

DRAINAGE.

INTRODUCTION.

THE FIRST CENSUS OF DRAINAGE.

The act of Congress providing for the Fourteenth Census, in the paragraph defining the scope of the census of agriculture, provides: "Inquiries shall be made as to the quantity of land reclaimed by * * * drainage and the crops produced; also as to the location and character of * * * drainage enterprises, and the capital invested in such enterprises." No provision for inquiries regarding drainage had been contained in any previous census act, and nothing comparable to a census of drainage has been taken heretofore.

In gathering these statistics, some difficulties have been encountered incident to a new investigation, and some due to the nature of an improvement that is partly hidden beneath the ground surface and that usually operates more or less effectively for a few years, at least, without expense or attention. These difficulties will be indicated more specifically in the paragraphs regarding method of canvass and accuracy of the statistics. It is believed, however, that the information obtained gives a reasonably accurate idea of the amount of farm land provided with artificial drainage; also of the extent and condition of land in enterprises organized for securing drainage in units of considerable size, which are larger than individuals could undertake and which affect many landowners; of the utilization of that land for agriculture; of the nature and extent of the drainage improvement works of those enterprises; and of the capital invested in them.

SCOPE OF THE DRAINAGE CENSUS.

The scope of the census of drainage is as defined in general terms by the act making provision for the Fourteenth Census. The number of farms having land provided with artificial drainage and the area of that land were determined, also the number of farms having land that needed drainage in order to be suitable for crops and the acreage of such land in farms. The area embraced in enterprises organized by a number of individuals to drain land that is used for agricultural purposes, or will be so used, also was determined, together with the condition of that land on the census date and before the drainage was undertaken. The figures for capital invested in enterprises to December 31, 1919, were obtained, with the estimated amounts required to complete construction of the improvement works authorized. The kind and amount of those works installed by the enterprises were learned.

The information concerning the character of the enterprises required that a study be made of the drainage statutes of the various states. The names of the principal crops raised on the drained land were obtained, but not the acreage devoted to each crop. In planning the census, it was deemed quite impracticable to attempt to segregate for each farm the crops produced upon land artificially drained.

The statistics for farms and farm acreage provided with artificial drainage include all the states; those for drainage enterprises omit Alabama, Virginia, and West Virginia, where no organized drainage enterprises of a public nature had begun actual construction of the improvements, and all states north of Potomac River.

Drainage census reports.—For each of the 29 states in which drainage of land for agriculture is most important, a separate drainage bulletin has been issued. These bulletins show by counties the number of farms and the land in farms reported as provided with artificial drainage, and likewise the number of farms and the additional farm acreage reported as needing such drainage. The part of this land that needs clearing also, to be suitable for growing crops, is given by counties. Acreage and capital invested for all organized enterprises, and the estimated additional investment required to complete the enterprises, are classified according to the progress of construction of the drainage works; according to the drainage basin; according to condition of the land as regards improvement, timber, and drainage condition; and according to character of the enterprises. For those undertakings that had completed or had begun actual construction by January 1, 1920, the classification is made also according to kind of drainage works, maintenance provided for those works, and date of organization of the enterprises. For the same enterprises the statistics are given by counties regarding area and condition of the land, kind and length of drains, area drained by pumping, cost of drainage per acre, increase in improved land since drainage was begun, and the principal crops grown upon the drained land.

A summary bulletin for the United States has been issued, of the same form and subject matter as the state bulletins, but giving the more detailed statistics by states instead of by counties.

This volume presents all the published statistics for drainage collected at the Fourteenth Census. Following the general discussion of results, the tabular and other matter in the United States summary and

the state bulletins are printed, together with similar information for the states for which no separate bulletins were issued.

Schedules and method of canvass.—The information regarding number of farms and farm acreage provided with artificial drainage or needing drainage, and the number of farms in drainage and levee districts, was obtained from the farm operators as a part of the general agricultural information by the enumerators who visited every farm.

The statistics relating to organized enterprises were secured on a special drainage schedule by special agents, except that enumerators were instructed to secure those schedules in the more remote sections where it was expected that few or no drainage enterprises would be found. The information relating to the enterprises was obtained from a present or former official of each enterprise, or from some landowner having personal knowledge of the undertaking, wherever practicable. Where a county board or some county official serves as the executive authority for all or a large number of drainage enterprises in the county, as is provided by the laws of several states, it was necessary that the statistics be compiled by the special agents from county records and other available sources. This information was verified as far as possible by consultation with county officials and with other persons having knowledge of drainage in the locality.

The appendix to this volume contains a copy of the drainage questions from the agricultural schedule and of the instructions to enumerators regarding those questions; it contains also a copy of the special drainage schedule, and of the instructions to special agents regarding the inquiries on that schedule.

DEFINITIONS AND EXPLANATION OF TERMS.

Drainage of agricultural land.—For determining the scope of the drainage census, the drainage of agricultural land was defined as the act or process of drawing off an excess of water by underground conduits, pipes, or tiles, or by open or covered trenches in the surface of the ground for the purpose of improving the condition of the soil and crops. In this connection the area drained does not include land from which water flows without artificial aid into natural water courses; nor does it include land protected from overflow by levees, dikes, or embankments, nor areas guarded by trenches from the run-off from higher land, unless some form of drainage works has been constructed on the protected land.

The statistics for drainage naturally divide into two parts, one relating to the work which each farm owner may do independently and for himself only, the other relating to the work that is done by cooperation among a few or many landowners associated in some form of organization recognized by law. In

the census publications, the former has been designated as "drainage on farms," and the latter as "drainage enterprises," terms used not uncommonly to distinguish these parts are "farm drainage" and "district drainage."

Drainage on farms.—Drainage on farms may be either inside or outside of drainage enterprises; that which is inside usually is connected with and supplemental to the work done by the enterprises.

The area provided with drainage, however, does not distinguish between land benefited by works of individual owners and that benefited by works of organized enterprises, but includes all the acreage of which the soil actually has been made of more value for agricultural purposes by drainage. Such temporary work as bedding the fields or laying out dead furrows to cause the surface water to flow away quickly is not considered as drainage, and the land thus treated has not been included in the statistics unless other more permanent drains also have been provided. Information was not obtained to show the amount of drainage on farms that is located within drainage enterprises.

The land needing drainage, in farms, is the area additional to that reported as provided with drainage, which could be made suitable for crops by drainage only, or by drainage and clearing. The acreage needing clearing was defined as that which was covered with trees, stumps, or perennial woody shrubs; the acreage covered with only grass, weeds, or other annual growth was considered not to need clearing.

Drainage enterprises.—Drainage enterprises comprise public and private corporations and local improvement districts organized to secure the drainage of land to be used for agricultural purposes; also government projects and other organizations engaged in extensive land drainage work. Schedules were obtained also for drainage undertakings, each to benefit 500 acres or more, by individual farm owners, and the figures are included in the statistics for enterprises. By the definition of drainage of agricultural land, mere flood-protection is not drainage, so statistics are not included for levee or diking districts that have not undertaken the construction of open ditches or tile drains.

Each drainage enterprise comprises that area organized into a separate drainage district, or assessed for the same public drain, or drained by works operated or constructed as a separate undertaking. In order to present the statistics by counties, an organized enterprise embracing land situated in more than one county was divided and a separate schedule was prepared for the part in each county; thus the number of enterprises given for each state represents the number of schedules, and exceeds the number of separate organizations if any enterprise in the state extends across a county boundary.

Operating and nonoperating enterprises.—The term "operating" has been applied by the census to those enterprises that had completed or had begun actual construction of the drainage improvement works, and the term "nonoperating" to those that had not begun construction, on or before January 1, 1920. This was deemed the most practicable way of dividing the actual from the prospective enterprises, though the completion of certain of those classed as nonoperating may be as little in doubt as the completion of many that were under construction on the census date.

Land in enterprises and assessed acreage.—The land in drainage enterprises is the acreage that has been or is to be benefited by drainage works constructed by the enterprises and, except in a few instances noted, is the land assessed to pay the cost of the enterprises. The exceptions are irrigation projects installing drains to benefit land damaged by seepage or by alkali as a result of the irrigation, and assessing the cost against the entire irrigation enterprise instead of against only the area needing drainage or protection. Under such circumstances the area thus assessed but not needing drainage has been omitted from the tabulations.

As some drainage enterprises are located wholly or partly within other enterprises, addition of the separate acreages would show more than the actual amount of land in the enterprises in some states and counties; therefore, in order to eliminate duplications, from the area in each enterprise was deducted the area situated in enterprises organized previously. The summation of the areas in the enterprises was tabulated and is shown as "assessed acreage," for comparison with the actual land in enterprises.

The condition of the land in enterprises, without respect to the amount of drainage needed or supplied, has been shown by dividing all the land into three classes—improved, timber and cut-over, and other unimproved land. The question on the drainage schedules asked for the percentage cultivated, but it is believed that all improved land in farms was so reported, and perhaps any other improved land in the enterprises. Timber and cut-over land is shown to indicate the amount of land that must be cleared as well as drained, to be fitted for agriculture, rather than the value of the land for lumbering operations.

To show the drainage condition, the acreage swampy, subject to overflow, or too wet for cultivation is stated, including the area damaged by seepage water and by alkali in those regions where irrigation is generally practiced. The condition of this part as to timber or improvement is not indicated. It is to be assumed that all land in drainage enterprises was in need of drainage before the improvement works were constructed. Nearly all the drainage laws imply, and many of them state, that no land shall be included in drainage districts or be assessed for drainage improvements unless it will be benefited by the works of the

enterprises. The area suffering a loss of crops shows the acreage which the owners or tenants planted to crops that suffered damage, either partial or complete, due to defective drainage. As the schedules were returned by special agents, effort was made to ascertain whether these figures included any land that merely would have been cultivated if it had been drained and protected against overflow, and to eliminate such acreages.

Capital invested.—The capital invested in drainage enterprises is the total cost of those enterprises. It includes the attorneys' fees, court costs, and other expenses for organizing the enterprises; the cost for engineering investigations and surveys, and for plans and specifications for the improvement works to be constructed; the purchase of land to be used as right of way for the ditches, and of land and buildings for other purposes necessary for the enterprise; the payment of awards to landowners claiming damages; expenditures for machinery and tools for constructing and maintaining the works; payments for labor, and payments to contractors for construction and installation of the improvements; expenses for supervision and administration; and any other items properly chargeable to drainage and paid by the enterprise. It does not include the cost of land or other property that is to be sold or used for any other purpose than the operation and maintenance of the drainage works, neither does it include the cost of operation for drainage pumping plants.

Drainage works.—The drainage works of an enterprise were defined to include all kinds of drains and all accessory structures for protecting the land in the enterprise against overflow or seepage and other waters that are constructed by or for the enterprise. Supplementary works constructed by private individuals or corporations were not included. The drains include both open ditches or canals, and covered or underground conduits of clay, concrete, wood, or other material. Ditches, as the term is used in the drainage census, include all open trenches artificially constructed or enlarged to drain away surface or soil waters; tile include all varieties of pipes, of whatever shape or material, placed beneath the surface of the ground in such manner as to permit the excess water to flow away. The dimensions of the ditches are expressed by the depth and the width of the ditch bottom; the size of tile, if circular, by the inside diameter in inches.

The accessory structures include all levees, dikes, dams, weirs, gates, sluices, pumping machinery, and other devices for draining away or controlling surface and soil waters. These are not considered drainage works in the strict sense of that term, but the cost of such accessory works as have been constructed by the drainage enterprises is included in the cost of those enterprises, and the other information is given in the statistics herein published.

Enterprises are called pumping districts if a part or all of the water from the drains is collected at some low point and must be raised by some form of machinery in order to be removed from the area. The type of drainage is the classification as to whether the drainage water is removed by pumping or by gravity. All kinds of machinery or devices for lifting the drainage water are classed as drainage pumps, and all varieties of engines or motors for operating those pumps are termed pumping engines.

ACCURACY OF THE STATISTICS.

Drainage on farms.—The figures relating to number of farms and farm acreage having drainage or needing drainage are probably as accurate as could be obtained, and sufficiently so for all practical purposes. The area provided with drainage could only be determined by the farm operator's estimate of the amount of land that had received benefit from the drains. The additional area that could be made suitable for crops by drainage, or by drainage and clearing, could only be estimated by the farm operator. It is not improbable that a few tenants or recent purchasers of farms did not report some land that actually had been artificially drained, through lack of knowledge of the work that had been done, but it is not believed such errors would affect the accuracy of the statistics.

A comparison of the figures by counties regarding number of farms in drainage and levee districts with the acreage in drainage enterprises indicates positively that in some states, at least, too few farms were so reported. The discrepancy undoubtedly is due in many instances to the fact that a new owner may not know of drainage assessments paid by a former possessor, and that a tenant may not be aware of payments for drainage work made by the owner. In other instances the enumerators or the farm operators may not have been properly diligent in answering all questions, and no answer regarding a drainage inquiry on the agricultural schedule was tabulated the same as an answer "No" or "None."

Drainage enterprises.—The land in drainage enterprises is believed to be reasonably accurate in most counties, and the acreage assessed subject to only such error as might be due to using approximations when exact figures were not obtainable by the persons making the canvass. Agents who were obliged to compile the figures from records found the information incomplete in several respects. In a few instances, drainage records of a county had been destroyed by fire, and in other cases some of the records had been misplaced or lost. The records frequently were incomplete and indefinite; acreages were not always given, and descriptions often were inadequate. Very often overlapping of enterprises could be determined only by platting the boundaries upon a map, no mention of such overlapping appearing in the records. For those counties where overlapping was believed to exist,

such platting was done as accurately as possible in the Census Bureau from the descriptions given on the schedules, and it is believed that the duplication of area thus determined is approximately correct.

In nearly all states, the number of enterprises stated is too large by reason of intercounty enterprises being counted in each county; otherwise, the number undoubtedly is correct for the states where each enterprise has a continuing existence and maintains the improvement works systematically. In some states, particularly Indiana, Michigan, and Ohio, new enterprises have been organized when old public drains have needed cleaning or enlarging, and the greater number of enterprises have been established for repairing, reconstructing, extending, and combining old ditches rather than for constructing new drains or for benefiting additional acreage.

The figures regarding capital invested should fairly represent the cash cost of the enterprises. In few of the cases where the work of construction was divided among the persons benefited, probably, was there a record made of the value of the work thus performed. It is known that the figures for a few counties include expenditures for repairing and extending the drains; it is probable that the same is true in some other counties. In states where it is customary to establish a new enterprise whenever an old drain is to be improved, the records give no basis for determining what amount should be considered as repair charges and what amount for new construction; no deduction has been made from the total cost of all the enterprises. Estimates of additional investments necessary to complete the works authorized are in some cases based upon contract prices for works under construction and in some cases upon engineers' estimates; the instructions to special agents explained that estimates were wanted for only works that had been authorized.

The condition of the land in drainage enterprises can be given only by estimates secured from the persons acquainted with the enterprises or with the localities. In the case of small enterprises mostly under cultivation, the estimates should be very nearly correct, but for large enterprises mostly undeveloped, for some counties the estimates of improved land in drainage enterprises exceeded the total improved land in farms as determined by the general census of agriculture. Under such circumstances a reduction was made in the bureau from the best information obtainable; the estimates thus determined have been indicated in the state reports. The figures for condition before drainage may be slightly less accurate than those for conditions on January 1, 1920. The condition before drainage does not refer to any specific date, but for each enterprise refers to the time when that enterprise was organized. In a number of counties where a great many enterprises have been completed, and the work has been done during a period of several decades, the figures for condition of land were obtained

as averages for all of each township or, in a few cases, for the county as a whole.

The lengths of completed and incompletd drains for enterprises having works under construction were computed on the assumption that the ditches and levees would be completed before the tile were installed. In some instances only lengths of completed drains were reported, and the statistics do not include the additional lengths to be installed to complete the improvements for which expenditures have been authorized. So far as was possible, deduction was made from the length of ditches in each enterprise to cover the amount that was merely enlarging or cleaning out a ditch tabulated in an earlier enterprise, or that was replacing such a ditch with tile, but in those states where maintenance and enlargement are done by organizing new enterprises the actual lengths of ditches probably are somewhat less than the figures show.

GENERAL DISCUSSION OF RESULTS OF DRAINAGE.

A complete analysis of all the statistics is not attempted. Such explanations are given as are deemed necessary to prevent a misunderstanding of the figures, and the significance of some of the more important items is noted. Maps have been used in the state bulletins and in the United States summary to show the approximate location and area of the operating drainage enterprises. Throughout the publications, effort has been made to give the statistics complete in tabular form so that the comparable figures would be brought close together and be most easily comprehended.

DRAINAGE ON FARMS.

The first drainage of land for agriculture was, naturally, by individual effort of each farm owner or operator upon his own farm. Though proper drainage many times requires cooperation by a great number of landowners, and most states have enacted laws specially designed to accommodate organized cooperative enterprises, the full benefits from the cooperative drainage works usually are not obtained until supplemental drains have been installed by the individual owners. It is known, however, that a few districts organized for draining irrigated land in western states have undertaken to drain and protect all the land in those enterprises so thoroughly that supplemental construction by the individual owners will be unnecessary. Land lying close to the outlet drains constructed by public enterprises also may be made more suitable for crop production by those drains. The statistics for artificial drainage provided on farms relate to the area actually improved by the installation of ditches, tile, or other drainage works. While no distinction is made between the land drained by individual effort and that benefited by the work of organ-

METHOD OF PRESENTING THE STATISTICS.

As has been stated previously, this volume contains all the statistics relating to drainage that have been printed by the census. In the discussion that follows, most of the data are grouped according to the nine geographic divisions of the country. The principal advantage of this arrangement is to combine the figures into a smaller number of divisions that are more easily comprehended than the larger number of individual states; it also makes easier the comparison of the statistics for neighboring states.

Since no census of drainage has been taken heretofore, no opportunity is afforded for making comparison with the status of drainage at some previous date, other than the classifications given by date of organization of the enterprises. However, the importance of drainage in agriculture is suggested by comparison of the acreages drained with the acreages of all land and with the acreages of improved land in farms.

ized enterprises, examination of the information obtained indicates that land receiving merely outlet facilities through the construction of public drains has not been included in this part of the statistics.

In presenting the figures for drainage on farms, it is recognized that undoubtedly there has been considerable difference in the conception of when land is provided with drainage. Where the more intensive methods of agriculture are not generally practiced, fields often are considered as drained if a few shallow ditches have been dug across or around them to carry away the surface water; elsewhere, in regions where expensive farm drainage is common, land will be said still to need drainage though many lines of tile may have been laid through it, if the excess moisture is not removed from the soil so promptly that there is no interference with farming operations and no diminution in the crop yield.

Need for drainage on farms.—In any region or locality, the amount of land that actually requires artificial drainage to make it suitable or most profitable for growing crops depends chiefly upon the topography, soil, and climate. A level ground surface, or dish-like pockets or depressions in a rolling surface, ordinarily must have more than the natural drainage before the land can have a high value for agriculture. A pervious subsoil or fissured stratum may provide natural drainage if it connects with some lower surface or subterranean watercourse. The amount and distribution of the rainfall and of the run-off from melting snow, particularly as related to the growing season and the kinds of crops suitable to the region, affect the practical sufficiency of the natural drainage. In the West where irrigation is generally practiced, seepage losses from canals and deep percolation from irrigated fields in a great many localities may water-log the soil

in depressions or at the foot of the benches, or may raise the water table sufficiently for evaporation from the ground surface to concentrate mineral salts, commonly called alkali, in the top soil until the crops are

injured or killed. The amount of land reported as needing drainage is affected, too, by the opinions of the farm operators regarding the potential value of the soil and the benefits that will accrue from drainage.

TABLE 1.—NUMBER OF FARMS AND LAND IN FARMS, PROVIDED WITH DRAINAGE AND NEEDING DRAINAGE: 1920.

DIVISION AND STATE.	NUMBER OF FARMS.						LAND IN FARMS.							
	All farms.	Provided with or needing drainage.		Provided with drainage.		Needing drainage.		All land in farms (acres).	Provided with drainage.		Additional needing drainage.			
		Number. ¹	Per cent of all farms.	Number.	Per cent of all farms.	Number.	Per cent of all farms.		Acreage.	Per cent of all land in farms.	Acreage.	Per cent of all land in farms.	Clearing required, also.	
													Acreage.	Per cent of all land in farms.
United States.....	6,448,343	1,478,287	22.9	924,815	14.3	956,095	14.8	855,883,715	53,024,975	5.5	39,169,639	4.1	28,710,458	3.0
GEOGRAPHIC DIVISIONS:														
New England.....	156,564	22,577	14.4	9,083	5.8	17,571	11.2	16,980,642	129,799	0.8	397,267	2.3	310,276	1.8
Middle Atlantic.....	425,147	102,567	24.1	61,549	14.5	69,216	16.3	40,572,901	1,673,638	4.1	1,412,038	3.5	906,128	2.2
East North Central.....	1,084,744	539,146	49.7	429,584	39.6	302,008	27.8	117,735,179	30,737,056	26.1	8,870,356	7.5	5,628,929	4.8
West North Central.....	1,096,951	256,383	23.4	163,714	14.9	169,593	15.5	256,973,229	11,758,939	4.6	7,260,539	2.8	3,073,154	1.2
South Atlantic.....	1,158,976	219,890	19.0	114,983	9.9	156,780	13.5	97,776,243	2,865,072	2.9	7,511,230	7.7	6,814,543	7.0
East South Central.....	1,051,600	150,530	14.3	69,597	6.6	106,972	10.2	78,597,463	1,720,517	2.2	4,279,968	5.4	3,817,928	4.8
West South Central.....	996,088	125,285	12.6	44,835	4.5	61,595	6.2	173,449,127	2,365,701	1.4	7,134,572	4.1	6,400,267	3.7
Mountain.....	244,109	21,740	8.9	9,754	4.0	14,988	6.1	117,337,226	456,016	0.4	969,948	0.8	640,589	0.5
Pacific.....	234,164	40,160	17.2	21,716	9.3	27,372	11.7	58,152,705	1,318,238	2.3	1,333,721	2.4	1,120,644	2.0
NEW ENGLAND:														
Maine.....	48,227	6,499	13.5	2,068	4.3	5,425	11.2	5,425,968	26,302	0.5	142,063	2.6	122,123	2.3
New Hampshire.....	20,523	2,351	11.5	1,013	4.9	1,794	8.7	2,603,806	11,777	0.5	40,783	1.6	30,869	1.2
Vermont.....	39,075	4,116	14.2	1,728	5.9	3,042	10.5	4,235,811	35,649	0.8	68,912	1.6	49,647	1.2
Massachusetts.....	32,001	5,736	17.9	2,655	9.2	4,112	12.8	2,494,477	39,022	1.6	80,883	3.2	59,671	2.4
Rhode Island.....	4,083	414	10.1	116	2.8	369	8.8	331,600	2,403	0.7	8,174	2.5	5,934	1.8
Connecticut.....	22,655	3,461	15.3	1,203	5.3	2,839	12.5	1,898,980	14,646	0.8	56,462	3.0	42,032	2.2
MIDDLE ATLANTIC:														
New York.....	193,195	56,496	29.2	33,896	17.5	38,523	19.9	20,632,803	1,180,423	5.7	779,467	3.8	460,602	2.2
New Jersey.....	29,702	6,712	22.6	4,903	16.5	3,428	11.5	2,282,585	174,280	7.6	77,881	3.4	48,688	2.1
Pennsylvania.....	202,250	39,359	19.5	22,760	11.2	27,265	13.5	17,667,513	318,955	1.8	554,690	3.1	396,838	2.2
EAST NORTH CENTRAL:														
Ohio.....	256,695	148,022	57.7	130,117	50.7	85,326	33.2	23,515,888	7,365,532	31.3	2,014,889	8.6	1,128,332	4.8
Indiana.....	205,126	122,268	59.6	111,435	54.3	66,413	32.4	21,063,332	8,308,844	39.4	1,717,068	8.2	1,043,116	5.0
Illinois.....	237,181	111,769	47.1	99,240	41.8	33,731	14.2	31,974,775	11,247,637	35.2	1,228,739	3.8	587,246	1.8
Michigan.....	196,447	95,215	48.5	66,948	34.1	64,310	32.7	19,032,061	3,156,632	16.6	2,070,387	10.9	1,490,574	7.8
Wisconsin.....	189,295	61,882	32.7	21,838	11.5	52,228	27.6	22,148,228	658,411	3.0	1,839,273	8.3	1,377,661	6.2
WEST NORTH CENTRAL:														
Minnesota.....	178,478	93,458	52.4	53,011	29.7	73,905	41.4	30,221,758	2,993,034	9.9	3,504,574	11.6	1,703,117	5.6
Iowa.....	213,439	107,740	50.5	58,895	27.6	56,083	26.3	33,474,896	7,334,404	21.9	2,052,942	6.1	391,198	1.2
Missouri.....	263,004	28,653	10.9	11,917	4.5	19,572	7.4	34,774,679	859,663	2.5	830,693	2.4	667,515	1.9
North Dakota.....	77,690	3,147	4.1	682	0.9	2,669	3.4	36,214,751	89,054	0.2	211,305	0.6	158,144	0.4
South Dakota.....	74,637	13,918	18.6	4,077	5.5	11,828	15.8	64,636,491	161,371	0.5	446,915	1.3	90,866	0.3
Nebraska.....	124,417	4,701	3.8	2,356	1.9	2,963	2.4	42,225,475	214,423	0.5	145,818	0.3	30,393	0.1
Kansas.....	165,286	4,768	2.9	2,806	1.7	2,573	1.6	45,425,179	106,985	0.2	68,292	0.2	31,921	0.1
SOUTH ATLANTIC:														
Delaware.....	10,140	5,114	50.4	4,246	41.9	2,488	24.5	944,511	185,831	19.7	68,969	7.3	61,002	6.5
Maryland.....	47,908	10,964	22.9	6,911	14.4	6,058	12.6	4,757,999	249,799	5.3	184,320	3.9	151,553	3.2
District of Columbia.....	204	30	14.7	21	10.3	12	5.9	5,068	197	3.5	115	2.0	57	1.0
Virginia.....	180,242	32,854	17.6	9,899	5.3	27,740	14.9	18,561,112	225,068	1.2	1,172,580	6.3	1,095,388	5.9
West Virginia.....	87,289	11,238	12.9	1,949	2.2	10,304	11.8	9,569,790	38,464	0.4	310,868	3.2	278,615	2.9
North Carolina.....	269,763	65,976	24.5	45,246	16.8	42,247	15.7	20,021,736	1,066,933	5.3	1,025,343	9.6	1,735,942	8.7
South Carolina.....	192,694	40,015	20.8	26,963	14.0	24,508	12.7	12,426,675	670,152	5.4	1,341,903	10.8	1,216,355	9.8
Georgia.....	310,732	42,912	13.8	15,121	4.9	34,337	11.1	25,441,061	274,688	1.1	1,819,611	7.2	1,676,424	6.6
Florida.....	54,005	10,787	20.0	4,567	8.5	8,486	15.7	6,046,691	147,940	2.4	687,021	11.4	599,207	9.9
EAST SOUTH CENTRAL:														
Kentucky.....	270,626	23,424	8.7	5,817	2.1	19,592	7.2	21,612,772	225,228	1.0	573,289	2.7	489,110	2.3
Tennessee.....	252,774	26,739	10.6	8,887	3.5	20,997	8.3	19,510,856	254,118	1.3	640,479	3.3	563,835	2.9
Alabama.....	256,099	46,675	18.2	19,967	7.8	36,511	14.3	10,676,856	415,293	2.1	1,610,656	8.2	1,460,628	7.5
Mississippi.....	272,101	53,698	19.7	34,926	12.8	29,872	11.0	18,196,079	826,878	4.5	1,455,534	8.0	1,304,355	7.2
WEST SOUTH CENTRAL:														
Arkansas.....	232,604	43,223	18.6	13,426	5.8	33,437	14.4	17,456,750	497,489	2.8	1,642,403	9.4	1,512,416	8.7
Louisiana.....	135,463	31,964	23.6	21,271	15.7	14,985	11.1	10,019,822	1,004,935	10.0	1,095,769	10.9	916,464	9.1
Oklahoma.....	191,988	9,366	4.9	2,032	1.1	8,065	4.2	31,951,984	107,014	0.3	265,786	0.8	225,998	0.7
Texas.....	436,033	40,782	9.3	8,106	1.9	35,108	8.1	114,020,621	756,263	0.7	4,130,614	3.6	3,745,389	3.3
MOUNTAIN:														
Montana.....	57,677	2,222	3.9	756	1.3	1,728	3.0	35,070,656	51,146	0.1	113,293	0.3	76,951	0.2
Idaho.....	42,106	3,704	8.8	1,167	2.8	2,895	6.9	8,375,873	64,648	0.8	199,874	2.4	162,308	1.9
Wyoming.....	15,748	1,430	9.1	433	2.7	1,127	7.2	11,809,351	35,654	0.3	69,066	0.6	45,229	0.4
Colorado.....	59,934	6,138	10.2	2,749	4.6	4,399	7.3	24,462,014	127,037	0.5	270,997	1.1	190,876	0.8
New Mexico.....	29,844	1,990	6.7	1,264	4.3	993	3.3	24,409,633	47,311	0.2	49,102	0.2	20,096	0.1
Arizona.....	9,975	550	5.5	241	2.4	435	4.4	5,802,126	9,651	0.2	41,951	0.7	32,355	0.6
Utah.....	25,602	5,093	19.7	2,729	10.6	3,085	12.0	5,050,410	74,316	1.5	165,926	3.3	91,140	1.8
Nevada.....	3,103	638	20.2	385	12.0	321	10.1	2,357,163	46,262	2.0	69,739	2.5	21,644	0.9
PACIFIC:														
Washington.....	66,288	19,155	28.9	10,020	15.1	14,323	21.6	13,244,720	274,696	2.1	576,005	4.3	530,799	4.0
Oregon.....	50,208	13,450	26.8	6,613	13.2	9,862	19.6	13,542,818	229,582	1.7	471,396	3.5	396,333	2.9
California.....	117,070	7,555	6.4	5,078	4.3	3,187	2.7	29,365,667	813,960	2.8	286,320	1.0	193,512	0.7

¹ There are 402,623 farms reported as having both land provided with drainage and additional land needing drainage.

The conditions influencing the need for artificial drains to remove water from the ground surface are generally recognized, while the unfavorable conditions that could be eliminated or mitigated by better drainage of the soil itself are not generally recognized. Lack of drainage makes a soil hard and lumpy when dry, difficult to cultivate and unsuited to the development of plant roots or to the release of plant food; it keeps the soil acid or "sour," counteracting the inherent fertility; it keeps the soil cold, delaying planting in the spring; and when only part of a field has poor drainage, it interferes with cultivation of the other parts. In the irrigated region, the need of protection against seepage and alkali often is not recognized until injury has resulted. If the benefits to be derived from soil drainage were more generally understood, undoubtedly in some sections a larger acreage would have been reported as needing drainage. The statistics given, as previously explained, relate only to the land included in farms on the date of the census.

Number of farms having drainage.—The figures in Table 1 show rather less than one-fourth (22.9 per cent) of all the farms in the United States as having land that has needed or does need artificial drainage. The percentages of such farms range from 8.9 for the Mountain division to 49.7 per cent for the East North Central division; for the individual states they range from 2.9 for Kansas to 59.6 for Indiana. For all the 1,478,287 farms not having adequate natural drainage, 35.3 per cent have provided the additional drainage recognized as necessary, 27.2 per cent have provided part of the work, and 37.4 per cent have yet to begin construction of the artificial drains required in order that the land may be most fully available for growing crops.

Area provided with drainage.—Drainage of farm land is most universally practiced in northern Indiana and the adjacent parts of Illinois and Ohio. This kind of farm improvement is general also in north central Iowa and southeastern Michigan, and it is common in southern and northwestern Minnesota, in

western New York; between the Delaware and Chesapeake Bays, in the coastal plain of the Carolinas, Louisiana, and eastern Texas, along lower Mississippi River, and in the San Joaquin Valley of California.

Table 1 shows that 9.6 per cent of all land in farms in the United States was reported as having been provided with artificial drainage or to be in need of that improvement. The portions in the geographic divisions and states range from 1.2 per cent for the Mountain division to 33.6 per cent for the East North Central division, and from 0.4 per cent for Kansas, Montana, and New Mexico to 47.6 per cent for Indiana.

Of the total area that has or requires artificial drainage on farms, the greatest portion is in the East North Central division, which embraced 43.0 per cent of all that land at the beginning of 1920. The West North Central division has the second largest portion, 20.6 per cent. Illinois has a greater area of such land than any other state, having 13.5 per cent of the total; Indiana has 10.9 per cent and Iowa and Ohio each has 10.2 per cent.

It was deemed impracticable to undertake to secure information regarding the kind and amount of drains, or the cost or value of the drainage provided. Seldom would an operator have definite knowledge of the work that was done before he came upon the farm. It is even probable that some land which was provided with tile drainage many years ago has been omitted from the enumeration because the present operator was entirely ignorant of the fact that such work had been done, but it is not supposed that the total of such omissions would materially affect the statistics obtained.

Farms in drainage enterprises.—The census of agriculture endeavored to learn the number of farms in drainage and levee districts, asking of each farm operator, "Has any part of this farm been afforded drainage or protection against overflow by a drainage or levee district, or by the state, county, or by a private company or individual?"

TABLE 2.—FARMS REPORTED IN DRAINAGE AND LEVEE DISTRICTS: 1920.

DIVISION.	Number of all farms.	FARMS IN DRAINAGE AND LEVEE DISTRICTS.		Approximate land area (acres).	LAND IN OPERATING DRAINAGE ENTERPRISES.		IMPROVED LAND IN FARMS.				
		Number.	Per cent of all farms.		Acreage.	Per cent of total land area.	For all farms.		For farms in drainage enterprises.		
							Total acreage.	Average per farm (acres).	Total acreage.	Acreage.	Per farm. Per cent of average for all farms.
United States ¹	5,278,750	168,840	3.2	1,717,932,160	65,495,038	3.8	441,728,054	83.7	44,288,235	*262.3	*313.4
East North Central.....	1,084,744	63,789	5.9	157,160,960	31,627,176	20.1	87,894,885	81.0	25,282,065	*396.3	489.3
West North Central.....	1,096,951	47,883	4.4	326,914,560	19,217,367	5.9	171,394,439	156.2	11,630,279	242.9	155.5
South Atlantic ¹	827,193	5,213	0.6	123,405,440	2,385,384	1.9	29,735,048	35.9	388,345	74.5	207.5
East South Central ¹	795,501	16,938	2.1	82,067,200	2,323,595	2.8	34,486,725	43.4	1,349,791	79.7	183.6
West South Central.....	996,088	25,010	2.5	275,037,440	7,924,197	2.9	64,189,606	64.4	3,877,166	155.0	240.7
Mountain.....	244,109	3,551	1.5	549,765,760	810,076	0.1	30,105,868	123.3	635,808	179.1	145.3
Pacific.....	234,164	6,456	2.8	203,580,800	1,207,243	0.6	23,921,533	102.2	1,124,721	174.2	170.5

¹ Omitting Alabama, Virginia, West Virginia, and all states north of Potomac River.

² These figures indicate that, especially in the East North Central states, the actual number of farms in drainage and levee districts is greater than the number so reported.

Computation of the average acreage of improved land per farm in drainage enterprises, in comparison with the average improved acreage for all farms, indicates that the number of farms reported as in such enterprises is much less than the actual number so included. (See Table 2.) The discrepancy is much more evident when comparisons are made for individual states and counties.

DRAINAGE ENTERPRISES.

Statistics were collected relating to both operating and nonoperating drainage enterprises. Concerning many of the nonoperating enterprises, complete information could not be secured because plans for the improvement works had not been completed, and the cost of the enterprise, and even the area to be included, were in some instances more or less uncertain. Therefore it is expedient, in much of the discussion that follows, to consider only the operating enterprises.

Character of enterprises.—It is a general condition in considerable parts of most states that the drainage of one individual's land can not be obtained without the construction of an artificial drain or the improvement of a natural watercourse through the land of another individual, or without materially benefiting other owners. Usually, under such circumstances the cost of the outlet drain is much greater than the benefit to any one farm, and much greater than any of the individuals could assume. In order that some farm owners may not be prevented from obtaining such drainage as is necessary for the full utilization of their land, and that the expense of reclaiming or improving considerable areas may be equitably apportioned, very nearly all of the states have recognized, directly or tacitly, that drainage of land for agriculture is a public good, and have passed laws permitting or encouraging the organization of public corporations or local improvement districts for this purpose.

Drainage laws have been enacted in all the states covered by the census of organized drainage enterprises. These statutes for each state are abstracted briefly in the bulletin for that state. The year in which the first general statute authorizing such organizations was enacted in each state is shown in Table 3. Before these dates, many enterprises were authorized by special acts of the legislatures, each act creating a special district. The information secured by the census indicates, however, that most if not all of those early districts have been abandoned or have been reorganized under later statutes. There are still a considerable number of special districts, particularly in Arkansas, California, and Florida, created either because the general laws were defective or because the promoters of the projects deemed it easier to secure special legislation than to adapt their plans to the laws then in force and perhaps not fully tested in practice.

TABLE 3.—DATES OF FIRST GENERAL LAWS AUTHORIZING THE ESTABLISHMENT OF PUBLIC DRAINAGE ENTERPRISES, BY STATES.

(Statutes authorizing merely the construction of levees, or drainage for sanitary purposes, are not included.)

STATE.	Year.	STATE.	Year.
Michigan.....	1847	Colorado ²	1893
Ohio.....	1847	Florida.....	1893
Indiana.....	1852	Kentucky.....	1893
South Carolina.....	1856	Texas.....	1895
Minnesota.....	1858	Utah.....	1896
Missouri.....	1859	Mississippi ³	1898
Wisconsin.....	1862	Idaho ⁴	1903
Illinois.....	1865	Montana.....	1905
California.....	1868	Oklahoma.....	1905
North Carolina.....	1869	Virginia.....	1906
Kansas.....	1870	Tennessee.....	1909
Iowa.....	1872	Georgia.....	1911
Nebraska.....	1873	Nevada.....	1911
Washington ¹	1875	Wyoming.....	1911
Oregon.....	1880	Arizona.....	1912
North Dakota ¹	1883	New Mexico.....	1912
South Dakota ¹	1883	Alabama.....	1915
Louisiana.....	1888	West Virginia.....	1917
Arkansas.....	1891		

¹ These first statutes were enacted by the territories before admission as states.

² A law was enacted in 1883 and repealed in 1885.

³ A law applying only in Lee County was enacted in 1886.

⁴ This statute was declared unconstitutional in 1912, and a new law was enacted in 1913.

Table 4 shows, by periods, the date of organization of the first public drainage enterprise in each state as reported upon the schedules secured. Undoubtedly enterprises were organized before 1860 in Michigan as well as in Indiana and Ohio, as laws providing for the establishment of public drains were enacted as early as 1847. Then all the East North Central and West North Central states except the Dakotas had organized drainage enterprises before 1890, and before any other states except California and North Carolina.

TABLE 4.—DATE OF ORGANIZATION OF FIRST DRAINAGE ENTERPRISES REPORTED, BY STATES.

DATE OF ORGANIZATION.	STATES.
Before 1860.....	Indiana, Ohio.
1860 to 1869.....	California.
1870 to 1879.....	Illinois, Iowa, Kansas, Wisconsin.
1880 to 1889.....	Minnesota, Missouri, Nebraska, North Carolina. ¹
1890 to 1899.....	Kentucky, Louisiana, Michigan, ² Mississippi, North Dakota.
1900 to 1904.....	Texas, Washington.
1905 to 1909.....	Arkansas, Florida, Montana, New Mexico, Oklahoma, South Dakota, Utah.
1910 to 1914.....	Arizona, Colorado, Georgia, ³ Idaho, South Carolina, Tennessee, Wyoming.
1915 to 1919.....	Nevada, Oregon.

¹ The enterprises reported in North Carolina before 1880 were under individual ownership.

² The canvass in Michigan omitted the enterprises established before 1897.

³ The enterprises reported in Georgia before 1910 were under individual ownership.

Previous to the earliest acts for establishing public drains, a number of the states had recognized the right of every landowner to a drainage outlet by providing that an owner desiring drainage might apply to a designated official, and, if the necessity were proved, upon payment of damages secure easement to construct and maintain a private drain across his neighbor's land. The first of these laws were enacted by North Carolina in 1795, Florida in 1834, Michigan in 1839, Tennessee in 1842, and Virginia in 1848. Such private drains, however, are not generally included in the census statistics for drainage enterprises.

There are many shades of difference between the drainage laws of the various states, but there are in

general two principal types of organization. The corporate district is governed by its own officers, who either are elected by the residents or land owners of the district, or are specially appointed by the authority which creates the enterprise. The county drain is established and constructed as any other public work or local improvement, the enterprise being managed by regular officers who have charge of all these enterprises in their county. Some enterprises are administered by a commission or board consisting of one or more officials of the county and one or more members selected by the owners of the land assessed for the cost of the drainage.

The drainage districts and county drains represented, on January 1, 1920, 96 per cent in area of all the organized drainage enterprises, and 94 per cent in amount of capital invested. The other enterprises included in the statistics are township drains, similar in form to county drains but controlled by officers of the townships; state drainage projects controlled by state officials and embracing considerable amounts of state land; irrigation districts, similar in character to drainage districts, that have undertaken drainage of land in those districts; irrigation projects of the United States Reclamation Service; commercial companies reclaiming and improving wet land for sale; and individual owners draining as much as 500 acres each, to be used for agricultural purposes. The total acreage and capital invested in all drainage enterprises are shown classified by character of enterprise in Table 6, page 369.

Area in drainage enterprises.—The area embraced in all the organized drainage enterprises is approximately 69,419,859 acres. This is 3.65 per cent of the total land area of the United States, and 4.04 per cent of the land area of the 34 states included in the census of drainage enterprises. Nearly half (46.2 per cent) of the land in these enterprises is situated in the East North Central division, and more than a fourth (28.7 per cent) in the West North Central division. The West South Central division has 13.1 per cent of the total, and none of the others has more than 5 per cent.

The area in operating drainage enterprises is 65,495,038 acres, 94.3 per cent of that in all enterprises. The location and area of these enterprises are shown by the map following page 345, and by the state and county tables. The single states having the largest areas in operating enterprises are, in order, Michigan, Minnesota, and Indiana, each with more than 9,000,000 acres. Of the 3,924,821 acres in nonoperating enterprises, 1,138,283 acres are reported in Arkansas and Louisiana together, and more than 1,000,000 acres in Florida. State Table II, page 373, shows also the distribution of the land in nonoperating enterprises by geographic divisions and states.

The drainage works authorized to be constructed by the enterprises have been completed for 56,763,751

acres. This may be interpreted as indicating that the farms in this area have been at least fairly well provided with main or outlet drains. In some regions it is customary for the drainage districts to construct the drainage systems in such detail that a public drain will reach each farm; in other regions, where there is much unimproved land not in farms, a large district may construct only the main ditches that will serve the area as a whole, leaving the branch drains for construction by subdistricts to be organized as the landowners in those sections to be benefited by the respective branches may desire the improvements. Of the enterprises that have completed construction, 53.7 per cent in area is in the East North Central division and 29.9 per cent in the West North Central division. In each of the South Atlantic, Mountain, and Pacific divisions, the enterprises that have completed the authorized works comprise less than 1,000,000 acres.

The enterprises that were constructing drainage works on January 1, 1920, comprised 8,731,287 acres, of which more than 2,000,000 acres are situated in each of the West North Central and West South Central divisions and more than 1,000,000 acres each in the East North Central and South Atlantic divisions. In Arkansas and Florida together there are 2,640,150 acres in the partly completed enterprises. In some of these enterprises that are nearing completion a considerable part of the land may have been completely drained, and in others that had been started but recently no benefit may have yet been secured.

The condition of the land in drainage enterprises, both operating and nonoperating, is shown in State Table IV, page 375. As has already been explained, the entire acreage in the enterprises is divided under the three headings, improved, timber and cut-over, and other unimproved land, and the area reported as swampy or subject to overflow includes land injured by seepage or alkali and is partly timbered and partly open or cleared land.

The portions improved of the total areas in operating enterprises range from 16.3 per cent in the South Atlantic division to 79.9 in the East North Central division and 93.2 per cent in the Pacific division, the average for the United States being 67.6 per cent. The states having the greatest portions improved of all land in operating enterprises are Oregon and California, for which the percentages are 100.0 and 93.7, respectively. The improved portion in nonoperating drainage enterprises is 35.1 per cent for all the states, varying from 3.5 per cent for the South Atlantic division to 72.1 per cent for the Mountain division. The states having the largest portions are Kansas, with 93.4 per cent, and Arizona, with 87.9 per cent.

The percentage improved of all land in operating drainage enterprises is greater than the percentage improved of all land in farms for the United States as a whole, and for each geographic division except

the West North Central and the South Atlantic. For nonoperating enterprises the percentages improved are less than the averages for all farms, except in the Mountain and Pacific divisions where so large a part of the enterprises are for draining irrigated land.

Of the unimproved land in operating enterprises, slightly more than half is covered with timber, stumps, or other growth that will necessitate more or less expensive clearing in addition to drainage, to make it fully available for cultivation. The amount of land covered with merchantable timber was not determined by the census, nor were inquiries made to learn what part of all land in the enterprises is included in farms. In the nonoperating enterprises the relation between timbered and cleared land is roughly the same as for the operating enterprises, in all the divisions and in most of the states, suggesting that the open land has not been developed after drainage to any remarkably greater proportion than the timbered land. This fact is shown by the statistics for development of land in State Table V (pages 376 to 379), which show that in the operating enterprises the area timbered or cut-over prior to drainage has been reduced 48.1 per cent, and the other unimproved land 48.2 per cent for the United States as a whole. The percentages for the geographic divisions and for the individual states vary considerably, but the figures seem to indicate that development and utilization of the land usually have been determined by other conditions than the amount of clearing required. The amount of timber and stumps and the cost of clearing undoubtedly have their influence in determining whether any particular enterprise shall be organized.

Crops on drained land.—The crops grown upon the drained land generally are those most common to the regions in which the drainage enterprises are situated. The area actually devoted to any crop was not determined in any instance, but corn was reported as the principal crop by enterprises embracing 61 per cent of the improved land in all operating enterprises in the United States. It was reported as the principal crop by enterprises having 55 to 72 per cent of the improved land in enterprises in the East and West North Central and the South Atlantic divisions, and by enterprises having the greatest improved acreages in 12 of the 34 individual states canvassed. Wheat was reported the principal crop for Michigan, Minnesota, North Dakota, Kansas, Montana, and California; cotton for South Carolina, Mississippi, Arkansas, Oklahoma, and Arizona; vegetables for Florida; sugar cane for Louisiana; hay for Wisconsin; and alfalfa for Washington, Oregon, and the Mountain states except Arizona and Montana.

DRAINAGE WORKS OF ENTERPRISES.

Drains and levees.—The improvement works of the operating drainage enterprises consist of 107,468.2

miles of open ditches and 42,311.7 miles of tile drains completed, and 4,301.8 miles of ditches and 2,862.1 miles of tile drains under construction, together with accessory levees, pumping plants, and appurtenant structures. Of the levees, 3,519.8 miles had been completed and 810.2 miles additional were under construction at the beginning of 1920.

More than half the open ditch drains and more than half the tile drains constructed by organized enterprises are located in the East North Central states, and 40 per cent of the tile are in the West North Central states. The length of the open ditches is very much greater than the length of tile drains for the United States as a whole, and for each geographic division except the Mountain states, where the length of tile drains is two and one-half times as great as the length of open ditches (see Table 5). The drainage there is almost entirely for the reclamation or protection of land under irrigation, and in soils containing so-called alkali the ground water table should be kept below the range of capillarity to prevent evaporation from the ground surface and the concentration of the alkali in the top soil with the consequent injury to crops. Where the required capacity is much less than that of an open ditch of the necessary depth, covered tile drains of clay, concrete, or wood, though often more costly, usually have many advantages.

TABLE 5.—DRAINAGE WORKS OF OPERATING ENTERPRISES, CLASSIFIED BY KIND AND BY GEOGRAPHIC DIVISIONS: 1920.

KIND OF WORKS.	ALL AUTHORIZED.		Completed (miles).	Under construction (miles).
	Miles.	Per cent of total.		
UNITED STATES:				
Total.....	161,273.8	100.0	153,299.7	7,974.1
Open ditches.....	111,770.0	69.3	107,468.2	4,301.8
Tile drains.....	45,173.8	28.0	42,311.7	2,862.1
Levees and dikes.....	4,930.0	2.7	3,519.8	810.2
EAST NORTH CENTRAL:				
Total.....	90,007.2	100.0	89,115.9	891.3
Open ditches.....	65,333.2	72.6	64,924.3	408.9
Tile drains.....	23,694.8	26.3	23,325.2	369.6
Levees and dikes.....	979.2	1.1	866.4	112.8
WEST NORTH CENTRAL:				
Total.....	43,837.0	100.0	41,720.6	2,116.4
Open ditches.....	24,658.3	56.2	23,912.7	745.6
Tile drains.....	18,394.3	42.0	17,109.3	1,285.0
Levees and dikes.....	784.4	1.8	698.6	85.8
SOUTH ATLANTIC:				
Total.....	5,441.7	100.0	3,914.8	1,526.9
Open ditches.....	4,931.0	90.6	3,701.6	1,229.4
Tile drains.....	262.5	4.8	101.5	161.0
Levees and dikes.....	248.2	4.6	111.7	136.5
EAST SOUTH CENTRAL:				
Total.....	4,169.7	100.0	3,631.4	538.3
Open ditches.....	3,692.9	88.6	3,256.9	436.0
Tile drains.....	380.6	9.1	325.3	55.3
Levees and dikes.....	96.2	2.3	49.2	47.0
WEST SOUTH CENTRAL:				
Total.....	9,861.4	100.0	8,318.7	1,542.7
Open ditches.....	8,906.8	90.3	7,672.8	1,234.0
Tile drains.....	22.6	0.2	20.6	2.0
Levees and dikes.....	932.0	9.5	625.3	306.7
MOUNTAIN:				
Total.....	3,115.0	100.0	2,113.4	1,001.6
Open ditches.....	863.8	27.7	827.7	36.1
Tile drains.....	2,213.7	71.1	1,248.2	965.5
Levees and dikes.....	37.5	1.2	37.5	.....
PACIFIC:				
Total.....	4,841.8	100.0	4,484.9	356.9
Open ditches.....	3,384.0	69.9	3,172.2	211.8
Tile drains.....	205.3	4.2	181.6	23.7
Levees and dikes.....	1,252.5	25.9	1,131.1	121.4

The length of levees for the drainage enterprises is less than 3 per cent of the length of ditches and tile drains authorized for the whole country, but in the Pacific states slightly more than one-third as much as the total length of the drains.

When the works under construction have been completed, the drains provided by the enterprises will be all open ditches for three-fourths of the land in the operating enterprises. For one-sixth of the area, systems combining tile and open drains will be used, and for the remaining small amount tile drains only. The areas in operating enterprises in each geographic division are thus classified by kind of works in Table 6, which shows also the average length of drain per acre.

TABLE 6.—AREA DRAINED AND LENGTH OF DRAINS PER ACRE FOR OPERATING ENTERPRISES, CLASSIFIED BY KIND OF DRAINS AND GEOGRAPHIC DIVISIONS: 1920.

KIND OF DRAIN.	AREA DRAINED.		LENGTH OF DRAINS.		
	Acreage.	Per cent of total.	Total authorized (miles).	Per acre.	
				Feet.	Per cent of mean.
UNITED STATES:					
Total or mean.....	65,495,038	100.0	156,943.8	12.7	100.0
Open ditches only.....	49,314,485	75.3	93,244.3	10.0	78.7
Tile drains only.....	4,974,261	7.6	23,204.4	24.6	193.7
Open ditches and tile drains.....	11,206,292	17.1	40,495.1	19.1	150.4
EAST NORTH CENTRAL:					
Total or mean.....	31,627,176	100.0	89,028.0	14.9	100.0
Open ditches only.....	21,339,687	67.5	51,959.9	12.9	86.6
Tile drains only.....	3,098,495	9.8	12,524.0	21.3	143.0
Open ditches and tile drains.....	7,188,994	22.7	24,544.1	18.0	120.8
WEST NORTH CENTRAL:					
Total or mean.....	19,217,367	100.0	43,052.6	11.8	100.0
Open ditches only.....	14,301,750	74.4	20,886.3	7.7	65.3
Tile drains only.....	1,747,658	9.1	10,096.3	30.5	258.5
Open ditches and tile drains.....	3,167,959	16.5	12,070.0	20.1	170.3
SOUTH ATLANTIC:					
Total or mean.....	2,385,384	100.0	5,193.5	11.5	100.0
Open ditches only.....	2,376,184	99.6	4,816.0	10.7	93.0
Tile drains only.....					
Open ditches and tile drains.....	19,200	0.4	377.5	216.7	1,884.3
EAST SOUTH CENTRAL:					
Total or mean.....	2,323,595	100.0	4,073.5	9.3	100.0
Open ditches only.....	2,263,610	97.4	3,548.3	8.3	89.2
Tile drains only.....	8,917	0.4	115.0	68.1	732.3
Open ditches and tile drains.....	51,068	2.2	410.2	42.4	455.9
WEST SOUTH CENTRAL:					
Total or mean.....	7,924,197	100.0	8,929.4	5.9	100.0
Open ditches only.....	7,882,741	99.5	8,809.2	5.9	100.0
Tile drains only.....	3,100	(*)	20.0	34.1	578.0
Open ditches and tile drains.....	38,356	0.5	100.2	13.8	233.9
MOUNTAIN:					
Total or mean.....	810,076	100.0	3,077.5	20.1	100.0
Open ditches only.....	242,028	29.9	451.0	9.8	48.8
Tile drains only.....	105,525	13.0	402.8	20.2	100.5
Open ditches and tile drains.....	462,523	57.1	2,223.7	25.4	126.4
PACIFIC:					
Total or mean.....	1,207,243	100.0	3,589.3	15.7	100.0
Open ditches only.....	908,485	75.3	2,773.6	16.1	102.5
Tile drains only.....	10,566	0.9	46.3	23.1	147.1
Open ditches and tile drains.....	288,192	23.9	769.4	14.1	89.8

* All individual ownership enterprises.

* Less than one-tenth of 1 per cent.

It is to be understood that these figures are only approximations. Owing to the method of eliminating the overlapping of enterprises, as previously explained, the classification of land by drainage works was made according to the kind of works provided by the first

enterprise embracing any particular area. To correct the errors in this classification would increase the area shown for open ditches and tile together, and decrease the areas for open ditches only and for tile drains only. While some ditches have been replaced by tile drains, and probably a few tile by open drains, it is not probable that such changes would offset more than a small part of those in which ditches or tile have been supplemented by tile or ditches, respectively.

The average length of all drains per acre varies from 5.9 feet to 20.1 feet for the geographic divisions, and is 12.7 feet for the United States as a whole. These lengths are equivalent to parallel drains 1.40, 0.41, and 0.65 miles apart, respectively, without making any deduction of length for connecting one drain with another. The figures for the United States show an equivalent of drains 0.83 mile apart for drainage by open ditches only, and 0.34 mile apart for tile drains only, without deducting for connections.

The earliest drains constructed by public drainage enterprises were mostly open ditches. This was natural, because tile were relatively costly and were not generally made in large sizes; land was sufficiently plentiful that the area occupied by the ditches was not considered important; and the cost of construction could be paid in labor by the persons to be benefited by the drains. Before 1880, tile drains comprised less than 5 per cent in length of the public drains begun. During the next twenty years tile were adopted for 20 per cent of all drains undertaken. For the enterprises organized since 1900, tile are used for 34 per cent of the total length, and those operating enterprises organized in 1915 to 1919 have planned to use tile for 46 per cent of the total length of drains. The increase in use of tile for public drains is shown in Table 7.

TABLE 7.—OPEN DITCHES AND TILE DRAINS OF OPERATING ENTERPRISES, SHOWING INCREASING USE OF TILE DRAINS: 1920.

DATE.	ALL DRAINS.		OPEN DITCHES.		TILE DRAINS.	
	Miles.	Per cent of total.	Miles.	Per cent of all drains.	Miles.	Per cent of all drains.
Total.....	156,943.8	100.0	111,770.0	71.2	45,173.8	28.8
Before 1860.....	177.9	0.1	173.7	97.6	4.2	2.4
1860 to 1869.....	2,343.0	1.5	2,295.5	98.0	47.5	2.0
1870 to 1879.....	7,044.4	4.5	6,671.9	94.7	372.5	5.3
1880 to 1889.....	17,345.2	11.1	14,763.2	85.1	2,582.0	14.9
1890 to 1899.....	17,053.3	10.9	12,747.3	74.7	4,306.0	25.3
1900 to 1904.....	16,043.7	10.2	12,308.3	76.7	3,735.4	23.3
1905 to 1909.....	28,416.7	18.1	20,538.9	72.3	7,877.8	27.7
1910 to 1914.....	36,688.0	23.4	24,875.7	67.8	11,812.3	32.2
1915 to 1919.....	31,135.2	19.8	16,897.5	54.3	14,237.7	45.7
Not reported.....	696.4	0.4	498.0	71.5	198.4	28.5

The length of drains per acre provided by the enterprises was 9.7 feet for those undertakings organized before 1860. It increased to 17.1 feet for all organized before 1880, and has decreased to 12.7 feet for all established before 1920. The changes are shown, by periods, in Table 8.

TABLE 8.—LENGTH OF DRAINS PER ACRE IN OPERATING ENTERPRISES, SHOWING CHANGE IN LENGTH PROVIDED PER ACRE: 1920.

DATE.	Land in enterprises (acres).	Length of all drains ¹ (miles).	Length per acre ¹ (feet).
All operating enterprises reported as established before 1860.....	97,319	177.9	9.7
1870.....	880,676	2,520.9	15.1
1880.....	2,958,393	9,565.3	17.1
1890.....	8,382,687	26,910.5	17.0
1900.....	14,409,624	43,963.8	16.1
1905.....	22,016,377	60,007.5	14.4
1910.....	36,546,774	88,424.2	12.8
1915.....	53,890,872	125,112.2	12.3
1920.....	65,265,491	156,247.4	12.6
Total, including those not reporting date.	65,495,038	156,943.8	12.7

¹ When works under construction have been completed.

Drainage by pumping.—The area drained by pumping, wholly or for part of the time, is 1,544,010 acres. Of this, 781,441 acres are in enterprises drained entirely by pumping, the other 762,569 acres are embraced in enterprises drained partly by pumping and partly by gravity (see Table 14, page 363). The total capacities of all the pumping plants are 67,189 horsepower and 15,949,166 gallons per minute. The figures for each state and the totals for each geographic division are given in State Table V, pages 376–379 and by counties in the state reports, pages 381–728.

TABLE 9.—PUMPING PLANTS OF OPERATING DRAINAGE ENTERPRISES: 1920.

DIVISION AND STATE.	PUMP CAPACITY.			Mean lift of water (feet).	Engine capacity (horsepower).	Plant ratio. ¹
	Total (gallons per minute).	Per acre (gallons per minute).	Depth per 24 hours (ins.).			
UNITED STATES.....	15,949,166	10.3	0.55	11.4	67,189	1.46
GEOGRAPHIC DIVISIONS:						
East North Central.....	2,964,014	9.4	0.50	11.0	20,190	2.45
West North Central.....	1,086,800	5.2	0.28	10.9	6,003	2.01
South Atlantic.....	1,083,600	10.1	0.54	4.9	1,275	0.95
East South Central.....	78,000	1.8	0.10	5.0	250	2.54
West South Central.....	5,965,150	25.8	1.37	7.1	10,465	0.98
Mountain.....	72,560	2.1	0.11	13.4	480	1.95
Pacific.....	4,699,042	7.8	0.41	19.5	28,526	1.23
EAST NORTH CENTRAL:						
Ohio.....	3,600	2.1	0.11	8.1	125	16.98
Indiana.....	55,348	9.9	0.52	15.9	625	2.81
Illinois.....	2,843,066	9.7	0.51	10.8	18,225	2.35
Michigan.....	62,000	6.1	0.32	11.9	1,065	5.72
Wisconsin.....					150	
WEST NORTH CENTRAL:						
Iowa.....	530,800	3.9	0.21	11.3	3,153	2.08
Missouri.....	552,000	7.9	0.42	10.7	2,785	1.87
Kansas.....	4,000	1.8	0.10	12.0	65	5.36
SOUTH ATLANTIC:						
North Carolina.....	1,000,000	10.0	0.53	4.5	1,000	0.88
South Carolina.....	44,600	15.2	0.81	17.4	155	0.79
Florida.....	39,000	8.7	0.46	2.1	120	5.80
EAST SOUTH CENTRAL:						
Mississippi.....	78,000	1.8	0.10	5.0	250	2.54
WEST SOUTH CENTRAL:						
Arkansas.....	720,000	8.0	0.42	10.0	2,800	1.54
Louisiana.....	5,245,150	37.3	1.98	6.6	7,665	0.88
MOUNTAIN:						
Idaho.....	36,200	4.6	0.24	18.0	285	1.73
Arizona.....	33,660	1.3	0.07	9.0	175	2.29
Utah.....	2,700	1.9	0.10	8.0	20	3.67
PACIFIC:						
California.....	4,699,042	7.8	0.41	19.5	28,526	1.23

¹ Engine capacity divided by product of total pump capacity into mean lift reduced to horsepower.

The enterprises that pump either all or a part of the drainage water, because drainage by gravity is not obtainable, are situated mostly in the states bordering the Mississippi River, although California has nearly twice as great an acreage drained by pumping as any

other state, and North Carolina has the largest pumping district of any state. The information concerning pumping plants is summarized in Tables 9 and 14 and in State Table V, pages 376–379. In Table 9 the average computed capacities of the pumps are given both in gallons per minute per acre and in depth in inches of water per day over the area served. The mean heights that the water is lifted by the pumps are shown, and the ratios of the engine capacities to the effective horsepower of the pumps operating at their stated capacities and at the mean lifts. The mean lift of water is computed from the average lift for each enterprise weighted according to the capacity of the pumps of that enterprise. Louisiana has the greatest total capacity of pumps of any state, and more than twice the capacity per acre of any other state. California has much the greatest total engine capacity, which is reasonably required by the greatest mean lift of water and greatest area served by pumps.

More than nine-tenths of the drainage pumps are of the centrifugal type (see Table 10, page 370), having fully nine-tenths of the total capacity of all the pumps. The average capacity of the centrifugal pumps is 34,280 gallons per minute each. The eleven screw pumps have an average capacity of 111,242 gallons per minute each. More than half the power is supplied by electric motors (see Table 9, page 370), and almost 30 per cent by steam engines. Internal combustion engines supply only about one-tenth of the total horsepower.

COST OF DRAINAGE ENTERPRISES.

The statistics gathered by the census for capital invested in drainage enterprises to December 31, 1919, represent actual cash expenditures for drainage. Though a large part of the earlier drains were constructed by the labor of the men whose land would be benefited, no estimate of the value of such labor is included. It was intended that the figures should represent the cost for original construction and for enlargements and extensions, but not expenses for maintenance or repairs. However, where the enterprises do not have a continued separate existence, and repair of the drains is undertaken only by the establishment of new enterprises, part or all of the cost of many enterprises would be properly chargeable as for repair or renewal work. Information for making even an estimate of the expenditures for this kind of work was not obtainable, and the amount has been tabulated with the cost of new drains. It is known also that the costs for a small part of the enterprises that have a continuous existence included some charges for repairs. The amount thus included for those enterprises, though not known, is believed to be relatively small.

The capital invested in all operating drainage enterprises and the cost per acre, for each geographic division and state, are shown in Table 10. The aver-

age investment for those enterprises that have completed construction of drainage improvements undertaken is shown to be \$5.18 per acre, and that for all the enterprises to December 31, 1919, is \$5.68 per acre. The estimated investment, when the works under construction have been completed, is \$6.64 per acre, which is 28 per cent greater than the cost of the enterprises already completed. For the United States, the estimated average cost for the enterprises under construction, when they have been completed, is \$14.84 per acre upon the total area assessed. This cost probably would be increased slightly if the amount of overlapping among these enterprises were known and eliminated. However, it is undoubtedly much nearer

correct than the average cost computed after eliminating all overlapping, including duplication with completed enterprises, which would be \$16.12 per acre. In a few states the average for the later enterprises is less than in the completed enterprises, but in 11 states it is more than twice as great. Table 11 shows the capital invested and cost per acre assessed for each 10-year period before 1900 and each 5-year period since that date. It shows also the average cost per acre for all land in operating enterprises organized prior to the end of each period. It will be noted that the average cost per acre assessed was continuously less than \$3 before 1905, but for each period since then has increased by \$1.78 to \$1.92 over the preceding period.

TABLE 10.—CAPITAL INVESTED AND COST PER ACRE OF ALL OPERATING ENTERPRISES, AND OF OPERATING ENTERPRISES DRAINED WHOLLY BY GRAVITY: 1920.

DIVISION AND STATE.	ALL OPERATING ENTERPRISES.					COMPLETED ENTERPRISES.			ENTERPRISES UNDER CONSTRUCTION.			GRAVITY DISTRICTS ONLY.		
	Land in enterprises (acres).	Cost when completed.		Cost to Dec. 31, 1919.		Land in enterprises (acres).	Cost.		Assessed acreage.	Cost when completed.		Acreage.	Cost when completed.	
		Total.	Per acre.	Total.	Per acre.		Total.	Per acre.		Total.	Per acre.		Total.	Per acre.
UNITED STATES..	65,495,038	\$434,594,979	\$6.64	\$372,273,567	\$5.68	56,763,751	\$293,857,023	\$5.18	9,482,414	\$140,737,956	\$14.84	63,602,475	\$354,839,625	\$5.58
GEOGRAPHIC DIVISIONS:														
East North Central.	31,627,176	143,722,327	4.54	134,269,666	4.25	30,475,905	119,525,193	3.92	1,446,710	24,197,134	16.73	31,276,297	125,862,718	4.02
West North Central.	19,217,307	133,194,663	6.93	121,562,077	6.33	16,959,103	102,305,303	6.04	2,520,812	30,822,357	12.23	18,998,695	129,704,641	6.83
South Atlantic.	2,353,384	33,323,268	13.97	18,847,093	7.90	861,312	6,805,235	7.90	1,533,572	26,517,083	16.75	2,271,184	32,204,394	14.18
West South Central.	2,323,585	33,323,268	5.95	11,523,833	4.96	1,732,536	9,085,234	5.24	1,594,049	4,745,017	7.99	2,226,195	13,120,151	5.89
Mountain.	7,824,197	42,357,007	5.35	28,946,335	3.65	5,750,955	20,473,333	3.56	2,303,839	21,833,674	9.50	7,584,727	32,948,089	4.34
Pacific.	810,078	12,508,817	15.44	7,839,941	9.68	236,872	3,248,713	13.72	573,204	9,260,104	16.15	745,464	10,585,817	14.20
	1,207,243	55,658,046	46.10	49,284,572	40.82	747,015	32,353,359	43.31	460,228	23,304,687	50.64	499,913	10,413,815	20.83
EAST NORTH CENTRAL:														
Ohio.	8,107,204	30,771,620	3.80	30,680,145	3.78	8,093,994	30,636,857	3.79	15,857	134,763	8.50	8,104,275	30,687,591	3.79
Indiana.	9,087,183	31,043,858	3.52	31,147,682	3.43	8,867,674	30,154,296	3.40	392,310	1,780,562	4.56	9,078,072	31,714,794	3.49
Illinois.	3,909,049	51,393,244	13.15	33,595,069	11.15	3,430,474	31,424,167	9.16	484,775	19,969,077	41.19	3,583,206	34,042,167	9.50
Michigan.	9,728,171	25,048,980	2.57	24,653,715	2.54	9,511,555	24,100,929	2.53	331,407	948,051	2.86	9,718,471	24,873,641	2.56
Wisconsin.	794,569	4,564,625	5.74	4,163,055	5.24	372,208	3,203,944	8.61	222,361	1,355,681	6.10	792,273	4,539,625	5.73
WEST NORTH CENTRAL:														
Minnesota.	9,232,709	44,183,838	4.79	42,017,447	4.55	8,552,900	36,764,850	4.30	703,309	7,418,988	10.55	9,232,709	44,183,838	4.79
Iowa.	5,224,478	54,169,878	10.37	49,627,304	9.50	4,685,080	44,630,537	9.53	608,235	9,539,341	15.68	5,085,312	53,024,686	10.43
Missouri.	2,596,204	24,749,735	9.53	20,723,128	7.93	1,856,945	13,294,035	7.15	907,470	11,455,700	12.62	2,518,898	22,468,905	8.92
North Dakota.	1,240,328	2,261,449	1.82	2,208,049	1.78	1,100,044	1,863,788	1.69	140,284	397,661	2.83	1,240,328	2,261,449	1.82
South Dakota.	222,032	1,732,729	7.80	1,461,063	6.58	124,132	942,757	7.59	97,930	789,972	8.07	222,032	1,732,729	7.80
Nebraska.	607,730	4,886,681	8.04	4,588,578	7.55	565,222	4,121,486	7.29	42,508	765,195	18.00	607,730	4,886,681	8.04
Kansas.	93,856	1,210,353	12.90	936,508	9.98	72,780	747,853	10.28	21,076	462,500	21.94	91,656	1,146,353	12.51
SOUTH ATLANTIC:														
North Carolina.	542,828	4,526,018	8.34	3,623,513	6.68	440,657	3,075,018	6.98	102,171	1,451,000	14.20	442,828	3,790,644	8.56
South Carolina.	140,031	936,514	6.69	582,133	4.16	24,864	198,370	7.98	115,167	738,144	6.41	131,831	661,514	5.02
Georgia.	65,452	1,098,239	16.78	794,585	12.14	43,723	614,636	14.06	21,729	483,603	22.26	65,452	1,098,239	16.78
Florida.	1,637,073	26,762,497	16.35	13,846,807	8.46	352,068	2,917,261	8.29	1,344,505	23,845,236	17.74	1,631,073	26,658,997	16.34
EAST SOUTH CENTRAL:														
Kentucky.	358,480	1,820,996	5.08	1,521,725	4.24	288,143	1,278,701	4.44	70,337	542,295	7.71	358,480	1,820,996	5.08
Tennessee.	363,671	3,447,991	9.48	2,925,944	8.05	268,667	2,283,589	8.50	95,004	1,164,402	12.26	363,671	3,447,991	9.48
Mississippi.	1,601,444	8,561,264	5.35	7,076,164	4.42	1,175,776	5,522,944	4.70	428,708	3,038,320	7.09	1,504,044	7,851,164	5.22
WEST SOUTH CENTRAL:														
Arkansas.	3,479,591	25,888,599	7.44	14,147,174	4.07	2,124,446	9,385,025	4.42	1,456,545	16,503,574	11.33	3,294,591	20,888,599	6.34
Louisiana.	2,266,328	9,990,788	4.41	9,021,991	3.98	1,534,634	5,956,938	3.88	760,894	4,033,850	5.30	2,111,858	5,681,770	2.64
Oklahoma.	12,150	77,415	6.37	76,415	6.29	11,750	76,165	6.48	400	1,250	3.13	12,150	77,415	6.37
Texas.	2,166,128	6,400,805	2.95	5,700,805	2.63	2,080,128	5,055,805	2.43	86,000	1,345,000	15.64	2,166,128	6,400,805	2.95
MOUNTAIN:														
Montana.	168,682	846,466	5.02	664,990	3.94	44,682	383,969	8.82	124,000	452,497	3.65	168,682	846,466	5.02
Idaho.	64,642	1,788,569	27.67	1,668,569	25.81	43,892	1,237,578	28.20	20,750	550,991	26.55	32,730	890,569	27.21
Wyoming.	95,474	1,667,367	17.46	1,175,962	12.32	11,740	32,231	2.75	83,734	1,635,136	19.53	95,474	1,667,367	17.46
Colorado.	171,656	1,285,070	7.49	1,081,875	6.30	66,816	508,663	7.61	104,840	776,407	7.41	171,656	1,285,070	7.49
New Mexico.	140,219	2,906,296	20.73	1,710,796	12.20	20,169	361,989	17.95	120,050	2,544,307	21.19	140,219	2,906,296	20.73
Arizona.	39,640	1,026,425	25.89	414,425	10.45	9,640	101,425	10.52	30,000	925,090	30.83	9,640	101,425	10.52
Utah.	113,823	2,870,773	25.22	1,005,473	8.83	23,993	495,007	20.63	89,830	2,375,766	26.45	111,123	2,770,773	24.93
Nevada.	15,940	117,861	7.39	117,861	7.39	15,940	117,861	7.39				15,940	117,861	7.39
PACIFIC:														
Washington.	94,924	1,436,419	15.13	1,397,419	14.72	90,084	1,376,809	15.28	4,840	59,610	12.32	94,924	1,436,419	15.13
Oregon.	4,000	200,000	50.00	200,000	50.00	4,000	200,000	50.00				4,000	200,000	50.00
California.	1,108,319	54,021,627	48.74	47,687,153	43.03	652,931	30,776,550	47.14	455,388	23,245,077	51.04	400,989	8,777,396	21.89

Cost according to location.—The capital invested in operating enterprises is divided among the geographic divisions and states somewhat differently than the land in the enterprises, which fact is reflected in the cost per acre. The East North Central division has the largest portion of the total investment to Decem-

ber 31, 1919, and the lowest expenditure per acre in the enterprises except the West South Central division; it has the greatest portion of the total estimated investment when the drainage works under construction have been completed, but the smallest cost per acre of any division. The Pacific division,

with 13 per cent of the capital invested and less than 2 per cent of the acreage, on the census date had expended four times as much per acre as the average for any other division, and upon completion of the works authorized will have expended three times as much per acre as any other division. The costs per acre are greatest in Oregon and California, being nearly

twice that in any other state. For the central and eastern divisions, where irrigation is not generally practiced, the past investment per acre is greater in Illinois than in any other state except Georgia, and the anticipated investment for the operating enterprises is greater than in any other state except Georgia and Florida.

TABLE 11.—CAPITAL INVESTED AND COST PER ACRE FOR OPERATING ENTERPRISES, WHEN WORKS UNDER CONSTRUCTION HAVE BEEN COMPLETED, CLASSIFIED BY DATE OF ORGANIZATION: 1920.

DATE OF ORGANIZATION.	United States.	GEOGRAPHIC DIVISIONS.						
		East North Central.	West North Central.	South Atlantic.	East South Central.	West South Central.	Mountain.	Pacific.
Total:								
Capital invested when works completed.....	\$434,594,979	\$143,722,327	\$133,194,663	\$33,323,268	\$13,830,251	\$42,357,607	\$12,508,817	\$55,658,046
Land in enterprises..... acres.....	65,495,038	31,627,176	19,217,367	2,385,384	2,323,595	7,924,197	810,076	1,207,243
Cost per acre.....	\$6.64	\$4.54	\$6.93	\$13.97	\$5.95	\$5.35	\$15.44	\$46.10
Acreage assessed.....	95,629,291	59,131,073	21,262,129	2,517,852	2,326,635	8,363,124	810,076	1,217,796
Cost per acre.....	\$4.54	\$2.43	\$5.26	\$13.23	\$5.94	\$5.06	\$15.44	\$45.70
Before 1860:								
Capital invested when works completed.....	\$182,716	\$172,716		\$10,000				
Land in enterprises..... acres.....	97,319	95,969		1,650				
Cost per acre.....	\$1.88	\$1.81		\$6.06				
Acreage assessed.....	98,119	99,469		1,650				
Cost per acre.....	\$1.86	\$1.79		\$6.06				
1860 to 1869:								
Capital invested, including earlier periods.....	\$1,872,568	\$1,512,568		\$10,000				\$350,000
Land in enterprises..... acres.....	880,676	865,826		1,650				13,200
Cost per acre.....	\$2.13	\$1.75		\$6.06				\$26.52
Capital invested for this period.....	\$1,689,852	\$1,339,852						\$350,000
Acreage assessed for this period.....	932,665	919,365						13,200
Cost per acre.....	\$1.81	\$1.46						\$26.52
1870 to 1879:								
Capital invested, including earlier periods.....	\$9,998,959	\$7,101,571	\$37,388	\$10,000				\$2,850,000
Land in enterprises..... acres.....	2,958,393	2,913,243	4,200	1,650				39,300
Cost per acre.....	\$3.38	\$2.44	\$8.90	\$6.06				\$72.52
Capital invested for this period.....	\$8,126,391	\$5,589,003	\$37,388					\$2,500,000
Acreage assessed for this period.....	3,413,277	3,382,977	4,200					26,100
Cost per acre.....	\$2.38	\$1.65	\$8.90					\$95.79
1880 to 1889:								
Capital invested, including earlier periods.....	\$35,774,118	\$29,317,100	\$197,083	\$23,000	\$4,000			\$6,232,935
Land in enterprises..... acres.....	8,882,687	8,198,459	53,234	14,157	800			116,037
Cost per acre.....	\$4.27	\$3.58	\$3.70	\$1.62	\$5.00			\$53.72
Capital invested for this period.....	\$25,776,159	\$22,215,529	\$159,695	\$13,000	\$4,000			\$3,382,935
Acreage assessed for this period.....	8,843,654	8,704,576	49,034	12,507	800			76,737
Cost per acre.....	\$2.91	\$2.55	\$3.26	\$1.04	\$5.00			\$44.08
1890 to 1899:								
Capital invested, including earlier periods.....	\$60,794,289	\$47,609,287	\$1,931,577	\$23,000	\$226,326	\$460,949		\$10,543,150
Land in enterprises..... acres.....	14,409,624	13,189,926	856,464	14,157	19,061	142,280		187,736
Cost per acre.....	\$4.22	\$3.61	\$2.26	\$1.62	\$11.87	\$3.24		\$56.16
Capital invested for this period.....	\$25,020,171	\$18,292,187	\$1,734,494		\$222,326	\$460,949		\$4,310,215
Acreage assessed for this period.....	11,575,924	10,523,526	815,158		13,261	142,280		71,699
Cost per acre.....	\$2.16	\$1.74	\$2.13		\$12.17	\$3.24		\$60.12
1900 to 1904:								
Capital invested, including earlier periods.....	\$88,209,816	\$66,139,124	\$3,214,056	\$23,000	\$553,825	\$1,056,949		\$12,222,862
Land in enterprises..... acres.....	22,016,377	18,623,198	2,694,038	14,157	59,075	401,278		224,631
Cost per acre.....	\$4.01	\$3.55	\$3.05	\$1.62	\$9.37	\$2.63		\$54.41
Capital invested for this period.....	\$27,415,527	\$18,529,837	\$6,282,479		\$327,499	\$596,000		\$1,679,712
Acreage assessed for this period.....	12,200,485	9,852,345	2,012,216		40,014	258,998		36,895
Cost per acre.....	\$2.25	\$1.88	\$3.12		\$8.18	\$2.30		\$45.53
1905 to 1909:								
Capital invested, including earlier periods.....	\$171,913,215	\$100,201,042	\$41,788,030	\$487,500	\$1,648,270	\$7,458,339	\$226,599	\$20,153,435
Land in enterprises..... acres.....	36,546,774	23,747,473	8,846,849	73,680	372,829	2,953,158	38,223	514,562
Cost per acre.....	\$4.70	\$4.22	\$4.72	\$6.62	\$4.42	\$2.53	\$5.93	\$39.17
Capital invested for this period.....	\$83,703,399	\$34,061,918	\$33,523,974	\$464,500	\$1,094,445	\$6,401,390	\$226,599	\$7,930,573
Acreage assessed for this period.....	20,228,636	10,136,903	6,681,182	67,723	315,794	2,698,880	38,223	289,931
Cost per acre.....	\$4.14	\$3.36	\$5.02	\$6.86	\$3.47	\$2.37	\$5.93	\$27.35
1910 to 1914:								
Capital invested, including earlier periods.....	\$306,644,221	\$122,456,477	\$33,971,896	\$19,667,293	\$7,797,858	\$25,850,833	\$4,396,596	\$42,503,268
Land in enterprises..... acres.....	53,890,872	28,293,569	15,282,766	1,309,757	1,546,730	6,216,975	283,401	957,674
Cost per acre.....	\$5.69	\$4.33	\$5.49	\$15.02	\$5.04	\$4.16	\$15.51	\$44.38
Capital invested for this period.....	\$134,731,006	\$22,255,435	\$42,233,866	\$19,179,793	\$6,149,588	\$18,392,494	\$4,169,997	\$22,340,838
Acreage assessed for this period.....	22,245,539	8,538,560	7,117,670	1,271,677	1,173,901	3,450,898	245,178	447,655
Cost per acre.....	\$6.06	\$2.61	\$5.93	\$15.08	\$5.24	\$5.33	\$17.01	\$49.93
1915 to 1919:								
Capital invested, including earlier periods.....	\$430,770,285	\$143,103,508	\$132,879,715	\$33,323,268	\$13,809,963	\$42,157,607	\$12,090,998	\$58,405,231
Land in enterprises..... acres.....	65,265,491	31,585,556	19,183,609	2,385,384	2,321,795	7,876,197	783,016	1,129,934
Cost per acre.....	\$6.60	\$4.53	\$6.93	\$13.97	\$5.95	\$5.35	\$15.44	\$47.26
Capital invested for this period.....	\$124,126,064	\$20,647,026	\$48,907,819	\$13,655,975	\$6,012,105	\$16,306,774	\$7,694,402	\$10,901,963
Acreage assessed for this period.....	15,828,501	6,897,435	4,548,753	1,164,295	776,065	1,764,068	499,615	173,270
Cost per acre.....	\$7.84	\$2.99	\$10.75	\$11.73	\$7.75	\$9.24	\$15.40	\$61.15
Date not reported:								
Capital invested when works completed.....	\$3,324,694	\$618,824	\$314,948		\$20,288	\$200,000	\$417,819	\$2,252,815
Land in enterprises..... acres.....	229,547	41,620	33,758		1,800	48,000	27,060	77,309
Cost per acre.....	\$16.66	\$14.87	\$30.33		\$11.27	\$4.17	\$15.44	\$29.14
Acreage assessed.....	262,608	74,523	33,918		1,800	48,000	27,060	77,309
Cost per acre.....	\$14.56	\$8.30	\$30.29		\$11.27	\$4.17	\$15.44	\$29.14

The higher cost of drainage in many of the Pacific and Mountain states is at least partly due to the fact that the drainage of irrigated land is usually more expensive than the drainage of land in the humid

region, where nature has provided a part of the drains and generally has washed from the soil whatever salts may have been formed there. Deeper drains are required to prevent concentration of the alkali

in the top soil by the upward movement of the water as evaporation occurs at the ground surface. The nature of the soil when saturated often is such that the sides of open ditches must have comparatively flat slopes, and trenches for tile many times must be elaborately braced or sheeted during construction of the drains. No inconsiderable part of the cost in many localities has been due to inexperience with the new engineering problems involved, and in work that proved to be experimental in character.

Cost by character of enterprise.—The anticipated costs per acre for drainage work authorized are least for township and county drains, and greatest for irrigation districts and irrigation projects of the United States Reclamation Service, as shown by Table 12. Practically all of the enterprises not reporting character are in Indiana, and are either drainage districts or county drains.

TABLE 12.—CAPITAL INVESTED AND COST PER ACRE FOR OPERATING ENTERPRISES, CLASSIFIED BY CHARACTER OF ENTERPRISE: 1920.

CHARACTER OF ENTERPRISE.	Land in enterprises (acres).	Capital invested when works completed.	COST PER ACRE.	
			Amount.	Per cent of mean.
Total or mean	65,495,038	\$434,594,979	\$6.64	100.0
Drainage districts.....	22,069,597	211,150,540	9.57	144.1
General acts.....	20,239,956	172,104,782	8.50	128.0
Special acts.....	1,829,641	39,045,758	21.34	321.4
County drains.....	37,870,803	179,425,570	4.74	71.4
Township drains.....	1,195,133	579,463	2.97	44.7
State enterprises.....	1,422,844	13,279,869	9.33	140.5
U. S. Reclamation Service.....	1,287,890	6,442,613	22.38	337.0
Irrigation districts.....	1,175,200	4,013,543	22.91	345.0
Commercial developments.....	212,421	4,407,829	20.75	312.5
Individual ownerships.....	432,397	7,291,002	16.86	253.9
Not reported.....	2,828,744	8,004,550	2.83	42.6

¹ The area actually assessed for the cost of drainage in United States Reclamation Service projects and irrigation districts includes 600,578 acres that did not require drainage or protection.

The reasons for the low cost for the township and county drains may be that in those states where most drainage has been done these forms were the earliest used, when the price of labor was lowest; that the forms are most suited and economical for the smaller and simpler undertakings; and that much of the cost was paid in labor for which no value was entered in the records. The cost of draining irrigated land generally is greater than for land in the humid region, for reasons already stated. The higher cost is justified by the higher value of the land, which is largely improved. As explained on page 349, the cost of the drainage in the irrigation enterprises is charged partly against other land contributing to the injury, this other land considerably exceeding the acreage to be drained or protected. The average cost of the drainage by irrigation enterprises is \$9.83 per acre on all the land assessed.

The states reporting drainage districts established by special acts of the legislatures are Wisconsin, Florida, Arkansas, Louisiana, and California. Table

12 shows these districts to cost two and one-half times as much per acre as those districts organized under the general drainage laws. In three of these states the special act districts average less per acre than the others, but in Arkansas and California, which together have 1,577,061 acres in special districts, the average costs per acre are, respectively, \$11.40 and \$69.52 for the special districts and \$5.22 and \$50.92 for those formed under the general statutes.

Commercial enterprises reclaiming wet land for sale generally consist of land that is less favorably situated, which is mostly if not entirely unimproved, and which has relatively few natural drainage courses. Therefore the drainage systems that the commercial companies must undertake to construct, in order to find ready sale for the land, ordinarily will be more elaborate and more costly than those constructed by public drainage enterprises comprised more largely of land in farms.

Cost by nature of drainage works.—The kind of drains and accessory works installed by the enterprises materially affects the cost of the drainage in most cases. Table 13 shows that the average cost per acre for the operating enterprises that have installed only open ditches is not much more than half the average cost of those that have installed tile drains entirely; the cost per acre for systems combining both tile and open drains is just one and one-half times as great as for those providing open ditches only.

The costs per acre for most of the geographic divisions show the same general relation—the cost where only tile drains are used is much larger than where only open ditches are constructed, and the cost of combined systems lies between. The exceptions are that the combined systems have cost most per acre in the East South Central division, while in the Mountain and Pacific divisions the combined systems have cost least and open ditches only have cost most per acre.

The drainage enterprises that have constructed levees as part of the improvement works comprise less than 10 per cent of the area in all operating enterprises, but will have cost nearly 29 per cent of the total investment when the works under construction have been completed. As shown in State Table V, pages 376-379, the average cost for all enterprises constructing levees is \$20.22 per acre, and for those not constructing levees is \$5.23 per acre. For the United States, and for each geographic division except the East South Central, the cost of the enterprises constructing levees is from one and one-third to seven times as great per acre as for the other enterprises. These figures do not include the cost of levees or dikes built by the government, or by levee districts or flood protection enterprises that had not constructed ditches or other drains, even though land in the drainage enterprises receives protection by reason of those levees and may have been assessed for the cost of them.

TABLE 13.—CAPITAL INVESTED AND COST PER ACRE FOR OPERATING ENTERPRISES, CLASSIFIED BY GEOGRAPHIC DIVISIONS AND KIND OF WORKS: 1920.

KIND OF WORKS.	Land in enter- prises (acres).	CAPITAL INVESTED.				KIND OF WORKS.	Land in enter- prises (acres).	CAPITAL INVESTED.			
		When works completed.		To Dec. 31, 1919.	Addi- tional required to com- plete.			When works completed.		To Dec. 31, 1919.	Addi- tional required to com- plete.
		Total.	Per acre.					Total.	Per acre.		
UNITED STATES.											
Total or mean.....	65,495,038	\$434,594,979	\$6.64	\$372,273,567	\$62,321,412	Total or mean.....	2,323,595	\$13,830,251	\$5.95	\$11,523,833	\$2,306,418
Open ditches only.....	49,314,485	287,125,105	5.82	238,211,512	48,913,593	Open ditches only.....	2,263,610	13,109,485	5.79	10,951,137	2,158,348
Tile drains only.....	4,974,261	49,318,155	9.91	46,801,986	2,516,169	Tile drains only.....	8,917	80,479	9.03	84,979	15,500
Open ditches and tile drains	11,206,292	98,151,719	8.76	87,260,069	10,891,650	Open ditches and tile drains	51,068	640,287	12.54	507,717	132,570
EAST NORTH CENTRAL.											
Total or mean.....	31,627,176	143,722,327	4.54	134,269,666	9,452,661	Total or mean.....	7,924,197	42,357,607	5.35	28,946,385	13,411,222
Open ditches only.....	21,339,687	84,958,586	3.98	77,413,340	7,545,246	Open ditches only.....	7,882,741	42,023,607	5.33	28,649,385	13,374,222
Tile drains only.....	3,098,495	17,961,089	5.80	17,740,956	220,137	Tile drains only.....	3,100	41,000	13.23	41,000	.....
Open ditches and tile drains	7,188,994	40,802,652	5.68	39,115,374	1,687,278	Open ditches and tile drains	38,356	293,000	7.64	256,000	37,000
WEST NORTH CENTRAL.											
Total or mean.....	19,217,367	133,194,663	6.93	121,562,077	11,632,586	Total or mean.....	810,076	12,508,817	15.44	7,839,941	4,668,876
Open ditches only.....	14,301,750	63,695,299	4.45	58,302,566	5,392,733	Open ditches only.....	242,028	4,356,347	18.00	2,725,123	1,631,224
Tile drains only.....	1,747,658	28,945,695	16.56	27,014,796	1,930,899	Tile drains only.....	105,525	1,837,577	17.41	1,487,944	349,623
Open ditches and tile drains	3,167,959	40,553,689	12.80	36,244,715	4,308,954	Open ditches and tile drains	462,523	6,314,893	13.65	3,626,874	2,688,019
SOUTH ATLANTIC.											
Total or mean.....	2,385,384	33,323,268	13.97	18,847,093	14,476,175	Total or mean.....	1,207,243	55,658,046	46.10	49,284,572	6,373,474
Open ditches only.....	2,376,184	32,913,268	13.85	18,584,093	14,329,175	Open ditches only.....	908,485	46,088,513	50.71	41,585,898	4,482,645
Tile drains only.....	.....	.....	.....	.....	.....	Tile drains only.....	10,566	452,315	42.81	452,315	.....
Open ditches and tile drains	19,200	1410,000	44.57	263,000	147,000	Open ditches and tile drains	288,192	9,137,218	31.71	7,246,389	1,890,829

1 All individual ownership enterprises.

To investigate more minutely the cost of drainage for agricultural land, those enterprises in which the length of levees equaled or exceeded the length of drains, and those sanitary districts which evidently were not established primarily to improve land for agricultural uses, were deducted from the total acreages and costs stated in the tables. The costs per acre were then computed in the same way as those given in Table 13. The differences between the costs thus found and those given in the table were slight, exceeding approximately 5 per cent in only three instances: The cost of open ditches only in the East North Central states was computed as \$3.57 instead of \$3.98; in the Mountain states, \$15.91 instead of \$18; in the Pacific states, \$53.69 instead of \$50.71, being greater there than when all drainage enterprises were included.

Cost of pumping districts.—The capital invested when the works under construction have been completed, and the costs per acre, for those enterprises drained entirely by gravity are given in Table 10. It will be noted that the acreage costs vary but little from

those for all operating enterprises, except for Illinois, Louisiana, Arizona, and California, due to the comparatively small acreage in pumping districts in most states.

Table 14 shows the investment and the cost per acre for the pumping districts for the United States, and for each state having as much as 25,000 acres drained by pumping. Of those states not shown separately, Michigan has 10,100 acres served by pumps wholly or partly, and no other has so much as 8,000 acres. The capital invested to December 31, 1919, and the total estimated for the operating enterprises when they have completed construction of the works authorized, are more than six times as great per acre as for the gravity districts. In Iowa and North Carolina the estimated investment when construction has been completed is slightly less per acre than for the gravity districts; in the other states the cost of the pumping districts is greater by from \$2.07 per acre in Mississippi to \$42.07 in California and \$43.75 in Illinois.

TABLE 14.—CAPITAL INVESTED AND COST PER ACRE FOR PUMPING DISTRICTS: 1920.

STATE.	ALL PUMPING DISTRICTS.					DRAINAGE BY PUMPING ONLY.			PART GRAVITY DRAINAGE.			
	Acreage in enterprises.	Cost when completed.		Cost to Dec. 31, 1919.		Acreage in enterprises. ¹	Cost when completed.		Acreage in enterprises.	Cost when completed.		Acreage served by pumps. ²
		Total.	Per acre.	Total.	Per acre.		Total.	Per acre.		Total.	Per acre.	
United States.....	1,892,563	\$79,755,354	\$42.05	\$65,830,264	\$34.70	781,441	\$34,022,568	\$43.54	1,111,122	\$45,732,786	\$41.00	762,569
Illinois.....	325,843	17,351,077	53.25	12,061,591	37.02	157,360	6,809,372	43.27	168,483	10,541,705	62.57	134,456
Iowa.....	139,166	1,145,192	8.23	1,145,192	8.23	79,686	778,770	9.77	59,480	366,422	6.16	54,930
Missouri.....	77,306	2,280,830	29.50	2,200,830	29.25	100,000	735,374	7.35	77,306	2,280,830	29.50	70,308
North Carolina.....	100,000	735,374	7.35	735,374	7.35	100,000	735,374	7.35	100,000	735,374	7.35	100,000
Mississippi.....	97,400	710,100	7.29	885,100	9.09	97,400	710,100	7.29	97,400	710,100	7.29	44,000
Arkansas.....	185,000	5,000,000	27.03	500,000	2.70	185,000	5,000,000	27.03	185,000	5,000,000	27.03	90,000
Louisiana.....	154,470	4,409,518	28.55	3,969,743	25.70	137,250	4,261,518	31.05	17,220	148,000	8.59	3,559
Arizona.....	30,000	925,000	30.83	313,000	10.43	30,000	925,000	30.83	30,000	925,000	30.83	25,000
California.....	707,330	45,244,231	63.96	42,626,402	60.26	300,422	21,297,006	70.89	406,908	23,946,625	58.85	304,024
Other states.....	76,048	1,954,032	24.32	1,833,032	22.81	6,723	139,928	20.81	69,325	1,814,104	24.64	36,292

¹ Drained entirely by pumping.² An undetermined part of this acreage may at times be drained by gravity.

The cost of the pumping plants was not secured separately from the other costs of the enterprises, and it is not to be inferred that the difference between the cost of gravity districts and pumping districts, even for a state, represents only the cost of the plants. The condition is that those enterprises that require pumping generally are so situated that the other

drainage works also are more costly than the average, but an unusually high value of the land is believed to warrant the extraordinary expense. The real cost of drainage by pumping includes, of course, operating charges such as labor and fuel for which statistics were not obtained and no estimates are attempted.