out to the six-foot water line, where the marl sets in and thickens rapidly. In the south half of the northeast bay there is muck close to shore but 125 feet out marl 10+ feet thick underlies two feet of muck in six feet of water. In the extreme northeast corner of the lake 100 feet from shore, 11+ feet of marl is found at the seven-foot water line. At the point where the east-west township line strikes the lake, the marl is 14+ feet in three feet of water, and runs about the same until near the outlet, where it is partially replaced by muck. Along the north half of the west shore it is everywhere 10+ feet thick beneath six feet of water, while in three-foot water, 175 feet out, it has thinned down to three feet.

The tests show that practically the entire lake bottom is a bed of marl of good thickness and fair quality. That portion in shallow water is, now, small. The proposed ditch will greatly enlarge it, but will not likely make available an area sufficient to justify its development for cement making.

LITTLE EAGLE LAKE.

Workable Deposit.

This lake occupies parts of sections 24, 25, 26 and 35 (33 north, 6 east), Plain Township. It is about three and a half miles northeast of Warsaw and two and one-half miles east from the Michigan Division of the Big Four Railway.

The banks of the lake are irregular, in places being flat some distance back, in others rising gradually 20 or more feet above the water level. The lake has been twice lowered, the total decrease in level being about six feet, thus rendering prominent broad belts of low land along the south side and the northeast corner of the main basin; most of the old west embayment is also dry. A strip some 225 yards wide between the main lake and the south arm, through which a channel is cut, is also a wet marsh, while large areas of the western side of the south arm are above water. The former water area of the lake was about 850 acres. The present area is at least 150 acres less, the difference being left as marsh except a small portion of gravel beach on the south side.

Marl.—In the south arm of the lake the shallow water belt is narrow along the east side and the marl is shallow except on the edge of deep water. Along the west side the reed covered marsh extends well out into the lake. Drillings on the edge of this showed at every point marl to below 16 feet. The marsh of 30 or more acres lying to the west of this lobe of the lake is covered with muck, the depth of which ranges from four to 20 feet. Beneath the muck on its northern third is marl running from six to 12 feet in thickness, but the southern portion is wholly of muck. There appears to be at least 50 acres underlain with marl in this part of the lake.

Between the south lobe and the main lake there is a marsh (F. J. K.) of 30 or more acres in which marl comes to the surface, over the most of which it ranges from six to 25+ feet in depth. At the south end of the channel, cut through this marsh, there is about a foot of muck above the marl, but elsewhere the marl forms the surface. The former lobe of the lake, west of the point at (K), is now nearly all a marsh, which, in summer, is covered with wire grass, rushes and sedges. At the east side of this marsh the marl is shallow, running only from two to five feet in depth. This is owing to the proximity of the high point which separates this arm from the main lake. The remainder of this marsh area of 80 or more acres is underlain with a fine quality of marl which runs from nine to 25 feet in thickness.

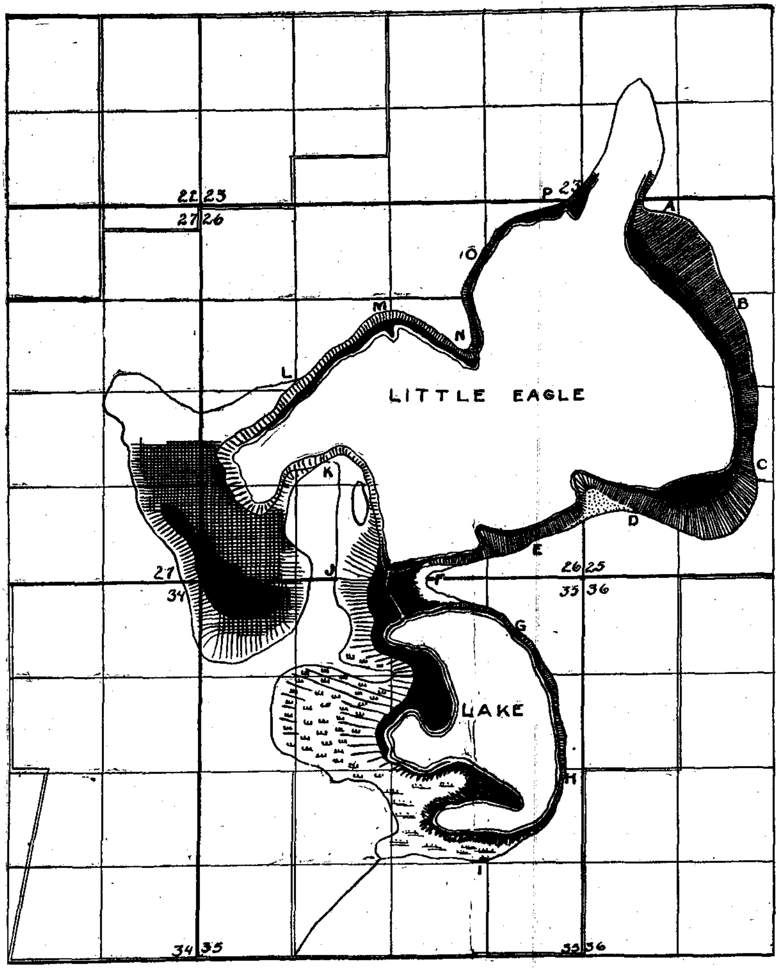

Fig. 51. Map of Little Eagle Lake, Kosciusko County, Ind.

Along the south side of the main lake the shallow water forms a broad belt from 200 to 1,000 feet wide, deepening very gradually. Near the center a broad point of hard bottom covered with very shallow water extends well out into the lake, otherwise the shallow water is underlain by marl. This tends to deepen gradually from the shore outward, so that the average depth under the shallow water is probably not over 10 or 12 feet. For a space along the east shore the bottom is hard for some distance out, but in six or seven feet of water showed marl to below reach of pole. The northern half of the east shore shows a broad belt of shallow water marl, the width being in places between 500 and 1,000 feet. The depth seemed irregular but is similar to that along the south side. Along the north bank the belt of shallow water marl is narrow, ranging at most places between 50 and 150 feet wide. The marl, however, seems to run much deeper than at corresponding distances from the south shore. There is little doubt but that three-fourths or even more of the deep water area of the lake is underlain with a thick deposit. The shallow water and marsh areas are, however, sufficient in acreage and thickness to furnish material for a large cement factory for many years.

The quality of the marl in Little Eagle Lake runs from poor to good. In the south lobe of the lake much of the deposit appeared mucky, especially at the south end. That in the main lake appeared of much higher quality, being a light brown to gray. An analysis by Dr. Noyes of a sample, taken from about two feet below the surface by Geo. W. McCarter, the owner of a large part of the marsh area about the lake, gave the following percentage composition:

Calcium carbonate ($CaCo_3$)	84.75
Magnesium carbonate ($MgCo_3$)	2.84
Ferric oxide (Fe_2O_3)	0.35
Alumina (Al_2O_3)	0.15
Calcium sulphate ($CaSo_4$)	0.07
Insoluble inorganic matter (*silica, etc.*)	4.61
Organic matter	5.69
Total	98.46

An average sample from a greater depth will, without doubt, show a higher percentage of carbonate of lime, and a lower of organic matter.

CENTER AND PIKE LAKES.

WORKABLE DEPOSIT.

CENTER LAKE.

Center Lake lies north of and adjoining the city of Warsaw. It is situated in sections 5 and 8 (32 north, 6 east), Wayne Township, and its eastern shore is but a few rods west from the Michigan Division of the Big Four Railway. The present water area covers about 200 acres. The banks are low on the north and northwest; otherwise the ground around the lake slopes up gently to a height of 10 to 20 feet The water is 80 feet deep not far from the shore in the southwest part and nearly as deep in places near the east shore. The lake is fed by a small stream from the northeast. The outlet leaves the west side and after a tortuous course of two or three miles flows into the Tippecanoe River. The area of shallow water is, as a rule, narrow, 50 to 150 feet wide, except at the north end, where there are several acres of shallow water, partly grown up with rushes.

MARL.—The most of the marl found was at the north end, where none of the tests reached bottom at 16 feet in one to four feet of water. Along the east side the distribution of the marl is irregular. Near the center of this side the bottom was found to be hard out to beneath 10 feet of water, then marl sets in. A little north of this six feet of marl was found in three feet of water.

In the southeast corner tests in water from three to 15 feet deep gave only one or two feet of marl. Just north of the end of Buffalo street, at the extreme south end of the lake, five and a half feet of marl was found in one and a half feet of water close to shore and at 50 feet out in four feet of water, the marl ran below pole, as it also did 200 feet out in seven feet of water. The southwest part of the lake showed marl just equaling in depth the water up to eight feet as far as we could test. In the northwest part of the lake hard bottom or only a few feet of marl occurs.

PIKE LAKE.

Pike Lake lies one-half mile east of Center Lake, the Michigan Division of the Big Four Railway passing between the two. It occupies parts of sections 4, 5, 8 and 9 (32 north, 6 east), Wayne Township. The north end is within a few rods of the Big Four Railway and its south end is a little over half a mile from the Pittsburg, Ft. Wayne & Chicago Railway. On the west, east and southeast the banks slope up 15 to 25 feet above water level. On the north and extreme south the banks are low. The embayment on the east is shallow, most of its surface being covered with less than 10 feet of water. Just west of the point at the cemetery the deep water comes quite close to the shore. Around the rest of the shore, the water deepens gradually. The total area of the lake is about 250 acres.

MARL.—A small lobe of the lake at the north end is now practically shut off from the main body and was not examined. The main deposit of marl occurs in the eastern embayment, covering probably 20 to 30 acres and extending at every point tested to below

16 feet under the water surface. West of the cemetery no marl was found. At the south end of the lake, nearest Warsaw, the marl runs back under the bank 75 to 100 feet, having at the former distance a depth of five feet with little or no muck overlying. At the water's edge the marl is six feet deep, and nine feet deep in three feet of water. In the southwest corner the marl does not set in close to shore, only one foot of marl occurring in seven feet of water and four feet of marl in 10 feet of water, 75 feet from shore. Along the west bank next to the park no marl was found, until the north end was approached, where three feet of marl is found in eight feet of water, while further out it deepens to below reach of drill.

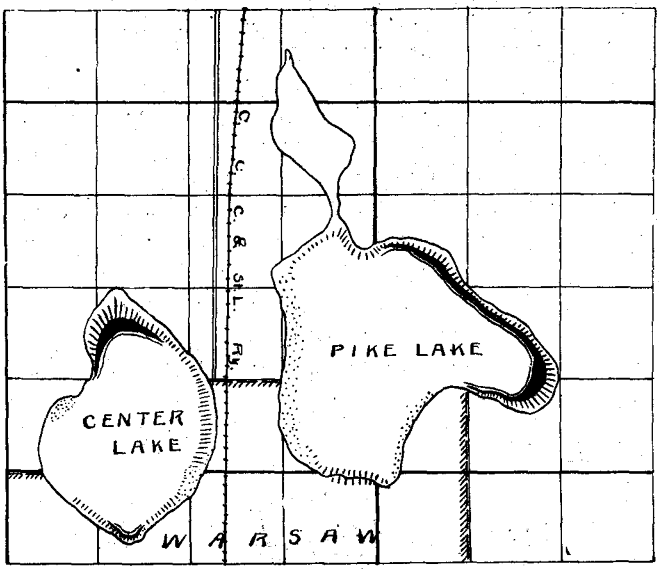

Fig. 52. Map of Center and Pike Lakes, Kosciusko County, Ind.

Along the north side the marl does not set in until the water reaches a depth above three feet. In four-foot water the marl runs from one to three feet, while near the section line the marl is only three feet deep in 10 feet of water. Further east it extends below reach of drill in five feet of water.

The quality of the marl is variable, the best occurring just north of the cemetery. The marl in the north part of the lake is mucky; that at the south end generally good. The deposit beneath Pike Lake is not of itself large enough to be termed workable, but taking it in connection with that beneath Center Lake, a fair workable deposit is presented. Lying as close as it does to excellent railway facilities, it offers a good location for a factory site.

EAGLE OR WINONA LAKE.*

Workable Deposit.

This lake lies one mile southeast of Warsaw and occupies parts of sections 15, 16, 17, 21 and 22 (32 north, 6 east), Wayne Township. It consists of a main body of water, almost a square mile in area, and a small bay on the northwestern side connected by a narrow channel. The catchment basin is large as compared with the size of the lake itself. Unusually heavy rains change the lake level as much as two to two and a half feet. The tributary streams are three in number. The largest is Cherry Creek, which flows into the lake on the southeast. For the most part it flows through woodlands. Two other streams, the larger of which is Clear Creek, enter the lake at its extreme southern part, The output of Clear Creek is nearly as much as that of Cherry Creek. Numerous springs on the Winona Assembly grounds, as well as a number bubbling up from the bottom, also add to the waters of the lake. The outlet is a small stream from the south end of the northwest bay, which finds its way into the Tippecanoe River at a point one mile northwest of Warsaw. The shore line, for the most part, is low. On the north, a small stretch of cultivated land rises rapidly to a 10-foot elevation line. The Winona Assembly grounds on the east have the greatest elevation. This elevation is from 10 to 50 rods back from the lake. The other parts of the grounds lie below a 10-foot line. The south shore is uniformly low and swampy. On the west, an abrupt rise is found at Yarnell's Landing. To the north of the landing the shore is low, and the elevation gradual. Natural woodland is found at Yarnell's, at the outlets of both Clear Creek and Cherry Creek and on the Assembly grounds.

The greatest depth of water in the lake is 81 feet near the center of the main body. The contour lines on the accompanying map show the depth in other portions. It will be seen that the embayment in the northeast corner runs shallow, and a belt of shallow water from 50 to 150 feet or more wide, runs all along the eastern and southern side. Along the north shore the belt of shallow water is broad but irregular.

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*Much of the general data relative to this lake, as well as all of the information concerning the plants and vertebrate animals, was kindly furnished by Prof. Earl E. Ramsey of the Muncie High School. Prof. Ramsey has been connected with the Summer Biological School at Winona for several seasons, and has thus had most excellent opportunities for securing information.

The area covered by water is .987 of a square mile, or 631 acres, and there are probably 125 acres of marsh land adjacent. By reference to the map of Eagle Lake prepared by the U. S. survey in 1834, it will be seen that the lake was then considerably larger than now. The difference in area has been brought about, first by dredging the outlet channel and lowering the level of the lake. Second, the en-

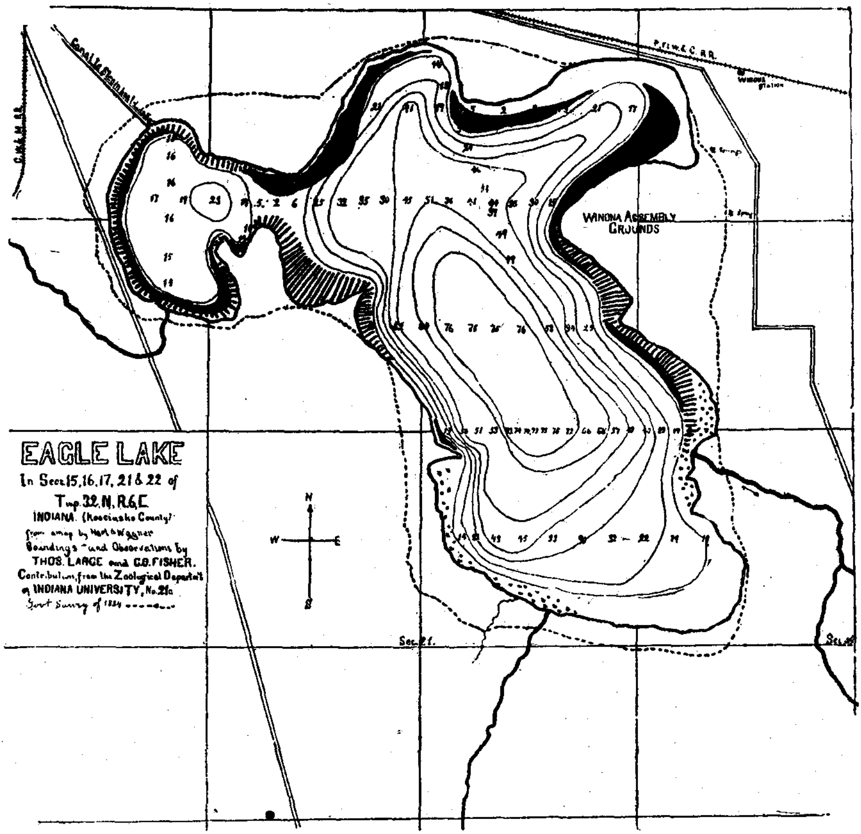

Fig. 53. Map of Eagle Lake, Kosciusko County, Ind.

croachment of plant life upon the lake proper and the luxuriant plant life on the land partially dried by lowering the lake level. As noted farther on, the plant life in the lake is abundant. The dense beds of *Scirpus, Nuphar*, etc., tend to collect material that may float into them and also contribute their own growth to the formation of new lake bottom. A third agency which has acted in some parts of the lake—notably the southern part—is that of the ice.

With the lowering of the lake level, stretches of lake bottom were left barely covered by water and were in most cases separated from the land by deeper water. As the ice formed, it pushed the ground higher on these shallow places. The ice cracks in exceedingly cold weather. The cracks fill with water and freeze again and crowd the ice and the substratum of earth still farther shoreward. Very much of the south shore of the lake shows such a formation. The ice beach near the outlet of Clear Creek is at least 30 inches above lake level and separates a dense swamp from the lake. In this swamp thus isolated from the main lake, the semi-aquatic plants readily establish themselves and thus finally reclaim the swamp land.

The plant life in the lake is abundant. A bank of *Scirpus* practically encircles the lake. *Nuphar, Nymphæa, Typha, Potamogeton, Ceratophyllum* and *Chara* are abundant. The outlet is now entirely "overgrown" by *Nuphar, Nymphæa, Typha* and *Scirpus* arranged in water zones.

The average temperature of the water from July 6th to August 23d, 1899, was 80 degrees at a depth of two feet; the air temperature for the same time was 81.5 degrees. The deep water of the lake marked 41 degrees, and was of course subject to no diurnal changes. The prevailing winds during the summer months are west to southwest.

THE COLD BLOODED VERTEBRATES OF WINONA LAKE.

By Earl E. Ramsey.

FISHES.

The number of species of fishes thus far secured in Winona Lake, its inlets and outlets, is 41. Considering the great variety of physical conditions, the number of species is small. But the number of individuals of each species is much more disappointing. The scarcity of the larger food fishes is due to the great amount of fishing in the lake. But the scarcity of the smaller fishes, the *Cyprinidæ*, many species of the darters, *Labidesthes*, etc., is not accounted for in this way.

To show the relative numbers of a very common form which serves as food for the larger species, I may take the *Labidesthes sicculus*. As many as a gallon of this form may be secured in either Turkey Lake or Tippecanoe Lake, Kosciusko County, at a single haul of the seine. Not more than three or four dozen were secured in Eagle Lake during the entire summer. The same relative proportions are true of many other forms.

The following list gives the species and localities from which they were secured. The column marked N* gives some notion of the relative abundance. Thirteen families are represented and 33 genera. The +'s in the other columns indicate the localities in which the various species are found.

	Cherry Creek.	Clear Creek.	Lake.	Outlet.	Tippecanoe River.	N.
Lampetra wilderi Gage				+		1
Lepisosteus osseus (L.). Common Gar-pike			+			1
Lepisosteus platostomus Raf. Short-nosed Gar			+			×
Amia calva L. Mudfish; Dogfish			+			—
Amieurus nebulosus (Le S.). Yellow Cat			+			×
Amieurus melas (Raf.)				+		2
Schilbeodes gyrinus (Mitch.). Slender Mud Tom				+		3
Carpiodes (sp........)†			+	+		2
Catostomus commersoni (Lacépède)		+				—
Catostomus nigricans Le S. Hog Sucker; Stone Roller	+	+	+	+		×
Erimyzon sucetta oblongus (Mitch.). Chub Sucker; Sweet Sucker				+		×
Minytrema melanops (Raf.). Winter Sucker		+				1
Campostoma anomalum (Raf.). Stone Roller	+	+				+
Pimephales notatus Raf.). Blunt-nosed Minnow	+		+			+
Notropis whipplei (Girard). Silver-fin	+		+	+		+
Notropis cornutus (Mitch.). Silver-side; Shiner	+			+		×
Hybopsis kentuckiensis Raf.). Horny-head	+	+				—
Semotilus atromaculatus (Mitch.). Horned Dace; Creek Chub	+	+		+		+
Abramis chrysoleucus (Mitch.). Golden Shiner			+			×
Umbra limi (Kirtland). Mud Minnow	+					5
Lucius vermiculatus (Le S.). Little Pickerel	+		+	+		×
Fundulus notatus (Raf.). Top Minnow			+			+
Fundulus dispar (Agassiz). Top Minnow				+		—
Labidesthes sicculus (Cope). Brook Silverside	+		+	+		—
Pomoxis sparoides Lacépède). Calico Bass; Grass Bass			+			1
Ambloplites rupestris (Raf.). Red-eye; Goggle eye	+		+	+	+	+
Chænobryttus gulosus (Cuv. and Val.). War-mouth	+		+	+		×
Lepomis pallidus (Mitch.). Blue-gill; Blue Sunfish	+		+	+	+	+
Lepomis megalotis (Raf.). Long-eared Sunfish				+	+	×
Eupomotis gibbosus (L.). Common Sunfish	+		+	+		×
Micropterus dolomieu (Lacépède). Small-mouthed Black Bass					+	5
Micropterus salmoides (Lacépède). Large-mouthed Black Bass	+		+	+	+	+
Percina caprodes (Raf.). Log-Perch; Manitou Darter	+		+		+	×
Hadropterus aspro (Cope and Jor.). Black-sided Darter	+		+		+	3
Boleosoma nigrum (Raf.). Johnny Darter	+	+	+	+	+	+
Diplesion blennioides Raf. Green-sided Darter					+	2
Etheostoma iowæ Jor. and Meek. Iowa Darter	+			+		—
Etheostoma cæruleum Storer. Blue Darter; Rainbow Darter	+	+	+	+	+	+
Microperca punctulata Putnam. Least Darter				+		—
Perca flavescens (Mitch.). Yellow Perch; Ringed Perch	+		+	+		×
Cottus ictalops (Raf.). Bullhead; Blob	+	+		+		+

BATRACHIANS.

This group is represented by but eight species, as follows:

1. *Necturus maculosus* Raf. Mud Puppy; Water Dog.

Three or four specimens were found by workmen who were deepening the channel of Cherry Creek.

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*In some cases the number of specimens collected is marked; + indicates that the species is abundant; ×, not so abundant; —, but few.

†Two large specimens taken by fishermen were seen. The species was probably *C. velifer* (Raf.), but no positive identification further than genus could be made.

2. *Bufo lentiginosus americanus* (Le Conte). American Toad.
3. *Acris gryllus gryllus* (Le Conte). Southern Cricket Frog.
4. *Acris gryllus crepitans* (Baird). Northern Cricket Frog.
5. *Hyla versicolor* (Le Conte). Common Tree Toad.

But two specimens of this interesting animal were gotten.

6. *Rana pipiens* Kalm. Leopard Frog.

This is the most abundant of the frogs.

7. *Rana clamitans* Latreille. Green Frog.

This species is nearly as numerous as *R. pipiens*.

8. *Rana catesbiana* Shaw. Bull-frog.

But one or two specimens found.

SNAKES.

Eight species of snakes have been found in the vicinity of the lake.

1. STORERIA DEKAYI (Holb.). Dekay's Brown Snake. Rare.
2. CLONOPHIS KIRTLANDI (Kennicott). Kirtland's Snake.

Only two or three specimens were taken.

3. THAMNOPHIS SIRTALIS PARIETALIS (Say.).

3a. THAMNOPHIS SIRTALIS SIRTALIS L.

These two varieties of the garter-snake are the most abundant of the forms found in the vicinity of the lake. On July 19th, a female bearing 30 well developed embryos was killed. On August 5th, one kept in a pen gave birth to young, the number of which could not be ascertained.

4. REGINA LEBERIS (L.). Leather Snake; Queen Snake.

The leather-snake is abundant in the locality of the lake, being perhaps third in point of number. On August 12th, 1899, a gravid female was found having 10 well developed embryos. Its haunts are along creeks.

5. NATRIX SIPEDON (L.) Water Snake.

This form is plentiful. On July 23, 1900, a female containing 26 embryos was killed. The water-snake is a swamp-loving form, and is of a sullen, vicious disposition.

6. Bascanion constrictor (L.). Blue-racer; Black Snake.

This is the largest snake in the vicinity of the lake, and is comparatively abundant. When captured and put in a pen, it soon tames and seems to take delight in being handled. Its movements and shape are peculiarly graceful. Its food consists of frogs, garter-snakes, etc. A specimen 42 inches long swallowed a garter-snake 28 inches long. I have known it to lay its eggs about the middle of June and have found the young hatching about the middle of September. Its egg-laying habit is worthy of note. One specimen selected the soft ground between two rows of potatoes and pushed her way under the ground. As she crawled along in this underground passage, the eggs, 22 in number, were lain in the channel which her body had made. Another laid her eggs in the hollow root of a half decayed stump.

The eggs are white in color, are about an inch in length and have a uniform diameter of about one-half inch. The soft shell is so tough that it will sustain a weight of more than 100 pounds without breaking. The young, when first hatched, are seven or eight inches in length. The first action when the little head is thrust through the leathery shell is to stick out its tongue. The blue racer frequents the woods or high grass and weeds.

7. Lampropeltis doliatus triangulus (Boie.). Milk Snake; House Snake.

This species is found rarely.

8. Sistrurus catenatus (Raf.). Prairie Rattlesnake.

The prairie rattlesnake is second in point of numbers, the garter-snake being more plentiful. During the summer of 1899, eleven specimens were caught, and nine were taken during the following summer. They are usually found in low land and run but little during the day unless disturbed. Nothing was learned concerning their food, since they persistently refused to eat when kept in confinement. A female kept in a pen gave birth to seven young on August 13th. Several of the little ones were kept in a glass aquarium for a time. On August 17th they drank some water and were given small bits of fresh meat. Three days later they began their first moult. They were about eight and a half inches long at birth. A case was reported to me in which 13 young were born. The adults are inoffensive, and move slowly. They are easily captured by means of a noose slipped over their head or by an insect net.

TURTLES.

The land and water forms together number eight species. Of these, the soft-shelled turtle, the speckled tortoise, Blanding's tortoise and the box tortoise are rare. Even the commoner species are not very abundant. No more than two dozen eggs were found. They were those of the stink-pot, *Aromochelys odoratus* (Latreille), and were laid in heaps of debris which had been washed up along the shore. The species are as follows:

1. *Aspidonectes spinifer* (Le S.). **Common Soft-shelled Turtle.**
2. *Chelydra serpentina* (L.) **Common Snapping Turtle.**
3. *Aromochelys odoratus* (Latreille). **Musk Turtle.**
4. *Graptemys geographicus* (Le S.). **Map Turtle.**
5. *Chrysemys marginata* (Agassiz). **Lady Turtle.**
6. *Clemmys guttata* (Schneider). **Speckled Tortoise.**
7. *Emydoidea blandingii* (Holb). **Blanding's Tortoise.**
8. *Terrapene carolina* (L.). **Common Box Turtle.**

MARL.—The largest body of marl appears to lie along the north shore and in the embayment in the northeast corner. Except near the ice house on the northeast shore the marl, at practically every point tested in the area mentioned, extended below depth of drill. There would seem to be 50 acres of marl in that area in less than 15 feet of water. South of the embayment mentioned is an area of low ground underlain with marl. Rounding the point and running south the marl occurs along the shore with a good width and depth until the Indiana University Biological Station is reached where, for a distance past the mouth of an inlet from the east, the bottom is sandy. Along most of the south end of the lake the belt of shallow water marl is broad and the marl below reach of pole. At the edge of the water the marl appears to be replaced with muck. In the southwest corner of the lake the bottom is sandy. South of the center of the lake is a shoal of 10 or 15 acres of shallow water over which the bottom of marl was below reach of drill. Along the north half of the west shore the marl sets in, but over a very narrow belt. Passing through the "Narrows" one enters a small bay or arm in which the marl occurs all around the shore in a belt of medium width and at most points tested was over 16 feet in thickness. Apparently some of the low land adjacent to this bay is underlain with marl but it was not tested. All told, there appears to be 75 to 100 acres of shallow water marl, most of which extends over 16 feet below the water level.

The quality of the marl, while variable, generally appeared good, that toward the northeast being the best.

HUFFMAN LAKE.

Large Deposit, Mostly Under Deep Water.

This lake occupies parts of sections 30 and 31 (33 north, 5 east), Prairie Township. It lies half a mile northwest of the village of Atwood and a quarter of a mile or less from the Pittsburg, Ft. Wayne & Chicago Railway. The lake was lowered four feet in the summer of 1899. The former water area, according to the county atlas, was about 250 acres. The present area is probably 75 or 100 acres less. Due to the lowering of the lake the present water area is everywhere surrounded by a broad bench running from 200 to 300 feet wide or over. The waves are already at work leveling this off so that at most points the bench ends abruptly at the water's edge in a perpendicular

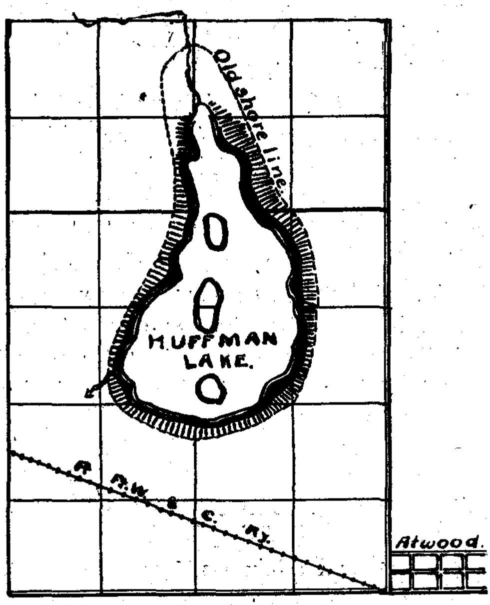

Fig. 54. Map of Huffman Lake, Kosciusko County, Ind.

or partly undermined bank a foot or two high and extending to just below the water level. Back of this bench, at the north, occurs a broad and extensive marsh; at the south, low ground, while at the east and west the banks rise gradually into upland of moderate height. In the lake the water at every point becomes deep only a yard or two from the bluff described above. Three small islands rise six to eight feet above the water in the south part of the lake.

MARL.—The lowering of the lake has brought the surface of all of the former shallow water marl above the present water level. This forms the bench described above, at all points except at the extreme north end of the lake. Toward the shore this bench tends to become mucky. Sometimes the surface of clean marl forms the larger part of the bench, as at the southeast corner, while again, as along the northwest shore, the marl is exposed over only a part of the bench. Thus near the southeast corner the old shore line was 300 feet back of the present line and there the muck starts in a few inches deep. Going out the muck runs out and the marl increases in depth until half way between the old and new shore lines the marl is 16 feet deep. Further north in places the depth increases more rapidly so that 16 feet of marl is found only 75 feet from the old shore line, and 225 feet from the new. At the north end of the lake no marl is exposed and as far as drilled only a marly muck occurs. Along the west side the band of marl seems much narrower and the muck increases rapidly in depth from the edge of the exposed marl. Thus at one point, 15 feet from the inner edge of the exposed marl, the muck was found to be almost 10 feet deep, while below that was marl to beyond depth of auger. The three islands appear to be wholly composed of marl.

The quality of the marl did not appear of the best, it being a dark gray. The cutting of the water exposes well the shells in the marl, and the penetration of the *Chara* roots, in many cases the roots running into or through the shells. The amount of marl with surface exposed or in shallow water is not sufficient for manufacturing purposes. If the entire lake were drained, or if facilities are obtained for securing the deep water marl, a workable deposit will doubtless be found.

SILVER LAKE.

NOT A WORKABLE DEPOSIT.

Silver Lake lies in section 6 (30 north, 6 east), a little west of Silver Lake station on the Michigan Division of the Big Four Railway. It has an area of about 125 acres. The surrounding hills are about 15 to 20 feet high with much flat land but little above the lake level, especially on the southwest. The lake has been lowered a little, so that deep water sets in close to the present shore line.

MARL.—Along the side of the water's edge the marl runs from nothing to a maximum of 13 feet, being 13 feet deep at (A), nothing at (B), then thickening up to 12 feet at the boat houses at (C). It evidently extends back several rods but with increasing cover. At the south end of the southeast lobe only muck was found. From (D) to (E) the deep water sets in about 20 feet from shore. Here the marl runs from 10 to over 16 feet deep. South and west of this is

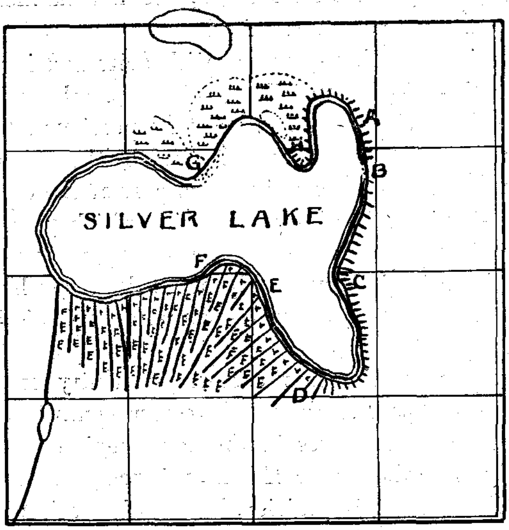

Fig. 55. Map of Silver Lake, Kosciusko County, Ind.

a flat area, probably exceeding in size the area of the lake, which consists of marl overlain by muck. At the shore the muck is about six inches deep; 300 feet back from shore the muck has increased to four feet with 10 feet of marl below. Marl is reported to have been struck down the outlet under from two to four feet of muck. North and west of (F) and south of (G) the marl is over 16 feet deep, though available over only a very narrow strip. Just east of (G) the marl runs a foot thick in water from one to six feet deep. At (H) the marl is again deep.

This can not be considered a workable deposit.

FULTON COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 217.

1875.—G. M. Levette, 7th Ann. Rep. Geol. Surv. Ind., p. 474.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 46.

Fulton County is located near the center of the northern half of Indiana. It is in the third tier of counties south of the Michigan-

Indiana line and is bounded on the north by Marshall, on the east by Kosciusko, Wabash and Miami, on the south by Miami and Cass and on the west by Pulaski County. In outline it is very irregular, the south and east sides being dove-tailed in with some of the townships of the adjoining counties, in a very peculiar manner. The total area of the county is 380 square miles.

The surface is everywhere covered with drift and is very diversified. The Maxinkuckee moraine covers the northern third of the county, while the eastern and southeastern portions are covered by the western slope of a bulky moraine formed by the Erie lobe. These two moraines connect in the northeastern part of the county to form the great Erie-Saginaw interlobate moraine which passes northeastward into Michigan through the northeastern part of Indiana. The thickness of the drift is known only at Rochester, where it ranges between 155 and 245 feet, and at Kewanna, where it is between 167 and 208 feet.

The county lies on the southeastern extremity of the prairies which cover a great part of the northwestern counties of the State. These prairies lose themselves in the oak openings, and disappear almost entirely after the center of Fulton is reached. Nearly fifteen per cent. of the surface is prairie; the remainder is pretty equally divided between oak openings, or barrens, and heavy timbered lands. The surface is level, as a rule, but broken into considerable hills in Henry Township in the eastern and in Richland in the northern part.

The principal stream is the Tippecanoe River, which enters from Marshall County in the northeast, and, curving south some five miles, it leaves near the northwest corner, flowing into Pulaski County. Mill and Mud creeks, the former the outlet of Lake Manitou, and the latter of the Mud Lakes, are the principal tributaries of the Tippecanoe in the county. Chippewa-Nuck, rising in Henry Township, and another stream, also known as Mill Creek, in Wayne Township, are creeks of some size, and flow, also, into the Tippecanoe. West of Rochester there is much marsh land with sandy ridges, which is imperfectly drained by Mud Creek and other streams and ditches, into the Tippecanoe.

The county is well supplied with railways, three passing entirely through it. These are: The Michigan City Division of the Lake Erie & Western, which passes north and south through the central portion; the Chicago & Erie, which enters the county near DeLong in the northwest corner, passes through Rochester, where it crosses the L. E. & W., and leaves the county at the extreme southeastern corner, thus passing diagonally across its bounds; and the Michigan Division of the Vandalia, which runs north and south a few miles east of the western boundary, passing through Kewanna and crossing the C. & E. at DeLong. The following is the altitude in feet above tide of the principal stations along these railways: Akron, 858; Bruce Lake, 776; DeLong, 748; Germany, 750; Kewanna, 786; Leiters, 745; Rochester, 779; Tiosa, 826.

The lakes of Fulton County are few in number and are as far south as any in the State. There are several of small size about Akron which we did not find time to visit and which may contain marl in sufficient quantity for commercial use.* Of the lakes visited and described on the pages which follow, only Manitou contains a marl deposit of workable size.

MANITOU LAKE.

Workable Deposit.

This large and beautiful lake lies southeast of the city of Rochester, its northwestern shore being about one mile from the corporate limits. It occupies parts of sections 10, 11, 15 and 16 (30 north, 3 east), Rochester Township. The extreme length, from the outlet at the northwest corner to the inlet at the end of the southeastern lobe, is about two and one-fourth miles and the greatest width a little more than one and one-fourth miles. The present water area, according to careful computation by Mr. Hugh B. Holman, who prepared the accompanying map, is 886¾ acres.

Three or four separate bodies of water are now comprised in Manitou Lake. These were united and their total water area greatly increased by a dam which was first constructed across the outlet in 1830.† This dam raised the water level about seven feet, and so covered the intervening areas of low ground between the several smaller lakes. The greater portion of Manitou Lake is therefore covered

*For detailed information concerning the marl deposits about Akron anyone interested can write Mr. J. J. King, who has given the matter some attention.

†This data was furnished by Dr. Vernon Gould, who wrote under the date of December 24, 1900, as follows: "The original dam at the foot of the lake must have been built about 1830. It was built by the U. S. Government and a mill erected there for the use of the Pottawottomi Indians, who had, at that time, a village and cornfields west of the lake. After the removal of the Indians west of the Mississippi, about 1836, the dam was discontinued and a dam built lower down the stream at the town site of Rochester, then just laid out and plotted.

"Later, about 1850, the dam was rebuilt at the lake and the water raised as a reservoir, the water being taken from the lake by an artificial race to the mill in Rochester. This mill was burned three years since and has not been rebuilt. No use is made at the present time of this water power below the lake."

with shallow water, much of which is not over five feet in depth. The deepest water occurs south of Long Island, where one sounding in August, 1900, showed 49 feet. The main inlet, Mill Creek, is a small sluggish stream, which enters the lake near its extreme southern end. White's Creek, still smaller, enters the east side opposite Long Island. The outlet flows about four miles northwestward and empties into the Tippecanoe River.

According to Dr. G. M. Levette: "At the time white men first visited this section of country it was inhabited by the Pottawottomi Indians, and from that tribe came the name of the lake and the legend which gave rise to it. They believed this body of water to be the home of "*Manitou*," or "Bad Spirit;" that during heavy storms and certain nights in the dark of the moon, he might be seen disturbing and tossing the water, and, in defiance of repeated warnings, a number of dauntless "braves" of the tribe, who ventured to the shore of the lake after nightfall, were never heard of afterward. So firm was their belief in this musty and absurd tradition, they would not venture upon the lake in canoes, or eat fish taken from it."*

The word "Manitou" among certain of the American Indians signified spirit or other object of religious awe or reverence. Two manitous or spirits are spoken of in Indian traditions—one the spirit of good, the other the spirit of evil. The latter must have been the one from which Lake Manitou was named, as Dr. Gould states that "it was also known as 'Devil's Lake' to the Indians and to all the early settlers. Most of the latter believed 'Manitou' means 'Devil.' The Devil was even reputed to have been seen by some of these early settlers, especially when they had snakes in their boots."

The shores of the lake have lost much of their primitive beauty on account of the destruction of timber formerly covering the bordering territory. They are much diversified in character, being, for the most part, low and marshy. In places, however, they rise 15 to 40 feet above the water level and are prettily wooded with oak and other timber. This is especially true of a stretch on the east shore above and below the East Side Hotel. Here the bank rises abruptly and the wooded grove on its crest offers fine sites for cottages—a number of which have been erected. The bottom of the lake bordering this stretch is of gravel and affords fine facilities for bathing, the water increasing gradually to 10 feet in depth 50 feet from shore.

* Loc. cit., p. 475.

Three wooded islands, Coney, Long and Round, rise 10 to 15 feet above the water level. Coney Island has one or two buildings upon it and is quite a resort for a certain element of Rochester's population. The other two are often occupied as fishing camps. West and south of Long Island are the remains of many oak stumps and logs in water three to five feet deep, showing that the area of the island was formerly much larger than at present. Southwest of Round Island is an extensive marsh known as the Goose Pond. Its bottom is of muck, and the water only from one to five feet in depth. The spatterdock or yellow pond lily, *Nymphæa advena* Soland, and immense numbers of cat-tails, *Typha latifolia* L., flourish there, and so clog the waters that they are impassible for a boat. By their decay they are slowly adding to the thickness of the muck so that but a few years will elapse until this portion of the lake will become a muck meadow. Now it is the abiding place of myriads of muskrats and, in spring and autumn, the temporary home of thousands of water fowl.

A lake possessing so large a shallow water area as does Manitou, is always productive of an extensive aquatic flora. A number of species of pondweed, *Potamogeton,* flourish everywhere in water under 10 feet, and their flowering and fruiting tips rise above the surface and are swayed by every passing breeze. The water weed or ditch-moss, *Philotria canadensis* (Michx.), abounds beneath the surface of all the bays and at the mouth of the inlets. The eel grass, *Vallisneria spiralis* L., famous food for ducks, grows around the edges of the deeper water of the original lakes, its curiously coiled, fruiting stem showing prettily through the clearer depths. Two or three species of rushes, *Scirpus,* form wide belts of vegetation in many parts of the lake, being especially common along the shelving margins of the original lakes. The peltate leaves of the water shield, *Brasenia purpurea* (Michx.), float placidly and reflect the sunshine from their dark green surface in many places, while great patches of the bottom here and there are carpeted with the waving plumes of *Chara.* Scores of other plants abound within or about the margins of this lake, those mentioned being only the ones which caught our notice during a hurried reconnaisance of the marl resources of its bottom. One could with profit spend an entire season, if not several of them, in studying and making a permanent record of its flora, paying especial attention to the zone of depth in which each species grows, and grouping those of each zone in its proper class.

The fish fauna of the lake is well worthy of mention as it attracts hundreds of anglers each season. The first 19 species of the following list were taken from it in one day a few years ago by Messrs.

Eigenmann and Norman. The remaining five species are said to occur therein by Dr. Vernon Gould, who for years has given special attention to the geology, flora and fauna of Fulton County.

LIST OF FISHES KNOWN TO OCCUR IN LAKE MANITOU.

1. *Polydon spathula* (Walbaum). Spoon-bill Cat; Duck-bill Cat. One weighing 114½ pounds was taken from the lake some years ago.
2. *Lepisosteus platystomus* Raf. Short-nosed Gar-pike.
3. *Ameiurus natalis* (Le S.). Yellow Cat.
4. *Erimyzon sucetta oblongus* (Mitch.). Chub Sucker; Sweet Sucker.
5. *Pimephales notatus* (Raf.). Blunt-nosed Minnow.
6. *Notropis whipplei* Girard. Silver-fin.
7. *Hybopsis kentuckiensis* (Raf.). Horny Head; River Chub; Jerker.
8. *Zygonectes dispar* Agassiz. Top Minnow.
9. *Umbra limi* (Kirtland). Mud Minnow.
10. *Lucius vermiculatus* (Le S.). Little Pickerel.
11. *Labidesthes sicculus* Cope. Brook Silverside.
12. *Pomoxis sparoides* (Lacépède). Calico Bass; Grass Bass; Croppie.
13. *Lepomis pallidus* (Mitch.). Blue Sunfish; Blue-gill; Dollardee.
14. *Lepomis heros* (B. and G.). Chain-sided Sunfish.
15. *Lepomis gibbosus* (L.). Common Sunfish; Bream; Pondfish; Pumpkinseed.
16. *Micropterus salmoides* (Lacépède). Large-mouthed Black Bass; Green Bass.
17. *Etheostoma blennioides* Raf. Green-sided Darter.
18. *Perca flavescens* (Mitch.). Yellow Perch; Ringed Perch.
19. *Cottus bairdi* (Girard). Miller's Thumb; Blob; Muffle-jaw.
20. *Amia calva* L. Dogfish; Mudfish.
21. *Ictiobus cyprinella* (Cuv. and Val.). Buffalo Fish. Said to reach a weight of 65 pounds.
22. *Coregonus artedi* Le S. Cisco; Lake Herring. Inhabit only the deeper waters, except in late autumn, when they visit the shoals.
23. *Esox lucius* L. Pike. Formerly common, but now rarely taken.
24. *Chænobryttus gulosus* (Cuv. and Val.). War-mouth; Indian Fish.

Eight species of turtles occur in and about Manitou Lake. Representatives of all were seen by the writer, either in the lake or in the collection of turtle shells made by Dr. Gould. This number is exceeded only at one other lake in the State, viz., Bass Lake, Starke County, where one additional species is known to occur. Those found at Manitou Lake are as follows:

1. *Aspidonectes spinifer* (Le S.). Common Soft-shelled Turtle.
2. *Chelydra serpentina* (L.). Common Snapping Turtle.
3. *Aromochelys odoratus* (Latreille). Musk Turtle; Stink-pot.
4. *Malaclemmys geographicus* (Le S.). Map Turtle.
5. *Pseudemys elegans* (Weid.). Elegant Terrapin.
6. *Chrysemys marginata* (Agassiz). Painted Turtle; Mud Turtle.
7. *Clemmys guttatus* (Schneider). Speckled Tortoise.
8. *Emys meleagris* (Shaw). Blanding's Box Tortoise. This and the last named species are more often found in the ditches leading into the lake than within its actual water area.

The mollusca of the lake appeared to be few in number of species. But little attention was, however, given to them, the following bivalves alone being noted: *Unio iris* Lea; *U. subrostratus* Say; *U. luteolus* Lam.; *Anodonta footiana* Lea and *A. grandis* Say, all of which were common.

MARL.—The testing of Manitou Lake for marl was more thorough than in most other lakes, Mr. Blatchley having put down 60 bores in May, 1900, and Mr. Hugh Holman 137 at a later date. The results show that the area covered by the original lakes is all underlain with marl, the thickness of the deposits ranging between one and 19+ feet, the length of the auger used being 22 feet. In but a few places was marl found in water less than four feet deep, the bottom being of muck and sand, and no marl occurs in one and two-foot water. Marl was almost everywhere present beneath four-foot water, 47 out of 66 bores put down at that depth finding it ranging in thickness up to 18+ feet. Fourteen of the 47 did not reach the bottom of the deposit, while the average thickness of the deposit pierced by the 33 bores reaching bottom was 7.8 feet. In all water over four feet, within the bounds of marl territory shown on the map, marl was found, and by far the greater number of bores did not reach bottom, thus showing that it occurs only within the limits of the original lakes. The best deposit, but not the most available, probably occurs in what was formerly Clear Lake, in the southwestern corner of the main body of the present water area. This lake had an area of 80 or more acres, and everywhere in four to six feet of water about its former margin the marl was beyond the depth of the auger and of a fine quality. About twenty-five acres of this deposit is at present available, the remainder being beneath water 10 to 39 feet in depth. There is not much shallow water in the long southern lobe of the lake below Long Island. The four-foot water-line along the west shore is about 100 feet from the margin of the lake and the bottom usually shelves off rapidly into deep water. About the margins of

Round Island several bores showed marl to be 16+ feet in six-foot water, while in four-foot water it was reduced to 10 feet with gravel beneath. Half way down the south lobe and about 200 yards east of the west margin "a blind island" or shoal several acres in extent comes within a few feet of the surface. Here the marl is everywhere below reach of auger in four to 17 feet of water. For a long distance north of the inlet the southern lobe is choked with vegetation underlain with deep muck. Along the east shore opposite the hotel and cottages, the 10-foot water line is only 40 to 50 feet from the margin of the lake. Marl sets in in six to eight feet of water and in water over 12 feet the bottom of the deposit was beyond reach of the auger.

East and north of Long Island the shallow water area is wide, in places extending out 700 feet from shore. In all places tested the marl is over 10 feet thick in five-foot water and, within the limit line shown on the map, but few bores were put down in which the bottom of the deposit was reached, and they were close to the shore of the lake or island in three and four-foot water. The quality of the marl in this region is not so good as in Clear Lake and the area west of Long Island, it being darker in color and coarser grained. In some places the marl is overlain by one to three feet of muck.

West of Long Island and north of the east-west section line is a large area of water from four to 20 feet in depth which is almost everywhere underlain with marl. No bore in water over five feet reached the bottom of the deposit, while most of those in four and five feet of water found the deposit to be 10 to 14 feet in thickness. Along the north shore, for 100 to 350 feet out the bottom is for the most part of gravel and the water less than four feet in depth. Mr. Holman has computed the total area of marl in the lake to be 519¼ acres. Of this fully one-half is beneath water less than 10 feet in depth. The average thickness of the deposit, as shown by the 137 bores put down by him, was 10.34 feet, but it must be remembered that most of his tests were made in shallow water, so that the average depth of the entire deposit is much greater.

An analysis of an average sample of the marl from Manitou Lake showed its composition to be as follows:

Calcium carbonate ($CaCo_3$)	87.65
Magnesium carbonate ($MgCo_3$)	2.60
Alumina (Al_2O_3)	.19
Ferric oxide (Fe_2O_3)	.30
Insoluble inorganic matter (silica, etc.)	6.39
Organic matter	2.88
Total	100.01

This shows the quality of the marl to be in every way suitable for the manufacture of Portland cement. The percentage of insoluble silica is rather high, but as silica is one of the ingredients of the clay used as a factor of the cement it is not harmful. It must be remembered that the samples were obtained and brought up by the auger, and in passing through the surface of the marl deposit were liable to be mixed with diatoms and other siliceous impurities. Samples taken in another manner, from the midst of the deposit and carefully kept from all impurities would without doubt show a higher percentage of carbonate of lime.

Finally, it may be said that the marl deposit of Maintou Lake is well worthy the attention of capitalists. Its area, thickness, and availability are all excellent. It lies within one-quarter of a mile of the Lake Erie & Western and within three-fourths of a mile of the Chicago & Erie railways, which furnish excellent transportation facilities in all directions.

NORTH AND SOUTH MUD LAKES.

Deposit of Doubtful Workable Size, Partly Under Deep Water.

These two lakes lie in sections 15, 16, 21 and 22 (29 north, 3 east), Liberty Township, eight miles south of Rochester and three miles west of the L. E. & W. Railway. By the encroachment of decaying vegetation and by draining, their water area has been reduced more than one-half within the past 20 years.

NORTH MUD LAKE.

This lake has at present a water area of only 60 acres. It is about 160 rods long by 40 to 60 rods wide and is divided into two lobes, which are connected by a channel 75 feet wide by 300 feet in length. The upper and larger lobe has low marshy shores on its east and north sides. About the inlet which enters near the middle of the east shore the marsh extends back for a long distance, forming an area of 60 or more acres. This was formerly covered with water and comprised a portion of the lake shown on the older maps. The banks of the west shore rise 20 to 30 feet, back 10 or more rods from the water's edge, a marsh intervening, except on the south half, where the bluff rises close to the water. The margins of the water contain many rushes, spatterdock and other aquatic plants. The south lobe comprises about 25 acres of water with high cultivated banks on the north and west and low marshy ones on the south and east. The marsh on the east is, however, not more than 20 rods wide and then rises into sloping wooded hillsides. The maximum depth of water in the lake is 50 feet and the shallow water area is everywhere very narrow.

Along those portions of the water margin of this lake on the east and north shores, which bordered the tracts of bare marsh marl were myriads of the dead shells of small univalve mollusks. They had been thrown up by the waves into ridges, several inches thick and a foot or two wide. This was the only lake where such an accumulation of univalve shells was noted, and it is possible that in the past their remains have contributed largely to the formation of the surrounding and underlying marl. A pint or so of the shells were scraped up, and their determination discloses the following species. The approximate relative abundance of each as represented in the mass collected, is also given:

Limnophysa desidiosa Say	4 per cent.
Limnophysa humilis Say	2 per cent.
Physa heterostropha Say	12 per cent.
Helisoma trivolvis Say	5 per cent.
Helisoma bicarinata Say	3 per cent.
Menetus exacutus Say	1 per cent.
Gyraulus parvus Say	12 per cent.
Amnicola limosa Say	20 per cent.
Amnicola cincinnatiensis Anthony	20 per cent.
Amnicola lustrica Say	10 per cent.

Remains of broken shells, in part species of *Sphærium*, undeterminable, made up the remaining 11 per cent. It will be noted that the three species of *Amnicola* make up 50 per cent. of the mass collected. Of these *A. lustrica* has not heretofore been collected in the State.

MARL.—At Minter's boat landing on the east side, near the north end of the south lobe, the bottom is of muck 20+ feet thick, and shelves rapidly, 20-foot water being found 50 feet from shore. One hundred yards northwest, on the south shore of the point of land separating the two lobes, the marl forms the bottom, being 20+ feet thick in two-foot water, and seven feet thick at shore. On the east side of the north lobe south of the inlet, the marl at the shore is 15 feet thick, and 75 feet back is three feet thick, there being probably five acres of marsh underlain with shallow depths of marl. North of the inlet for 30 or more rods deep muck only occurs in all the shallow water area. Marl then sets in again, being seven feet thick in four-foot water and beyond reach of auger in 10-foot water. A short distance farther on it forms the surface of several acres of marsh, being 10 feet thick at the shore line and 12 feet thick 200 feet back, after which muck begins to cover it and rapidly thickens. The northeastern corner of this lobe of the lake is also bordered by a strip of marsh marl, 200 yards long by 150 feet wide which runs from 20+ feet in thickness at shore to 0 at the eastern side. Along all of the north and west shores muck 12+ feet thick forms the bottom of all water less than 15 feet in depth, except in a few places, where shallow deposits of marl occur. Along the west side of the south lobe the shallow water area is only 15 to 25 feet in width and is underlain with marl five to eight feet thick, with sand beneath. The bottom along the south shore is wholly of deep muck. The south half of the east shore is bordered with marl which at shore line is 15 feet thick. Marl also forms the surface of the marsh between the water and the wooded slope, for 150 feet back, where it is six feet thick. Muck then sets in and forms the surface to the base of the hills.

There is probably 25 acres of available marl 10 to 12 feet in average thickness on this lake and probably as much or more beneath its deep water. The large marsh east of the mouth of the inlet was not tested, except along its margins, where it was wholly of muck.

SOUTH MUD LAKE.

The north line of the water area of this lake is within a quarter of a mile of the southern end of North Mud Lake, a low divide intervening which formerly could be crossed with a boat during high water. The lake now contains about 50 acres of water, with a marsh of equal or greater area bordering the northeast shore. The present water area is elliptical in shape, its shores everywhere low, and bordered with marsh. A small island covered with underbrush is located near the center of the northern half, and just north of this the maximum depth of water, 26 feet, occurs. The water is much more turbid than in the North Lake, containing myriads of the lower forms of vegetable life.

MARL.—At the boat landing on the east side, one-third of the distance from the south shore, marl forms the surface of the marsh for 50 to 75 feet back from the water's edge, and averages 10 feet in thickness. The bottom of the shallow water area all around the south half of the lake is, however, mostly of muck. Fifty feet out from shore the water is usually 16 to 20 feet in depth. The north half has a wider shallow water area about its margins which is usually underlain with marl. Near the northwest corner there is a marsh area of two or three acres on the west shore which is composed wholly of marl 12 to 16 feet in thickness. The island at the center of the north half is surrounded by marl 10+ feet thick in eight feet of water, and seven to 10 feet thick at the water's edge. East of the island along the eastern shore of the lake the marl runs from 10 feet in thickness in one foot of water to beyond 15 feet in three feet of water. As far as could be ascertained the large marsh to the northeast of the lake is covered with deep muck. Along the north shore of the lake the marl forms the surface over a strip 150 feet wide and 300 yards long, being 10 to 15 feet in thickness at the edge of the shore and gradually thinning out to the northward.

The area of available marl in the south lake is less than in the north one. If the two lakes were drained so that their depth would be everywhere below 10 feet, there is little doubt but that a workable deposit would be disclosed and the greater thickness of the marl bed would counterbalance its small acreage.

MARSH DEPOSITS NORTH AND NORTHWEST OF ROCHESTER.

Not of Workable Size.

Several beds of marl occur in marshes north and northwest of Rochester. Of these two were visited.

SMITH DEPOSIT.

On the land of Jerry D. Smith, southeast quarter of the northwest quarter of section 31 (31 north, 3 east), one-third of a mile south of the Tippecanoe River and two miles northwest of Rochester, marl occurs beneath the marsh of a valley which was formerly occupied by a small lake. The marl averages 16+ feet in thickness over an area of 10 to 12 acres. Over the larger part of this area muck one to four feet thick overlies the marl. The latter is of excellent quality and was, in the early settlement of the county, burned into lime.

SISSON & MILLER DEPOSIT.

Seven miles northwest of Rochester, on the land of Chas. Sisson and Peter Miller, in the northwest quarter of the northeast quarter of section 21 (31 north, 2 east), there is a small lake, surrounded by a wide marsh, both of which are partly underlain by a thick deposit of a good quality of marl. Fifteen bores were put down about 10 rods apart in the marsh or at the edge of the water, no boat being available. All of these found marl which varied in thickness from two to 18+ feet, the latter being at the water's edge. The marl in the marsh is generally overlain with muck from six inches to two feet thick. From indications about the shores, the present water area of 15 acres is all underlain with a thick bed of marl, there being 35 to 40 acres in the entire deposit.

BRUCE'S LAKE.

NOT A WORKABLE DEPOSIT.

This lake, formerly noted for its beauty and its fine fishing facilities, is now a desolate stretch of water bordered by bare, gravelly shores, and in many places choked by aquatic vegetation. These changes have mainly been brought about in the past three years by a dredged ditch on the west side of the lake which has drained off its water into the Tippecanoe River. The lake, as outlined on the maps of 10 years ago, occupied parts of sections 6 and 7 (30 north, 1 east), Union Township, Fulton County, and section 1 (30 north, 1 west), Harrison Township, Pulaski County. That portion in Pulaski County and at least one-third of that in Fulton County, is now a marsh.

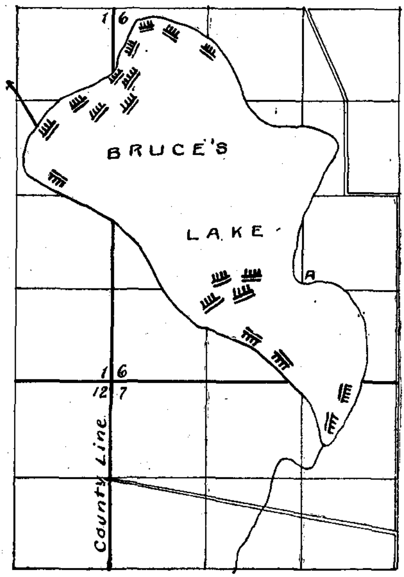

Fig. 56½. Map of Bruce's Lake.

The immediate shores of the lake are, for the most part, low, and the shallow water area is now wide. Only on the north half of the east side do the gravelly banks rise any distance above the water level. Here they are 30 feet high with a gravelly plain 10 to 15 rods wide intervening between them and the lake. On the northeast shore the gravel banks slope gradually up 15 to 20 feet above the water and a small timbered area, the only one about the lake, lies back of them. The giant bulrush, *Scirpus lacustris* L., extends out 250 or more feet from the shore, the six-foot water line being that distance out. The west half of the north shore, for 40 rods out in places, is a vast muck bed, over which flourishes a thick growth of cat-tail flags, *Typha latifolia* L. The north half of the west shore is similarly belted with a growth of cat-tails, about three rods wide. Back of this belt the bare hills of gravel and clay rise 10 to 15 feet. Opposite the point of land extending out from (A) the lake is almost filled with muck and aquatic plants and it will be but a few years before the smaller southern lobe is wholly separated from the larger one to the north. This southern lobe is now not over 40 rods wide and the deepest water found in it was 18 feet at several points near its center. The extreme southeastern bay is about 30 rods in average width, and the water ranges up to 15 feet in depth. The eastern shore of this portion, as well as of the main body of water, is everywhere bordered with rushes which, on an average, extend out 10 rods from the water's edge, though in one place north of (A) they extend out 40 rods. The maximum width of the main body of the lake is about one-half a mile, and its greatest depth, in October, 1900, was 26 feet.

Bruce's Lake has long been noted as an excellent fishing resort. Black bass, blue-gills, cat-fish, war-mouth, goggle-eye, sunfish, perch and occasionally a pickerel, were caught before the lake was lowered. Since then all kinds of fish have been growing gradually fewer in number, and many of the fishermen who formerly sought its bounds with an assurance of a good catch now cast their lines in more distant lakes. Water fowl, too, were then abundant. Being distant from any other lake, most of the migratory ducks, geese, snipe and rails, passing anywhere near its surface, stopped to feed or to float on its quiet waters, and many hunters were attracted thither in autumn and spring. At the present annual rate of decrease of its water area, but a few years can elapse before this Mecca of fishermen and hunters will be wholly a marsh of cat-tails and rushes. A score of years will see it changed into a vast acreage of corn-producing land—which change is doubtless what the gold-seeking land owners, who have begun the drainage of its waters, most fervently desire.

MARL.—The marl in Bruce Lake, where it occurs at all, is a long distance from the present shore line and is mostly overlain with muck. Numerous tests along the north half of the east shore, 150 to 250 feet out, at the six-foot water line, showed muck eight feet, marl 4+ feet. Along the east half of the north shore sand only occurs beneath three-foot water 200 feet from shore; but in six-foot water 300 feet out, the marl was 12+ feet thick and dark in color. The west half of the north shore is a muck bed, as above stated. Along the west shore marl four to 8+ feet thick is found in a few places beneath muck of varying thickness, but for the most part muck only occurs beneath all water less than 10 feet in depth. The same conditions prevail in the shallow water around the southern lobe, the muck being almost everywhere beyond reach of 18-foot auger. Beneath shallow water in the middle of the lake opposite (A) marl was found beneath six to eight feet of muck, but it was of a yellowish cast, due to the seepage through the overlying muck. While the deeper waters of the lake may in places overlie isolated beds of marl, the total deposit is too small to ever become available for cement manufacture.

MARSHALL COUNTY.

References.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 209.

1885.—W. H. Thompson, Fifteenth Ann. Rep. Dep. Geol. & Nat. Hist. of Ind., p. 177.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 37.

Marshall County lies south of St. Joseph in the second tier south of the Michigan-Indiana line. It is bounded on the east by Elkhart and Kosciusko; on the south by Fulton and on the west by Starke and St. Joseph counties. In outline it is almost square and contains an area of 440 square miles. The Tippecanoe River forms a loop in the extreme southeast corner, entering three miles north and leaving three and a half miles west of the corner. Yellow River is formed by the junction of its three main branches in the northeastern part of the county and, flowing in a southwesterly direction, leaves the western edge on the line between West and Union townships. Yellow Bank and Pine Creek, tributaries of the Kankakee, drain the northwestern fourth of the county.

Railway facilities are ample, three great trunk lines, viz., the Baltimore & Ohio, Pittsburgh, Ft. Wayne & Chicago and "Nickel Plate," crossing the county from east to west, while the Logansport Division of the Vandalia crosses from north to south, and the Lake Erie & Western from southeast to northwest. Three of these lines converge at Plymouth, the county seat, and furnish an excellent outlet in all directions. The following is the altitude in feet above sea level of the principal stations along these railways: Argos, 824; Bourbon, 836; Bremen, 813; Burr Oak, 782; Culver, 751; Donelson, 783; Harris, 838; Hibbard, 783; Inwood, 839; La Paz Junction, 851; Plymouth, 790; Tee Garden, 768; Tippecanoe, 783; Twin Lakes, 807; Tyner, 790.

The entire county is covered with glacial debris the bottom of which has been reached only at Plymouth, where stratified rock was found at a depth of 242 feet. The prominent Maxinkuckee moraine passes through the western range of townships from south to north. In the southwestern part of the county it forms a series of morainic knolls and ridges about Lake Maxinkuckee which add much to the attractiveness of the scenery about the lake. Outside of the area covered by this moraine the surface of the county is, for the most part, a gently undulating plain, broken only by shallow ravines and valleys formed by the erosion of the streams above mentioned.

The lakes of the county are few in number, but two—Maxinkuckee and Lake of the Woods—being large enough to attract tourists and sportsmen to their bounds. Of these Lake Maxinkuckee is fully described below. It ranks among the larger and is one of the most picturesque and best known of all the morainic lakes of northern Indiana. But two workable deposits of marl occur in the county, both being in Union Township in the southwestern corner.

LAKE OF THE WOODS.

Not a Workable Deposit.

This lake lies two miles south of the Baltimore & Ohio Railway, on the line between the civil townships of German and North. It is about four miles southwest of Bremen and the same distance southeast of La Paz, and occupies parts of sections 1 and 12 (34 north, 2 east) and sections 6 and 7 (34 north, 3 east).

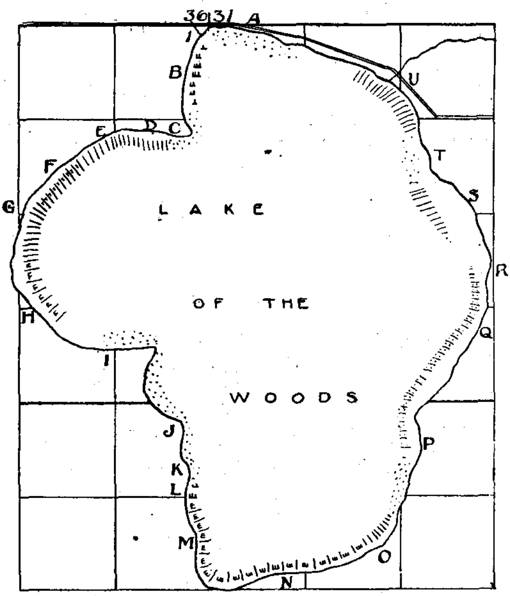

Fig. 57. Map of Lake of the Woods, Marshall County, Ind.

The length of the lake from north to south is one and one-half miles and its extreme breadth about one and one-fourth miles. In shape it is oval with a fairly regular outline except on the west, where a broad bay increases the width half a mile. In most places the area of shallow water is rather broad, the shores in general sloping back gently from the water's edge.

MARL.—Marl is found at most points around the lake, but is generally quite shallow. Starting with a sandy bottom at (A) tests out to 10 feet of water showed only muck which, at (B), was from three to seven feet thick. Around the point at (C) the bottom is hard. Between (D) and (H) some marl is struck at all points, running in thickness from one to seven feet. At (F) and (H) from three to five feet of muck overlies the marl.

From (I) to (K) the bottom is sandy, becoming toward (K) a marly sand. At (L) eight feet of muck was found. Toward (M) this becomes marly, while near (N) a foot of marl is found beneath eight feet of muck. At (O) the thickest marl was found, there being nine feet beneath seven feet of water. From (P) to (R) the marl is from one to two feet thick overlain by a few inches of sand. Over a considerable area near (S) the marl is only a few inches deep. At (T) the bottom is sandy, while at (U) a few feet of marl are found.

While there may be a large deposit of marl under the deeper water of the lake, that beneath shallow water is not sufficient to justify further consideration.

LAKE MAXINKUCKEE.

BY DR. J. T. SCOVELL.

LARGE WORKABLE DEPOSIT, PARTLY UNDER DEEP WATER.

Lake Maxinkuckee occupies parts of sections 15, 16, 21, 22, 27, 28 and 34 (32 north, 1 east). The lake is a little more than two and one-half miles long from north to south and about one and a half miles wide, having an area of nearly 1,900 acres. The surface of the lake is about 734 feet above tide. It is 150 feet above Lake Michigan, but 130 feet below the summit of the divide between Lake Michigan and the Wabash River. The lake is 15 feet above the Tippecanoe River five miles south, and about 75 feet above English Lake, 20 miles west. These elevations show that it is on a slope that descends gently toward the south and west. The lake is near the southwestern angle of the Saginaw moraine and the country surrounding it is quite varied. There are hills and valleys, broad undulating plateaus, wet marshes and boggy swamps. The soils are sand, gravel, boulder clay and swamp muck. There are more hills and clay and boulders on the east, more sand and gravel, more marshes and swamps on the west. On the east the surface rises somewhat abruptly to a general level of 75 or 80 feet above the lake, some hills reaching an elevation of about 140 feet. On the west there is a narrow divide 25 to 30 feet above the lake, then low land and swamp. The confused mingling of sand, gravel, clay and boulders, the irregular hills and the numerous kettle holes, show plainly that the surface features about the lake are of glacial origin.

Wells drilled from 75 to 150 feet through sand, gravel and clay without reaching bed rock indicate that the lake bed is wholly composed of morainic materials. In fact, it seems to occupy a cluster of kettle holes, one long and deep surrounded by several of lesser size and depth. In outline the lake is regular, Long Point on the west forming the only acute angle in its shore line.

The region drained into the lake is quite limited, being scarcely more than three times its area. On the north, west and south the divide is not, on the average, more than 40 rods from the lake. On the east and northeast, in some places, the divide is a mile and a half distant. On the east the drainage area has been much extended by ditches which reach into undrained areas. The largest inlet flows into the northeastern part of the lake, sometimes called Culver Bay. The main stream rises about a mile and a half east and flows northwesterly, westerly and southwesterly into the lake. A large branch of this stream rises about the same distance north of the lake and flowing southerly through a broad shallow valley joins the main stream near the lake. The middle course of the main stream is through a deep narrow valley and is largely made up by springs. The current in the main stream is quite strong, while the branch is a sluggish stream. Along the lower course of this inlet there are perhaps 100 acres of low ground, sometimes boggy, sometimes marshy, but generally the hard sand is at or near the surface. Through this tract the stream flows in an artificial channel. This low area seems to be rich in small springs. A second inlet, sometimes called the Norris Inlet, flows into the southeastern angle of the lake. It rises about a mile and a half east and flows westerly through a broad valley into the lake. Much of its upper course is through an artificial channel. The lower course is through a marsh about 80 rods wide and half a mile long. In this the current is very sluggish and so obstructed by vegetation that in summer it is difficult to follow the stream. This stream is fed by springs, but they are not as abundant as along the one flowing into Culver Bay. The southeast inlet is generally considered the main inlet, but the one from the northeast carries the most water. A third inlet, Aubeenaubee Creek, comes into the lake from the east. It rises about one mile east of the lake and flowing westerly and northwesterly, breaks through the low bluff, entering the lake about midway between the other two streams.

It is a small, sluggish stream, and much of its course is through low, marshy or swampy ground. The greater part of its upper course is through an artificial channel. Like the others, this stream is largely fed by springs. The low ground, some 200 acres in area, through which it flows, is separated from the lake by a narrow ridge. It seems possible that it might formerly have been a shallow lake or pond, whose outlet gradually cut down its bed till the pond was drained nearly to the level of the main lake. The marsh and swamp vegetation advancing as the water was drained away at length took possession of the whole area. Besides these larger streams there are three other small streams from the east and two from the south, but none rise more than half a mile from the lake. Those from the east are largely fed by springs and flow during the year, but those from the south are generally dry during much of the summer. On the extreme northwest of the lake there are 30 or 40 acres of marsh land. Around this area are many springs that contribute to the waters of the lake.

The outlet is a sluggish stream which flows from the west side of the lake southerly into the Tippecanoe River. The valley of the outlet is about 80 rods wide and consists mainly of marsh land. As it leaves the lake the outlet is about 16 feet wide and 20 inches deep. About 80 rods from its exit the outlet expands into a shallow pond or lake having an area of about 60 acres and a depth of from three to 12 feet. This is commonly known as Lost Lake, but is sometimes called Little Maxinkuckee or Little Lake. Below Lost Lake there is perhaps 80 rods of definite stream, and then a half mile or so of marshy pond and then a definite stream again with low marshy banks. During the summer the stream in many places is clogged by vegetation so that the current is almost imperceptible. The marshes along the east and southeast inlets, the one along the outlet and the one on the northwest of the lake all seem to be underlain by a bed of hard sand, the muck or black mud varying from one to 20 feet in depth. The lake shore even along these marshes is generally hard sand. There is a little black mud near the outlet and some near the southeast inlet, but fully 99/100 of the beach is hard sand or gravel.

Springs and Flowing Wells.—*"The springs which feed Maxinkuckee are very abundant, not only from the shores, but they may be seen in the clear water at a depth of 10 feet gushing up from the bottom, and from the deepest parts of the lake rise columns of cold water, chilling the bather like an ice bath. These springs suggested the probability of obtaining successful flowing wells, and along the eastern and northern borders of the lake a number of such wells

*This section is taken verbatim from the reports of W. H. Thompson and Frank Leverett, locs. cit.—W. S. B.

have been obtained which rise to a height of 12 to 30 feet above the lake surface. The water from these wells is very clear and cold, and more or less ferruginous, a few of the wells being so highly impregnated with iron as to render the water slightly unpleasant to the taste until one gets used to it. Most of the water, however, is excellent at the first taste, and all of it is perfectly wholesome in use. The first well driven was only 13 feet in depth. Several have a depth of but 20 or 25 feet. Others are put down to a depth of 50 to 75 feet. One well has a depth of 160 feet, and one reached a depth of 203 feet. There appear to be several water horizons, but the head is no greater from the deep wells than from the shallow ones, and the upper horizon is as strong as any.

"The deepest of these flowing wells it at the residence of D. W. Morman. At the time of the writer's visit the water scarcely reached the surface, 20 feet above the level of the lake. Of the 203 feet penetrated, fully 90 per cent. is thought to have been till, the sand beds being but a few feet in thickness.

"Two wells on the northeast shore have a head 31 feet above the surface of the lake. These wells are each 72 feet in depth and have the following section:

Soil and yellow clay	8 feet.
Sand	14 feet.
Blue clay	38 feet.
Sand and gravel	12 feet.
Total	72 feet.

"A short distance east of these wells the head in a well 50 feet in depth is but 19 feet above the lake. The well at the Peru Clubhouse, on the east side of the lake, was bored to a depth of 160 feet and obtained only a weak flow. At the Indianapolis Clubhouse a good flow was obtained at only 27 feet. At the Highland House a well 33 feet in depth entered water-bearing sand at a depth of 13 feet. Near the Highland House D. W. Morman, of Indianapolis, has several wells. Four of them, averaging about 22 feet in depth, are estimated to have a combined discharge of 15 barrels per minute. These wells feed a ram which supplies the grounds with water. Mr. Morman also has a deeper well, with the following section, in which the flow was obtained from the sand above the blue clay:

Yellow clay	11 feet.
Sand	25 feet.
Blue clay	62 feet.
Total	98 feet."

SURFACE LEVELS OF THE LAKE.—The level of the lake varies but little, probably not more than two or three feet. Records made by the Vandalia Railway people show the elevation of the ground at Culver Station to be 751 feet above tide. The surface of the lake is about 734 feet. Between October 18, 1895, and December 7, 1898, the variations were from 733.30 feet up to 735.17 feet, a total of only 1.87 feet. I could get no account of very high water, but the lake is said to have been very low in the autumn of 1871, when for nearly two months there was no water flowing in the outlet. When the level of the water in the lake is 734 feet there is about 20 inches of water in the outlet. During the low water of 1871 the level of the lake must have been down to or below 732 feet. This would indicate an extreme variation of only a little more than three feet in the level of the lake. During the greater part of the year the outflow about equals the inflow, so there is but little change of level, but during a dry summer the inflow is greatly lessened and the rapid evaporation quickly lowers the water in the lake. The flow of water in the outlet is so sluggish that the level of the lake is much affected by rains. Two days of heavy rain in August, 1895, raised the level of the lake about six inches. A rain beginning during the night of February 24, 1899, and continuing through the next day raised the level about five inches. During the high water the flow in the outlet is, of course, more vigorous, but it takes weeks and sometimes months to carry off the surplus water from a rain of two or three days.

The physical conditions about Lake Maxinkuckee seem quite permanent. The lake can not be drained much below 732 feet nor can it be raised much above 735 feet. These changes could only affect the character of some 200 acres of marsh land. When the level is about 735 feet much of the marsh along the southeast inlet and along the outlet is flooded so that perhaps from 75 to 100 acres of marsh grass can not be cut with a mower. When the level is 733 or less this marsh land is comparatively dry and teams can work over most of it without difficulty.

TOPOGRAPHY OF THE LAKE BED.—In studying the bed of the lake over 1,200 soundings were made. They were taken along 23 different lines, which were located with reference to fixed lines and points in the U. S. survey. They were made at intervals of 10 or 15 oar strokes. The length of an oar stroke of course varied, but for a given line they would be practically the same. Knowing the length of the line and the number of soundings the average distance between soundings was easily worked out, and the locations may be regarded as fairly accurate. While tracing out the outlines of bars and deep holes several hundred soundings were made between the lines mentioned. The soundings were made during the summers of 1897-1898 and 1899, at intervals as the wind and other circumstances were favorable. In sounding along the established lines we used piano wire and a wheel of known circumference. In work on the bars a sounding pole 13 feet in length was used. Much of the lake bed is covered with a very fine mud which made it difficult to tell just where the water stopped and the bed began. But in spite of this and other difficulties, the accompanying map gives a fairly correct idea of the topography of the lake bed. On the east and west line, through the center of sections 21 and 22, just east of the center of the lake we found water 85 to 89 feet deep. We heard about much deeper water but could not find it. There is only a small area of this deepest water, about 18 or 20 acres, but it is just north of the center of some 300 acres of deep water, water from 40 to 80 feet in depth. This body of deep water is near the geographical center of the lake and includes nearly all the water that is over 40 feet in depth. In this central mass toward the southwest there is a detached body of water over 60 feet deep, and there are two similar bodies of water over 50 feet deep, one north and the other south. In the southern part of the lake there is a small area of 40-foot water and there are two small areas of 40-foot water in the northwestern part of the lake. Fully one-half the area of the lake is shallow water, 10 feet or less in depth. These areas of shallow and deep water are very irregular in outline, and the connecting slopes are sometimes gradual, but often very abrupt, so that the surface of the lake bed is quite as varied and irregular as the surface of the surrounding country.

The body of deep water, nearly three times longer than wide, suggests the idea that an old preglacial drainage channel was possibly the origin of the lake bed. Kettle holes are numerous on both sides of the lake, forming prominent features of the moraine, and they seem to be the rational explanation of the lake bed. The original bed may have been a number of kettle holes, and the surface was doubtless sand and clay and gravel. But changes have occurred. The shallow parts have been modified by waves and currents and floating ice. The remains of the plants and animals living in the lake have contributed materials to the lake bed and so have the forests and other vegetation around the lake.

The distribution of soils and vegetation in Lake Maxinkuckee is very interesting. Along the shore near the marshes, bogs and inlets there is some soil and considerable vegetation. Where the banks are abrupt and gravelly or clayey, soil and vegetation are both scanty. Almost everywhere from a depth of one or two feet out to a depth of six or eight feet the same conditions prevail. On the east large areas in this zone are almost devoid of vegetation, but on the north, west and south the bed of the lake in this zone is well covered with a stunted growth of lime-encrusted chara, with occasional plants of *Potamogeton natans*, *P. lucens*, and *Scirpus lacustris*. From six to eight feet to 20 or 25 feet the white mud or marl forms a soil, and 12 to 15 different species of plants abound, generally forming a rank growth. The zone of shallow water is swept clean of all fine material, whether mud or marl. This seems to have been done by undertow currents caused principally by the winds. Westerly winds are more common and are generally stronger than other winds, and on the east, where such winds would make the stronger current, we find the hard gravel bed reaching out into much deeper water than on the other sides of the lake.

During the summer of 1899, from June 27th to September 6th, inclusive, I noted the direction of the wind 223 times, morning, noon and night, as follows: Easterly 90, westerly 31, northerly 34, southerly 47, calm 21. During the summer months the easterly winds prevail, but during the year the westerly winds prevail and are in general stronger than the winds from the other quarters. The westerly winds probably account for the broader, barren zone on the east, while the winds from other quarters cause currents over lesser areas on the other sides of the lake. It seems possible that differences of temperature between the shallow and deep water, while seldom more than two or three degrees, might also cause currents toward the deeper water strong enough to move fine materials. On July 29th, 1899, when the lake was quiet, I found a bottom temperature of 77° F. in shallow water and 79° in water seven feet deep. On the 30th it was 76° in the shallow water and 79° in the deeper water. On September 1st, 1899, it was 77° in shallow water and 79½° in the deeper water. This difference of temperature would not cause a very vigorous current, but it might do something. The difference in temperature between the surface and bottom of the deeper portions of the lake is much greater, the bottom temperature in summer being 47° to 50° F., while the surface gets as warm as 77° to 80°.

A few of the temperature observations taken in different months on the air and water are as follows:

	On West Side Lake.	6 A. M. (Deg. Fahr.)	2 P. M. (Deg. Fahr.)	8 P. M. (Deg. Fahr.)
July 28, 1899	Air	74	83	81
July 28, 1899	Water, 18 inches	78	84	82
July 29, 1899	Air	77	81	72
July 29, 1899	Water, shallow	77	87	80
July 30, 1899	Air	62	75	73
July 30, 1899	Water, shallow	74	82	78
July 31, 1899	Air	69	77	75
July 31, 1899	Water, shallow	75	84	80
August 1, 1899	Air	68	83	77
August 1, 1899	Water, shallow	76	82	79
August 5, 1899	Air	70	76	74
August 5, 1899	Water, shallow	79	82	80
August 6, 1899	Air	71	80	76
August 6, 1899	Water, shallow	75	80	78

	Ice. (Inches.)	Air. (Deg. Fahr.)	Water. Surface. (Deg. Fahr.)	Water. Bottom. (Deg. Fahr.)
November 24, 1898	....	20	40	....
November 26, 1898	....	5	35	....
November 27, 1898	....	20	34	....
December 7, 1898	....	16	32	....
December 8, 1898	....	5	32	....
December 9, 1898	3	10	32	....
December 14, 1898	7½	5	32	34
January 4, 1899	8	0	32	34
January 8, 1899	6	30	33	34
January 29, 1899	10	13	32	34½
January 30, 1899	10½	0	32	33
January 31, 1899	11	9	32	34
February 1, 1899	11½	8	32	35
February 2, 1899	12	10	32	34
February 10, 1899	16	20	33	36
February 13, 1899	18	8	32	35
February 15, 1899	18	19	32	34
February 27, 1899	15	16	36	39
March 11, 1899	10	50	33	38

On March 11th and 12th the ice melted rapidly, and on the 13th was broken up by a strong west wind and gradually piled up on the east side of the lake. There was some snow and cold weather, but the ice was all out on the 25th. The thickest ice of which I could hear was about 28 inches in 1884.

As has been noted, the winter ice forms to a thickness of from 15 to 25 inches. As the ice expands it crushes against the banks with great force. Where the shores are low the ice often pushes great quantities of sand and other materials up into ridges, sometimes two or three feet high. These ridges or ice beaches are generally washed away by the high water common in spring, but sometimes they remain, making a distinct and somewhat peculiar plant region. Along the steep banks, the boulders that have fallen to the beach during the summer are crowded against the bank by the ice, making in some places quite extensive stone walls.

FLORA OF THE LAKE.—With such a variety of soils as occur in and about Lake Maxinkuckee, a varied flora may be expected. In the waters of the lake there are great quantities of microscopic life which, in its totality, is called *plankton.* Of the microscopic plants *Protococcus, Rivularia, Oscillaria,* diatoms, desmids and others are common everywhere in the open lake, but were most abundant among the higher vegetation along the shores. Occasionally *Rivularia* would occur in such quantities as to be conspicuous to the naked eye. *Spirogyra, Vaucheria, Œlogonium, Hydrodiction, Stigeoclonium, Nostoc, Cladophera, Zygnema, Chetophora* and others, often occurred in masses in the shallow waters. Besides these lower forms, the following strictly aquatic members of the higher plants occur in the waters of either Lake Maxinkuckee or Lost Lake, or both. The nomenclature of the Phanerogams is that of Britton & Brown's "Illustrated Flora of the Northern United States."

NITELLA SP. ?

A tall slender plant; was abundant between 18 and 22 feet, ranging from 12 to 25 feet. In water from 20 to 25 feet deep we seldom found anything besides this Nitella.

NITELLA SP. ?

A small delicate plant found in shallow water, common in the marshes and in the lake out to a depth of two feet.

CHARA SP. ?

A slender, rank growing plant, quite free from lime; was abundant between 10 and 14 feet, ranging from eight to 24 feet. In some localities this chara was the only plant found between 10 and 14 feet.

CHARA SP. ?

A stout plant, seldom more than eight inches high, was thickly coated with lime. It was most abundant at a depth of from six to eight feet, often forming a thick mat of vegetation to the exclusion of other plants.

CHARA SP. ?

Much smaller than the above mentioned, quite abundant in shallow water, often the only vegetation. It was usually thickly coated with lime.

There are doubtless other species of Chara and Nitella about the lake, but the ones mentioned are the most abundant.

POTAMOGETON NATANS L. Common Floating Pondweed.

This plant was more common in the southwestern portion of the lake, growing in water from four to six feet deep.

POTAMOGETON AMPLIFOLIUS Tuckerm. Large-leaved Pondweed.

This plant was abundant in water from five to eight feet deep but ranged from two to 24 feet. On the Sugar Loaf Bar it was abundant and rank in depths from nine to 24 feet.

POTAMOGETON LONCHITES Tuckerm. Long-leaved Pondweed.

This pondweed was common everywhere in shallow water. A cluster of rank potamogetons growing in eight to ten-foot water on Weed Patch Bar I called *lonchites,* but I do not feel quite sure that I was correct.

POTAMOGETON HETEROPHYLLUS Schreb. Various-leaved Pondweed.

This plant was quite common out to a depth of four feet.

POTAMOGETON LUCENS L. Shining Pondweed.

This plant, sometimes called Perchweed, was widely distributed growing most commonly in water from six to eight feet deep.

POTAMOGETON PRELONGUS Wulf. White-stemmed Pondweed.

Not very common; growing in water from eight to 10 feet deep.

POTAMOGETON PERFOLIATUS L. Clasping-leaved Pondweed.

Not common but quite abundant in a few localities in the south part of the lake. More common in water from eight to 12 feet deep.

POTAMOGETON ZOSTERÆFOLIUS Schurm. Eel-grass.

Quite common. More abundant between 10 and 16 feet, but ranging from two to 26 feet.

POTAMOGETON FRIESII Ruprecht. Fries' Pondweed.

Widely distributed. More abundant between 12 and 16 feet, but ranging from eight to 25 feet.

POTAMOGETON PUSILLUS L. Small Pondweed.

More common in the southeastern portion of the lake in deep water, ranging from 10 to 24 feet.

POTAMOGETON PECTINATUS L. Fennel-leaved Pondweed.

Forming thick masses, excluding other vegetation, in water 10 to 16 feet deep; also in shallow water. It often stands at the head of a steep slope.

POTAMOGETON ROBBINSII Oakes Robbins' Pondweed.

Very common in the shallow waters of the Little Lake, but in the large lake more common in water from 10 to 18 feet deep, ranging from two to 24 feet.

NAIAS FLEXILIS (Willd.) Rost and Schmidt. Slender Naias.

Very abundant, ranging from one to 24 feet. Most common in the northeastern part of the lake.

NAIAS FLEXILIS ROBUSTA Morong.

This plant, while not common, was found in several localities.

SAGITTARIA GRAMINEA Michx. Grass leaved Arrow-head.

In the shallow water of the Little Lake.

PHILOTRIA CANADENSIS (Michx.) Britton. Water-weed.

Very abundant in a few localities in shallow water, as near the head of the outlet. It is widely distributed in deep water, ranging from one to 22 feet.

VALLISNERIA SPIRALIS L. Eel-grass; Tape-grass.

Said to be the wild-celery of Chesapeake Bay. The plants bearing pistillate flowers grow in shallow water. I saw none deeper than two or three feet. The male plant was most abundant in water from eight to 18 feet. We found it as deep as 24 feet. The pistillate flower is carried to the surface of the water by a long threadlike scape. After fertilization the scape forms a spiral of several coils drawing the ovary several inches under water, where the seeds ripen. The staminate flower has a short peduncle. When the pollen is mature, the flower separates from the plant and rises to the surface. The pollen, escaping from the anther, floats away to the pistillate flowers. The buds or stolons formed in the fall, on the male plant, are highly prized by mud hens and ducks as food. They will dive 10 or 15 feet for them. The shores are often thickly covered with the leaves they break off while getting these dainty bits of food.

ELEOCHARIS INTERSTINCTA (Vahl.) R. and S. Knotted Spike-rush.

In shallow water in both lakes, often forming large patches.

ELEOCHARIS MUTATA (L.) R and S. Quadrangular Spike-rush.

Abundant in shallow water near the mouth of the southeast inlet.

ELEOCHARIS PALUSTRIS (L) R. and S. Creeping Spike-rush.

Found along the southern shore of Lake Maxinkuckee.

SCIRPUS AMERICANUS Pers. Chair-makers' Rush.

Common in the shallow water of both lakes.

SCIRPUS LACUSTRIS L. Great Bulrush.

Common in the western and southern portions of the lake out to a depth of seven or eight feet. Specimens from 10 to 13 feet long often occur.

SPIRODELA POLYRHIZA (L.) Schleid. Greater Duckweed.

Common in quiet waters about the lake shores.

LEMNA TRISULCA L. Ivy-leaved Duckweed.

Common in the outlet and in the southeast inlet.

LEMNA MINOR L. Lesser Duckweed.

Often found with *Spirodela.*

WOLFFIA COLUMBIANA Karst.

In the southeast inlet and in the outlet.

ERIOCAULON SEPTANGULARE With. Seven angled Pipewort.

In Lake Maxinkuckee, but not common.

BRASENIA PURPUREA (Michx.) Casp. Water Shield.

Very abundant in the outlet, only occasionally found in the lake.

NYMPHÆA ADVENA Soland. Large Yellow Pond Lily.

Common.

CASTALIA ODORATA (Dryand) Wood and Wood. White Water Lily; Pond Lily.

Abundant in the outlet and in the Little Lake. Only occasionally found in the larger lake.

CERATOPHYLLUM DEMERSUM L. Hornwort.

Common everywhere to a depth of 24 feet. Abundant in shallow water and quite plentiful between 14 and 20 feet.

BATRACHIUM TRICHOPHYLLUM (Chaix.) Bosscb. Stiff White Water Crowfoot.

Abundant in the southeastern part of the Little Lake.

RORIPA NASTURTIUM (L.) Rusby. Water Cress.

Abundant in the northeast inlet and in other places.

MYRIOPHYLLUM SPICATUM L. Spiked Water Millfoil.

Abundant in the Little Lake and in the outlet. In water from two to eight feet deep.

MYRIOPHYLLUM VERTICILLATUM L. Whorled Water Millfoil.

Found in both lakes; not deeper than 14 feet.

UTRICULARIA PURPUREA Walt. Purple Bladderwort.

In outlet.

Utricularia vulgaris L. Greater Bladderwort.

In the outlet and Little Lake, and also in the northeast inlet.

Utricularia intermedia Hayne. Flat-leaved Bladderwort.

In the outlet and Little Lake.

Utricularia minor L. Lesser Bladderwort.

In the Little Lake and outlet.

Utricularia gibba L. Humped Bladderwort.

In the outlet.

Utricularia biflora Lam. Two-flowered Bladderwort.

In the Little Lake.

Bidens beckii Torr. Water Marigold.

Found in both lakes. Not very abundant, but ranging from two to 20 feet in depth.

The two following are found in the mud along shore:

Peltandra virginica (L.) Kunth. Green Arrow-arum.

Found in shallow water of both lakes, often in the mud along shore.

Pontederia cordata L. Pickerel-weed.

Common in shallow water of both lakes, often above water line along shore. Both of these plants, after fertilization, bend over, thrusting the ovary into the water or mud, where the seeds ripen.

On the marshes below the level of high water are found the following species and more than 60 others, largely sedges and grasses:

Dryopteris thelypteris (L.) A. Gray. Marsh Shield Fern.

Equisetum fluviatile L. Swamp Horsetail.

Found on Long Point, west of the lake.

Typha latifolia L. Broad-leaved Cat-tail.

Common in the marshes along the outlet and in the southeast inlet.

Alisma plantago-aquatica L. Water Plantain.

Common along the margins of both lakes.

Sagittaria latifolia Willd. Broad-leaved Arrow-head.

Common.

Dulichium arundinaceum (L.) Britton.

Eleocharis acicularis (L.) R. and S. Needle Spike-rush.

More common along the east shore of the Little Lake.

SCIRPUS SMITHII A. Gray.

ACORUS CALAMUS L Sweet Flag; Calamus-root.

In the marsh just north of the Little Lake.

ALETRIS FARINOSA L. Star-grass; Colic Root.

In the marsh along the outlet.

IRIS VERSICOLOR L. Larger Blue Flag.

In the marshes along the outlet and the southeast inlet.

XYRIS FLEXUOSA Muhl. Slender Yellow-eyed Grass.

In the marsh north of the Little Lake and in swampy ground along the railroad just south of the main lake.

HABINARIA CILIARIS (L.) R. Br. Yellow Fringed Orchis.

Along the outlet.

HABENARIA LACERA (Michx.) R. Br. Ragged Orchis.

Along the outlet.

GYROSTACHYS CERNUA (L.) Kuntze. Nodding Ladies' Tresses.

In marshes west of the lake.

SAURURUS CERNUUS L. Lizards'-tail.

In woods along the northeast inlet.

JUNCUS EFFUSUS L. Common Rush; Bog Rush.

SALIX NIGRA Marsh. Black Willow.

Common.

SALIX DISCOLOR Muhl. Pussy Willow.

POLYGONUM SAGITTATUM L. Arrow-leaved Tear-thumb.

Common.

BETULA PUMILA L. Low Birch.

In swamps west of the lake.

SARRACENIA PURPUREA L. Pitcher-plant; Side-saddle Flower.

In swamps west of the lake.

DROSERA ROTUNDIFOLIA L. Round-leaved Sun-dew.

On the east side of Little Lake.

DECODON VERTICILLATUS (L.) Ell. Swamp Loosestrife.

Abundant at the mouth of the southeast inlet and about the Little Lake.

MIMULUS RINGENS L. Monkey-flower.

Common along the edge of marshes.

LOBELIA SYPHALITICA L. Great Lobelia.

Common.

CUSCUTA CEPHALANTHI Engelm. **Button-bush Dodder.**
Common.

CEPHALANTHUS OCCIDENTALIS L. **Button-bush; Globe-flower.**
Common.

NYSSA SYLVATICA Marsh. **Black or Sour Gum.**
CAMPANULA APARINOIDES Pursh. **Marsh Bellflower.**
Common in the marshes.

POLYGALA CRUCIATA L. **Marsh Milkwort.**
Along the outlet below the Little Lake.

SPIRÆA TOMENTOSA L. **Steeple-bush.**
Common.

Along the beach between low and high water we found:

PANICUM CRUS-GALLI L. **Barn-yard Grass.**
MUHLENBERGIA SYLVATICA Torr. **Wood Muhlenbergia.**
CYPERUS DIANDRUS Torr. **Low Cyperus.**
POLYGONUM PENNSYLVANICUM L.
IMPATIENS BIFLORA Walt. **Spotted Touch-me-not.**
Common along the shores of both the lakes.

HIPPURIS VULGARIS L. **Mares'-tail; Joint-weed.**
At the head of the outlet.

TEUCRIUM CANADENSE L. **Wood Sage.**
LYCOPUS VIRGINICUS L. **Bugle-weed.**
MENTHA PIPERITA L. **Peppermint.**
MENTHA SPICATA L. **Spearmint.**
Common.

MENTHA CANADENSIS L. **Wild Mint.**
XANTHIUM CANADENSE Mill. **Hedgehog Burweed.**
ECLIPTA ALBA (L.) Hassk. **Eclipta.**
In low ground south and west of the lake.

BIDENS CONNATA Muhl. **Swamp Beggar-ticks.**

Besides the above more than fifty others were found along the beach, making in all over two hundred plants in and about Lake Maxinkuckee growing below high water mark.

A LIST OF THE MOLLUSCA KNOWN TO OCCUR IN LAKE MAXINKUCKEE.

By W. S. Blatchley.

The writer has collected shells in and around Lake Maxinkuckee almost every summer since 1890. From his collection and from various notes on the species taken, the present list is prepared.

UNIVALVES.

1. Succinea avara Say.

   Common on the stems and leaves of water lilies and beneath rubbish on the south and west shores.

2. Limnæ stagnalis Linn.

   A fragile and beautiful shell. Rather common among the reeds and water vegetation, especially in the vicinity of muck beds. More common in Lost Lake. Not mentioned by Call in his paper on Indiana Mollusca, but occurs in a number of the northern Indiana lakes.

3. Limnophysa reflexa Say.

   Common in both Lost and the main lakes, in the same situations as the last.

4. Limnophysa palustris Muller.

   Much less common than *reflexa*, a half dozen specimens only having been taken.

5. Limnophysa desidiosa Say.

   Abundant on the stems of water plants along the shores. One of the principal foods of snipe, and other shore-frequenting birds.

6. Physa gyrina Say.

   Frequent on the lily pads and in piles of rubbish along shore.

7. Physa heterostropha Say.

   Abundant in and about Lost Lake, and in the southeast corner of the main lake.

8. Planorbella campanulata Say.

   Common in shallow water with sandy bottom; the prettiest of the discoidal group.

9. Helisoma trivolvis Say.

   Abundant among the reeds and rushes all about the margin.

10. Menetus exacutus Say.

A minute and handsome species found sparingly on the under side of lily pads in different parts of the lake.

11. Vivipara contectoides Binney.

The most abundant univalve in the lake, unless it be *Goniobasis livescens*. After a wind storm in July and August, thousands of the dead shells of this species are washed up in windrows all along the shore. The living shells are often seen clinging to weeds in six to 10 feet of water.

12. Vivipara intertexta Say.

Much less common than *contectoides*. Reaches only about half the size. The specimens taken were very pretty, being of a uniform, rich wine color and highly polished.

13. Campeloma subsolidum Anthony.

This is the most common of the three species of the genus occurring in the lake. Numerous living specimens were taken in the seine in water two to five feet in depth, and dead ones are abundant along the shore after every summer storm.

14. Campeloma decisum Say.

Frequently taken while crawling along on the muddy or sandy bottom in shallow water.

15. Campeloma rufum Haldeman.

A half dozen or more specimens only were taken in company with the last two. Readily known by the pinkish color of the apex.

16. Goniobasis livescens Menke.

Abundant in shallow water areas, especially so where the bottom is sandy.

BIVALVES.

1. Unio gibbosus Barnes.

Quite frequent in one to five-foot water, especially along the west shore south of Long Point. This species, as represented in the lake, is smaller and the shells thinner than in the river forms of southern Indiana. The nacre of the lake forms is a deep purple, while in those from the larger streams it is usually white.

2. Unio phaseolus Hildreth.

This species is accredited to the fauna of the lake on the authority of Dr. R. E. Call, Proc. Ind. Acad. Sci., 1895, p. 145. It occurs rather commonly in the Wabash and White rivers, but in the lakes was noted only in Lake Tippecanoe.

3. **Unio iris Lea.**

One of the most common bivalves of the lake. "The species is found in all portions of the State, and is characterized by its beautiful nacre, the short, erect teeth, and the beautiful bands of green, together with the foldings on the beaks."—Call.

4. **Unio subrostratus Say.**

Not common in the main lake; more so in the muck and mud along the margins of Lost Lake, where a well marked variety, with a larger and broader beak, was taken. A specimen of this was sent, among others, to Mr. Chas. T. Simpson, of the Smithsonian Institute, for verification. In his reply he says: "The variety of *subrostratus* which you send is, so far as I know, confined to northern Indiana. It is quite remarkable, and would seem to be almost a distinct species. I have seen quite a number of specimens of it, and at first thought it a variety of *U. nasutus* (which occurs in northern Ohio, and probably in northern Indiana), but there seem to be intermediate forms connecting it with *U. subrostratus.* The variety will be described in a forthcoming monograph on the group."

5. **Unio pressus Lea.**

Several specimens were secured in low water along the south shore. It is common in some of the larger streams of the State, notably White river at Indianapolis.

6. **Unio luteolus Lam.**

This is also a very common shell in the main lake; but does not reach as large size there as in some of the lakes in northeastern Indiana.

7. **Unio ventricosus Barnes.**

Common, but smaller than in the streams farther south.

8. **Unio circulus Lea.**

Scarce; several specimens, of a depauperate form only, having been secured.

9. **Unio coccineus Lea.**

Not common. A few fine specimens were gotten along the south shore in 1894. In the streams of northern Indiana, especially in the Kankakee and Yellow rivers, it is abundant.

10 **Unio rubiginosus Lea.**

Common along the west and south shores on gravelly bottom.

11. UNIO PARVUS Barnes.

Not so common as the next which it closely resembles. Dr. Call has, however, given a table which enables one to readily separate the two, on page 517 of his paper on the Mollusca of Indiana.

12. UNIO GLANS Lea.

Quite common in the shallow water along the west and south shores. The smallest member of the family taken in the lake; the average size being about 1.2 x.7 inches.

13. MARGARITANA DELTOIDEA Lea.

This is also a small form, averaging about 1.5 x.8 inches. It is quite common in Lost Lake and along the south shore of the main lake.

14. MARGARITANA MARGINATA Say.

Quite common, especially on muddy or mucky bottom in three to five-foot water.

15. ANODONTA IMBECILLIS Say.

This very fragile and brilliantly colored form is frequent in both lakes; being found in the bays whose bottoms are of muck or mud; also in the outlet.

16. ANODONTA EDENTULA Say.

A common form on the sandy and gravelly bottom along the west and south shores.

17. ANODONTA SUBCYLINDRACEA Lea.

This is a handsome species of medium size; cylindrical in form, greenish in color, and with recurved and neatly folded beaks. It is quite common in the vicinity of muck beds and in the outlet. *A. ferussaciana* Lea is a synonym.

18. ANODONTA FOOTIANA Lea.

This is the largest and the most common *Anodonta* found in the lake. The average measurements are about 4x2 inches. Mature specimens are usually much eroded and the shells are reddish in color from the iron oxide in the mud which they inhabit.

THE FISHES OF LAKE MAXINKUCKEE.

By W. S. Blatchley.

Forty-five species of fishes are known to the writer to occur in Lake Maxinkuckee, or in the inlets and outlet of the lake. The following is a list of these, with brief notes on their comparative abundance, local habitat, etc. The nomenclature is that of Jordan & Evermann's "Fishes of North and Middle America:"

1. Lepisosteus osseus (Linn.). **Long-nosed Gar; Common Garpike.**

   Common in the lake, where it reaches a length of four feet. It and its congenor, the short-nosed gar, are rapacious pirates, ever preying upon the young and weaker members of the higher orders of fishes.

2. Lepisosteus platostomus Raf. **Short-nosed Gar.**

   Much less common in Lake Maxinkuckee than the preceding, but in Bass Lake, 12 miles west, it is abundant, and the only one there known.

3. Amia calva Linn. **Mudfish; Dogfish.**

   Common; especially so in Lost Lake. Reaches a weight of 10 pounds or more. Its food is also made up largely of other fishes, and, therefore, it and the gar pikes should be destroyed at every opportunity.

4. Amieurus natalis (Le S.). **Yellow Cat.**

   Not as common as the next, except in Lost Lake. The largest catfish of these lakes, often reaching a weight of two pounds.

5. Amieurus nebulosus (Le S.). **Common Bullhead.**

   Taken only in Lost Lake, where it is not common; but probably occurs also in the large lake.

6. Amieurus melas (Raf). **Black Bullhead.**

   Frequent in Lake Maxinkuckee in the deeper waters off the mouths of the inlets.

7. Schilbeodes gyrinus (Mitch.). **Slender Mud Tom.**

   Scarce in the lake. More frequent in the northeast inlet. This is one of the small "stone catfishes," which have a poison gland near the base of the pectoral fin. When handled they use the spine of this fin in defense, and a wound from it is more painful than that of the sting of a bumble-bee.

8. **Catostomus nigricans** Le S. **Hog Sucker; Stone Roller.**

Scarce in the lake, but occurring in small numbers in the larger inlets. A curious spindle-form species; usually found hugging the bottom in clear, rippling water. Known to every boy who has ever wielded a snare, but seldom caught with a hook.

9. **Erimyzon sucetta oblongus** (Mitch.). **Chub Sucker; Sweet Sucker.**

Frequent in the mouths of the inlets and in mucky places along shore.

10. **Campostoma anomalum** (Raf.). **Stone roller; Stone-lugger.**

Common in the inlets, especially in Aubeenaubee Creek. The members of this genus are readily known from all other minnows by their having the air bladder surrounded by many convolutions of the long intestine. In the spring the males have the head and often the whole body covered with large rounded tubercles.

11. **Pimephales notatus** (Raf.). **Blunt-nosed Minnow.**

Very common in both lakes and inlets. One of the best minnows for bass fishing.

12. **Semotilus atromaculatus** (Mitch.). **Horned Dace; Creek Chub.**

Scarce in the lake; abundant in the inlets. The largest of our Indiana minnows, and excellent bass bait.

13 **Notropis heterodon** (Cope). **Variable-toothed Minnow**

In the lake only; not common.

14. **Notropis whipplii** (Girard). **Silver-fin.**

Next to *Pimephales notatus*, the most common minnow in the lake. The males, in the spring, have the fins and belly covered with a clear satin-white pigment, whence the common name. The head is then armed with numerous small tubercles.

15. **Notropis cornutus** (Mitch.) **Silver side; Shiner; Rot-gut.**

The most common minnow in the inlets; much less common in the lake. The males are more brightly colored and have the lower jaw and top of the head armed in the breeding season.

16. **Rhinichthys atronasus** (Mitch.). **Black-nosed Dace.**

Only in the inlets where it is scarce. One of the most handsome of our smaller minnows.

17. **Hybopsis kentuckiensis** (Raf.). **Horny-head; River Chub.**

Occurs in the lake only near the mouth of the inlets, where it is scarce. In the deeper pools toward the sources of the inlets it is more frequent. An excellent bait for the larger game fishes.

18. **Umbra limi (Kirt.). Mud Minnow.**

Scarce in the lake, where it is found only near the mouths of the inlets or at the bottom of water 14 to 25 feet deep, from which it was occasionally dredged by Dr. Scovell, being found entangled in the plant *Nitella flexilis* brought up from those depths. More common in the inlets, especially in Aubeenaubee Creek. "A locality which, with the water perfectly clear, will appear destitute of fish will perhaps yield a number of mudfish on stirring up the mud at the bottom and drawing a seine through it."—(Baird.)

19. **Lucius vermiculatus (Le S.). Little Pickerel.**

Frequent in the lake; more so in Lost Lake. Found about the weedy margins in shallow water.

20. **Lucius lucius (Linn.). Common Pike; Pickerel.**

Formerly quite common in the lake, but now scarce, but one or two being taken each season. Frequents for the most part the bayous, mouths of inlets and patches of weeds in eight to 16-foot water.

21. **Fundulus diaphanus menona (Jor. and Cope). Common Killifish.**

Abundant in the shallow water near shore.

22. **Fundulus dispar (Agassiz). Top Minnow.**

Less common than the preceding; smaller and more prettily colored.

23. **Eucalia inconstans (Kirt.). Brook Stickleback.**

This handsome and interesting little fish has been taken in Indiana only in streams in Wabash and Decatur counties, and in Lake Maxinkuckee. In the lake it is quite common among the masses of *Nitella flexilis* at the bottom of 15 to 24-foot water. In dredging Dr. Scovell often found four or five entangled in the masses of *Nitella* which were brought to the surface.

24. **Labidesthes sicculus (Cope). Brook Silverside; Skipjack.**

Abundant. Frequents for the most part, shoal water, though it often occurs in schools, swimming close to the surface of the deep water. Into these schools the bass and other game fish dart and create sad havoc. The prolonged beak-like jaws and the slender translucent body render it easily noticeable and distinguishable from all other fresh water fishes.

25. **Pomoxis annularis Raf. Crappie; Bachelor.**

This species is inserted on the authority of Dr. Scovell. It is much less common than the next, which it closely resembles.

26. **POMOXIS SPAROIDES (Lacépède). Calico Bass; Grass Bass.**

Frequent about the weeds in 10 to 18-foot water, but much less common than in Bass Lake. Often confounded with the preceding species, the name "croppie" or "crappie" being given indiscriminately to both. This species and the blue-gill, *Lepomis pallidus*, are, more often than any of the other game fishes, thrown by the waves in a dying condition on the shore, especially in July and August. They then appear to be attacked by some sort of a fungus growth.

27. **AMBLOPLITES RUPESTRIS (Raf.). Red-eye; Goggle eye.**

Common in the lake in water from eight to 30 feet in depth. Frequents the vicinity of the weed covered slopes on the bottom. An excellent pan fish, easily hooked but not very gamy. Specimens weighing a pound and a quarter have been taken.

28. **CHÆNOBRYTTUS GULOSUS (Cuv. and Val.). War-mouth; Indian Fish.**

Found sparingly in the lake in water from 10 to 40 feet in depth; more common in the outlet and in Lost Lake. Reaches a weight of three-quarters of a pound, and is a fine food fish.

29. **APOMOTIS CYANELLUS (Raf.). Blue-spotted Sunfish; Green Sunfish.**

Inserted on the authority of Drs. Evermann and Jenkins, who note it as "very common" in their "List of the Fishes of Lake Maxinkuckee."*

30. **LEPOMIS MEGALOTIS (Raf.). Long-eared Sunfish.**

Common in water from two to 10 or more feet in depth; nesting, as do several other of the smaller species of sunfish, among the rushes on the sandy bottom. This is one of the most brilliantly colored of our fresh water fishes. They are the lords and ladies of the respective pools wherein they abide. When they move other smaller fry clear the way. If a worm or a gnat, falling upon the surface, tempts them, it is theirs. A leaf falls near them and is seemingly unnoticed—a fly, and how quickly their dormant energy is put into motion. With a dart and a gulp the insect is swallowed and a new stage of waiting expectancy is ushered in.

31. **LEPOMIS PALLIDUS (Mitch.). Blue-gill; Blue Sunfish.**

Rather common in the lake in waters from eight to 40 feet. Probably the most gamy of all the sunfishes and a most valuable food fish. Specimens 11 inches in length to the base of the caudal fin have been recorded from the lake.

* Proc. U. S. Nat. Mus., 1888, p. 54.

32. EUPOMOTIS EURYORUS (McKay). **Broad-eared Sunfish.**

Scarce. A few specimens have been taken in 15 to 40-foot water. A handsome species reaching a length of eight inches.

33. EUPOMOTIS GIBBOSUS (Linn.). **Common Sunfish; Pumpkinseed.**

Common in the shallow waters of the lake and in pools in the inlets. One of the smaller sunfishes; ranking with *L. cyanellus* in size, and approaching *L. megalotis* in the brilliancy of its colors.

34. MICROPTERUS DOLOMIEU Lacépède. **Small-mouthed Black Bass.**

Probably less common than the next species, but in every sense as gamy. Occurs at all depths, but is more common about the weed covered slopes in 10 to 25-foot water. Reaches a weight of nearly five pounds.

35. MICROPTERUS SALMOIDES (Lacépède). **Large-mouthed Black Bass.**

This is the larger of the two black bass, and the one most sought by fishermen. Specimens weighing from four to six pounds are frequent and, according to Mr. A. J. Knapp, proprietor of the Arlington Hotel, one weighing eight pounds and 11 ounces was taken in the lake a few years ago. Mr. Knapp himself has taken three which weighed over seven and a half pounds each, and one that weighed eight pounds three ounces.

36. STIZOSTEDION VITREUM (Mitch.). **Wall-eyed Pike; Jack Salmon.**

Frequent in the deep waters only. Large specimens are caught from September 15th to November 1st in 60 to 80-foot water. At night they go near the shores to feed and are then sometimes taken by trolling. Specimens 10 inches long have also been taken by seining at night. Two taken October 28, 1900, by Mrs. Knapp, weighed together eight pounds nine ounces.

37. PERCA FLAVESCENS (Mitch.). **Yellow Perch; Ringed Perch.**

Common in all water under 30 feet. This species, the bluegill and goggle-eye, are the fish most commonly caught by still fishing from boats. The perch in Lake Maxinkuckee are mostly of small size, seldom exceeding three-quarters of a pound in weight.

38. PERCINA CAPRODES ZEBRA (Agassiz). **Log Perch; Manitou Darter.**

The largest and most common of the darters taken in the lake. Reaches a length of six inches.

39. **HADROPTERUS MAXINKUCKIENSIS Everm. The Maxinkuckee Darter.**

Described from a single specimen taken in Aubeenaubee Creek, a half mile east of the lake in 1899. No others known. Length 3.5 inches. Closely related to and probably a variety of *H. scieurus* (Swain), the latter occurring in numbers in Yellow River, 11 miles north, and in Tippecanoe River, at De Long, five miles south.

40. **BOLEOSOMA NIGRUM (Raf.). Johnny Darter.**

Next to *P. caprodes*, the most common darter in the lake; found everywhere along the sandy shores in one to 15-foot water. "In the spring the males have the head jet-black, and this dark color often extends on the back part of the body so that the fish looks as if he had been taken by the tail and dipped into a bottle of ink. But with the end of the nuptial season this color disappears and the fish regains his normal strawy hue."—(Jordan.)

41. **ETHEOSTOMA IOWÆ Jor. and Meek. Iowa Darter.**

Common along the shores in company with the preceding species.

42. **ETHEOSTOMA AUBEENAUBEI Evermann. Aubeenaubee Darter.**

Quite frequent in Aubeenaubee Creek, where the species, up to the present, has only been found. Evidently derived from and closely related to *Etheostoma iowæ;* more brightly colored than that species. Reaches a length of only two inches.

43. **ETHEOSTOMA CŒRULEUM Storer. Blue Darter; Rainbow Darter; Soldier Fish.**

Common, especially in the inlets. Reaches a length of two and a half inches. In the spring the male is the most gorgeously arrayed of all the darters. Then the blackish bars of other seasons are changed to indigo blue, while the space between them assumes a hue of the brightest orange. The fins are broadly edged with blue and have the bases orange, or orange and scarlet, while the cheeks assume the blue and the breast becomes an orange. Clad in this suit he ventures forth on his mission of love, and if successful, as he almost always is, the two construct a nest of tiny stones in which the eggs of the mother fish are laid and watched over with jealous care by both parents until in time there issue forth sons destined some day to wear a coat of many colors, and "darters" to be attracted by those coats, as was their mother by the one their father wore.

44. **Bolichthys fusiformis (Girard). Spindle-shaped Darter.**
Scarce. Found along the sandy shores of the lake in company with the johnny, iowæ and rainbow darters.

45. **Microperca punctulata Putnam. Least Darter.**
Rather common in the outlet and in Lost Lake; much less common in Lake Maxinkuckee. Frequents shallow water along sandy and weedy shores. The smallest of our Indiana darters; the length when full grown being but one and one-half inches.

NOTES ON THE TURTLES AND BATRACHIANS OF LAKE MAXINKUCKEE.

By W. S. Blatchley.

TURTLES.

The following species of turtles have been noted in and about the lake, either by Dr. Scovell, Prof. O. P. Hay or the writer:

Aspidonectes spinifer (Le S.). Common Soft-shelled Turtle.
Common; strictly aquatic; seldom seen basking in the sun as do many of the hard-shelled forms. Feeds on small fish, shrimps, tadpoles, etc.

Chelydra serpentina (L.). Common Snapping Turtle.
Common; the largest turtle in the lake. Lives for the most part in the muck and mud along the margins. Feeds upon frogs, fish, crayfish, the young of the water fowl, etc.

Aromochelys odoratus Latreille. Musk Turtle; Stink-pot.
Frequent; reaches a length of five or six inches, though most specimens seen were smaller. Occurs in all parts of the lake, but more especially among the reeds and rushes near shore.

Malaclemmys geographicus (Le S). Map Turtle
Common; reaches a length of 10 to 12 inches. Often noted basking on roots, logs, etc. Several of the largest ones which have come to my notice were on a narrow ledge or platform of the boat-house at Culver Park on July 5, 1900. After crawling up from the water they spread out their broadly webbed feet in the sun and at intervals raised their heads and gaped widely. They were in company with a number of lady turtles of smaller size, and occasionally a large map turtle would crowd against one of its smaller neighbors and push it off its perch into the water. Prof. Hay says of this species: "At Lake Maxinkuckee three persons caught about 30 specimens of this species in a few hours.

Without probably an exception they were found near the shores, where there were great numbers of water-breathing univalves. After a number had been kept for a few days in a tub there were found in it large numbers of the opercles of such mollusks; and in the intestines of one were the remains of a crayfish, some fish scales, and what appeared to be the cases of some kind of caddis worm. Its broad masticatory surfaces are well fitted for crushing the shells of mollusks."*

CHRYSEMYS MARGINATA (Agas.). **Lady Turtle.**

Very common; especially in shallow water among rushes and water lilies. Reaches a length of seven inches. Feeds upon small mollusks, shrimps, tadpoles, etc.

CLEMMYS GUTTATUS (Schneider). **Speckled Tortoise.**

Scarce in the lake; frequent, especially in the spring, in the streams and ditches leading to it. Two specimens were picked up one morning at Lake Maxinkuckee in May, 1891, by members of the Indiana Academy of Science. One of our smallest and prettiest turtles.

EMYS MELEAGRIS (Shaw). **Blanding's Tortoise.**

Scarce; more often seen in spring during the mating season. Dr. Hay saw one on the lake margin in May. Frequent at Bass Lake, 12 miles west.

CISTUDO CAROLINA (L.). **Common Box Turtle.**

One or more, taken on different occasions in the strip of woods between the main lake and Lost Lake. A strictly terrestrial species.

BATRACHIANS.

The following species of Batrachians have been taken in the lake or close to its margin:

NECTURUS MACULATUS Raf. **Mud Puppy; Water Dog.**

A single specimen was found by the writer beneath a chunk in shallow water, south of the Arlington Hotel, in August, 1896. Said by both Hay and Scovell to be quite common. Is perfectly harmless, though almost universally believed to be very venomous.

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*Seventeenth Ann. Rep. Ind. Geol. and Nat. Hist. Surv., 1891, p. 576.

Amblystoma tigrinum (Green). Tiger Salamander.

Dr. Hay records the taking of this species in the vicinity of Lake Maxinkuckee. It is our largest salamander and is quite common in many parts of the State.

Amblystoma jeffersonianum laterale Hallowell. Jefferson's Salamander.

According to Dr. Hay* this variety of Jefferson's salamander was taken by him near the margin of the lake.

Chondrotus microstomus Cope. Small-mouthed Salamander.

Several were taken from beneath chunks close to the water's edge in the woods east of Lost Lake, in May, 1899.

Plethodon erythronotus (Green). Red-backed Salamander.

Found on a number of occasions beneath rubbish in the woods bordering the south shore of the main lake.

Plethodon glutinosus (Green). Slimy Salamander.

Three half-grown beneath oak chunks some distance from water, at the southwest side of Lost Lake. All these salamanders doubtless visit the water of the lakes during the breeding season.

Diemyctylus viridescens Raf. Newt; Green Triton.

This species was taken by Dr. Hay in the lake, according to his statement in the report already cited. It exists in two or three forms, the one called *viridescens* being always found in water. It is among the most beautiful of our native salamanders.

Bufo lentiginosus americanus Anthony. American Toad.

Common along the sandy shores of the lake from May to October.

Acris gryllus crepitans Le Conte. Cricket Frog.

Very common in the short grasses and rushes along the shallow water margins.

Chorophilus triseriatus (Weid.). Swamp Tree Frog.

Two specimens were taken from the leaves of button bush in a marshy tract in the woods on the south shore in July, 1900.

Hyla versicolor Le Conte. Common Tree Frog.

Common in the trees and bushes about both lakes.

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* Loc. cit., p. 431.

HYLA PICKERINGII Holb.

Two or three specimens of this pretty little tree frog have been taken on the stems of tall marsh grasses near the southeastern corner of the lake.

RANA VIRESCENS Kalm. Leopard Frog.

Everywhere along the marshy and grassy margins.

RANA PALUSTRIS Le Conte. Swamp Frog.

In the State Normal School collection are two specimens that were taken at Lake Maxinkuckee.

RANA CLAMATA Daudin. Green Frog.

Much more common than the above; occurs most frequently in the inlets and about the springs and runs from flowing wells.

RANA CATESBIANA Shaw. Bull Frog.

Frequent; especially so in Lost Lake and in the mouth of the southeast inlet.

MARL.—As noted above, Lake Maxinkuckee seems to occupy a cluster of kettle holes, one long and deep surrounded by several lesser ones. The original bed of the lake appears to have been composed of sand and gravel with perhaps some boulder clay. Over the greater part of this original bed thick beds of mud and marl have been deposited. In general, on the north, west and south, out to a depth of five or six feet, the present bed of the lake is of hard sand or gravel. On the east the hard bottom extends out to a depth of seven or eight feet and in some places there is hard bottom even under water 10 or 12 feet deep. Near the head of the outlet and about the mouth of the southeast inlet there is some black mud and muck in the shallow water. On the north, west and south sides of the lake marl begins at a depth of six or seven feet, and everywhere, under water up to 10 feet in depth, we found from eight to 15 feet of marl. On the east the marl begins a little farther out, generally in eight or 10 feet of water, and the marl was abundant in 12-foot water. Almost everywhere along the bars or along the shore, except on the east, there is an abundance of marl at the 10-foot water line; the thickness of the bed at this line averaging more than eight feet. Investigations in more than 200 different localities, under water from eight to 25 feet deep, disclosed beds of marl. Sometimes the marl was covered by a thin layer of black mud, but in general marl alone makes the bed of the lake.

Opposite the gravel pit, about 80 rods northwest of the center of section 28, we found marl more than 18 feet thick under water five feet deep. This was the only locality in which a thick body of marl occurs under shallow water. Wherever the bottom of the marl was reached, it was found to be resting upon a bed of sand and gravel. Under water deeper than 20 to 25 feet the marl is quite dark. It seems to be composed largely of calcium carbonate, mingled with more or less decaying vegetable matter. The samples from these greater depths were, however, secured with a dredge and were from the top of the deposit. There is little doubt but that the deeper marl would be of greater purity. Everywhere in the lake under water from eight to 16 feet deep the marl is almost white in color.

To be more specific as to locations we will say that beds of marl more than eight feet in thickness cover the greater portion of each *of the following tracts of land, to wit:*

The southeast quarter of the southwest quarter of section 15.
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The marl in different parts of the lake seems to differ in color and consistency, but whether such variations mean any important difference only chemical analysis or practical tests can show. An analysis of a sample from a bar east of the Long Point bar, just south of the center of the northeast quarter of section 28, made by Dr. W. A. Noyes, is as follows:

Calcium carbonate ($CaCo_3$)	85.02
Magnesium carbonate ($MgCo_3$)	3.85
Ferric oxide (Fe_2O_3)	0.33
Alumina (Al_2O_3)	0.12
Calcium sulphate ($CaSo_4$)	0.17
Insoluble inorganic matter (silica, etc.)	5.67
Organic matter	3.21
Total	98.37

This sample was taken five feet below the surface of the marl under about eight feet of water. A second sample, taken from the shore bar just east of the ice houses, had the following composition:

Calcium carbonate ($CaCo_3$)	85.38
Magnesium carbonate ($MgCo_3$)	3.50
Ferric oxide (Fe_2O_3)	.33
Alumina (Al_2O_3)	.05
Calcium sulphate ($CaSo_4$)	.17
Insoluble inorganic matter (silica, etc.)	6.40
Organic matter	3.15
Total	98.98

It will be seen that the composition of this sample is very similar to that of the first one and either analysis may be taken as about the average of the better marl beds of the lake.

An analysis of a third sample from the surface of a marl bed in deeper water in front of the gravel pit resulted as follows:

Calcium carbonate ($CaCo_3$)	75.07
Magnesium carbonate ($MgCo_3$)	4.18
Ferric oxide (Fe_2O_3)	.51
Alumina (Al_2O_3)	.09
Calcium sulphate ($CaSo_4$)	.11
Insoluble inorganic matter (silica, etc.)	15.26
Organic matter	3.65
Total	98.87

This shows too high a percentage of magnesium carbonate and insoluble matter, for cement making. These impurities are probably much less in the marl at a greater depth from the surface of the bed.

ORIGIN OF THE MARL AND MUD.—The marl and the mud of Lake Maxinkuckee seem to be secondary deposits upon an original bed of sand and gravel. What were the sources of the marl, what of the black mud, and what determined their distribution or arrangement? The well water and some of the spring water entering the lake is hard, much harder than the lake water, which is usually designated as soft water. The water of the lake does not contain an excessive quantity of calcium carbonate, yet it appears to be the source of the calcium carbonates found in the bed of the lake.* Several different forms of life, common in the lake, separate calcic compounds from the water, changing them into compounds that are practically insoluble in the waters of the lake. Perhaps the form of life that is most efficient in this work of separating calcic carbonate from the lake water is a species of *Chara*. This is abundant in the bed of the lake from near the shore to a depth of 10 or 12 feet, especially on the north, west and south. It must cover nearly one-quarter of the entire bed of the lake. The stems are from two to 10 inches long, making a thick mat over the bed of the lake. This plant is everywhere covered with a thick coating of calcic carbonate which makes it very brittle. There are other species of *Chara*, one, of much ranker growth, being found in water from 10 to 18 feet deep, but it seldom shows an appreciable coating of lime. Besides the *Chara*, several Potamogetons, as *P. amplifolius, P. zosteræfolius, P. robbinsii, P. friesii, P. lucens, P. lonchitis, P. natans* and *P. heterophyllus*, are generally found with a thick coating of lime over their leaves. Other plants separate lime from the water, but in such small quantities that they need not be mentioned.

Besides these plants, all mollusks of the list above given do much toward bringing about a deposition of the calcic carbonate. In many places, especially on the north, west and south, the bed of the lake is thickly covered with the bivalve mollusks. On the east the bed is too stony and the water too rough for many shells. We often found live shells in water from 20 to 30 feet deep, but they were much more common in shallow water. The univalves are abundant on the vegetation down to a depth of 20 feet. Frequently a half bushel of *Nitella* and *Potamogetons*, dredged from a depth of 18 to 20 feet, would contain more than 100 univalves, mainly *Vivipara*.

The marl of Lake Maxinkuckee, then, seems to have had its origin in calcic carbonate, which was separated from the shallow water by

***When the lake was young, the amount of calcium carbonate in its waters was probably far in excess of what it is to-day, and the rate of its deposition was, without doubt, more rapid. See p. 36.—W. S. B.**

mollusks and different species of *Chara*. This material, with other substances, carried into deeper water, became the foundation of the marl beds and formed a soil in which grew other plants that could separate calcic carbonate from the water. These plants furnished food for several species of mollusks and crustacea whose shells contributed largely toward the growth of the marl beds.

It is impossible, from data at present available, to estimate with any degree of accuracy the quantity of carbonate of lime deposited each year. On some Potamogeton leaves I found a coating of lime about 1/100 of an inch in thickness. Many shells of the univalves were but little thicker; perhaps 1/100 of an inch representing the thickness of the lime. Other shells were much thicker, but the amount given would probably represent the average thickness of lime formed each year. Add to these sources the lime from the stems of *Chara* and *Nitella* and the lime contributed by the plankton, and it seems as if 1/100 of an inch would be a conservative estimate for the thickness of the layer of carbonate of lime deposited each year over certain areas in Lake Maxinkuckee. If we estimate the average thickness of these deposits to be 10 feet, the lake would be some 12,000 years old. While these estimates seem conservative for the present, it is quite probable that the waters of the lake formerly contained a larger percentage of lime than they do now and that the deposition was more rapid than now. This circumstance might reduce the estimate by one-third, making the lake about 8,000 years old. I could find no data from which to estimate the rate of deposition of the black mud.

Lost Lake is protected by hills and forests from the easterly winds, while those from the west are unobstructed. On the east there is a hard sand beach, and bivalve mollusks are abundant. On the other sides it is generally muddy and the water vegetation is abundant. We found some marl in this lake and some in the marshes along the outlet and the inlets, but the areas were small and the material was generally quite dark from a mixture of vegetable matters.

TWIN LAKES.

BY DR. J. T. SCOVELL.

NOT A WORKABLE DEPOSIT.

A group of four small lakes near the center of the western third of Marshall County are known as "Twin Lakes." They are about eight miles north of Lake Maxinkuckee, and the Logansport Division of the Vandalia Railway runs between them. Holem Lake is about three-quarters of a mile long from northeast to southwest, and has an average width of about 30 rods. The banks in general are steep, with a narrow marsh between them and the water. Cook Lake is just northwest of Holem Lake and separated from it by a narrow ridge of gravel perhaps 20 feet high and 200 to 300 feet wide. It is about a mile long and about 40 rods wide. In this lake, as in the others, there is generally a narrow marsh between it and a steep bank. Holem and Cook lakes are, for the most part, in the northwest quarter of section 24 and the northeast quarter of section 23 (33 north, 1 east).

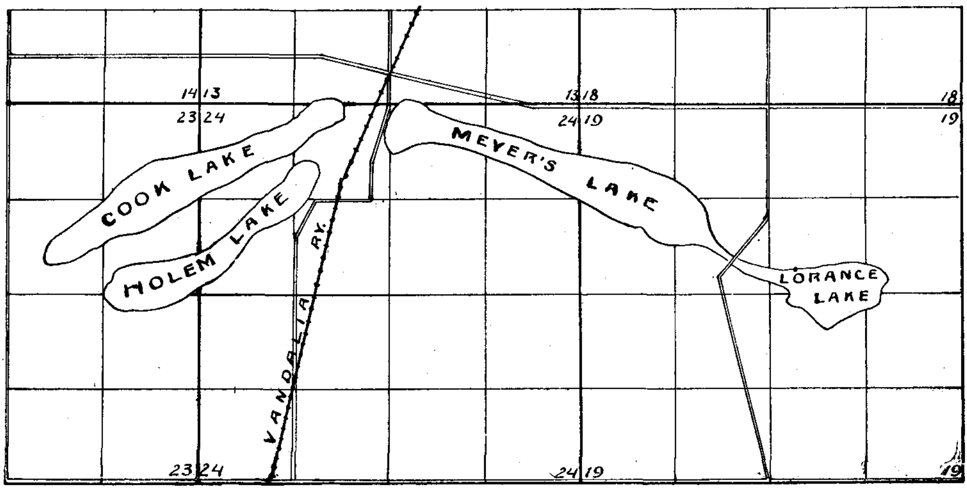


Fig. 59. Map of Twin Lakes, Marshall County, Ind.

Just east of the northeastern extremity of Holem Lake, across a low divide along which runs the branch of the Vandalia, is the head of Meyer's Lake. It is about one mile long and 40 rods wide, and extends from the northwest corner of the northeast quarter of section 24 (33 north, 1 east) southeasterly nearly to the center of section 19 (33 north, 2 east).

Extending southeasterly from Meyer's Lake is a narrow stream which, after a course of 40 or 50 rods, expands into a body of water known as Lorance Lake. This is separated from Meyer's Lake by the grade of a common wagon road. The lake has a length and breadth of about 80 rods each, and is about equally divided between the northeast and southeast quarters of section 19 (33 north, 2 east). Holem, Meyer's and Lorance lakes occupy what seems to be a portion of an old drainage channel. The banks of the valley are generally steep and are, for the most part, composed of clay with some sand and gravel. The forest trees about the lakes are mainly oaks. In the water there was *Chara, Myriophyllum, Ceratophyllum, Potamogeton,* pickerel weed, pond lilies, bulrushes, and other vegetation quite similar to that in Lost Lake west of Maxinkuckee. Almost the whole shore line of each lake is marshy and muddy, there being only a few bits of hard sand beach. The lakes are comparatively shallow, 15 to 20 feet, and the area drained into them is very limited. In its widest place the valley is scarcely one-half mile wide. Two small streams flowing into Meyer's Lake were the only inlets I saw. From the southwestern extremity of Holem Lake an outlet flows into Cook Lake and from the southwestern extremity of Cook Lake an outlet flows southwesterly into Yellow River. Meyer's and Lorance lakes drain southeasterly, but finally reach Yellow River.

MARL.—All bores in Holem Lake pierced only a fine grayish to black mud over 12 feet deep. There was in general a thin layer of black mud, then a whiter marl-like mud that contained many fragments of shells. The water was nowhere more than 12 feet in depth. In Cook Lake 10 tests were made. In eight of these soft mud over 12 feet in thickness was found. In the others there was about one foot of mud upon hard gravel. The marly mud in every case was very dark. In Meyer's Lake 12 soundings were made. In eight cases hard sand under shallow mud was found, while in four cases mud over 12 feet in depth occurred. The hard bottom was in the northwestern part of the lake. The tests in Lorance Lake showed deep black mud in three places, fairly good marl in one and hard sand in one. Forty soundings, somewhat uniformly distributed about these lakes, disclosed only one locality where fairly good marl occurred.

Univalve shells were abundant in the lakes and there were a few bivalves, but the latter were not as common as at Lake Maxinkuckee.

HOUGHTON AND MOORE LAKES.

WORKABLE DEPOSIT.

These are two small lakes, lying about 50 rods apart and occupying parts of sections 7 and 18 (32 north, 1 east), Union Township. The north end of Houghton Lake is one and one-quarter miles south of the New York, Chicago & St. Louis (Nickel Plate) Railway, and the east side of Moore Lake is two and a quarter miles west of the Logansport Division of the Vandalia Railway. The lakes occupy narrow parallel valleys which trend northeast and southwest. Between the two lakes are two wooded islands, the southern and larger of which is about 15 feet above the level of the water. A low and narrow marshy tract separates the islands. Through this was formerly an artificial ditch, connecting the waters of the two lakes. This is now choked up with muck and decaying vegetation.

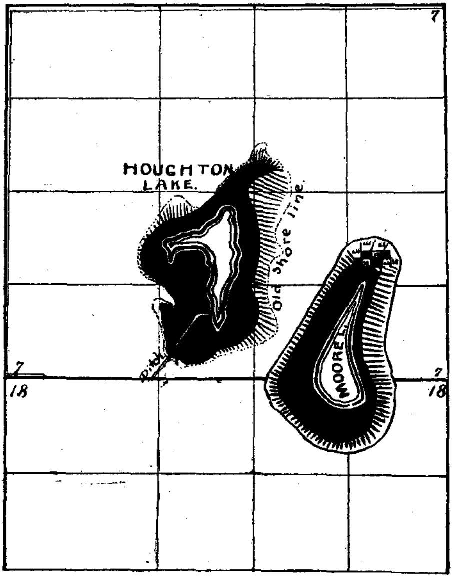


Fig. 60. Map of Houghton and Moore Lakes, Marshall County, Ind.

HOUGHTON LAKE.

This, the western lake, was drained in 1897, by a dredge ditch running to the southwest. The water was lowered about five feet and three-fourths of the former water area was laid bare. In September, 1900, the water remaining covered a little more than 13 acres, and ranged in depth up to 20 feet. The former lake bed was surrounded on all sides by low, marshy banks, which merged gradually upward into the higher cultivated fields. On the south there is a tamarack grove of 20 or more acres, and on the northeast an isolated ridge or island of gravel 15 to 20 feet in height, from which a good spring flows into the lake. To the northeast extensive marshy tracts extend for a half mile or more. These are covered with wire and other marsh grasses, and in the dryer seasons are mowed for hay.

MARL.—With the aid of Mr. Amos Osborne, of Culver, Indiana, who owns the greater portion of the old bed of Houghton Lake, 83 bores were put down in this former lake area. As no boat was available the present water area was not tested, but judging from the surrounding tests close to the water margin, there is no doubt but that marl more than 25 feet in depth underlies the whole of the water.

Over two-thirds of the former lake area, now dry, marl forms the surface. In many places this surface was so soft that in walking over it we sank six or eight inches. In other places it was too soft to walk over without miring down. Rank growths of bulrushes, *Scirpus lacustris* L., occurred over these softer springy portions. Of the 83 bores put down, for the most part 10 rods apart in each direction, 36 did not find the bottom of the marl with a 25-foot auger. These were, for the most part, on the south and west sides of the present water area, though a few of them were north of that area and east of the gravel island above mentioned. Twelve of the bores found the marl between 15 and 25 feet in thickness, while 12 others found it between eight and 15 feet deep. Of the remaining 23 tests, 11 showed six to eight feet of marl and seven of the others found between one and six feet. Except on about 15 acres of marsh in the northeast corner, not a single test within the border of the area recently covered with water failed to find marl. East of the present water area the marl between the water and wooded island is only from six to 10 feet in thickness except close to the water, where it increases to 18 feet. Just west of the gravel island north of the lake, it is but six feet in thickness over quite an area. West of the old lake bed, as shown on the map, there is a marsh area of six or eight acres, in which muck three to six feet thick overlies a marl bed from three to 10 feet in thickness. In one place in the ditch at the southwest corner the marl is over 28 feet thick, as the ditch is three feet deep and bottom was not reached with the auger. Wherever bottom of marl was reached gravel was found. It is estimated that, including the present water area, there are 50 acres in the old bed of Houghton Lake over which the marl will average 20 feet in thickness.

MOORE LAKE.

This lake lies east of Houghton Lake, and over half of its surface is in the southeastern quarter of section 7 (32 north, 1 east). It is about 200 rods long by 60 rods wide. According to the County Surveyor, it contains 92+ acres. This must include the area out to the meander lines, as there is probably not over 70 acres now covered with water. There is a small island near the south end, and the water is nowhere over 15 feet deep, while three-fourths of its area is less than five feet in depth. The shores are everywhere low, and on the north, west and south are bordered by extensive muck-covered meadows. On the east a wooded ridge rises about 20 feet, back eight to 15 rods from the water's edge. A wide and deep dredged ditch already exists about 30 rods south of the southern margin of the lake, and to it a ditch can be joined for $35 which will lower the water of the lake five feet, and so drain three-quarters of its area.

MARL.—A large number of tests showed that at least two-thirds of the area of Moore Lake is underlain with a deposit of marl which will average 12 or more feet in thickness. In fact it may run in most places 20 feet or more, as our tests were made in a leaky boat, with a shovel as a paddle, so that only an 18-foot auger could be used. The large majority of the bores put down did not reach bottom in one to five feet of water. The best deposit of marl is found beneath the wide areas of shallow water on the south and west sides. Here in many places it was 17+ feet in thickness. Along the east shore, 100 to 150 feet out, it is from eight to 15 feet thick with gravel beneath. In the northeast corner there is a thick bed of muck overlying the marl, but everywhere else the muck was lacking.

With 50 acres in Moore Lake, averaging, at a low estimate, 12 feet, and the same area in Houghton Lake averaging 20 feet in thickness, there is here a first-class deposit of marl, located within two and one-half miles of two good railways. An analysis of an average sample, obtained by mixing the samples from the two lakes, gave the following percentage composition:

Calcium carbonate ($CaCo_3$)	89.22
Magnesium carbonate ($MgCo_3$)	2.73
Alumina (Al_2O_3)	.04
Ferric oxide (Fe_2O_3)	.20
Insoluble inorganic matter (silica, etc.)	2.02
Organic matter	4.15
Total	98.36

This shows the marl to be in every way suitable for cement making, the calcium carbonate being above the average and the magnesium carbonate and other impurities low.

ST. JOSEPH COUNTY.

References.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 199.

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. of Ind., p 456.

1898.—W. S. Blatchley, Twenty-second Ann. Rep. Ind. Dep. Geol. & Nat. Resources, p. 140.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv. No. 21, p. 21.

St. Joseph County is bordered on the north by the State of Michigan, on the east by Elkhart County, on the south by Marshall and Starke and on the west by Laporte. It comprises an area of 477 square miles, the surface of which is diversified by prairies, marshes, "oak openings," and rolling timber lands. The "oak openings" are covered with a light sandy soil excellently suited to the raising of small fruits; the timber-lands possess a subsoil of clay, covered with a dark rich soil, which under proper cultivation and rotation of crops, yields all the cereals in abundance. The prairies, both old and young —for the marshes are but incipient prairies—where properly drained, are unexcelled for the raising of any farm products except wheat, which in places winter-kills.

The Kankakee River rises about two miles southwest of South Bend, and flows in a southwesterly direction through the county. The most of the marsh land adjacent to it has been or is being drained. The St. Joseph River is the principal stream within the county, entering it a little north of the middle of the eastern boundary, flowing westerly about 10 miles, and then northerly into the State of Michigan. On its great bend to the northward is the flourishing city of South Bend, possessing a population of almost 36,000, and noted for its manufactures, especially wagons and plows, which are shipped to all portions of the world.

Six important railways pass through the county: the Lake Shore & Michigan Southern; the Grand Trunk; the Michigan Central; the Indiana, Illinois & Iowa, commonly known as the "Three I;" the Logansport Division of the Vandalia, and the Chicago Division of the Wabash. The Baltimore & Ohio and Lake Erie & Western cross the southwestern corner, their junction with that of the "Three I" being at Walkerton, while the Michigan Division of the "Big Four" cuts the northeastern corner. Most excellent transportation facilities are thus furnished in every direction.

There is not an outcrop of rock in the county, the entire surface being covered with glacial drift which will probably average 200 feet in thickness. The only place where this drift has been pierced to the underlying stratified rock is at South Bend, where it was 137 feet thick. This, however, was in the valley of the St. Joseph River and only 725 feet above tide, or fully 150 feet lower than the uplands in the southeastern portion of the county. The levels of the more important railway stations in the county show the following altitude in feet, above tide: Lakeville, 837; Mishawaka, 700 to 743; Notre Dame, 710; Osceola, 736; South Bend, 708 to 726; Walkerton, 711; Warren, 730.

The drift over about one-half of the county is a gravel plain formed by the outwash from the ice sheet. "In the northwestern portion of the county the outwash is from the Valparaiso moraine, and the plain descends from about 800 feet at the border of the moraine to 725 feet at the border of the Kankakee marsh. In the southwestern portion of the county the outwash is westward from the Maxinkuckee moraine of the Saginaw lobe, and there is a similar descent from the moraine to the Kankakee marsh. In the northeastern portion of the county there is an extensive gravel plain along the St. Joseph River, whose head is in southern Michigan in a later moraine of the Saginaw lobe. The southeastern part of the county is occupied by a till plain which borders the Maxinkuckee moraine on the east. The Maxinkuckee moraine passes diagonally across the county from the southwest to the north border and has a width of about five miles. It is interrupted by a gap at the St. Joseph River near South Bend two or three miles in width. The highest portions of this moraine stand fully 300 feet above Lake Michigan, or about 900 feet above tide."*

The lakes of St. Joseph County are small in size and most of them are rapidly becoming extinct. But one deposit of marl of good workable area and thickness is located in the county. That is at Chain and Bass lakes, west of South Bend, and is fully described below.

NOTRE DAME LAKES.

Thick Deposit, Mostly Beneath Deep Water.

These lakes, two in number, lie just northwest of Notre Dame College, in section 36 (38 north, 2 east), a little more than a mile northeast of South Bend. St. Joseph's Lake, the larger of the two, has an area of about 65 acres, and a maximum depth on the west side of 25 feet. The water area of St. Mary's Lake is a little more than 30 acres. The two lakes are separated by a stretch of low ground containing 10 or more acres. In the past this was covered with water, forming one continuous body or lake.

*Levette, loc. cit., p. 21

MARL.—The marl deposit in and about these two lakes is of especial interest in that it furnished the carbonate of lime material to the first, and for more than 20 years the only, Portland cement factory in Indiana. At St. Mary's Lake the water deepens abruptly and close to shore. The marl extends back several rods from shore, and it is mainly this shore marl that has been worked in the past

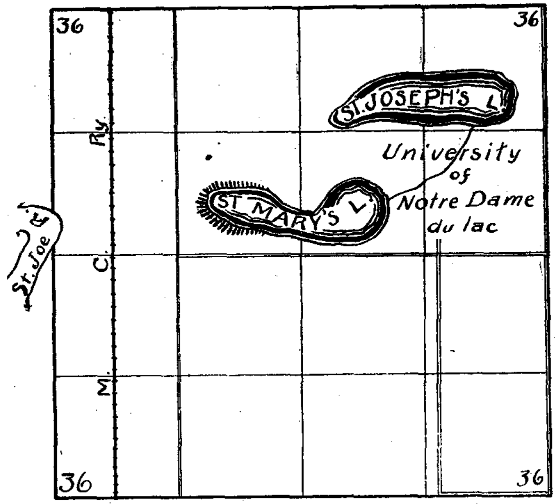


Fig. 61. Map of Notre Dame Lakes, St. Joseph County, Ind.

for the cement factory at South Bend. The entire lake, as well as that of St. Joseph, is underlain with a thick deposit. This, where tested, was everywhere beyond reach of auger and, it is claimed, has an average thickness of more than 30 feet. The marl was secured by dredges, the cut of one of which is shown on plate IV. It was piled up on the shore and hauled to the factory as needed. The University received a royalty or specified sum per ton, and at the same time had its lake deepened and cleaned up.

An analysis of the marl made by Dr. Noyes proves it to be of excellent quality, its percentage composition being as follows:

Calcium carbonate	91.62
Magnesium carbonate	4.02
Alumina (Al_2O_3)	0.05
Ferric oxide (Fe_2O_3)	0.07
Calcium sulphate	0.14
Insoluble portion (silica)	0.19
Organic matter	2.25
Total	98.34

CHAIN AND BASS LAKES.

Workable Deposit.

The basin occupied by the remnants of these lakes is in sections 35 and 36 (38 north, 1 east), and sections 1, 2, 11 and 12 (37 north, 1 east), Warren Township, about five miles west of South Bend. The Lake Shore & Michigan Southern Railway runs over a high grade and trestle be-between the two lakes, while the Michigan Division of the "Three I" is but a short distance south of Chain Lake.

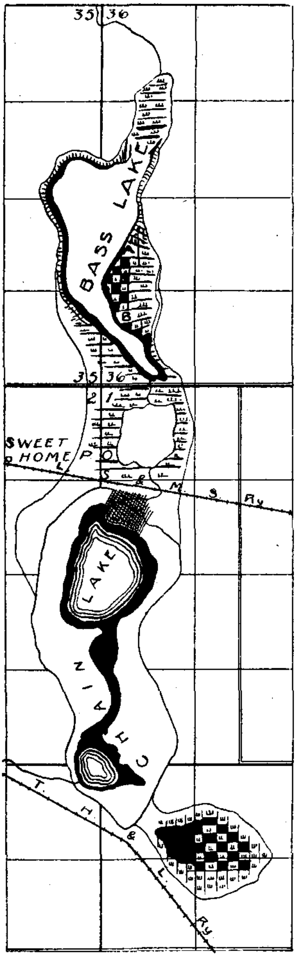


Fig. 62. Map of Chain and Bass Lakes, St. Joseph County, Ind.

Chain Lake has been partially drained and at present consists of two small bodies of water connected by a rather broad channel and lying between the railways above mentioned. Around parts of the larger body the shore is so low as to be readily flooded by a slight rise in the lake, while elsewhere the muck has built up the surface two or three feet above the former level of the water. Southeast of Chain Lake, between Chain and Bass lakes, and northeast from Chain Lake, are flat stretches that at one time, though not recently, formed a part of the water area of the lake. Outside of these areas the hills are rather abrupt, though not high.

Bass Lake lies north of the L. S. & M. S. Railway and is separated from Chain Lake by a low marshy tract, of 30 or more acres, which lies between the railway and the grade of a wagon road. The extreme length of the present water area of Bass Lake is a little over one-half mile, while the average width is not more than 30 rods. The southern half of the water area is only about one-half the width of the northern, a wide, grass covered marsh, three feet above the water level, lying on the east side south of the northern and wider main body of water. On the north and south the shores are low and marshy. On the east of the main water area a marsh a few rods in width separates the edge of the water from the steep slope of a prettily wooded ridge, 30 to 40 feet in height. The western shores rise more gradually from the edge of a narrow marsh into cultivated fields whose surface is 20 to 30 feet above the water. The greatest depth of water in Bass Lake is 32 feet, but more than one-half of the water area is less than 10 feet deep.

MARL.—With the exception of a strip five to eight rods wide, which lies next to the hills on the east, the present water area of Bass Lake is underlain with marl which will average over 12 feet in thickness. In four-foot water the marl runs from 15 to 18 feet in thickness. There is no muck over the marl beneath water. North of the main body of water is an extensive marsh in which a thick bed of muck overlies most of the marl. Several bores showed the marl to run from six to 12+ feet and the muck from three to five feet in thickness. The marsh on the southeast, about 10 acres in area, is underlain with marl which, at (A), is 10 feet thick at the water's edge, while 10 rods back from the water it is six feet thick beneath two and a half feet of muck. On the east shore of the southern end of the lake, at (B), the marl was 19+ feet thick at the edge of the water, with about one foot of thin muck at the surface. Ten rods north, on the marsh, the muck was two and a half feet thick above 10 feet of marl. Ten rods southeast of (B) the muck is three feet and the marl nine and a half feet, while 15 rods farther southeast at the southeast corner of the lake the marl is 11 feet beneath the same depth of muck. Over most of the marshy tract between the wagon road and the L. S. & M. S. Railway the marl is 16 to 18 feet thick beneath two to four feet of muck. The water area of this tract was not tested, as no boat was available.

Examination from a boat on Chain Lake showed marl to below 16 feet at every point, and it is claimed that in the center of the lake, tests with a 25-foot pole failed to reach the bottom of the marl. On the low west shore between the lake and the L. S. & M. S. Railway the marl showed a depth of 13 feet and over, with no cover. In the southern part of the original basin and the partly enclosed arm to the southeast, tests showed from one to five feet of muck, with marl beneath to below 16 feet. The muck, of course, is thin near the water and increases in thickness at the expense of the marl as the shore is approached. An analysis by Dr. Noyes of an average sample of the marl from Chain and Bass lakes shows the following percentage composition:

Calcium carbonate ($CaCo_3$)	87.92
Magnesium carbonate ($MgCo_3$)	2.64
Ferric oxide (Fe_2O_3)	.20
Alumina (Al_2O_3)	.10
Calcium sulphate ($CaSo_4$)	.23
Insoluble inorganic matter (silica, etc.)	3.10
Organic matter	4.18
Total	98.37

This analysis proves the quality of the marl to be excellent for cement making purposes.

It is estimated on what was seen and on reports received that the marl covers at least 225 acres in and around Chain Lake alone, while the area in and around Bass Lake is fully one-half as much. The proximity of railways and the city of South Bend, renders the deposit a valuable one and well worthy of development.

CEDAR AND MUD LAKES.

Not a Workable Deposit.

These lakes occupy parts of sections 2, 11, 12, 13 and 14 (38 north, 1 east). They lie on or just south of the Michigan-Indiana line, about eight miles northwest of South Bend, the northern two-thirds of Cedar Lake being in Michigan.

Cedar Lake furnishes a typical example of a lake whose water area has been encroached upon by decaying vegetation until it has become almost extinct. Twenty years ago, according to the report of persons living near, its entire basin of 80 or more acres was covered with water to a depth of 20 to 30 feet. Then there was no aquatic vegetation except along the south shore. Now the southern half is a vast morass of muck and spatterdock, with water nowhere more than six inches in depth. The western margin for one-third the distance across the lake is similarly filled. Many floating islands or moving morasses of muck rise nearly to the surface in other parts of the lake, so that its clear water area is but little over 15 acres, and its deepest water only about 12 feet.

A fine wooded ridge, much frequented by picnic and fishing parties, and with a gravelly margin at the water's edge, rises 20 or more feet along the north half of the east side. The banks on the north and west are lower, while the southern shores are marshy. The lake has been for years a favorite resort for the fishermen of South Bend, bass, blue-gills, perch, croppies and other food and game fishes being abundant. Among the more common of the many plants growing in the water in September, 1900, were the following:

TYPHA LATIFOLIA L. Broad-leaved Cat-tail.
Close to margin along south and west shores.

SPARGANIUM EURYCARPUM Engelm. Common Bur-reed.
Quite common with the above.

POTAMOGETON NATANS L. Common Floating Pondweed.
Frequent in water from three to seven feet in depth.

POTAMOGETON HETEROPHYLLUS Schreb. Diverse-leaved Pondweed.
With the above.

POTAMOGETON PECTINATUS L. Fennel-leaved Pondweed.
Wholly submerged in three to eight feet of water.

TRIGLOCHIN PALUSTRIS L. Marsh Arrow-grass.
In shallow water on north and west shores.

ALISMA PLANTAGO-AQUATICA L. Water Plantain.
Common in the marshy southern area.

SAGITTARIA GRAMINEA Michx. Grass-leaved Arrow-head.
Along the north and east shores in shallow water.

PHILOTRIA CANADENSIS (Michx.) Britton. Water-weed; Ditch-weed.
At the bottom of all water two to four feet in depth.

VALISNERIA SPIRALIS L. Tape grass; Eel-grass.
Common in water three to five feet deep.

PELTANDRA VIRGINICA (L.). Green Arrow-arum.
Along the margins in company with arrow-head, water-plantain and pickerel-weed.

SPIRODELA POLYRHIZA (L.). Greater Duckweed.
Covers the surface in many places.

ERIOCAULON SEPTANGULARE With. Seven-angled Pipewort.
In abundance on the floating islands of muck. Noted elsewhere only at Bass Lake, Starke County, and Round Lake, Whitley County.

PONTEDERIA CORDATA L. Pickerel-weed.
In one to two feet of water on the south and west shores.

BRASENIA PURPUREA (Michx.). Watershield.
Everywhere in water three to five feet in depth.

NYMPHÆA ADVENA Soland. Spatterdock; Yellow Pond Lily.
Covers the southern half of the lake basin.

CASTALIA ODORATA (Dryand.) White Water Lily.
Along the margins of the northern and deeper waters; common also with the preceding where the water was of sufficient depth.

UTRICULARIA VULGARIS L. Greater Bladderwort.
Common in water up to six feet in depth.

UTRICULARIA PURPUREA Walt. Purple Bladderwort.
Frequent in water four to six feet in depth, the purple flowers floating just at the surface. Not noted by the writer elsewhere in the State, but has been reported from Lake County.

Numerous other aquatic plants, especially rushes and sedges, were seen during the two hours spent on this lake. The above were the ones which in the past have formed most of the muck which has replaced the water. No one who has not visited a lake like Cedar can realize how varied the kind and how abundant the individuals of plant life which can flourish in water. It is one of the best examples at present in Indiana, of a dying lake—an incipient marsh. Here one can see in actual progress many of those intermediate stages and processes which in time change a body of fresh water into a body of land without the aid or intervention of man.

The northern edge of the basin of former Mud Lake lies south of that of Cedar Lake about one-third of a mile. Its former water area was over 300 acres and its outline was very irregular. Now by draining and by the encroachment of vegetation it has become a vast marsh, with not more than 30 acres of water, and that shallow and occupying two or three small isolated areas. In places where the local residents fished for bull-heads and bass a score of years ago are now cultivated cornfields. The vegetation in and about the remaining water area is not nearly so dense or so varied in character as at Cedar Lake.

MARL.—A trace of marl was found only in two places in Cedar Lake. In general the bottom of muck was beyond reach of an 18-foot auger, though along the east shore gravel was struck beneath six feet of muck 100 feet from the bank.

No boat was available for exploring the water area of Mud Lake. A number of tests in the marsh on the north and west shores disclosed only muck, which varied in thickness from three to 18+ feet.

GOOSE OR SONSLEY'S LAKE.

Not a Workable Deposit.

This lake or marsh lies a little over two miles north of North Liberty in sections 9, 10, 15 and 16 (36 north, 1 east), Greene Township. It is less than a mile from the "Three I" railway and about the same distance from a gravel pit switch of the Grand Trunk Railway. Sonsley's Lake formerly covered most of section 16, a small area in the east part of section 17, a small area in sections 9 and 10, and ex-

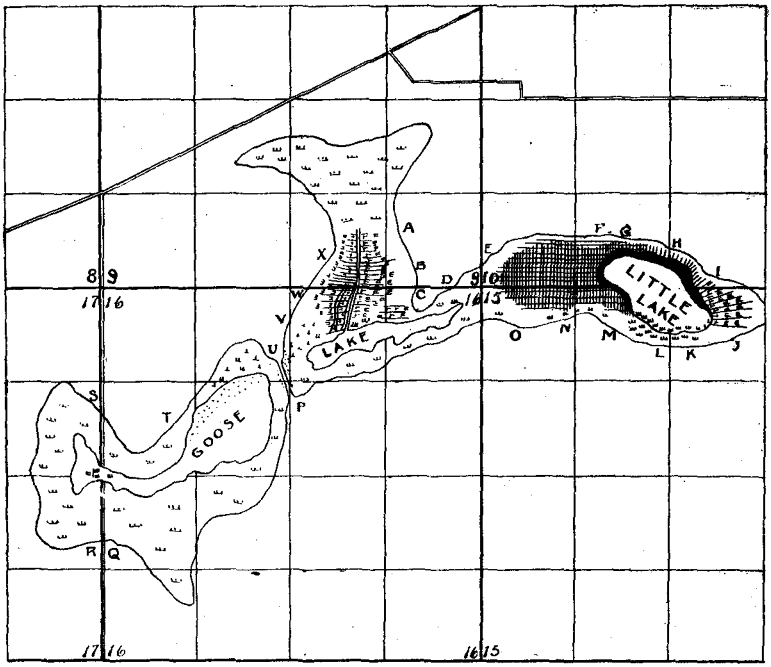


Fig. 63. Map of Little and Goose Lakes, St. Joseph County, Ind.

tended east to include most of the northern half of section 15, now in part occupied by what is called Little Lake. The total area of lake and marsh is not far from 400 acres. When examined, Little Lake had an area of about 30 acres, and the remnant of Goose or Sonsley's Lake covered 40 or 50 acres.

Some years ago the whole area, now occupied by the lakes and marsh, except Little Lake, was drained, but the filling up of the drain has allowed several feet of water to accumulate over a considerable area in the western part of section 16, and a small area in the eastern part of the same section. Between these two water areas an esker of glacial origin stretches across the lake basin. It appears as a sandy bar rising four or five feet above the water level. Goose Lake is very shallow, Little Lake somewhat deeper. The surrounding bluffs are usually rather abrupt and 15 to 20 feet high. A slight rise in the water would cause it to cover no small part of the area around Goose Lake.

MARL.—Lack of a boat prevented examination of the area covered by water, except around the edges. It is reported that drillings made by prospectors through the ice showed about 45 acres of marl with a maximum thickness of 30 feet. Drillings near the raised road along the west line of section 16 showed from four to 10 feet of muck with traces of marl. Tests along the north side of the larger water body showed only sandy bottom in shallow water, with from three to four feet of muck over the sand back from the water's edge.

Most of the area east of the sand bar was dry. Near the sand bar the ground is sandy. Then out from (V) there are three to four feet of muck until, as the ditch from the north is approached, marl sets in, soon running to below reach of drill, while the muck thins down to two feet or a little less. Between (W) and (C) the muck runs up to seven feet toward the shore without marl, but for a few hundred feet from the ditch either side the muck is about three feet thick, with marl thickening to below end of drill. This continues to the north with narrowing width into section 9, but toward (A) thins down, drillings between (A) and (X) showing an average of only four or five feet.

Just east of the mouth of the drain, 10+ feet of muck was found, and out from (D) only muck occurs, but southwest of (C) there is a good depth of marl under two feet of muck.

Passing east into the basin of Little Lake there is a good deposit of marl between the section corner and the lake (E-F-N-O-E). Over most of this area the muck was from one to one and a half feet thick, running out entirely toward (G), with marl to below reach of drill. Near the banks the marl thins out and the muck gets thicker. Tests around the north, west and southwest sides of Little Lake showed clear marl to below reach of pole, but on the south side it is covered by a greater depth of muck, which toward the east end of the lake entirely replaces the marl. East of the lake the muck rapidly increases to a thickness of nine or 10 feet, with very mucky marl underneath.

On the whole, this deposit, while extensive, appears to be of small value, due to the depth of muck overlying much of the marl and the poor quality of the latter.

RUPEL'S LAKE.

NOT A WORKABLE DEPOSIT.

This is a small lake lying just southeast of North Liberty, in section 33 (36 north, 1 east). It appears to be shallow and is surrounded, except on the west, by flat marshy land.

MARL.—No marl was found immediately east or southeast of the lake. Along the ditch which enters the lake from the southwest marl occurs with a thickness ranging from 0 to 10 feet. It is everywhere overlain by at least three feet of muck, often sandy. The marl appears to extend only a short distance east of the ditch. Over the marsh just west of the lake only muck was found, but

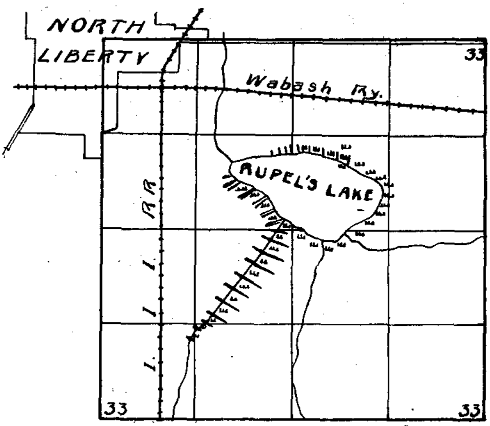


Fig. 64. Map of Rupel's Lake, St. Joseph County, Ind.

further back in the corn field marl of good depth occurs under from four to six feet of muck. It is said that 22 feet of marl has been found here. It seems, however, to occupy a very limited area.

A little marl was found on the north side of the lake, in one place the bore showing six feet under three and a half feet of muck. In places the marl reaches the surface. A series of tests back from the lake at one point showed 10 feet of muck at water's edge; 25 yards back, three and a half feet of muck, six feet of marl; 50 yards farther, seven feet of muck, trace of marl; 50 yards farther, 10+ feet of muck.

KANKAKEE MARSH DEPOSITS.

Not of Workable Size.

Three miles southwest of South Bend a dredged ditch has, for some distance, replaced the original channel of the Kankakee River through the marsh. It was reported that in digging the ditch large quantities of marl had been struck in two places, viz., in section 25 (37 north, 1 east), and in section 20 (37 north, 2 east). At the first named place we failed to find the marl, though we examined all the ditches and made many drillings. The muck here ranged from three to six feet in thickness.

At the second locality marl was found in the north half of section 20 and the south half of section 17, on the land of Hon. Clem. Studebaker, between the Grand Trunk and "Three I" railways. The Kankakee ditch was first driven into the northwest quarter of the northeast quarter of section 20, where it ran into marl to such an extent that the line surveyed had to be abandoned and a new direction taken. The greatest depth of marl found at this point of abandonment was eight feet under three feet of muck. Going back nearly a quarter of a mile the ditch was driven east until the right of way of the "Three I" railway was reached; it continued along that for nearly a quarter of a mile, then turned north again. Marl shows above the water in the ditch at two places, where it runs beside the railway, the marl being five feet deep under four feet of muck at the best, though only a few feet back from the edge of the ditch the muck is seven feet thick and marl only three feet. The marl in this marsh becomes very white after drying, and the following analysis by Dr. Noyes shows that it has an excellent composition:

Calcium carbonate ($CaCo_3$)	91.30
Magnesium carbonate ($MgCo_3$)	2.90
Ferric oxide (Fe_2O_3)	.08
Alumina (Al_2O_3)	
Calcium sulphate ($CaSo_4$)	.22
Insoluble inorganic matter (silica, etc.)	.82
Organic matter	3.88
Total	99.20

Tests in the northwest part of the southwest quarter of the northeast quarter of section 20 showed from four to five feet of muck with from 0 to three and a half feet of marl beneath. In the southwest of the southeast of section 17 the muck runs from eight to nine feet deep and overlies from one to three feet of marl. In the southeast quarter of the southwest quarter of section 17 and northeast quarter of the northwest quarter of section 20 the muck measured from seven to nine feet and the thickest marl a little over three feet.

An interesting feature of the deposit in these marshes is the pockety nature of the marl, as indicated in the banks of the ditch, and the association of these pockets with chalybeate springs.

Marl was reported as having been struck in ditching just west of Walkerton. An extended series of tests were made, but all the marl that was found was under nine feet or more of muck. Some of the small marshes east of Walkerton were also examined, but only traces of mucky marl, generally overlain by a considerable depth of muck, were found.

LAPORTE COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 201.

1873.—G. M. Levette, Fifth Ann. Rep. Geol. Surv. of Ind., p. 461.

1875.—Id., Seventh Ann. Rep. Geol. Surv. of Ind., p. 478.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 18.

Laporte County is in the third tier of counties from the western line of Indiana, and lies adjacent to the south border of the State of Michigan. Its northwestern corner is bordered by the shore of Lake Michigan for a distance of seven miles. It is bounded on the east by St. Joseph, on the south by Starke and on the west by Porter County. The Kankakee River forms a small portion of the eastern boundary and then cutting across the southeastern corner forms the greater part of the boundary line between Laporte and Starke counties. Mill Creek and several smaller tributaries drain the southern half of the county into the Kankakee, while north of the continental divide, which passes northeast and southwest through the center of the county, are several small streams which flow into Lake Michigan.

Transportation facilities are most excellent, six railways crossing the county from east to west, two from north to south and one from southeast to northwest, thus furnishing an outlet in every direction.

The area of the county is 562 square miles. Of this the northern third is somewhat broken and hilly and was formerly covered with timber. The central and southern portions contain about 200 square miles of fine prairie and a large area of Kankakee marsh land, much of which has been drained, and now forms excellent grazing and farming lands. The entire surface is of glacial origin, the Valparaiso moraine, with a width of six miles, passing northeastward across the northwestern corner of the county. The crest of this moraine lies from 225 to 300 feet above the level of Lake Michigan. This moraine "rises very abruptly on its northwest border above the low plain which lies between it and Lake Michigan, but on its southeast border a gravel outwash from the moraine is built up nearly to the level of the crest, and the descent is gradual from the moraine to the Kankakee marsh. The marsh stands fully 100 feet above Lake Michigan in eastern Laporte County and about 75 feet at the western border of the county. It is, therefore, 150 to 200 feet or more below the crest of the moraine. The gravel plain makes a descent of 75 or 100 feet in the interval of eight or 10 miles between the moraine and the marsh.

"On the low plain bordering Lake Michigan, in the northwestern part of the county, there are series of narrow till ridges or feeble moraines which govern the drainage of that region to a marked degree, though having a relief of but 30 to 50 feet. On the immediate border of the lake there are prominent dunes, rising in places to a height of 150 feet above lake level."*

The thickness of the drift is known at but three places where gas well borings have penetrated to the underlying stratified rock. These are at Laporte, where it is 295 feet thick; La Crosse, 38 feet, and Michigan City, 250 feet. The surface levels at the more important railway stations are as follows in feet above tide: Hanna, 703; Haskell's, 771; La Crosse, 675; Laporte, 812; Michigan City, 600; Oakwood, 727; Otis, 765; Rolling Prairie, 820; Stillwell, 731; Wanatah, 730; Westville, 789.

The lakes of Laporte County are few in number and are, for the most part, situated near the crest of the divide. But two of them, Du Chemin and Fish, contain workable deposits of marl. Those near Laporte have, for 35 years, furnished immense quantities of ice for shipment to Indianapolis and other cities.

HUDSON OR DU CHEMIN LAKE.

Workable Deposit.

This lake lies about 11 miles northeast of Laporte, in sections 28, 29 and 30 (38 north, 1 west), and is just west of Hudson station, on

*Leverett, loc. cit.

the Lake Shore & Michigan Southern Railway. The total length of the lake from east to west is nearly two miles and the average width about one-half a mile. The area is 750 or more acres.

MARL.—The whole lake appears to be underlain by marl, but, for the most part, it is not very thick, being thickest toward the west end. West of the island the lake was nearly dry when examined in September, 1899, there being only a small body of water, mostly in the southwest lobe, and much of that was less than a foot deep. Tests at one point showed the marl to have the following depths at the given distances from shore: At five yards from shore, marl two

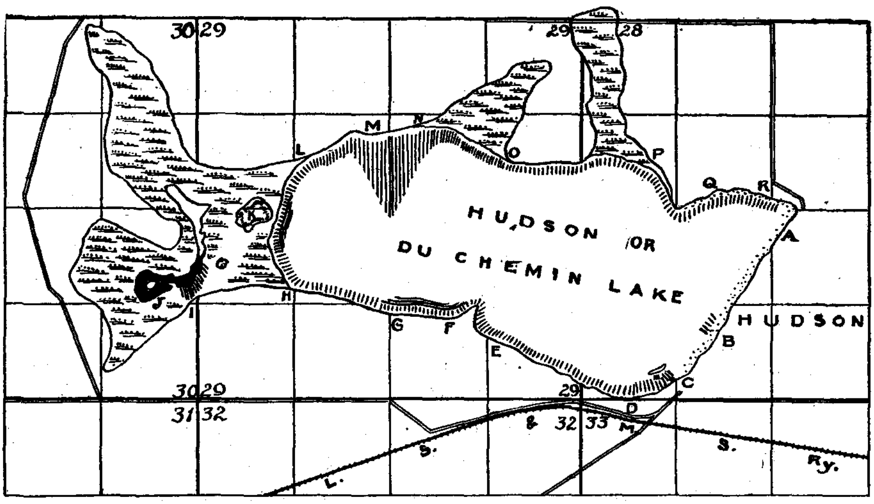


Fig. 65. Map of Hudson Lake, Laporte County, Ind.

feet; at 10 yards, two and a half feet; at 15 yards, four feet; at 20 yards, seven feet; at 25 yards, nine and a half feet; at 30 yards, $12\frac{1}{2}$ feet; at 50 yards, 14 feet. At other points the space between the water and shore was inaccessible. In the water area no solid marl was found, but a mushy mixture of marl and muck, through which the drill would sink rapidly of its own weight to its full length. The most of the marl here not only appeared to be of poor quality, but too soft to be handled except by a pipe.

In the main body of the lake the marl is not so thick, but more solid, and apparently of much better quality. Just east of the island it ran 10+ feet thick in seven feet of water, but the average will hardly run over five or six feet. Only a few of the tests in less than 10 feet of water failed to find the bottom of the marl at depths of 16 feet or less. At the east end the marl runs from seven to nine feet thick in from three to five feet of water, but along most of the north side in that depth of water the marl runs from four to six feet thick. In deeper water the marl shows a tendency to become thinner. Thus at one point there was but one foot of marl in 11 feet of water, though but a short distance away nine feet of water overlay seven feet of marl. At another point 13 feet of water gave but one and a half feet of marl, though six feet of water between that and shore gave six feet of marl.

Along the south shore the marl runs a little thicker, few of the tests showing less than six feet, and a few on the edge of deep water not reaching the bottom. At the southeast end of the lake near the hotel the marl runs thin or in places runs out, being replaced by muck.

On the whole, the large acreage more than offsets the thinness of the bed, and a fair workable deposit may be said to occur beneath the shallow water area. If the lake should ever be lowered a much larger quantity would, without doubt, become available.

CLEAR, PINE, STONE AND FISH-TRAP LAKES.

Not a Workable Deposit.

Of the lakes lying north and northwest of Laporte the following were visited: Clear, Stone, Pine, Mud and Fish-trap lakes. Of these the first three are connected by channels and furnish water to the Laporte waterworks, situated on the western lobe of Clear Lake. The effect of this has been to lower the surface of the lakes a few feet, yet enough to convert considerable areas of them from lake to marsh or dry land.

CLEAR LAKE.

This lake lies north of and adjoining the city of Laporte. In 1875, Dr. G. M. Levette wrote of it as follows: "Clear Lake has uniformly low, sandy shores, and sustains a scattered growth of vegetation in the shallow portions. The water owes its turbid, dirty green color to the great quantity of suspended organic matter, confervae, and perhaps minute animal organisms. Just west of the center of this lake, for a space of two or three acres, the water is only a few inches deep; this may have been a small hill in the original bed of the lake, but the fishermen insist that it has formed there within a few years; that being true and no currents in the lake, the cause of the accumulation is not clearly understood.

"A careful search with the sounding line, for half a day, failed to find any water more than nine and a half feet deep. Forty-two soundings were made, showing from four to nine and a half feet of water, and the temperature ranged from 66 degrees at the surface to 65 degrees at the bottom, in deepest parts. Notwithstanding the high temperature of this shallow basin of turbid water, it is more resorted to for line fishing from boats than any other lake in the vicinity."

In September, 1899, the irregular area formerly occupied by Clear Lake was nearly all a mud flat. A small pool occupied the center of each of the end lobes and a somewhat larger body of water was in the central basin. This was shallow, and except for some sandy bottom on the south side, has a bottom of muck extending at all points tested to over 16 feet. No marl was found.

PINE LAKE.

This lake lies two miles northwest of Laporte. It is the largest lake near that city, and is about one and a half miles long in a north and south direction and nearly three-quarters of a mile in width. On the east and west sides the hills, composed almost wholly of sand, rise from 30 to 40 feet above the water.

In 1875 Dr. Levette took the following temperature soundings, beginning on the east side about 500 feet from shore and moving north; depth and temperature at intervals of 300 feet:

1. Bottom at 41 feet, temperature.................. 59° F.
2. Bottom at 34 feet, temperature.................. 61° F.
3. Bottom at 20 feet, temperature.................. 63° F.
4. Bottom at 17 feet, temperature.................. 64½° F.
5. Bottom at 12 feet, temperature.................. 67° F.
6. Bottom at 10 feet, temperature.................. 67° F.
7. Bottom at 14 feet, temperature.................. 66° F.
8. Bottom at 38 feet, temperature.................. 60° F.
9. Bottom at 40 feet, temperature.................. 61° F.
10. Bottom at 39 feet, temperature.................. 61° F.
11. Bottom at 30 feet, temperature.................. 62° F.
12. Bottom at 25 feet, temperature.................. 64° F.
13. Bottom at 40 feet, temperature.................. 61° F.
14. Bottom at 12 feet, temperature.................. 66½° F.

Returning to the ninth station and moving toward the southwest corner of the lake, a second line of soundings, the same distance apart, were taken, which resulted as follows:

1. Bottom at 50 feet, temperature.................. 56° F.
2. Bottom at 40 feet, temperature.................. 61° F.
3. Bottom at 45 feet, temperature.................. 59° F.
4. Bottom at 42 feet, temperature.................. 60° F.
5. Bottom at 38 feet, temperature.................. 61° F.
6. Bottom at 30 feet, temperature.................. 62° F.
7. Bottom at 52 feet, temperature.................. 55° F.

The lowering of the surface of Pine Lake in recent years has divided it into two bodies separated by a narrow sandy channel. The water is deep and clear, the southern arm having a depth of 50 feet in front of the ice houses and a depth of 38 feet very close to shore near the eastern end of the tongue of land separating the two lobes.

Dr. Levette and Mr. Caleb Cooke made a collection of fishes in Clear and Pine lakes in 1875. These were afterward studied and classified by Dr. D. S. Jordan; with their nomenclature brought up to date, the list of 21 species is as follows:

LIST OF FISHES KNOWN TO OCCUR IN CLEAR AND PINE LAKES.

1. *Amieurus natalis* (Le S.). Yellow Cat.
2. *Amieurus nebulosus* (Le S.). Common Bullhead; Horned Pout.
3. *Noturus flavus* Raf. Stone Cat.
4. *Erimyzon sucetta oblongus* (Mitch.). Chub Sucker; Sweet Sucker.
5. *Pimephales notatus* (Raf.). Blunt-nosed Minnow.
6. *Notropis megalops* (Raf.). Common Shiner; Silverside.
7. *Hybopsis storerianus* (Kirtland). Kirtland's Minnow.
8. *Hybopsis kentuckiensis* (Raf.). Horny Head; River Chub.
9. *Notemigonus chrysoleucus* (Mitch.). Golden Shiner.
10. *Fundulus diaphanus menona* (Jor. and Copel.). Common Killifish.
11. *Umbra limi* (Kirtland). Mud Minnow.
12. *Lucius vermiculatus* (Le S.). Little Pickerel; Grass Pike.
13. *Labidesthes sicculus* Cope. Brook Silverside; Skipjack.
14. *Chœnobryttus gulosus* (Cuv. and Val.). War-mouth; Red-eyed Bream.
15. *Lepomis cyanellus* (Raf.). Green Sunfish.
16. *Lepomis pallidus* (Mitch.). Blue Gill; Blue Sunfish.
17. *Lepomis gibbosus* (L.). Common Sunfish; Pumpkin-seed.
18. *Micropterus dolomieu* (Lacépède). Small-mouthed Black Bass.
19. *Etheostoma eos* (Jor. and Copel.). Sunrise Darter.
20. *Etheostoma microperca* Jor. and Gil. Least Darter.
21. *Perca flavescens* (Mitch.). Yellow Perch; Ringed Perch.

MARL IN PINE LAKE.—The northern arm of Pine Lake showed no marl. The bottom at the eastern end is sandy. Around the rest of the shore is muck having a depth of from three feet to over 13 feet. The southern arm has hard bottom under most of the shallow water of the eastern half. A narrow westward extension of the lake was at the time of our visit out of water, while a considerable area just east of this was dry. This showed some marl, most of the tests in this area revealing from a few inches to seven feet or more. Around the edges some bare marl is exposed, but it is generally only a few inches thick. As the marl increases in depth it comes to have muck over it, the muck usually about equaling the marl in depth, so that where the marl is over seven feet deep it is overlain by nine feet of muck. In quality the marl is inferior, most of it showing a considerable admixture of muck.

STONE LAKE.

This lake lies about one mile northwest of Laporte and is about three-quarters of a mile long by one-half mile broad. In 1875 Dr. Levette wrote of it as follows: "Stone Lake is nearly surrounded by sandy hills from 20 to 40 feet high, and is one of the most beautiful sheets of water in the county. Why it should be called 'Stone' Lake is quite incomprehensible, as no rock of any description is visible in or near it; not a single pebble was seen in the clean, well washed sand which constitutes the bottom, the shores and the adjacent hills. The water is very free from suspended matter, and so clear that shells can be distinctly seen resting in their oozy bed, under 20 feet of water.

"All the eastern half of the lake is shallow, varying in depth from six to 10 feet; over a great part of which aquatic grasses grow luxuriantly, reaching, in many places, to the surface of the water. In the western half of the lake, near the high bold shore, the water is deeper, reaching 42 feet at the deepest point found by the sounding line."

The eastern lobe of this lake, including its former connection with Pine Lake, is now dry. This area showed only a very small deposit of fair marl, but even it was under 14 or more feet of muck. Otherwise all tests found only muck to a depth of 16 feet or over, except just at the shore. In a few places along the south shore the bottom was sandy; otherwise it was of muck which runs from three to seven feet near shore, but is deeper at the western end of the lake.

FISH-TRAP LAKE.

The former basin of this lake is now mostly a mud flat, though the water is reported as 20 feet or more deep over a narrow strip on the east and north sides. Drillings showed only muck at the bottom of the lake, ranging in thickness from three feet to a depth of 10 feet near the center. What was once Mud Lake is now dry and partly under cultivation.

Horseshoe Lake, which was not visited, is also reported to be, at present, mainly an impassable mud flat or weedy marsh, though in a few places the water reaches a depth of 20 or more feet.

FISH LAKE.

Workable Deposit.

This lake lies in the east central part of Laporte County, in sections 16, 17, 20 and 29 (36 north, 1 west). Narrow channels divide it into four basins known as the Upper and Lower Fish lakes and Upper and Lower Mud lakes, while east of the last named is an area known as Goose Lake, which is dry much of the year. The two Fish lakes have each an area of about 100 acres and a maximum depth of 40 feet of water. The shallow water belt along shore is narrow, as a rule, though more irregular and wider in the Lower Lake than in the Upper. The two Mud lakes were, when examined in September, 1899, little more than swamps. Goose Lake was dry at the time, though it is said to have two feet of water over it in the Spring. The banks are everywhere less than 20 feet high. East of Goose Lake there is an extensive flat. The Grand Trunk Railway just touches the north end of Fish Lake, while the Chicago Division of the Wabash Railway runs only half a mile south of the south end.

Marl.—Upper Fish Lake shows marl all along the shore. It usually sets in, in less than two feet of water. Along the north and northeast shores the marl is over 12 feet deep in two feet of water, and at most points runs from three to eight feet in that depth of water. Beyond that depth the marl reached to below reach of drill.

Lower Fish Lake shows mostly muck just at the shore line, though often with marl beneath. By the time the water has reached a depth of four feet the marl was usually clear and extended to beyond reach of a 16-foot drill.

The water area of Mud lakes was not examined, but drillings on the east shore showed 13 feet of marl, suggesting the presence of a considerable body of marl beneath the water.

Goose Lake has an area of probably 160 acres. Though overflowed in the wet season, it becomes dry in the summer, at which time it shows a large area of bare marl, sparingly covered with bulrushes. In the center of this area the bottom of the marl could not be reached with our drill, though it was thought to be less than 20 feet. Away from the center the marl showed an average depth of about 10 feet. Between Goose Lake and Fish Lake the marl runs from two to 10 feet or more thick, but is, in part, overlain by muck,

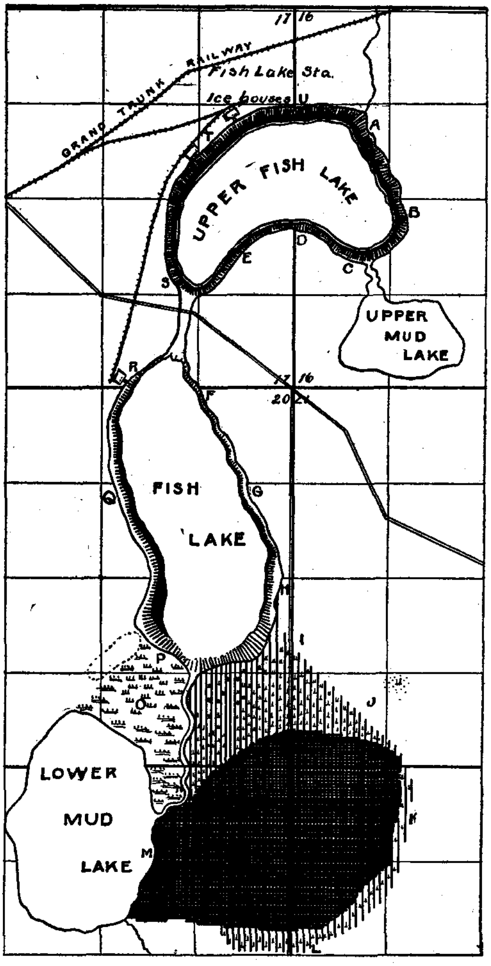


Fig. 67. Map of Fish and Mud Lakes, Laporte County, Ind.

the latter usually only a foot or two in thickness, but in a few places running up to five or six feet. The quality of the marl in all parts of this deposit appeared to be excellent.

The tests showed that this deposit has an area of at least 100 acres of bare dry marl, 10 feet or more thick; probably as much more under less than two feet of muck or in less than 10 feet of water, and an indefinite but probably still larger area of marl existing beneath deep water, under less workable conditions. This is perhaps the closest workable deposit to Chicago and lies adjacent to two good railways, so that its location can hardly be excelled.

STARKE COUNTY.

REFERENCES.—

1859.—Richard Owen, Geol. Reconn. of Ind., p. 210.

1885.—W. H. Thompson, Fifteenth Ann. Rep. Ind. Dept. Geol. & Nat. Hist., p. 221.

1897.—W. S. Blatchley, Twenty-second Ann. Rep. Ind. Dept. Geol. & Nat. Res., p. 124.

1899.—Frank Leverett, Water Supply and Irrigation Papers, U. S. Geol. Surv., No. 21, p. 39.

Starke County lies in the second tier of counties south of Michigan, and in the third east of Illinois. Its eastern border is 18 miles and its southern border 24 miles in length. Nine miles west of its northeastern corner the Kankakee River intervenes between it and Laporte County, and, flowing southwesterly, forms the remainder of the northern and all but five miles of the western boundary. Yellow River, flowing west through the center of the county, and Bogus River and Pine Creek, north through the southwestern fourth, empty into the Kankakee. The township of North Bend, in the southeastern corner of the county, is drained by several small streams flowing southerly into the Tippecanoe River, which, making a bend to the north, cuts through two sections on the southern line of the township and then leaves the county.

The county is well supplied with railways, four passing entirely across it, while one, the Pan Handle Division of the Pennsylvania System, cuts its southwestern corner. Those crossing it from east to west are the Pittsburgh, Fort Wayne & Chicago across the northern third; the New York, Chicago & St. Louis (Nickel Plate) across the center, and the Chicago & Erie across the southern third. The Indiana, Illinois & Iowa ("Three I") enters the extreme southwestern corner of the county and leaves the northeastern, thus cutting diagonally its full length.

The county has an area of 314 square miles, the surface of which is diversified by marsh, wet prairie, dry prairie and sand ridge, the latter predominating. More than half the area is covered to a depth of two to 15 feet by the fine grained buff sand so characteristic of all the region adjacent to the Kankakee on the south. Experience has proven that this sandy soil, if properly cultivated, will produce excellent melons, cucumbers, sugar beets, berries, grapes, etc. Where ploughed deep and fertilized it also yields good crops of corn, oats and potatoes. Within the past ten years colonies of frugal, industrious Germans and Swedes have bought at a low price large areas of this once despised land and are making a good living from it. They utilize all fertilizers produced on the farm; they haul muck from the lowlands and mix it with the sand; they plough deeply each season; and by these means and others are proving the land of far greater productive power than it was ever believed to be.

Many thousand acres of the marsh land in the northern half of the county have been recently drained, and where a few years ago the waters were waist deep the year round bountiful crops of corn are now produced. That the county is rapidly coming to the front agriculturally is proven by the growth of Knox, the county seat, where a number of fine business blocks have been erected since 1897, and where a $90,000 court house was finished in 1898.

Not an outcrop of rock occurs in the county. The only bores known to have pierced the thick mantle of drift are at Knox and North Judson, in both of which stratified rock was found about 200 feet below the surface.

The elevation in feet above tide of the principal railway stations in the county is as follows: Aldine, 710; Davis, 681; Grovertown, 715; Hamlet, 695; Jackson, 717; Knox, 710 to 716; North Judson, 695 to 700; Ober, 741; Ora, 721.

With one exception the lakes of the county are small and of little note. Bass Lake, formerly known as Cedar Lake, is, however, one of the largest and best known fishing resorts of the State. It is fully described on subsequent pages. The English Lake of the older maps was but an enlargement of the Kankakee River. Much of its former bed is now annually producing immense crops of corn.

KOONTZ LAKE.

Not a Workable Deposit.

This lake lies in sections 1 and 12 (34 north, 1 west), Oregon Township. It is a shallow body of water covering 200 or more acres and is largely artificial. All the shallow water area around the shores was tested, but only hard bottom was found, except in a few places where beds of muck had accumulated. Many aquatic plants abound in the lake, and as a result the fishing is excellent.

EAGLE LAKE.

Not a Workable Deposit.

Eagle Lake lies in the northwest quarter of section 13 (33 north, 1 west), Washington Township. Its area has been recently reduced one-half or more by draining. At the time of our visit, in May, 1900, the water covered about 70 acres, and there were extensive marsh meadows on the east and west shores. The north and south shores slope gradually upward into sandy, cultivated fields or woodland. The outlet, Eagle Creek, leaves the west end and flows almost due west into Yellow River. The lake is nowhere more than 18 feet in depth, while much of its area is less than five feet, and bids fair to soon become extinct, as the decay of the abundant water vegetation is rapidly adding to the already extensive beds of muck. Numerous large examples of the bivalve shell, *Anodonta grandis* Say, were found in the muck beds of the lake. The univalves, *Campeloma subsolidum* Anthony and *Helisoma trivolvis* (Say), were also common. The only turtles noted were the stink-pot *Aromochelys odoratus* (Lat.), and the lady turtle, *Chrysemys marginata* (Agas.), which were frequent, especially the last named. A school of carp of large size were routed out of a pool covered with spatterdock on the east end, and made the water boil in their frantic efforts to escape.

Marl.—The only deposit of marl of any size in and about Eagle Lake is in the marsh at the west end. This marsh comprises about 20 acres, and in several bores near the south side the marl was 18+ feet in thickness. It decreases in thickness toward the north and west and becomes overlain with two to four feet of muck. The marsh of 80 or more acres on the east and northeast borders of the lake is wholly of muck, or, if the marl be present, it is more than 16 feet below the surface. In the lake itself, several tests along the north and west shores showed marl ranging from 12 to 15 feet in thickness, but over most of its area muck beds, whose bottom could not be reached, occur. The marl found is of excellent quality, but its quantity is altogether too small for utilization in cement manufacture. It might, however, be used to advantage as a fertilizer on some of the surrounding lands, or for some of the other purposes mentioned on a previous page.

ROUND LAKE.

Not a Workable Deposit.

This is a small and nearly circular lake lying in the east half of section 8 (32 north, 2 west), California Township. Its area is about 120 acres. The water is, for the most part, quite deep, the only shallow area of any size lying along the north shore. The lake abounds in plant life, pondweeds *(Potamogeton)* and millfoils *(Myriophyllum)*, being especially common. The banks of the lake are everywhere low and, except on the north, marshy.

Marl.—The shallow water on the north side was tested in a number of places, but only sand and muck were found. A large area of marsh adjacent to the lake on the southeast was reported to be underlain with marl, but tests showed muck only to a thickness of 16+ feet.

NORTH JUDSON DEPOSIT.

Workable.

This, the only workable bed of marl found in Starke County, is wholly a marsh deposit, lying in sections 10 and 15 (32 north, 4 west), Railroad Township, about three and a half miles west of North

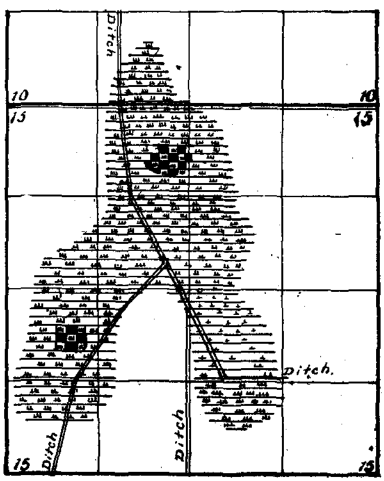


Fig. 68. Map of Marsh Deposit West of North Judson, Starke County, Ind.

Judson. The deposit occupies the basin of an extinct lake. Thirty years ago the lake had become replaced by a marsh over which duck hunters and muskrat trappers hunted and trapped with great success.

Now part of it is cultivated in corn and the remainder furnishes large and excellent crops of hay. The marl is everywhere overlain with muck, except in one or two places, where it forms the surface. The muck varies in thickness from one to five feet, averaging about two and a half feet. The center of the deposit is two miles from the Chicago and Erie Railway; one and a half miles from the "Three I" Railway, and three miles from the Pan Handle Division of the Pennsylvania Railway. The surrounding country is quite level, so that switches from any one or all of these lines could be constructed at small expense. The most of the land containing the deposit belongs to Jacob Keller of North Judson and F. M. Trissal, 204 Dearborn street, Chicago.

But about 15 acres of the deposit lies north of the east and west wagon road between sections 10 and 15, the remainder being in section 15. In making the tests, 86 in number, over this tract, a hole was dug through the muck to the top of the stratum of marl, and accurate measurements both of the muck and the marl were taken. The 86 bores, made with a 16-foot auger, were put down from 10 to 20 rods apart. They passed through a total thickness of 519 feet of marl, thus showing the average thickness of the bed to be a little more than six feet. These tests include three in which no marl at all was found, and seven where the bottom of the marl could not be reached with the auger. More bores proportionally were put down in the poorer or thinner areas than in the thicker ones, so that the average thickness is above, rather than below, six feet.

A careful estimate of the amount of marl found on the different 40-acre tracts is as follows:

Southeast quarter of southwest quarter of section 10.	.15 acres.
Northeast quarter of northwest quarter of section 15.	.30 acres.
Northwest quarter of northeast quarter of section 15.	.10 acres.
Southwest quarter of northeast quarter of section 15.	.20 acres.
Southeast quarter of northwest quarter of section 15.	.35 acres.
Southwest quarter of northwest quarter of section 15.	.15 acres.
Northwest quarter of southwest quarter of section 15.	.30 acres.
Southwest quarter of southwest quarter of section 15.	.15 acres.
Northeast quarter of southwest quarter of section 15.	.10 acres.
Northwest quarter of southeast quarter of section 15.	.25 acres.
Southwest quarter of southeast quarter of section 15.	.15 acres.
Total	220 acres.

The best and thickest portions of the deposit occur in the northwest quarter of the southeast quarter of section 15, and the northwest quarter of the southwest quarter of section 15. In the first

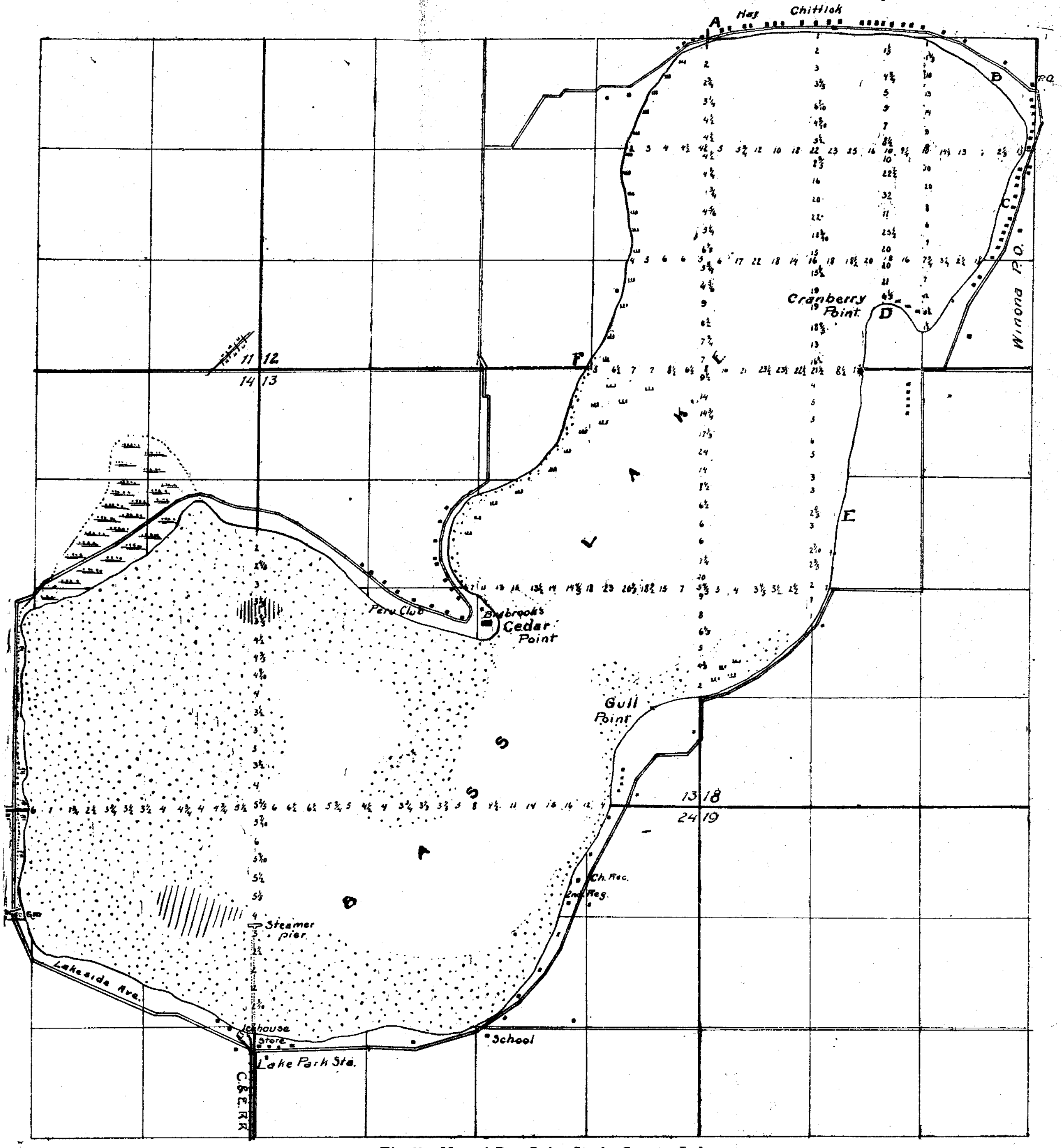


Fig. 69. Map of Bass Lake, Starke County, Ind.

named tract the top of much of the marl is within six to 10 inches of the surface and the bed is five and a half feet thick. In the second 40 mentioned a fine wire grass, characteristic of marshes containing thick deposits of marl, covered most of the surface. The marl ran from seven and a half to 12 feet thick, with muck from six inches to two and one-half feet overlying.

In color the marl of this deposit is darker than that found in the lakes to the eastward, but this is no doubt due largely, if not wholly, to the seepage from the overlying muck. An analysis of an average sample made by Dr. Noyes, showed the percentage of its constituents to be as follows:

Calcium carbonate ($CaCO_3$)	89.92
Magnesium carbonate ($MgCO_3$)	2.46
Alumina (Al_2O_3)	.45
Ferric oxide (Fe_2O_3)	.74
Insoluble inorganic matter	2.06
Organic matter	4.51
Total	100.14

The large percentage of organic matter shows the presence of the seepage above mentioned. This, however, will burn out in the kiln and is, therefore, harmless. An analysis of a picked sample made for Mr. Keller, by the chemist of the Sandusky (Ohio) Portland Cement Works, showed 90.57 per cent. calcium carbonate and 2.36 of magnesia.

Besides the tract above mentioned, another of 40 or more acres lies about a mile to the eastward in the southwest quarter of the southwest quarter of section 11 and the northwest quarter of the northwest quarter of section 14, on both sides of the road running east and west. The thickness of both muck and marl is here practically the same as that in the Keller—Trissal deposit. Other beds of minor size are said to occur in the same township between these and the Kankakee River.

BASS LAKE.

Not a Workable Deposit.

This lake ranks fourth in size among those found in Indiana; its water area comprising 2.23 square miles. It lies about six miles south of Knox and covers parts of sections 7 and 18 (32 north, 1 west), North Bend Township, and sections 12, 13, 14, 23 and 24 (32 north, 2 west), California Township. The extreme length from northeast to southwest is just about three miles. The northern or longer lobe averages about three-quarters of a mile in width, while the southern basin is a little over a mile wide. These two lobes are separated by long sandy bars which extend out from Cedar and Gull points. Over the bars the water in many places is less than two feet deep. A narrow channel of deeper water intervenes between the ends of the sand spits.

The lake occupies a shallow basin on top of a ridge, the natural surface drainage being all away from its area. The fall from its water level to that of the water in the Tippecanoe River, five miles southeast, is 15 feet. It has at present no outlet or natural inlet. Two artificial ditches drain into it from the marsh land on the east. Its overflow formerly found its way through the marshes at the southwest in a northwesterly direction to the Kankakee River. A portion of the old outlet is now a shallow water marsh, filled with spatterdock, rushes and cat-tail flags. It was formerly an arm or bay of the lake, but has been separated from the main body of water by the levee or fill constructed for a roadway along the northwest shore of the south basin. For a number of years there has been little or no overflow, and the waters of the lake seem to be slowly receding. It is fed almost wholly by subaqueous springs and by the waters of flowing wells, a number of which occur on the north and east shores of the northern lobe. These wells range from 20 to 80 feet in depth. They pass through two to 10 feet of sand, then through a hard-pan clay into a stratum of gravel in which the water is found. More than half of the water area is less than seven feet in depth and fully one-third is less than five feet. Of 516 soundings made by the U. S. Fish Commission in the summer of 1900, 307 showed less than seven feet of water, while 200 showed less than five feet. The average depth found by the 516 soundings was 8.7 feet, while the maximum depth was 32 feet at a point one-third of the way across the lake, north of Cranberry Point. The map will show additional details ascertained by the soundings made.

The greater part of the shore line of Bass Lake is low and marshy. This is especially true of the west half of the south shore, almost the entire west shore, and the west third of the north shore. Between (A) and Winona P. O. at (B), on the accompanying map, the banks at the water margin are low and sandy, but slope up gradually to a height of 10 or more feet, thus furnishing excellent sites for cottages, a number of which have been erected. From (B) to (C) the banks rise more abruptly 15 to 20 feet, and this stretch is also occupied by a number of cottages. Between (C) and (D) the immediate shore is mostly low and marshy. On Cranberry Point there is higher ground and a fine grove, which is the resort of numerous picnic and fishing parties. South of (D) as far as (E) the banks are mostly high and wooded, but as yet few cottages have been erected. The remainder of the shore, with the exception of a stretch of high ground at Lake Park Station is, for the most part, low and flat. On Cedar Point a large hotel has been built on rather low ground. The north and east shores about Winona P. O. furnish by far the better quarters for summer visitors. If by draining the lake were to be lowered two feet, as has been attempted several times, it would render bare extensive tracts of muck and sand bordering all the shores and destroy much of the charm and healthful surroundings of what is now a beautiful though shallow sheet of water.

At Lake Park Station are several large ice houses belonging to the Knickerbocker Ice Co., of Chicago. A switch connects these with the Chicago & Erie Railway at Bass Lake Station, two miles south. Over this switch a regular train runs daily during the tourist season, and connects with steamers which land passengers at the end of long piers on various sides of the lake. A hack from Winona also connects with all trains at Bass Lake Station.

The bottom of the lake is, for the most part, sand or blue, sticky clay. In the bay east of Cranberry Point there are extensive muck beds. Muck also occurs in quantity beneath a strip 200 feet or more wide, along the west shore between (A) and (F). These muck deposits contain a luxuriant growth of aquatic vegetation. In June the waters of the lake are said to contain vast quantities of a green sediment—probably unicellular plants. When these are present the fishing is poor. The sandy and clay bottoms of the shallow water produce also their characteristic water-plants, so that the lake flora is a very rich one, and worthy of extended study. During the few days spent on and about the lake in May and July, 1900, the following species were noted or collected:

A Partial List of the Plants Known to Occur in Bass Lake or on Its Mucky Margins.*

Juniperus virginiana L. Red Cedar.

Formerly grew in abundance on Cedar Point, where scattering examples still exist. Large cedar logs are occasionally uncovered in the marsh just to the west.

*Mr. H. Walton Clark, of Fort Wayne, kindly identified a number of the pondweeds and other strictly aquatic forms.

TYPHA LATIFOLIA L. Broad-leaved Cat-tail.

Abundant in the marsh at the northwest corner, also in the old bay west of the south basin.

POTAMOGETON NATANS L. Common Floating Pondweed.

One of the most common pondweeds in the State. Occurs abundantly in the lake in two to six-foot water.

POTAMOGETON AMPLIFOLIUS Tuckerm. Large-leaved Pondweed.

Common in three to eight-foot water in the bay north of Cedar Point. Its leaves are larger and more noticeable than those of any other.

POTAMOGETON LONCHITIS Tuckerm. Long-leaved Pondweed.

Frequent in water up to 10 feet in depth. The leaves long and slender.

POTAMOGETON HETEROPHYLLUS Schreb. Diverse-leaved Pondweed.

Frequent in water less than five feet in depth. The foliage varies exceedingly, the submerged leaves usually lanceolate or linear; the floating ones narrowly ovate.

POTAMOGETON PRÆLONGUS Wulf. White-stemmed Pondweed.

Not common. The stem is white and very long and branching, the leaves bright green. Roots at the bottom of eight to 14-foot water, and fruits just at the surface in June or July. It usually withdraws the head of the fruit beneath the water after fertilization has taken place.

POTAMOGETON PUSILLUS L. Small Pondweed.

A short, narrow-leaved species, growing in shallow water with sandy or mud bottom. Quite common along the north and east shores in two to four-foot water.

POTAMOGETON PECTINATUS L. Fennel-leaved Pondweed.

Stem slender, filiform, branching; leaves very narrow linear, in tufts or interrupted masses. Most common in four to eight-foot water. A handsome and easily distinguished species.

POTAMOGETON FRIESII Ruprecht.

Found in the bays with muck bottoms. Leaves linear, about two inches in length. Fruit similar to that of *P. pusillus* L., but with a recurved style, a shallow pit on each side, and with the apex of the embryo pointing toward the basal end. Not before recorded from the State except from Maxinkuckee by Dr. Scovell in the present volume, though it occurs in a number of the other lakes.

NAIS FLEXILIS (Willd.) **Rost. and Schmidt.**
Quite common in six to 20-foot water.

PHILOTRIA CANADENSIS (Michx.). **Water-weed; Ditch Moss.**
Abundant in much of the water less than five feet in depth. Varies much in the character of the foliage. Blossoms in June and July. The staminate (male) flowers break off and float free on the surface where they open and set free the pollen, thus enabling it to come in contact with the stigmas of the pistillate flowers which have been raised slightly above the surface by the lengthening of the calyx tube, the latter varying in length according to the depth of the water.

VALLISNERIA SPIRALIS L. **Tape-grass; Eel-grass.**
Quite common in the bays and along the margins wherever muck occurs. Grows in water between two and 10 feet in depth. A plant of peculiar habits, fertilized much as in the preceding; the long thread-like scapes coiling spirally after fertilization and drawing the fruit beneath the water to ripen.

SAGITTARIA LATIFOLIA Willd **Broad-leaved Arrow-head.**
Common along the shore in mucky places, and in ditches.

SAGITTARIA RIGIDA **Pursh. Stiff-stemmed Arrow-head.**
With the preceding but much less common.

SAGITTARIA GRAMINEA Michx. **Grass-leaved Arrow-head.**
Occurs frequently in mucky places where the water is less than a foot in depth.

ZIZANIA AQUATICA L. Wild Rice.
Frequent in the marshy area on the west side of the south basin, also in shallow water in several places along the west shore. The stems were many of them 10 to 12 feet in height, and the leaves often a yard long.

ELEOCHARIS MUTATA (L.). **Quadrangular Spike-rush.**
This pretty and rather scarce rush grows in numbers in the shallow water along the north shore of the south basin.

SCIRPUS AMERICANUS **Pers. Chairmaker's Rush.**
Abundant in many places along the shores, in water one to four feet in depth.

SCIRPUS LACUSTRIS L. **Great Bulrush.**
Abundant, growing on sandy bottom in water up to eight feet deep.

LEMNA TRISULCA L. Ivy leaved Duckweed.

Common on the surface over muck beds. In late summer a large number of the fronds are connected into one sheet or mass.

LEMNA MINOR L. Lesser Duckweed.

Abundant with the above.

ERIOCAULON SEPTANGULARE With Seven-angled Pipewort.

Common in the bay east of Cranberry Point, also in the shallow water near the northwest shore. Varies much, according to the depth of water, in the length of the scape.

PONTEDERIA CORDATA L. Pickerel-weed.

Frequent in company with arrow-head and spatterdock about the margins of the muck areas.

BETULA NIGRA L. River Birch; Red Birch.

A number grow in the marsh on the northwest shore of the main basin.

BRASENIA PELTATA Pursh. Water-shield.

Common in the bays which contain muck. Notable on account of its shield-shaped floating leaves which are borne on long mucilage-coated stems.

NYMPHÆA ADVENA Soland. Large Yellow Pond Lily.

Abundant in muck beds in water a foot or less deep.

CASTALIA ODORATA (Dryand). White Water Lily.

Less common than the yellow lily. Grows in water a foot or two deeper.

CERATOPHYLLUM DEMERSUM L. Hornwort.

Abundant. Wholly submerged at the bottom of water 6 to 20 feet in depth, forming thick masses or beds which serve as shelter and feeding places for many fishes and other aquatic animal forms.

CALTHA PALUSTRIS L. Marsh Marigold.

Several large patches occur in the marshes at the northwest corner of the north basin.

RIBES FLORIDUM L' Her. Wild Black Currant.

A number of bunches occur in the marsh above mentioned. In flower May 8, 1900.

RHUS VERNIX L Poison Elder.

Common in the same marsh. The large compound leaves are often two feet in length. More poisonous than the common poison ivy, the juice or exhalation of its leaves causing small white blisters everywhere on the surface of the exposed skin. An infallible remedy is a saturated alcoholic solution of sugar of lead several times applied to the skin as soon as the blisters appear. A water solution is of little if any value.

TRIADENUM VIRGINICUM L. **Marsh St. John's-wort.**

Found in the same marsh as the last three; not common.

DECODON VERTICILLATUS (L.). **Swamp Loose strife.**

Borders of the muck marshes along the west shore; abundant. Its long, recurved stems bend gracefully over the water's edge and when in blossom the rose purple flowers make it truly a notable and handsome plant.

HYDROCOTYLE UMBELLATA L. **Marsh Pennywort.**

In water three to six inches deep or on the sandy margin along the north shore.

CHAMÆDAPHNE CALYCULATA (L.). **Leather-leaf.**

Abundant in the bog northwest of the main basin. A low branched shrub, with nearly evergreen, oblong leaves and white bell-shaped flowers, which are in blossom about May 1st. Forms a close cover over the surface of much of the bog area.

GAULTHERIA PROCUMBENS L. **Creeping Wintergreen.**

This pretty trailing shrub is plentiful in the woods north of the main lake. It is common in wet shaded places about tamarack and pine swamps in Lake, Porter and Laporte counties, and has been found by the writer as far south as the Pine Hills, Montgomery County, where it occurs on the "Devil's Back Bone."

OXYCOCCUS MACROCARPUS (Ait). **Large Cranberry.**

Occurs sparingly in the bog at the northwest corner of the main basin.

MENYANTHES TRIFOLIATA L. **Marsh Bean.**

Common about the margins of bogs in different places around the lake shore.

BIDENS BECKII **Torrey. Water Marigold.**

Occurs in abundance in different parts of the lake in water between four and 15 feet in depth. A peculiar member of the family Compositæ in that it is strictly aquatic—its long and slender stems bearing at intervals bunches of crowded, capillary, many dissected leaves.

A Partial List of the Mollusca Inhabiting Bass Lake.

No especial search was made for the mollusca inhabiting the lake, only such specimens being taken as came readily to hand. The list is therefore much smaller than that of the corresponding group from Lake Maxinkuckee.

UNIVALVES.

1. **Succinea ovalis** Gould.

A number were taken from the stems of rushes and other aquatic plants along the margin of the north basin.

2. **Limnophysa palustris** Müller.

Quite common about the margins of the muck beds. Readily distinguished from its allies by the numerous slightly raised reticulating lines and wrinkles. The adults are much larger than either of the next two species.

3. **Limnophysa desidiosa** Say.

This and the next species were very abundant on the stems of rushes and other water plants in the shallow water, especially along the north shore.

4. **Limnophysa humilis** Say.

With the preceding and probably more abundant.

5 **Physa gyrina** Say.

Occurs sparingly along the margins of the muck beds and in the ditches flowing into the lake.

6. **Physa heterostropha** Say.

Common in the ditches and in the swamp at the northwest margin.

7 **Planorbella campanulata** Say

This very pretty shell is found in company with its larger congener, *H. trivolvis*, in the shallow sandy and muddy marginal waters all around the lake.

8. **Helisoma trivolvis** Say.

This, the largest of the discoidal univalves, is very common, not only in Bass Lake, but in most if not all of the lakes of northern Indiana. It frequents the reedy shallow water margins.

9. **Gyraulus parvus** Say.

This little shell, the smallest of the discoidal group of which it is a member, was quite common on lily pads and stems of pondweeds in the shallow-water bays.

10. **Amnicola porata** Say.

Several were taken from the stems of aquatic plants. They were in company with the small species of *Limnophysa.*

11. **Vivipara contectoides** Binney.

One of the most common univalves in the lake. Readily known by the three or four brownish-red revolving bands on the body whorl. Occurs everywhere in shallow water.

12. **Vivipara intertexta** Say.

Occurs with the last named but less common. The adults are wholly brownish-red in color.

13. **Campeloma decisum** Say.

A few dead specimens of this mollusk were found along the sandy margins of the north shore. In Maxinkuckee three species of *Campeloma* occur in abundance.

14. **Goniobasis livescens** Menke.

Very abundant, the young occurring by thousands in the sand at the bottom of the shallow water along the south shore of Cedar Point. The different stages vary much in appearance and the tyro is apt to consider them distinct species.

BIVALVES.

No examples of the genus *Unio* were found in the lake, though six species are known to occur in Lake Maxinkuckee. One reason for their greater numbers there is doubtless the presence of several inflowing streams, as the thick shelled *Unios* are much fonder of flowing water than their more fragile allies, the *Anodontas.* But four species of bivalves were noted. No one of them was common. A careful search of the lake will probably bring to light a number of others.

15. **Anodonta grandis** Say.

Several living half grown specimens and a number of dead shells of this large bivalve were found on and about the various muck beds.

16. **Anodonta salmonia** Lea.

This is also a mud-loving form. A number were secured while seining in the channel in front of the hotel on Cedar Point.

17. ANODONTA FOOTIANA Lea.

A number were taken along the north shore. It is a very common mollusk in the Indiana lakes. Frequents for the most part sandy or marl bottom beneath two to five feet of water.

18 ANODONTA FRAGILIS Lam.

Several specimens were taken with the above. This is its first definite record for the State, though it is said to be common in the lakes of Michigan, New York and Canada.

THE FISHES OF BASS LAKE.

Bass Lake is one of the best and most noted fishing resorts of Indiana. The large amount of aquatic vegetation furnishes much available food for the smaller species, while they in turn are preyed upon by the larger. Many visitors from Chicago, Indianapolis and other smaller cities and towns of northern Indiana and eastern Illinois visit the lake, some of them several times each year. Many of them have cottages on the lake and spend a month or more there, while the hotels are always crowded with guests during the summer season.

The number of species of fish known from Bass Lake is not as large as from Maxinkuckee for two reasons: First. The waters of the latter have been much more thoroughly worked by the members of the U. S. Fish Commission and others in order to determine the species found therein. Second. The numerous inlets entering Lake Maxinkuckee contain several species which often find their way into that lake but which have not yet been found in Bass Lake, as it has no inlets of any size. The following list of species is based upon a collection made by the writer and assistant in Bass Lake on August 8 and 9, 1900, and upon notes taken May 8 to 10, 1900. Mr. Frank Hay furnished much of the data concerning the time and place of spawning and the size to which the food and game fishes grow:

1. LEPISOSTEUS PLATOSTOMUS Raf **Short-nosed Gar.**

Very common; feeds mostly upon minnows and the young of many game fishes, and is therefore hated by all fishermen. In the spawning season, which occurs in May, they swim in schools, and Mr. Hay killed with a shot gun 115 in one day in the shallow water along shore. The females, which are much the larger, reach a length of three feet and a weight of 10 to 12 pounds.

2. AMIA CALVA L. **Dogfish; Mudfish; Bow-fin**

Common. Also rapacious and very harmful to food and game fishes. Reaches a weight of 18 pounds. The flesh is pasty and generally regarded as worthless but is eaten by some people. The dogfish is a quick and ready biter, is full of pluck, and a large one furnishes much sport before it is landed. It is extremely tenacious of life and will live out of water for a long time. It is sometimes shut in shallow bays which gradually dry up and the fish will be found alive in the slimy mud, after all vestige of water has disappeared. Besides small fishes, its principal food is univalve and bivalve mollusks, insects and insect larvæ, crayfish, shrimps, etc.

3. **Ameiurus natalis** (Le S). Yellow Cat.

The largest catfish of the lake and the one most commonly caught on hooks. It will bite almost anything in the way of fish or flesh and can be caught from March to December in from six to 25-foot water, especially that with muck bottom.

4. **Ameiurus nebulosus** (Le S.). Common Bull-head.

Probably more common than the last, but less often caught. Reaches a weight of 1½ pounds. Feeds on everything that usually serves as food for fishes, and many other things besides. The following, by one of the former editors of the Milwaukee Sun, well illustrates the habits of this well-known fish: "To catch the Bull-head it is not necessary to tempt his appetite with porter-house steak, or to display an expensive lot of fishing tackle. A pin hook, a piece of liver and a cistern pole is all the capital required to catch a Bull-head. He lies upon the bottom of a stream or pond in the mud, thinking. There is no fish that does more thinking or has a better head for grasping great questions, or chunks of liver, than the Bull-head. His brain is large, his heart beats for humanity, and if he can't get liver, a piece of tin tomato can will make a meal for him. It is an interesting study to watch a boy catch a Bull-head. The boy knows where the Bull-head congregates, and when he throws in his hook it is dollars to buttons that 'in the near future' he will get a bite. The Bull-head is democratic in all its instincts. If the boy's shirt is sleeveless, his hat crownless, and his pantaloons a bottomless pit, the Bull-head will bite just as well as though the boy is dressed in purple and fine linen, with knee breeches and plaid stockings. The Bull-head seems to be dozing on the muddy bottom, and a stranger would say that he would not bite. But wait. There is a movement of his continuation and his cow-catcher moves gently toward the piece of liver. He does not wait to smell of it, and canvass in his mind whether the liver is fresh. It makes no difference to him. He argues that here is a family out of meat. 'My country calls and I must go,' says the Bull-head to himself, and he opens his mouth and the liver disappears.

"There is one drawback to the Bull-head, and that is his horns. We doubt if a boy ever descended into the patent insides of a Bull-head to mine for limerick hooks, that did not, before the work was done, run a horn into his vital parts. But the boy seems to expect it and the Bull-head enjoys it. We have seen a Bull-head lie on the bank and become dry and to all appearances dead to all that was going on, and when a boy sat down on him and got a horn in his elbow, and yelled murder, the Bull-head would grin from ear to ear, and wag his tail as though applauding for an *encore*."

5. Catostomus nigricans Le S. **Hog Sucker.**

Not seen by the writer, but Mr. Hay reports a sucker reaching a weight of half a pound which, from his description, is probably this species.

6. Erimyzon sucetta oblongus (Mitch.). **Chub Sucker; Sweet Sucker.**

Common, especially so in the channel in front of Brabrook's hotel, where many young were taken August 9th. Readily known by the entire absence of the lateral line. Rarely reaches a length of a foot, but the flesh is soft and of little food value. Lives in pools with muck bottom and feeds upon the algæ, insect larvæ, decaying plants and similar vegetable matter. The young are rather pretty, the black band on the sides being very distinct and some of the fins usually tinged with reddish or orange.

7. Cyprinus carpio L. **Carp.**

Common in the lake, where it was probably introduced, as it could not have entered by overflow waters. Seldom used for food by the residents near the lake. One weighing 13 pounds was speared on May 9th, and specimens weighing 18 to 20 pounds are often taken. It is regarded as harmful to our native fish and is destroyed by sportsmen whenever possible.

8. Campostoma anomalum (Raf.). **Stone-roller; Stone-lugger.**

A few examples of this interesting minnow were taken in the ditch leading into the lake between Cranberry and Gull points.

9. Pimephales notatus (Raf.). **Blunt-nosed Minnow.**

Abundant. This and the next species are the most common forms used for bait. Known by the blunt, decurved snout, de-pressed top of head, and dark spot on front rays of dorsal fin. Old males in spring have numerous tubercles on the head.

10. NOTROPIS HETERODON (Cope). Variable-toothed Minnow.

Quite common in all the shallow portions of the lake, where it doubtless forms much of the food of the larger game fishes. Distinguished from the above by the incomplete lateral line, and the more pointed head.

11. NOTROPIS WHIPPLII Girard. Silver fin.

A common form, ranging in width between the last named and the next, and also distinguished by the dark blotch on the last rays of the dorsal fin. In the breeding season one of the most handsome of minnows.

12. NOTROPIS CORNUTUS (Mitch.). Silver-side; Shiner; Rot-gut.

Apparently much more common in Bass Lake than in Maxinkuckee. Forms much of the food of the black bass and other game fishes. The exposed portion of the scales on the sides are much higher than long. The body cavity is lined with black. The flesh is soft and spoils very soon after death, whence the common name of Rot-gut.

13. ABRAMIS CRYSOLEUCAS (Mitch.). Golden Shiner; Bream.

Very common in the bays with muck bottoms, especially so in the one in front of Brabrook's. Resembles the shiner, but distinguished by the long anal fin which has a sharp ridge or carina in front of it.

14. UMBRA LIMI (Kirt.). Mud Minnow.

Scarce. One specimen was taken with a dip net in May from the marsh at the northwest corner of the lake, and another in July from the main ditch on the east side. Reaches a length of only four inches. It is the only small fish found in Indiana which has a rounded caudal fin with black bar at the base. It is notable for the length of time which it can survive in mud after the water has evaporated, and it is said that living specimens are often ploughed up in the bed of a dried up pond or swamp.

15. LUCIUS VERMICULATUS (Le S.). Little Pickerel; Grass Pike

Common in shallow pools about the weedy margins. Reaches a length of a foot and a weight of a pound, or a little more. Like its larger relatives it is very voracious and sometimes pays the penalty of its life in attempting to swallow something too large for its gullet. A dead specimen was taken at the margin of the lake in May which was 11 inches long. It had attempted to swallow a blue-gill, *Lepomis pallidus* (Mitch.) four inches long and three inches wide, but the size and spines of the latter interfered and the pike was choked to death, the throat being badly torn.

16. LUCIUS LUCIUS (Linn.). Common Pike; Pickerel.

Formerly common but now rarely seen. One, taken in the lake in May, 1899, was 31 inches long and weighed 10 pounds. The largest one known to have been taken in the lake in the past weighed 28 pounds. They frequent, for the most part, six to 20-foot water, near the edges of the beds of hornwort and other plants.

17. FUNDULUS DIAPHANUS MENONA (Jor. and Cope). Barred Killifish; Spring Minnow.

Abundant in the shallow water over sandy bottom. Full grown specimens are four inches long. Known by the 12 to 16 dark cross bars on the sides. Feeds on the smaller mollusks, larvæ of insects, etc.

18. FUNDULUS DISPAR (Agassiz). Top Minnow.

Frequent. Thicker and shorter than the preceding. A pale spot on top of the head, and about 10 narrow lengthwise bars on the sides. The males have also about nine line-like cross bars. Frequents for the most part the bays and inlets, where it is seen in small schools swimming close to the surface.

19. LABIDESTHES SICCULUS (Cope). Skipjack; Brook Silverside.

Abundant. A small and graceful species which is usually seen in schools close to the surface. It often throws itself above the water, whence its common name. Known by its slender translucent body, two dorsal fins and bright silvery stripe along the sides. Feeds on minute crustacea, mollusks, etc.

20. POMOXIS SPAROIDES (Lacépède). Calico Bass; Grass Bass; Croppie.

Common. Much more so than in Lake Maxinkuckee. Frequents six to 25-foot water. Reaches a weight of 1½ pounds. Nests in the sand in six to eight-foot water. A handsome and valuable food fish, which takes the hook best in April, May and October.

21. AMBLOPLITES RUPESTRIS (Raf.). Goggle-eye; Red-eye; Black Perch.

Common. Frequents six to 12-foot water along the edges of immersed banks of vegetation. Spawns in May in sand at the bottom of four to six-foot water. According to Dr. S. A. Forbes, the young, up to an inch in length, live principally on minute crustaceans; beyond this size up to three inches, on aquatic insects and their larvæ, while the larger specimens feed on minnows, insects and crayfish.

22. CHÆNOBRYTTUS GULOSUS (Cuv. and Val.). **War-mouth; Indian Fish.**

Abundant among the weeds at the bottom of six to 12-foot water, it and the blue-gills being the most common species caught while still-fishing. Mr. Hay reports that it spawns in the mud below three to five-foot water. Its food at different ages is the same as that of the goggle-eye. It is, however, more gamy. Both are excellent pan fishes.

23. APOMOTIS CYANELLUS (Raf.) **Green Sunfish; Rock Bass.**

Frequent, especially in the bays with muck bottom. Known by its oblong body, large mouth, low spines and narrow wavy stripes of blue on the cheeks. A handsome species, which reaches a weight of little over half a pound.

24. LEPOMIS MEGALOTIS (Raf.). **Long-eared Sunfish.**

Frequent, especially in two to four-foot water, among the weeds growing from sandy bottom. Readily distinguished by its brilliant colors and long black ear flap margined with paler. Reaches a length of six or eight inches. Years are spent by these long-eared sunfish in a dreamy sort of existence, their energies quickened by the vernal season and growing duller on the approach of winter. Excepting the times when they are tempted by a wriggling worm on some boy's hook, theirs is a life exempt from danger. A kingfisher glancing down from his perch on a bent sycamore limb may, at times, discern them and lessen their ranks, but, methinks, the chub minnows, with fewer spines in their dorsal fins, are more agreeable to the kingfisher's palate. With all the tints of the rainbow gleaming from their sides they move to and fro, the brilliant rulers of the quiet pools in which they abide.

25. LEPOMIS PALLIDUS (Mitch.) **Blue-gill; Blue Sunfish.**

Common in schools at the bottom of six to 25-foot water. Reaches a weight of three-quarters of a pound. Spawn in shallow circular nests in the sand, which they scoop out with the tail, the nests being beneath three to four-foot water. A valuable food fish and one of the gamiest of the sunfishes.

26. **Eupomotis euryorus** (McKay). **Broad-eared Sunfish.**

Scarce. Three specimens were taken in June, 1900, by Mr. Hay, which were eight inches long by five wide. It was first thought they were the Chain-sided sunfish, *Lepomis machrochirus* (Raf.), but a more careful examination proved them otherwise. They were caught while still-fishing among a school of blue gills. Known from the blue gill, which it most closely resembles, by the bluntly conic pharyngeal teeth and by the ear flap being margined with reddish orange. Taken before in Indiana only in Cedar and Shriner lakes, Whitley County, and in Lake Maxinkuckee.

27. **Eupomotis gibbosus** (Linn.). **Common Sunfish; Pumpkin Seed.**

Abundant. Known by its deep body with strongly curved outline, short rounded ear flap, small mouth, high dorsal spines and brilliant coloration. Reaches a weight of one-half pound or more. Feeds on insects, small crustaceans and, especially, univalve mollusks. The eggs are laid in nests in the mud, sand and gravel and are guarded carefully by the male. The "sunny," as it is sometimes called, bites with vigor at almost any kind of bait small enough for it to swallow.

28. **Micropterus salmoides** (Lacépède). **Large-mouthed Black Bass.**

Common; reaches a weight of eight pounds. Frequents three to 12-foot water. Spawns in sandy places beneath two to three-foot water. The most noted game fish in the State and, according to Mr. Hay, the only bass occurring in Bass Lake.

29. **Perca flavescens** (Mitch.). **Yellow Perch; Ringed Perch.**

Abundant but mostly of small size. Specimens weighing one and one-half pounds have, however, been taken. Occurs in water of all depths, the larger in the deeper water. Will bite almost any kind of bait. "The perch is a tough and heedless fish, biting from impulse, without nibbling and from impulse refraining to bite, and sculling indifferently past. It is a true fish, such as the angler loves to put into his basket or hang on the top of his willow twig, on shady afternoons, along the banks of the streams. So many unquestionable fish he counts and so many shiners which he counts, and then throws away."—*Thoreau.*

30. **Bolesoma nigrum** (Raf.). **Johnny Darter; Tessellated Darter.**

Abundant. Reaches a length of only two and a half inches; occurs everywhere in shallow water with sandy bottom. The only darter taken in the lake, though three or four others doubtless dwell therein. The "Johnny" lurks on the bottom, moving when disturbed with great rapidity for a short distance, then resuming its former quiet position. "Crouching cat-like before a snail shell it will snap off the horns which the unlucky owner pushes timidly out, or at times seizes the animal by the head and dashes the shell against a pebble or larger stone until it pulls the body out or breaks the shell."

Turtles of Bass Lake.

More species of turtles have been taken in and about Bass Lake than about any other lake in the State. During our visits in May and July, the following species were noted:

1. **Aspidonectes spinifer** (Le S.). Common Soft-shelled Turtle.
   Frequently seen swimming gracefully close to the bottom and resting among the lily pads in the coves and bays. This turtle is much relished as food, and several turtle catchers from Chicago visit the lake each season and set nets for it and the next species.

2. **Chelydra serpentina** (L.). Common Snapping Turtle.
   The largest turtle in the lake—very common among the vegetation growing from the muck beds.

3. **Aromochelys odoratus** (Latreille). Musk Turtle; Stink-pot.
   Next to *Chrysemys marginata* the most common turtle in the lake. It was noted for the most part in the vicinity of the sedges and rushes along the sandy shores in water up to a foot or two in depth. One specimen was taken in May which had a mollusk, *Helisoma trivolvis* (Say), in its mouth.

4. **Malaclemmys geographicus** (Le S.). Map Turtle.
   Much less common in Bass Lake than in Maxinkuckee. Frequents the shallow water in the vicinity of the shore, where it feeds principally upon mollusks, especially the thin-shelled species of *Limnophysa*, which occur in abundance upon the rushes and other vegetation.

5. **Kinosternon pennsylvanicum** (Bosc). Mud Turtle.
   A number of specimens of this small box-turtle were taken from the shallow water along the north shore. It is a uniform dusky brown in color, and the lobes of the plastron are nearly equal in size and hinged so that they are movable at will. The animal can, therefore, when threatened with danger, retire

wholly within the shell in a manner similar to the common dry land box-turtle, *Cistudo carolina* (L.). The food of the mud turtle consists of small fish, insects, mollusks, leeches, and other small water and mud inhabiting animals. This species is rather scarce in Indiana, having been recorded heretofore only from Knox and Vigo counties.

6 **Pseudemys elegans (Wied.). Elegant Terrapin.**

As the specific name implies, this is one of the most handsome of the fresh water turtles. In Bass Lake it is quite frequent and reaches a large size, two which were captured by Mr. Hay, being respectively 10 and 11 inches in length. They were taken after night while moving rapidly along the bottom of the shallow water. It has been reported from no other lake in the State, but has been taken in the Tippecanoe River near Winamac, and in the Wabash at New Harmony; also by the writer in a large pond in Vigo County.

7. **Chrysemys marginata (Agas.). Lady Turtle.**

Abundant, especially in bays and coves among the masses of spatterdock and white water lilies. Here on warm sunny days it may be seen by dozens lying upon any object large enough to bear its weight, basking in the sunlight. When approached it stretches aloft its neck and gazes an instant or two at the intruder, then with a splash tumbles into the water and burrows into the protective mud at the bottom. A few bubbles of marsh gas which it has set free, rising to the surface, usually betray its resting place.

8. **Chelopus guttatus (Schneider). Speckled Tortoise.**

This handsome little turtle was very common in the ditches putting into the lake, and in the marsh area at the extreme northwestern corner. It is found in similar localities all over the northern third of the State.

9. **Emys meleagris (Shaw). Blanding's Tortoise.**

Two specimens, one living, the other dead, of this rather scarce turtle were found in the lagoon or marsh adjoining the western end of the south basin. Mr. Hay has often noted them along the northern margin of the main lake. The yellow spots on the carapace vary much in size and number. Several specimens were also taken from ditches along the roadside about four miles northeast of the lake. It occurs sparingly in similar localities through the lake region of the State.

10. CISTUDO CAROLINA (L.). Common Box Turtle.

This strictly dry-land species has been frequently noted by Mr. Hay in the sandy upland woods, bordering the lake on the north.

MARL.—Little if any marl occurs in the northern lobe of Bass Lake. A few traces of it were found beneath the muck along the west shore. At a point about 1,500 feet west and 500 feet north of the steamer landing at Winona P. O. a bed of marl three feet thick underlies about 20 acres of seven-foot water.

In the southern basin a small deposit of marl was found, lying northwest of Lake Park Station. It is estimated to cover about 35 acres. The greatest depth found was five feet in four feet of water at 200 to 300 feet from shore. At twice that distance from shore, still in four feet of water, the marl was only three feet thick. The deposit does not appear to run much if any east of the long pier near the ice house, and thence westward a quarter of a mile or less. The assistants on the U. S. Fish Commission, while making soundings, found also a small bed in the northern half of the same basin, but its bounds were not accurately determined. The quality of the marl is not of the best, it being darker than the average and in places more or less mixed with muck or sand.

In the southeast corner of section 11, just west of Bass Lake, marl was found in a large dredged ditch, but proved on examination to have a thickness of only one foot, with five feet of muck overlying.

LAKE COUNTY.

REFERENCES—

1897.—W. S. Blatchley, Twenty-second Ann. Rep. Dep. Geol. and Nat. Resour. of Indiana, p. 25.

The report above cited contains an extended paper giving in detail the facts relative to the topography and geology of Lake County. To it the reader is referred for the general information which in the present paper it has been customary to give under the county heading. There is but one lake of any size in the county, namely, Cedar Lake, described below.

CEDAR LAKE.

NOT A WORKABLE DEPOSIT.

Cedar Lake, or "Lake of the Red Cedars," is located in parts of sections 22, 23, 26, 27, 34 and 35 (34 north, 9 west), on the line between Center and Hanover townships, about four miles southwest of Crown Point. Its general outline somewhat resembles that of a kidney. Its length is about two and one-eighth miles and its greatest breadth a little more than three-quarters of a mile. Its water area, as computed by Thomas Large,* is at present about 1.17 square miles.

Cedar Lake owes its origin to the irregular deposition of the surrounding drift. On all sides, except the south, it is embraced by wooded ridges of sand or clay, those to the north rising 60 feet above the level of its waters. Between these ridges, on the southern slope of the moraine, a long, low valley was left by the retreating ice sheet. The bottom of this valley was covered with an impervious stratum of clay. In its depression collected the waters of the melting glacier, and the lake resulted. Its waters once covered all the low, marshy land to the southward and overflowed the lowest part of the rim of its basin toward the Kankakee. At that time they covered the present shores as far as the foot of the ridges on the east and north, and were probably 40 feet deep in places. Now they nowhere exceed 20 feet in depth. Within the memory of man they have receded from 50 to 90 feet from the former margins.

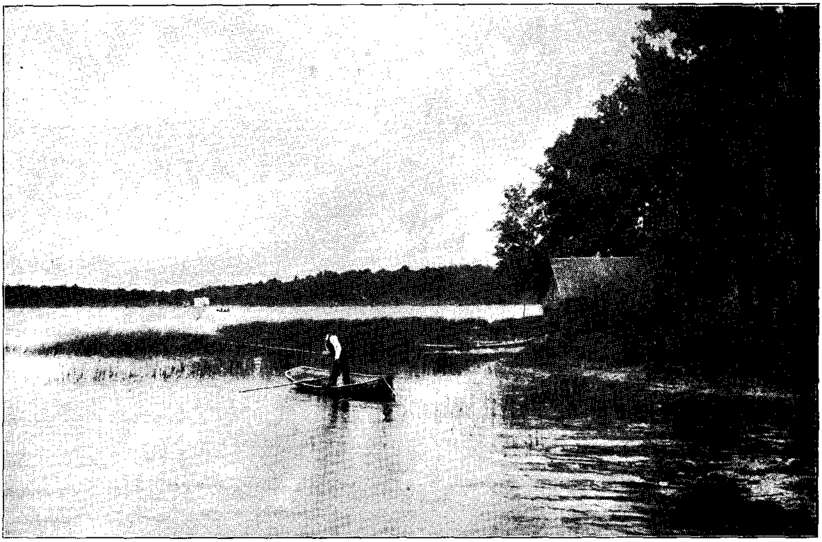
The principal cause of this recession was artificial drainage. To reclaim 200 acres of comparatively worthless marsh land—at its southern end— a ditch was cut on its eastern side which lowered the level of the water from eight to 12 feet. This outlet is the present source of Cedar Creek, which flows southward through the town of Lowell and empties into the Singleton ditch.

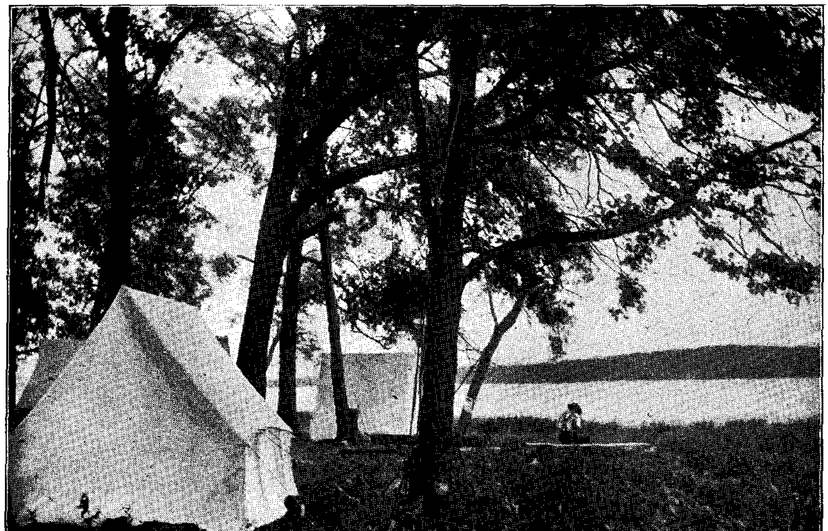
Thick beds of muck and black mud along the southern and western margins produce a luxuriant growth of water vegetation which each year decays and adds to the thickness of the slowly rising bottom. Again, situated as it is so near the crest of the moraine, the area from which the lake draws its supply of water is very limited, being but a few square miles in extent. At present the season's evaporation is, probably, almost as great as the supply. For these causes the area and depth of the lake have for years been slowly diminishing and will continue to diminish until it wholly disappears.

Within the past 10 years many cottages have been erected on the wooded ridges about Cedar Lake. The C., I. & L. (Monon) Railway, which runs along its western border, has possessed itself of the high wooded ridge on that side and has transformed it into a so-called park. Thousands of visitors are each season brought from

*See Proc. Ind. Acad. Sci., 1896, pp. 299-301. The accompanying map of Cedar Lake was also drawn by Mr. Large and published in the Proceedings of the Academy, loc. cit. By permission it is reproduced in this connection.

PLATE 12.





GLIMPSES OF CEDAR LAKE, LAKE COUNTY, INDIANA.

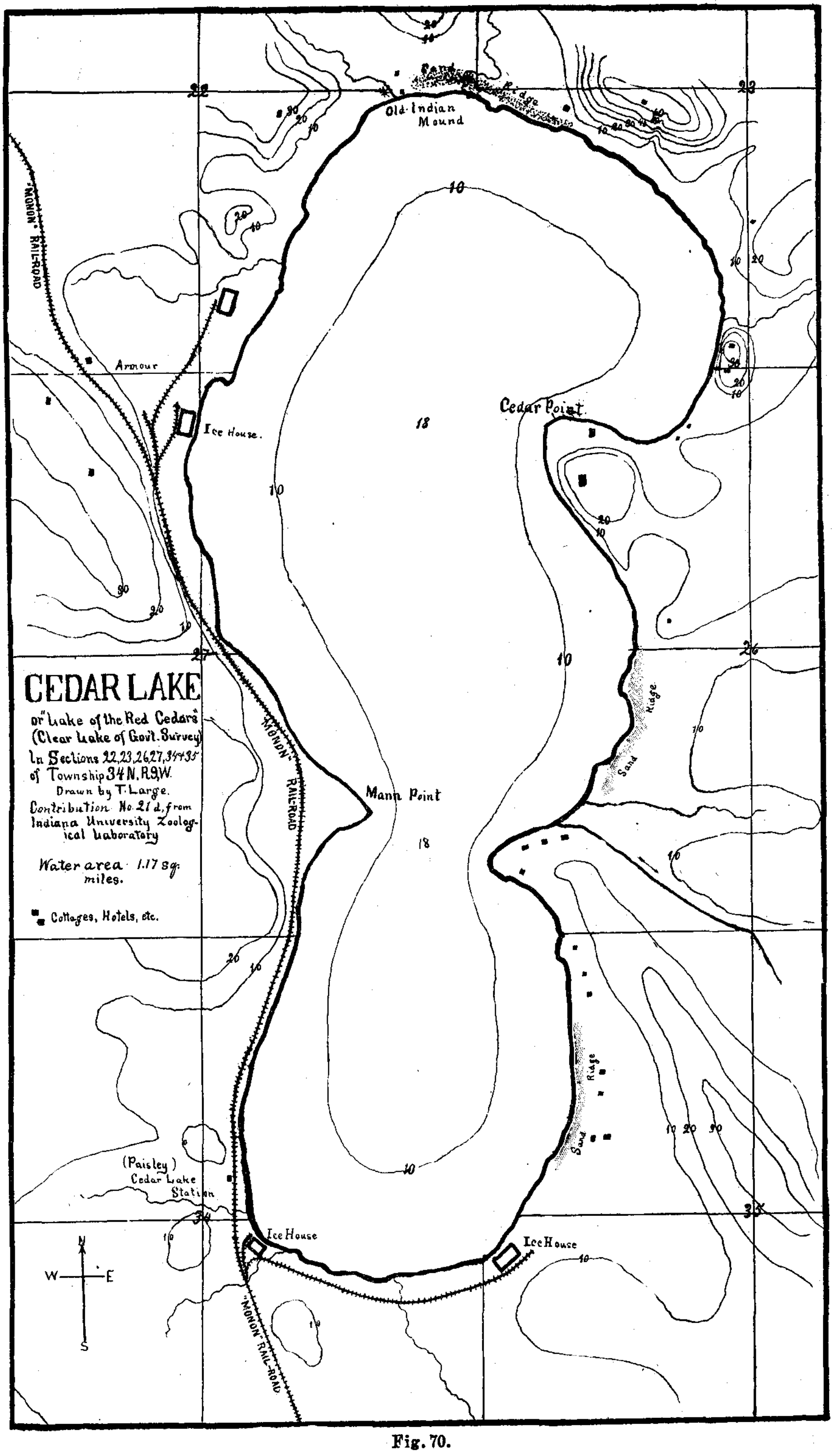

CEDAR LAKE
or "Lake of the Red Cedars"
(Clear Lake of Gov't. Survey)
In Sections 22,23,26,27,34 & 35
of Township 34 N. R.9.W.
Drawn by T. Large.
Contribution No. 21 d. from
Indiana University Zoological Laboratory
Water area 1.17 sq. miles.
Cottages, Hotels, etc.
Old Indian Mound
Sand Ridge
Cedar Point
Mann Point
Ice House
Ice House
Ice House
Armour
"MONON" RAIL-ROAD
"MONON" RAIL-ROAD
"MONON" RAIL-ROAD
(Paisley) Cedar Lake Station
Sand Ridge
Sand Ridge
N
S
E
W

Fig. 70.

Chicago and from the cities to the southward. The quiet beauty and repose which for centuries existed along the margins of the lake have forever disappeared. In their stead have sprung up those artificial surroundings which the ever increasing wants of the Twentieth Century seeker after pleasure demand and eventually secure.

MARL.—No sign of marl was found in this lake. Sand only occurs along the east and west sides, in places running into sandy muck. At the south end the bottom is a stiff, blue clay, with a foot of muck over it. Tests made in the marsh one-quarter of a mile south of the ice houses showed one to four feet of muck over blue mud.

MINOR DEPOSITS OF MARL.

A large number of deposits of marl, not mentioned on the preceding pages, occur in various parts of northern Indiana. They are too small to develop for cement making, but might be utilized for some of the other purposes given in the list of uses. For the most part they occur in marshes and are usually overlain by muck of varying thickness. Information concerning, and samples from, a number of them have been received by this Department, but lack of time forbade a personal investigation of but two or three. Those concerning which we have information deemed worthy of publication are as follows:

NEAR BRIGHTON, LAGRANGE COUNTY.—Mr. Chas. N. Libey, of Brighton, wrote that he had 40 acres of marsh marl and that there was enough adjoining to make, perhaps, 100 acres in all. It had been examined to some extent by parties wishing to purchase marl lands. They reported the bed to run from seven to 25 feet in thickness.

NEAR NAPPANEE, ELKHART COUNTY.—Samples excellent in quality were received from George Meeker. He reports it as outcropping for a distance of one-fourth of a mile or more in the bed of a small creek and then disappearing beneath the muck. At one place there is exposed a bank or face surface of the marl more than four feet in thickness. No tests were reported as to its actual thickness in the bed of the creek. The muck over the marl along the bank is about two feet thick. Mr. Meeker adds: "From the lay of the land I would think there are several hundred acres of this material, but this is only guesswork."

TWELVE MILES NORTHWEST OF SOUTH BEND.—This deposit is in Michigan, just north of the Indiana line, in the northeast quarter section 16 (18 west, 8 south). It is in a marsh, the bed of an extinct lake, on the land of John Curran, two miles south of the Michigan Division of the "Three I" Railway. There are probably 40 acres underlain by marl which varies between two and 21+ feet in thickness. In places it comes to the surface, but it is mostly overlain with a thick deposit of muck. The marl is of good quality, as is evinced by the following chemical analysis made for Mr. Curran by Prof. Frank S. Kedzie, Agricultural College, Michigan:

Calcium carbonate ($CaCO_3$)	89.63
Magnesium carbonate ($MgCO_3$)	2.12
Iron and aluminum oxides	.62
Insoluble matter (mostly clay)	.42
Organic and undetermined matter (alkalies, etc.)	7.55
Total	100.35

NEAR WELLSBORO, LAPORTE COUNTY.—Mr. Othie Way, of Wellsboro, sent samples of good quality, accompanied by the following information: The deposit is beneath a marsh on his farm, nine miles south of Laporte and less than a mile east of Wellsboro. It covers an area of 55 to 60 acres by the side of the Grand Trunk Railway. Muck running from two to three feet in thickness overlies the marl. The latter is known to be eight feet in thickness in places, but neither its maximum nor average thickness has been determined.

NEAR PATTON, WHITE COUNTY.—A small deposit occurs on the land of A. A. McKain, one-half mile west of Patton, near the C., I. & L. (Monon) Railway. It is less than 10 acres in size, is covered with two feet of muck, and averages six feet in thickness.

NEAR PERU, MIAMI COUNTY.—A deposit of undetermined area occurs four miles southwest of Peru on the land of Milton Shirk. The Wabash Railway runs through this deposit. The marl is of good quality and is known to be over four feet in thickness in a number of places, with two to three feet of earth overlying.

Another marsh deposit overlain by muck occurs just west of the Catholic cemetery and north of the driving park at Peru. It is on the land of Edward Riley and lies alongside the Wabash Railway. It is said to run from nine to 12 feet in thickness and to range in color from almost pure white to dark gray.

NEAR ADAMSBORO, CASS COUNTY.—A deposit of some size occurs near Spring Creek, on the land of Mac. Colgan. It underlies an area of more than 40 acres and is covered with muck or soil to a depth of two to four feet. At one place on the bank of the creek it shows a face of nearly six feet, and in another place more than four feet.

NEAR FOREST, CLINTON COUNTY.—Prof. J. W. Hadley sent in samples of a good quality of marl. He stated that it had been found in three different localities within less than two miles of Forest. The area of the different beds was not determined. They are from two to four feet below the surface and range from 18 inches to 10 feet in thickness.

NEAR BLOOMINGPORT, RANDOLPH COUNTY.—Samples were sent in by C. S. Hunt, who reports that the deposit occurs to quite a depth in the bottom of an old pond of large size. It is overlain by muck, two feet in thickness. Mr. Hunt also states: "I have used the marl as a polish on different metals and find it equal to any polish on the market."

NEAR CLINTON, VERMILLION COUNTY.—An examination of this deposit was made by Mr. J. W. Robb, of Clinton, who reported it to cover about three acres, and running from 18 inches to three feet in thickness, with six to 18 inches of muck overlying. The samples sent in were of first-class quality.

Samples of marl varying in quality are also in the State collection from the following points, but no data is at hand regarding the area and thickness of the deposits:

From a point two and a half miles south of Oxford, Benton County; from the land of Roeske Bros., near Michigan City, Ind.; from the land of Dr. Chenowerth, near Winchester, Ind., and from the land of Hon. J. C. Stevens, near Centerville, Ind.

CHEMICAL ANALYSES OF INDIANA MARLS.—In the table below given are included the marl analyses which are scattered through the foregoing pages. They are given here in tabular form for ready reference and comparison. The large majority of these analyses were made expressly for this report by the chemist of this Department, Dr. W. A. Noyes, of the Rose Polytechnic Institute, Terre Haute, Ind. The method of analysis as furnished by him is as follows: "The marls were dissolved in warm dilute hydrochloric acid. The solution was filtered on an asbestos (Gooch) filter, and the residue dried at 105°. The loss of this residue on ignition was counted as organic matter. The incombustible residue is recorded as the 'insoluble portion.' The 'alumina' and 'ferric oxide' given comprise only that portion of these substances which passed into solution in dilute hydrochloric acid. The ferric oxide probably represents *ferrous carbonate* in the marl. All determinations are based on the material dried at 135°."

ANALYSES OF INDIANA MARLS.

ORIGIN OF SAMPLE.			Calcium Carbonate ($CaCO_3$).	Magnesium Carbonate ($MgCO_3$).	Alumina (Al_2O_3).	Ferric Oxide (Fe_2O_3).	Calcium Sulphate ($CaSO_4$).	Insoluble Inorganic (Silica, etc.).	Organic Matter.	Total.	AUTHORITY.
LAKE.	COUNTY.	PAGE DESCRIBED.									
Hog Lake	Steuben	73	90.42	2.88	.14	.28	......	.68	4.13	98.53	W. A. Noyes.
Lime	Steuben	75	86.00	9.42	......	1.16*	......	1.08	2.32	99.98	Chas. R. Dryer.
Deep and Shallow	Steuben	77	93.29	2.67	.04	.12	......	.47	1.56	98.15	W. A. Noyes.
James	Steuben	82	92.41	2.38	......	.29	.15	1.16	1.97	98.36	W. A. Noyes.
Silver	Steuben	96	84.00	6.46	......	1.34*	......	4.52	3.68	100.00	Chas. R. Dryer.
Turkey Lakes	Lagrange	112	91.14	2.75	.61	.25	......	.85	......	95.60	W. R. Oglesbey.
Loon	Whitley and Noble	156	82.07	2.63	.41	.42	.22	5.95	6.71	98.41	W. A. Noyes.
Mud	Elkhart	164	82.89	2.04	.41	.23	......	7.94	3.67	97.18	Osborn Engineering Co.
Cooley	Elkhart	164	88.21	4.78	.52	.36	......	1.42	2.58	97.87	Osborn Engineering Co.
Syracuse	Kosciusko	182	88.49	2.71	.90	.31	1.58	1.78	4.23	100.00	S. B Newberry.
Dewart	Kosciusko	185	92.35	3.54	.37	.16	......	2.00	2.12	100.54	A. W. Burwell.
Dewart	Kosciusko	185	84.24	2.85	.18	.30	......	4.52	5.02	97.11	W. A. Noyes.
Tippecanoe (James Basin)	Kosciusko	192	90.67	2.42	.06	.26	......	2.48	2.87	98.76	W. A. Noyes.
Tippecanoe	Kosciusko	194	91.02	2.28	......	.29	.05	2.92	2.10	98.66	W. A. Noyes.
Little Eagle	Kosciusko	205	84.75	2.84	.15	.35	.07	4.61	5.69	98.46	W. A. Noyes.
Manitou	Fulton	224	87.65	2.60	.19	.30	......	6.39	2.88	100.01	W. A. Noyes.
Maxinkuckee	Marshall	263	85.02	3.85	.12	.33	.17	5.67	3.21	98.37	W. A. Noyes.
Maxinkuckee	Marshall	263	85.38	3.50	.05	.33	.17	6.40	3.15	98.98	W. A. Noyes.
Houghton and Moore	Marshall	270	89.22	2.73	.04	.20	......	2.02	4.15	98.36	W. A. Noyes.
Notre Dame	St. Joseph	273	91.62	4.02	.05	.07	.14	.19	2.25	98.34	W. A. Noyes,
Chain and Bass	St. Joseph	275	87.92	2.64	.10	.20	.23	3.10	4.18	98.37	W. A. Noyes.
Kankakee Marsh Deposit	St. Joseph	282	91.30	2.90	......	.08	.22	.82	3.88	99.20	W. A. Noyes.
North Judson Marsh Deposit	Starke	297	89.92	2.46	.45	.74	......	1.56	4.51	99.64	W. A. Noyes.
Curran Marsh Deposit	Berrian (Mich.)	319	89.63	2.12	.37	.25	......	.42	7.55†	100.35	Frank S. Kedzie.

* This was given by Dr. Dryer as ferrous carbonate, the form in which the iron probably occurs in the marl.

† This includes undetermined matter, alkalies, etc.