UNITED STATES DEPARTMENT OF COMMERCE
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BUREAU OF THE CENSUS
J. C. CAPT, Director (Appointed May 22, 1941)
WILLIAM LANE AUSTIN, Director (Retired January 31, 1941)
PHILIP M. HAUSER, Assistant Director

SIXTEENTH CENSUS OF THE UNITED STATES : 1940

IRRIGATION OF AGRICULTURAL LANDS

TABULAR AND GRAPHIC PRESENTATION

OF

SPECIFIED IRRIGATION CENSUS STATISTICS

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1943

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price, 00 cents

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Department of Commerce
Bureau of The Census
Washington

E R R A T A

Irrigation of Agricultural Lands
(Tabular and Graphic Presentation of Specified Irrigation Census Statistics)

Page 18.—Chart X
Upper Colorado, including Green River
Lower Colorado
} Base data (Table 4, page 31) for 1920 and 1930 revised as indicated below.

Page 31.—Table 4

			From	To
Upper section of table:				
Line 15 (Upper Colorado River), Column	2	(1919)	1,844,258	1,348,548
	3	(1929)	1,968,667	1,449,042
	5	(1920)	2,360,597	1,809,091
	6	(1930)	2,516,149	1,844,032
	8	(1920)	3,236,592	2,508,266
	9	(1930)	3,485,341	2,162,222
Line 17 (Lower Colorado River), Column	2	(1919)	482,432	978,142
	3	(1929)	568,457	1,088,082
	5	(1920)	648,622	1,200,128
	6	(1930)	819,765	1,491,882
	8	(1920)	865,504	1,593,830
	9	(1930)	950,188	2,273,307
Lower section of table:				
Line 15 (Upper Colorado River), Column	2	(1920)	58,964,034	36,749,102
	3	(1930)	67,315,624	37,321,241
	6	(1920)	24.98	20.31
	7	(1930)	26.75	20.24
Line 17 (Lower Colorado River), Column	2	(1920)	29,975,850	52,190,782
	3	(1930)	65,034,623	95,029,006
	6	(1920)	46.21	43.49
	7	(1930)	79.33	63.70

SIXTEENTH CENSUS OF THE UNITED STATES: 1940

REPORTS ON AGRICULTURE, IRRIGATION, AND DRAINAGE[1]

Volume I.—Statistics by Counties for Farms and Farm Property, with Related Information for Farms and Farm Operators; Livestock and Livestock Products; and Crops (six parts).

Part 1.—New England, Middle Atlantic, and East North Central States
Part 2.—West North Central States
Part 3.—South Atlantic States
Part 4.—East South Central States
Part 5.—West South Central States
Part 6.—Mountain and Pacific States

Volume II.—Statistics by Counties for Value of Farm Products, Farms Classified by Major Source of Income, and Farms Classified by Total Value of Products (three parts).

Part 1.—Northern States
Part 2.—Southern States
Part 3.—Western States

Volume III.—General Report—Statistics by Subjects for the United States, Geographic Divisions, and States (one volume).

Chapter I.—Farms and Farm Property
Chapter II.—Size of Farms
Chapter III.—Color, Tenure, and Race of Farm Operator
Chapter IV.—Farm Mortgages and Farm Taxes
Chapter V.—Work Off Farm, Age, and Years on Farm
Chapter VI.—Cooperation, Labor, Expenditures, Machinery, Facilities, and Residence
Chapter VII.—Livestock and Livestock Products
Chapter VIII.—Field Crops and Vegetables
Chapter IX.—Fruits and Nuts, and Horticultural Specialties
Chapter X.—Value of Farm Products

United States Summary Bulletins.—Statistics for the United States, Geographic Divisions, and States in condensed form as follows:

First Series Summary—Number of Farms, Uses of Land, Values, Principal Classes of Livestock and Livestock Products; and Specified Crops Harvested.
Second Series Summary—Farm Mortgages, Taxes, Labor, Expenditures, and Miscellaneous Farm Information; Goats and Mohair; and Fruits, Vegetables, and Minor Crops.
Third Series Summary—Value of Farm Products, Farms Classified by Major Source of Income, and Farms Classified by Total Value of Products.

Territories and Possessions.—Farms and Farm Property, Livestock and Livestock Products, and Crops (one volume). (Separate agricultural bulletins are available for Hawaii and Puerto Rico.)

Territories: Alaska, Hawaii
Possessions: American Samoa, Guam, Puerto Rico, Virgin Islands of the United States

Irrigation of Agricultural Lands.—Statistics by Drainage Basins and by Counties for 20 Irrigation States and a Summary for the United States (one volume).

Twenty Separate State Maps Showing Irrigation by Drainage Basins.
A Separate Composite Map Showing Irrigation by Drainage Basins.

Drainage of Agricultural Lands.—Statistics for 38 Drainage States with County Data for 36 States and a Summary for the United States (one volume).

A Separate Map of the United States Showing Location of Land in Drainage Enterprises for 38 States.

SPECIAL STUDIES AND MONOGRAPHS

Special Poultry Report.—Statistics by Geographic Divisions and States for Poultry of All Kinds on Hand and Raised; by Counties for Chickens and Chicken Egg Production by Number of Chickens on Hand; and by Counties for Farms Reporting Chickens and Turkeys Raised by Numbers Raised (one volume).

Cows Milked and Dairy Products.—Number of Cows Milked, Milk Produced, Disposition of Dairy Products, and Number of Cows Kept Mainly for Milk Production, Classified by Number of Cows Milked, by Counties; with Related Data for Other Classes of Livestock and Livestock Products for the States and also for the United States (one volume).

Special Cotton Report.—Cotton Harvested by Number of Bales Harvested, and by Counties, with Acreage and Production of Cotton, and Value of Farm Products (one volume).

Special Cross-line Acreage Report.—Farms Reporting and Acreage by Place of Enumeration and by Location of Acreage, with Relationship to All Farms, by Counties: 1940 and 1935 (one volume).

Drainage Monograph.—A Comparison of Agriculture Within and Outside of Drainage Enterprises in the Alluvial Lands of the Lower Mississippi Valley (paper bound).

Irrigation Monograph.—A Tabular and Graphic Presentation of Specified Irrigation Census Statistics (paper bound).

[1]Agriculture volumes I and II and the volumes "Irrigation of Agricultural Lands" and "Drainage of Agricultural Lands" are comprised of State bulletins. Separate bulletins for each State are available. Separate chapters of Agriculture volume III are also available.

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TABLES

A TABULAR AND GRAPHIC[1] PRESENTATION OF SPECIFIED IRRIGATION CENSUS STATISTICS

BY MILO B. WILLIAMS

INTRODUCTION

Statistics relating to the irrigation of agricultural lands and irrigation enterprises in the United States have been gathered by the Bureau of the Census, at somewhat irregular intervals and with varying degrees of completeness, over a period of 50 years. The first Census of Irrigation was taken in 16 western States in 1890, as a part of the Eleventh Decennial Census of the United States, and the statistics were published in a separate volume, "Agriculture by Irrigation in the Western Part of the United States." The Twelfth Decennial Census taken in 1900 included, as a part of the Census of Agriculture, irrigation inquiries in the same 16 States but the statistics were published in the State bulletins with the Census of Agriculture. A special Census of Irrigation, covering irrigated lands in the arid, semiarid, and humid States, was taken in 1902 and the statistics were published in Bulletin of the Census No. 16, 1904. This 1902 Census of Irrigation was the first to display irrigation statistics by drainage basins of principal rivers and streams. Since 1902, Irrigation Censuses have been taken as a part of the Census of Agriculture in the years of 1910, 1920, 1930, and 1940, but the data have been published for each Census, except 1910, in separate State bulletins. Summary volumes containing State maps were published for the Irrigation Censuses of 1920 and 1930. A summary volume and separate irrigation State maps, by drainage basins, were published for the 1940 Census.

This monograph presents data in tabular[2] and graphic forms for the principal comparable statistics compiled by the Censuses of Irrigation up to and including those of 1940. Statistics regarding number of irrigation enterprises, number of farms irrigated, areas involved, capital invested, costs of maintenance and operation, and inventories of physical works for the Census years are related graphically in parallel to indicate trends with time. More detailed statistics for recent censuses than are shown in the following tables and graphs may be obtained for each State from the Bureau of the Census State bulletins and summary reports, "Irrigation of Agricultural Lands, 1940," for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C.

The available statistics are arranged in accordance to area, type, and water source groups and presented in summary and for individual groups by States (17 western States and Arkansas and Louisiana), by specified drainage basins (10 major basins with selected secondary tributary basins), by type of irrigation enterprise (individual and partnership, cooperatives, irrigation districts, commercial companies, United States Bureau of Reclamation projects, and "all other" types grouped), and by source of water supply (surface sources, underground sources, and mixed, and all other sources grouped). The "all other" group under type of enterprise includes projects of the United States Office of Indian Affairs, State enterprises, city and/or sewage enterprises, and Reclamation Districts in California. The "surface source" group of water supplies consists of streams, lakes, springs, stored storm water, waste, seepage, or drainage water diverted by gravity and/or pumped. The "underground source" group of water supplies consists of wells pumped and/or flowing, and the "mixed and all other" group includes city water, sewage, streams and wells, and all other mixed or not reported sources diverted by gravity and/or pumped.

Definitions and Explanations

The Census year is the year in which the actual enumeration of irrigation enterprises was made.

An irrigation enterprise is an independent irrigation establishment owning or operating physical works for supplying water to agricultural land. An enterprise may represent a short canal, or a pumping plant watering a single small farm, or a great system of canals and reservoirs operating under one management supplying many farms. In the recent censuses, only such enterprises as supplied water for irrigation in the crop year prior to the census year, or were capable of supplying water for irrigation in the census year, or were in advance stages of construction January 1 of that year were included in the tabulated statistics. In the 1940 Census, each irrigation enterprise was classified as "primary," "supplemental," or a combination of both according to the water service it rendered to irrigators.

A primary enterprise is one which furnishes to the irrigators all, or the principal portion, of the irrigation water used. A stream diversion or pumping plant which one or more farmers consider a principal source of water, and which is used first in preference to other available sources because of ownership of works or water rights, or lower costs of water, is a typical primary enterprise regardless of the proportion of water obtained from such other available sources. All irrigated land must receive water from one primary enterprise, and the acreage statistics for primary enterprises represent all the acreage for States, drainage basins, or other area classifications.

A supplemental enterprise is one which, directly or indirectly, furnishes a user with water from a source, either like or different from the primary source, in addition to the water he receives from a primary enterprise. Notable supplemental enterprises are upstream or offstream storage projects established for conservation of winter run-off and floodwater and to augment the insufficient primary supplies of downstream users. Likewise, many supplemental pumping plants have been installed, either by individuals or groups, for lifting ground water or water from streams to provide for areas served inadequately from primary sources alone. This acreage is always included in the primary acreage.

Farms irrigated.—The number of irrigated farms, as shown in the tabulations and graphs for each State, are those reported in the Census of Agriculture, and not the irrigation units or irrigated parcels of land reported by the irrigation enterprises. For the purpose of the Agriculture Census a farm is defined as:

> All the land on which some agricultural operations are performed by one person, either by his own labor alone or with the assistance of members of his household, or hired employees. The land operated by a partnership is likewise considered a farm. A "farm" may consist of a single tract of land, or a number of separate tracts, and the several tracts may be held under different tenures, as when one tract is owned by the farmer and another tract is rented by him. When a landowner has one or more tenants, renters, croppers, or managers, the land operated by each is considered a farm. Thus, on a plantation the land operated by each cropper, renter, or tenant should be reported as a separate farm, and the land operated by the owner or manager by means of wage hands should likewise be reported as a separate farm.

The enumerators were instructed not to report as a farm any tract of land of less than 3 acres, unless its agricultural products in the year preceding the enumeration were valued at $250 or more.

Area irrigated is the acreage to which water was actually applied during the calendar year preceding the Irrigation Census year. It is not necessarily the area for which water was available or the area entitled to water; hence it does not include land under canals and sometimes irrigated but which was not watered in 1939, 1929, or 1919. Moreover, it takes no account of the degree of sufficiency of the irrigation.

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[1] Due to wartime conditions many statistics published herein are not shown graphically as originally planned.

[2] Special acknowledgment is due Gladys L. Eagle for the preparation of tables.

Land is classed as irrigated which had water supplied to it for agricultural purposes by artificial means or by seepage from canals, reservoirs, or irrigated lands. Land which is flooded during high-water periods is classed as irrigated if water is caused to flow over it by dams, canals, or other artificial means, but is not classified as irrigated if the overflow is due to natural causes alone. Land which has natural ground water sufficiently near the surface to support plant life and to which no water is artificially applied at any time, is not classed as irrigated.

Area that existing works were capable of supplying with water represents the area which the constructed works, as they existed on January 1 of the Irrigation Census year, could serve regardless of whether or not the land was farmed.

Area irrigable represents the extent of the plans of those controlling the enterprises. Possible extensions of projects not definitely planned in 1930 and 1940 were not included in the areas reported as irrigable.

Tables 3 to 6 and charts IX to XI show the areas which existing irrigation works were reported capable of supplying with water and the irrigable areas in enterprises from which the expansion possibilities from the standpoint of capacity of irrigation works can be determined. Statistics indicate that 7,051,509 acres out of the 10,302,210 acres of irrigable land now in irrigation projects, which were not irrigated in 1939, could be irrigated with the present system. This leaves 3,250,701 acres of irrigable land for which works have not been constructed. The States with the greatest acreages under irrigation works but not irrigated are: California with constructed works capable of supplying water to 2,329,008 acres more than were irrigated in 1939; Texas, with 728,588 acres; Colorado, with 692,857 acres; and Montana with 632,981 acres. Similarly, the Sacramento and San Joaquin Delta and tributary streams Basin, California, with works capable of supplying water to 1,738,715 acres more than were irrigated in 1939; the Missouri River Basin, with 1,532,573; the Colorado River Basin, with 729,624; and the Rio Grande Basin, with 656,127; indicate the location of the largest areas by drainage basins under irrigation works but not irrigated in 1939.

Capital invested is the amount reported by irrigation enterprises as the original cost of irrigation works, improvements, enlargements, lands, cost of water rights, buildings, and equipment used for maintenance and operation. Investments reported for many individuals, partnerships, and older enterprises are largely estimates furnished by owners or others who had no records or intimate knowledge of the money or time expended by the original builders. However, most of the larger enterprises supply accurate cost figures and, therefore, the composite investments shown can be considered substantially correct and time trends dependable. Average investment per acre is the ratio of the investment to the acreage existing enterprises were capable of supplying with water in the corresponding census year.

Maintenance and operation refers to the costs of maintaining the irrigation enterprise, including ordinary cleaning and repairs, and operation costs, including costs of fuel, electric energy, and amount paid the personnel. The average annual cost of maintenance and operation per acre is the ratio of the annual cost to the acreage irrigated in the crop year enumerated. This item does not include assessments for payments on principal and interest on bonds, notes, warrants, or for special or unusual expenditures.

Main canals and laterals.—A main canal is any open conduit conveying water from the source of supply to the tract of land to be irrigated or to a storage reservoir. A lateral canal is a branch of a main canal conveying water from a main canal to one or more farms. Main canals and laterals are tabulated as "canals." Farm ditches which distribute water to fields within the boundaries of the individual farm are not included.

Capacity at main canal heading is considered as the capacity of the canal headgate, pumping plant, or other structure used for the diverting of water from a surface source into a distribution system and does not necessarily mean the carrying capacity of a canal or other main conduit. A second-foot, or cubic foot per second (sec.-ft. or c.f.s.), is the rate of discharge of water flowing in a channel when the cross-sectional area is 1 square foot and the average velocity is 1 foot per second.

Pumping plants.—The census of pumping plants was confined to those used for lifting irrigation water and were enumerated and tabulated according to the kind of motive power, i.e., "electric motors," "internal-combustion engines," and "other power"; and by type of pump, i.e., "centrifugal," "turbine," "plunger," and "other pumps." Steam, water, and wind were classed in "other power." Hydraulic rams, air lifts, rotary and home-made pumps were classed as "other pumps." The inquiry regarding the average lift of pumping plants called for the vertical distance, in feet, between the average elevation of the water in the source of supply when the pump is running at usual capacity and the average elevation to which the water is lifted. It does not take into account friction and velocity heads. The statistics for 1940 show separately the lifts from wells and from all sources to indicate the lifts of ground water in areas irrigated from wells.

Capacity of a pump and yield of a well is given in gallons per minute (g.p.m.). Approximately 450 gallons per minute equals 1 second-foot.

Capacity of a motor or engine is given in horsepower (hp.). One horsepower is the energy required to lift 33,000 pounds through a vertical distance of 1 foot in 1 minute.

The drainage basin of a stream is the geographic area drained by that stream and its tributaries. Large river systems drain major basins, each of which for the purpose of the Irrigation Census of 1940 has been divided into secondary and minor tributary basins. Each basin, major or minor, is usually designated by the name of its arterial stream. Waters from most major basins ultimately reach the sea through surface or underground channels. However, the areas of the "Great Basin" comprising portions of Wyoming, Utah, Nevada, Oregon, and California, and similar smaller areas in other western States, drain into landlocked lakes or sinks and are considered as closed, or independent basins. Areas drained by the many smaller streams flowing from the irrigated States into the Gulf of Mexico or the Pacific Ocean are grouped and these groups are considered as drainage basins.

Precipitation for Census Years

The Irrigation Census of 1940 completed a span of 50 years in which the Federal Government has gathered statistics on irrigation. Table 1 shows the 8 individual years for which irrigation enumerations were made; and the mean annual precipitation and departures from normal for those years, as recorded by the United States Weather Bureau. The average monthly precipitation, by States, for the water year October 1938 through September 1939, is given in table 2. These data, together with those for recorded rainfall and departures from normal for all years from 1888 to 1939, are presented graphically in charts I to VIII. An analysis of these figures indicates that in most States the annual precipitation was below normal in most of the census years. In many sections of the West, the areas most affected by variations in the amount and distribution of precipitation are land reported as irrigated pasture. This acreage seems to accord largely with the fluctuations in the amount of water available for pasture irrigation in the spring and fall, before and after the requirements of other more valuable crops are satisfied, a relation and practice which should be taken into consideration in the use of irrigated-pasture data. When a census year falls in, or at the end of, a drought or period of excessive precipitation, the available water supply, areas irrigated, and crop yields are correspondingly affected. Therefore, users of Census data should take into consideration, in their interpretation of Irrigation Census statistics, the precipitation factor for the years concerned.

Precipitation for the calendar year 1939 and the water year October 1938 through September 1939 was below normal in the 19 Irrigation States. Colorado, California, and Nebraska received the least rainfall during 1939, amounting to 65, 67, and 72 percent of normal, respectively. Idaho, Kansas, eastern Oregon, eastern Washington, and Wyoming received approximately 75 percent of their normal precipitation (see tables 1 and 2).

Irrigation Statistics by States

Table 3 and chart IX present historic Census statistics summarized and by States on irrigation in the 17 western States and Arkansas and Louisiana for the Decennial Censuses, 1890 to 1940. The statistics show number of irrigation enterprises, farms irrigated, areas involved, capital invested, and average annual costs of maintenance and operation.

As graphically shown on summary chart IX the most rapid expansion of irrigated agriculture in these 19 States took place prior to 1920, reaching the greatest acceleration in the decade 1899 to 1909, when the area irrigated was increased by 6,688,793 acres compared with an increase of 4,758,431 acres in the 10-year period 1909 to 1919, and an expansion of only 1,812,023 acres in the 20 years between 1919 and 1939. Although the number of irrigation enterprises increased during each decade, the size of enterprise, in acres irrigated, only increased up to 1919. During the 20 years from 1919 to 1939, the size of enterprise decreased in both area and number of farms irrigated, as is shown by the table following:

ITEM	1889	1899	1909	1919	1929	1939
	Averages					
Acres irrigated per enterprise	------	------	253.8	303.2	258.8	229.2
Number farms per enterprise	------	------	2.9	3.5	3.5	3.2
Acres per farm irrigated	68.6	68.0	88.7	86.1	73.7	72.0
Cost of maintenance and operation per acre irrigated	------	------	$1.07	$2.43	$2.77	$2.28

The average size of the irrigated farm increased to 88.7 acres in 1909, but decreased to 72.0 acres in 1939. During the 20 years prior to 1940, the trend in number and size of irrigation enterprises and irrigated farms has been materially affected by the increased number of individual and small partnership developments for irrigation from underground water by pumping. In recent years, the number of irrigation enterprises has been increased in many areas by the formation of projects to supply supplemental water. In 1939, the 91,637 enterprises reported were composed of 80,502 primary enterprises averaging 260.9 acres irrigated per enterprise, and 11,135 supplemental enterprises averaging 295.2 acres per enterprise.

The capital invested, as reported by irrigation enterprises, has continuously increased in total and in average investment per acre based on the area that existing works were capable of supplying with water.

The reported capital invested by individual States does not in all cases follow an upward trend. Some States show an actual decline in total and average investment per acre, while others display a steeper trend upward than indicated in the "Summary" (chartIX). In 1940, the average investment was $37.50 per acre for the 19 States; while Kansas with $15.12 per acre and Arizona with $98.94 per acre represent the extremes in investments. Arizona statistics show a continous increase in investment per acre, while the average per acre in Kansas decreased 50.4 percent in the 20-year period 1920 to 1940.

The absence of records for persons reporting and the lack of knowledge of the actual costs of construction and water rights of the older irrigation projects and of many individually owned irrigation systems are elements of uncertainty in the investment figures of all censuses. These elements, however, probably do not affect the trends materially. In individual States, drainage basins, or counties, the trend in investment has been sometimes affected by the abandonment of portions or all of infeasible projects, the development of costly supplemental water supplies or the addition of betterments, such as lined canals, pipe lines, increased pumping facilities, or water-spreading works to augment ground-water storage. In many instances the construction of multipurpose water-conservation projects which contribute to irrigation water supplies may locally raise the per acre investment for lands already under irrigation or lower the average investment for new lands brought under water, depending upon the proportion of the costs of the multipurpose enterprise allocated to irrigation. In general, the cost per acre for the development and application of irrigation water from underground sources is considerably higher than from surface sources. Therefore, irrigated areas which expand by increased pumping from wells show higher capital costs. Many areas, heavily pumped, experience a lowering of the ground-water level which requires the abandonment of initial pumping equipment and the installation of more expensive equipment capable of making the higher lift of the required water. In other pumped areas, additional costs become necessary to purchase water rights, install physical works for spreading surface run-off water, or to bring in a supplemental supply.

The average annual cost per acre irrigated for maintenance and operation of irrigation enterprises, based on irrigated areas reporting this item in the crop year 1909, was $1.07 per acre for the 19 States. This rose to $2.43 in 1919, and to $2.77 in 1929 but dropped to $2.28 in 1939. This item seems to be fairly constant between censuses, but varies greatly between areas. The States having mostly surface supplies of water diverted by gravity, such as Colorado, Montana, and Wyoming, report average annual costs for maintenance and operation of less than $1.00 per acre irrigated; while States dependent more or less upon pumped water supplies, like Arkansas, Arizona, and California, reported average costs of maintenance and operation for 1939 of $5.46, $5.00, and $4.73 per acre, respectively.

Irrigation Statistics by Drainage Basins

Irrigation statistics have been obtained according to selected drainage basins, i. e., areas drained by a large stream system or a number of small streams, for the Censuses of 1902, 1920, 1930, and 1940 covering a period of 38 years. The principal data are presented in tables 4, 9, and 11 and chart X. The Census of 1902 shows only areas irrigated in the crop year enumerated, capital invested, and lengths of canals. Area for which existing irrigation works were capable of supplying with water, irrigable area, number and capacity of wells used for irrigation, and data relating to pumping equipment are also shown in tables and charts for the Censuses of 1920, 1930, and 1940.

The irrigated States of the West lie wholly, or in part, within 12 major drainage basins. Data for 10 major drainage basins and 10 secondary or tributary basins of these major basins are displayed graphically. The area drained by the Missouri River, although tributary of the Mississippi River, is considered a major drainage basin. The lower Mississippi River and Rio Grande flowing into the Gulf of Mexico are each treated as major basins. The remaining Gulf of Mexico streams are grouped in one basin. The Colorado River Drainage Basin is divided into an upper basin and a lower basin at a point in the river below the mouth of the Paria River at Lees Ferry near the Utah-Arizona line. The Great Basin is divided into two areas named for the prehistoric lakes, "Bonneville" and "Lahonton." The drainage basin called the Sacramento-San Joaquin Delta and tributary streams Basin includes the Sacramento and San Joaquin River systems and their delta areas, Streams tributary to San Pablo and San Francisco Bays are considered part of the Pacific Ocean streams Basin, exclusive of the Gulf of California streams, the Columbia and Klamath Rivers, and the Sacramento-San Joaquin Delta and tributary streams.

Data are not plotted graphically for the drainage basins, Red River of the North representing all streams flowing from the United States into Lake Winnepeg, Canada, or for Whitewater Draw and Vamori Wash, Arizona, closed basins in the Gulf of California watershed.

Specific boundary lines of drainage basins are delineated on separate, 3 color, State irrigation maps, and a 4 color composite map for the 17 western States, Arkansas, Louisiana, and Florida. Maps "Irrigation—By Drainage Basins—1939" are for sale by the Superintendent of Documents, Washington, D. C.

Areas Irrigated

The area irrigated in 1939 in the 17 western States and Arkansas and Louisiana, reported by the Census of Irrigation (table 3), was 21,003,739 acres an increase of 1,456,195 acres, or 7.4 percent since 1929. This is a greater rate of increase than the 1.9 percent increase during the preceding decade, yet much less than that for the decade 1909 to 1919 when an increase of 33.0 percent was shown. In the 1929 to 1939 period, increases were shown in 15 States, and decreases were recorded for Colorado of 5.1 percent, Louisiana of 0.8 percent, South Dakota of 10.3 percent, and Utah of 11.2 percent. The 1939 irrigated areas by principal drainage basins show increases in all basins, with the exception of the Rio Grande which shows a decrease of 2.8 percent, since 1929.

The distribution of 1939 irrigated areas by type of irrigation enterprise shows increases for all types, with the exception of "Commercial," which shows a decrease of 17.3 percent; and "All other" (miscellaneous), 2.4 percent. The transferring, during the past decade, of "Commercial" and "All other" types of enterprises into water-user organizations such as "Cooperatives," "Irrigation districts," and "Government projects" probably accounts for the most of these area changes by type of organization. The greatest decade increases of area irrigated, by type of enterprise, were reported by individual and partnership, 903,571 acres, cooperatives, 381,154 acres, and Bureau of Reclamation, 338,976 acres.

Chart XII shows graphically the historic trends of areas by type of enterprise related to investment. For the Census year of 1940, the areas and investment involved in developments for supplemental water are graphically presented with the supplemental investment shown; this is also added to the primary investment column. Investment for earlier Census years represent total expenditures for primary and supplemental projects unsegregated. Therefore, the total investment (primary plus supplemental) in 1940 is comparable with the investment of previous years. Likewise, the average investment per acre is based on totals for all years except 1940 when separate averages for primary and supplemental enterprises are shown. An average based on totals for 1940 is also shown because the total investment applies to the total primary acreage. In the chart for the individual type of enterprise, an average investment per acre based on total investment is not shown, because the supplemental investment usually applies to areas administered under one or more types other than the one credited with the investment. This is also true of chart XI which presents areas and investments by source of water supply. However, since less than 18 percent of total area and 16 percent of total investment is reported in "underground sources" and no supplemental enterprises are reported in "other mixed" sources, the total averages are shown in table 5.

Capital Invested

The total investment in irrigation works and water rights reported by enterprises in the 1940 Irrigation Census for the 17 western States and Arkansas and Louisiana continued the trend upward with an increase of $159,293,411, or 17.8 percent, since 1930. The change in investment per acre, based on the area irrigation works were capable of supplying with water, was from $34.20 in 1930 to $37.50 in 1940, indicating that the costs of additional irrigation works and betterments per unit irrigated also continue to increase, as has been true from the beginning according to Census Records. Likewise, the estimated cost to complete the irrigation works in existing enterprises based on the irrigable lands in these projects changed from $33.17 per acre in 1930 to $35.99 per acre in 1940, an increase of $2.82 per irrigable acre in the projects. Chart XII shows graphically the historic trends of capital invested as related to project areas.

California, with $318,889,218, or 30.3 percent of the total, with a decade increase of 2.5 percent, ranks first in the 19 Irrigation States in capital invested in irrigation enterprises; Colorado, second with $106,849,343, or 10.2 percent of the total, with a decade increase of 22.0 percent; and Idaho, third with $102,585,798, or 9.8 percent of the total, with a decade increase of 21.4 percent. Investment increases for the decade were reported in each of the 17 western States. The States of Arkansas and Louisiana, where irrigation is principally pumping water for rice, showed capital decreases of 15.6 percent and 26.5 percent, respectively; but the number of irrigation enterprises increased in both States, while the irrigated area in Arkansas increased 6.5 percent. Some of the factors which caused the decreases are revealed by the statistics which show losses and gains in capital invested and which indicate considerable shift of location of irrigation practice, by counties and parishes, within these States since 1930. Such shifts required the abandonment of old wells and pumping plants, many of which were installed prior to 1920 at high costs, and the installation of new wells and/or pumping equipment. Irrigation statistics of the Census of 1940 compared with 1930 also indicate a change from steam and internal-combustion engines to more efficient electric motors at less cost per horsepower. There were indications that new engines and wells installed during the decade 1930 to 1940 cost less than those they had replaced which were of the earlier installations.

The Columbia River Drainage Basin ranks first of the 12 principal drainage basins in capital invested in irrigation enterprises ($206,523,302, or 19.6 percent of the total) and also reported the greatest decade increase ($49,168,188, or 31.2 percent). The Missouri River Drainage Basin ranks second ($179,750,238 invested, or 17.1 percent of the total, with a decade increase of $43,243,517, or 31.7 percent); and the Sacramento-San Joaquin Delta and tributary streams Drainage Basin ranks third ($171,004,939, or 16.2 percent of the total, with a decade increase of $6,376,846, or 3.9 percent).

By type of organization, irrigation districts continue to lead in investment with $265,737,810, or 25.3 percent of the total, an increase within the decade of 26.1 percent (chart XII). The United States Bureau of Reclamation ranks second, with $250,245,359, or 23.8 percent of the total, a decade increase of 29.0 percent; and cooperatives rank third, with $224,140,876, or 21.3 percent of the total, a decade increase of 25.0 percent.

Irrigation Statistics by Sources of Water Supply

The Irrigation Census of 1940 grouped the various sources of water supply into (a) "Primary sources" (i.e., sources from which the principal part or all of the water is obtained for irrigation of the land involved), and (b) "Supplemental sources" (i.e., sources from which a part of the supply of water is obtained to supplement an inadequate primary supply). These two groups are, in turn, segregated into the various surface and underground sources.

Water diverted from streams by gravity and/or pumped, and used alone or in connection with water from wells, continues to be the major supply of irrigation water.

The total area reported entirely irrigated from streams was 16,054,903 acres in 1939, comparable to 14,952,049 acres in 1929, or an increase of 7.4 percent. The area reported as irrigated entirely from wells, either pumped or flowing, was 2,570,392 acres in 1939, comparable to 2,117,012 acres in 1929, or an increase of 21.4 percent. However, areas irrigated entirely from flowing wells decreased 14.4 percent, and those from wells, pumped and flowing, increased 24.0 percent, indicating wells originally flowing are being pumped. This transition is particularly true in the States of Utah, New Mexico, and Louisiana. The area reported as irrigated from all sources other than entirely from streams or entirely from wells was 2,378,444 acres in 1939, comparable to 2,478,483 acres in 1929, or a decrease of 4.0 percent.

Areas irrigated entirely from stream diversions increased in 13 States and decreased in 6 States from 1929 to 1939. The greatest increases were reported in Wyoming, 267,163 acres, or 22.6 percent; Oregon, 223,880 acres, or 30.3 percent; California, 208,597 acres, or 9.3 percent; Nevada, 186,359 acres, or 47.2 percent; and Montana, 169,747 acres, or 11.4 percent. The greatest decreases were reported in Colorado, 130,362 acres, or 4.1 percent; and Arizona, 51,053, or 29.9 percent. Areas irrigated entirely from wells, increased in 15 States and decreased in 4 States. The greatest increases were reported in Texas, 204,240 acres, or 326.1 percent; Nebraska, 57,582 acres, or 245.5 percent; and California, 54,342 acres, or 3.7 percent. The greatest decreases were reported in Louisiana, 39,009 acres, or 22.2 percent; and Utah, 3,717 acres, or 18.9 percent.

The area irrigated entirely from "streams gravity and wells pumped" was 1,252,329 acres in 1939. Increases in acreage irrigated from this source were reported in 14 States. Decreases were reported in Idaho of 32,859 acres, or 45.0 percent, and in Montana of 2,198 acres, or 44.5 percent. In 1939, the States of North Dakota, South Dakota, and Oklahoma reported no lands irrigated from this source. The net increase for the 16 States reporting was 87,980 acres, or 7.6 percent. Area irrigated entirely from springs was 210,373 acres in 1939, a decrease of 3.2 percent in the 10 years. Of the total acreage irrigated from springs in 1939, Nevada reported 54,945 acres; Utah, 35,898 acres; and California, 28,538 acres; representing a decrease of 11.4 percent and 27.6 percent for Nevada and Utah, respectively, but an increase of 18.9 percent for California.

Irrigation Works

Tables 8 to 12 present an inventory of irrigation works by States and principal drainage basins for the Censuses of 1940, 1930, and 1920, and chart XIV shows the number and capacity of irrigation pumps by States. The marked increase in the number of practically all physical structures during the last decade indicates the installations of betterments and increased efforts to conserve water and develop additional water supplies. Storage dams increased from 2,949 in 1930 to 4,607 in 1940, or 56.2 percent. The number of storage reserviors increased from 5,122 in 1930 to 7,709 in 1940, or 50.5 percent. The total storage capacity of reservoirs increased from 24,508,590 acre-feet in 1930 to 33,787,382 in 1940, or 37.9 percent. Although the number of reservoirs reported decreased in a few States, each of the 19 Irrigation States, except Kansas, shows increased storage capacity. The statistics presented on storage dams and reservoirs for the Census of 1920 include some developments installed for other than irrigation purposes. Therefore, in several States, the data are not comparable with those of later censuses when only structures installed primarily for irrigation purposes were included.

Judging from increases in storage capacity, the most important developments in the conservation of water by storage in the decade 1930 to 1940 took place in the States of Arizona, Nebraska, and Utah and in the principal drainage basins of the Missouri, Colorado, and Columbia Rivers, and the Great Basin.

The lengths and capacities of canals show only slight increases, while the lengths of reported pipe lines of all kinds increased from 17,363.1 miles in 1930 to 28,584.9 miles in 1940, or 64.6 percent. The major portion of this increase was concrete pipe lines installed in California, Arizona, and Texas.

The number of flowing wells, (see tables 10 and 11), decreased from 4,811 in 1930 to 4,641 in 1940 and their capacities decreased from 609,367 gallons per minute to 555,073, or 8.9 percent.

Number and Yields of Pumped Wells

Tables 8 and 9 show the number and yield of wells pumped for irrigation, by States and principal drainage basins and chart XIII shows this data by States. The total of 68,279 pumped wells reported in 1940 represents a net increase for the 19 Irrigation States of 11,550, or 20.4 percent, during the decade compared to an increase of 24,635 wells, or 76.8 percent, during the decade 1920 to 1930.

Yields of pumped wells also increased at the net rate of 33.5 percent in the decade 1930 to 1940 compared to 98.0 percent increase during the previous decade. The average yield per well was 635 gallons per minute in 1940 as compared to 572 in 1930, which indicates that larger wells are being developed with the more modern drilling and pumping equipment.

Each of the 19 Irrigation States, excepting Utah, shows an increase for 1940 contrasted with 1930 in number of wells pumped, while the reported yields decreased in Louisiana (22.1 percent), Nevada (6.0 percent), and Washington (6.5 percent). The greatest increases in number of pumped wells were reported for Texas (2,294), Colorado (2,224), Nebraska (1,875), and California (1,831). The greatest increases in yields, gallons per minute, were in California with 4,031,802; Colorado, 1,691,895; Nebraska, 1,625,126; and Texas, 1,598,835. These yields raised the average per well in these States as follows: California, from 519 gallons per minute to 583; Colorado, from 364 to 670; Nebraska, from 797 to 851; and Texas, from 558 to 652.

Pumped wells increased from 1930 to 1940, in the principal drainage basins, excepting the Red River of the North in North Dakota, Whitewater Draw and Vamori Wash, Arizona, and the Great Basin which alone reported a decrease of 1,401 wells, or 51.8 percent, representing a decrease of 50.6 percent in the total yield.

Pumping Equipment

Tables 10 and 11 present comparable statistics on pumping equipment for the Censuses 1910, 1920, 1930, and 1940, by States and for 1920, 1930, and 1940 by principal drainage basins. The average pumping lift is also shown.

The installed horsepower for pumping water for irrigation in the 19 States increased from 1,283,419 horsepower to 1,762,687, or 37.3 percent, during the decade 1930 to 1940. Likewise, the pumps installed increased 27.8 percent in number and 32.4 percent in capacity. The average pumping lift reported for all pumping plants remained static for the decade at 51 feet.

The use of electric power increased 241,858 installed horsepower and represents 63.4 percent of the total in 10 years. The installed horsepower of internal-combustion engines increased 322,387 horsepower and represents 33.4 percent of the total.

A marked increase (13,370 to 38,204, or 185.7 percent) took place in the installation of turbine pumps during the decade. Since this type of pump is used almost exclusively for the pumping of water from wells, and there was no substantial reduction in the use of all other types of pumps, it can be reasoned that the trend is toward turbine pumps and that the increased number of turbine pumps, is indicative of a new development involving pumped wells, since 1930. Although turbine pumps exceed in number and require 51.1 percent of the total installed horsepower, centrifugal pumps exceed them in capacity, with 55.4 percent of the total. The average lift for centrifugal pumps is 29 feet compared to 70 feet for the turbines. This higher lift largely accounts for the greater horsepower required by the turbine installations. It is notable that the total number of centrifugal pumps decreased slightly. However, the total capacity increased 10.1 percent and the installed horsepower decreased 17.8 percent, indicating replacements of machinery of higher efficiency.

All States show a marked increase for the decade in the installation of pumping equipment, with the exception of Utah, which showed a decrease of 11.1 percent. California, with 52,016 pumps, or 66.1 percent of the total installations, ranks first, followed by Texas, with 6.1 percent, and Colorado and Nebraska, each with 3.6 percent of the total. Marked increases in reported average lifts are shown in Arizona and Texas.

Pumping-plant installations in the principal drainage basins increased, with the exception of the Red River of the North, Whitewater Draw, Vamori Wash, and the Great Basin (which decreased 48.1 percent). The Sacramento-San Joaquin Delta and tributary streams Basin contains 44.3 percent of the total irrigation pumps in the 19 States. Other Pacific Ocean Basins, exclusive of the Colorado, Columbia, and Klamath Basins, rank second with 21.1 percent, and the Missouri River Basin ranks third with 7.6 percent of the total number of pumps installed. However, the Gulf of Mexico streams, other than the Mississippi River and the Rio Grande, rank third in installed horsepower and second in capacity of pumps.