
General Explanation

PLANNING AND DEVELOPMENT

Planning for the survey started in 1999 with a review of the previous farm and ranch irrigation survey. Letters were sent to more than 200 individuals in water-related government organizations, industry, and academic positions to solicit their comments on report form content and table format. Presentations were made to several associations seeking their comments. Sixty responses were received. All responses were reviewed and categorized to evaluate data collection feasibility and priority needs.

METHOD OF ENUMERATION AND DATA COLLECTION

The 2003 Farm and Ranch Irrigation Survey was conducted primarily by mail and was supplemented by telephone calls and personal enumeration by NASS State Statistical Office (SSO) staff and enumerators. A sample of 25,014 irrigators was selected and mailed a report form in January 2004. This was a 6 percent increase over the 1998 sample size and was designed to enhance data quality for the 2003 survey. The initial mail packet included a report form and letter requesting a prompt response. The operators were asked to complete and return the report form. The initial mailing was followed by one follow-up mailing to those who had not responded in the first 4 weeks. The follow-up packet included a reminder letter and a report form. Six weeks after the initial mailing, the SSOs were provided nonresponse lists. SSOs made telephone calls and personal visits to maximize the response. For a description of the adjustment for nonresponse, see Statistical Methodology.

DATA PROCESSING

All report forms were reviewed by NASS staff prior to data keying to identify inconsistencies and ensure that

the data could be keyed. Major inconsistencies, respondent remarks, blank forms, and large irrigation cases were reviewed by analysts and adjusted prior to data keying as needed. All forms with data were scanned and keyed from image. Data from each report form were processed through a computer edit which flagged inconsistent entries. Each flagged entry was reviewed manually. During the edit process, an imputation program supplied missing data and made adjustments based on responses of similarly sized farms within the same geographic area. Data entries of large magnitude and data items that were changed significantly in the computer edit process were reviewed and verified by analysts.

Prior to publication, tabulated totals were reviewed to identify and resolve remaining inconsistencies and potential coverage problems. Comparisons were made to 2002 census data and other available check data.

DATA COMPARABILITY

The 2002 Census of Agriculture introduced new methodology to account for all farms in the United States. All 2002 published census items were reweighted for incompleteness in the mail list. This adjustment for undercoverage was also used for the 2003 Farm and Ranch Irrigation Survey. To provide comparable data, 1998 data published in 2003 were also reweighted for undercoverage. An explanation of the methodology is included in the 2002 Census of Agriculture Volume 1, Appendix C.

Differences exist between the expanded results of the 2003 Farm and Ranch Irrigation Survey and published data from the 2002 Census of Agriculture. Some of these are as follows:

1. The survey excludes horticultural specialty farms and institutional, research, and experimental

farms. The effect of these exclusions is listed in the following table:

	Irrigated farms	Acres irrigated
2002 U.S. totals ..	299,583	55,311,236
Excluded from survey	23,767	1,136,547
Eligible for selection in survey	275,816	54,174,689

2. The survey includes data only for operators who irrigated in both 2002 and 2003. Operators in some areas, especially the Eastern States, irrigate intermittently according to moisture needs. Operators having irrigation capabilities may not irrigate depending on the amount of rainfall for a particular year or geographic area. The number of operators who irrigated in 2002 but discontinued irrigation in 2003 is tabulated in Table 42 by reason of discontinuance.
3. Some operators reported that they had been misclassified as irrigators and did not irrigate in either 2002 or 2003. An estimated 22,719 operators with 948,400 acres irrigated in 2002 were misclassified as irrigators in the 2002 census. This is estimated by expanding reports in the survey where the respondents reported that they did not irrigate in 2003 or 2002. In addition to errors in processing data, some operators misreported or misinterpreted the questions. Most of the operators misreporting irrigation in the 2002 census reported irrigation of small acreages of vegetables, fruits and nuts, tobacco, potatoes, or berries. Small amounts of water were applied to these crops at the time of transplanting.
4. Some respondents indicated they had quit farming, retired, moved, gone bankrupt, etc., since 2002. After analytical review of the 2003 receipts, an estimated 16,088 operators accounting for 2,941,413 acres irrigated in 2002 after expansion, were dropped from processing because they were no longer farming. Special care was taken with large operations to ensure that they were not erroneously dropped due to reorganization or name

change rather than discontinuing agricultural operations. This included the use of field and telephone enumeration.

5. New irrigators in 2003 (not included in the 2002 census) did not have a chance of being selected in the sample and, therefore, were excluded from the survey. It is believed that the impact of new irrigators is probably minimal. This conclusion is supported by comparisons between the 1997 and 2002 censuses which show little change in acres of irrigated cropland harvested.
6. For the 2002 census and the 2003 Farm and Ranch Irrigation Survey, farms were classified by type of activity or activities according to the North American Industry Classification System (NAICS). Table 33 provides irrigation data for farms classified by NAICS.

Table A. Farms with Irrigation by Acres Irrigated: 2003 Survey Compared with 2002 Census

Item	2002 Census of Agriculture	2003 Farm and Ranch Irrigation Survey	
	U. S. totals	U.S. totals (expanded)	Percent of 2002 census totals
Acres irrigatedfarms	299,583	220,163	73.5
..... acres	55,311,236	52,583,431	95.0
1 to 49 acres farms	183,120	116,256	63.5
..... acres	2,032,251	1,658,408	81.6
50 to 99 acresfarms	27,094	22,288	82.3
..... acres	1,878,687	1,551,154	82.6
100 to 199 acresfarms	28,011	24,657	88.0
..... acres	3,851,651	3,454,895	89.7
200 to 499 acresfarms	31,449	28,032	89.1
..... acres	9,883,105	8,922,430	90.3
500 to 999 acresfarms	17,329	16,771	96.8
..... acres	12,001,034	11,827,596	98.6
1,000 acres or more farms	12,580	12,159	96.7
..... acres	25,664,508	25,168,948	98.1

When comparing the number of farms and irrigated acres between the 2003 survey and the 2002 census published U.S. totals, most of the differences are for operators reporting less than 100 acres irrigated. This is expected since the excluded horticultural farms average 48 acres irrigated per farm and the other categories of discontinued or excluded irrigators

generally are smaller than average irrigators. Table A shows acres irrigated in the 2003 survey (expanded) compared with U.S. totals from the 2002 census. The expanded survey accounts for 95 percent of all land reported as irrigated in the 2002 census and all irrigation characteristics associated with that land.

DEFINITIONS AND EXPLANATIONS

This section provides definitions and explanations of selected items that are used on the report form or in the tables. A facsimile of the 2003 Farm and Ranch Irrigation Survey report form is in the appendix.

Water Resources Areas (WRA)

Data from the 2003 Farm and Ranch Irrigation Survey were tabulated by WRA. Boundaries of these areas are shown on the map on page I. These boundaries are essentially the same as the water resources regions (WRR) delineated and defined in the past by the U.S. Water Resources Council. The areas differ somewhat from the regions because of the method used for boundary delineation. Region boundaries are delineated on the basis of topographic drainage characteristics, whereas areas are delineated on the basis of county boundaries which approximate actual drainage-basin boundaries. Geographic descriptions of each water resources region that were used to approximate the area included in each water resources area are as follows:

01 New England Region - The drainage within the United States that ultimately discharges into the Bay of Fundy and the Atlantic Ocean. These points of discharge are located within and between Maine and Connecticut; Long Island Sound and the St. Francis River, a tributary of the St. Lawrence River.

02 Middle Atlantic Region - The drainage within the United States that ultimately discharges into the Atlantic Ocean, whose point of discharge is located within and between New York and Virginia, and the Richelieu River, a tributary of the St. Lawrence River.

03 South Atlantic-Gulf Region - The drainage that ultimately discharges into the Atlantic Ocean, whose point of discharge is located within and between North Carolina and Florida; and the Gulf of Mexico, whose

point of discharge is located within and between Florida and Mississippi, including the Pearl River.

04 Great Lakes Region - The drainage within the United States that discharges into the Great Lakes system, including the Lakes' surfaces; and the St. Lawrence River as far east as, but excluding the Richelieu River.

05 Ohio Region - The drainage of the Ohio River, excluding that of the Tennessee River.

06 Tennessee Region - The drainage of the Tennessee River.

07 Upper Mississippi Region - The drainage of the Mississippi River above the mouth of the Ohio River, excluding drainage of the Missouri River above a point immediately below the mouth of the Gasconade River.

08 Lower Mississippi River - The drainage of the Mississippi River below the mouth of the Ohio River, but excluding the drainage of the Arkansas, White, and Red Rivers and above the points of highest backwater affects of the Mississippi River in those parts; and the coastal streams, other than the Mississippi River, that discharge into the Gulf of Mexico from the boundaries of, but excluding the Pearl and Sabine Rivers.

09 Souris-Red-Rainy Region - The drainage within the United States of the Souris, Red, and Rainy Rivers.

10 Missouri Region - The drainage within the United States of the Missouri River above a point immediately below the mouth of the Gasconade River and the Saskatchewan River.

11 Arkansas-White-Red Region - The drainage of the Arkansas River above the point of highest backwater affect of the Mississippi River, the Red River above the point of highest backwater affect of the Mississippi River, and the White River above the point of highest backwater affect of the Mississippi River near Peach Orchard Bluff, AR.

12 Texas-Gulf Region - The drainage that discharges into the Gulf of Mexico from and including Sabine Pass to, but excluding the Rio Grande and the Lower Rio Grande Valley.

13 Rio Grande Region - The drainage within the United States of the Rio Grande; the San Luis Valley, North Plains, San Augustine Plains, Mimbres, Estancia Jonado del Muerto, Tularosa, Salt, and various smaller closed basins; and the Lower Rio Grande Valley.

14 Upper Colorado Region - The drainage of the Colorado River above the Lee Ferry Compact Point, which is about 1 mile below the mouth of the Paria River; and the Great Divide closed basin.

15 Lower Colorado Region - The drainage within the United States of the Colorado River below the Lee Ferry Compact Point, which is about 1 mile below the mouth of the Paria River; the Rios Yaqui, Magdalena, Sonoita, and other lesser streams that ultimately discharge into the Gulf of California; and the Animas Valley, Wilcox Playa, El Dorado Valley, and other smaller closed basins.

16 Great Basin Region - The drainage of the Great Basin that ultimately discharges into Utah and Nevada.

17 Pacific-Northwest Region - The drainage within the United States that ultimately discharges into the Straits of Georgia and Juan de Fuca and the Pacific Ocean. The point of discharge is within Washington and Oregon, including the Columbia river.

18 California Region - The drainage within the United States that ultimately discharges into the Pacific Ocean, whose point of discharge is within California, which includes the Central Valley; and that portion of the Great Basin and other closed basins in California.

19 Alaska - entire State.

20 Hawaii - entire State.

Acre-Foot of Water - An acre-foot of water is the quantity of water required to cover 1 acre to a depth of 1 foot. This is equivalent to 43,560 cubic feet or 325,851 gallons.

Acres and quantity harvested - If two or more crops were harvested from the same land during the year, the acres were counted for each crop. Therefore, the total acres of all crops harvested generally exceeds the acres of harvested cropland. Exceptions to this procedure

are hay crops. When more than one cutting of hay was taken from the same acres, the acres were counted only once, but the quantity harvested included hay from all cuttings.

For interplanted crops or “skip-row” crops, acres were reported according to the portion of the field occupied by each crop. If a crop was interplanted in an orchard or vineyard and harvested, then the entire orchard or vineyard acreage was reported under the appropriate fruit crop and the interplanted estimated crop acreage was reported under the appropriate crop.

Acres of land in bearing and nonbearing orchards, citrus or other groves, vineyards, and nut trees were reported as harvested cropland regardless of whether the crop was harvested or failed. Abandoned orchards were reported as cropland idle, not harvested cropland.

Acres irrigated - Acres irrigated are the acres of agricultural land to which water was artificially applied by controlled means including preplanted, partial, supplemental, and semi-irrigation. Land flooded during high water periods was to be included as irrigated only if the water was diverted to agricultural land by dams, canals, or other works.

All other land - This category includes land in house lots, barn lots, ponds, roads, ditches, wasteland, etc. It includes those acres in the farm operation not classified as cropland, pastureland, or woodland.

Average operating pressure - This is the pressure at the well head.

Average pumping capacity - This category includes the gallons per minute discharged from wells.

Chemigation - This is the process of applying pesticides, fertilizers, other chemicals, or animal waste through agricultural irrigation water.

Cropland harvested - This category includes land from which crops were harvested and hay was cut, and land used to grow short-rotation woody crops, land in orchards, citrus groves, Christmas trees, vineyards, nurseries, and greenhouses. Land from which two or more crops were harvested was counted only once. Land in tapped maple trees was included in woodland

not pastured. The 1997 census definition for harvested cropland was the same as the 2002 definition. Short-rotation woody crops were not explicitly referenced in the 1997 census definition, but were included as “Other nursery and greenhouse crops.”

Cropland used only for pasture or grazing - This is land used only for pasture or grazing that could have been used for crops without additional improvement. Also included are acres of crops hogged or grazed but not harvested prior to grazing. However, cropland that was pastured before or after crops were harvested was to be included as harvested cropland rather than cropland for pasture or grazing.

Crops unit of measurement - Respondents were instructed to report crops in the units published.

Flowing or artesian wells - Flowing or artesian wells are wells which flow freely and provide water used for irrigation without pumping. All flowing or artesian wells were excluded from pumping data on Tables 14 and 15. This should be taken into consideration when using data from these two tables. The 1998 survey was the first time the question was a respondent-reported item. Past surveys subtracted the reported number of pumped wells from the reported total wells used to derive the number of artesian wells.

Institutional, research, experimental, and American Indian reservation farms - Institutional, research, and experimental farms were previously called abnormal farms. In the 2002 census, these farms were combined with Indian Reservation farms into one category. However, in the 2003 survey American Indian Reservations are included while the others are excluded. Research farms include farms operated by private companies as well as those operated by universities, colleges, and government organizations for the purpose of expanding agricultural knowledge.

Irrigated farms - Irrigated farms or ranches are those with any agricultural land irrigated by any artificial or controlled means in the specific calendar year. The acreage irrigated may vary from a very small portion of the total acreage in the farm or ranch to irrigation of all agricultural land in the farm or ranch. Livestock lagoon waste water distributed by sprinkler or flood systems was also included.

Land in farms - The acreage designated as “land in farms” consists primarily of agricultural land used for crops, pasture, or grazing. It also includes woodland and wasteland not actually under cultivation or used for pasture or grazing, provided it was part of the farm operator’s total operation. Large acreages of woodland or wasteland held for nonagricultural purposes were deleted from individual reports during the edit process. Land in farms includes acres in the Conservation Reserve and Wetlands Reserve Programs.

Land in farms is an operating unit concept and includes land owned and operated as well as land rented from others. Land used rent free was reported as land rented from others. All grazing land, except land used under government permits on a per-head basis, was included as “land in farms” provided it was part of a farm or ranch. Land under the exclusive use of a grazing association was reported by the grazing association and included as land in farms. All land in American Indian reservations used for growing crops or grazing livestock was included as land in farms. Land in reservations not reported by individual American Indians or non-Native Americans was reported in the name of the cooperative group that used the land. In many instances, an entire American Indian reservation was reported as one farm.

Market value of agricultural products sold - The market value of agricultural products sold represents the gross market value before taxes and production expenses of all agricultural products sold or removed from the place in 2003 regardless of who received the payment. It is equivalent to total sales. It includes sales by the operator as well as the value of any shares received by partners, landlords, contractors, or others associated with the operation. The market value of agricultural products sold represents the sum of all crops, including nursery products, and livestock and poultry and their products. It does not include income from farm-related sources, such as custom work or agricultural services, or income from nonfarm sources.

The 2003 Farm and Ranch Irrigation Survey is the first time sales data from the survey year has been collected. In the previous surveys, these data were taken from the previous census report forms of the irrigation survey respondents. Therefore, the market value of sales did not always match up to the commodities reported in the

survey due to differing yields and prices and operation changes from year to year.

North American Industry Classification System - Beginning with the 1997 Census of Agriculture and the 1998 Farm and Ranch Irrigation Survey, farms were classified by type of activity according to the North American Industry Classification System, (NAICS). Prior to 1997, the Standard Industrial Classification System (SIC) was used. An establishment primarily engaged in crop production (major group 111) or production of livestock and animal specialties (major group 112) is classified in the four-digit industry and three-digit industry group which accounts for 50 percent or more of the total value of sales of its agricultural products. If the total value of sales of agricultural products of an establishment is less than 50 percent from a single four-digit industry, but 50 percent or more from the products of two or more four-digit industries within the same three-digit industry group, the establishment is classified in the miscellaneous industry of that industry group. Otherwise, it is classified as "All Other Crop Farming" in industry 11199 or a general livestock farm in industry 11299.

Classifications of irrigated farms by selected NAICS groupings are shown in Table 33. The NAICS codes for the 2003 survey respondents were determined from their 2002 census report.

Off-farm water supply - Off-farm water supply is water from off-farm water suppliers, such as the U.S. Bureau of Reclamation; irrigation districts; mutual, private, cooperative, or neighborhood ditches; commercial companies; or community water systems.

On-farm surface supply - On-farm surface supply is water from a surface source not controlled by a water supply organization. It includes sources such as streams, drainage ditches, lakes, ponds, and reservoirs on or adjacent to the operated land.

Other cropland - Other cropland includes cropland not harvested and not grazed which was used for cover crops or soil-improvement crops, land on which all crops failed, land in cultivated summer fallow, idle cropland, and land planted in crops that were to be harvested after the survey year.

Other pastureland and rangeland - This land use category is very inclusive and encompasses all grazable land that does not qualify as cropland pasture. It may be irrigated or dry land. In some areas, it can be a high quality pasture that could not be cropped without improvements. In other areas, it is barely able to be grazed and is only marginally better than wasteland.

Sprinkler systems - Sprinkler irrigation is divided into four areas to reflect current trends in irrigation. The center pivot and mechanical-move methods have, by definition, high-pressure delivery with water delivered at 60 psi or more, medium pressure delivery with water delivered at 30 to 59 psi, and low pressure delivery with water delivered at less than 30 psi. The mechanical-move systems are classified as either linear move, side roll, wheel move, or big gun where the sprinkler device is moved across the field either by self-propelled methods or by tractor. Since all big guns operate at high pressure, pressure was not asked.

Hand move systems include distribution systems laid out in the spring and removed at the end of the season, as well as other sprinkler systems which are moved without mechanical assistance. Solid set and permanent systems are sprinklers placed in the ground permanently and used mostly for perennial crops.

Total cropland - This category includes cropland harvested, cropland used only for pasture or grazing, cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed, cropland on which all crops failed or were abandoned, and cropland in cultivated summer fallow.

Woodland - Woodland includes natural or planted woodlots or timber tracts, cutover and deforested land with young growth which has or will have value for wood products and woodland pastured. Land covered by sagebrush or mesquite was reported as other pastureland and rangeland or other land. Land planted for Christmas tree production and short rotation woody crops was reported in cropland harvested and land in tapped maple trees was reported as woodland not pastured.

STATISTICAL METHODOLOGY

Target Population

The target population for the survey was composed of all farms irrigating in the reference year 2003, excluding horticultural specialty farms and institutional, research, or experimental farms. To obtain measurement for this target population, the frame population was constructed to include all farms that reported irrigated acres in the 2002 Census of Agriculture except for farms that reported horticultural crop sales of at least \$10,000 and all institutional, research, and experimental farms. The farms in the excluded categories represented 11 percent of the total number of irrigators and 2 percent of the irrigated land reported in the 2002 census.

Undercoverage existed in the frame population to the extent that there were farms that either erroneously reported not irrigating in the 2002 census, started irrigating in 2003, or had succeeding irrigators in 2003 (i.e., an operator who, since 2002, took over control of an irrigating farm through sales, rental, or other arrangements). Overcoverage existed in the frame because some operations were misclassified as irrigators and did not irrigate in 2002 or had either stopped farming or irrigating in 2003. Farms in these groups that were selected into the sample were identified during the survey and estimates of their number and acres irrigated are provided. Table B provides the farm count and acres irrigated by State for both the survey frame population and the 2002 census.

Sample Design

Sampling frames were created at the State level and consisted of the farm operations reported in that State in the 2002 census that satisfied the frame definition stated above. The survey estimates were based on a probability sample of farms from each State frame. The sample design consisted of a stratified systematic sample selected independently from each of the 50 State frames. All farms in a sampling frame were stratified on the basis of total irrigated acres reported in the 2002 census. The stratification boundaries varied among the States and were dependent on the distribution of total acres irrigated variable within the State. A certainty stratum, whose farms were selected

with probability one, was included in each State so that the major irrigators in each State were included.

The State sample sizes necessary to obtain the desired level of precision were determined by analyzing the variation of the total acres irrigated variable in each State's sampling frame. These sample sizes were adjusted using historical nonresponse data to the survey. The total national sample size was 25,014 farms; 1,823 of these farms were selected from the certainty strata and the remaining 23,191 farms were systematically selected from the noncertainty strata. Table B provides the State sample sizes.

Survey Error

The statistics in this report are estimates derived from a sample survey. There are two types of errors possible in an estimate-based sample survey: sampling and nonsampling. Sampling error is the error caused by observing only a sample instead of the entire population. The sampling error is subject to sample-to-sample variation. Nonsampling errors include all other errors and can arise from many different sources. These sources may include respondent or enumerator error or incorrect data keying, editing, or imputing for missing data. Nonsampling error due to mail list incompleteness and duplication, as well as misclassification of records on the mail list, is referred to as coverage error.

Measures of Precision

The survey sample was one of a large number of possible samples of the same size that could have been selected using the same sample design. Survey estimates derived from the different samples will differ from each other.

The relative standard error is used as an indicator of the precision in the survey estimates and is reported for major survey items in Table C. The relative standard error expresses the standard error of an estimate as a percent of the estimated value. The standard error of a survey estimate is a measure of the variation among the estimates from all possible samples. It is a measure of the precision with which an estimate from a particular sample approximates the average result of all possible samples.

Table B. Irrigated Farms: 2003 Farm and Ranch Irrigation Survey and the 2002 Census of Agriculture

Geographic area	2003 Survey						2002 Census			
	Initial mailout counts		Final reports processed and tabulated				Published totals		Sample universe ¹	
			Unexpanded ²		Expanded ³					
	Farms	2002 acres	Farms	Acres irrigated	Farms	Acres irrigated	Farms	Acres irrigated	Farms	Acres irrigated
United States	25,014	20,963,602	17,310	15,358,202	220,163	52,583,431	299,583	55,311,236	203,123	49,031,141
Alabama	509	68,986	264	32,778	578	52,722	1,698	108,783	940	74,220
Alaska	45	2,278	32	2,013	73	2,252	150	2,742	84	2,353
Arizona	505	676,385	328	513,907	2,777	836,587	4,172	931,735	2,377	849,354
Arkansas	823	1,282,455	584	963,372	4,834	3,944,867	5,847	4,149,766	4,957	3,903,271
California	1,202	2,668,447	862	1,931,009	46,841	8,471,936	55,596	8,709,353	37,803	7,551,425
Colorado	591	692,926	449	483,183	11,567	2,562,329	13,623	2,590,654	10,346	2,311,638
Connecticut	104	3,257	81	1,428	234	2,213	801	10,139	276	3,764
Delaware	207	83,194	140	46,321	213	69,088	439	97,167	300	87,109
Florida	672	1,174,105	411	972,930	8,335	1,497,653	13,456	1,815,174	7,485	1,485,803
Georgia	783	499,744	559	307,172	2,847	710,893	5,369	870,810	3,415	754,538
Hawaii	402	56,022	279	69,553	1,214	78,538	2,231	69,194	1,406	58,352
Idaho	773	1,242,864	575	1,003,451	14,303	3,126,857	15,901	3,288,522	11,976	3,145,799
Illinois	569	279,261	484	254,915	1,195	374,919	2,031	390,843	1,221	336,963
Indiana	580	228,105	416	160,319	1,193	276,294	2,212	313,130	1,464	287,687
Iowa	462	122,167	305	89,159	709	134,164	976	142,109	756	128,731
Kansas	616	876,807	434	623,085	4,878	2,543,950	5,915	2,678,277	5,381	2,623,544
Kentucky	647	19,689	457	11,860	943	20,685	3,606	36,751	2,415	30,334
Louisiana	919	666,876	625	453,143	2,280	838,717	3,496	938,841	2,243	803,247
Maine	105	15,910	84	13,078	507	18,163	1,031	19,703	490	16,846
Maryland	305	61,501	197	34,415	509	53,734	1,265	80,828	708	65,597
Massachusetts	125	9,611	109	7,282	842	16,151	1,580	23,720	816	17,021
Michigan	584	298,638	405	231,642	2,366	432,665	4,413	456,278	2,588	377,628
Minnesota	659	331,676	447	254,765	1,639	434,500	2,433	454,850	1,647	396,265
Mississippi	791	1,064,232	469	768,247	1,567	1,169,793	2,235	1,175,530	1,662	1,153,086
Missouri	791	740,514	591	580,131	1,966	1,020,728	3,304	1,032,973	2,083	883,096
Montana	647	575,696	495	478,008	8,625	2,131,955	10,150	1,976,111	8,409	1,807,548
Nebraska	585	774,332	457	630,357	16,278	7,516,171	17,970	7,625,170	14,450	6,650,859
Nevada	404	487,946	299	341,918	1,722	639,310	1,981	746,653	1,539	608,589
New Hampshire	129	689	96	425	161	818	451	2,292	214	871
New Jersey	383	51,162	253	30,041	807	46,679	2,124	96,893	967	56,130
New Mexico	579	501,622	417	359,750	6,741	769,787	8,282	844,799	5,499	745,851
New York	404	45,914	203	16,166	1,284	48,545	3,307	74,663	1,629	62,723
North Carolina	495	115,094	270	26,948	2,281	101,055	6,721	264,057	4,127	220,792
North Dakota	352	162,327	257	129,461	541	207,772	659	202,817	520	175,369
Ohio	314	19,086	205	9,393	670	14,476	2,623	40,685	932	21,128
Oklahoma	568	351,478	391	273,820	1,819	508,842	2,942	517,553	2,104	434,217
Oregon	771	793,879	569	591,991	14,205	1,731,660	17,776	1,907,627	11,641	1,604,468
Pennsylvania	470	19,383	283	7,621	1,589	19,633	4,108	42,516	1,928	26,046
Rhode Island	56	612	35	497	58	648	264	3,963	98	719
South Carolina	285	61,627	158	31,985	951	52,046	1,918	95,642	1,122	70,523
South Dakota	409	204,243	316	149,250	1,444	390,406	1,755	401,083	1,301	312,647
Tennessee	411	38,198	215	26,109	759	34,429	2,592	61,217	1,043	39,602
Texas	1,054	1,365,569	698	880,953	15,441	4,947,745	21,164	5,074,638	14,038	4,509,969
Utah	591	351,200	495	267,931	10,070	1,082,213	11,587	1,091,011	8,950	966,653
Vermont	97	724	62	326	204	825	508	2,335	175	887
Virginia	414	49,728	228	14,622	905	33,635	3,331	98,913	2,027	74,402
Washington	733	818,305	506	617,101	12,862	1,806,782	15,534	1,823,155	9,780	1,523,908
West Virginia	83	1,039	55	507	100	801	408	1,981	185	1,248
Wisconsin	513	310,106	409	285,661	1,414	391,763	2,457	385,902	1,405	344,976
Wyoming	498	697,994	351	378,203	4,822	1,415,037	5,191	1,541,688	4,201	1,423,345

¹ Excludes institutional, research, and experimental farms and horticultural specialty farms.

² Includes 2,361 farms that discontinued irrigation since 2002.

³ Includes 32,489 farms that discontinued irrigation since 2002.

Table C. Relative Standard Error (percent) for Selected Irrigation Data: 2003

[Excludes abnormal and horticultural specialty farms. For meaning of abbreviations and symbols, see introductory text]

Geographic area	Irrigated farms	Land in farms	Acres irrigated				Acre-feet of water applied, all sources	Wells used in 2003	Pumps, all types	Expenses for irrigation		
			Total	Cropland harvested	By sprinkler systems	By gravity flow				Energy used for pumping	For wells, pumps, equipment, and facilities	Maintenance and repair
United States	1.0	3.1	1.0	3.2	1.7	1.4	1.4	1.8	1.6	3.0	4.3	3.0
Alabama	6.6	9.4	6.1	9.5	6.5	31.2	7.7	10.3	7.4	6.3	18.1	18.1
Alaska	6.5	8.8	3.9	6.9	4.2	53.5	35.4	12.6	11.3	8.2	13.9	12.4
Arizona	9.9	7.1	2.4	2.6	7.9	2.8	2.6	28.9	32.4	6.5	11.0	7.7
Arkansas	3.6	2.9	2.3	2.7	9.0	2.6	3.4	3.5	3.3	3.5	15.7	7.0
California	2.8	8.5	3.5	3.9	11.2	3.8	3.4	7.5	5.5	9.9	15.0	8.7
Colorado	3.9	10.2	3.9	12.7	5.0	7.8	5.3	9.2	8.2	5.5	15.4	10.9
Connecticut	10.5	17.0	8.2	15.3	10.7	-	11.0	24.8	11.9	7.9	26.8	29.9
Delaware	12.4	5.6	4.1	5.7	4.0	-	9.8	4.7	5.4	5.7	13.4	16.0
Florida	5.9	8.7	2.3	6.8	8.9	5.6	3.2	7.5	6.2	4.6	12.0	6.1
Georgia	7.1	5.3	4.3	4.3	5.0	19.0	5.2	6.1	4.6	6.1	19.7	7.1
Hawaii	3.4	34.7	14.1	20.3	9.6	22.2	19.7	25.8	11.4	16.9	17.4	12.6
Idaho	3.1	8.9	2.1	4.8	3.0	6.0	3.0	7.9	6.1	3.4	9.2	6.7
Illinois	3.5	4.8	1.7	5.0	1.7	29.9	2.2	2.2	2.2	2.2	9.9	5.6
Indiana	5.8	6.5	2.4	6.6	2.4	35.5	3.3	5.4	4.6	3.3	9.7	12.3
Iowa	3.8	15.3	2.8	16.2	2.9	15.2	3.3	4.5	4.0	3.9	12.7	7.3
Kansas	3.6	5.2	2.5	4.9	2.9	9.2	3.4	3.2	4.9	4.0	11.3	7.4
Kentucky	6.5	8.4	5.6	8.7	6.1	24.4	6.4	15.7	7.9	9.4	18.6	18.4
Louisiana	5.5	9.9	3.1	8.8	7.1	3.4	3.7	5.0	18.0	3.8	7.5	43.6
Maine	12.6	18.0	9.6	26.2	11.6	41.0	13.2	21.9	14.5	20.4	17.6	25.0
Maryland	10.5	12.1	5.6	12.1	5.7	97.9	8.0	9.6	12.1	13.0	18.1	13.8
Massachusetts	7.0	10.2	6.7	11.8	7.8	43.5	10.6	29.4	8.4	14.8	19.9	11.6
Michigan	4.6	4.5	2.2	4.6	2.4	98.0	2.8	6.9	6.8	2.8	11.0	5.2
Minnesota	4.0	3.6	2.2	3.6	2.4	13.8	2.6	3.2	3.4	2.7	38.1	5.2
Mississippi	21.3	3.5	2.4	2.6	4.1	3.1	3.3	4.8	4.4	3.7	6.9	5.9
Missouri	6.2	4.8	2.3	4.3	4.0	3.5	3.1	2.8	2.7	2.9	7.5	7.4
Montana	4.0	14.2	4.1	35.6	7.0	5.1	5.4	30.1	9.2	7.7	18.9	9.4
Nebraska	2.2	8.4	3.2	7.4	4.5	6.8	4.4	3.9	3.7	5.1	16.1	8.5
Nevada	3.5	8.4	3.6	6.5	7.5	4.9	4.3	7.5	7.0	6.8	13.6	11.4
New Hampshire	6.5	13.6	9.4	14.2	13.4	21.4	18.0	13.0	9.2	14.0	24.1	26.5
New Jersey	8.6	7.8	4.0	8.8	5.0	29.7	8.7	8.8	6.6	5.8	19.4	8.3
New Mexico	5.7	25.5	4.7	5.8	5.4	8.5	4.4	7.2	8.1	5.0	9.9	8.0
New York	11.7	12.8	10.7	14.0	12.0	-	13.7	19.9	13.9	15.1	18.4	17.5
North Carolina	12.3	11.6	7.9	14.2	8.5	59.9	15.7	26.8	11.3	10.7	20.6	16.1
North Dakota	2.7	8.0	2.8	10.0	3.6	10.4	6.2	5.5	4.7	5.2	12.3	13.6
Ohio	9.1	10.1	9.6	10.1	11.4	53.5	36.2	18.4	11.9	31.7	23.1	14.3
Oklahoma	8.0	12.5	3.8	8.2	4.4	11.4	5.4	7.4	7.1	4.0	14.3	8.8
Oregon	4.5	9.4	2.8	16.1	5.0	4.8	3.5	17.2	8.2	5.8	14.7	11.9
Pennsylvania	7.7	17.8	11.0	20.3	11.1	34.8	11.5	16.9	11.4	11.7	18.5	24.0
Rhode Island	15.1	11.9	8.7	16.1	6.0	13.0	12.1	37.8	19.5	8.6	27.3	55.9
South Carolina	15.7	17.1	6.8	12.4	7.0	74.6	11.1	21.6	15.1	11.3	16.2	13.9
South Dakota	3.8	9.5	2.7	9.1	4.1	8.7	49.9	6.4	5.9	5.6	20.5	10.1
Tennessee	10.0	7.8	5.1	8.1	6.0	34.4	7.5	16.1	10.8	17.7	21.8	14.5
Texas	5.9	13.6	5.4	5.6	7.6	8.8	6.0	4.9	5.0	9.0	12.2	12.7
Utah	3.2	14.7	3.2	6.7	6.2	4.3	4.4	15.7	15.0	9.2	14.3	10.2
Vermont	8.0	17.9	13.9	22.8	25.3	50.9	17.2	16.7	14.0	24.4	35.8	53.1
Virginia	16.7	19.6	8.9	12.4	10.9	-	10.9	28.8	15.7	12.1	30.3	32.3
Washington	3.8	10.0	3.5	6.5	4.4	9.2	3.9	13.0	7.4	5.3	13.6	8.2
West Virginia	16.5	22.8	11.5	33.2	10.1	(Z)	7.0	31.1	22.1	17.1	49.7	62.5
Wisconsin	4.1	4.3	1.8	5.0	1.8	74.9	4.2	3.6	10.2	3.4	9.3	5.1
Wyoming	2.2	13.5	3.8	9.1	8.8	4.9	4.7	16.6	11.8	10.8	25.1	8.6
Water Resources Areas												
WRA 01 New England	4.8	11.6	5.3	17.1	6.4	35.5	9.4	12.7	6.0	11.7	11.8	9.8
WRA 02 Mid-Atlantic	6.0	7.2	2.7	6.5	2.9	24.0	4.5	6.9	5.7	4.2	9.4	10.0
WRA 03 South Atlantic-Gulf	4.5	5.1	2.0	3.9	3.7	5.3	2.7	5.6	4.1	3.4	8.9	4.7
WRA 04 Great Lakes	5.0	3.8	2.1	3.9	2.2	74.7	2.4	5.6	5.5	2.6	8.9	4.3
WRA 05 Ohio	6.1	6.4	3.7	6.7	3.7	31.4	6.3	6.4	5.1	6.4	9.6	13.1
WRA 06 Tennessee	20.0	14.2	10.8	13.7	11.7	97.2	12.7	20.2	17.7	17.3	19.7	48.3
WRA 07 Upper Mississippi	2.8	3.9	1.5	4.3	1.5	14.8	2.2	2.5	4.5	2.2	14.2	3.4
WRA 08 Lower Mississippi	3.3	2.8	1.7	2.5	4.2	2.0	2.6	2.5	3.7	2.6	11.0	11.0
WRA 09 Souris-Red-Rainy	10.7	6.1	4.3	6.3	4.6	15.2	5.4	6.3	6.7	6.3	11.5	9.1
WRA 10 Missouri	2.5	6.2	2.2	9.0	3.2	3.6	4.0	3.3	3.0	3.9	11.2	6.0
WRA 11 Arkansas-White-Red	6.6	8.3	5.4	5.2	6.9	6.7	5.6	5.2	4.9	9.7	12.7	13.7
WRA 12 Texas-Gulf	8.1	10.5	3.9	6.3	4.8	10.7	4.8	5.7	5.9	4.4	11.3	8.4
WRA 13 Rio Grande	10.9	29.4	6.4	6.7	8.5	9.4	6.3	8.0	8.0	7.4	10.6	11.6
WRA 14 Upper Colorado	8.8	23.7	7.9	23.5	11.6	9.8	8.0	53.1	20.3	16.5	26.8	11.9
WRA 15 Lower Colorado	10.1	18.0	2.6	2.7	8.2	2.8	2.6	26.1	28.5	6.3	11.3	7.6
WRA 16 Great Basin	6.5	10.1	3.4	6.6	6.1	4.1	3.7	8.5	11.6	6.1	10.8	15.6
WRA 17 Pacific Northwest	2.7	5.6	1.7	6.4	2.3	3.9	2.1	8.1	4.4	2.7	7.1	4.4
WRA 18 California	2.9	8.4	3.4	3.8	10.6	3.8	3.3	7.5	5.4	9.8	14.8	8.6
WRA 19 Alaska	6.5	8.8	3.9	6.9	4.2	53.5	35.4	12.6	11.3	8.2	13.9	12.4
WRA 20 Hawaii	3.4	34.7	14.1	20.3	9.6	22.2	19.7	25.8	11.4	16.9	17.4	12.6

The relative standard errors given in Table C can be used to construct confidence intervals for the major survey items. Confidence intervals are another way to express the precision of an estimate by calculating the upper and lower bounds for a level of confidence. This confidence interval is designed to contain the true value being estimated. If all possible samples were selected, each of the samples were surveyed under essentially the same conditions, and an estimate and its standard error were calculated from each sample, then:

1. Approximately 67 percent of the intervals from one standard error below the estimate to one standard error above the estimate would include the average value of all possible samples.
2. Approximately 90 percent of the intervals from 1.65 standard errors below the estimate to 1.65 standard errors above the estimate would include the average value of all possible samples.

The computations necessary to construct the confidence intervals associated with these statements are illustrated in the following example: Assume that the estimated number of irrigated acres of a certain item is 669,813 and the relative standard error of the estimate is 1.6 percent (0.016). Multiplying 669,813 by 0.016 yields 10,717, the standard error. Therefore, a 67 percent confidence interval is 659,096 to 680,530 (i.e., 669,813 \pm 10,717). Similarly, a 90 percent confidence interval is 652,130 to 687,496 (i.e., 669,813 \pm 1.65 x 10,717).

Estimation

Estimates were produced for the Nation as a whole, for each of the 50 States, and for the geographic domains known as Water Resources Areas (WRA). The estimation methodology accounted for both selection of the survey sample and survey nonresponse. The estimator for the State totals was a direct expansion reweighted estimator. The expansion factor was the inverse of the selection probability for the sample farms in a stratum. This expansion factor was reweighted at the stratum level to account for whole-farm nonresponse. The nonresponse adjustment factor used to reweight the expansion factor was the ratio of the number of sample farms in a stratum to the number of sample farms that responded to the survey in that

stratum. The assumption underlying this weighting approach to survey nonresponse was that survey respondents and nonrespondents within a stratum constitute a homogeneous population, thus allowing respondents to represent nonrespondents. The reweighted expansion factor is the product of these two factors and is equal to the ratio of the total number of farms in the stratum to the total number of sample farms that responded to the survey in that stratum. An expanded data value for a sample record was obtained by multiplying the data value by the reweighted expansion factor. State totals for a characteristic were estimated by summing the expanded data values from all responding sample records across all strata within the State. National estimates were obtained by summing across all States. The WRA estimates were obtained by summing the expanded data values for the portion of the sample falling into the WRA.

EDITING

Reported data that were obviously incorrect due to misinterpretation of a question were either corrected or deleted prior to the computer edit. In some cases, respondents may have failed to provide all of the information requested, only indicating the presence of an item but not the amount. Imputations were made for missing data on acres irrigated, quantity of water used, method of water distribution, yield of crops harvested, maintenance and repair costs, cost of water received from off-farm water suppliers, well characteristics, and energy cost of well pumps.

QUALIFICATIONS OF THE DATA

Analysts reviewing the returned report forms and results of the computer edit detected a few inquiries that were not uniformly interpreted by all respondents. Data users should be aware that respondent interpretation of some questions may affect the final results in their use of these selected statistics. Clarification of data items with potential extortions and data impacted by unique problems or definitions are provided below.

Irrigated land - Irrigated land is defined as “all land watered by artificial or controlled means.” No attempt has been made to define the degree or intensity of irrigation. Therefore, the figures for irrigated land

include land with as little as one inch of water applied as well as land having several feet of water applied.

Nonirrigated crop yields - Data users are reminded that the nonirrigated crop yield averages in Table 27 are for nonirrigated crops harvested from farms having land irrigated and may not be comparable with crop yield averages for total farms in the State. Yields for sweet corn, tomatoes, and lettuce were asked for the first time in 2003. However, many respondents left yields blank which required a large amount of imputation and the yields that were reported for these crops covered an extremely large range indicating respondents did not always use the hundredweight unit requested on the form. Therefore it was decided that these three vegetable yields would not be published.

Estimated quantity of water applied - Most water used for irrigation is not metered or measured accurately. The quantity of water data are on the basis of best estimates provided by irrigators. Generally, in areas of water scarcity such as southern California and Arizona, irrigators are more likely to be able to provide actual quantities of water used than in Mountain States such as Montana, Wyoming, and Idaho where scarcity of water is less of a problem. In the Mountain States where water from snow-melt is diverted for use in season, the amount of water used may be a rough estimate, seldom a measured figure.

Farms using off-farm water - In 2003, respondents were asked to report the amount (none, some, all, or unknown) of off-farm water supplied by the U.S. Bureau of Reclamation, other federal agencies, and all other suppliers. However, many respondents did not answer this question. No imputation was used to determine an amount by source. Instead, the edit set the entry to unknown. The number using water from U.S. Bureau of Reclamation, other federal agencies, and all other suppliers may be understated.

Average hours of operation - The total hours a well pump operated was collected for each of the first three wells reported. For the remaining number of well pumps, respondents were asked to report the average hours the pumps operated. Some data collected in this entry exceeded 8,760 hours, the maximum number of hours in a year, meaning that some respondents had entered their total pump operating hours rather than the

average hours used. Records exceeding the 8,760 hour threshold were edited, but other records may have been tabulated with inflated operating hours.

Application of commercial fertilizers or pesticides in irrigation water - This inquiry was intended to measure the number of farms and acres on which fertilizer and pesticides were distributed through irrigation systems. The question was redesigned in 2003 to avoid the overstated farm count and acres thought to have occurred in 1998 because respondents misinterpreted the inquiry to include conventional application of fertilizer and pesticides to the irrigated crop as well. Review of the 2003 data suggests that farmers may have missed the question on the report form and left it blank. Therefore, farms and acres may be understated in 2003.

Cost of water received from off-farm water suppliers - Irrigators receiving water from off-farm water suppliers are generally required to pay for the water in charges, fees, or assessment. The computer edit procedures called for imputing an estimate for cost of water based on other reports from the same geographic area. The final tabulated results for this item may be overstated because it was not possible to distinguish cases where the respondent received free water from cases where the cost amount was omitted in error, leading to imputation of a dollar amount. States with small sample sizes, mostly in the Northeast, reported a wide range for the cost of water with data skewed to the high end which may be due to the use of expensive municipal water on small acres.

Irrigation wells - The question was intended to capture only those wells used for irrigation purposes. However, some farm operators reported wells used for domestic purposes or livestock as well. When such errors were identified, these entries were deleted.

Artesian wells - A specific entry space was provided for artesian wells. The data for well pumps exclude any pumps that may have actually been used to pump water from artesian wells.

Irrigation pumps - The inventory figures for number of irrigation pumps reported in Table 16 include reserve pumps not actually used in 2003, but exclude any pumps on wells not used in 2003. By definition,

flowing or artesian wells do not have well pumps.

Expenditures for maintenance and repair and investment in irrigation facilities and equipment -

The data reported are for expenditures that occurred only in 2003. Some respondents found it difficult to separate expenditures for maintenance and repairs from investment in irrigation facilities and equipment as defined on the report form. For example, replacement of worn-out sprinkler nozzles, pumps, and motors could be considered as either repair cost or investment in new equipment. Data users are reminded that the distinction between the two expenditure categories was left up to the respondent.

Government programs - This item shows the effect of government programs on irrigation practices.

Improvements to irrigation systems that reduce energy and/or conserve water used in irrigation -

This item shows the benefits of new resource-conserving irrigation systems. Respondents were asked to respond for the period covering 1998 to 2003. The information was tabulated as reported. No imputation was made for a blank response.

Sources of irrigation information - This question identifies where farmers look for help in making irrigation decisions. The information for this item was tabulated as reported. No imputation was made for a blank response.

Reason for discontinuance of irrigation since 2002 -

The data shown in Table 42 reflect the expansion of reported entries. Some respondents reported multiple reasons, while others gave no specific reason.

Table D. Leading Irrigation States: 2002, 1997, and 1992 Censuses

Geographic area	Acres irrigated			Rank			2002 cumulative percent of U.S. total
	2002	1997	1992 ¹	2002	1997	1992	
United States	55,311,236	56,289,172	49,404,030	(X)	(X)	(X)	100.0
20 Leading States	50,812,487	52,266,055	45,703,882	(X)	(X)	(X)	91.9
California	8,709,353	8,886,693	7,571,313	1	1	1	15.7
Nebraska	7,625,170	7,065,556	6,311,633	2	2	2	29.5
Texas	5,074,638	5,764,295	4,912,308	3	3	3	38.7
Arkansas	4,149,766	3,785,338	2,701,651	4	4	7	46.2
Idaho	3,288,522	3,543,805	3,260,006	5	5	4	52.2
Kansas	2,678,277	2,695,816	2,680,343	6	7	6	57.0
Colorado	2,590,604	3,374,233	3,169,839	7	6	5	61.7
Montana	1,976,111	2,101,548	1,978,167	8	8	8	65.3
Oregon	1,970,627	1,963,478	1,622,235	9	9	9	68.7
Washington	1,823,155	1,787,120	1,641,437	10	11	11	72.0
Florida	1,815,174	1,873,823	1,782,680	11	10	10	75.3
Wyoming	1,541,688	1,749,908	1,464,585	12	12	12	78.1
Mississippi	1,175,530	1,110,145	882,976	13	14	19	80.2
Utah	1,091,011	1,218,474	1,142,514	14	13	13	82.2
Missouri	1,032,973	921,113	708,864	15	17	20	84.0
Louisiana	938,841	960,831	897,641	16	16	17	85.7
Arizona	931,735	1,075,336	956,454	17	15	14	87.4
Georgia	870,710	773,066	724,792	18	19	18	89.0
New Mexico	844,799	851,735	738,272	19	18	16	90.5
Nevada	746,653	763,742	556,172	20	20	15	91.9

¹ 1992 data have not been adjusted for farms not on the mail list.

SUMMARY

Irrigated Crops

Compared with 1998, the number of farms and ranches irrigating fell 2 percent to 220,163 in 2003, and total land irrigated was down 3 percent to 52.6 million acres. The leading States in total acreage of irrigated land in 2003 were California (16 percent of U.S. total), Nebraska (14 percent), and Texas (9 percent). Table D shows the top twenty states from the 2002 census and their previous census acres irrigated and rank.

Corn for grain or seed continues to be the dominant irrigated crop accounting for nearly 19 percent of irrigated land. The top irrigated crops in the United States in 2003 were corn for grain or seed, alfalfa hay, soybeans, land in orchards, and cotton. These crops accounted for 56 percent of all irrigated land. Irrigated pastureland accounted for 3.63 million acres in 2003, down 8 percent from 1998.

Estimated Quantity of Water Applied

The total quantity of water applied in 2003 was down 11 percent from 1998. Nationally, irrigators estimated a total of 86.9 million acre-feet of water was applied to the 52.6 million acres irrigated in 2003 for an average of 1.7 acre-feet per acre irrigated. Table E shows the average acre-feet of water applied per irrigated acre in the U.S. over the last 29 years. The average amount of water applied per acre in 2003 ranged from a high of 5.6 acre-feet in Massachusetts, to a low of 0.4 acre-feet in several States.

Table E. **Average Acre-Feet of Water Applied: 2003 and Earlier Surveys and 1974 Census**

Year and source	Amount applied (acre-feet)
2003 Farm and Ranch Irrigation Survey	1.65
1998 Farm and Ranch Irrigation Survey	1.79
1994 Farm and Ranch Irrigation Survey	1.72
1988 Farm and Ranch Irrigation Survey	1.82
1984 Farm and Ranch Irrigation Survey	1.8
1979 Farm and Ranch Irrigation Survey	1.86
1974 Census of Agriculture	2.09

Method of Irrigation

In 2003, farmers and ranchers irrigated 52.6 million acres by different water distribution systems. Of the total acres irrigated, 26.9 million acres were irrigated by sprinkler systems and 23.1 million acres by gravity flow systems. For the first time, the Farm and Ranch Irrigation Survey shows more acres irrigated with sprinkler systems than gravity flow systems.

Sprinkler systems were used on 51 percent of the total land irrigated in 2003 compared with 46 percent in 1998, 46 percent in 1994, and 40 percent in 1988. Gravity flow systems were used on 43 percent of the land in 2003, compared with 50 percent in 1998, 50 percent in 1994, and 59 percent in 1988. Table F shows acres irrigated by method in 2003 and 1998.

Table F. **Acres Irrigated by Method of Irrigation: 2003 and 1998 Surveys**

Method	1998 acres irrigated	2003 acres irrigated	Percent change
Sprinklers	24,865,142	26,937,835	+ 8.3
Center pivot - low pressure	9,292,022	9,696,930	+ 4.4
Center pivot - medium pressure	7,419,409	9,657,353	+30.2
Center pivot - high pressure	1,983,869	1,938,808	- 2.3
Linear move towers	284,756	344,162	+20.9
Solid set and permanent	1,222,683	1,177,953	- 3.7
Side roll	2,033,825	1,825,901	-10.3
Big gun or traveller	765,794	633,188	-17.3
Hand move	1,862,784	1,663,540	-10.7
Gravity flow	27,273,419	23,124,131	-15.2
Down rows or furrows	14,025,125	11,723,084	-16.4
Controlled flooding	8,472,646	8,847,392	+ 4.4
Uncontrolled flooding	3,273,796	2,297,956	-29.8
Other gravity	1,501,852	255,699	-83.0
Drip, trickle, or low-flow	2,259,176	2,988,101	+32.3
Subirrigation	549,655	279,522	- 49.2

Data tabulations for farms having only one of the four kinds of distribution systems - sprinklers, gravity, drip, or subirrigation - show noticeable differences in the amount of water applied per acre by each system. For example, farms using only sprinkler systems applied 1.3 acre-feet per acre irrigated, compared with 2.0 acre-feet for farms using only gravity flow systems.

Source of Water

Of the 52.6 million acres irrigated by water from all sources in 2003, about 32.3 million acres (61 percent) were irrigated from farm irrigation wells, 7.28 million acres (13 percent) from on-farm surface sources, and 13.9 million acres (26 percent) from off-farm water suppliers. Of the 86.9 million acre-feet of water estimated to be used for irrigation in 2003, 43.5 million were pumped from wells, 11.8 million were provided by on-farm surface sources, and 31.6 million came from off-farm water suppliers. Table G shows how these data correspond to previous farm and ranch irrigation surveys.

Table G. Irrigation Water Used by Source: 2003 and Earlier Surveys

Source	2003	1998	1994	1988	1984
Total:					
Acre-feet (million)	86.9	97.3	79.6	84.1	82.7
Wells:					
Acre-feet (million)	43.5	43.8	39.4	40.5	36.2
Percent	50	45	49	48	44
On-farm:					
Acre-feet (million)	11.8	11.9	8.6	8.9	10.2
Percent	14	12	11	11	12
Off-farm:					
Acre-feet (million)	31.6	41.5	31.6	34.9	36.2
Percent	36	43	40	41	44

The average amount of water applied per acre varies significantly by source. Land irrigated from wells only averaged 1.2 acre-feet per acre, while land irrigated from off-farm water suppliers averaged 2.3 acre-feet per acre. Sprinkler irrigation is more closely related to the distribution of well water, while gravity flow systems are generally used to distribute water from off-farm water suppliers.

Irrigation Wells

There were 401,193 irrigation wells capable of being used on 104,776 farms. Of these, 375,851 wells were actually pumped in 2003 and 3,823 were artesian or free flowing. All irrigation wells supplied 43.5 million acre-feet of water to 32.3 million acres of land,

averaging 1.35 acre-feet of water applied and 85.2 acres irrigated per well. Farms with wells used in 2003 averaged 3.6 wells per farm. Nearly 66 percent of the farms using wells in 2003 used one or two wells. However, the majority of wells used, 229,626, were on the 18,618 farms using more than five wells, indicating the impact of the large irrigators. Pumped wells for the United States averaged 238 feet in well depth, 158 feet in pumping depth, 819 gallons per minute in pumping capacity, and 1,039 hours in operation.

Irrigation Expenditures

Pumping costs - There were 497,443 irrigation pumps of all kinds used on 153,117 farms in 2003 irrigating 42.9 million acres of land. These pumps were powered by fuels and electricity costing irrigators a total of \$1.55 billion or an average of \$10,135 per farm. The principal energy source used was electricity, for which \$953 million was spent to power 319,102 pumps that irrigated 24.1 million acres at an average cost of \$39.50 per acre. Solar energy was reported as the source for pumping wells on 360 farms irrigating 16,430 acres.

Cost of water from off-farm water suppliers - The 31.6 million acre-feet of water received from off-farm water suppliers to irrigate 13.9 million acres cost irrigators \$579 million, for an average cost of \$18.29 per acre-foot of water or \$41.73 per acre irrigated. There were 20,349 farms receiving off-farm water at no cost.

Maintenance and repair cost - Expenditures for maintenance and repairs totaled \$492 million on 119,952 farms, for an average of \$4,099 per farm.

Expenses for hired and contract labor - In 2003, 62,260 farms paid \$658 million for labor, an average of \$10,559 per farm or \$24.13 per acre. Nearly 90 percent of the wages were paid to hired laborers.

Investment in irrigation equipment, facilities, and land improvement - Investments totaled \$1.13 billion for an average of \$13,056 per farm in 2003. The

principal investment was the purchase of irrigation equipment and machinery which totaled \$817 million and represents 73 percent of total investments.

Discontinuance of Irrigation in 2003

An estimated 32,489 farmers who irrigated a total of 1.85 million acres in 2002, according to the 2002 census, did not irrigate in 2003. The majority, 91 percent, of these operators reported that their discontinuance was not permanent.

Improvements to Irrigation Systems

Approximately 26.4 million acres irrigated were reported to have had improvements made on them to reduce energy use or conserve water since 1998. These improvements resulted in reduced water requirements on 18.5 million acres irrigated, improved crop yield on 18.7 million acres irrigated, and decreased energy costs on 15.3 million acres irrigated.