Farm-Size Characteristics of Western Irrigated Agriculture: Contributing to Water Conservation and Small Farm Policy Goals *

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USDA's 1998 National Commission on Small Farms brought to the forefront of the farm policy debate the plight of the small farm and the need for farm policy to influence the structure of U.S. agriculture in the future (USDA, 2000). In addition, USDA also recognizes the policy importance of improving agricultural water conservation to meet farm economic objectives, as well as "increasing water demands" for municipal/urban, industrial, and recreational uses under "increasingly scarce water-supply conditions" (USDA, 2001). In addition to growing water demands, the rising importance of high quality water supplies for both human and ecosystem health, and adequate water supplies to meet endangered species requirements and Native American water-right claims, have helped to clarify onfarm agricultural water conservation within USDA's resource conservation policy goals. The new farm bill, **The Farm Security & Rural Investment Act of 2002,** provides $250 million in new funding for a ground and surface water conservation program emphasizing cost-sharing of more efficient farm irrigation systems. This paper hypothesizes that the structure of irrigated agriculture in the western U.S. will play a significant role in the success of USDA water conservation and farm-structure policy goals applied to irrigated agriculture.

In 1997, irrigated agriculture in the 17 western States accounted for 29 percent of all farms in the West, with about 43.0 million irrigated acres (NASS - 1997 Census of Agriculture). In 1995, irrigated agriculture also accounted for 75 percent of total freshwater withdrawals in the West [132.1 million acre-feet (maf) out of 177.2 maf for all sectors], and 90 percent of consumptive water-use in the West (78.1 maf out of 87.2 maf for all sectors) (Solley, Pierce, and Perlman, 1998). In the 17 western States, most irrigated farms (81 percent) are "small farms" (farms with < $250,000 in total farm sales). But irrigated farms with ≥ $250,000 in total farm sales account for 61 percent of irrigated crop acres and 66 percent of the total farm water applied. Irrigated farms with total farm sales ≥ $500,000 alone (only 9.5 percent of all irrigated farms in the West) account for 48 percent of total farm water applied in the West.

Given the skewed nature of these distributions, meeting both USDA water conservation and small-farm policy goals requires understanding the farm-size structural distributions for irrigated farms, acres irrigated, applied irrigation water, irrigation technologies, water-management practices, barriers to irrigation system improvements, and producer participation in public cost-share water-conservation programs. This paper examines the status of the structural distributions of irrigation characteristics across farm-size classes for the 17 western States. In addition, the paper evaluates the degree of existing water-conserving and higher-efficiency irrigation occurring throughout the West, by farm-size class. Particular attention is given to assessing the capacity for additional water conservation improvement across western irrigated agriculture by farm-size class, and the implications farm-structural differences will likely have for USDA resource conservation and small farm policy goals.

Research Approach and Data Sources

Structural characteristics of western irrigated agriculture were evaluated using data from USDA's 1998 Farm & Ranch Irrigation Survey (FRIS). FRIS data were grouped into four farm-size classes, defined using the "total farm sales" variable from the 1997 Census of Agriculture – carried over to FRIS (by observation). The four farm-size classes, defined to be consistent with the farm typology as designed by the Economic Research Service (ERS), USDA (Hoppe and MacDonald, 2001), are presented in Table 1. Sampled observations for FRIS were selected from irrigated farms and ranches identified in the 1997 Census of Agriculture (6,875 farm operations across the 17 western States). Table 2 identifies, by farm-size class, the actual number of FRIS irrigated farm observations (and their corresponding NASS expanded farm numbers) used for this analysis. For a detailed explanation of FRIS sample design characteristics, coverage, statistical methodology, estimation, response rates, and reliability measures, see the National Agricultural Statistics Service, USDA website for FRIS at www.nass.usda.gov/census/census97/fris/fris.htm.

For this analysis, two additional data reliability issues deserve attention. First, for such key variables as the number of irrigated farms, acres irrigated, and water applied (total and by water source), values for the "total" column in the appropriate summary tables are equivalent to values reported in the FRIS report (NASS, 1999). The significance here is that the data tables for this analysis present a farm-size "structural" view of irrigation characteristics reported in the NASS-USDA FRIS report. Second, for all data tables summarizing a weighted-average statistic, coefficient of variation (CV) statistics were computed by farm-size class and by State (and region). Coefficient of variation values were computed as [(standard error of the estimate divided by the estimate) x 100], and reported in the appropriate data tables using * for CV ≤ 25; ** for 25 < CV ≤ 50; *** for 50 < CV ≤ 100; and **** for CV > 100. For most summary tables, CV values across farm-size classes across the western States were generally less than 25 and most often less than 50, indicating relatively low variability of irrigation characteristics within most farm-size classes.

FRIS-summarized data used for this paper were developed using the west-wide summarized values derived from a set of 147 summary data tables developed as an ERS electronic Data Product (in process), which includes irrigated farm characteristics across farm-size class by State, and for the 17 western-State region. Because of space limitations for this paper, only values for the 17-State region are reported in the attached Tables 3 – 12.

Table 1. Farm-Size Class Definitions Used to Examine Structural Characteristics of Irrigated Agriculture

Farm-Size Classes (1 – 4) [1] (based on total farm sales)	**Corresponding ERS Farm Typology Definitions** [2]
\$0 ≤ 1 < \$100,000	Includes ERS's limited resource, retirement, residential/-Lifestyle, & lower-sales/farm occupation groups.
\$100,000 ≤ 2 < \$250,000	Higher sales, farming-occupation group.
\$250,000 ≤ 3 < \$500,000	Large family farm group.
4 ≥ \$500,000	Very large family farm group.

[1] Farm-size classes were defined using the value of the total farm sales variable carried over to the 1998 FRIS data from the 1997 Census of Agriculture (by observation).
[2] Non-family corporate farms could not be identified with FRIS data.

Table 2. FRIS Irrigated Farm Numbers by Farm-Size Class for the 17 Western States

FRIS Sample Results:	Farm-Size Class (1 – 4) 1	2	3	4	Total (All Farm-Size Classes)
Actual FRIS Farm Observations:	1,498	1,373	1,386	2,618	6,875
NASS Expanded (Represented) Farms:	95,933	22,910	14,251	13,996	147,090

Summarized Farm-Size Characteristics for Western Irrigated Agriculture

Aggregate Irrigated Farm Values by Farm-Size Class

Irrigated Farms. For the 17 western States, most irrigated farms in 1998 were "small farms." Out of 147,000 irrigated farms (FRIS total expanded farms), 65 percent were farms with less than $100,000 in total farm sales (Table 3). Nearly 81 percent of irrigated farms had farm sales of less than $250,000. Just less than 20 percent had farm sales greater than or equal to $250,000 and only 9.5 percent of irrigated farms had farm sales greater than or equal to $500,000. These structural attributes are characteristic of irrigated farms for most western States, with Utah having the largest percent of "small irrigated farms" at 94 percent.

Total Irrigated Farm Sales. For the West as a whole, of the $38.7 billion in 1997 total farm sales (FS) for FRIS irrigated farms, 85 percent were from irrigated farms with sales ≥ $250,000 (Table 3). Small irrigated farms (FS < $250,000) accounted for only 15 percent of irrigated farm sales. These structural attributes are also characteristic of irrigated farms for most western States. While exceptions do exist for some States, overall, the largest 9.5 percent of irrigated farms in the West (FS ≥ $500,000) accounted for 72 percent of 1997 farm sales from irrigated farms. In addition, irrigated farms in the West are generally larger (in crop sales) than non-irrigated farms, averaging $850 and $120 per harvested acre for irrigated and non-irrigated farms, respectively (NASS, 1997).

Total Farm Irrigated Acres. Westwide, farm irrigated acres are more heavily skewed toward larger irrigated farms. Of the 38.5 million FRIS irrigated acres for the West, 61 percent are associated with farms with ≥ $250,000 in farm sales, while at least 41 percent are associated with farms with ≥ $500,000 in farm sales (Table 3). Arizona, California, Kansas, and Washington have the most heavily skewed distributions of farm irrigated acres toward larger farms (ranging from 74 to 89 percent). The structural distributions of irrigated acres are skewed toward smaller irrigated farms (FS < $250,000) for several States, including Montana, Utah, and Wyoming (64, 72, and 60 percent, respectively).

Total Farm Water Applied. Farm water use in the West is even more heavily skewed toward larger irrigated farms. Farms with farm sales ≥ $250,000 account for 66 percent of the 76.2 million acre-feet (maf) of total farm water applied by FRIS irrigated farms (Table 3). [*An acre-foot of water equals the volume of water that covers an acre of land to a depth of one foot, or 325,851 gallons*.] The nearly 81 percent of all smaller irrigated farms (FS < $250,000) account for only 34 percent of total farm water applied. At the same time, the 9.5 percent of the largest irrigated farms (FS ≥ $500,000) account for 48.4 percent of total farm water applied.

This skewed distribution in farm water applied is most dramatic for Arizona, California, Kansas, and Washington where larger farms (FS ≥ $250,000) account for between 75-87 percent of total farm water applied. For these States, irrigated farms with ≥ $500,000 in farm sales (5.2 percent of all irrigated farms in the West) account for 31 percent of total farm water applied in the West (about 23.4 maf out of 76.2 maf).

Total Groundwater Applied. While groundwater accounted for only 39 percent of all farm water use westwide, nearly 73 percent of groundwater use was by larger irrigated farms (FS ≥ $250,000), with 50 percent of all groundwater being applied by the largest farms (FS ≥ $500,000) (Table 3). Smaller irrigated farms (81 percent of all irrigated farms) accounted for only 28 percent of farm groundwater applied. A point worth noting, however, is that groundwater-dependent States (those States dependent upon groundwater for at least 50 percent of their farm water use) -- including Kansas, Nebraska, Oklahoma, New Mexico, Texas, and North Dakota -- are not the States with the more dramatically-skewed groundwater use distributions. These skewed groundwater-use distributions occur for heavily surface-water dependent States -- Arizona, California, and Washington. About 85 percent of the groundwater use for each of these States was applied by larger irrigated farms (FS ≥ $250,000), which are likely heavily dependent on using groundwater as a supplemental water supply to support their more extensive-margin irrigated agriculture.

Total Onfarm Surface Water Applied. While total surface-water use accounted for 61 percent of total farm water-use westwide, only about 12 percent originated from onfarm surface water sources. Use of onfarm surface water is less skewed toward larger farms than either groundwater use or water use from off-farm surface supplies. For the West, larger irrigated farms (FS ≥ $250,000) accounted for 59 percent of onfarm surface water use, while farms with FS ≥ $500,000 alone accounted for 40 percent of onfarm surface water use (Table 3). California and Oklahoma have the most skewed distributions for onfarm surface water use. Larger irrigated farms (FS ≥ $250,000) accounted for 93 percent of onfarm surface water use in California and 81 percent in Oklahoma.

Total Off-Farm Surface Water Applied. Westwide, off-farm surface water use (publicly-supplied water) accounted for 49 percent of all farm water use. In addition, off-farm surface-water is more heavily skewed toward larger irrigated farms (FS ≥ $250,000) than it is for onfarm surface water, but not as skewed as the distribution for groundwater (Table 3). Larger irrigated farms accounted for 63 percent of off-farm surface-water use, while the largest farms (FS ≥ $500,000) accounted for 49 percent. Again, Arizona, California, Oklahoma, and Washington are the States where off-farm surface-water use is the most skewed toward larger farms (91, 74, 72, and 76 percent, respectively).

Weighted-Average Irrigated Farm-Size Statistics

Average Value of 1997 Farm Sales Per Irrigated Farm ($/Irrigated Farm). Westwide, the average value of total farm sales (for 1997) for FRIS farms was $263,211 per irrigated farm. However, the westwide average is really not all that "telling". The real story exists in the average irrigated farm sales value across farm-size classes. About 65 percent of irrigated farms (with FS < $100,000) had an average total farm sales value of $22.6 thousand dollars, while 9.5 percent of irrigated farms (with FS ≥ $500,000) had an average total farm sales value of nearly $2.0 million dollars (Table 4). Also, considerable variability exists across States by farm-size class. For all farm-size classes together, the average per irrigated-farm sales value ranges from $54 thousand for Utah to $640 thousand for Kansas. For the smallest farm-size class (FS < $100,000), the average per irrigated-farm sales value ranges from $7.3 thousand for Arizona to $59.7 thousand for Kansas. For the largest irrigated farms (FS ≥ $500,000), the average per farm total sales value ranges from $846 thousand for Montana to $2.9 million for Oklahoma (interestingly, not California).

Average Total Farm Acres Per Irrigated Farm (Acres/Irrigated Farm). For all western States, the average total farm acres per FRIS farm is 1,010 acres, ranging from 355 acres for the smallest farm-size class to 3,650 acres for the largest farm-size class (Table 4). However, it is important to note that for the western States, numbers for average total farm acres include the influence of rangeland, that is, privately owned/leased pastureland and grazing lands (but exclude lands grazed under a government grazing permit). Across States, average irrigated farm size (in total farm acres) varies dramatically. Among the smallest farms (FS < $100,000), average farm size ranges from 68 acres for Washington to 1,314 acres for North Dakota. For the largest irrigated farms (FS ≥ $500,000), average total farm acres ranges from 1,351 acres for Washington to 21,685 acres for Wyoming.

Average Total Farm-Irrigated Acres Per Irrigated Farm (Acres/Irrigated Farm). For all western States, average farm irrigated acres is 262 acres per FRIS irrigated farm (Table 4). This size statistic, however, varies across farm-size classes, from 79 irrigated acres for the smallest irrigated farms (FS < $100,000) to 1,132 irrigated acres for the largest farms (FS ≥ $500,000). Because these statistics remove the "rangeland" influence, the farm-size class variability across States is somewhat more meaningful. For the smallest irrigated farms, average irrigated acres ranges from 23 acres for Arizona to 360 acres for Kansas, and for the largest irrigated farms, from 757 acres for Washington to 2,286 acres for Nevada.

Average Total Farm Water Applied Per Irrigated Farm (Acre Feet/Irrigated Farm). Westwide, average acre-feet of total water applied per irrigated farm is 518 acre feet (Table 4). Average farm water use ranges from 145 acre feet per farm for the smallest irrigated farms (FS < $100,000) to 2,632 acre feet per farm for the largest irrigated farms (FS ≥ $500,000). For all farm-size classes, New Mexico and Utah have the lowest per farm applied water rates, averaging 287 acre-feet per irrigated farm, while Arizona has the largest rate, averaging 1,562 acre-feet per irrigated farm. However, a point worth noting here, is that these averages reflect the greater degree of extensive-margin irrigation/water use that occurs with larger irrigated farms.

Average Irrigation Application Rates - Total & by Water Source (Acre Feet/Acre). Based on westwide statistics for average total water applied per farm irrigated acre, the largest irrigated farms (FS ≥ $500,000) tend to be the more intensive-margin irrigation operations, that is, their average applied-water rates (acre-feet per acre) tend to be slightly greater (Table 4). Irrigated farms in Arizona, California, New Mexico, and Washington influence this result more so than irrigation in other western States. Westwide, the average total water-application rate is 2.0 acre-feet per acre, while for the smallest farm-size class total water application is also at 2.0 acre-feet per acre, and for the largest farm-size class it is at 2.2 acre-feet per acre. For all farm-size classes, the average total water-application rate varies significantly across States, from a low of .8 acre-feet per acre for Nebraska and North Dakota, to a high of 3.9 acre-feet per acre for Arizona – reflecting differences in crops grown, climatic factors, technologies, water costs, and other factors.

Also, for the West as a whole, intensive-margin water use tends to be greater for surface-water irrigation (particularly for water applied from off-farm sources). The average application rate for groundwater for the West is 1.5 acre-feet per acre, ranging from 1.3 acre-feet per acre for the smallest farms to 1.7 acre-feet per acre for the largest farms (Table 4). On the other hand, the average application rate for off-farm surface water for the West is 2.6 acre-feet per acre, ranging from 2.2 acre-feet per acre for the smallest farms to 2.9 acre-feet per acre for the largest farms. Application rates for onfarm surface water for the West generally fall between application rates for groundwater and for off-farm surface water. So, barring consideration of crops irrigated (and all other factors), intensive-margin water-use statistics based on FRIS data indicate that groundwater irrigation is likely more efficient than irrigation using surface water sources. This is understandable, given that groundwater is generally viewed as the higher-cost irrigation alternative.

Weighted Average Farm Irrigation Costs By Farm-Size Class

Average Purchased Water Costs ($/Acre). Westwide, purchased water costs (for publicly-supplied water) average about $41.29 per acre (Table 5). However, for the West this average ranges from $26.65 per acre for the smallest irrigated farms (FS < $100,000) to $56.72 per acre for the largest farms (FS ≥ $500,000). Significant variability exists across States, both in total and by farm-size class. In total (across all farm-size classes), average purchased water costs range from a low of $9.96 per acre for Wyoming to a high of $84.69 per acre for Arizona. For the smallest farm-size class, average purchased water costs range from $8.97 per acre for Nebraska to $65.06 per acre for Arizona. For the largest irrigated farms, average purchased water costs range from $4.45 per acre for South Dakota to $81.75 per acre for Arizona.

Average Irrigation Energy (Pumping) Costs – Total & by Energy Source ($ Per Acre). Irrigation water is delivered and/or applied using either a gravity-based system or a pressurized system (which uses a pump to generate the required pressure for water movement). Irrigation pumping costs vary by the energy source used to power the pump (electric, natural gas, diesel fuel, gasoline, or the use of LP gas, propane, or butane). For the West, irrigation pumping costs (over all energy sources) average about $37.70 per acre, but they tend to be somewhat higher for larger farms, ranging from $29.41 per acre for the smallest irrigated farms (FS < $100,000) to $41.36 per acre for the largest irrigated farms (FS ≥ $500,000) (Table 5). These costs also vary across States, ranging from a low of $14.68 per acre for Montana to a high of about $62.60 per acre for both California and Arizona.

Average irrigation pumping costs by power source are generally relatively uniform across farm-size classes for all power sources, except for electricity. Here a distinct difference exists. Electric powered pumps are generally the higher-cost power source for irrigation pumping, averaging $43.75 per acre (these costs average $34.05 per acre for natural gas, $21.52 per acre for diesel fuel, $18.25 per acre for gasoline, and $17.82 per acre for LP gas, propane, and butane). Pumping costs for electric powered pumps range from $32.76 per acre for the smallest farms (FS < $100,000) to $48.44 per acre for the largest farms (FS ≥ $500,000). Pumping costs per acre for all other power sources are generally relatively uniform across farm-size classes throughout the West, with some small differences by farm-size for gasoline powered pumps.

Average Irrigation Maintenance & Repair Costs ($ Per Acre). Westwide, irrigation maintenance and repair costs (which average $11.11 per acre) are relatively uniform across farm-size classes (Table 5). However, these costs do vary significantly across States. For the smallest farms (FS < $100,000), these costs range from $3.77 per acre for Montana to $25.19 per acre for Arizona. For the largest farms (FS ≥ $500,000), these costs range from $2.65 per acre for Montana to $20.94 per acre for Washington.

Irrigation Technologies by Farm-Size Class

Sprinkler and Gravity Irrigation (Farm #'s & Acres Irrigated). The 1998 FRIS identifies acres irrigated for four broad irrigation-system technology categories, namely gravity-based systems, sprinkler systems, drip/trickle systems, and sub-irrigation systems. FRIS also identifies the irrigated acres that have been laser-leveled. Gravity irrigation is further subdivided into four field water-application systems, namely water applied through furrow-gravity application, between borders or within basins, uncontrolled flooding, or "other" gravity systems. In addition, for each of these field-application systems, gravity technology is identified across five field water-conveyance (delivery) methods, namely lined or unlined open-surface ditch delivery, underground pipe delivery, or above-ground pipe (including gated-pipe) delivery. Sprinkler irrigation is further subdivided between low, medium, and high-pressure sprinkler irrigation for center-pivot systems, linear-move systems, and side-roll, wheel-move, or "other" mechanical-move systems. Low-pressure sprinkler systems operate with an average water pressure under 30-pounds per square inch (PSI), medium-pressure systems operate with a PSI ranging from 30 to 59, while high-pressure systems operate with a PSI of 60 or greater. In addition, sprinkler irrigation is identified for hand-move systems and for solid-set or permanent systems. Drip/trickle irrigation technology includes surface and subsurface drip, and low-flow micro-sprinkler systems. Sub-irrigation technology involves the use of a water delivery or drainage system designed to maintain the aquifer water table at a predetermined depth (within the crop root zone). Laser-leveled irrigation involves grading and earthmoving to eliminate variation in field gradient using a laser-guided system for the purpose of controlling water advance and improving water distribution uniformity. For a detailed explanation of irrigation technologies, see the ERS website at www.ers.usda.gov/briefing/wateruse/questions/qa5.htm.

Table 6 summarizes, for all 17 western States, the number of farms and acres irrigated by major irrigation technology category and by farm-size class. Results indicate that a different story exists between the number of farms using particular irrigation technologies and the irrigated acres associated with these technologies. With all four broad irrigation technology classes, small farms (FS < $250,000) dominate in the total number of farms for each technology class across the West. However, this should not come as a surprise, since most irrigated farms are small farms. Small irrigated farms represent about 71 percent of all irrigated farms using a sprinkler irrigation system, 81 percent of farms using a gravity system, 82 percent of farms using drip/trickle irrigation, and 94 percent of farms using sub-irrigation. However, with acres irrigated by broad technology type, the structural distributions are generally skewed more heavily toward larger farms (more so for pressure-based technologies than for gravity or sub-irrigation systems). For ***sprinkler irrigation***, 68 percent of all sprinkler-irrigated acres in the West are irrigated by larger farms (FS ≥ $250,000), with 44.2 percent irrigated by the largest farms (FS ≥ $500,000). For ***drip/trickle irrigation***, 79 percent of all drip/trickle irrigated acres are irrigated by larger farms, with 73 percent being irrigated by the largest farms (FS ≥ $500,000). However, it is important to recognize that 86 percent of drip/trickle irrigated acres are from California (1.0 million acres out of 1.2 million acres). Within California, 80 percent of drip/trickle irrigated acres are with larger irrigated farms.

For gravity and sub-irrigation systems, the structural distribution story is a little different (Table 6). Here, the westwide acres-irrigated distributions are somewhat less skewed toward larger farms (FS ≥ $250,000), particularly for flood irrigated acres. First, for ***furrow gravity systems*** westwide, the acres-irrigated distribution only moderately favors larger farms, at 63 percent. For eight States, acreage distributions for furrow-gravity systems favor smaller irrigated farms (FS < $250,000) (Colorado, Idaho, Montana, New Mexico, Oregon, South Dakota, Utah, and Wyoming). But, these States account for only 26 percent of furrow-gravity acres irrigated westwide. Second, for ***flood irrigation systems*** westwide, the acres-irrigated distribution slightly favors smaller farms, at 55 percent. However, this percent ranges from a low of 17 percent for South Dakota to a high of 87 percent for Arizona. Third, for ***sub-irrigation systems*** westwide, irrigated acres are only slightly skewed toward larger farms (FS ≥ $250,000), at 55 percent. Across States, this percent ranges from about 17 percent for Nevada to 90 percent for California. Three States -- California, Idaho, and Wyoming -- account for 52 percent of sub-irrigated acres.

For ***laser-leveled irrigated acres***, the westwide structural distribution again heavily favors larger irrigated farms (FS ≥ $250,000), which account for 71 percent of these acres (Table 6). The largest farm-size class alone (FS ≥ $500,000) accounts for 56 percent of laser-leveled irrigated acres westwide. Across States, the percent for larger farms (FS ≥ $250,000) ranges from 19 percent for South Dakota to a high of 94 percent for Arizona. Only five western States have distributions for laser-leveled irrigated acres favoring smaller irrigated farms, these include Colorado, Idaho, Montana, South Dakota, and Utah (but they account for only 7 percent of all laser-leveled irrigated acres across the West).

Water-Conserving/Higher-Efficiency Irrigation by Farm-Size Class

Farm-level irrigation technologies vary widely in their irrigation-application efficiency potential. Application efficiency here refers to the relative amount of water applied that gets taken-up through plant consumptive-use; that is, the ratio of plant consumptive-use to actual water applied. Uncontrolled flood irrigation is widely recognized as the least efficient irrigation system, generally below 50 percent, but potentially 35 percent or lower (Negri and Hanchar, 1989). In general, gravity-based irrigation-application efficiencies can range from 35 to 80/85 percent, with higher efficiencies realized for improved gravity systems. These systems may involve distributing water across a field using furrows, between borders, or within a basin, in combination with a lined or piped field water-delivery system, cablegation or surge-flow water application, or gravity water-management practices, such as use of tail-water reuse pits, furrow-diking, alternate-row irrigation, and limited-irrigation set times. Pressure or sprinkler-based system application efficiencies can range from 50 to 90/95 percent, with low-pressure systems, low-energy precision application (LEPA) and drip/trickle systems all potentially realizing efficiencies as high as 85-95 percent. The higher the irrigation-application efficiency, generally the more water conserving the irrigation technology.

To gain a better perspective on the extent of water-conserving and higher-efficiency irrigation occurring by farm-size class in the West, FRIS acres irrigated by irrigation technology subcategory were used to structure a relative measure of "water-conserving/higher-efficiency" irrigation, from an aggregate system perspective, separately for pressure-based sprinkler irrigation (Table 7 below) and for gravity irrigation (Table 8 below). For each of these broad system types, acres irrigated across irrigation technology subcategories were summarized for three different levels (or definitions) of "water-conserving/higher-efficiency" irrigation. The purpose of the three alternative definitions is to provide a likely estimate of a relative range (or extent) of aggregate sector "water-conserving/higher-efficiency" irrigation across the 17 western States.

Water-Conserving/Higher-Efficiency Pressure/Sprinkler Irrigation by Farm-Size Class

Table 7 below presents statistics, by farm-size class, for three alternative definitions of the most "water-conserving/higher-efficiency" pressure-based sprinkler irrigation in the West (across all 17 western States) based on irrigated acres by pressure/sprinkler irrigation system category for 1998 FRIS irrigated farms.

Conserving Pressure-Irrigation Definition (1) defines water-conserving/higher-efficiency pressure-sprinkler irrigation as consisting only of acres irrigated with drip/trickle irrigation systems, accounting for about 1.2 million FRIS irrigated acres westwide in 1998 (Table 7). Given this definition, smaller irrigated farms (FS < $250,000), which make up nearly 81 percent of all irrigated farms in the West, account for only 21 percent of the most water-conserving/higher-efficiency irrigation (drip/trickle irrigated acres) in the West. Slightly more than 73 percent of FRIS drip/trickle irrigated acres in the West (or 873 thousand acres) are irrigated by the largest irrigated farms (FS ≥ $500,000). However, drip/trickle irrigated acres for the largest irrigated farms account for only 9.7 percent of all pressure-sprinkler irrigated acres for this farm-size class. In addition, given definition (1), water-conserving/higher-efficiency pressure irrigation would account for only about 6.1 percent of all FRIS pressure-based sprinkler irrigation in the West.

Conserving Pressure-Irrigation Definition (2) defines water-conserving/higher-efficiency pressure-sprinkler irrigation as including acres irrigated with low-pressure sprinkler systems (those operating with PSI < 30) and with drip/trickle irrigation systems. Expanding the scope of the "conserving" definition to include low-pressure sprinkler systems increases "conserving" irrigated acres westwide to about 9.1 million irrigated acres, accounting for 46.2 percent of all FRIS pressure-sprinkler irrigated acres in the West (Table 7). Again, about 72 percent of these acres westwide (or 4.3 million acres) are irrigated by the larger irrigated farms (FS ≥ $250,000). Given definition 2, the "water-conserving/higher-efficiency" irrigation rating for pressure-sprinkler irrigation for smaller irrigated farms (FS < $250,000) averages about 41.1 percent, while for larger irrigated farms (FS ≥ $250,000) the rating averages about 48.5 percent. Westwide, this "conserving" definition accounts for only about 24 percent of all farm-irrigated acres.

Conserving Pressure-Irrigation Definition (3) expands the concept of water-conserving/higher-efficiency pressure-sprinkler irrigation even further, to include all low- and medium-pressure sprinkler irrigated acres (for systems operating with PSI < 60) and drip/trickle irrigated acres. While it is likely a relatively "loose" definition, this definition does provide a reasonable estimate (based on FRIS data) of an "upper-bound" for the most water-conserving/higher-efficiency pressure-sprinkler irrigation occurring in the West. This definition accounts for 15.3 million FRIS irrigated acres, or about 78 percent of all pressure-sprinkler irrigated acres westwide, and about 39.8 percent of all farm-irrigated acres westwide (Table 7). Most of these acres (10.6 million acres, or 69.3 percent) are irrigated by larger irrigated farms (FS ≥ $250,000). However, even given this skewed distribution, the "water-conserving/higher-efficiency " rating for pressure-sprinkler irrigation for smaller irrigated farms (FS < $250,000) averages 76.4 percent, while for larger irrigated farms (FS ≥ $250,000) the rating averages about 78.7 percent.

Westwide then, based on 1998 FRIS data and given the alternative "conserving" definitions, an estimate of an approximate relative range for "water-conserving/higher-efficiency" pressure-sprinkler irrigation in the West is likely between 46 percent (conserving definition 2) and 78 percent (conserving definition 3). Using the irrigation efficiency rating for definition 2 as a lower bound is probably quite reasonable. However, the efficiency rating for definition 3 as the upper bound could potentially be too broad. Even so, FRIS irrigation technology data indicates that room likely still exists for considerable "conservation improvement" in irrigation water-use efficiency across pressure-sprinkler irrigated agriculture in the West. Across farm-size classes, the relative "improvement potential" is slightly greater for smaller irrigated farms (FS < $250,000) than for larger farms (FS ≥ $250,000) [as much as 66 and 52 percent, respectively, when based on conserving definition (2)]. However, larger farms irrigate many more acres, so the extensive-margin "conservation effect" will likely be much greater for these farms.

Water-Conserving/Higher-Efficiency Gravity Irrigation by Farm-Size Class

Table 8 below presents statistics, by farm-size class, for three alternative definitions of the most "water-conserving/higher-efficiency" gravity-based irrigation in the West (across all 17 western States) based on irrigated acres by gravity irrigation system category for 1998 FRIS irrigated farms.

Conserving Gravity-Irrigation Definition (1) defines more water-conserving/higher-efficiency gravity irrigation as including furrow gravity-irrigated acres involving the use of an above or below ground pipe or a lined open-ditch field water-delivery system. In other words, furrow gravity irrigation, for this definition, is defined as "more conserving/efficient" because the irrigation system makes use of more efficient water delivery to the field. Based on this definition, 40.5 percent of all FRIS gravity-irrigated acres across the West are defined as conserving/efficient, or 7.8 million acres out of 19.2 million gravity-irrigated acres (Table 8). Nearly 64 percent of these more-conserving furrow irrigated acres are with larger irrigated farms (FS ≥ $250,000). In addition, for larger irrigated farms, conserving/efficient furrow-irrigated acres account for an average of 47.4 percent of all gravity-irrigated acres, while accounting for only 22.2 percent of all gravity-irrigated acres for the smallest irrigated farms (FS < $100,000). Clearly then, given this definition for conserving gravity irrigation, larger gravity-irrigated farms overall are likely relatively more irrigation efficient than the smallest gravity irrigated farms.

Conserving Gravity-Irrigation Definition (2) expands the gravity definition (1) to also include gravity-irrigated acres for flood irrigation that occurs between borders or within basins (but only for farms using laser-leveled acres and using a pipe or a lined open-ditch field water-delivery system). Nearly 93 percent of these additional gravity-irrigated acres are in larger farms (FS ≥ $250,000) (Table 8). Westwide, this definition of conserving/efficient gravity irrigation still accounts for only 44.1 percent of all gravity irrigated acres (8.5 million acres out of 19.2 million acres). In addition, the overall water-conserving/higher-efficiency irrigation rating for gravity irrigation increases to 53.3 percent for larger irrigated farms, while remaining under 23 percent for the smallest irrigated farms. Clearly, the addition of laser-leveled flood-irrigated acres had a greater impact on larger irrigated farms than on smaller farms. The high capital costs of this technology option most likely significantly influenced this outcome.

Conserving Gravity-Irrigation Definition (3) further expands the gravity definition (1) to also include all flood irrigated acres supplied with water by an above or below ground pipe or a lined open-ditch field water-delivery system. Definition (2) is more restrictive because it excludes flood-irrigated acres that are not laser-leveled, but are irrigated using a pipe or lined open-ditch field water-delivery system. Westwide, the expanded definition (3) includes an additional 3.2 million acres as "conserving/efficient" gravity irrigation, increasing the share of water-conserving/higher-efficiency gravity irrigation in the West to 57.3 percent (nearly 11.0 million irrigated acres out of 19.2 million acres) (Table 8). Across farm-size classes, this conserving/efficiency rating for gravity irrigation remains much higher for the largest irrigated farms (at 63.9 percent) than for the smallest irrigated farms (at 42.7 percent).

Westwide then, based on 1998 FRIS data and given the alternative definitions for conserving/efficient gravity-irrigation, an estimate of an approximate relative acreage-share for "water-conserving/higher-efficiency" gravity irrigation in the West will likely range between either 40 to 44 percent, or 40 to 57 percent. The conserving gravity definition (1) likely provides a reasonable lower-bound estimate. However, the question arises as to whether an approximate upper-bound estimate of water-conserving/higher-efficiency gravity irrigation is a definition (2) or a definition (3), or somewhere in-between (2) and (3). But, whether definition (2) or (3) is used as the upper-bound, a range of 40 to 44 percent or 40 to 57 percent still strongly suggests that there exists considerable room for conservation improvement in irrigation water-use efficiency across gravity-irrigated agriculture in the West. Across farm-size classes, the relative improvement potential for gravity irrigation is much greater for the smallest irrigated farms than it is for larger farms (57.3 percent versus 36.1 percent, respectively). The difference here between water-conserving/higher-efficiency gravity irrigation, and similar statistics for pressure-sprinkler irrigation is that gravity irrigation is more uniformly distributed across farm-size classes. Therefore, because smaller farms irrigate a significant share of gravity-irrigated acres in the West, the potential exists for a water-conservation program that emphasizes improved gravity irrigation to have a more uniform "conservation effect" across farm-size classes.

Irrigation Water-Management Practices by Farm-Size Class

Two farm-level water-management items in FRIS help to shed additional insight on the potential for "conservation-improvement" across farm-size classes for western irrigated agriculture. The first relates to the degree producers participate in gravity water-management practices. The second item, a more general item across all irrigation, addresses producer irrigation water-management intensity, that is, the level at which producers use water management at the intensive-margin, or alternatively, the degree of sophistication used in determining when to apply irrigation water for a given crop. Applying water when the crop requires it and applying only what the plant requires for crop consumptive use (excluding any salt leaching requirement) will significantly improve irrigation efficiency. The structural-character for each of these water-management items is summarized below (in-turn).

Producer Participation in Gravity Water-Management Practices. For the 1998 FRIS, producers reported their participation in up to six gravity water-management practices (on an acreage basis). Gravity-irrigated acres were reported for the use of tailwater-reuse pits, surge-flow or cablegation irrigation, limited-irrigation techniques (that is, using limited irrigation set times and/or number of irrigations), alternative-row irrigation practices, water-soluble polyacrylamide, and special furrow water-management practices (including wide-spaced bed furrowing, compact furrowing, or furrow diking). Polyacrylamide (or PAM) is a water-soluble soil amendment, that when added to irrigation water has the effect of stabilizing soil and water-borne sediment. PAM reduces irrigation-induced soil erosion, enhances water infiltration, improves the uptake of nutrients and pesticides, reduces the need for furrow-reshaping operations, and reduces the need for sediment-control requirements below the field (Aillery and Gollehon, 1997).

Westwide, only about 44 percent of gravity-irrigated farms use one or more of the gravity water-management practices (Table 9). A greater percent of larger irrigated farms use gravity water-management practices (ranging between 62 – 64 percent) than do smaller farms (ranging between 37 – 53 percent). In addition, relative to total gravity-irrigated acres, gravity irrigators have a relatively low participation rate with any particular gravity water-management practice (ranging from a low of 2 percent for use of polyacrylamide to a high of 15 percent for use of alternate-row irrigation practices). This low participation is consistent across farm-size classes, although the distributions for each gravity water-management practice show that larger irrigated farms participate to at least a moderately higher degree than do smaller farms. Across the West, only 13 percent of gravity-irrigated acres make use of tailwater-reuse systems, about 4 percent of gravity-irrigated acres make use of surge-flow or cablegation systems, 15 percent use limited-irrigation practices, 15 percent use alternate-row irrigation, 2 percent use PAM, and only 9 percent make use of special-furrow water-management practices. Similar to earlier results for "more water-conserving/higher-efficiency" gravity systems, these results also suggest that there likely exists significant potential for "conservation improvement" with respect to gravity-irrigated agriculture in the West.

Producer Decisions on Irrigation Water-Management Intensity. The available means by which producers make their decisions on when to apply irrigation water generally involve an increasing level of producer management intensity. [Here, management intensity refers to a required increase in the level of management skill and time, as well as an increased level of understanding of more complex relationships integrating soil/hydrologic and atmospheric sciences to determine plant water needs at specific periods of time.] The means producers use to decide on when to apply irrigation water can be grouped into two categories. The first category, referred to as "conventional" means, include applying irrigation water upon delivery of the water to the farm-gate, observing the condition of the crop, feeling the soil, use of a crop calendar schedule, and/or use of media reports on crop-water needs. The second category, referred to as "intensive water-management practices", include use of soil-moisture sensing devices (such as moisture blocks or tensiometers), use of a commercial irrigation-scheduling service, and/or use of computer simulation models (which generally use fairly complex mathematical equation systems to monitor seasonal variations in both soil hydrologic and atmospheric weather conditions that influence crop evapotranspiration (ET) requirements). The increasing level of sophistication and complexity of the means used to decide irrigation applications reflect producer irrigation water-management skill and intensity. The higher the level of water-management intensity, generally the more water-conserving is irrigated agriculture.

FRIS information on irrigation water-management intensity is available only on a "farm-level participation basis," not on an acreage basis. Therefore, summaries of these results are based on the percentage of FRIS farms using alternative means of deciding when to apply irrigation water.

In general, conventional means of deciding when to apply irrigation water dominate producer decisions on irrigation water-management intensity across the West. Both "condition of the crop (by producer observation)" and "feel of the soil" are by far the dominant means irrigated farms use to decide on when to apply irrigation water. Nearly 71 percent of irrigated farms across the West simply observe the condition of the crop, and 40 percent judge irrigation water needs by feeling the soil (Table 10). The next level of reported water-management intensity involves the irrigation decision using crop calendar schedules (used by 19.8 percent of irrigated farms), or simply applying water whenever it is delivered to the farm "in-turn" by the local water-supply organization (used by 12.5 percent of irrigated farms). Use of media reports on crop water needs is the conventional means least used to decide on when to apply irrigation water (used by only 5.3 percent of irrigated farms in the West).

Across farm-size classes, for each of the conventional means of deciding when to apply irrigation water, all are decision means heavily favored by smaller irrigated farms. Westwide, of the irrigated farms using "condition of the crop (by producer observation)" as a means to decide on when to apply irrigation water, 77 percent are smaller farms (FS < $250,000), with the smallest farms (FS < $100,000) accounting for 59.4 percent (Table 10).

Likewise, smaller farms make up nearly 76 percent of the farms using "feel of the soil," 91 percent of farms applying water when it is delivered "in-turn," and 82 percent of farms using a crop calendar schedule. Therefore, even though the farm-size distribution for farms using "media reports on crop water needs" is fairly uniformly distributed, use of conventional, less-efficient means of onfarm water management remains characteristic of most smaller irrigated farms (FS < $250,000) in the West.

For the modern, more intensive water-management means of deciding when to apply irrigation water (including use of either soil-moisture sensing devices, commercial irrigation-scheduling services, and/or computer simulation models), only about 11.6 percent of irrigated farms in the West use one or more of these means. In addition, in aggregate, use of intensive water-management practices are relatively uniformly distributed between smaller and larger irrigated farms (49.6 and 50.4 percent, respectively). However, both the level of use and the farm-size distributions vary significantly across the alternative management-intensive means of deciding when to apply irrigation water.

Westwide, only 8.1 percent of irrigated farms reported that they used soil-moisture sensing-devices to make their decision on when to apply irrigation water (Table 10). In aggregate for the West, the farm-size distribution for this decision tool is relatively uniform between small and large irrigated farms (51 and 49 percent, respectively). For commercial irrigation-scheduling services, only about 4 percent of irrigated farms in the West use these services to assist in their decisions on when to apply irrigation water. Nearly 64 percent of these farms are larger irrigated farms (FS ≥ $250,000). On the other hand, computer simulation models (the most management-intensive means of deciding when to apply irrigation water) are used by only one percent of irrigated farms in the West. However, 60 percent of the farms using this decision means are surprisingly smaller farms [with 47 percent alone being the smallest irrigated farms (FS < $100,000)].

Clearly, across all the 1998 FRIS data on irrigation water-management intensity, the data indicate that use of the less management-intensive, less water-use efficient means of deciding when to apply irrigation water dominates western irrigated agriculture. This farm-level inefficiency in irrigation water-management is particularly acute for smaller irrigated farms. Most irrigated farms use very conventional means of deciding when to apply irrigation water. Less than 12 percent of western irrigated farms make use of the more water-management intensive/water-conserving means to apply irrigation water. Even for the largest irrigated farms (FS ≥ $500,000), less than 35 percent of these farms make use of the more water-management intensive means of deciding when to apply irrigation water. Overall then, these results support and confirm the conclusions drawn earlier, that there likely exists significant potential for water conservation improvement within irrigated agriculture across much of the West.

Barriers to Irrigation System Improvements by Farm-Size Class

From a private economic perspective, irrigators will generally adopt newer irrigation technologies in order to conserve water, reduce irrigation pumping (energy) costs, and/or to increase crop yields when benefits exceed costs. However, research that examines the transitions of irrigation technology over time in the West indicates that the transitions to more water conserving, and generally more water-management intensive and often yield-enhancing irrigation systems are likely relatively slow (Schaible, et al., 1991; Schaible and Aillery, 2003). The relatively slow pace of change in the adoption of more efficient irrigation technology systems reflects the impact of barriers to farm-level irrigation system improvements. FRIS reports data on up to eight specific barriers to producers implementing irrigation system improvements that might reduce energy and/or conserve water. For FRIS, producers were asked to identify all listed barriers that apply to their farm operation. Listed barriers included: i) the producer did not investigate improvements; ii) risk of reduced yield or poorer quality crop yields from not meeting water needs; iii) physical field/crop conditions limit system improvements; iv) improvements will reduce costs (but not enough to cover installation costs); v) cannot finance improvements (even if they reduce costs); vi) landlord(s) will not share in the cost of improvements; vii) uncertainty about future availability of water; and viii) the producer will not be farming this place long enough to justify investments in water-conserving improvements.

From a westwide perspective, results show that any particular barrier to system improvements is generally more of a problem for smaller irrigated farms (FS < \$250,000) than for larger irrigated farms (FS ≥ \$250,000) (Table 11). For example, a small-farm skewness ranges from 60.0 percent (for farm-size classes 1 and 2) for the barrier "landlord will not share in the cost of improvements," to 88.3 percent for the barrier "have not investigated improvements." Results also show that for both small farm-size classes, three barriers to system improvements standout as the most important. These barriers include "have not investigated improvements" (22.8 percent of FRIS irrigators westwide); "improvement installation costs are greater than benefits" i.e., perceived benefits don't cover installation costs (23.8 percent of FRIS irrigators westwide); and "lack of financing ability" (23.4 percent of FRIS irrigators westwide). However, for both large farm-size classes, the dominant producer perceived barriers to irrigation system improvements are "improvement installation costs are greater than benefits" and "lack of financing ability." In other words, "perceived economic benefits" or "financing" problems are the likely more important producer barriers to farm-level irrigation system improvements across all irrigated farms, while for smaller irrigated farms, "not investigating" the merits of such system improvements represents an additional barrier. These results suggest a strong likelihood for a beneficial water-conservation payoff from increased extension/educational efforts on the economic merits of water-conserving/more efficient irrigation systems and to alternative private and public financing options, particularly for smaller irrigated farms. Such efforts could also help to focus implementation of water conservation programs in meeting desired regional resource and small-farm policy objectives.

Producer Participation in Irrigation-Related Public Cost-Share Programs by Farm-Size Class

The 1998 FRIS collected data on farm-level participation in public cost-share programs designed to encourage irrigation or drainage system improvements. More specifically, FRIS farm operators reported whether in the previous five years (1994-98) they received irrigation-related cost-share payments for irrigation improvements from one or more of the following funding sources: i) USDA conservation cost-share programs [including the Environmental Quality Incentive Program (EQIP) or other earlier USDA cost-share programs]; ii) non-USDA Federal cost-share programs [including those from the Environmental Protection Agency (EPA), the Bureau of Reclamation (BoR), or other programs]; iii) State programs, local water management or supply district programs; and iv) other cost-share programs.

FRIS information on farm participation in public cost-share programs is available only on a "farm-level participation basis," not on an acreage basis. Therefore, summaries for these results are based on a percentage of FRIS farms participating in a public cost-share program.

Westwide, FRIS results indicate that only about 13 percent of FRIS irrigated farms participated in any public cost-share program for irrigation or drainage improvements between 1994-98 (Table 12). Most of these farm participants were smaller irrigated farms (FS < \$250,000), accounting for 74 percent of all FRIS cost-share program participants (across all programs). However, a larger percent (21 percent) of irrigated farms within the largest farm-size class (FS ≥ \$500,000) participated in public cost-share programs than participated (11 percent) from the smallest farm-size class (FS < \$100,000). This likely implies that a larger share of larger irrigated farm operators recognize and/or are capable of taking advantage of irrigation-related public cost-share programs, more so than are smaller irrigated farms.

Westwide, Federal programs have accounted for a greater level of cost-share program participation (11.1 percent of FRIS farms) than have State and local water-management/water-supply districts (7.1 percent of FRIS farms). In addition, among Federal program participants, a greater share (10.5 percent) of FRIS farms participated in cost-sharing programs through USDA (for example, use of EQIP), than participated (at 6.7 percent) through non-USDA Federal programs (for example, through EPA and the BoR). Of USDA program participants, 77 percent were smaller farms (FS < $250,000). Of non-USDA Federal program participants, 86 percent were smaller farms. Of FRIS irrigated farms using State and/or local cost-share programs, 81 percent were smaller farms.

Summary and Policy Implications

This paper summarizes the farm-structural characteristics of irrigated agriculture in the 17 western States using data from USDA's 1998 Farm and Ranch Irrigation Survey. Farm-structural characteristics were summarized across four farm-size classes representing 147,090 irrigated farms in the West. The four farm-size classes were defined to be consistent with ERS's farm-typology definitions.

Most irrigated farms are small farms. Westwide, about 81 percent are small farms (FS < $250,000), but State distributions can range as high as 94 percent (Utah). Almost 65 percent of irrigated farms are within the smallest farm-size class (FS < $100,000), with average total farm sales of $22.6 thousand dollars. Only 9.5 percent of irrigated farms in the West had total farm sales for 1997 greater than or equal to $500,000, with average total farm sales of $2.0 million per irrigated farm. However, small-irrigated farms accounted for only 15 percent of total farm sales from all irrigated farms, while about 85 percent of irrigated farm sales were from larger irrigated farms (FS ≥ $250,000), and 72 percent were from the largest 9.5 percent of irrigated farms (FS ≥ $500,000).

Irrigated acres and farm water use are also heavily skewed toward larger irrigated farms. About 61 percent of irrigated acres are with larger farms, with 41 percent alone with the largest 9.5 percent of irrigated farms. Average irrigated acreage per farm in the West is 262 acres. This ranges from 79 irrigated acres for the smallest farm-size class (FS < $100,000) to 1,132 irrigated acres for the largest farm-size class (FS ≥ $500,000). Farm water use is even more heavily skewed. About 66 percent of all farm water use is applied by larger irrigated farms (FS ≥ $250,000), with the largest 9.5 percent of irrigated farms (FS ≥ $500,000) accounting for 48 percent of total farm water applied. Small farms (81 percent) account for only 34 percent of total farm water use. The average total farm water applied per farm in the West is 518 acre-feet. This ranges from 145 to 2,632 acre-feet per farm between the smallest and largest irrigated farms. On average, it takes the equivalent of 18.2 smallest irrigated farms to apply the same amount of water as one largest irrigated farm.

For irrigation technologies throughout most of the West, pressure-based sprinkler irrigation systems are more heavily skewed toward larger irrigated farms, which account for 68 percent of sprinkler-irrigated acres and 79 percent of acres irrigated with drip/trickle systems. For gravity irrigation systems across the West, furrow-based gravity systems are also skewed toward larger irrigated farms, which account for nearly 63 percent of gravity, furrow-irrigated acres. However, flood irrigation systems are slightly skewed toward smaller irrigated farms, which account for nearly 55 percent of flood-irrigated acres. Also, larger irrigated farms account for nearly 71 percent of laser-leveled irrigated acres throughout the West.

For much of irrigation occurring in the West, results demonstrate that there exists considerable potential for conservation improvement in irrigation water-use efficiency. For pressure-based sprinkler irrigation, the relative acreage-share in "water-conserving/higher-efficiency" systems likely ranges from a low of 46 percent to a high of 78 percent. For gravity irrigation, similar relative shares likely range from a low of 40 percent to a high of 57 percent. For pressure/sprinkler irrigation, the relative conservation improvement potential is slightly greater for smaller irrigated farms than for larger farms (66 and 52 percent, respectively). However, larger irrigated farms irrigate many more acres, so conservation policy could be designed to encourage a greater extensive-margin conservation effect for these farms. For gravity irrigation, the relative conservation improvement potential is also much greater for smaller irrigated farms than for larger farms (57 and 36 percent, respectively). However, because gravity irrigated acres are more uniformly distributed across farm-size classes, a water-conservation program emphasizing improved gravity irrigation is likely to have a more uniform conservation effect across farm-size classes.

The level of farm water-use conservation in the West is also restricted by the relatively low rate of adoption of gravity water-management and/or irrigation application-management practices. Westwide, only about 44 percent of gravity-irrigated farms use one or more of available gravity water-management practices. Gravity irrigators have a relatively low participation rate for most gravity water-management practices (ranging from a low of 2 percent for use of polyacrylamide to a high of 15 percent for use of alternate-row irrigation). In general, across western States, a greater percent of larger irrigated farms use improved gravity water-management practices (ranging between 62 – 64 percent) than do smaller irrigated farms (ranging from 37 – 53 percent).

Use of irrigation application-management practices involves the means by which irrigators make their decisions on when to apply irrigation water. Across the West, conventional means of deciding when to apply irrigation water dominate producer irrigation application-management practices. Over 70 percent of irrigated farms simply observe the condition of the crop and 40 percent judge irrigation water needs by feeling the soil for its moisture content. Only 8 percent of irrigated farms make use of soil-moisture sensing devices, 4 percent use commercial irrigation-scheduling services, and 1 percent use computer-based crop-water simulation models. Smaller irrigated farms are the dominant users of conventional means of deciding when to apply irrigation water, ranging from 76 – 91 percent of irrigated farms across conventional application-management practices. For the more management-intensive means of deciding when to apply irrigation water, these practices are more uniformly distributed between smaller and larger irrigated farms.

Survey results demonstrate that use of less management-intensive, less water-use efficient means of deciding when to apply irrigation water dominates western irrigated agriculture. This farm-level inefficiency in irrigation water-management is particularly acute for smaller irrigated farms. Overall, these results suggest that considerable potential exists for additional water-conservation improvement across western irrigated agriculture.

Westwide, "perceived economic benefits" and "availability of financing" are the key producer barriers to irrigation system improvements common to all farm-size classes. However, smaller irrigated farms are confronted with an additional barrier to system improvements, that is, these farms generally have "not investigated" the merits of system improvements. The results imply that increased extension-educational efforts could help demonstrate the economic/conservation and nutrient/pest-management merits of efficient irrigation systems. In addition, innovative private/public financing options could help encourage broader adoption of more water-conserving irrigation systems, particularly among larger irrigated farms.

Results also indicate that across the West, only about 13 percent of FRIS irrigated farms participated in any public cost-share program for irrigation or drainage improvements between 1994-98. However, nearly 75 percent of all FRIS cost-share program participants have been smaller irrigated farms (FS < $250,000). USDA cost-share programs account for the largest share of all FRIS program participants (nearly 80 percent), with 77 percent of its participants being smaller farms. These results suggest that public cost-share programs for irrigation and drainage improvements very likely contribute to the support of small farms.

Finally, summarized FRIS results across farm-size classes suggest: 1) that considerable potential exists for conservation improvement in irrigation water-use efficiency throughout the West; and 2) that farm size matters in the effectiveness of agricultural water conservation programs to serve both conservation/environmental and small-farm policy goals. The emphasis of past conservation cost-share programs (1994-98) on strong small-farm participation is likely consistent with efforts to support small farms. However, increased targeting of conservation programs for greater large farm participation will enhance the likelihood of conserved-water supplies to contribute to future environmental policy goals (including water needs for human health, ecosystem habitat, and bio-diversity requirements) and to meet Native American trust responsibilities. In other words, given that larger irrigated farms are a source for 66 percent of farm water use, conservation cost-share programs that more heavily target larger irrigated farms will have the capability of conserving more water. In addition, conventional conservation cost-share programs could potentially be integrated more closely with innovative institutional arrangements (including use of water banks, water markets, and conserved-water right programs) to enhance the opportunity for greater conservation across larger irrigated farms.

* The views expressed in this paper are the sole responsibility of the author and do not necessarily reflect those of the Economic Research Service or the U.S. Department of Agriculture.

Table 3. Aggregate Irrigated Farm Values by Farm-Size Class (Westwide – 17 Western States)

Farm Characteristic:	Farm Size Class (1 to 4) [1] 1		2		3		4		All Farm-Size Classes	
		Row %		Row %		Row %		Row %		Row %
Total # of Irrigated Farms:	95,933	65.2	22,910	15.6	14,251	9.7	13,996	9.5	147,090	100.0
1997 Value of Farms Sales: ($ millions)	2,167.3	5.6	3,788.4	9.8	4,995.5	12.9	27,764.6	71.7	38,715.8	100.0
Total Farm Irrigated Acres: (1,000 ac.)	7,537.2	19.6	7,326.4	19.0	7,793.1	20.2	15,837.1	41.1	38,493.8	100.0
Total Farm Water Applied: (1,000 ac. ft.) [2]	13,924.7	18.3	11,887.7	15.6	13,536.3	17.8	36,834.9	48.4	76,183.6	100.0
-- Total GW: [3]	3,182.3	10.6	5,077.8	16.9	6,719.3	22.3	15,091.0	50.2	30,070.3	100.0
-- Total OnFSW:	2,185.2	24.7	1,438.9	16.3	1,710.9	19.4	3,500.5	39.6	8,835.6	100.0
-- Total OfFSW:	8,557.2	23.0	5,371.0	14.4	5,106.1	13.7	18,243.3	48.9	37,277.7	100.0

[1] Farm size classes were defined using the value of farm sales variable carried over to the 1998 FRIS data from the 1997 Census of Agriculture (by farm). Farm size classes (1 – 4) are: $0 ≤ 1 < $100,000; $100,000 ≤ 2 < $250,000; $250,000 ≤ 3 < $500,000; and class 4 ≥ $500,000. These size-class groups correspond to the ERS typology groups with class 1 including limited resource, retirement, residential/lifestyle, and lower-sales/farm occupation groups; class 2 including the higher sales, farming occupation group; class 3 including large family farms; and class 4 including very large family farms. (Non-family corporate farms could not be identified with FRIS data.)

[2] One acre-foot of water = 325,851 gallons.

[3] GW = Groundwater; OnFSW = Onfarm Surface Water; OfFSW = Off-Farm Surface Water.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Table 4. Irrigated-Farm Characteristics, Weighted-Average Values By Farm-Size Class (Westwide – 17 Western States)

Farm Characteristic:	Farm Size Class (1 to 4) [1] 1	2	3	4	All Farm-Size Classes
Total # of Irrigated Farms:	95,933	22,910	14,251	13,996	147,090
-- (% of All Irrigated Farms)	65.2	15.6	9.7	9.5	100.0
Ave. Farm-Size Characteristics					
1997 Value of Farm Sales: ($ Per Irrigated Farm)	$ 22,591	$ 165,362	$ 350,534	$ 1,983,753	$ 263,211
Ave. Total Farm Acres Per Irrigated Farm: (Ac.)	355	1,343	2,291	3,650	1,010
Ave. Total Irrigated Acres Per Irrigated Farm: (Ac.)	79 [4]	320	547	1,132	262
Farm Water-Use Characteristics					
Ave. Total Farm Water Applied (Ac.Ft./Irr.Fm.)[2]	145	519	950	2,632	518
Ave. Total Water Applied Per Irrigated Acre (Ac.Ft./Ac.)	2.0	1.7	2.1	2.2	2.0
By Water Source[3]					
Ave. GW Applied Per Acre (Ac.Ft./Ac.)	1.3	1.3	1.3	1.7	1.5
Ave. OnFSW Applied Per Acre (Ac.Ft./Ac.)	1.6	1.5	1.9	2.1	1.8
Ave. OfFSW Applied Per Acre (Ac.Ft./Ac.)	2.2	2.2	2.6	2.9	2.6

[1] See footnote 1 in Table 3 for a description of farm-size classes.
[2] One Acre-Foot of Water = 325,851 Gallons.
[3] GW = Groundwater; OnFSW = Onfarm Surface Water; and OfFSW = Off-Farm Surface Water.
[4] Coefficient of variation (CV) statistics were ≤ 25 for all values. CV statistics were computed as follows: [standard error of the estimate / estimate] x 100.
Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Table 5. Farm Irrigation Costs, Weighted-Average Values By Farm-Size Class (Westwide – 17 Western States)

Farm Characteristic:	Farm Size Class (1 to 4) [1] 1	2	3	4	All Farm-Size Classes
Total # of Irrigated Farms:	95,933	22,910	14,251	13,996	147,090
-- (% of All Irrigated Farms)	65.2	15.6	9.7	9.5	100.0
Ave. Purchased Water Cost for Off-farm Surface Water: ($/Acre)	26.65	25.35	42.36	56.72	41.29
Ave. Energy (Pumping) Costs (All Energy Sources): ($/Acre)	29.41	29.33	42.52	41.36	37.70
-- For Pumps Powered With:					
Electricity	32.76	30.29	52.47	48.44	43.75
Natural Gas	26.27	34.98	35.51	34.38	34.05
LP Gas, Propane, Butane	17.67	18.02	15.45	21.21	17.82
Diesel Fuel	20.66	20.41	25.46	20.19	21.52
Gasoline	23.38	9.12**	15.19**	13.09**	18.25
Ave. Irrigation Maintenance & Repair Costs: ($/Acre)	10.56	8.76	12.24	11.72	11.11

[1] See footnote 1 in Table 3 for a description of farm-size classes.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Coefficient of variation (CV) statistics were computed for all values, for **, 25 < CV ≤ 50, for all other values, the CV statistics were ≤ 25. CV statistics were computed as follows: [standard error of the estimate / estimate] x 100.

Table 6. Sprinkler & Gravity Irrigation: Farms & Acres Irrigated By Farm-Size Class (Westwide - 17 Western States)

Irrigated Farms:	Farm Size Class (1 to 4)[1] 1		2		3		4		All Farm-Size Classes	
	Farms	%	Farms	%	Farms	%	Farms	%	Farms	%
Total # of Irrigated Farms:	95,933	65.2	22,910	15.6	14,251	9.7	13,996	9.5	147,090	100.0
# of Farms Using a Sprinkler Irrigation System:	29,543	47.9	14,288	23.1	9,287	15.0	8,605	13.9	61,723	100.0
# of Farms Using a Gravity Irr. System:	58,246	65.5	13,917	15.7	8,037	9.1	8,573	9.7	88,773	100.0
# of Farms Using a Drip/Trickle System:	14,665	79.1	515	2.8	1,233	6.6	2,138	11.5	18,551	100.0
# of Farms Using a Sub-Irrigation System:	3,270	83.1	431	11.0	128	3.3	107	2.7	3,963	100.0

Irrigated Acres:	1		2		3		4		All Classes	
	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%
Total Farm Irrigated Acres:	7,537.2	19.6	7,326.4	19.0	7,793.1	20.2	15,837.1	41.1	38,493.8	100.0
<u>Pressure Irrigated Acres</u>										
All Sprinkler Systems:	2,368.8	12.8	3,537.8	19.2	4,407.4	23.9	8,157.2	44.2	18,471.2	100.0
All Drip/Trickle Systems:	189.3	15.8	61.2	5.1	71.2	6.0	873.0	73.1	1,194.8	100.0
<u>Gravity Irrigated Acres</u>										
All Gravity Systems:	4,984.5	26.0	3,743.8	19.5	3,314.8	17.3	7,121.7	37.2	19,164.7	100.0
- Gravity Furrow Systems:	1,759.7	17.2	2,066.1	20.2	2,086.9	20.4	4,305.6	42.1	10,218.3	100.0
- Flood Irrigation Systems:	3,224.8	36.0	1,677.7	18.8	1,227.9	13.7	2,816.5	31.5	8,946.8	100.0
<u>SubIrrigation Systems</u>:	61.3	27.8	39.1	17.7	46.2	21.0	73.7	33.5	220.3	100.0
<u>All Laser-Leveled Acres</u>:	897.1	17.1	634.1	12.1	765.2	14.6	2,938.3	56.1	5,234.7	100.0

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.) [1] See footnote 1 in Table 3 for a description of farm-size classes.

Table 7. Water-Conserving/Higher Efficiency Pressure/Sprinkler Irrigation By Farm-Size Class (Westwide – 17 Western States)

Alternative Technology Definitions:	Farm Size Class (1 to 4) [1] 1		2		3		4		All Farm-Size Classes	
	Acres (1,000)	%[2]	Acres (1,000)	%[2]	Acres (1,000)	%[2]	Acres (1,000)	%[2]	Acres (1,000)	%
For All Sprinkler & Drip/ Trickle Irrigation Systems:	2,558.1	13.0	3,599.0	18.3	4,478.6	22.8	9,030.2	45.9	19,666.0	100.0
Water-Conserving/- Higher Efficiency <u>Pressure Irrigation</u>										
Definition (1) -- **For All Drip/Trickle Irrigation Systems:**	189.3	15.8	61.2	5.1	71.2	6.0	873.0	73.1	1,194.8	100.0
- [% of All Pressure Irrigated Acres (for Farm-Size Class)**]** [3] **:**	(0.7)		(1.7)		(1.6)		(9.7)		(6.1)	
Definition (2) -- **For All Low-Pressure Sprinkler (PSI < 30) & Drip Trickle Irrigation Systems:**	883.2	9.7	1,648.9	18.2	2,249.6	24.8	4,302.7	47.4	9,084.5	100.0
- [% of All Pressure Irrigated Acres (for Farm-Size Class)**]** [3] **:**	(34.5)		(45.8)		(50.2)		(47.6)		(46.2)	
- [% of All Pressure Irrigated Acres (**Westwide**)**]:**	(4.5)		(8.4)		(11.4)		(21.9)		(46.2)	
- [% of All Farm Irrigated Acres (**Westwide**)**]:**	(2.3)		(4.3)		(5.8)		(11.2)		(23.6)	
Definition (3) -- **All Low/Medium Pressure Sprinkler (PSI < 60) & Drip/Trickle Irrigation Systems:**	1,768.7	11.5	2,937.2	19.2	3,626.6	23.7	7,000.5	45.6	15,333.0	100.0
- [% of All Pressure Irrigated Acres (for Farm-Size Class)**]** [3] **:**	(69.1)		(81.6)		(81.0)		(77.5)		(78.0)	
- [% of All Pressure Irrigated Acres (**Westwide**)**]:**	(9.0)		(14.9)		(18.4)		(35.6)		(78.0)	
- [% of All Farm Irrigated Acres (**Westwide**)**]:**	(4.6)		(7.6)		(9.4)		(18.2)		(39.8)	

[1] See footnote 1 in Table 3 for a description of farm-size classes.
[2] For each farm-size class column, the second column number (percent) reflects the percent of the row total or the farm-size class percent of the total of all farm-size classes for that row technology definition. For example, for row definition (1) and farm-size class 1, the value 15.8 indicates that 15.8 percent of all drip/trickle irrigated acres westwide are irrigated by the smallest-sized irrigated farms.
[3] The corresponding row values in ( ) reflect a column percent; for example, for pressure technology definition 1 and farm-size class 1, the value (0.7) indicates that drip/trickle irrigation accounts for .7 of one percent of all sprinkler and drip/trickle irrigated acres for farm-size class 1.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA, October 2002.)

Table 8. Water-Conserving/Higher Efficiency Gravity Irrigation By Farm-Size Class (Westwide -- 17 Western States)

Alternative Technology Definitions:	Farm Size Class (1 to 4) [1]								All Farm-Size Classes	
	1		2		3		4			
	Acres (1,000)	Row %[2]	Acres (1,000)	Row %[2]	Acres (1,000)	Row %[2]	Acres (1,000)	Row %[2]	Acres (1,000)	%
For All Gravity (GR) Irrigation Systems:	4,984.5	26.0	3,743.8	19.5	3,314.8	17.3	7,121.7	37.2	19,164.7	100.0
More Water-Conserving/ Higher Efficiency <u>Gravity Irrigated Acres</u>										
***Definition (1)* – Furrow Gravity Irrigation** [for farms using an above or below ground pipe or lined open-ditch water delivery system]**:**	1,107.6	14.3	1,707.4	22.0	1,735.9	22.4	3,206.9	41.3	7,757.8	100.0
- (% of Total GR Acres)[3]**:**	(22.2)		(45.6)		(52.4)		(45.0)		(40.5)	
***Definition (2)* – Flood Irrigation Between Borders or Within Basins** [for farms with laser leveled acres & using pipe or lined open-ditch water delivery systems]**:**	32.6	4.6	21.7	3.1	61.6	8.8	586.6	83.5	702.6	100.0
Sum of (1) & (2) Above:	1,140.2	13.5	1,729.1	20.4	1,797.5	21.2	3,793.5	44.8	8,460.4	100.0
- (% of Total GR Acres)[3]:	(22.9)		(46.2)		(54.2)		(53.3)		(44.1)	
***Definition (3)* – Flood Irrigation** [all flood for farms using above or below ground pipe Or lined open-ditch field water delivery systems]**:**	1,019.1	31.6	530.1	16.4	336.2	10.4	1,345.1	41.6	3,230.6	100.0
Sum of (1) & (3) Above:	2,126.7	19.4	2,237.5	20.4	2,072.1	18.9	4,552.0	41.4	10,988.4	100.0
- (% of Total GR Acres)[3]:	(42.7)		(59.8)		(62.5)		(63.9)		(57.3)	

[1] See footnote 1 in Table 3 for a description of farm-size classes.

[2] For each farm-size class column, the second column number (percent) reflects the percent of the row total or the farm-size class percent of the total of all farm-size classes for that row technology definition. For example, for row definition (1) and farm-size class 1, the value 14.3 indicates that 14.3 percent of all furrow-gravity irrigated acres west-wide (for farms using an above or below ground pipe or lined open-ditch water delivery system) are irrigated by the smallest-sized irrigated farms.

[3] The corresponding row values in ( ) reflect a column percent; for example, for gravity technology definition 1 and farm-size class 1, the value (22.2) indicates that furrow-gravity irrigation accounts for 22.2 percent of all furrow-gravity irrigated acres for farm-size class 1.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA, October 2002.)

Table 9. Producer Participation in Gravity Water Management Practices By Farm-Size Class (Westwide – 17 Western States)

Westwide (17 Western States):	Farm Size Class (1 to 4) [1]								All Farm-Size Classes	
	1		2		3		4			
	Farms	%	Farms	%	Farms	%	Farms	%	Farms	%
# of Farms Using a Gravity (GR) Irrigation System:	58,246	65.6	13,917	15.7	8,037	9.1	8,573	9.7	88,773	100.0
# of Farms Using GR and One or More GR Mgmt. Practice:	21,297	54.4	7,318	18.7	5,008	12.8	5,518	14.1	39,141	100.0
-- (% of All GR Farms):	(36.6)		(52.6)		(62.3)		(64.4)		(44.1)	
	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%	Acres (1,000)	%
Total Gravity Irrigated Acres:	4,984.5	26.0	3,743.8	19.5	3,314.8	17.3	7,121.7	37.2	19,164.7	100.0
Irrigated Acres by GR Water Mgmt. Practice										
Tailwater ReUse Pits:	376.7	15.8	335.6	14.1	388.4	16.3	1,286.6	53.9	2,387.3	100.0
-- (% of All GR Irr. Acres):	(7.6)		(9.0)		(11.7)		(18.1)		(12.5)	
Surge-Flow/Cablegation:	66.0	8.8	252.8	33.6	206.4	27.4	228.2	30.3	753.3	100.0
-- (% of All GR Irr. Acres):	(1.3)		(6.8)		(6.2)		(3.2)		(3.9)	
Limited Irrigation Techniques:	662.7	23.4	607.0	21.4	419.3	14.8	1,145.6	40.4	2,834.6	100.0
-- (% of All GR Irr. Acres):	(13.3)		(16.2)		(12.6)		(16.1)		(14.8)	
Alternate-Row Irrigation Practices:	372.4	12.7	718.5	24.4	660.1	22.4	1,190.6	40.5	2,941.6	100.0
-- (% of All GR Irr. Acres):	(7.5)		(19.2)		(19.9)		(16.7)		(15.3)	
Water-Soluble Polyacrylamide (PAM)[2]:	42.7	13.4	51.3	16.1	80.1	25.1	144.8	45.4	318.9	100.0
-- (% of All GR Irr. Acres):	(0.9)		(1.4)		(2.4)		(2.0)		(1.7)	
Special-Furrow Water Management Practices:	154.6	9.0	251.8	14.7	468.7	27.3	839.5	49.0	1,714.6	100.0
-- (% of All GR Irr. Acres):	(3.1)		(6.7)		(14.1)		(11.8)		(8.9)	

[1] See footnote 1 in Table 3 for a description of farm-size classes.

[2] Polyacrylamide (or PAM) is a water-soluble soil amendment, that when added to irrigation water has the effect of stabilizing soil and water-borne sediment.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Table 10. Irrigation Water-Management Intensity: Alternative Means Used to Decide When to Apply Irrigation Water, By Farm-Size Class (Westwide – 17 Western States)

Westwide (17 Western States):	Farm Size Class (1 to 4) [1]								All Farm-Size Classes	
	1		2		3		4			
	Farms	%	Farms	%	Farms	%	Farms	%	Farms	%
Total # of Irrigated Farms:	95,933	65.2	22,910	15.6	14,251	9.7	13,996	9.5	147,090	100.0
Alternative Producer Means of Deciding When To Apply Irrigation Water:	Column %	Row %	Column %	Row %	Column %	Row %	Column %	Row %	Column %	Row %
(1) Condition of Crop (by Observation):	(63.9)	59.4	(80.6)	17.9	(82.1)	11.3	(84.1)	11.4	(70.2)	100.0
(2) Feel of the Soil:	(36.2)	59.4	(41.8)	16.4	(46.7)	11.4	(53.4)	12.8	(39.7)	100.0
(3) Soil-Moisture Sensing Devices:	(4.1)	33.2	(9.2)	17.8	(15.9)	19.1	(25.5)	30.0	(8.1)	100.0
(4) Commercial Irrigation Scheduling Services:	(0.9)	14.5	(5.5)	21.7	(12.4)	30.5	(13.8)	33.3	(3.9)	100.0
(5) Media Reports on Crop Water Needs:	(2.2)	27.3	(8.7)	25.6	(11.9)	21.7	(14.1)	25.3	(5.3)	100.0
(6) Water Delivered "In-Turn" by Irrigation Organization:	(15.1)	78.5	(10.0)	12.5	(6.1)	4.7	(5.6)	4.3	(12.5)	100.0
(7) Use Calendar Schedule:	(22.0)	72.7	(11.7)	9.2	(19.5)	9.6	(17.8)	8.6	(19.8)	100.0
(8) Use Computer Simulation Models:	(0.7)	46.8	(0.8)	13.3	(1.1)	11.5	(2.9)	28.4	(1.0)	100.0
Most Water-Management Intensive/Water-Conserving Means to Apply Water: [Includes farms using one or more of the above means for Items (3), (4), and/or (8)]	(5.3)	30.1	(14.5)	19.5	(26.0)	21.8	(34.8)	28.6	(11.6)	100.0

[1] See footnote 1 in Table 3 for a description of farm-size classes.
Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Table 11. Barriers to Farm-Level Irrigation System Improvements that would Reduce Energy Use and/or Conserve Water, By Farm-Size Class (Westwide – 17 Western States)

Westwide (17 Western States):	Farm Size Class (1 to 4) [1]								All Farm-Size Classes	
	1		2		3		4			
	Farms	%	Farms	%	Farms	%	Farms	%	Farms	%
Total # of Irrigated Farms:	95,933	65.2	22,910	15.6	14,251	9.7	13,996	9.5	147,090	100.0
Barriers to Irrigation System Improvements:	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %
(1) Have not investigated Improvements:	(25.9)	74.2	(20.6)	14.1	(12.8)	5.4	(15.2)	6.3	(22.8)	100.0
(2) Perceive increased risk Of reduced yield or poorer quality crop yield (from not meeting water needs):	(13.5)	69.2	(9.9)	12.2	(12.2)	9.3	(12.5)	9.3	(12.7)	100.0
(3) Physical field/crop Conditions limit system improvements:	(8.4)	48.0	(18.2)	24.9	(16.5)	14.1	(15.5)	13.0	(11.4)	100.0
(4) Improvement installation costs are greater than benefits: (benefits don't cover installation costs)	(22.8)	62.5	(24.0)	15.7	(24.1)	9.8	(30.3)	12.1	(23.8)	100.0
(5) Lack financing ability (even with reduced costs):	(23.0)	64.1	(26.4)	17.6	(23.6)	9.8	(21.2)	8.6	(23.4)	100.0
(6) Landlord will not share in cost of improvements:	(4.1)	36.5	(10.9)	23.5	(14.3)	19.2	(15.8)	20.7	(7.2)	100.0
(7) Uncertainty about future water availability:	(9.5)	60.0	(12.0)	18.2	(12.9)	12.1	(10.5)	9.7	(10.3)	100.0
(8) Will not be farming the farm in the near future:	(5.0)	58.0	(7.7)	21.1	(7.3)	12.5	(5.0)	8.4	(5.7)	100.0

[1] See footnote 1 in Table 3 for a description of farm-size classes.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

Table 12. Participation in Public Cost-Share Programs for Irrigation or Drainage Improvements (1994-98), By Farm-Size Class (Westwide – 17 Western States)

Westwide (17 Western States):	Farm Size Class (1 to 4) [1]								All Farm-Size Classes	
	1		2		3		4			
	Farms	%	Farms	%	Farms	%	Farms	%	Farms	%
Total # of Irrigated Farms:	95,933	65.2	22,910	15.6	14,251	9.7	13,996	9.5	147,090	100.0
Funding Sources for Cost-Share Payments:	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %	% of Column Total	Row %
(1) From Any Program Source (Federal, State, Or Other):	(10.9)	54.0	(16.6)	19.6	(15.9)	11.7	(20.5)	14.8	(13.2)	100.0
(2) From Any Federal Program Source (USDA & Non-USDA):	(9.7)	56.8	(14.4)	20.3	(11.9)	10.4	(14.5)	12.5	(11.1)	100.0
(3) From USDA Programs Only (EQIP or any Previous Programs):	(9.3)	57.3	(13.3)	19.7	(11.8)	10.8	(13.5)	12.2	(10.5)	100.0
(4) From Non-USDA Programs (EPA, BoR, & Others):	(7.0)	68.2	(7.7)	18.0	(4.5)	6.5	(5.1)	7.2	(6.7)	100.0
(5) From State Programs or Local Water Mgmt. or Supply Districts:	(7.0)	64.1	(7.7)	16.9	(6.6)	9.0	(7.4)	10.0	(7.1)	100.0

[1] See footnote 1 in Table 3 for a description of farm-size classes.

Source: 1998 Farm & Ranch Irrigation Survey, National Agricultural Statistics Service, USDA. (Data was summarized by the Economic Research Service, USDA.)

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