DRAINAGE IN MICHIGAN

MILLER and SIMONS

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

Publication 28

Geological Series 23

DRAINAGE IN MICHIGAN

BY

DALTON G. MILLER AND PERRY T. SIMONS

SENIOR DRAINAGE ENGINEERS, UNITED STATES DEPARTMENT OF AGRICULTURE

PREPARED UNDER THE TERMS OF AN AGREEMENT BETWEEN THE

MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

R. C. ALLEN, Director

AND

THE UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS

LOGAN WALLER PAGE, Director

PREPARED UNDER DIRECTION OF

S. H. McCRORY, Chief of Drainage Investigations

PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF
GEOLOGICAL SURVEY FOR 1918

FORT WAYNE PRINTING COMPANY
CONTRACTORS FOR MICHIGAN STATE PRINTING AND BINDING
FORT WAYNE, INDIANA
1919

BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY, 1918

EX OFFICIO:

THE GOVERNOR OF THE STATE,

HON. ALBERT E. SLEEPER

THE SUPERINTENDENT OF PUBLIC INSTRUCTION

HON. FRED L. KEELER

THE PRESIDENT OF THE STATE BOARD OF EDUCATION,

HON. THOMAS W. NADAL

DIRECTOR,

R. C. ALLEN

SCIENTIFIC ADVISORS

Geologists.—Dr. L. L. Hubbard, Houghton; Prof. W. H. Hobbs, Ann Arbor; Prof. W. H. Sherzer, Ypsilanti, Prof. E. C. Case, Ann Abor.

Botanists.—Prof. E. A. Bessey, East Lansing; Prof. F. C. Newcomb, Ann Arbor.

Zoologists.—Prof. W. B. Barrows, East Lansing; Prof. J. Reighard, Ann Arbor; Dr. Bryant Walker, Detroit.

LETTER OF TRANSMITTAL

To the Honorable, the Board of Geological Survey:

Albert E. Sleeper, Governor.
Fred L. Keeler, Superintendent of Public Instruction.
Frank Cody, President of the State Board of Education.

Gentlemen:—I have the honor to transmit for publication a report on the drainage situation in Michigan. In recent years various proposals for State aid in drainage problems have been brought forward for the consideration of the Legislature. Through conferences with members of the Legislature, county drain commissioners, the State Highway Commissioner, judges, members of the State bar and others in official and civil life who have had to do with the drainage problems in their various ramifications it appeared that a thorough inquiry into the whole situation should be made preliminary to any material modification of or addition to the present laws and the administrative system which has been developed under them.

There is no special reason why this inquiry should have been initiated by the Board of Geological Survey; it may as well have been made by some other appropriate State agency. It was not until it became apparent that no inquiry would be made or perhaps could be made except through your Board that you consented to the plan which I laid before you late in 1917. Pursuant to this plan, early in 1918, an agreement was entered into between the Board of Geological Survey and the Bureau of Public Roads, U. S. Department of Agriculture which contained the following governing provisions:—

(a) The acquisition of complete and accurate information concerning the existing drainage conditions in Michigan.

(b) In so far as possible, the ascertainment of present and future drainage needs in Michigan.

(c) The study of the relations of drainage to other inter-related problems.

(d) Preparation of abstract of the drainage laws of other States having problems similar to those in Michigan.

(e) Recommendations for improvement in the general drainage situation in Michigan.

(f) The preparation of the manuscript and illustrations of a report which shall embody a complete account of the investigations and conclusions based thereon.

Pursuant to this agreement investigations were commenced and during 1918 every county in the State was visited by a representative of Drainage Investigations, Bureau of Public Roads, U. S. Department of Agriculture. The general plan followed in each county was to first meet the county drain commissioner and confer with him relative to the drainage situation in that county. Following this conference the drain records were examined and such data abstracted and compiled as was desired, the method followed in the different counties being as nearly uniform as was possible. In many of the counties the county surveyor was interviewed as was also the county clerk, treasurer, and such other officials and individuals as might have particular knowledge of or interest in drainage and as could be readily interviewed. In many of the counties, field trips were made and drains inspected in order to arrive at a better understanding of the practical phases and results obtained by the drains under actual working conditions. The investigations in the counties were made by Dalton G. Miller, Perry T. Simons, and Fred F. Shafer, Senior Drainage Engineers, Bureau of Public Roads.

Conditions beyond the control of either party to this investigation made it impracticable to secure all the assistants needed for the work, and it was not therefore possible to complete some parts of the investigation as had been originally planned, which would have made certain details of the report more complete.

In addition to the information obtained in the manner as outlined, the authors of this report have drawn upon such other reports and publications as in their opinions would throw any additional light on the whole drainage situation in Michigan. The single idea has been to make the report as complete as possible, working within the time and appropriation limits, and still keep it concise.

Certain parts of the report would have been amplified had time and means been less limited but I think it covers the subject in its present form in a way that will meet the purpose for which it has been prepared and any further delay in publication would make it unavailable for use in the impending session of the Legislature.

Thanks are tendered to the County Drain Commissioners, supervisors and other county officials without whose cooperation this report could not have been prepared.

Very respectfully yours,

R. C. ALLEN,
Director.

Lansing, Michigan.
Dec. 6, 1918.

CONTENTS

ILLUSTRATIONS

PLATES

FIGURES

DRAINAGE IN MICHIGAN

DALTON G. MILLER AND PERRY T. SIMONS

CHAPTER I

CONDITIONS AFFECTING DRAINAGE

RAINFALL AND CLIMATE

Rainfall in different parts of Michigan varies but slightly. In the Southern Peninsula, the total annual rainfall ranges from between 25 and 40 inches and averages about 33 inches, and in the Northern Peninsula it ranges about the same with an average of 34 inches.

The climate* of Michigan is insular to a marked degree on account of the Great Lakes.

The mean annual temperature of Southern Michigan as a whole, is about forty-six degrees, ranging from forty-nine degrees in the extreme southwestern part to forty-two degrees in the extreme northeastern portion. The mean temperature of the Northern Peninsula is about forty degrees. The average maximum, or day temperature, ranges from about eighty-two degrees in summer to twenty-eight degrees in winter, and the average minimum, or night temperature is approximately fifty-seven degrees in summer and twelve degrees in winter. Extreme temperatures of one hundred degrees or more are not of frequent occurrence, although they have been recorded at some places on one or two days, during a majority of the summers in the past twenty-five years. Zero temperatures are an invariable rule during most winter months in the northern half of the Southern Peninsula; in the southern half of the Peninsula zero temperatures usually occur, although there have been some winters in the extreme southern counties when there has been an entire absence of zero temperature.

TOPOGRAPHY

The surface topography of the Southern Peninsula varies from level to hilly, extreme elevations ranging from 580 feet to about 1,700 feet above sea level.

The surface of the Northern Peninsula ranges from level to mountainous, although the per cent of rugged area proper is very small as shown below under the classification of "rocky knobs and ridges." The extreme variation in altitude in the Northern Peninsula is from 580 feet to 2,023 feet above sea level.

*C. F. Schneider, "Climatic Conditions of Michigan." Michigan Geological and Biological Survey. Pub. 25, Geol. Series 21. 1917.

The surface slopes of both Peninsulas of the State, in so far as related to drainage, generally average between 3 to 7 feet to the mile although some of the larger streams have slopes of less than three feet per mile.

SOILS

Michigan lies in a heavily glaciated area and as a result the soils of both Peninsulas are very complex in the matter of distribution and range in texture. In different sections of the State certain types predominate and in many sections several distinct types will be found within very small areas.

The total areas of the principal types of soils have been classified by Leverett in Surface Geology of Michigan, Publication 25, Geological Series 21 as follows:

Southern Peninsula: Swamp and lake 11.60%, clayey and sandy till 55.20%, sandy and gravelly 33.20%.

Northern Peninsula: Swamp and lake 25.00%, clayey and sandy till 49.02%, sandy and gravelly 17.50%, rocky knobs and ridges 8.00%.

CHAPTER II

WET LANDS OF MICHIGAN

Michigan, generally, is given fifth place among the States in area of swamp and overflow lands, Florida, Louisiana, Mississippi, and Arkansas being placed ahead. Swamp and overflow lands do not, however, form a fair basis for comparison among the States of the total areas which will be benefited by drainage nor do they form a fair basis in any one particular State for estimating the actual agricultural benefits which will result from drainage.

In the first place there is much land which properly may not be classed as swamp or overflow land but which by proper drainage will receive benefits almost—if not wholly—equal to those that result from the drainage of these two types of wet land. This applies particularly to the clayey soils, which are usually rich in available plant foods, but through which, because of the fineness of the clay particles, soil moisture travels but slowly. As a result this type of soil, although frequently not appearing actually too wet and which may not even be low lying, is prone to retain an excess of free water and for this reason warms but slowly during the early spring months. These lands, frequently and with reason, are referred to as being cold and damp. By surface drainage, and thorough tiling the productivity of such land may be greatly increased and sometimes more than doubled. Therefore it is almost impossible to overestimate the actual monetary value of adequate drainage to any agricultural community, where there is as much of this kind of soil as there is in Michigan. It has been estimated* that about 22 per cent of the Southern Peninsula and about 15 per cent of the Northern Peninsula are of a clayey type.

Certain other types of wet land may have agricultural possibilities which have not been fully determined and which by ordinary methods of farming as practiced by the average farmer under average conditions, do not give satisfactory returns even after drainage. Consequently reclamation by drainage, alone, of certain types of land may be of questionable value unless followed by specialized intensive farming. This applies to sand bottom swamps covered by a thin layer of muck.

RECLAIMABLE WET LANDS OF SOUTHERN PENINSULA.

In order to secure some definite information as to the undeveloped wet land resources of Michigan the following questionnaire was sent

*Frank Leverett, Surface Geology of Michigan: Michigan Geological and Biological Survey, Pub. 25, Geol. Series, 21, 1917.

to each of the 1,111 township supervisors of the 68 counties of the Southern Peninsula. Replies were received from 666, or 60 per cent of the supervisors.

Information Regarding Drainage in Michigan for the U. S. Department of Agriculture and the Michigan Geological Survey

---

Name of County.....

Name of Township.....

1. Estimate of the total number of acres of land in your township which is too wet to profitably cultivate. This to include both timbered and cleared wet land of all kinds, —lakes, overflowed land and land too wet to farm during ordinary seasons.

Total.....Acres.

2. Estimate the number of acres of this wet land which can be reclaimed by proper drainage.

Total.....Acres.

3. Give present average assessed value of the land in your township.

Per acre, $.....

4. Give the present average assessed value *per acre* of the wet land in your township which might be reclaimed by drainage.

Per acre, $.....

Signed.....

Supervisor.

Date.....1918.

In the interviews with the county drain commissioners generally an estimate by him was secured as to the area of reclaimable wet land within the county.

From the questionnaires returned by Supervisors, from the interviews with the county drain commissioners, from field inspection trips and also from information obtained from Soil Survey and Geological Survey sheets and from the State Board of Equalization Reports the information contained in Table No. 1 was compiled. This table relates only to those 47 counties of the Southern Peninsula lying south of the U. S. Land Office 2nd Correction Line, about latitude 44°-10′; crossing the State just south of Manistee, Cadillac and Tawas City.

This estimate in no way represents the total area of swamp and lake lands of this section of the State but applies wholly to the wet lands which are deemed reclaimable by ordinary methods of drainage. The area totals 2,175,000 acres which is 12 per cent of the combined areas of the 47 counties and is just about equal in size to the combined areas of any six of the seven counties in the southern tier of the Southern Peninsula. This particular area of reclaimable wet land does not lie in a section of the State in which the benefits of drainage are in any sense uncertain or experimental as much of it is immediately contiguous to lands which already have been drained and all lies within that part of the State where more than 99 per cent of the total expenditures on county drains have been made during the past 20 years and where the benefits of drainage have been repeatedly proven.

The total increase in assessable value which will result when these lands in the 47 counties have been drained has been very conservatively estimated at $62,697,000 as shown by Table No. 1. This is more than three times as much as has been spent on county drains within these counties during the last 20 years.

In addition to the area of 2,175,000 acres of reclaimable wet land in the 47 counties just mentioned, it has been similarly estimated, as shown in Table No. 2, that there are 661,000 acres of reclaimable wet lands in the 21 counties of the Southern Peninsula lying north of the U. S. Land Office 2d Correction Line. There has been spent for drainage in these 21 counties in the last 20 years a total of but $125,316.

The character of the wet lands of this part of the State varies widely, the soil ranging from a clayey type to sand. Methods of reclamation of the clayey lands have been well worked out in the southern part of Michigan and in many of the other States. The sandy lands and those swamps in which a thin layer of muck overlies

the sand, should be reclaimed on a large scale only after careful consideration is given to the methods of drainage and the uses to which the lands will be put after drainage.

TABLE No. 1.

Showing Estimated Areas and Increase in Assessable Value of the Reclaimable Wet Lands of the South 47 Counties of the Southern Peninsula of Michigan.

Counties.	Areas of Counties (Acres).	Reclaimable Wet Lands.		
		Estimated Areas (Acres).	Increase in Assessable Value if Drained.	
			Per acre.	Per county.
Allegan	529,873	48,000	$27 50	$1,320,000
Arenac	235,098	93,000	14 00	1,302,000
Barry	354,029	35,000	24 50	857,500
Bay	284,627	36,900	20 50	738,000
Berrien	361,982	12,000	37 00	444,000
Branch	320,720	56,000	50 50	2,828,000
Calhoun	447,452	52,000	27 00	1,404,000
Cass	316,393	38,000	35 50	1,349,000
Clare	364,757	27,000	12 00	324,000
Clinton	364,793	38,000	35 00	1,330,000
Eaton	366,033	52,000	50 50	2,626,000
Genesee	403,980	48,000	32 00	1,536,000
Gladwin	330,765	100,000	14 50	1,450,000
Gratiot	364,624	40,000	32 50	1,300,000
Hillsdale	386,087	18,000	41 00	738,000
Huron	536,983	59,000	27 50	1,622,500
Ingham	355,273	24,000	35 00	840,000
Ionia	366,291	29,000	34 50	1,000,500
Isabella	368,746	32,000	22 50	720,000
Jackson	453,452	31,000	29 00	899,000
Kalamazoo	359,235	72,000	38 00	2,736,000
Kent	345,815	17,000	37 50	637,500
Lake	365,394	22,000	9 50	209,000
Lapeer	423,536	47,000	35 00	1,645,000
Lenawee	466,678	64,000	45 00	2,880,000
Livingston	370,871	29,000	33 00	957,000
Macomb	300,030	20,000	40 50	810,000
Mason	315,527	30,000	13 00	390,000
Mecosta	362,779	40,000	21 50	830,000
Midland	336,476	119,000	19 50	2,558,500
Monroe	355,293	24,000	44 00	1,056,000
Montcalm	454,461	51,000	27 50	1,402,500
Muskegon	322,435	34,000	16 00	544,000
Newaygo	542,741	39,000	12 00	468,000
Oakland	575,400	30,000	34 50	1,035,000
Oceana	345,416	15,000	12 00	180,000
Osceola	367,337	68,000	14,50	2,021,000
Ottawa	357,839	79,000	47 00	3,713,000
Saginaw	520,291	77,000	21 00	1,617,000
Sanilac	616,214	95,000	27 00	2,565,000
Shiawassee	345,200	25,000	34 50	862,500
St. Clair	443,391	65,000	27 00	1,755,000
St. Joseph	319,794	51,000	37 50	1,912,500
Tuscola	510,698	64,000	28 50	1,824,000
Van Buren	391,443	83,000	24 00	1,992,000
Washtenaw	454,047	27,000	34 00	918,000
Wayne	367,039	20,000	27 50	550,000
Totals	18,447,338	2,175,000	$28 83 (average)	$62,697,000

TABLE No. 2.

Showing Estimated Areas of Reclaimable Wet Lands in the North 21 Counties of the Southern Peninsula of Michigan.

Counties.	Areas of Counties (Acres).	Reclaimable Wet Lands.
		Estimated areas (acres).
Alcona	435,247	48,000
Alpena	371,152	101,000
Antrim	305,558	6,000
Benzie	204,192	8,000
Charlevoix	266,225	19,000
Cheboygan	462,440	73,000
Crawford	359,846	11,000
Emmet	300,885	23,000
Grand Traverse	229,278	14,000
Iosco	354,822	33,000
Kalkaska	359,669	8,000
Leelanau	220,234	24,000
Manistee	350,101	43,000
Missaukee	363,290	58,000
Montmorency	355,529	18,000
Ogemaw	366,811	26,000
Oscoda	364,769	20,000
Otsego	334,273	15,000
Presque Isle	428,875	53,000
Roscommon	338,315	56,000
Wexford	366,676	4,000
Totals	7,138,188	661,000

SWAMP AND WET LANDS OF THE NORTHERN PENINSULA

The data relative swamp land for the different counties of this Peninsula as shown in Table No. 3 were compiled as shown on the original survey plats of the United States Land Office. Because of the generally undeveloped agricultural conditions of the Northern Peninsula of Michigan no effort has been made to estimate the reclaimable wet land area of this part of the State.

As indicated by the table there are 2,598,000 acres of swamp lands in this section of the State which is very nearly 25% of the total area of the Northern Peninsula. There has been but little effort made to reclaim any of this, as only 4 of the counties have spent anything whatever on county drains; the total to date amounting to but $8,528 spent on about 12 miles of ditches. In addition to this there have been some 70 or 80 miles of open ditches constructed by individuals and corporations under land development schemes. The area of land fully reclaimed and made suitable for farming by these schemes has been very small.

The possibilities of drainage for improving the almost wholly undeveloped agricultural resources of the Northern Peninsula are only just beginning to be generally appreciated and only then in those counties where agriculture is well established.

TABLE No. 3.

Swamp Lands in Northern Peninsula of Michigan.

Counties.	Areas Countes (Acres).	Swamp lands.	
		Area in Acres.	Per cents of counties.
Alger	589,949	121,500	20.6%
Baraga	583,806	74,800	12.8%
Chippewa	999,960	340,500	34.0%
Delta	748,915	234,500	31.3%
Dickinson	491,925	110,500	22.5%
Gogebic	712,033	82,000	11.5%
Houghton	647,466	49,300	7.6%
Iron	760,143	115,300	15.2%
Keweenaw	348,468	50,000	14.4%
Luce	582,654	223,500	38.4%
Mackinac	650,255	259,000	39.8%
Marquette	1,182,851	235,000	19.9%
Menominee	670,279	292,700	43.7%
Ontonagon	844,754	27,200	3.2%
Schoolcraft	758,096	382,200	50.4%
Totals	10,571,544	2,598,000	Av. 24.6%

In addition to the part that drainage will play in the development of such of the swamp lands of the Northern Peninsula as may be profitably reclaimed, the history of the south half of the Southern Peninsula is sure to be duplicated to the extent that a large per cent of the clayey lands will also require drainage. As stated previously it has been estimated that almost 15 per cent of the soil of the Northern Peninsula is of a clayey type. This 15 per cent is largely in addition to the estimated 25 per cent of swamp land.

SUMMARY OF WET LANDS OF MICHIGAN

In a general way the wet land situation of Michigan can be summarized as follows. The estimates for the two Peninsulas are essentially different in character and are not comparable:

Southern Peninsula.
Reclaimable wet Lands:

47 southern counties ..... 2,175,000 acres
21 northern counties ..... 661,000 acres

Total for the 68 counties ..... 2,836,000 acres

Northern Peninsula
Swamp and Lakes:

Total for the 15 counties ..... 2,598,000 acres

In addition to the swamp and lake land the Northern Peninsula has about 1,586,000 acres of clayey land much of which will need drainage if the agricultural possibilities are to be fully realized.

CHAPTER III

DRAINAGE IN MICHIGAN

EARLIER DRAINAGE

As stated elsewhere in this report the first comprehensive drain law of Michigan was passed in 1839. Between 1839 and 1897 considerable drainage was done under both county and township systems but in compiling the statistics for the different counties no general attempt was made to ascertain the amount so expended as in many cases the township records were unobtainable and many of the earlier county records were incomplete and difficult of access.

Some little information relative to that part of the earlier drainage which is properly of the nature of county work was obtained in a few of the counties. The amounts recorded in Table No. 4 probably very nearly represents the total so spent during the inclusive periods. In most of the counties much more was spent on public drains during the same period but spent under the township plan. This may be of passing interest and is contained in the following table. No information is at hand relative to the number of miles of drains on which these sums were expended excepting for Wayne County, which expenditures for the period from 1859 to 1897 were on about 1,050 miles.

TABLE No. 4.

Early Expenditures on County Drains.

County.	Period.	No. years.	Expenditures.
Branch	1861–1897	37	$ 36,157 76
Calhoun	1871–1897	27	29,901 54
Cass	1871–1897	27	28,827 04
Hillsdale	1861–1897	37	26,126 18
Jackson	1867–1897	31	52,459 25
Kalamazoo	1878–1897	20	7,285 87
Oakland	1863–1897	35	104,940 40
Ottawa	1894–1897	4	10,639 73
St. Joseph	1887–1897	11	19,500 35
Van Buren	1882–1897	16	95,964 21
Wayne	1859–1897	39	516,423 21

DEVELOPMENT OF COUNTY DRAIN SYSTEM

Drainage in Michigan, under the county system as known at the present time, dates back a little more than 20 years when the county drain commissioners were given supervision of all county drains by Act 254 of the Michigan Laws of 1897. At present county drain commissioners are serving in 70 counties of the State; sixty three are located in the Southern Peninsula and 7 in the Northern Peninsula. Thirteen counties: Antrim, Crawford, Kalkaska, Oscoda and Otsego in the Southern Peninsula, and Baraga, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Mackinac and Schoolcraft in the Northern Peninsula are without county drain commissioners.

During the 20-year period from 1898 to 1917 expenditures were made on county drains in 63 of the 83 counties of the State. The following twenty counties, of which the first nine are in the Southern Peninsula and the remaining eleven in the Northern Peninsula, have spent nothing: Alcona, Antrim, Crawford, Kalkaska, Leelanau, Montmorency, Ogemaw, Otsego, Oscoda, Alger, Baraga, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Marquette, and Schoolcraft. One of these counties, Alcona, during 1917, established its first drain so that this county might almost properly be excluded from the list as the county records will show expenditures in 1918. However, strictly speaking these will not have been made within the 20-year period, and no expenditures are shown for Alcona in Table No. 5, although a cost anaylsis has been made of the expenditures for one drain as shown in Table 6.

Expenditures on County Drains

Table No. 5 shows expenditures in the State as a whole and in each county during the 20-year period from 1898 to 1917 inclusive.

In the chart in Figure 1 the different counties of the State have been arranged in the order of total expenditures for these 20 years and at the right hand side of the chart the expenditures in the different counties are compared graphically.

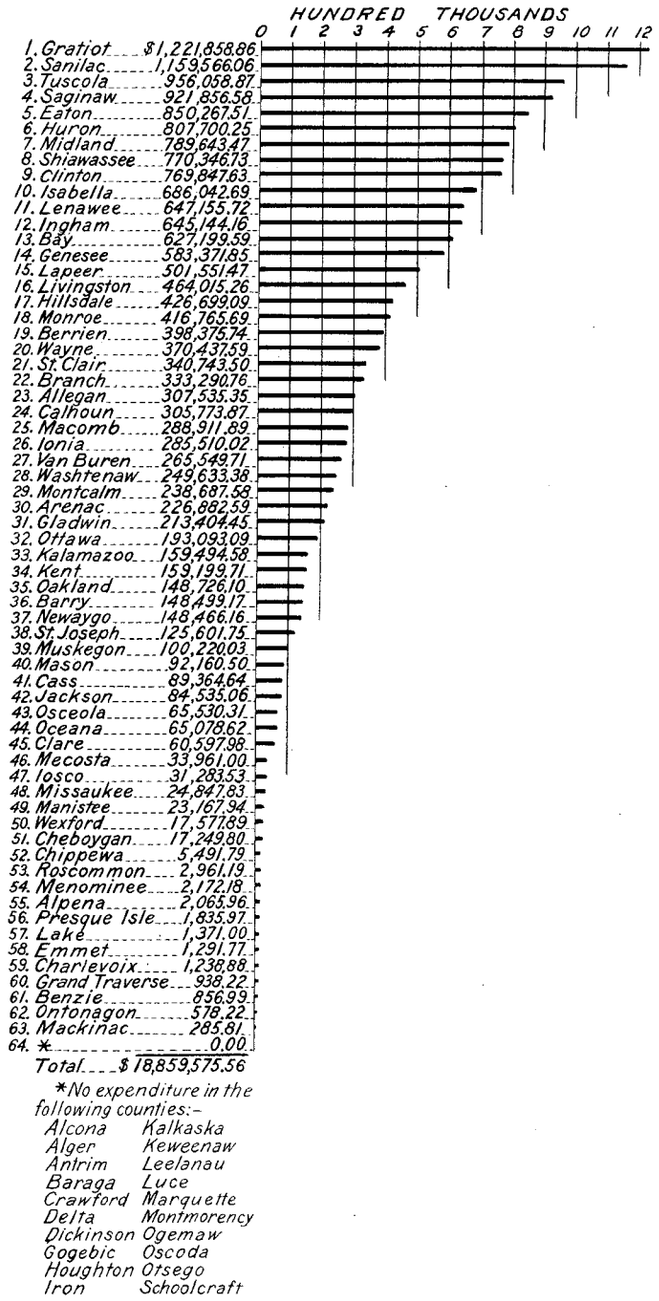


Figure 1. Expenditure on Michigan County Drains for 20-year period (1898 to 191 inclusive) showing relative importance of counties with respect to expenditures.

The average amount spent annually in the State on county drains has been $942,978 and totals $18,859,576 for the 20 years. Of this amount all except $135,209 has been spent in the 47 counties of the Southern Peninsula lying south of the U. S. Land Office 2nd Correction Line about latitude 44°-10′, crossing the State just south of Manistee, Cadillac and Tawas City. This represents, for these 47 counties, an average per county of $398,390 for the 20 years; and a yearly average per county of $19,920.

The chart in Figure 2 shows graphically the annual expenditures and clearly illustrates that the trend, although fluctuating to some degree, has been decidedly upward from 1898 to 1917 as the increase from $285,555 in 1898 to $1,683,457 in 1917 represents an increase of 490 per cent in 20 years.

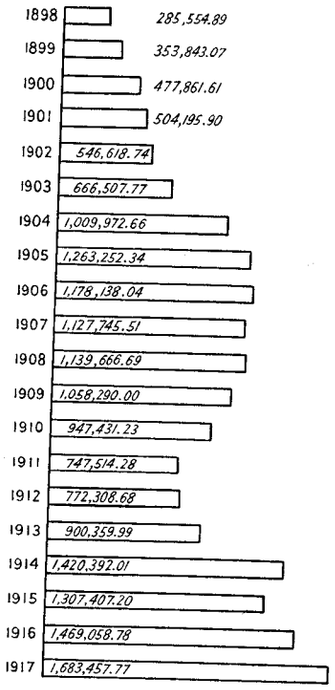


Figure 2. Chart showing total annual expenditures for county drains for 20-year period, 1898-1917 inclusive.

Note.—The expenditure $1,263,252,34 for 1905 is correct, although through an error the diagram for 1905 was made shorter than that for 1906 in which year the expenditure was less than in 1905.

As nearly as could be determined from the many records examined the total of $18,859,576 for the 20 years was expended on about 9,300 separate drains, having a length of approximately 19,400 miles, of which 1,775 miles were tile drains and 17,625 miles were open ditches. The average length of all classes of drains has been 2.1 miles, the average cost per drain $2,028, and the average cost per mile of drain $972, or $3.03 per rod.

During the last five years of this period as shown in Table No. 6, 2,605 drains were worked on, of which 1,395 were new and 1,210 were old drains that were cleaned, deepened, widened or extended. The 2,605 drains have a total length of 5,323 miles, of which 1,058 miles, or 20%, are tile. The average length per drain for the last 5 years is shown to be 2.0 miles and the average depth 4.4 feet. The drains have cost $3,057 per drain and $1,496 per mile of drain, while the average cost per acre of lands assessed has been $2.48. The number of acres assessed for each drain has averaged 1,234 acres or a little less than 2 square miles.

Comparing the data in Table No. 5 for the 20 years from 1898 to 1917 with that in Table No. 6 for the last 5 years of this period it is found that the amount spent per drain has increased 51% while the amount spent per mile of drain has increased 54%. The average length of drain has remained about the same so that this increased cost is accounted for, in part, by the increased cost of labor and material, but principally by the increase in depth and bottom widths of the open drains. This increase seems to have been quite general throughout the State. The use of tile has also materially increased as 1,058 miles, or 60% of the total of 1,775 miles of tile laid in county drains in the State has been installed within the five-year period from 1913 to 1917. As all the factors entering into the increased cost per drain and per mile of drain, the one of increase in the price of labor and material alone excepted, have made for more efficient drainage, from an agricultural standpoint the increases probably have been well justified.

Cost Analysis of County Drains

Table No. 6 is primarily an analysis of the cost of county drains for the 5-year period from 1913 to 1917 inclusive, for each county and for the State as a whole, compiled from data taken from the records of the county drain commissioners.

As shown in this table the total expenditure for the 5-year period is $7,962,998.98 as against $6,780,675.15 shown in Table No. 5. This apparent discrepancy is accounted for by the fact that nearly

all of the figures in Table No. 5 refer to actual disbursements made by the county treasurer on drain orders and are definite for the inclusive periods. On the contrary the expenditures for part of the drains analyzed in Table No. 6 for the years 1916 and 1917 will not be paid for until 1918 and some not until 1919. Also in selecting the drains at the beginning of the 5-year period it was the plan to analyze only such drains as were petitioned for after January 1, 1913. It was not always possible to secure complete detail data relative to every individual drain in each county. Sometimes within this 5-year period the records have shown that two or more drains were combined into one drain which sometimes made the number of drains worked on in a county rather indefinite.

In comparing expenditures one year with another, or one county with another, only those figures used in Table No. 5 or in Figures 1 and 2 should be used for the reason that Table No. 6, as already stated, is not entirely complete. It represents, however, an analysis of cost which is concise in detail and as nearly complete and uniform for all counties for the five years as it was practicable to prepare from the drain records.

A study of Table No. 6 shows that the division of expenditures in county drains for the State as a whole for the 5-year period between 1913 and 1917 has been as follows:

TABLE No. 7

Summarized Analysis of Expenditures on County Drains for 5-year Period 1913–1917, Inclusive.

Construction	74.31%
Bridges and Culverts	13.87%
Cost of Survey	2.76%
Printing	1.32%
Damages	1.27%
Recording and Abstracting	0.86%
Probate Fees and Special Commissioner	0.33%
Cost of Serving Notices	0.19%
Miscellaneous Expenses	0.66%
Contingent	4.43%
Total	100.00%

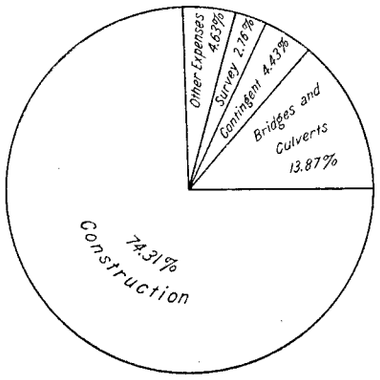


Fig. 3 Percentages of expenditures.

The item of construction includes the cost of all tile used in county drains and in fact includes everything entering into the actual construction of the drains with the exception of the bridges and culverts which have been recorded separately. All these expenditures can be classified under three general heads, (1) Construction Expenses, (2) Overhead expenses and (3) Contingent expenses, which includes items which if they could be properly classified, could be placed under either of the two foregoing heads. From this it is seen that of all moneys spent on county drains in the several counties in Michgan during the 5-year period from 1913 to 1917 inclusive, as shown in Table No. 6, that 88.18% was Construction expense, including bridges, 7.39% Overhead expense and 4.43% Contingent expense. This is a good showing as work of this character ordinarily goes. In view of the small size of the individual projects it would not have been surprising to have found that the everhead expense ran as high as 20% of the total cost of the work. However, it will be said in this connection, that a better showing could be obtained by combining drains wherever possible so as to reduce the number of separate projects to be handled. This would result at the same time, in increasing the average size of the area assessed per drain.

There are three items of expenses in connection with the operations of the Michigan county drain system that have not been included in the data of either Tables No. 5 or No. 6 as they are not paid for directly by the property owner. These are the items of drain commissioner's salary, expenses contracted by the drain commissioner while on official trips over the county, and in some of the counties the clerical hire for recording the proceedings in the Drain Record books. The drain commissioner is paid from the general fund and in about half the counties it is the practice to pay for recording from the contingent fund but in other counties this expense is charged against the individual drain funds. No data are at hand as to the exact amount so spent in the State but for the 5-year period, 1913 to 1917 inclusive, it has not averaged to exceed $1,400 per year per county for the 70 counties which at present have drain commissioners. In some of the counties the total will greatly exceed this but in others practically nothing whatever has been spent. Assuming $1,400 to represent a fair annual average, the total for the 70 counties for the five years immediately previous to 1918 would amount to $490,000. If this be added to the total given in Table No. 6 it will increase the amount from $7,762,998.98 to $8,452,998.98, and increases the overhead expense from a total of $588,856.27 to $1,078,-856.27.

Recomputing the percentages on the basis of these totals it is shown that 83.07% was for Construction expenses including bridges, 12.76% for Overhead expenses and 4.17% for Contingent expenses, which still makes a very credible showing.

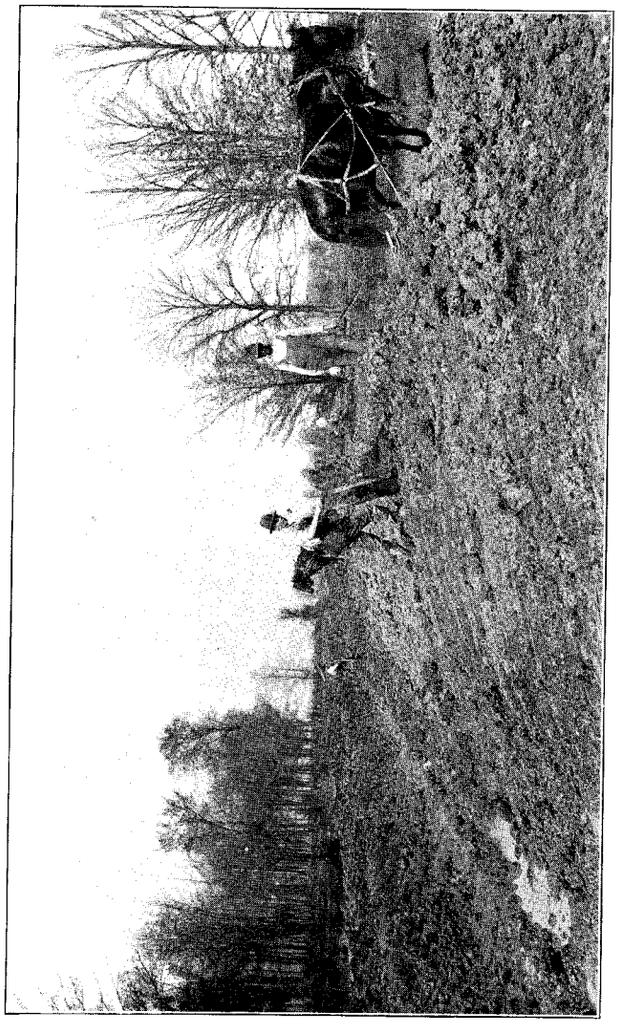
SUGGESTIONS ON DESIGN OF DRAINS

Certain defects of the present Michigan drain law with respect to the handling of the larger projects has resulted in the construction of too many small independent drains. In this manner many areas of considerable size have been drained piecemeal by the expensive and unsatisfactory method of building several small ditches which have been separately applied for, established and constructed where a single main outlet with a well planned system of laterals, looking towards the drainage either of the entire watershed or of complete units, would have served all the lands much better. Too often small drains constructed independently, without following any general plan has resulted in discharging the water from the individual drains into existing natural or artificial water courses which already may be overtaxed; resulting in the flooding of the lower lying lands, thus aggravating the necessity for improvements of the watercourses. Because of this situation, in fairness to all, an adequate outlet for all the lands should be designed after the manner indicated by the map in Figure 4, and in accordance with suggestions which follow later in this report.

The tendency in the construction of county drains in Michigan has too often been to limit the size and depth in order that they might be of a type readily constructed by teams and scrapers (Pl. III) or, as in many cases, by hand.

This frequently has resulted in securing ditches that were known to be of insufficient size at the time of construction and which has necessitated another petition for enlargement at a later date followed by all the other legal processes.

The evils which follow from this practice could be largely eliminated were the watershed considered in its entirety, or by complete units, and adequate outlets designed and constructed on this basis. Also in many cases contracts for the construction of part or all of the laterals could be let at the time of letting the contract for the outlet. In this way the contracts would be larger and attract more bidders owning and operating different types of ditching machines. Ultimately a much more effective type of drain would be secured than it is practical to construct by team or by hand. In the end the cost would also be less as the larger machine constructed ditches with



CONSTRUCTION OF OPEN DRAIN, THREE FEET BOTTOM WIDTH, FOUR FEET DEEP WITH BOARD SCRAPER AND TEAM

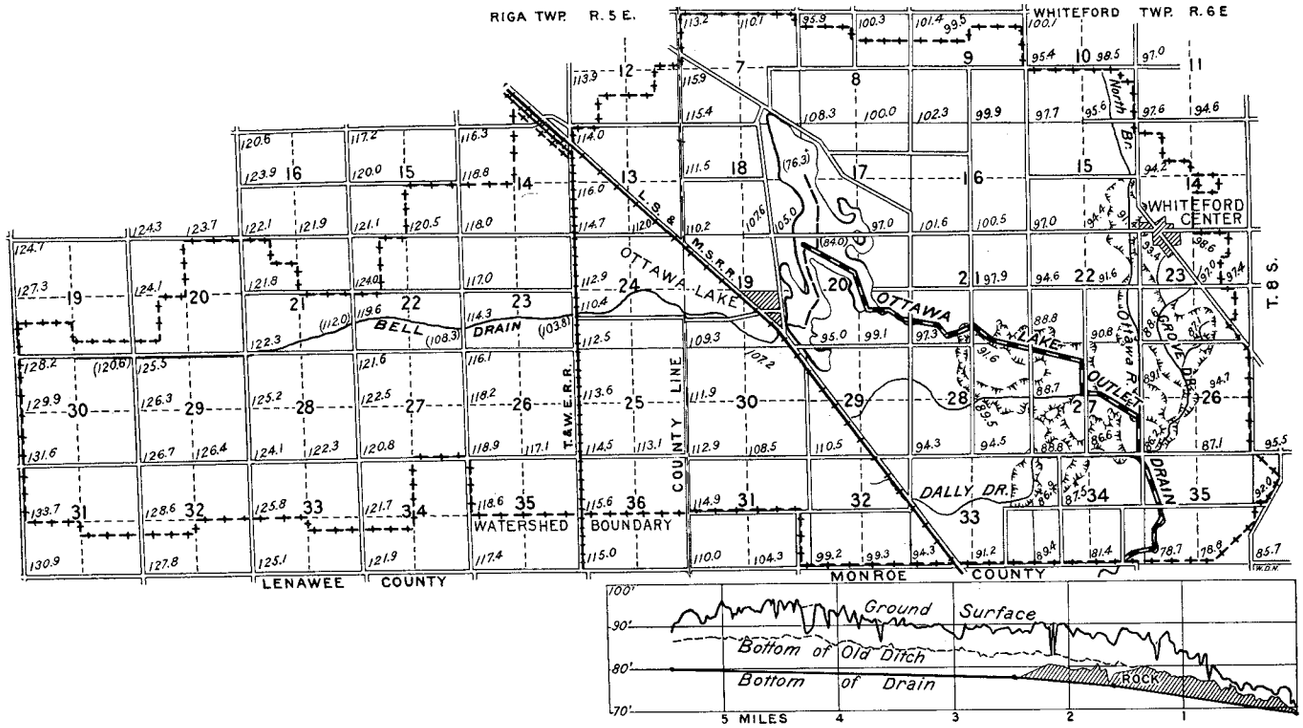


Figure 4. Map and profile of typical drainage project.

their greater capacities would require but infrequent cleanouts as compared with the smaller ditches. The drain shown in Pl. VI was constructed during 1918 to replace a shallow team and scraper ditch constructed but four years previously in 1914.

There are certain practical details that enter into the design of a drainage system which, of necessity must be left to judgment. Chief among these is the size and depth of the proposed ditch and whether it be open or tiled. It is not unusual for these details to be made wholly matters of guess work without a fair appreciation of certain well recognized underlying principals. The result of this is that often, in order to hold down the first cost, the drain is constructed too small and too shallow. This necessitates enlargement by deepening and widening at some future date, which all too frequently, is long postponed resulting in partial or entire loss of crops for several seasons because of insufficient drainage.

Run-off From Watersheds

In the design of a drainage system the first question arising is the quantity of water that must be cared for in order to give adequate relief. Now this quantity, called "run-off", will depend principally upon the amount and distribution of the rainfall and upon the size, shape and general nature of the area, or watershed under consideration—whether hilly or level—the type of soil, and the character of surface vegetation.

TABLE No. 8.

Number of storms occurring in different parts of Michigan during 15-year period from 1902 to 1917 inclusive. (Compiled from U. S. Weather Bureau Records.)

Station.	24-hour rainfall.			
	2–3 inches.	3–4 inches.	4–5 inches.	5–6 inches.
Alpena	5	0	0	0
Detroit	10	0	0	0
Escanaba (N. P.)	4	0	0	0
Grand Haven	11	3	2	0
Grand Rapids	19	2	1	0
Houghton (N. P.)	6	3	0	0
Lansing	7	2	0	1
Marquette (N. P.)	7	4	1	0
Port Huron	8	0	1	0
Saginaw	11	3	0	0
Sault Ste. Marie (N. P.)	3	0	0	1

The rains in Michigan come in a manner to make for economical drainage in that they are quite uniformly distributed throughout the growing season and exceptionally heavy rains of long duration such as cause a high rate of run-off, are of infrequent occurrence. Table No. 8 above clearly shows this and ditches constructed on

a basis of providing for relief from floods following a 24-hour rainfall of 2 to 3 inches will be satisfactory for ordinary drainage of agricultural lands throughout practically all of the State. However, in some few localities towards the northern part of the Southern Peninsula, and in some places in the northern Peninsula, the table indicates that 24-hour rains of 3 to 4 inches occur often enough to warrant some consideration in the future development by drainage.

Next in importance to rainfall the size, shape and general surface features of the watershed should be considered. Other things being equal, it naturally follows that the larger the watershed the greater the run-off, although the per cent of the run-off reaching an outlet ditch, within a given time, will be less for large watersheds than for small ones. The shape of the watershed should also be considered—as excess water from a long narrow divide or from a fan shaped watershed, all parts of which are more or less contiguous to the drain, will find its way to the drain more quickly than it will from a watershed of irregular shape, parts of which lie a considerable distance away from the drain. This does not necessarily increase the total amount of run-off but it causes heavier floods so that a larger proportion of the run-off is required to be cared for by the drain, within a given time. This can only be accomplished by increasing the size of the drain.

Next after the size and shape of the watershed the surface conditions should be given consideration as both the rate and actual amount of run-off will be greater from a hilly watershed than from a flat one.

The kind of soil is a factor in the matter of run-off as clay will shed surface water more rapidly than will soil of a sandy nature. For open ditches this is of considerable importance and also for the larger tile drains that are provided with inlets which permit the ready entrance of surface water. For a well designed farm lateral system of tile drains the variations in the type of the soil does not greatly influence the run-off as the drains are more closely spaced in the clay soils than in the sandy ones and consequently, while the water enters the clay more slowly than it does the sand, it has a less distance to travel after entering the soil before entering the drain.

After having made a study of the factors governing the run-off from a watershed the actual amount of water the drain should be designed to carry can then be estimated. This is best done by assuming that the ditch must be sufficiently large to remove a certain depth of water from the entire watershed within a period of 24 hours. This depth is generally expressed in fractions of an inch

and is usually spoken of as "coefficient of run-off." For open outlet drains for various sizes of watersheds representing average conditions in Michigan the coefficient of run-off should be ¾ inch in 24 hours, for the smaller watershed areas—one to five square miles; ⅝ inch in 24 hours for areas of 20 square miles; ½ inch for areas of 60 square miles; and ⅜ inch for areas of 150 square miles.

Table No. 9, following, has been compiled on this basis from the C. G. Elliott formula $C = \frac{673}{19.2 + \sqrt{M}} - 11.3$ in which C is the maximum rate of run-off in cubic feet per second per square mile and M is the drainage area in square miles. This table will serve as a guide to show the quantity of water for which it will be necessary to provide capacity in the drain if adequate drainage is to be secured.

TABLE No. 9.

Run-off from Michigan Watersheds.

Area.		Estimated Run-off (Cu. ft. per second).
Acres.	Square miles.	
500	0.8	18
1,000	1.6	34
1,500	2.3	50
2,000	3.1	65
2,500	3.9	80
3,000	4.7	95
3,500	5.5	110
4,000	6.3	125
4,500	7.0	135
5,000	7.8	150
5,500	8.6	165
6,000	9.4	180
6,500	10.2	190
7,000	10.9	205
7,500	11.7	215
8,000	12.5	230
8,500	13.3	240
9,000	14.1	255
9,500	14.8	265
10,000	15.6	275
11,000	17.2	300
12,000	18.8	325
13,000	20.3	345
14,000	21.9	370
15,000	23.4	390
16,000	25 0	415
17,000	26.6	435
18,000	28.1	455
19,000	28.7	475
20,000	31.3	495
25,000	39.1	590
30,000	46.9	680
35,000	54.7	765
40,000	62.5	845
45,000	70.3	920
50,000	78.1	990
75,000	117.2	1,305
100,000	156.3	1,550
150,000	234.3	1,925
200,000	312.5	2,170

As stated earlier the run-off from areas of equal size will vary, depending upon certain characteristics of the watershed. Consequently the quantities stated in foregoing table should be slightly increased or decreased as the local conditions seem to warrant.

Size and Shape of Open Ditches

After having estimated the run-off from the watershed and having ascertained the required capacity of the proposed drain the question of determining the depth and bottom width of the drain then arises. This will depend in considerable part, upon the grade or fall, that the drain will have, and upon the shape of the ditch,—whether side slopes are flat or steep. Generally throughout the State the side slopes are specified to be 1 to 1, 1¼ to 1 or 1½ to 1. It probably would be better were no slopes steeper than 1½ to 1 specified while for sandy soils the slope should be 2 to 1.

A deep ditch with a narrow bottom has slightly greater capacity than does a shallow ditch with a wide bottom when the amount of excavation for each is the same; it is more efficient as a drainage channel for the reason that it gives deeper, and consequently better drainage for the adjoining lands during all periods of small flow, and provides a much better outlet for the tile drainage systems of the individual farms. Also, water confined in a deep narrow channel flows more swiftly than it does in a wide shallow channel. This is important when the fall is light as the ditch with the highest velocity of flow will more nearly keep clean. A narrow bottom also serves better to confine the flow during low stages and thus eliminates the tendency to form bars such as are so frequently seen where the low water flow meanders back and forth across the bottom of a wide drain. However, it is not good practice to design open drains with bottom widths of less than 2 feet as small drains of this type are much better tiled.

Exceptions to the foregoing relative to the bottom widths should be made where the drains are constructed in sandy soils or in soft mucks. Under these conditions the bottoms of the ditches should be made wider and the side slopes flatter, no steeper than 2 to 1.

Ordinarily an open ditch should be so constructed as to carry a depth of water of not less than 6 feet during flood stages and as the size of the drain is increased the ditch should be designed to carry an increased depth of water. Ditches of these types must necessarily be machine constructed and more and more throughout the State the tendency is to build this better class of drains as indicated by Plates IV, VI, VII, VIII and IX in this Report. Such ditches afford good outlets for tile drains.

CAPACITIES OF OPEN DITCHES IN CUBIC FEET PER SECOND
(Based on Kutter's Formula (N. =.030) and side slopes of all ditches 1½ to1 .)

TABLE No. 10.

Depth of Water in Ditch 6.0 feet.

Fall in feet per mile.	Bottom width of ditch.										
	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0
1.0	90	110	135	160	185	210	235	260	285	315	375
2.0	125	155	190	224	260	295	330	365	405	440	530
3.0	155	190	235	275	315	365	405	445	495	540	655
4.0	180	220	270	315	365	420	470	520	570	625	755
5.0	200	245	305	356	410	465	525	580	635	700	845
6.0	220	270	335	390	450	510	575	635	700	760	930
7.0	235	295	360	420	485	550	620	685	755	825	995
8.0	250	315	380	450	520	590	655	730	.....	.....	.....
9.0	265	335	405	475	550	625	.....	.....	.....	.....	.....
10.0	280	350	425	500	.....	.....	.....	.....	.....	.....	.....

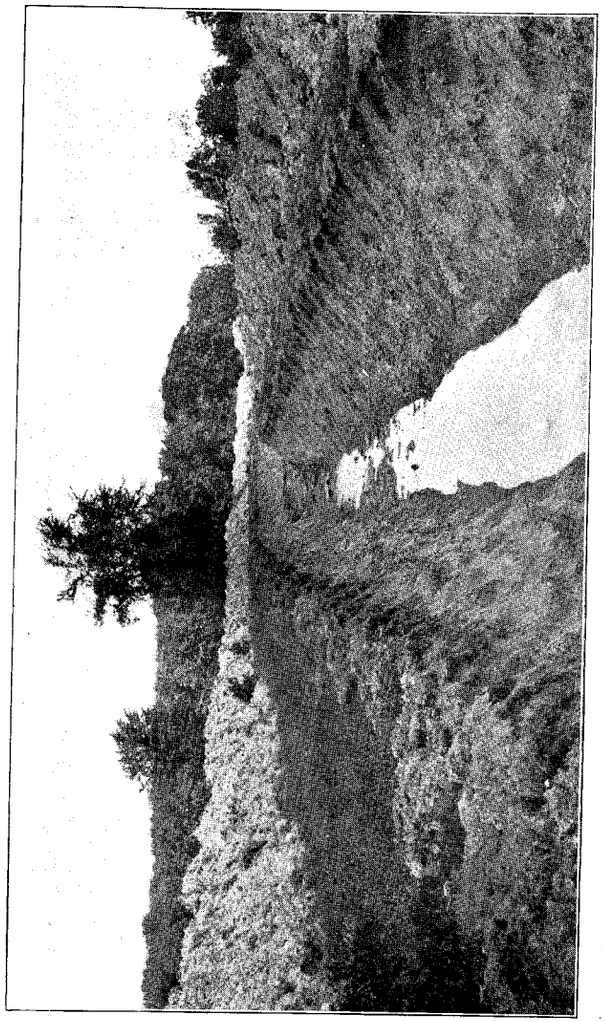
TABLE No. 11.

Depth of Water in Ditch 8.0 feet.

Fall in feet per mile.	Bottom width of ditch.									
	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0
1.0	215	255	300	340	380	420	460	500	540	650
2.0	310	360	415	470	530	590	645	705	760	905
3.0	380	440	510	580	645	720	785	855	930	1,115
4.0	435	510	590	675	745	825	905	985	1,065	1,280
5.0	485	570	655	740	830	920	1,015	1,105	1,200	1,430
6.0	530	625	720	810	910	1,010	1,105	1,205	.....	.....
7.0	575	675	775	880	.....	.....	.....	.....	.....	.....
8.0	615	720	.....	.....	.....	.....	.....	.....	.....	.....

Michigan Geological and Biological Survey.

Publication 28, Geological Series 23, Plate IV.



DREDGED DRAIN EIGHT FEET DEEP, SIX FEET BOTTOM WIDTH, IN CLAY SOIL. EATON COUNTY.

In accordance with the foregoing suggestions the following tables have been compiled showing the amount of water that open ditches of different bottom widths will carry. Side slopes in all cases 1½ to 1 and those ditches in Table No. 10 to carry water 6 feet deep, and those in Table No. 11 to carry water 8 feet deep, during flood stage. Taken in conjunction with Table No. 9 for run-off the proper size of open drains for watersheds within the limits of sizes covered by these tables, can readily be determined.

An open drain for a watershed should be so designed that it will not have insufficient capacity in certain sections and excess capacity in others. This will mean that no drain of any considerable length will be of the same size throughout its length. The ditch should be divided into sections and the run-off from the area of land draining through each section computed, beginning with the upper section and continuing in order with each section to the outlet. These sections need not be of the same length as this is often controlled by local conditions making it desirable to change the size of the drain where it changes grade or at a junction with another drain or natural water course.

Grade for Open Ditches

The grade of an open ditch should be as nearly uniform throughout, with as few changes, as possible. It will be impossible to keep the depth uniform and accomplish this—which will necessitate deeper cutting through the higher land resulting in a slight increase in the first cost of the drain. However, the general results will be much more satisfactory in that the ditch will keep cleaner, be more efficient and more nearly self-maintaining after construction so that the additional first cost will be well justified.

Width of Berm

The width of the berm is of importance in the problem of maintenance that develops after construction. This width should not be less than 6 feet for the small team constructed ditches and for the larger machine constructed ones a width of 8, 10 or 12 feet should be specified, depending largely on the depth of the ditch and the character of the soil. Pl. IV.

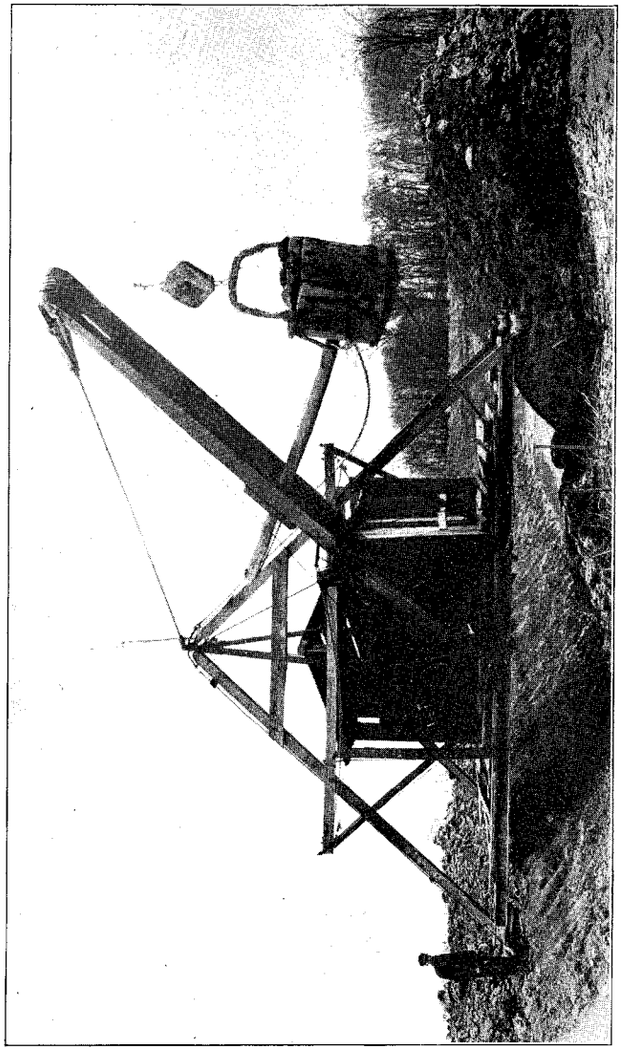
To illustrate the foregoing relative run-off and design of open ditches, suppose it be assumed that a project is under consideration, the total watershed of which embraces about 19,000 acres, 29.7 square miles, of gently rolling land. Assume the watershed to be fairly uniform in outline and that the soil of the area is part sand and part clay with some muck in the lowlands, a more or less typical

Michigan watershed. By survey the outlet drain proposed for the watershed has been found, should be 5 miles in length. Of these 29.7 square miles it has been determined that 5,000 acres will drain through the lower end of the upper section of the ditch which will be designated as Section No. 1 and which is ¾ mile long. It has also been found that 9,000 acres will drain through the lower end of the next section designated as Section No. 2 and this section is 1 mile long. Section No. 3 is 1¼ miles long and 14,000 acres drain through the lower end. The outlet end of the drain is at the lower end of Section No. 4. This section is 2 miles long and through the outlet the entire watershed of 19,000 acres drains. The survey shows that it is possible to construct the ditch so that Section No. 1 will have a fall of 2 feet per mile, Section No. 2, 4 feet per mile and Sections Nos. 3 and 4, five feet per mile.

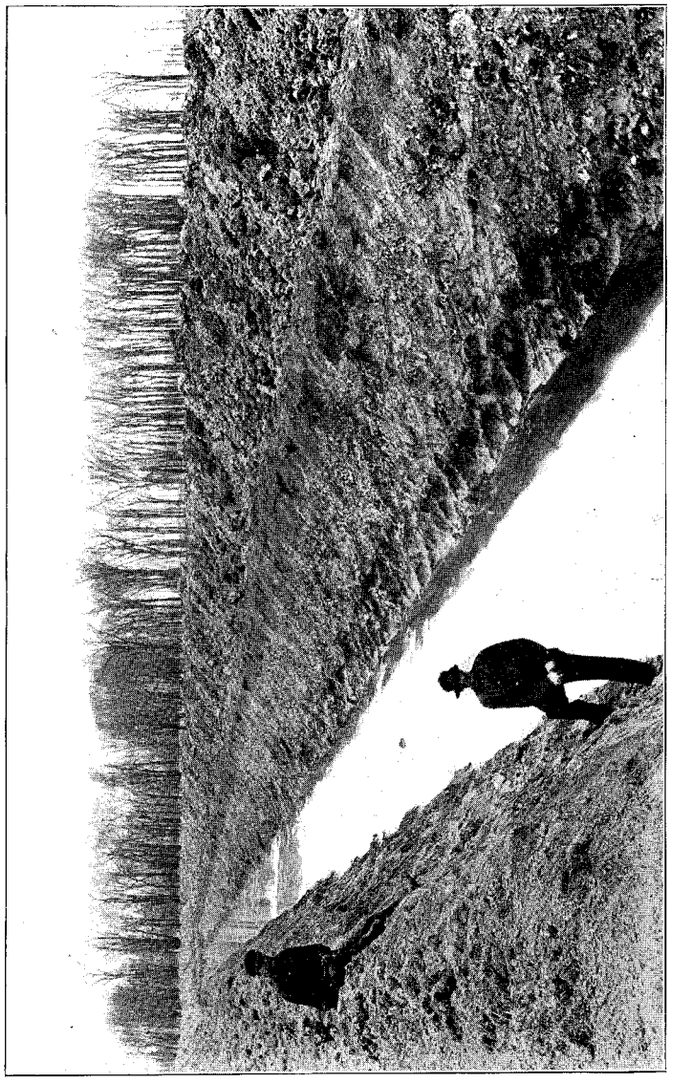
By consulting Table No. 9 it is found that Section No. 1 should have a capacity of 150 second feet, Section No. 2, 255 second feet, Section No. 3, 370 second feet and Section No. 4, 475 second feet. Now referring to Table No. 10 it is found that, with the fall per mile as determined for the several sections, a ditch with a 4.0 foot bottom, side slopes of 1½ to 1 and carrying water to the depth of 6.0 feet will be about right for Section No. 1 while for Sections Nos. 2, 3 and 4, the bottom widths should be 6, 9 and 12 feet respectively. The capacity of a ditch with a 9 foot bottom is not shown in the tables but from inspection it is obvious that such a ditch will come nearer having the desired capacity than one with either an 8 or a 10 foot bottom, as the quantity of 370 cubic feet per second is about half way between the capacity of the 8 and 10 foot bottom ditches when the fall is 5.0 feet per mile.

Such lateral drains as it will be necessary to construct in connection with the drainage of the larger watersheds should be designed on a basis of run-off from the area drained by each lateral in the same manner as for the outlet drain.

In the foregoing watershed of 19,000 acres assume it to be necessary to construct a lateral 1 mile long emptying into the main drain, having a fall at the rate of 5 feet to the mile, and through the outlet of which 3,000 acres will drain. The run-off from the 3,000 acres, as indicated by Table No. 9 will amount to 95 cubic feet per second. By reference to Table No. 10, it is readily seen that a ditch with a 2 foot bottom width, with a fall of 5 feet to the mile, will have more than twice the required capacity. As it is not to be desired that an open ditch with bottom width of less than 2 feet be constructed consequently this width should be specified for the lateral.



LAND DREDGE CONSTRUCTING DRAIN SHOWN IN PLATE VI. ST. CLAIR COUNTY



DRAIN EIGHT FEET BOTTOM WIDTH, EIGHT AND ONE-HALF FEET DEEP, CONSTRUCTED BY DREDGE SHOWN IN PLATE V, IN 1917, AT COST OF $7.25 PER ROD (ABOUT $.08½ PER CUBIC YARD) TO REPLACE SHALLOW TEAM AND SCRAPER DRAIN CONSTRUCTED IN 1914 AT A COST OF $1.00 PER ROD.

Open ditches with bottom widths, side slopes and fall per mile the same as in Tables Nos. 10 and 11, but designed to carry a depth of water of 7.0 feet, will have capacities which may be roughly estimated as half way between those given in Tables No. 10 and 11. When the depth of flow of water is 9.0 feet the capacities will be about 40% greater than in Table No. 10 and when the depth of flow is 10.0 feet they will be about 80% greater.

CONSTRUCTION METHODS

Greater progress has been made in the methods for handling contracts throughout the State generally than has been made in the organization and administrative affairs previously discussed and in many of the counties the construction and contract features of the work are on a substantial business basis.

There are still several localities where small open ditches constructed by team outfits are the rule. No doubt a great amount of land in Michigan has been drained by this method which however, is not, adapted to the construction of the deeper, more effective and more modern type of ditch which is rapidly displacing the shallow team constructed ditches in so many communities. But it has been found, that as the communities developed and more lands were cleared and the demand for the lower lying lands increased, that deeper and larger drains were needed in order to prevent overflow and to more completely drain the lower lying lands.

The necessity for new and deeper drains has led to the use of dredges of which there are two general types, the land dredge as illustrated by Pl. V, and Pl. IX, Fig. 1, and the floating dredge as illustrated by Pl. IX, Fig. 2. The land type of dredge is adapted to the construction of open drains with sloping sides, depths from 6 to 14 feet and bottom widths from 4 to 12 feet. The floating dredge is adapted to the construction of larger drains and ditches in swamp land which is too wet and too soft for any of the land type machines.

Outlets

A very fundamental part of any drainage system is an adequate outlet, the securing of which is sometimes a serious problem. Exemplifying this Pl. VIII, Fig. 2, shows the outlet for a drain which was dredged through a sandy ridge. This channel originally was opened with the land type of dredge similar to that shown in Pl. V. The original dimensions of this channel were about as follows: depth 23 feet, bottom width 4 feet, top width 28 feet. Dimensions at the

time the picture was taken less than two years after the channel was opened were found to be: depth 24 feet, bottom width 35 feet, top width 125 feet. Conditions seem to indicate that the material was at that time about stable and that very little, if any additional enlargement would take place.

In Pl. X, Fig. 2, is shown the lower end of a dredged ditch which has become more than half filled with fine sand and silt carried down by the water and deposited because there was no outlet below and the drain as located had very little, if any, fall.

Pl. XI, Fig. 2, shows the lower end of a drain which is so near the main stream that a satisfactory outlet cannot be secured until the water in the main stream is lowered and Pl. X, Fig. 1, shows a dredged ditch farther back from the main stream than the one shown in the preceding picture. At this point a good outlet can be secured. The soil of this particular area is muck and clay and is very fertile.

In the construction of drains to reclaim wet land it sometimes becomes necessary to construct outlets through ledges of rock. The outlet for the district shown on the map and profile in Fig. 5 is of this type. Pl. XI, Fig. 1, shows a waterfall over a rock ledge about 36 feet in height located in the Northern Peninsula. A large area of land along the stream above the falls cannot be drained until the rock ledge is lowered and a better outlet provided for the lands along the river above the fall. In one portion of the valley along this stream a few drainage ditches have already been constructed.

The utilization of land occupied by spoil banks along machine constructed channels may be carried out very successfully by grading off the material. In some counties it is specified that the contractor so spread the earth taken from the ditch that it may be readily leveled by the owners of the adjacent land. The beneficial results of such a practice is well illustrated by Pl. VII, showing a drain where this has been done and where the land ordinarily occupied by spoil banks is under cultivation.

Uniform Method of Staking Ditches

In the examination of the drain records in the different counties it was noted that no uniform practice prevails as to the length of the station used in staking the ditches, previous to receiving bids. In some counties a stake is set every 4 rods or 66 feet, in others every 6 roads or 99 feet, in still others every 100 feet while in many the stakes are set every 8 rods or 132 feet. The law specifically provides that the drain commissioner "shall set survey or grade stakes not more than eight rods apart," Compiled Laws of Michigan, 1915, Section 4881. Consequently the greatest length of stations allowable is definitely

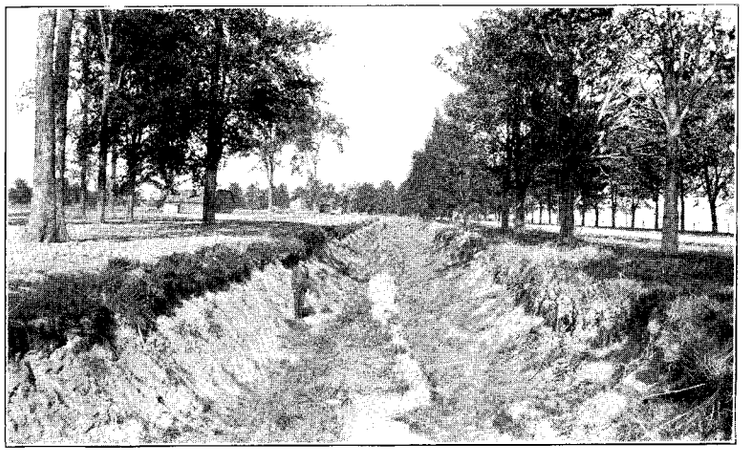


Fig. 1. DREDGED DRAIN WITH SPOIL BANKS LEVELED AND CULTIVATED.

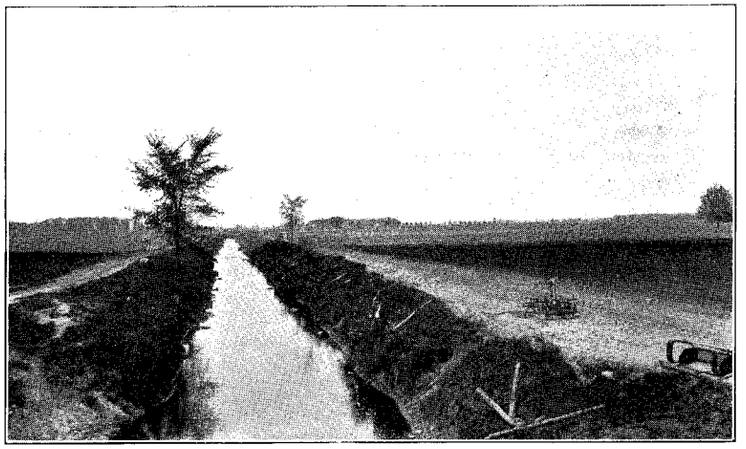


Fig. 2. DRAIN, WITH LEVELED SPOIL BANK, DREDGED IN 1896 MADE POSSIBLE THE RECLAMATION OF A LARGE AREA OF FERTILE LAND.

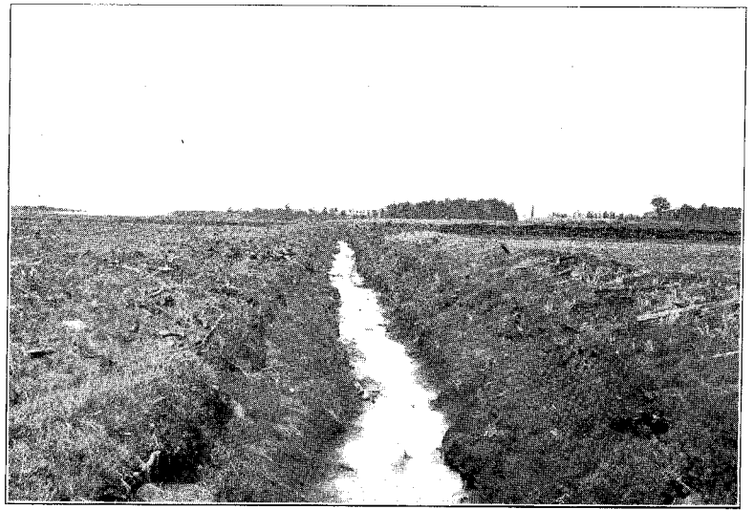


Fig. 1. DREDGED DRAIN THROUGH MUCK SOIL, SANDY SUBSOIL. SANILAC COUNTY.

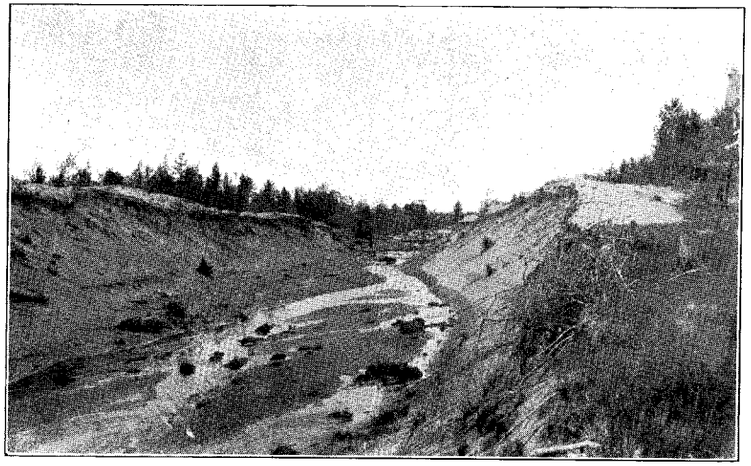


Fig. 2. DRAIN 23 FEET DEEP THROUGH RIDGE OF SAND, MUCK SUBSOIL. TO DRAIN SWAMP BACK OF RIDGE. HURON COUNTY.

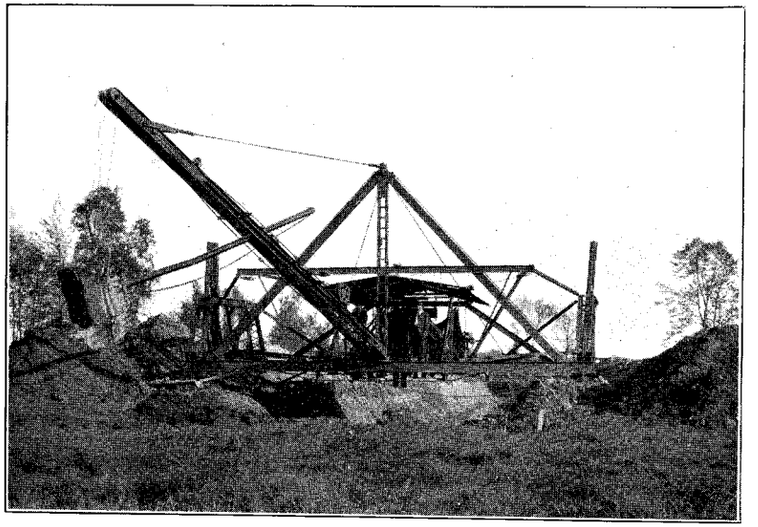


Fig. 1. LAND TYPE OF DREDGE CONSTRUCTING OPEN DITCH TEN FEET DEEP AND TWELVE FEET BOTTOM WIDTH

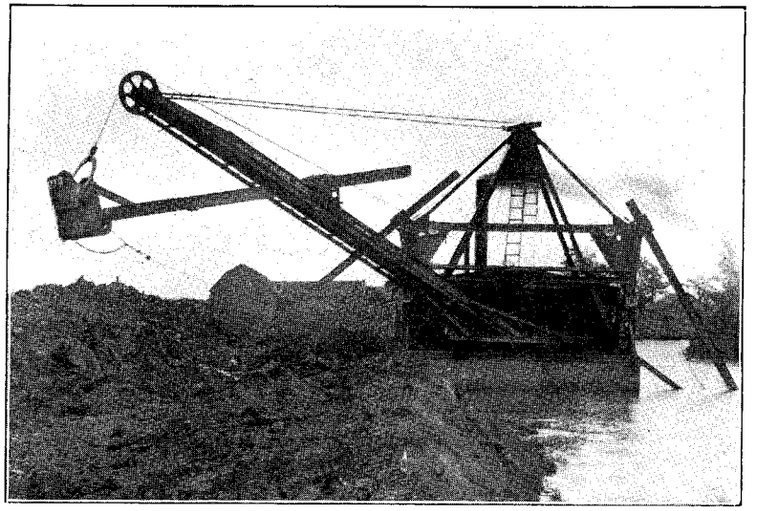


Fig. 2. FLOATING DREDGE, TWO-YARD DIPPER, SIXTY-FOOT BOOM, 28x30 HULL. SAGINAW COUNTY.

Fig. 1. DREDGED DRAIN WHICH DISCHARGED INTO LOWER FLAT AREA. THIS TYPE OF DRAIN MAY BE ADVANTAGEOUSLY REPLACED WITH TILE WHEN PROPER OUTLET IS PROVIDED.

Fig. 2. DREDGED DRAIN PARTLY FILLED WITH SEDIMENT BECAUSE IT IT HAS NO OUTLET.

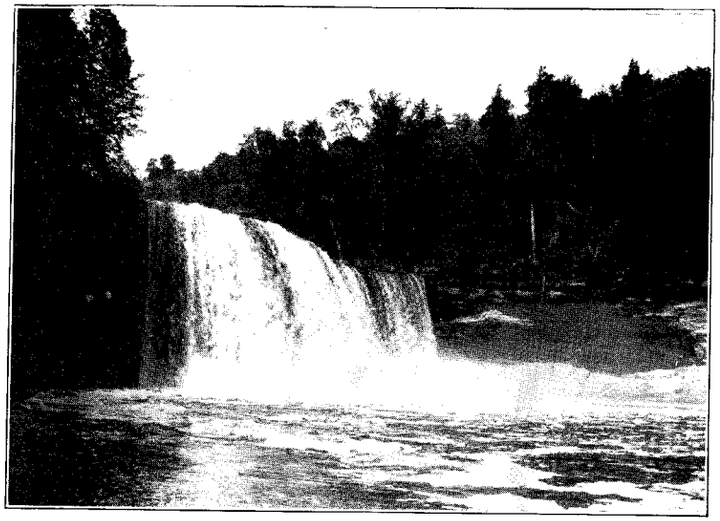


Fig. 1. FALLS THIRTY-SIX FEET HIGH ON THE TAHQUAMENON RIVER IN CHIPPEWA COUNTY. THE ROCK LEDGE AT THIS POINT OBSTRUCTS THE OUTLET FOR DRAINS IN THE VALLEY ABOVE THE FALLS. IN CHIPPEWA AND LUCE COUNTIES.

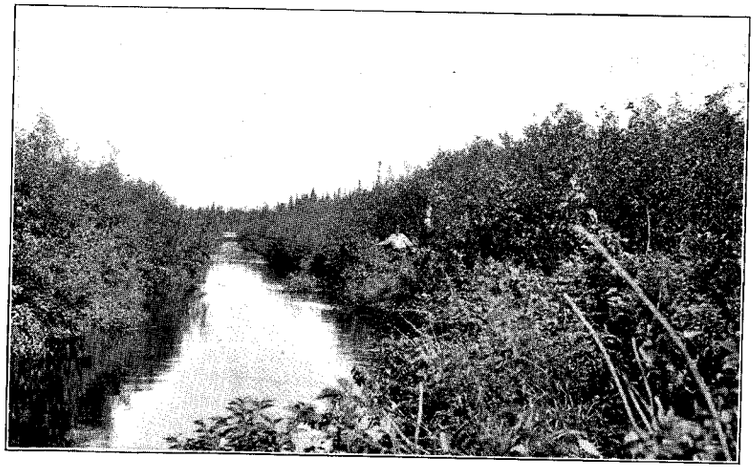


Fig. 2. DREDGED DRAIN WHICH HAS POOR OUTLET.

fixed but otherwise the length is entirely optional. It would simplify somewhat the prepartions of estimates and also make for a uniform method throughout the State, and at the same time conform with the general practice followed in all other public works, if the ditches were staked in 100 foot stations.

Cubic Yard Basis for Letting Contracts

In many of the counties it is still the custom to let the contracts for excavation, whether new or clean out work, on a basis of so much per rod of ditch leaving the bidders to estimate the volume of material to be moved. It would be more satisfactory were these contracts let on a basis of cubic yards of material to be excavated. An estimate of this kind has many advantages for the smaller drains and is almost indispensible for the larger machine constructed ditches, as a bidder must have this information if he is to bid intelligently on the job. If it is not of record, based on careful calculation, he guesses at it and in order to be safe generally guesses high.

In several counties this practice is already quite generally followed and were it done in all it would then be possible for contractors to bid more intelligently, and for drain commissioners to compare on a fair basis, prices paid for work in different counties. It would also enable a commissioner to more intelligently compare prices paid in different jobs in his own county. The yardage, after computation, should be made a part of the "Minutes of Survey" with the length, bottom width, depth, side slopes, width of berm and grade of the ditch and should be included in the published "Notice of Letting." This would give prospective bidders a definite idea of the nature of the work under consideration and in the end, in connection with a uniform length of station, would serve to further standardize and reduce the cost of the work throughout the State.

TILE DRAINS FOR COUNTY WORK

The use of tile in county drain work is increasing as indicated by the fact, previously stated in this report, that 60 per cent of the tile so used has been installed during the five year period, 1913 to 1917. This increase in the use of tile conforms with the practice in other States. In Pl. XII, Fig. 1, is shown 27-inch tile that are to be used in the reconstruction of the shallow open ditch shown in the same picture. In Pl. XII, Fig. 2, is shown the outlet of a 36-inch tile drain. The road culvert just above the outlet of this drain is necessary in this particular case because it is not possible that all the storm water which reaches the valley be carried off by the tile drain but a certain

portion of it will flow over the surface of the ground. Culverts of this type are to be found quite frequently.

Substitution of tile in county work for the smaller open ditches has many advantages. Chief among these is that, for a slight increase in first cost, a drain is obtained which wastes no ground, does not cut up fields, calls for but little maintenance, and is as efficient many years after construction as it was at first. So many of the small open ditches are no sooner constructed than they begin to fill in and become less and less effective as time elapses, finally necessitating a clean-out which ordinarily results in an expense about equal to the first cost of the drain.

The limit to the size of tile for county drains beyond which their use cannot be justified on account of the cost, must necessarily vary because of local conditions such as the slope of the land, soil and subsoil, and also upon the general development of the farming community. With the prices such as prevail in Michigan during normal times, the use of tile as large in diameter as 24 inches certainly is warranted and in many cases the use of tile larger than 24 inches is well justified. Much depends, however, upon the fall available, as the greater the fall the more capacity a tile will have. This means that the area which can drain through a tile of any size will increase as the fall increases. It is nearly always possible to so design the drainage system that the fall will somewhat exceed the natural surface slope of the land. This can be accomplished by deepenng the open ditch part of the system, giving the tile lines good deep outlets. These tile outlets, while being deep, should not be so near the bottom of the open ditch that they will be submerged, excepting for short periods during highwater stages. The depth to which the tile should be laid in the line should be governed by the top of the tile rather than by the bottom as is done in so many cases and which has resulted in laying many of the large size tile too shallow. Generally for county drains this depth should be not less than about 4½ feet which will mean that the bottom of a 15-inch tile—allowing for the thickness of the tile walls—will be very nearly 6.0 feet below the ground.

Table No. 12 following has been compiled to show the amount of land which different size tile will care for when laid with a fall per mile ranging from 1 foot to 26.4 feet per mile. This fall has been expressed in three different ways in the table, as a matter of convenience. The areas are figured for outlet drains where surface water is admitted directly into the tile by suitably constructed inlets and consequently from a drainage standpoint the tile will act essentially as an open ditch with respect to the removal of flood waters. For drains where surface water is not admitted directly into the tile the number of acres which each size of tile will care for, when laid with

Michigan Geological and Biological Survey.

Publication 28, Geological Series 23, Plate XII.

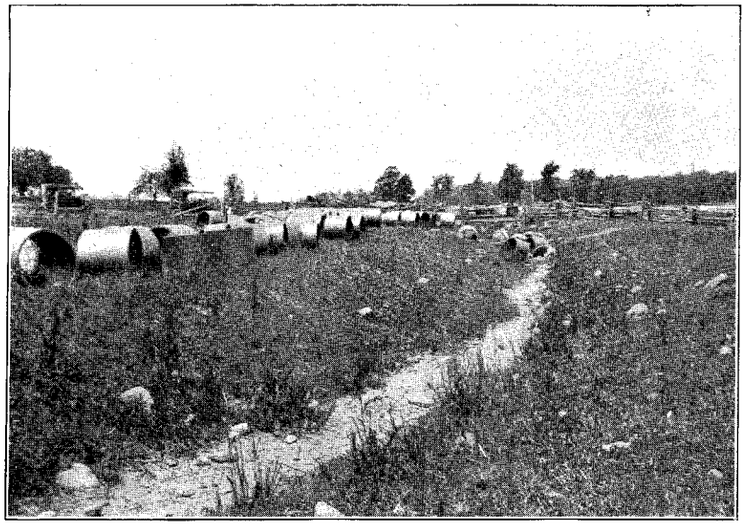


Fig. 1. OLD TEAM AND SCRAPER DITCH TO BE REPLACED BY 27-INCH TILE DRAIN. EATON COUNTY.

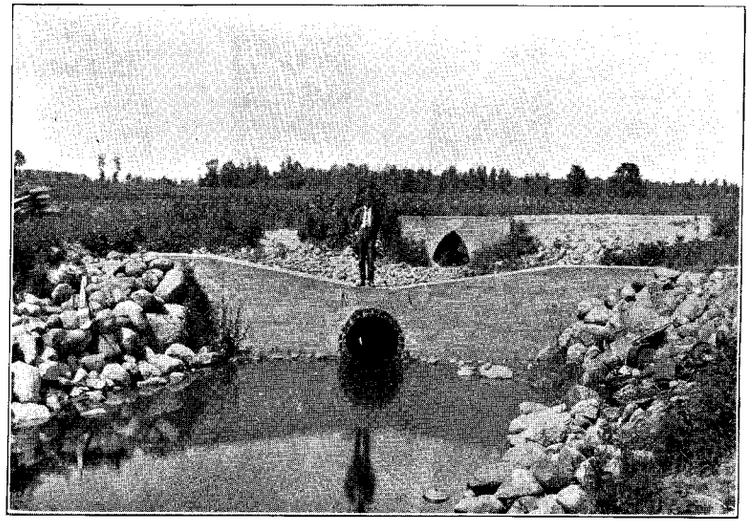


Fig. 2. OUTLET OF 36-INCH SEGMENTAL BLOCK DRAIN. EATON COUNTY.

TABLE No. 12

Number of acres drained by Tile Outlet Drains where surface water is admitted to the drain through inlets.

Fall in feet per mile.	Fall in feet per 100 feet.	Diameter of tile in inches.										Fall in inches per 100 ft.
		6″	8″	10″	12″	15″	18″	24″	27″	30″	36″	
2.64	0.05	4	9	17	29	53	89	198	311	328	600	19/32″
3.17	0.06	4	10	19	32	59	98	217	343	362	663	23/32″
4.22	0.08	5	12	32	37	68	114	252	397	420	767	31/32″
5.28	0.10	6	13	25	42	77	128	282	446	471	857	1 3/16″
6.60	0.125	7	15	28	47	87	143	318	500	528	962	1 1/2″
7.92	0.15	8	16	31	51	95	157	348	549	580	1,056	1 13/16″
9.24	0.175	8	18	33	56	103	170	377	591	625	1,140	2 3/32″
10.56	0.2	9	19	35	60	110	180	404	635	670	1,221	2 13/32″
15.84	0.3	10	24	44	73	136	224	496	780	823	1,500	3 19/32″
21.12	0.4	12	27	51	85	157	259	573	900	948	1,728	4 13/16″
26.40	0.5	13	31	57	95	176	290	642	1,005	1,062	1,935	6

Based on Kutter Formulae (N = .015). For farm drains or outlet drains where surface water is not admitted to the drain through inlets the number of acres drained by each size of tile may be doubled.

Note: Rate of run-off used, ½″ in 24 hrs.

the fall as indicated, will in each case be twice that given in the table.

The latter class of tile drains might well be used to gradually replace many of the small open ditches as they come up for clean out. As in many cases these small ditches have been constructed rather from the standpoint of under drainage than for the removal of flood waters and could safely be designed on the basis of ability to care for twice the area as indicated in Table No. 12.

INSPECTION

At frequent intervals in the progress of the construction of county ditches, it is advisable that the work be checked. In all cases before final acceptance enough measurements and levels should be taken by the engineer to definitely ascertain whether the depth and other dimensions of the ditch are in accordance with the specifications. The depths of the drain should be checked by the engineer from established benchmarks wherever possible. For tile work inspection and checking of grades and depths during construction of the drain and before final acceptance is even more important than for the open ditches.

MAINTENANCE

All drainage systems require some maintenance after construction, if they are to retain anything near their maximum efficiency. Rapidity of deterioration of ditches varies under different conditions of soil, subsoil, size and shape of cross sections, grade of the drain and upon the nature of the vegetation that thrives along the slopes of the ditch. The drain should be kept free from logs, brush, sods, from cave-ins, refuse and other obstructions. The slopes of the ditches should be kept free of rank growths of weeds and willows and saplings should be kept grubbed out. This was not done in the case of the drains shown in Pl. XIII, Figs. 1 and 2. In fact, everything that reasonably can be, should be done to maintain the efficiency of the drain for only by so doing can an expensive cleanout be long delayed.

Experience in other States indicates that a ditch properly maintained will cost less to the landowners over a period of years than if constructed and allowed to deteriorate until a reconstruction is necessary. As in the case of the ditch shown in Pl. XIII, Fig. 1, which is to be replaced by a machine dug ditch similar to that shown in Pl. IV.

The maintenance of tile drains is much less of a problem than that of the open ditches but they sometimes require attention which if long delayed, may necessitate the digging up and relaying of considerable sections.

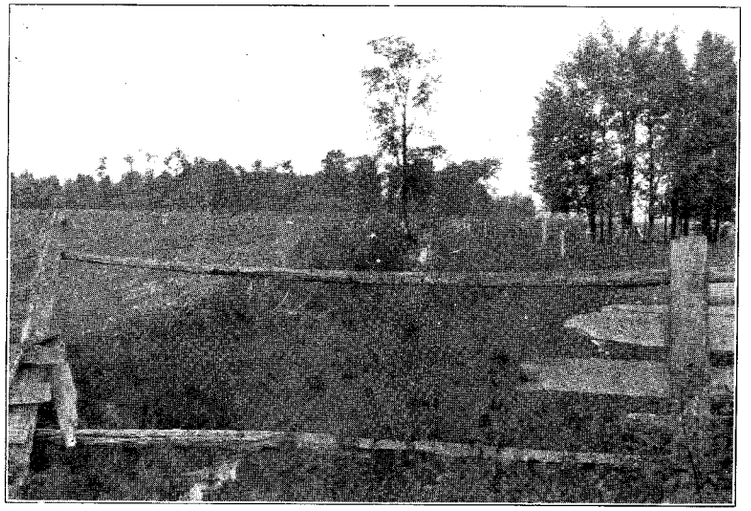


Fig. 1. OPEN DRAIN NEARLY FILLED IN. CONTRACT LET FOR RECONSTRUCTION WITH LAND TYPE DREDGE.

Fig. 2. TYPICAL OLD OPEN DRAIN IN MARSH PASTURE LAND. DRAIN ENTIRELY FILLED IN AND GROWN UP WITH VEGETATION. LARGE TILE WOULD BE PRACTICAL FOR REPLACING THIS DRAIN.

CHAPTER IV

THE MICHIGAN DRAIN LAW

PURPOSE OF THE LAW

The construction of drains is provided for in Chapter 93 of the Compiled Laws of Michigan, 1915, and in the Public Acts of the Legislature, 1917. The legislature has also passed certain acts which amend the provisions of certain sections of the general law in certain counties.

Since the passage of the law its constitutionality has been established by the Supreme Court of the State and various judicial decisions have made clear obscure provisions of the statute. The Act provides "For the construction and maintenance of drains and the assessment and collection of taxes therefor, and to repeal all other laws relative thereto." The law states, (Chapter 93, No. 4870, Sec. 1) "that drains may be located, established, constructed and maintained, and drains and water courses may be cleaned out, straighened, widened, deepened and extended whenever the same shall be conducive to the public health, convenience or welfare, (No. 4871, Sec 2). The word "drain" whenever used in this act shall be deemed to include any water course or ditch opened or proposed to be opened, and improved for the purpose of drainage and any artificial ditch or drain, levee, dike, or barrier, or tile drain proposed or constructed for such purposes."

The responsibility for initiating the petition for the drain rests entirely with the land owners whose lands will be traversed by such drain, who must file an application requesting the establishment of the drain with the county drain commissioner. The drain, but not the assessment district, is covered by the petition.

After the application is filed, the drain commissioner becomes the executive officer charged with the duty of carrying out the provisions of the law. The operation of the law and the relationship of the various parties to the proceedings are shown in diagram, Figure 5, to which references are made in the following paragraphs.

PROCEDURE IN ESTABLISHING A DRAIN

The law provides that when it is desired to take action in regard to a given drain that an application requesting the desired action, signed by not less than one-half the freeholders whose lands are traversed by the drain, shall be filed with the county drain commissioner (1, Figure 5).

Upon the filing of an application for a drain, the county drain commissioner is required to submit the petition to the township board in the township through which the drain passes (2, Figure 5).

The board advertises in a newspaper for one week and holds a meeting and proceeds to determine the necessity of said drain and whether the same is necessary and conducive to the public health, convenience and welfare. At this meeting all persons whose lands are liable to assessment for the drain, or whose lands are crossed by the drain may appear for or against the drainage proceedings. After hearing the evidence offered, the board determines whether or not the drain is necessary and conducive to the public health, convenience and welfare. If the board's action is unfavorable the petition is dismissed and no further petition for the drain is legal within one year of the date of such determination. If the board's action is favorable an order is made to that effect and filed with the county drain commissioner (3, Figure 5).

The commissioner, as a means of determining the practicability of the drain, now has a survey made of the proposed drain (4, Figure 5). The minutes of the survey are then prepared from the notes of the survey for use in the First Order of Determination. (5, Figure 5.)

If the commissioner finds that the drain is practicable, he makes the First Order of Determination naming the drain and giving the essential facts in regard to it and the drain is staked out on the ground to show its exact location as described in the petition. (6, Figure 5.)

Until twenty days after the first order of determination any person who may consider himself aggrieved by the determination of necessity or by the survey, may make application to the probate court for the appointment of an engineer. Upon receipt of such application the court notifies the County Drain Commissioner and the State Highway Commissioner. It is the duty of the State Highway Commissioner to appoint an engineer, who confers with the County Drain Commissioner and the aggrieved land owner and makes such investigations and surveys as he deems proper to determine the necessity for the drain. His decision in regard to the necessity for the drain is final.

The drain commissioner, after making the first order of determination proceeds to secure right of way for the drain. This seemingly minor matter is in reality a very considerable task on most drains, (7, Figure 5). In the event that any land owner refuses voluntarily or is prohibited by law to grant a release of right of way the commissioner makes application to the probate court for

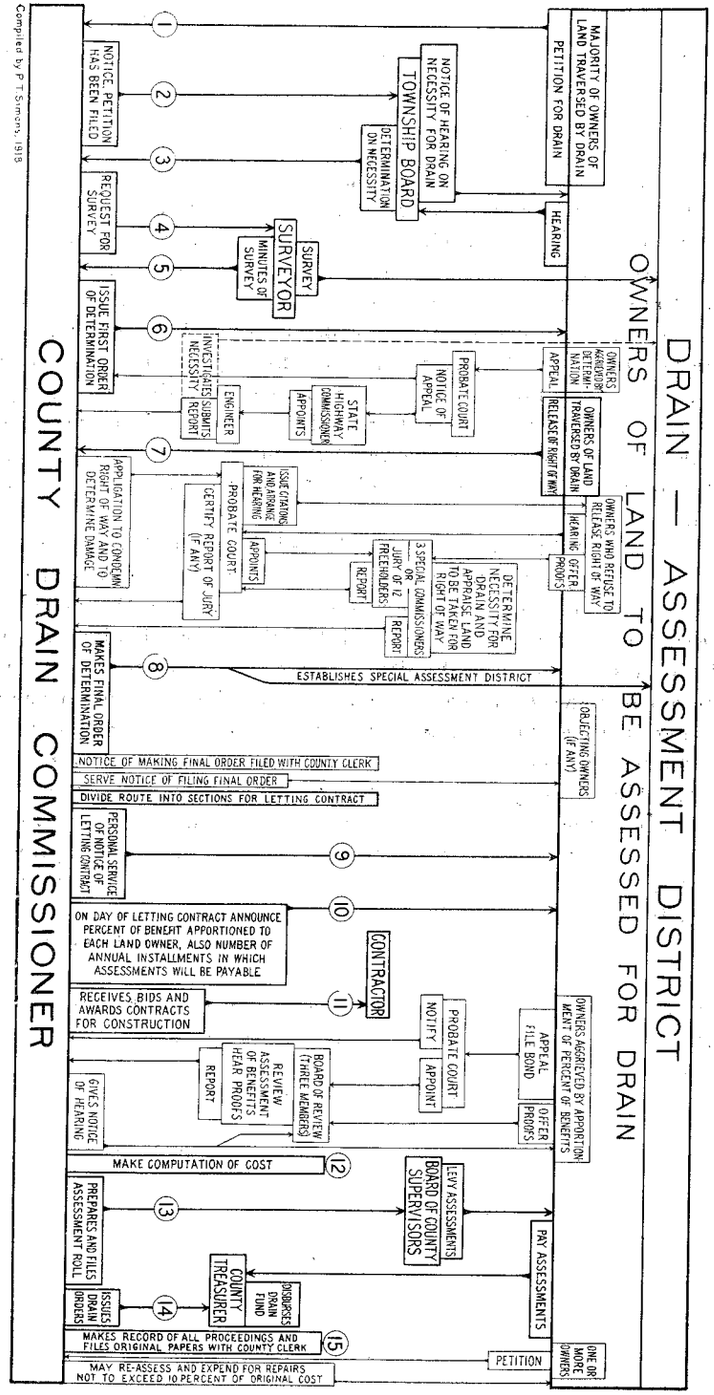


Figure 5. Diagram showing operation of Michigan Drainage Law

the appointment of three special commissioners or a jury of twelve freeholders to determine the necessity of the drain and for the taking of private property for the use and benefit of the public, and the just compensation to be made for the property taken.

The probate court to whom such application is made makes an examination of all the proceedings of the county drain commissioner so far as had and if they are found in accord with the statute the court sets a time and a place for the hearing and issues a citation to all persons who have not released rights of way and all who claim damages, to appear at the time and place and be heard. The court, at the time and place set, proceeds to hear all persons whose lands are traversed by the drain. If no sufficient cause is shown against granting the application, the court makes an order appointing three disinterested and competent freeholders as special commissioners to ascertain and determine the necessity for such drain and to appraise the compensation to be allowed to the owners of the property to be taken for the right of way.

Any freeholder who has not released the right of way may demand a jury at any time before the appointment of the special commissioners. The special commissioners or jury view the premises and hear the interested parties, and file their award with the county drain commissioner. The drain commissioner deducts the damages from the benefits when made and pays the balance to each land owner in case the damages exceed the benefits. Special provision is made for securing right of way across the property of railroad companies. The jury, if one be appointed, makes its report to the probate judge who reports to the Drain Commissioner. The special commissioners or jury may determine the drain to be unnecessary and in such case the drain commissioner shall dismiss the proceedings for a year at the cost of petitioners.

After all the right of way for a drain is secured the drain commissioner makes a Final Order of Determination establishing the drain along the route designated by the survey (8, Figure 4) and then proceeds to determine which lands will be benefited by the drain and to establish the special assessment district to apportion the per cent of benefit to each tract of land and to let contracts for the construction of the drain.

The county drain commissioner is required to give not less than 10 days notice of the time and place of letting by serving personal notice upon every person whose lands are affected by the assessment and who reside in the township or township affected. Notice must also be given by publication and by posting notices in the manner prescribed by the law. The notice shall contain a description

of the lands to be assessed and shall also state that the assessment of per cent of benefits on the land within the district shall be subject to review on the day of the letting or at such other time and place as the county drain commissioner may adjourn to. (9, Fig. 5.)

This notice although it is termed "Notice of Letting Drain Contract," is primarily intended to serve as a notice to land owners to inform them that special assessments are to be made against their lands to pay for the drain.

At the time and place of letting and before receiving bids, the county drain commissioner usually by a vote of the tax payers, determines whether the taxes to be spread for benefits to lands shall be assessed and collected in one, two or three years.

For approximately 60 per cent of the drains in the State the assessments have been paid in a single installment and for nearly all of the other drains the assessments have been paid in two annual installments, three installments being very rarely used. On the day of the letting the drain commissioner announces the per cent of benefit apportioned to each tract of land. (10, Figure 5.) Bids are then received and contract let for the construction of the drain to the lowest responsible bidder. (11, Figure 5.)

The owner of any land assessed for any benefit or the construction of a drain who may consider himself aggrieved by the assessment made by the county drain commissioner, may, within ten days after the day of review, make application to the probate court for the appointment of a board of review. The court, upon receipt of such application shall notify the county drain commissioner and shall then appoint three disinterested freeholders of such county not resident of the township or townships affected, as members of the board of review. A time and place where such board shall review the assessment shall then be fixed. Due notice of the hearing must be given to all interested parties. At such hearing the board shall hear all parties with respect to the matter of appeal and shall view the lands benefited by the drain and review all assessments on such drain and if in their judgment there be manifest error or inequality in such assessment, they shall order and make such changes as they deem equitable. The action and decision of the board shall be final and shall be delivered in writing to the county drain commissioner.

The proceedings in establishing any drain is also subject to review upon certorari, provided the proceedings are instituted within ten days after the Final Order of Determination is filed with the county clerk.

Within ten days after the letting of contract, or in case of an appeal immediately after the appeal is decided, the county drain

commissioner shall make a computation of the entire cost of the drain which shall include all expenses incurred in connection with the same. (12, Figure 5.)

The county drain commissioner shall make a special assessment roll for the drain for each township or townships and city affected thereby. This roll shall contain all information necessary for levying the tax and shall be filed in the office of the clerk of the township or city in which such lands are situated. The clerk shall deliver a certified statement of the several amounts of drainage taxes to be assessed during the coming year and a description of the property to be assessed to the supervisor of the township. It is the duty of the supervisor to spread on his roll the total amount of the drainage taxes and the description of the lands to which they are assessed. (13, Figure 5.)

All drainage taxes assessed are subject to the same provisions and are collected in the same manner as state and other general taxes by the township treasurer and paid by him to the county treasurer. The county drain commissioner issues orders on the county treasurer for services rendered and work done. The funds for each drain are kept separately and expended for that drain only. (14, Figure 5.)

The clause "public health, welfare and convenience" is the basis upon which all taxation for public improvements is made.

The benefits, however, which result to any agricultural community when certain of the lands are improved and made to produce more by drainage are actual benefits and definitely increase the welfare of the community, the county and the State, and are not dependent upon any real or fancied betterment of the health and increase in convenience.

Drainage under the county system is in every sense a community problem although it is often hard for some of the property owners of the higher lying and better drained lands (whether naturally or artificially drained) within a watershed, to realize that their lands should be assessed for benefits for the construction of a drain, from which they may apparently receive no direct benefits. It is true, however, that the rain falls in equal amounts on the highest and on the lowest acre in the watershed. It is also true that as much falls on the driest acre as on the wettest and is no respecter of fence lines or the farm unit. A part of all this water ultimately must be cared for by the drain. It becomes a burden upon the community and it is impossible for the individual farm unit to escape the responsibility of assisting in some measure in caring for such part of the burden as originates on land comprising the unit. It matters not whether this water reaches the county drain directly or indirectly, whether through

small open or tile farm drains or whether it runs in plow furrows into the roadside ditches, and from there finally into some part of the county system. All lands contributing water to a drain are not equally benefited by the drain and because of this the principal of assessing the costs of the drain in proportion to benefits has been worked out and when this principal is carefully applied the results are probably as equitable as it is possible to make any system of taxation.

It is the duty of the county drain commissioner to make a full record of each drain in the drainage record books of the county (15, Figure 5). All original papers must be filed with the county clerk and the law provides, "that no drain tax shall be spread until all records have been deposited and filed in the office of the county clerk."

The county drain commissioner may without petition, on the written request of one or more tax payers on a drain, expend an amount not to exceed 10 per cent of the original cost in repairing the drain where in his opinion an emergency condition exists, endangering crops or property.

Whenever a drain or portions thereof needs cleaning out, any five freeholders of the town or township in which the drain is situated one or more of whom must own land liable for assessment, may make application to the county drain commissioner setting forth the necessity of such proposed work and the county drain commissioner shall then proceed in the same manner as provided for locating, establishing or extending a drain. If the work is found necessary, he shall fix the per cent of cost that the owners of the land benefited shall pay. Assessments shall be made according to benefits received and shall be subject to appeal as when a drain is established. The commissioner shall cause to be published at least once in a newspaper a notice which shall give the time and place of letting the contract; and shall also cause notices to be posted in regard to the letting in the manner provided by law. The steps thereafter to be taken as provided for in laying out and establishing a drain. If necessity for such cleaning out arises from the act or neglect of any land owners such act or neglect shall be taken into consideration in making the assessment. The county drain commissioner may in his discretion without application use any surplus funds for cleaning out obstructions.

In case a drain is to be deepened, widened, or straightened, the county drain commissioner shall make his First Order of Determination and steps thereafter shall be taken as provided for by law in establishing a drain.

All the powers conferred for establishing and constructing drains and for the enforcement of assessment, shall include the deepening, the widening or extending of any drain which has been constructed or may be constructed and the straightening, cleaning out and deepening the channel of creeks or streams and the constructing and maintaining, remodeling and repairing of levees, dikes and barriers for the purpose of drainage. The commissioner may relocate or extend the line of any drain if the same be necessary to secure an outlet, provided that no proceeding affecting the rights of persons or property shall be had, except upon like application, notice, hearing and award as provided for the construction of the drains.

Whenever any person shall obstruct any established drain it is the county drain commissioner's duty to compel the removal of the obstruction. The person causing such obstruction shall be liable for all expenses of removing the obstruction provided that the owners or occupants be given five day's notice to remove the obstruction.

DRAINS WHICH AFFECT MORE THAN ONE COUNTY

When it is decided to locate, establish, widen, deepen or extend a drain traversing more than one county or affecting land in two or more counties, an application therefor shall be made to the county drain commissioner of either county traversed by the proposed drain. The application shall be subject to the same obligations and liabilities as for a drain in one county except that the application is not passed upon by the township boards. If upon examination, the county drain commissioner shall deem the drain necessary and for the good of the public health, welfare and convenience, he fixes a time and place of meeting and notifies the county drain commissioners of the other county or counties to be affected and furnishes them copies of the application. The commissioners meet at the time and place fixed and thereafter jointly take all steps and perform all acts and sign all papers as county drain commissioners are required to do in other drains, including application to probate court.

If they are unable to agree in regard to anything pertaining to the drain they may appeal to the State Highway Commissioner who has the right to subpoena witnessess and take testimony relative to the drain, and his decision is final.

Right of way is secured in the same manner as for a drain in one county. Before the contract for construction is let, the county drain commissioners agree upon the per cent of the cost of construction that each county shall bear. If they cannot agree they appeal

to the State Highway Commissioner who apportions the costs between the counties. Each county drain commissioner then assesses the per cent of benefit accruing to the lands in the county for which he serves in the same manner as he would for a drain located entirely in that county. Each commissioner is required to make a full record of the drain in the drainage record book of the county for which he serves and a certified copy of each paper shall be filed in the office of the county clerk of each county.

Cleaning and widening, deepening or extending, on joint county drains are handled in the same way as for drains in one county by the drain commissioners of the counties affected by the drain in a manner similar to that provided for drains in one county and if they are unable to agree they may appeal to the State Highway Commissioner whose decision is final.

DEFICIENCIES IN PRESENT PROCEDURE

The first law provided means by which a farmer could secure an outlet across his neighbor's lands for the ditch necessary to drain his farm. As the country became more thickly settled the necessity for larger drains in which a number of land owners were interested became apparent and the first crude public drain law was passed. As need for better drainage developed, or a clearer idea of existing need obtained, the law was either amended or a new law passed. In this manner, the present methods of drainage in the State and the present drain law were developed.

Under the provisions of the Michigan drain law now in force about 9,300 drains, having a combined length of nearly 20,000 miles and costing over $18,000,000 have been constructed. The investigations show that in general this law has quite successfully served the purpose for which it was passed. As a rule the organization of and construction of the drains have been accomplished within a reasonable period of time after the work was initiated, although on many drains there have been serious delays. The administration and overhead charges in most instances have been low. At every stage of the proceedings ample opportunity is given to land owners who may feel aggrieved to appear and have any mistakes or injustices corrected. The litigation over drainage matters, except in a few counties has been almost negligible and the showing in this respect compares very favorably with that of other States.

In working under the law the officials charged with the administration of the affairs of the drain find that certain difficulties in the operation of the law tend to increase the time required to establish

and construct a drain, to make it impossible to always secure the most efficient drain and to increase the cost of a drain and in few instances to entirely prevent land owners from securing drainage outlets. Any or all of these difficulties may occur in connection with any drain.

The petition or application for a drain on which the whole proceeding rests covers a drain limited as to size, location and kind by the petition of individuals who may have, but who frequently do not have, the best information obtainable as to size, location, kind of, and most economic drain which might be used in a given territory. A majority of the owners whose lands are to be traversed by a drain must sign the original petition and it is not possible for other owners whose land would not be crossed by the drain to initiate a project no matter how wet their lands may be or how badly they may need improved drainage. Parties desiring to drain certain lands have been unable to secure a lawful petition because a majority of owners of land to be traversed by the drain refused to sign the petition, even though a majority of the owners of the land to be assessed to pay for the drain were in favor of the project.

The interpretation of the law which requires the applicants for a drain to state in the petition the location of a drain, its course, commencement and ending point often hinders work which would otherwise be undertaken or it leads to the construction of inadequate drains. In many instances an inefficient poorly designed drain has been constructed because the location or size was limited by the petitioners who were not fully informed as to the proper location or size which should have been adopted. In certain sections of the State property owners would prefer to leave these facts to be determined by a survey, but drain commissioners are not authorized to establish a drain which is not definitely located by the application. Furthermore, the land to be benefited is not described in the petition although it would appear that the approximate amount of land to be benefited should be known before the necessity for the drain is determined.

For a small drain the land owners usually have a good idea as to the general requirements but for a large drain they have no idea of the necessary requirements and this can be obtained only after surveys have been made to determine the essential facts in regard to the project and the ditches are then designed to give the required drainage. The law makes no provision for such surveys and requires that certain facts in regard to the drain or drains shall be fixed in the application and these cannot be varied later. In certain counties of the State the necessity for this information has been recognized

and it has become the common practice in these counties for the drain commissioner and the engineer to work out a plan of drainage for a given area before the application for the drain is filed. However, it would be much better if the application merely described the land to be drained and the general location of the drain or drains, leaving the details in regard to the location, points of beginning and ending, and the size and depth of the drain necessary, to the Drain Commissioner or Engineer, after sufficient data have been secured by the preliminary surveys on which to base the design of the system.

Prior to the letting of the contract no official estimate or cost of a drain is prepared and consequently the tax payers have no definite basis from which to determine the probable amount of money they will require to pay for the drain. However, various unofficial estimates of cost are prepared for practically all drains by tax payers or other individuals and usually data for such estimates are incomplete or meager. This method often leads to the preparation of unreliable statements under the guise of estimates which frequently results in arousing opposition to worthy projects because the estimates of cost are excessive or on the other hand, it may result in making projects of doubtful worth appear to be feasible because the estimates are too low. Because of this situation a reliable official estimate of cost is desirable for all drains of any considerable size. The lack of proper information on which properly to base the application has resulted in the construction of many ineffective drains, and in many cases has greatly increased the cost of the work. The investigations forming the basis of this report show that the best results have been secured where the drain commissioner has realized the advantages that come from the construction of properly designed drains, but in many counties where larger work has been handled without competent engineering advice, many expensive mistakes have been made.

The time required to secure action by the township board causes a serious delay in the proceedings without adding any apparent corresponding benefit. Frequently the board in ascertaining and determining the necessity for a drain acts in a superficial or arbitrary manner and in reality contributes nothing of value to the drain proceedings. When the drain passes through two or more townships the proceedings become unnecessarily cumbersome.

The actual value of land required for right of way is much less than the value of the special assessments which are levied to pay for drain yet the acts necessary to secure the right of way are frequently more expensive and require more time than the making of assessments of benefits. The practice of not requiring land owners

to claim damages on account of the construction of the ditch, or for the land taken for rights of way, has been followed for several years in Arkansas, Missouri, Mississippi, and other States which have or have had, large drainage problems and the same authority that assumes benefits also allows damages; Kansas recently so amended its drainage law as to provide for this. This method has the effect of simplifying and expediting the proceedure, lowering the cost and reducing litigation—all desirable changes from the viewpoint of the land owner. Ordinarily the authority that assesses benefits has made a complete study of the project and consequently is in a better position to equitably assess damages than is any other authority.

In some of the counties of the State considerable difficulty also has been experienced under the Michigan Act in securing rights of way from railroads for drains.

The amount of recording now required for each drain is large and considerable duplication occurs. Frequently for a drain of ordinary size the record covers 100 or more large record book pages. The minutes of survey after having been recorded once reappear many times in other papers. In one record that was examined it had been copied 13 times. In preparing statements to show the area of land embraced in assessing districts, the per cent of benefit apportioned to the separate tracts of land, and the assessment of cost of a drain, three separate statements or lists are prepared and recorded. The records could be materially shortened by combining these three statements and making a single lists of lands benefited. The number of acres of land assessed in each tract and the total acreage in the district are not recorded on the assessment roll.

The law makes no provision for paying expenses incurred in connection with the drains before the taxes are levied and paid except that payment may be made for the surveyor's services from the general fund of the county. Orders cannot be drawn on the drain fund until the contract is let and are not payable until March 15 of the year in which the taxes are required to be paid, and do not bear interest except after drain taxes become delinquent. The inability to make payments in cash for expenses incurred in connection with the drain does not make for efficiency.

The law requires that personal notice of the letting of a contract for the construction of the drain shall be given to all land owners whose lands will be assessed. Notice is also given by advertising in a newspaper and by posting notices. On a large drain where there are many landowners the serving of personal notices is a task of considerable magnitude, the necessity for which is not apparent.

In some States formerly having drain laws similar to the Michigan Act, considerable change in procedure has been made. Personal service of notice in regard to the drain or assessment rolls has been quite generally abandoned; notice being given by publication in newspapers and by posting of notices in public places in the district.

The contractor for the work performed on Michigan County Drains is required to finance the construction until the taxes are paid. When the taxes are paid in one year this is not a serious matter, but when the taxes are paid in two or three installments it may materially increase the cost of the work to the land owners.

Information obtained during the investigation indicates that in a few counties the increased cost where payment was deferred to two years was from 10 to 20 per cent, and probably averages about 10 per cent. This increase is substantially the same as is found in other States where payments are deferred. The ability to pay a contractor in cash materially reduces the cost of the work as the contractor is not required to discount the orders or carry them until funds are available.

In order to have a drain cleaned out it is necessary to file an application with the county drain commissioner who determines the per cent of benefit assessed to each tract and then proceeds as though he were constructing a new drain. There is a demand for a simpler and more expeditious method of cleaning out drains. Experience in other States indicates that an annual tax for maintenance is advisable and results in better drainage at a lower average annual cost than where the drains are repaired and cleaned only after the have become practically imperative.

No provision is made in the law for a land owner whose land is not traversed by a drain to secure an entrance to the drain across land owned by another party. If the matter cannot be arranged between owners the only way the outlet can be secured is by securing necessary signatures to an application and then constructing a drain in the manner provided by law. A simpler and quicker method than that now available is needed.

Many features of the present method of handling drains which affect two or more counties are not very satisfactory. Some counties may be vitally interested in a project but others may be interested but slightly. This inequality of interest is certain to cause delay where no centralized authority is provided. When a number of counties are interested in a drain the procedure becomes very slow and cumbersome as each county drain commissioner must sign all orders and papers connected with the work. If a drain were to be

undertaken involving one of the larger streams in the State, as many as 20 drain commissioners might be required to sign each paper. Such a large body cannot work efficiently and rapidly and would make the administrative expense heavy.

NECESSITY FOR BONDING PROVISION

The problems connected with the drainage of agricultural lands are complex, depending upon many factors and are continually changing. In the early days land was cheap and when the cost of contemplated drainage went beyond certain limits, it was deemed cheaper to buy other land with better natural drainage. As the value of, and demand for land increased it often became profitable to reclaim lands which a few years earlier the cost for reclamation would have made prohibitive.

In many localities small drains have been constructed which empty into a natural water course, which does not give an adequate outlet, and which must be dredged before much of the land immediately tributary to it can be properly drained. The improvement of this outlet is frequently expensive and the cost to the lower lying lands, which frequently are undeveloped, is so high that it is very difficult if not impossible for the land owners to pay for the construction under the method that now prevails. When cultivated lands could be cheaply reclaimed by a drain, the land owners could readily pay for the work in one or two years. As the cost of drainage increased it became difficult and sometimes impossible to do this. The necessity for paying for the construction of drains within a comparatively short time has had the effect of delaying or wholly preventing the construction of large projects draining an entire watershed although from every standpoint these larger projects are most desirable. This difficulty in constructing outlet drains is one of the reasons why so many small drains such as are so numerous on Plates I and II are constructed.

Many large tracts of timbered wet land are still to be reclaimed in the State, and many of these are so located that physical conditions make it necessary that they be drained as units, if adequate drainage is to be secured. Much of this type of land is so wet that it cannot be cultivated until it is drained, so that drainage of necessity must be the first step in the development of these lands. After the outlet ditches are constructed the lands must then be cleared and the field ditches built before they can be made to yield an income to the owner. As is well known by everyone who has had experience with

such lands this takes considerable time especially if the fields to be cleared are large. The farmer who is trying to reclaim such lands usually is not in a position to make large payments for the construction of drains. To meet this condition it is desirable that some arrangement be made under the terms of which the construction work can be financed and payment for the work deferred until the land is producing and yielding returns.

Many States having undeveloped wet lands similar to many of those in Michigan, have met this difficulty by giving the assessment district the right to issue bonds which later are paid off from the taxes collected from the landowners. These bonds command a ready sale and in many States the landowner is given the privilege of paying only the interest on the bonds for the first few years while the lands are being brought under cultivation, after which the bonds are then paid off in annual installments. This arrangement has worked well in Minnesota and many of the southern States.