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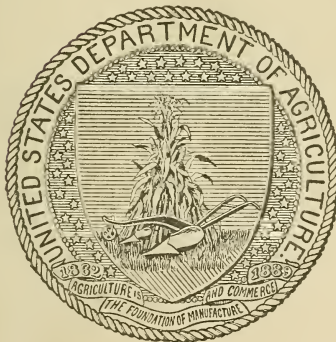
A. C. TRUE, Director.

A REPORT UPON THE DRAINAGE OF
AGRICULTURAL LANDS IN THE
KANKAKEE RIVER VALLEY,
INDIANA.

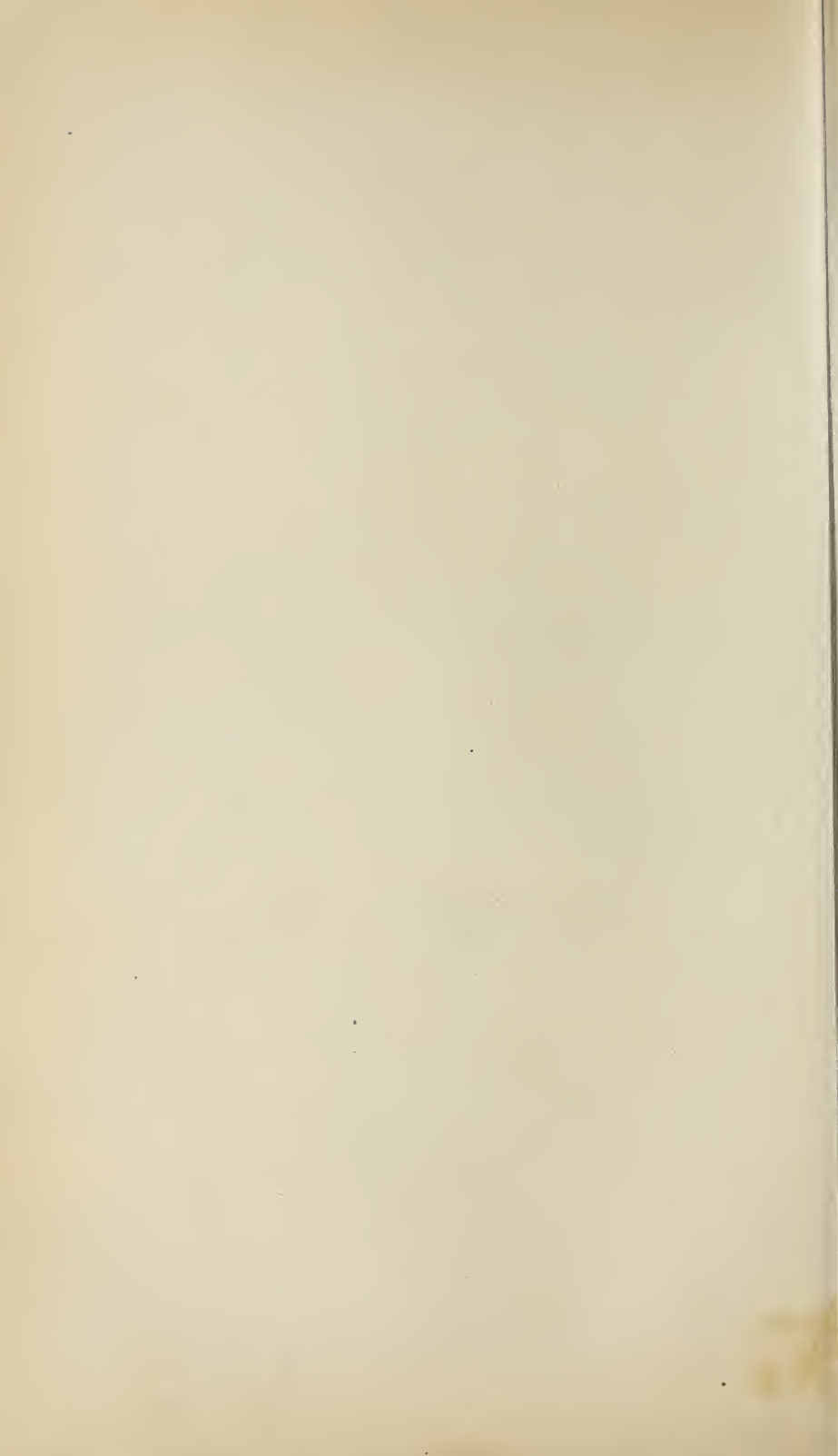
PREPARED FROM INVESTIGATIONS AND SURVEYS CONDUCTED BY
W. D. PENCE AND MORTON H. DOWNEY,

UNDER THE DIRECTION OF

C. G. ELLIOTT,

Chief of Drainage Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.



LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., November 2, 1908.

SIR: I have the honor to transmit herewith a manuscript accompanied by maps, giving the results of the drainage investigations and surveys made by this Office in the Kankakee River Valley during the years 1905 and 1906.

Special reports upon these investigations have been submitted to officers having charge of the drainage of certain parts of the valley, but, owing to the magnitude of the project and to the fact that a large number of property owners must cooperate in executing the work if the lands are to be effectually drained, I recommend that this report be printed as a circular.

Very respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

[Cir. 80]

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DRAINAGE OF AGRICULTURAL LANDS IN THE KANKAKEE RIVER VALLEY, INDIANA.

INTRODUCTION.

In 1904 a preliminary examination of the drainage conditions of the valley of the Kankakee River was made for the Office of Experiment Stations by Prof. W. D. Pence, of Purdue University. It was then ascertained that the activity of landowners in constructing drains wherever there was opportunity to reclaim or better the conditions of marsh farms was developing serious complications, especially in the lower part of the valley, and that there was no unity of opinion regarding the plan that should be adopted in the further reclamation of the lands. In 1905 the Office detailed Mr. M. H. Downey to continue the investigations begun by Professor Pence for the purpose of examining the peculiarities of this great valley, learning what had been accomplished by drainage and the bearing that the varied operations and experience of landowners had upon the solution of the drainage questions now arising in the lower half of the valley.

Mr. Downey's report, accompanied by maps displaying the character of the drainage work accomplished in the upper valley, with an account of its economic results, showed that at the close of the year 1906 the main channel of the river had been straightened by dredging from the upper end as far down stream as the west lines of Laporte and Starke counties. The improved channel at this point had a bottom width of 50 feet and discharged upon the flow line of the river. From this point to the Momence Rock in Illinois, a distance of 72 miles by river and across the width of two counties in Indiana, Porter and Lake on the north, and Jasper and Newton on the south, no attempt had been made to improve the river. The drainage operations in the upper part of the valley emphasized the necessity of some action being taken for the betterment of the conditions in the lower section. Confronted with these facts, the owners concerned in these lands held a mass meeting at Baum's bridge in Porter County on May 11, 1906, at which time a proposition submitted by the Office of Experiment Stations to locate and survey

a line for a corrected channel of the river from the east line of Porter County to Momence, Ill., was accepted. Irrigation and Drainage Investigations of the Office of Experiment Stations, U. S. Department of Agriculture, agreed to survey a new channel for the river and prepare a report upon the same, provided the citizens would furnish the labor required to assist the engineering force. A committee, known as the Kankakee Drainage Committee, was chosen at this time; Mr. F. J. Cook, of Lacrosse, was made secretary and given charge of the matter, and through this committee the four counties concerned cooperated by providing the assistance asked for.

This survey was conducted by Mr. M. H. Downey, assisted by Mr. Fred Shafer, until the resignation of the former from the service on October 1, 1906, at which time Mr. Omer Fairley, assisted by Mr. W. G. Miller and Mr. S. H. McCrory, entered the field and completed the work.

The following report, accompanied by a profile of the channel proposed and recommended for the lower section of the valley, with specifications of size of channel and estimate of cost, was presented to the committee and discussed at a public meeting held at Wheatfield in April, 1907. On account of its length a copy of the profile is omitted from this printed report.

DESCRIPTION OF THE VALLEY.

In order to obtain a clear understanding of the drainage problem considered in this report, a brief description of the valley of the river in Indiana should be given, together with its characteristics and the efforts made to convert this large marsh into arable land. The watershed lying above the Momence Rock comprises an area of 1,420,000 acres, of which approximately 400,000 acres was a marsh plain. It is about 85 miles long, the surface being characterized by scattered sand islands or ridges covered with a sparse growth of scrub oaks situated in the midst of extensive plains of marsh which were formerly covered with water during the larger portion of the year, making those favorite hunting grounds for which northern Indiana was so long noted. The crookedness of the channel is a characteristic commented upon by both geographer and hunter. Its light fall, only 5 to 6 inches per mile, has made it a favorite course for the houseboat and other summer craft and an ideal stream for the lover of fishing sports. The immediate banks are bordered with a varied timber growth, and, at various points, are high enough to suggest a bluff which furnishes safe locations for summer clubhouses and other transient residences. The entire marsh portion of the valley is devoid of rock except a few moraines containing scattered gravel and boulders, the meager remnants of the last glacial epoch to which this valley

largely owes its origin. The soil is not uniform in character nor equally fertile in the several parts of the valley, some being a sandy loam of high natural value and other that undeveloped turf and muck whose real value is not yet known. The upper portion is quite uniformly underlaid with clay, while the subsoil of the lower valley is river sand. The sand islands rise above the surrounding plain and furnish a welcome residence spot to farmers of partly reclaimed land. The character of the valley changes abruptly at the Momence Rock, an outcropping of the limestone ledge which passes through Illinois and Indiana in a southeasterly direction, leaving the upper Kankakee Valley the unique and interesting area just described.

The first reliable data respecting the comparative levels and elevations of this valley were brought out in a survey made by Prof. John L. Campbell, in 1882, in accordance with the provisions of an act of the State legislature of Indiana, which instructed him to ascertain the cheapest and the most practicable outlets for the drainage of the wet and swamp lands of the Kankakee region. The report of that survey, which was made upon a sea-level datum, states that Lake Michigan has an elevation of 585 feet, the upper end of the marsh near the river an elevation of 709 feet, the surface at the State line 624 feet, and a point above the Momence Rock 619 feet. It also shows a distance of 75 miles from the head of the river in an approximately direct line to the State line of Illinois and thence 6.8 miles to Momence, making the total length of the valley under consideration 81.8 miles. The data secured by this survey showed the feasibility of draining the valley and in a measure its agricultural possibilities.

WORK OF THE STATE.

While works of a comprehensive character for the drainage of the valley were projected as early as 1868, among which should be noted those of the Kankakee Valley Draining Company, organized in 1870, nothing of importance was attempted until 1893. During this year the work of enlarging and deepening the channel at Momence, Ill., by cutting the rock ledge at that point, was completed under authority of an act of the Indiana legislature in 1889, which appropriated \$40,000 and, at the next session, \$25,000 additional for the enlargement of the channel through the rock rapids in Illinois. These appropriations were authorized upon the plea of facilitating the drainage of the marsh lands in Indiana. The channel finally completed was 8,649 feet long, 300 feet wide, and $2\frac{1}{2}$ feet deep, requiring the removal of 66,447 cubic yards of rock. It may be here remarked that these appropriations and that for the survey made by Professor Campbell in 1882 cover the part the State has taken in the drainage of the Kankakee marsh.

PROGRESS AND METHODS FOLLOWED IN DRAINING THE LANDS
OF THE VALLEY.

The drainage of the higher lands of the watershed, together with other agricultural lands of the State, has proceeded for twenty years past, the ditches of varying size required in draining these lands having their discharge into the marsh plain. The surrounding belt of reclaimed land has been gradually pushed toward the river, resulting in a continued change of conditions in the marsh which have worked hardships upon the owners of the lower lands. The improvement of the channel of the river began at the upper end by straightening the bends and cleaning the natural channel. This being a comparatively small project, it was executed by individual effort and resulted in the making of a channel 7 miles long by means of which 8,000 acres were greatly benefited. The effect of this and succeeding changes in the channel of the river which speedily followed was to increase the flood conditions upon the lower lands to such an extent that it became imperative to continue the straightening of the stream. In this manner 46 miles of the upper portion of the stream has been improved under the following names: The first 7 miles, by individual effort without the assistance of the State drainage law; the next division, $7\frac{3}{4}$ miles, was constructed as the Miller ditch; the third section, $5\frac{1}{2}$ miles, by the Kankakee Improvement Company; the fourth section, 9.1 miles, is known as the Place ditch; the fifth section, 16.7 miles, was constructed by the Kankakee River Reclamation Company, and completed in 1906 at a cost of \$78,310. (Fig. 1.) This completes a continuous channel from the head of the valley to the west line of Porter and Starke counties, approximately one-half of its entire length. The channel is 8 feet wide on the bottom at the upper end and 50 feet at the lower end, so graded as to discharge into the river at the line named and receive at the lower end the drainage waters of 700,000 acres. The cost of this channel to the landowners concerned is approximately \$250,000, for which a comparatively small part of the watershed has been assessed, and has resulted in the material improvement of the upper valley. The work so far constructed has cost from 40 to 64 per cent of the estimated benefits and, with the exception of the first-named division, has been constructed under the provision of the State drainage law.

THE LOWER HALF OF THE VALLEY.

The drainage operations in the upper valley have brought about a situation of the utmost gravity to owners of lands in the lower portion, where the river channel remains in its natural condition—shallow, crooked, and sluggish of flow.

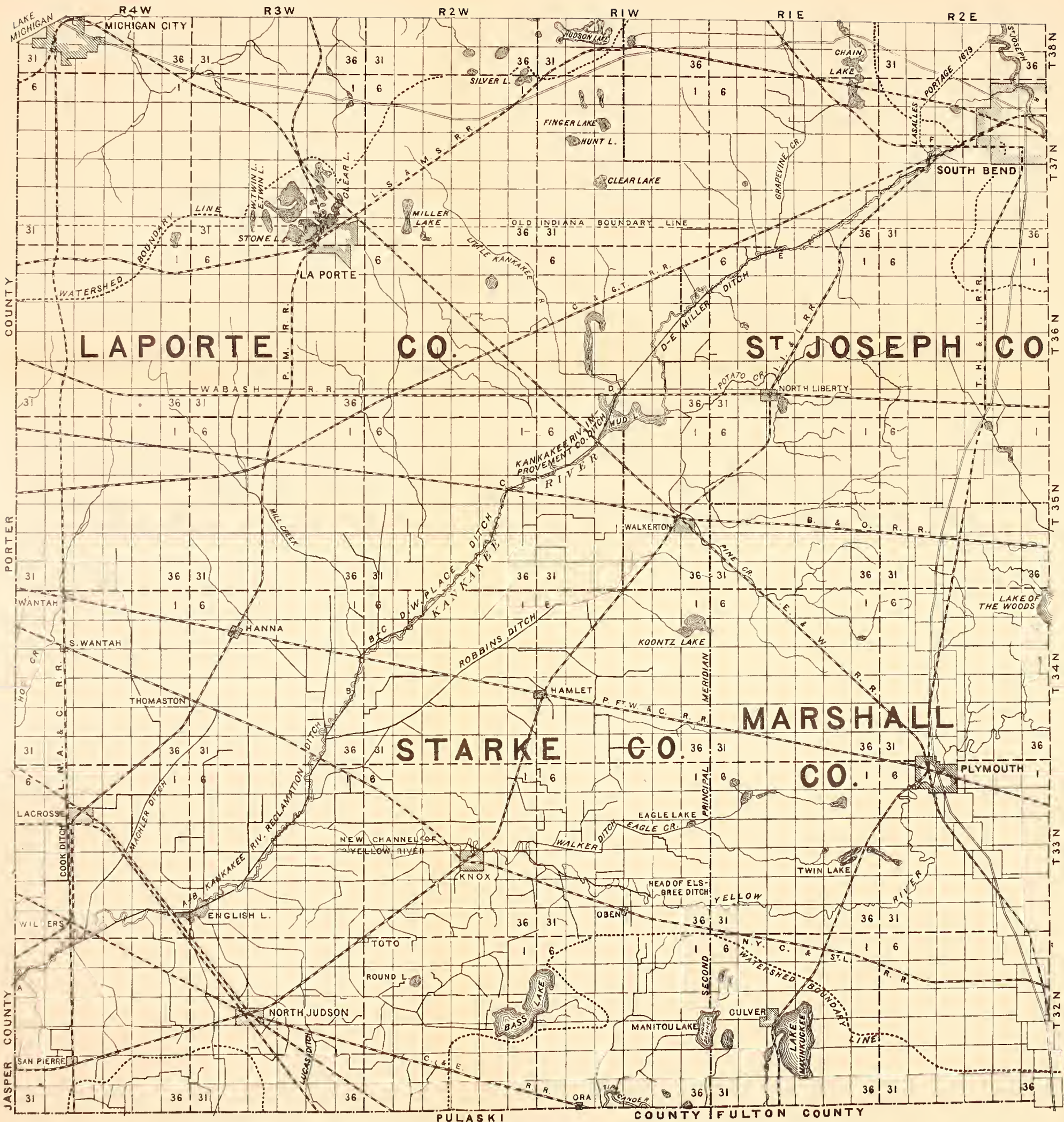


FIG. 1.—Drainage map of the Kankakee River Valley from the east line of Porter and Jasper counties to the head of the river near South Bend, Ind.

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Three plans for completing the reclamation of the lower part of the valley merit consideration:

First. The construction of levees on both sides of the present channel of sufficient strength and height to conduct the water from the upper part of the valley to the outlet point at Momence Rock without overflowing the adjoining land.

Second. The straightening of the present channel and the construction of levees on both sides of the improved channel.

Third. The straightening and enlarging of the present channel from the junction of the Yellow River with the Kankakee River to the Momence Rock to such an extent that it will carry the entire drainage of the lower valley without the assistance of levees.

The improvement by means of the first method would involve the construction of two strong levees, 6 feet high and approximately 300 feet apart, on each side of the present channel, and the clearing away of all trees and other obstructions to the flow of water in the channel and between the levees. The office of this channel would be to conduct the water collected by the main channel in the upper part of the valley, and that brought by the Yellow River directly through the lower half of the valley, and discharge it into the main channel at the Momence Rock. The drainage of the valley lying below the upper terminus of the levee system would be accomplished by means of large ditches constructed in approximately parallel lines to the main channel and converging just below the lower terminus of the river levees.

This plan presents several advantageous features and would be eminently successful, could the entire construction be carried out under one management as a unit. Under present conditions many of the important ditches which now serve the level lands discharge directly into the channel of the Kankakee. The levee system would cut off these outlets, requiring new ones to be constructed, which would probably so interfere with the present drainage systems that it would meet with violent opposition and involve a large expenditure for damages.

The second plan is the same as the one just discussed, except that the main channel and also the levees may be greatly diminished in length by the cutting of bends and thus shortening the course of the present river channel.

As between these two plans the former would doubtless be the better, for the reason that the area of the entire natural channel could be used, and while the length of the levees would be much greater than in the second method all excavation for the correction of the channel and expense for right of way would be avoided.

The third method, namely, the straightening and enlarging of the channel along the line of the most direct and greatest slope, is the one that commends itself to the engineer, and which, under the present condition of the drainage and other improvements of the lands already made in the lower valley, seems best adapted to the situation. It will accommodate the system of ditches already constructed. Should either the main channel or any of the lateral ditches prove inadequate for the work required of them, no massing or concentration of water would result, since there would be opportunity for the even distribution of a flood over a large section of the valley, and it would be removed evenly and simultaneously as soon as the flood in the main stream recedes. This plan of improvement is the one that has been selected and for which surveys and estimates have been made.

The course of the new channel was selected with care and is represented on the map both in alignment and section. The prominent facts regarding it are arranged in a concise and convenient form for reference in Tables 3 and 4 of this report, from which the following are selected as of most interest in a general description of the plan: The distance by river from the Starke-Porter county line west to the Momence moraine is 72 miles; the length of the straightened channel as established by this survey is 41.8 miles, of which 35.5 miles are in Indiana and 6.3 in Illinois. The new line cuts off eighty-four bends of the present stream, making $27\frac{1}{2}$ miles of entirely new channel and 14.3 miles of improved old channel; that is, one-third of the new course will be on the line of the present stream and two-thirds will be new work or cut-offs, the particulars of which are shown in the tables named. The fall in the 41.8 miles is 36 feet, or 6 inches per mile as distributed along the course of the existing channel. The grade determined for the channel, beginning at the Porter County line, will be 1 foot per mile for 1,600 stations or 30.33 miles. The grade from this point, which is near Schneider, Ind., to Momence, will be only 6 inches per mile. The depth will average about 10 feet and, in general, will be from 3 to 4 feet deeper than the present river, except in the lower part, especially in Illinois, where the new grade will not deepen the present channel. The boulder moraine crosses the river just above the rock and the terminus of the new channel, and presents an obstruction $2\frac{1}{2}$ feet high, which will be removed by the proposed improvement.

DESCRIPTION OF THE SURVEYED LINE.

The center line of the proposed channel was carefully located and accurately measured and marked upon the ground. At all changes in direction a permanent post, 6 inches in diameter and 3 feet long, properly marked, was set so as to project 10 inches above the surface

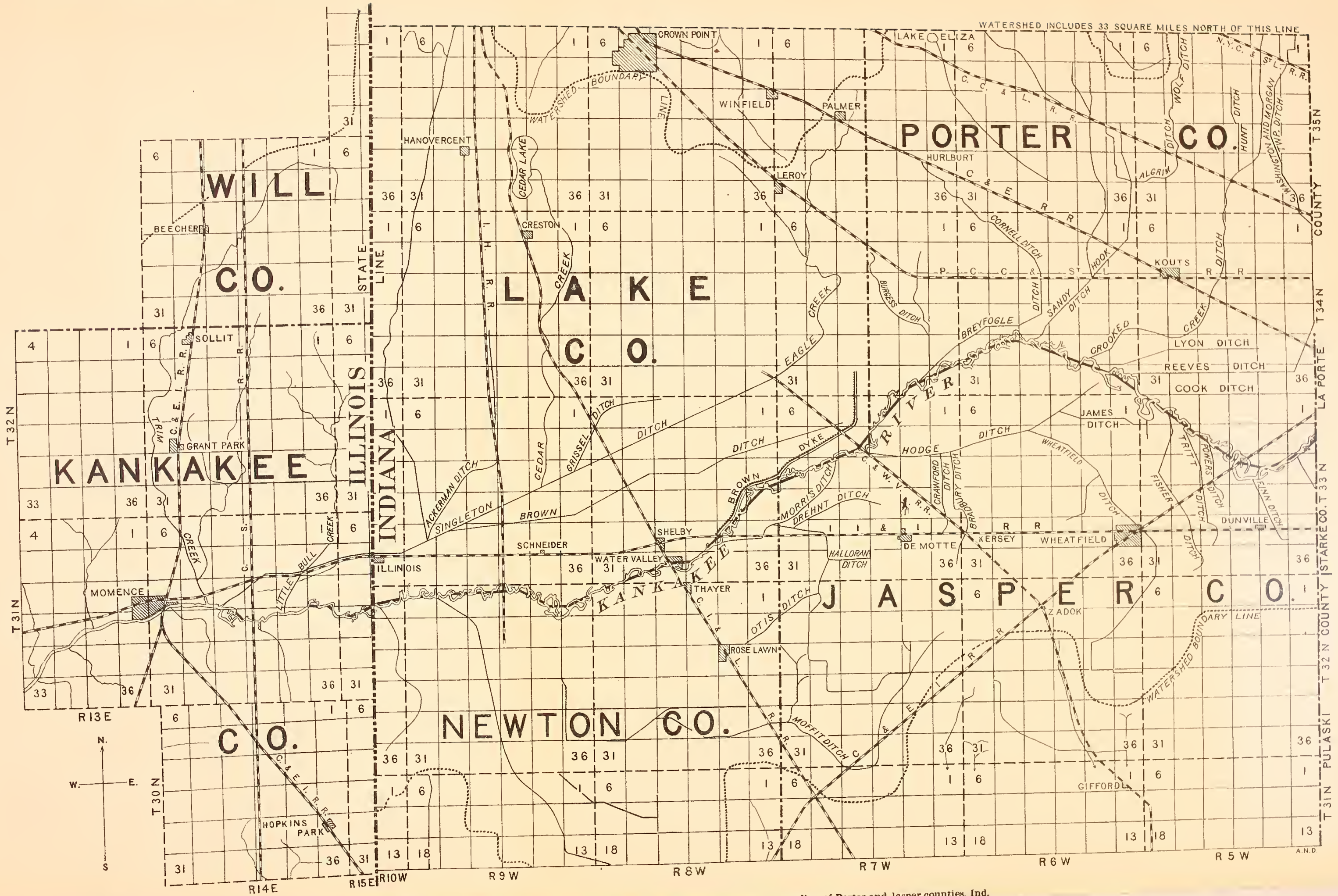


Fig. 2.—Drainage map of the Kankakee River Valley from Momence, Ill., to the east line of Porter and Jasper counties, Ind.

of the ground. The course of the present stream was meandered and has been carefully represented on the map. Bench marks were established, the location and elevation of which are recorded on the working map accompanying this report. (Fig. 2.) Every precaution was taken to connect the center line of the proposed channel with land lines and other important artificial features occurring along the banks of the stream. Side level lines were extended up the tributary ditches for a mile and their condition noted, and three cross sections were made across the valley to ascertain its lateral slope toward the arterial stream.

SIZE OF CHANNEL REQUIRED.

The grade line at both upper and lower termini of the channel under consideration is practically fixed, since it is to connect the dredged ditch at the Porter-Starke county line with the bed of the river in the rock channel at Momence. The alignment should be as direct as is consistent with efficiency and economy, due regard being given to the vested rights of property owners. It is believed that the new course for the river has been properly located with reference to these points. The capacity of the channel in this case must be increased or decreased by changing its width, and is a subject meriting the most careful investigation of all the factors of the problem.

The ditches which are found in the lower half of the valley, as shown in Table 1, are nine in number, and are estimated to furnish drainage in the aggregate for 440,660 acres. As previously shown, the watershed of the upper valley, including the Yellow River, which will be discussed later, comprises 700,000 acres, making a total area of 1,140,660 acres which discharges its drainage into the river at Momence. A part of the higher lands which contribute to the total watershed, given at 1,420,000, has not been listed in the watersheds of the several ditches.

DISCUSSION OF RAINFALL.

The normal annual rainfall is 34.5 inches, but ranges between 31 and 48 inches. The monthly maximum of rainfall reached 7 inches in May, 1902, and 8.6 inches in the following month, but the normal for each of those two months is about 3 inches. The maximum for twenty-four hours, as shown by the reports, is 2.15 inches, and for forty-eight hours 3.7 inches. The lack of distributed rainfall so common in the Mississippi Valley prevails here. A peculiarity not noted elsewhere is the variation of the precipitation in different parts of the valley for the same week or month. For instance, the rainfall for June, 1902, was 8.68 inches at Laporte, 7.29 inches at Hammond, and 13.9 inches at Rensselaer, the last being phenomenal. The precipita-

tion for May, 1905, at Rensselaer was 7.93 inches, at Hammond 4.79 inches, at Valparaiso 6.72 inches, and at South Bend 6.46 inches. The maximum rainfall occurs in May and June, at which season the soil is in a receptive condition. The maximum run-off, however, may occur during the late winter or early spring months, when rains and the melting of accumulated snow occur at a time when the ground will absorb but little water. In general, the climatic conditions are not far different from those prevailing in other parts of the central Mississippi Valley. This, however, is not true of the drainage properties of the soil. Its open physical structure, by reason of the liberal percentage of sand, its areas of turfy muck, the sand islands and outlying sandy areas of the upper portions of the watershed, and, above all, the sandy subsoil of the lower half of the valley, greatly modify the conditions affecting the discharge of water into drainage ditches. While the total run-off through ditches will probably be as great as that from more compact clay lands, it will be distributed over a longer time, since a large part of the surplus water will be held in the soil and delivered to the ditches more slowly than if it passed over the surface. There is a constant underflow through the subsoil wherever ditches afford a relief outlet.

The profile shows that the proposed channel will be for the most part 10 feet deep, which will carry its grade line into the subsoil sand, not only increasing its carrying capacity when flowing full but deepening the soil reservoir of the marsh plain.

Gaugings of the river at Momence indicate that the flood run-off, under present conditions of the stream and its tributary ditches, is from 5,000 to 8,000 cubic feet per second. Comparing the valley with other areas which have been drained, due regard being given to the drainage characteristics previously noted, the ditch for the lower part of the valley has been designed to carry $\frac{1}{8}$ inch in depth of water each twenty-four hours from the part of the watershed tributary to the several sections of the stream; that is, the channel at the Momence terminus should discharge a volume equal to $\frac{1}{8}$ inch in depth over the entire watershed each day without overflowing its banks. The size of the channel specified in Table 4 is computed upon this basis by the well-known Kutter's formula or its equivalent, in which the coefficient of roughness is given the value of 0.025. The results accord closely with the requirements from both of the standpoints named.

While upon this part of the subject it may be well to refer to the law of the flow of streams in relation to the area drained by them. The $\frac{1}{8}$ -inch standard used in computing the channel for the lower reach of the stream will not apply to that of the upper section or to

tributaries which drain a much smaller area. Some of the ditches in the upper half of the valley have, by actual measurement, been found to discharge a volume equivalent to $\frac{1}{2}$ inch, and in some cases $\frac{3}{4}$ inch, in depth in twenty-four hours from their respective watersheds. The time required for the water from distant parts of the valley to reach the main arterial channel and the storage and distribution of the water in the soil give rise to the law of flow, which may be mathematically expressed by a formula in such a way as to indicate the relation of the amount of drainage from small areas to that of large areas per unit of surface.

The width of the proposed new channel is 105 feet at the Porter County line, 135 feet at Station 1600—where the grade changes from 1 foot per mile to 6 inches per mile—and 190 feet wide at the State line.

YELLOW RIVER.

The largest tributary of the Kankakee River, and the one which from its nature overflows more territory and causes the most trouble within the limits of the marsh, is the Yellow River. This stream has its headwaters in the southwest corner of Elkhart County and the northwest corner of Kosciusko County, and drains a large part of Marshall County, part of St. Joseph County, and a part of Starke County, this being nearly one-fourth of the entire watershed of the Kankakee River above the Momence Rock. The area as drained in each of the aforesaid counties is as follows:

	Acres.
Elkhart County.....	6, 160
Kosciusko County.....	31, 135
Marshall County.....	176, 640
St. Joseph County.....	58, 240
Starke County.....	33, 920
Total.....	306, 095

Yellow River flows into the Kankakee at the head or near the head of English Lake and is the lowest and most desolate portion of the marsh country. This stream, through the western part of Marshall County and through the greater part of Starke County, flows through land with a sandy subsoil which is quite susceptible to erosion, and large quantities of silt are carried down onto the marsh. The fall through the eastern part of Starke County, where the stream has been improved, averages a little over 4 feet per mile, and that through Marshall County is at least as great, while on the 2 miles of the stream down near the Kankakee the fall is but 1 foot per mile. When the flat gradient is reached the character of the soil changes to a heavy clay soil which erodes but little.

About the year 1900 a petition was filed in the Starke circuit court to straighten about 14 miles of Yellow River in that county. The plan as reported by the drainage commissioners provided for a channel with a 20-foot bottom and an average depth of about 8 feet. Great opposition arose to this project, many remonstrances were filed, and the case was bitterly fought not only in the Starke circuit court, but, by a change of venue, was taken to an adjoining county and there finally decided in favor of the construction of the work. Instead of having a ditch constructed with a bottom width as provided for in the report of the drainage commissioners, the court ordered that it be constructed with an 8-foot bottom, giving the channel only a little over one-half the cross section provided by the drainage commissioners. The gradient for 12.11 miles was an average of 4.18 feet per mile; for 1.87 miles, an average of 1 foot per mile. The point of this change of gradient is near the center of section 14, township 33 north, range 3 west; and at almost exactly this point the nature of the soil changes as above indicated. Above this point the channel has washed out in many places until it is now 60 to 80 feet in width, while from this point on down the channel has the same width as that cut by the dredge. The great body of water coming from above, with its load of silt, becomes gorged in this narrow channel, rises and spreads all over the flat lands of this territory, and deposits sand on the adjacent lands in some places as much as 3 feet in depth. The lands on the lower part of this stream were heavily assessed for the construction of the ditch, but were really damaged instead of benefited.

One mistake in the construction of this ditch was in making it so small. The channel provided to carry the drainage from a watershed of 300,000 acres is only 8 feet wide, while in other parts of the marsh territory channels are constructed 30 feet wide to carry the drainage from not more than one-twentieth of the area.

Several plans have been presented to relieve this much distressed portion of the Grand Marsh. One is to tap the new channel of Yellow River about a mile and a half east of where it enters the Kankakee River, diverting the stream to the southwest and entering the river about 2 miles farther down. This plan also provides for the recutting of about 2 miles of the channel as heretofore constructed, making it 50 feet wide and carrying this same width on down to its proposed junction with the Kankakee.

Apparently no provision has been made to receive the waters of the Yellow River, which discharges into the improved channel above the old English Lake, a distance of $10\frac{1}{2}$ miles east of west line of Laporte County. This stream will continue to seriously injure a large area of land in the lower part of the Yellow River Valley until

it is connected with the Kankakee by an adequate channel. It is proposed to enlarge the present improved channel of the Kankakee so that it will be 90 feet wide from the Porter County line to the junction with the Yellow River, and so relieve the serious conditions existing at the mouth of that troublesome stream.

INTERSTATE DRAINAGE.

The plan covers the construction of a new channel for the Illinois as well as the Indiana section. We regard the carrying out of the completed plan as quite essential to its full measure of success. If, however, the improvement of the Indiana division alone is constructed, the new channel will discharge into the river at the State line at the bottom of the present channel in the same manner as does the new channel of the upper section at the Porter County line. It is not probable that an interstate agreement can be reached for the construction of the Illinois division. In any event, the part of the channel in Indiana should and may be constructed as one project.

COST OF THE WORK.

The estimate sheet, herein designated as Table 6, gives the estimated cost of the work in the several counties and in Illinois, including excavations, right of way, bridges, and organization expenses. The cost of the several sections is also recorded on the working profile, and, as shown in Table 6, aggregates \$991,500.91. Indeterminate expenses may augment the total cost to \$1,000,000. While the distribution of this expense is important and merits special consideration, it will not be discussed in this preliminary report. It may be observed, however, that the area drained by the ditches in the lower half of the valley, as indicated in Table 1, is 440,660 acres, while the entire upper valley of over 700,000 acres, including the Yellow River watershed, is dependent for its outlet upon the construction of the proposed channel. There are, undoubtedly, 500,000 acres which will receive benefits from the proposed work, the cost of which, if assessed at a flat rate, would be only \$2 per acre. If, however, as is probable, 250,000 acres may be properly assessed, the expense per acre will be \$4, which clearly places the cost of the project within the limits of a most profitable investment for the owners of the valley lands.

LATERAL DRAINAGE IN ITS RELATION TO THE MAINTENANCE OF THE RIVER CHANNEL.

Drains heretofore constructed, as well as the cross section taken of the valley, point out quite clearly that the main lateral drains should parallel the main stream and gradually approach it as they extend down the valley until they finally discharge into the river. The

stability of the river channel need not be feared by reason of its location in a soil of a sandy structure. The mean velocity of flow when running full will be about 4 feet per second, or 2.7 miles per hour, and only approximately two-thirds of that velocity at the bottom and sides of the channel. Under these conditions the channel will not be injured by erosion, and the distance which the lateral ditches must flow through the level bottomland adjoining the channel will cause them to drop their silt before discharging into the river. The difficulties arising from erosion and the presence of silt will be restricted to the lateral ditches. Those drains which proceed from higher lands at a steep grade erode badly and tend to fill the ditches when they reach the more level sections. The alignment of these ditches may be corrected, where they enter the marsh plain, in such a way as to largely eliminate or at least lessen this difficulty. Where possible they should be extended along the border of the valley or lower edge of the high land in such a way as to gradually diminish the grade instead of leading them directly across the flat to the intercepting ditch below, at which place they will deposit their silt and cause an overflow of the adjoining lands. These precautions may be taken in some cases, but the more practical and generally successful method will be to make provision for the annual removal of the sand from the ditches at points where it is deposited, thus keeping the ditches open in the upper and more easily managed sections. The injury in any case will result to the land near the foot of the slopes rather than to the main stream or the land adjacent to it.

EFFICIENCY OF THE PROPOSED IMPROVEMENT.

No provision is made for the improvement of the lower valley by levees. It is believed that a channel of the width and depth proposed will render them unnecessary if the improvement as outlined is continued to Momence. A straightening of the stream and lowering of the water table make it possible to fully accomplish the drainage of the land constituting the marsh plain. During the construction or in case only a portion of the stream is improved, levees will doubtless be required for the temporary protection of land in the lower valley. For this reason it is urged that every effort be made to carry out the proposed improvement as one project and thus avoid unnecessary expense and indeterminate damage to property, which will result from delayed construction or if the work is performed in small sections.

This brief report does not permit the full discussion of the engineering and economic features of the work. Its purpose is to bring before the owners of the valley lands the facts which are of most vital interest at this time and to invite their consideration and criti-

cism of the plan which we believe is the one which should be adopted in future drainage operations in the valley in order to complete the reclamation which will convert this historical marsh into farms and homes, for which, after thorough drainage, it will be so admirably adapted.

The tabulated statements which follow give, in a concise form for ready reference, facts and figures pertaining to the plan, while the map, which is prepared to accompany the report, shows the profile and alignment upon a scale of 400 feet to 1 mile, and also the benchmarks to which the levels are referred, and for convenience the estimated number of cubic yards of excavation required along the several divisions of the river.

TABLE 1.—Location and drainage area of ditches in Kankakee watershed.

Ditch.	County.	Station at which ditch enters new channel.	Drainage area.
			<i>Acres.</i>
Cook	Porter	375+00	10, 000
Reeves	do	440+00	27, 520
Crooked Creek	do	495+00	44, 800
Sandy Hook	do	600+00	42, 880
Breyfogle	do	825+00	26, 240
Brown Singleton	{Kankakee	} 2160+00	173, 500
Hodge	{Lake		
Morris	Jasper	960+00	44, 680
Beaver Lake	{do	} 1315+00	24, 960
	{Newton		
	do	1742+00	46, 080

TABLE 2.—Frontage of new channel by counties.

County.	State.	Length of channel.		Length in old channel.		Length of cut-offs.	
		<i>Feet.</i>	<i>Miles.</i>	<i>Feet.</i>	<i>Miles.</i>	<i>Feet.</i>	<i>Miles.</i>
Porter	Indiana	93, 300	17. 670	25, 290	4. 789	68, 010	12. 881
Lake	do	94, 100	17. 822	25, 710	4. 869	68, 390	12. 953
Kankakee	Illinois	33, 600	6. 364	24, 700	4. 678	8, 900	1. 686
Total			41. 856		14. 336		27. 520

TABLE 3.—Width, depth, and grade of new channel.

Station.	Base.	Average depth.	Grade.	
			<i>Per cent.</i>	<i>Feet per mile.</i>
0- 440	<i>Feet.</i> 105	<i>Feet.</i> 10. 8	0. 02	1. 056
440- 600	110	10. 6	. 02	1. 056
600- 825	120	10. 5	. 02	1. 056
825- 960	125	10. 5	. 02	1. 056
960-1315	130	10. 2	. 02	1. 056
315-1600	135	10. 1	. 02	1. 056
600-1874	190	10. 0	. 01	. 528
874-2160	200	8. 5	. 01	. 528
160-2210	230	8. 0	. 01	. 528

TABLE 4.—Length of old channel used, with amount of excavation, and length of changed channel, with amount of excavation.

Section.	Changed channel.		Excava- tion.	Old channel.		Excava- tion.
	<i>Feet.</i>	<i>Miles.</i>	<i>Cubic yds.</i>	<i>Feet.</i>	<i>Miles.</i>	<i>Cubic yds.</i>
Porter County	67,588	12.803	3,515,869	25,290	4.789	518,264
Lake County	68,390	13.033	3,761,170	25,710	4.869	977,519
Illinois	8,900	1.686	489,739	24,700	4.678	60,314

Number of cut-offs.^a

Porter County	41
Lake County	38
Illinois	5

TABLE 5.—Excavation per mile for proposed new channel of Kankakee River.

Miles.	Cubic yards.	Miles.	Cubic yards.	Miles.	Cubic yards.
1.....	147,953	16.....	267,339	31.....	336,539
2.....	129,061	17.....	252,300	32.....	350,664
3.....	209,357	18.....	265,328	33.....	276,698
4.....	227,460	19.....	270,323	34.....	307,472
5.....	253,573	20.....	266,719	35.....	256,981
6.....	229,574	21.....	259,961	36.....	219,713
7.....	197,233	22.....	259,579	37.....	104,301
8.....	248,346	23.....	220,701	38.....	147,439
9.....	193,579	24.....	214,024	39.....	28,798
10.....	235,070	25.....	174,603	40.....	76,909
11.....	221,866	26.....	225,078	41.....	80,936
12.....	256,949	27.....	278,421	42.....	9,745
13.....	264,035	28.....	256,690		
14.....	254,278	29.....	277,365	Total	9,322,902
15.....	268,757	30.....	301,185		

TABLE 6.—Estimate of cost of proposed new channel of Kankakee River.

Laporte County :

648,195 cubic yards, at 8 cents per yard.....	\$51,855.60
Right of way, 50 acres, at \$40 per acre.....	2,000.00
One highway bridge.....	5,000.00
Total	<u>58,855.60</u>

Porter County :

4,034,133 cubic yards, at 8 cents per yard.....	322,730.64
Organization and contingent expense, 15 per cent..	48,409.60
Right of way, 360.05 acres, at \$40 per acre.....	14,402.00
Three highway bridges.....	17,000.00
Total	<u>402,542.24</u>

Lake County :

4,738,689 cubic yards, at 8 cents per yard.....	379,095.12
Organization and contingent expense, 15 per cent..	56,864.27
Right of way, 419.56 acres, at \$40 per acre.....	16,782.40
Two highway bridges.....	15,300.00
Total	<u>468,041.79</u>

^a The length of the cut-off varies from 150 feet to 3,500 feet.

Illinois:

550,053 cubic yards, at 8 cents per yard-----	\$44, 004. 24
Organization and contingent expense, 15 per cent-----	6, 600. 64
Right of way, 61.41 acres, at \$40 per acre-----	2, 456. 40
One highway bridge-----	9, 000. 00

Total----- 62, 061. 28

Laporte County----- 58, 855. 60

Porter County----- 402, 542. 24

Lake County----- 468, 041. 79

Total cost in Indiana----- 929, 439. 63

Illinois----- 62, 061. 28

Total cost of project----- 991, 500. 91

TABLE 7.—Rainfall data, 1896-1906.

HAMMOND.

Months.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.
	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>	<i>Ins.</i>
January	2.68	5.58	2.41	0.53	1.75	0.96	1.44	2.25	5.19	1.85	2.57
February ...	3.40	3.42	.91	.71	3.65	2.30	2.62	3.36	2.64	2.38	3.30
March	3.69	7.35	.....	1.09	1.49	5.26	4.52	1.42	7.66	2.46	.89
April	3.92	.99	.....	.13	1.55	.69	2.27	4.71	4.45	3.96	1.70
May	3.95	2.40	4.07	4.07	4.15	1.82	6.89	3.21	3.54	4.79	3.74
June	2.82	.....	2.27	1.86	2.25	3.24	7.29	2.75	1.80	4.72	2.48
July	6.48	.74	1.37	3.15	4.09	2.58	4.54	2.69	5.93	3.93	2.75
August	5.78	.29	2.21	1.07	2.78	1.84	2.51	.....	2.88	3.47	2.41
September..	5.04	.81	1.53	2.99	1.43	1.83	5.16	2.96	3.56	3.79	2.92
October	1.11	.23	3.95	1.25	1.52	1.72	2.06	2.54	1.47	2.29	1.67
November..	3.27	.....	1.74	2.50	2.84	2.25	3.29	.79	.24	3.76	2.02
December ..	.42	.62	1.38	1.51	.66	4.15	2.08	2.57	2.74	1.34	1.89
Total .	42.56	21.93	21.84	20.38	28.16	28.14	44.67	29.25	42.10	38.74	28.84

SOUTH BEND.

January	1.04	5.53	3.52	2.01	0.87	2.51	1.16	2.91	3.76	2.85	2.42
February ...	1.77	1.79	2.66	2.13	3.97	1.88	1.45	3.33	2.40	1.61	1.28
March	2.28	3.31	4.47	3.81	2.46	4.32	3.85	1.86	5.51	2.59	2.98
April	3.34	2.52	1.01	.80	1.17	1.67	2.38	4.89	2.92	3.99	2.08
May	3.01	3.09	2.97	4.52	1.74	1.96	6.94	1.25	3.95	6.46	2.21
June	3.81	1.65	3.41	1.63	2.66	3.01	7.39	5.52	1.16	2.44	4.36
July	7.45	1.75	7.94	2.64	5.81	2.25	4.16	6.43	2.38	5.47	3.56
August	4.79	2.10	4.11	.66	6.43	2.46	1.58	5.21	3.00	4.96	4.08
September..	4.92	.23	1.81	4.05	2.25	1.42	4.50	3.72	2.11	3.93	1.13
October .....	.98	.71	6.56	3.70	1.31	3.95	1.46	2.47	2.12	1.25	3.77
November..	2.69	4.66	3.61	1.54	5.26	2.00	3.35	1.43	.37	2.22	3.57
December ..	.37	3.50	2.25	4.23	.63	3.50	3.31	3.30	1.79	1.50	4.09
Total .	36.45	30.84	38.32	31.77	34.54	30.93	41.53	42.32	31.47	39.27	35.53

LARGE LATERALS AND SUBDISTRICTS.

A necessary part of the drainage of the valley will be the organization of districts for the construction of large branches to the main or river channel. The manner in which such drains have been constructed in the valley is well illustrated in the history of the Machler ditch and the Cook ditch.

MACHLER DITCH.

As an example of the tributary drainage which has been constructed to the Kankakee River, the ditch petitioned for by Ernestina Machler on January 11, 1899, is taken. This begins on the south side of the Nickel Plate Railroad, in the northeast quarter of section 30, township 34 north, range 3 west; runs in a southwesterly direction, crossing the Chicago, Cincinnati and Louisville Railroad and the Pittsburg, Cincinnati, Chicago and St. Louis Railroad in the northeast quarter of section 22, township 33 north, range 4 west; continuing on in a southwesterly direction, it enters the Kankakee River in section 33 of the above township and range, having a total length of about $9\frac{1}{2}$ miles. (Fig. 3.)

The report of the commissioners was filed on June 20, 1899. The total acreage assessed as benefited by the construction of said ditch was 14,205 acres. The estimated cost of construction was \$30,000, and total assessed benefits \$82,181. An amended report was filed September 30, 1899. The amount of benefits assessed on each 40-acre tract is shown on the map accompanying this report. In addition to these, assessments were made against the highways of the townships through which the ditch runs and against the various railroads which crossed the line of the ditch. The amounts of the latter are also shown on the map. These figures were used as a basis for determining the proportion of the cost assessed to each piece of property. Among others, the Pittsburg, Cincinnati, Chicago and St. Louis Railroad was assessed the sum of \$3,000 benefits and no damages were allowed. On October 10, 1899, this company filed a remonstrance against the construction of the work and its assessment, claiming damages in a large amount and averring that the construction of the ditch was impracticable. The remonstrance of the railroad company was heard in the Laporte circuit court November 21 and 22, 1899, and on the 23d the court found that the railroad company would be benefited \$600 above all damages, and ordered the drain established. Later, on May 7, 1900, this decision was appealed from to the supreme court of Indiana. In the meantime, January 20, 1900, Mr. Charles B. Simmons was appointed construction commissioner, and on February 20, 1900, he awarded the contract for the construction of the work at 6 cents per cubic yard. The work of construction was begun June 1, 1900.

The specifications for this ditch required that the bottom widths should be as follows: First 50 stations, 15 feet; 82 stations, 20 feet; 82 stations, 25 feet; 108 stations, 30 feet; and 173 stations, 35 feet. The slope of the banks was estimated at 1 to 1.

At this time the Chicago, Cincinnati and Louisville Railroad had not as yet been constructed, and on October 25, 1900, when the dredge

reached the right of way of the Pittsburg, Cincinnati, Chicago and St. Louis Railroad Company, a temporary restraining order was ob-

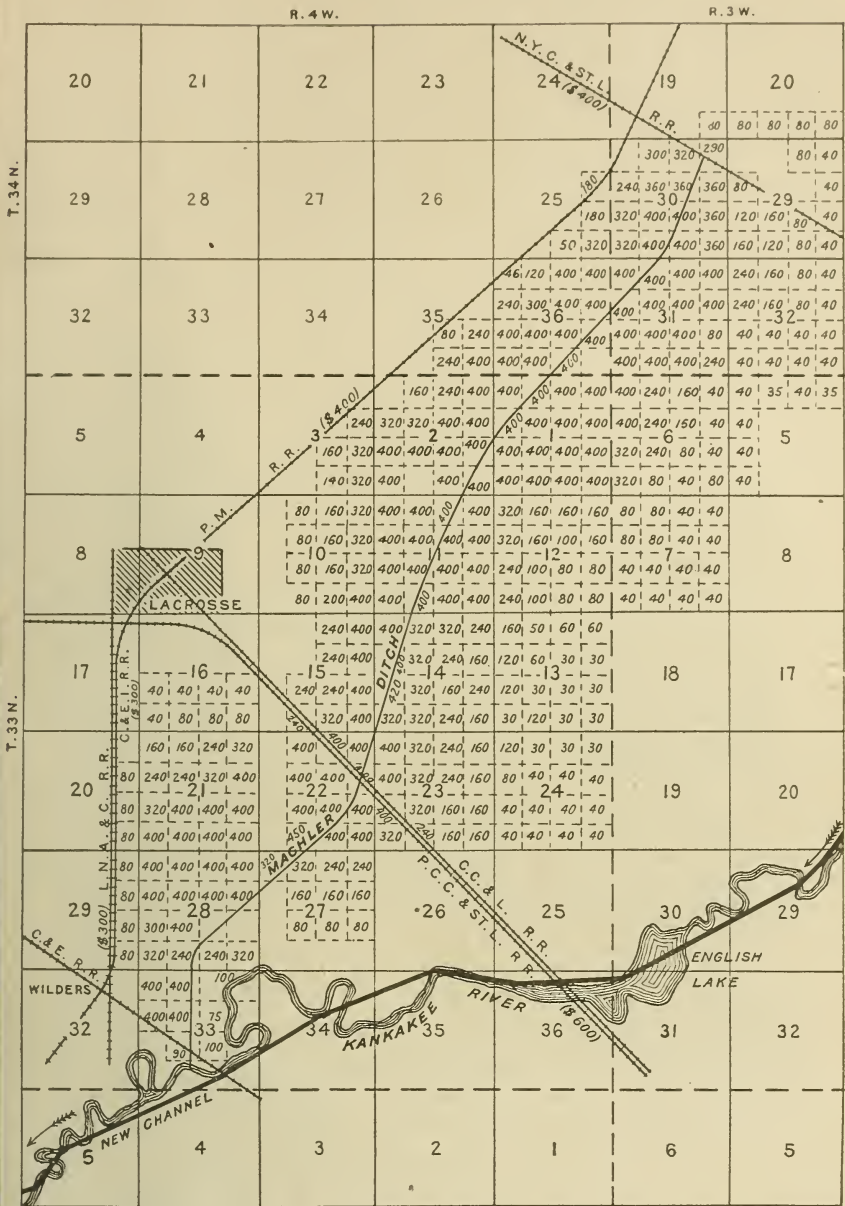


FIG. 3.—Map of Machler ditch, Laporte County, Ind., showing the line of the ditch and the territory assessed for its cost.

tained from the supreme court of Indiana, preventing further construction of the work on account of damages claimed by the railroad

company. This was heard and the restraining order dissolved on October 31, 1900. The matter was taken to the United States court for the district of Indiana on December 1, 1900. A restraining order was there refused on December 5, 1900. An appeal was taken from this to the United States district court of appeals for the seventh circuit. This appeal was perfected January 9, 1901, and was taken up and the injunction dissolved about June 1, 1901. The work of construction then proceeded and the ditch was completed November 6, 1901. The remarkable thing about this case is the rapidity with which the legal proceedings were had, it having been taken through four courts and five or six trials within a period of eight months. The original establishment of the ditch and the proceedings in connection with it were upheld at every point.

A statement of the costs and expenses of this work will, perhaps, be interesting here, this being an example of one of the large drainage operations tributary to the Kankakee River. These figures are given from the report of the commissioner in charge of the construction.

Court costs and preliminary expenses.....	\$1,464.80
Miscellaneous services	349.10
Recording, printing, and stationery	170.77
Engineering	320.50
Attorneys' fees, preliminary proceedings.....	800.00
Attorneys' fees in Supreme and United States courts.....	1,298.40
Costs in Supreme and United States courts.....	562.67
Court costs on change of venue.....	35.75
Commissioner in charge of construction	1,818.36
	<hr/>
Total expenses	6,820.35
Contract	25,506.87
	<hr/>
Total cost.....	32,327.22

The total cost was 40 per cent of the assessed benefits. The entire watershed of this stream was not assessed for the construction, this area being about 20,250 acres.

COOK DITCH.

Another example of the tributary drainage of the Kankakee Marsh is the Cook ditch, which was petitioned for in the Laporte circuit court about 1901. This ditch heads on the north line of section 8, township 33 north, range 4 west, on the west side of the Monon Railroad, runs south within the right of way of this railroad a distance of 3 miles, thence west and south until it reaches the southeast corner of section 36, township 33 north, range 5 west, where it turns directly west again for a distance of 6 miles, at which point it enters the Kankakee River. The total length of this ditch is $12\frac{3}{4}$ miles. The width of the bottom is as follows: The first 3 miles, 8 feet; $\frac{3}{4}$

mile, 13 feet; 2 miles, 18 feet; 7 miles, 24 feet. The grade for the first 3 miles is 3.2 feet per mile; the remaining $9\frac{3}{4}$ miles, 0.84 of a foot per mile. This ditch could have been run directly south from the southeast corner of the above-mentioned section 36 and have reached the river in about 2 miles, but in order to gain the advantage of the natural fall of the marsh it was carried westward in an almost parallel direction to that of the river, thus giving the advantage of this general slope of the marsh country. The area drained by this ditch is in Laporte County 7,840 acres, in Porter County 6,300 acres, making a total of 14,140 acres. But of this area there was assessed only 5,680 acres in Laporte County and 5,260 acres in Porter County, the total area assessed being 10,940 acres. The assessed benefits in Laporte County were \$41,182; in Porter County, \$39,770, or a total assessment of benefits of \$80,952. Of this there was levied against town lots in Lacrosse, \$1,287; against highways in Laporte County, \$2,180; against railroads in Laporte County, \$2,250; against highways in Porter County, \$3,400.

The commissioners awarded damages as follows in Laporte County: To the railroads, \$1,000; to oil and gas pipe lines, \$50; to telegraph companies, \$1,525. This damage to telegraph companies is, perhaps, on account of the Postal Telegraph Company having its lines along the Monon Railroad, and, coming in the line of the proposed ditch, it became necessary to remove the lines for a distance of 3 miles. The damages assessed in Porter County were to one of the oil pipe-line companies and amounted to \$200. The estimate of excavation on this work was 506,580 cubic yards. The contract was let at $5\frac{1}{2}$ cents per cubic yard. Forty per cent of the assessed benefits was collected to pay for the construction and expenses.

The following are the items of expense shown by the commissioners' report:

Preliminary expenses -----	\$658. 00
Miscellaneous -----	731. 49
Engineering -----	164. 00
Damages -----	1, 278. 00
Small bridge -----	32. 50
Attorneys' fees -----	1, 084. 55
	<hr/>
Total expenses -----	3, 948. 54
Contract -----	27, 861. 90
	<hr/>
Making total cost and expenses-----	31, 810. 44

This ditch has proven satisfactory as an outlet for the lands which were assessed for its cost.

