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Irrigation Organizations:

Water Storage and Delivery Infrastructure

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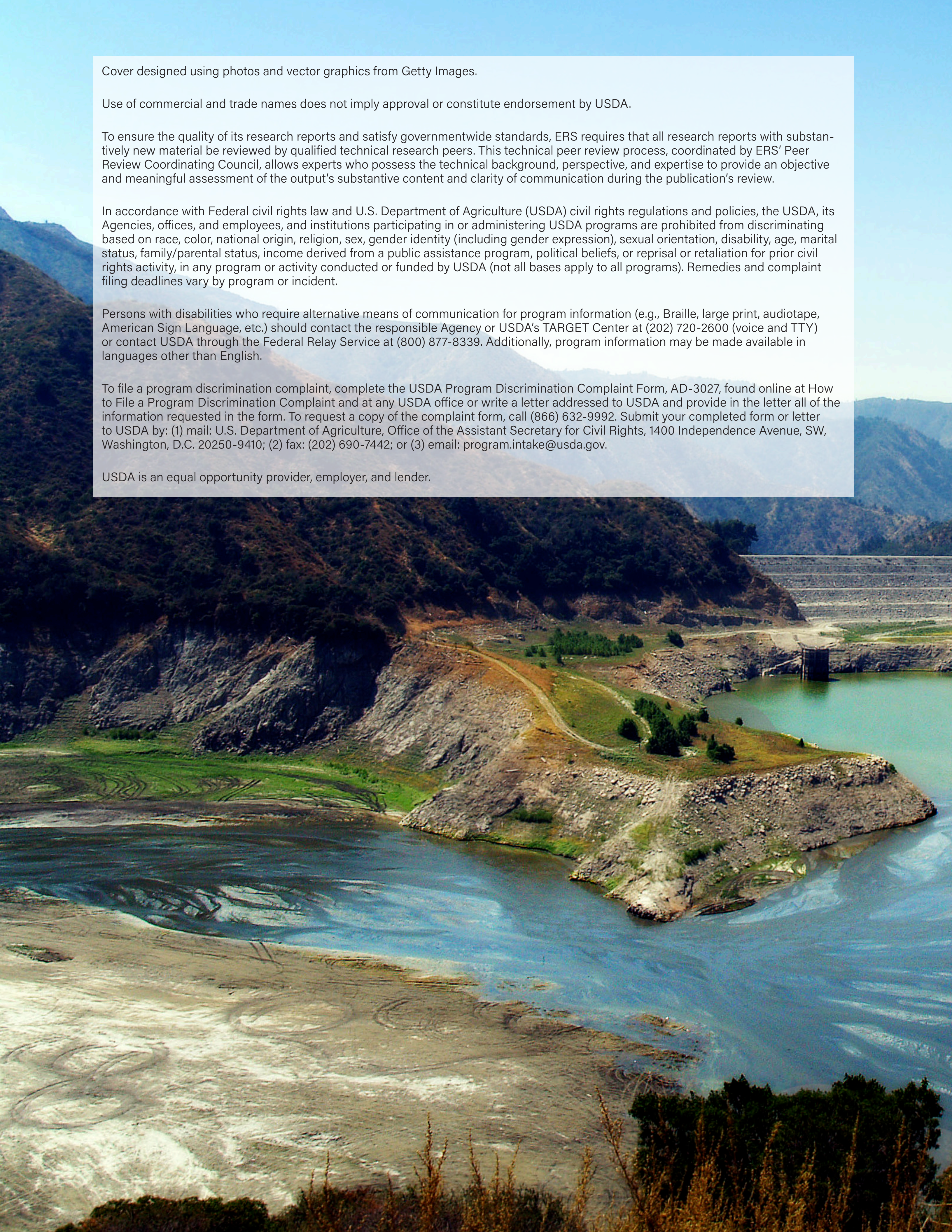


Abstract

In 2018, 40 percent of all water applied to irrigated cropland came from an off-farm water source. Irrigation districts, ditch companies, acequias, and other water delivery organizations use infrastructure such as canals, reservoirs, and turnouts to transport, store, and deliver off-farm water to farms and ranches. This infrastructure is a critical part of an organization's ability to meet the water needs of irrigated agriculture. The U.S. Department of Agriculture's 2019 Survey of Irrigation Organizations is a nationally representative review of the water management organizations that deliver water to farms or influence on-farm groundwater use. This report leverages these survey data to provide an overview of the vital irrigation infrastructure owned and managed by water delivery organizations.

Acknowledgments: The authors would like to thank the team at USDA's National Agricultural Statistics Service for their work implementing the 2019 Survey of Irrigation Organizations. This report benefitted significantly from a detailed review by Mark Brusberg and Chris Hartley of USDA's Office of the Chief Economist, as well as Landon Marston, assistant professor at Virginia Polytechnic Institute and State University.

Summary

The U.S. Department of Agriculture's (USDA) 2019 Survey of Irrigation Organizations (SIO) is a nationally representative overview of the local water management entities that deliver irrigation water directly to farms or influence on-farm groundwater use. Water delivery organizations include irrigation districts, ditch companies, acequias (communal irrigation ditches), and other similar entities that manage the infrastructure required to transport irrigation water. Groundwater organizations include groundwater districts as well as some delivery organizations. This is the first report in a series of economic briefs on key topics related to irrigation organizations using data collected in the 2019 SIO. USDA, Economic Research Service (ERS), USDA, Office of the Chief Economist (OCE), and USDA, National Agricultural Statistics Service (NASS) collaborated in the development and implementation of the 2019 SIO.

This report summarizes information from the SIO about the water storage, conveyance, and metering infrastructure owned and managed by irrigation organizations. This infrastructure is vital in irrigation organizations' ability to provide water to farms and ranches. In many scenarios, system-wide water losses relate to losses that occur within irrigation organization infrastructure. Much is known about the largest irrigation infrastructure projects operated by Federal (e.g., the United States Bureau of Reclamation) and State governments (e.g., California's State Water Project). However, less is known about the infrastructure that stores, conveys, and meters water after it is delivered by these projects to local irrigation organizations. This report answers several questions:

- Do irrigation organizations own their own water storage infrastructure or rely on upstream storage capacity?
- What is the average water storage capacity of those organizations that own storage infrastructure?

- What percentage of organization conveyance infrastructure is lined to reduce seepage losses? Why do organizations leave conveyance infrastructure unlined?
- How do organizations measure water use within their system?
- What infrastructure do organizations use to divert water from conveyance infrastructure to farms?

Key findings from this report include:

- Fewer than 20 percent of organizations that deliver water directly to farmers own or operate their own storage reservoirs.
- Large water delivery organizations, defined as those serving at least 10,000 irrigable acres, are more likely to own water storage infrastructure and tend to have greater storage capacity per acre.
- Large water delivery organizations have the most water conveyance infrastructure and have the largest share of their total conveyance infrastructure lined.
- The expense of lining is the most frequently cited reason for leaving water conveyance canals and laterals unlined, although some organizations cite limited seepage losses or recharge of groundwater as reasons for leaving canals and laterals unlined.
- Organizations generally use multiple methods to calculate water use within their system.
- Manual metergates, the majority of which are operated by irrigation organization staff, are the most used means to divert water from organization conveyance infrastructure to farms and ranches.
- Small water delivery organizations, defined as those serving less than 1,000 irrigable acres, are the most likely to be unable to meet peak irrigator water demand because of conveyance infrastructure constraints.

Introduction

Water is vital to the U.S. agricultural economy. In 2017, irrigated farms accounted for nearly 54 percent of the total value of U.S. crop sales on less than 29 percent of harvested cropland (USDA, NASS, 2019a). Water applied as irrigation allows for crop production in arid regions and supplements variable rainfall during the growing season in more humid regions. In 2018, 40 percent of all water applied to irrigated crops came from off-farm water sources, which irrigated 28 percent of all irrigated cropland in the United States (USDA, NASS, 2019b). Getting the off-farm water supply to farms and ranches requires off-farm infrastructure[1] to store, transport, and monitor water deliveries. Much of this infrastructure is owned by irrigation organizations that are responsible for delivery of the off-farm water used for irrigation purposes.

This irrigation infrastructure, owned and managed by irrigation organizations, is a critical component of the irrigated agricultural sector as it allows for inter-seasonal water storage in snowpack-dependent watersheds and water transport to arable land in water-scarce regions. In 2019, irrigation infrastructure owned and managed by irrigation organizations facilitated the delivery of more than 67 million acre-feet of water for agriculture and other purposes (USDA, NASS, 2020).

Off-farm irrigation infrastructure can be broadly divided into three categories: water storage, conveyance, and turnout infrastructure. Water storage infrastructure includes dams and reservoirs that provide a means to smooth water supplies across seasons and years. Water conveyance infrastructure uses canals, pipelines, and tunnels to transport water from natural water sources and storage reservoirs to irrigated farms and ranches. Turnout and metering infrastructure controls how water flows within an organization's system and water delivery from the organization's system to the irrigated farm.

The effects of climate change on water resources are already evident, expected to persist, and potentially become more prevalent (USGCRP, 2018). Projected changes in precipitation patterns, temperature, and the volume and timing of snowmelt runoff under climate change are likely to alter seasonal water flow regimes, further increasing the importance of water storage capacity across the Western United States (USDI, Reclamation, 2015; Evan and Eisenman, 2021). Current and projected water scarcity in the Southwestern United States and other regions where irrigated production is concentrated may catalyze efforts to more efficiently store and transport irrigation water supplies (Foti et al., 2012; Seager et al., 2013; Dettinger et al., 2015). At the same time, declining aquifers across major irrigated regions increase the need for more effective conjunctive management of surface water and groundwater supplies (Scanlon et al., 2012; Haacker et al., 2016).

This report focuses on irrigation organizations that deliver water to farms and ranches. Some irrigation organizations may also influence on-farm groundwater use in addition to delivering water to farms. However, groundwater organizations that do not deliver water are not included in this report. This report groups water delivery organizations according to the number of irrigable acres served by the organization. Irrigable acres are farmland that could have received water in 2019. Large organizations serve more than 10,000 acres; medium organizations serve 1,000 to 10,000 acres; and small organizations serve less than 1,000 acres.

The infrastructure owned and managed by irrigation organizations allows agriculture to flourish in arid and semi-arid regions where water is otherwise scarce. As this infrastructure is critical in providing sufficient and timely water supplies to irrigated farms and ranches, infrastructure characteristics are important to strengthen the resilience of the irrigated agriculture sector to drought, climate change, and long-term water scarcity. This report provides a national-scale overview and inventory of this vital infrastructure to inform resource planning, policy formation, and investment.

[1]Irrigating crops with off-farm water supplies requires both on- and off-farm irrigation infrastructure. On-farm irrigation infrastructure conveys water from the delivery organization's conveyance infrastructure to the field, stores water on-farm, applies water to irrigated crops, and manages on-farm irrigation drainage. On-farm system components may include small-scale irrigation ponds, water conveyance structures, and irrigation application technologies (e.g., center-pivots). The focus of this report is off-farm irrigation infrastructure managed by local irrigation organizations.

2019 Survey of Irrigation Organizations

The 2019 Survey of Irrigation Organizations (SIO) collected data on irrigation organizations in 24 States[1] within the Western, Southeastern, and Mississippi Delta regions of the United States, where these organizations are most common. The SIO was a collaboration between the U.S. Department of Agriculture's Economic Research Service (ERS), National Agricultural Statistics Service (NASS), and the Office of the Chief Economist (OCE). The SIO was funded through a congressional budget initiative aiming to expand research and data on agricultural drought resilience.

The SIO defined an irrigation organization as an entity that either delivers water to farms and ranches or influences on-farm groundwater use. Irrigation organizations are structured differently across the United States according to State water law and regional water resource development history. Examples of irrigation organizations that deliver water include irrigation districts, canal/ditch companies, acequias (communal irrigation ditches, see Hutchins (1928) for more information), and irrigation mutuals. Organizations that can influence on-farm groundwater use include groundwater management districts, natural resource districts, and groundwater sustainability agencies. Some irrigation organizations engage in both on-farm groundwater management and water delivery. The SIO determined that there were 2,677 irrigation organizations in the United States in 2019. Among these organizations, 2,543 delivered water to farms and ranches, 735 influenced on-farm groundwater use, and 601 engaged in both water delivery and groundwater management. The response rate for the SIO was 44 percent.

The 2019 SIO was the first nationally representative Federal data collection effort aimed at irrigation organizations since the U.S. Department of Commerce, Bureau of the Census conducted the 1978 Census of Irrigation Organizations (CIO). The 1978 CIO did not collect information on organizations that influence on-farm groundwater use, as these types of organizations largely did not exist in 1978. Additionally, the 1978 CIO collected information on "pass-through" entities, which are organizations that store and deliver water to irrigation organizations but do not deliver water directly to farms and ranches. The 2019 SIO did not collect information on "pass-through" organizations. For a summary of selected survey findings and additional information on survey design, see USDA, NASS' Irrigation Organizations publication (USDA, NASS 2020).

[1]Colorado, Montana, Wyoming, Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, Texas, Idaho, Oregon, Washington, California, Nevada, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Arizona, New Mexico, and Utah.

Water Storage

Water storage infrastructure includes dams and reservoirs that provide a way to smooth water supplies across seasons and years. Some irrigation organizations own and manage their own water storage reservoirs, while others rely on natural streamflow or storage infrastructure owned by other State or Federal agencies or other irrigation organizations (USDC, BC, 1978; USDA, NASS, 2020). Irrigation organizations may also supplement available water storage through Managed Aquifer Recharge (MAR), which uses recharge basins, injection wells, and on-field spreading to store excess surface water flows in aquifers (O'Geen et al., 2015; Kourakos et al., 2019). Organizations also manage water storage infrastructure for other purposes, such as hydroelectric power generation, flood mitigation, or recreation.

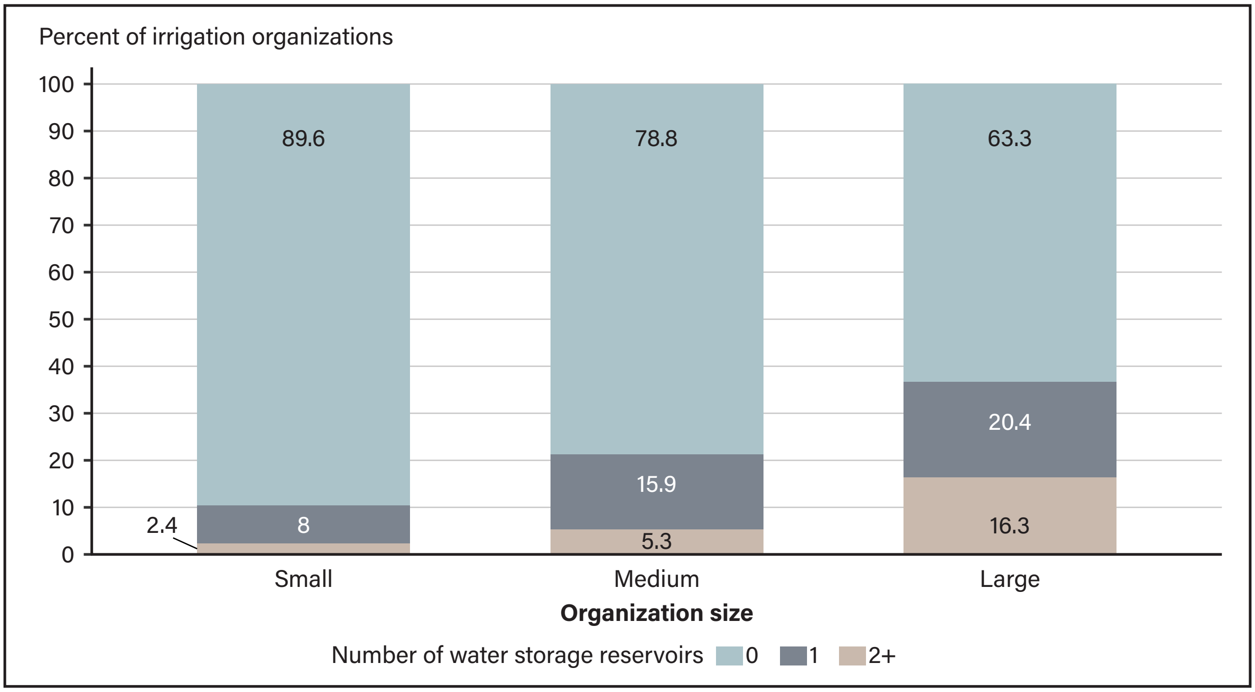
Storage infrastructure is particularly important in snowpack-dependent basins where the timing of spring runoff does not align with peak irrigation water demand. This importance may increase as climate change is expected to reduce snowpack and shift snowmelt runoff to earlier in the growing season while increasing water demand, particularly in the Western United States (USDI, Reclamation, 2015; Evan and Eisenman, 2021). Annual variability in seasonal precipitation may also expand the critical need for inter-annual water storage. Water storage infrastructure expansion to enhance water-supply security must consider potential environmental costs, as dams and reservoirs can harm riparian and other ecosystems by altering natural flow regimes and fragmenting habitats (Schmutz and Moog, 2018).

Most irrigation organizations do not have their own water storage reservoirs, with larger organizations most likely to own water storage infrastructure

- Of the 2,543 irrigation organizations that report delivering water to farms and ranches, 19 percent own or operate at least one water storage reservoir. Most water delivery organizations either do not have reservoir storage or rely on upstream reservoirs owned and managed by entities such as the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, State water projects, private reservoir companies, or other irrigation organizations.
- Over 37 percent of large irrigation organizations have at least one water storage reservoir. Meanwhile, 21 percent and 10 percent of medium and small organizations, respectively, have at least one storage reservoir. See appendix A for more details on organization size classifications.

Figure 1

Percent of organizations with 0, 1, and 2 or more water storage reservoirs by organization size



Notes: Figure represents only those organizations that identify as water delivery organizations. Large organizations serve more than 10,000 acres; medium organizations serve 1,000 to 10,000 acres; and small organizations serve less than 1,000 acres. Irrigable acres are farmland that could have received water in 2019.

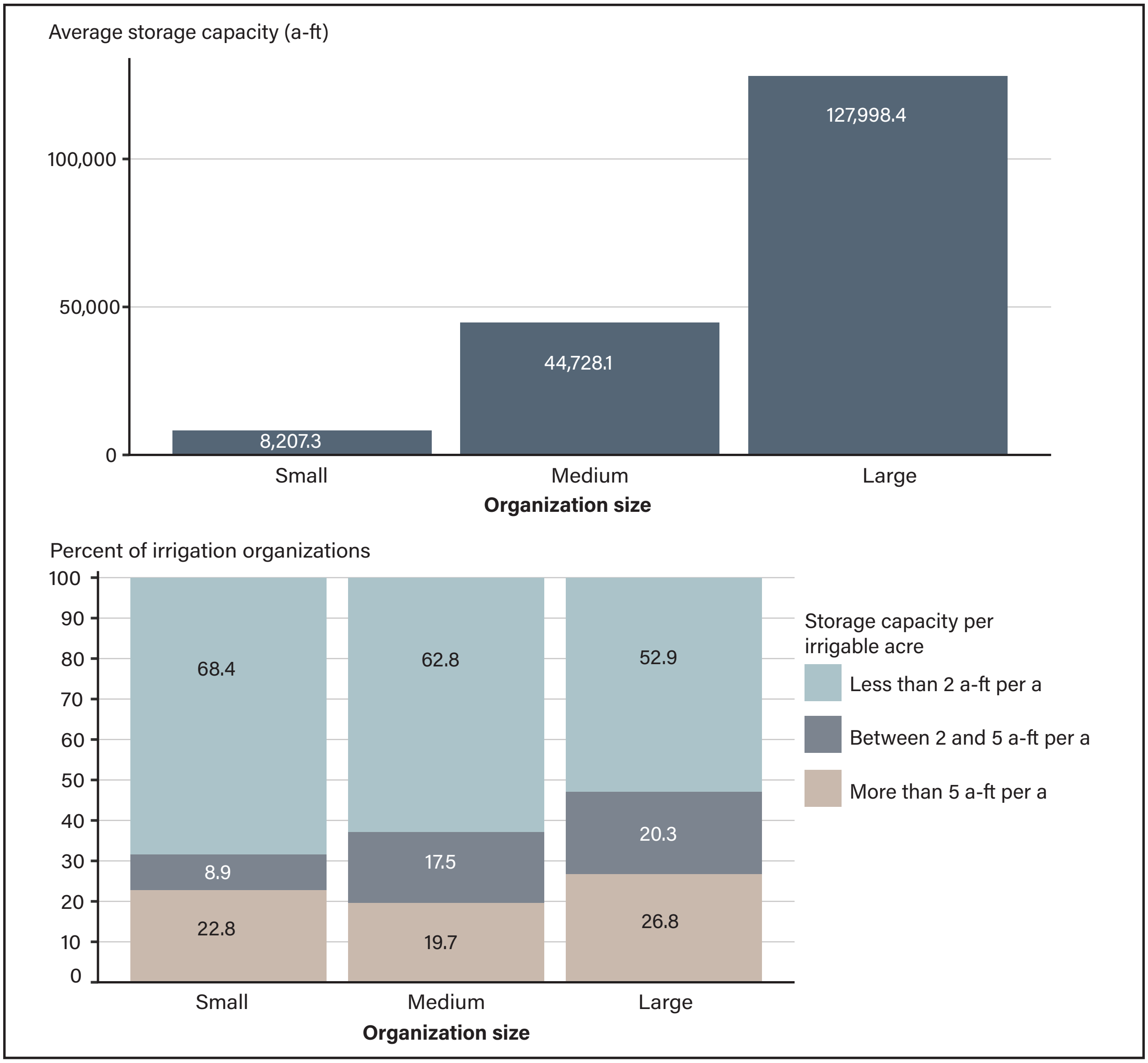
Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Large irrigation organizations have the most total water storage capacity and storage capacity per irrigable acre.

- Among organizations with at least one water storage reservoir, those classified as large, medium, and small have an average total storage capacity of approximately 128,000, 45,000, and 8,000 acre-feet (a-ft), respectively.
- Nearly half of the large organizations with at least one reservoir have a total storage capacity of more than 2 a-ft per irrigable acre, while approximately 37 percent and 32 percent of medium and small organizations, respectively, have storage capacity exceeding 2 a-ft per irrigable acre.

Figure 2

Average storage capacity and storage capacity per irrigable acre by organization size



Notes: Figure represents only those organizations that identify as water delivery organizations and report owning at least one water storage reservoir. Large organizations serve more than 10,000 acres; medium organizations serve 1,000 to 10,000 acres; and small organizations serve less than 1,000 acres. Irrigable acres are farmland that could have received water in 2019. a-ft = acre-feet.

Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Water Conveyance

Irrigation organizations that deliver water to farms and ranches use conveyance infrastructure, such as main and lateral canals, tunnels, and pipelines to transport water from natural waterways, reservoirs, or other conveyance infrastructure to irrigators. The extent of these conveyance systems depends, in part, on the size of the organization in terms of the amount of irrigated land served. Conveyance infrastructure is typically owned and managed by irrigation organizations, although in some regions, Federal (e.g., Bureau of Reclamation, Bureau of Indian Affairs) or State (e.g., California's State Water Project) agencies may own and operate conveyance infrastructure.

Transporting water from natural waterways, reservoirs, or other conveyance infrastructure to irrigators can result in conveyance losses,[2] or water that is unavailable for irrigation use because of evaporation, seepage, or phreatophyte[3] consumption (USDA, NASS, 2020). The lining of main and lateral canals—reinforcing the inside of conveyance canals with an impervious or semi-impervious material (e.g., concrete, plastic, clay)—can decrease these losses (USDA, Reclamation, 1976; Scherberg et al., 2018). However, the cost of lining canals may be prohibitively high for many irrigation organizations. In some scenarios lining canals may not be feasible or warranted. For example, soil and geologic attributes may minimize seepage losses or unlined canals may beneficially recharge[4] aquifers used for irrigation and/or environmental purposes, for example, downstream wetland habitat. Additionally, recharge from unlined canals may be subject to transboundary water compacts.[5]

On average, large organizations have a larger water conveyance network with a larger proportion of main and lateral canals lined

- On average, large organizations manage 121 miles of main canals and 100 miles of lateral canals. Medium organizations have an average of 13 miles of main canals and 7 miles of lateral canals. Small organizations, on average, manage 5 miles of main canals and 3 miles of lateral canals.
- Large organizations have the largest percentage of their total conveyance infrastructure allocated to lined canals and laterals. On average, 40 percent and 21 percent of large organizations' main and lateral canals, respectively, are lined. The average medium organization has 15 percent and 10 percent of their main and lateral canals, respectively, lined. Finally, an average 14 percent and 23 percent of main and lateral canals owned by small organizations are lined.

[2]Conveyance losses are not an actual loss of water in a broadly defined hydrologic system. Water seepage from main and lateral canals is stored in aquifers while evaporated water returns to the land in the form of precipitation. The water is lost in the sense that it is not immediately available for its intended use.

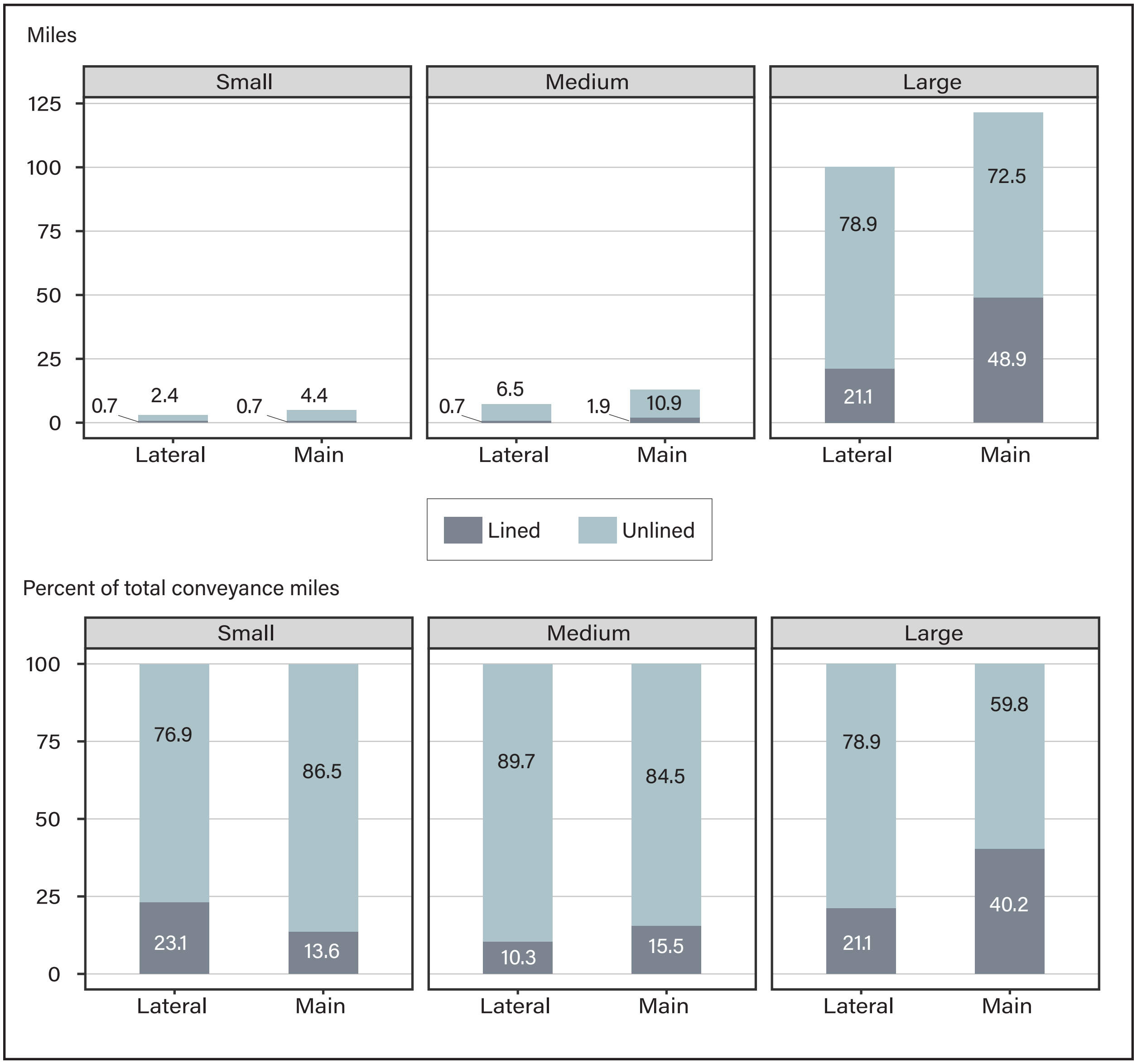
[3]Phreatophytes are non-crop plants that use groundwater within reach of their roots for evapotranspiration (USDI, USGS, 1958). Phreatophytes near water conveyance infrastructure can increase conveyance losses as root systems draw from the water being transported. Common species of phreatophytes include saltgrass, cottonwood, willow, and saltcedar.

[4]In some regions of Nebraska groundwater levels have increased substantially after the development of irrigation conveyance infrastructure (Young et al., 2018).

[5]Proposals to line the All-American Canal, which diverts water from the Colorado River to the Imperial Valley in Southeastern California, were met with several legal challenges related to the canal's lining infringing on the water rights of water users in Mexico (Kishel, 1993).

Figure 3

Average length and percentage of system miles of main and lateral canals (lined/unlined) by organization size



Notes: Figure represents only those organizations that identify as water delivery organizations. Large organizations serve more than 10,000 acres; medium organizations serve 1,000 to 10,000 acres; and small organizations serve less than 1,000 acres. Irrigable acres are farmland that could have received water in 2019.

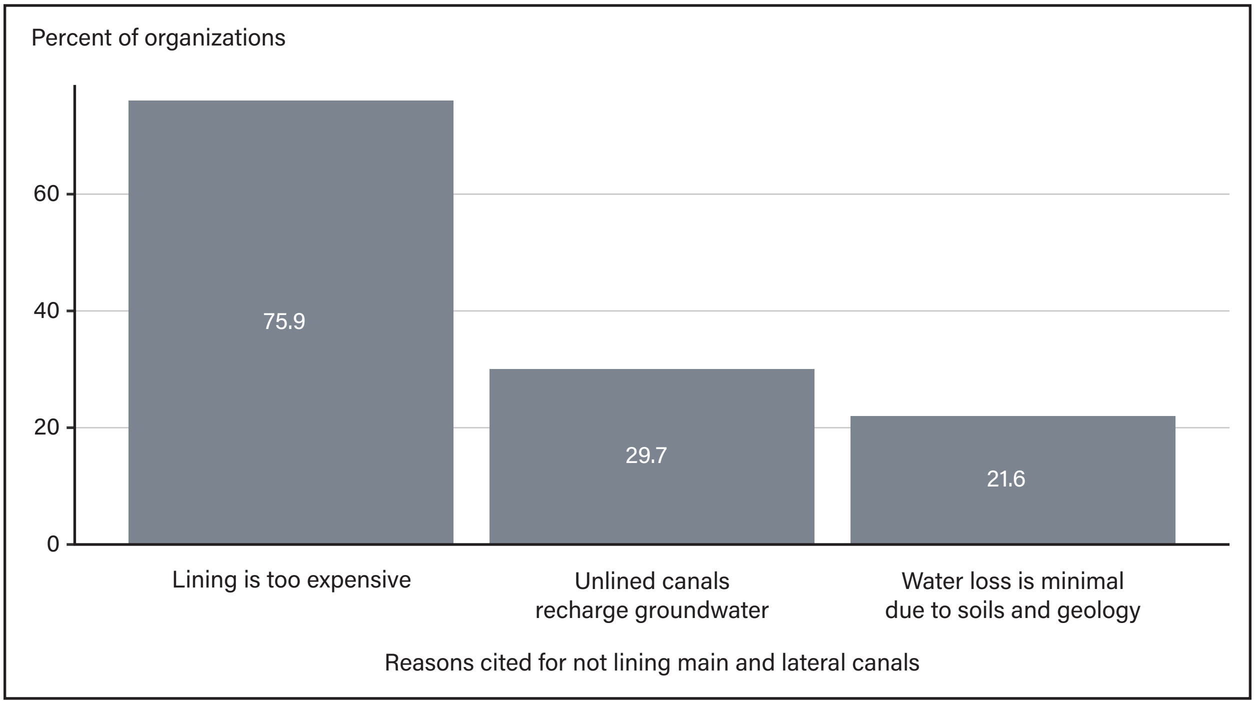
Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Cost constraints are an important factor influencing canal lining decisions for irrigation organizations

- Irrigation organizations cite several reasons for not lining main and lateral canals, including the expense of lining, minimal seepage losses because of soils and geology, and groundwater recharged by seepage from canals.
- Cost is the most frequently cited reason for not lining main and lateral canals. More than 75 percent of organizations indicate the expense of lining is a reason for keeping their canals unlined.
- The second most cited reason is the groundwater recharge benefits of water seeping from unlined canals. Nearly 30 percent of organizations indicate groundwater recharge is a reason for unlined main and lateral canals.
- The third most cited reason is that local soil and geologic attributes (e.g., high clay content in soil) minimize the seepage losses incurred when transporting water in unlined canals. More than 20 percent of organizations cite this as a reason for not lining canals.

Figure 4

Percent of organizations citing differing reasons for not lining conveyance infrastructure



Notes: Organizations can cite multiple reasons for not lining main and lateral canals. As such, aggregating the percentage of organizations citing differing reasons for not lining canals results in a percentage that exceeds 100. The figure represents only those organizations that identify as water delivery organizations.

Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Turnouts and Water Use Metering

Water flow within the complex storage and conveyance systems used to deliver water to farms and ranches is managed by turnouts.[6] Turnouts divert water and control flow volumes within an organization's water conveyance system and often serve as the interface between organization and farm conveyance infrastructure where control of the water shifts to the farm or ranch. Turnout infrastructure determines, in part, how accurately an irrigation organization can track and meter water use within its system. Modern turnout technologies can increase the efficiency of an organization's system and provide precise measurements of the volumes of water delivered (Romero et al., 2012). As such, turnouts are an important aspect of irrigation infrastructure that allow irrigation organizations to track water flows and meter water deliveries within their systems.

Many different types of turnouts may be operated, either by irrigation organization staff—such as a ditch rider[7]—or the farmer/rancher. Table 1 provides a brief overview of several of the most common turnout types. The type of turnout technology used in an organization's conveyance system in part determines the water metering methods available to the organization. More advanced turnouts, such as calibrated slide gates and automated flow control systems, facilitate the direct metering of deliveries to farms and ranches. Meanwhile, more traditional turnout types—such as manual metergates and siphon tubes—may require other methods such as time of use estimation, where the volume of water delivered is calculated based on delivery length. Additionally, the more traditional turnout types generally require additional labor and time to accurately track and control water flows and deliveries compared with more advanced turnouts, particularly automated flow control systems.

Characteristics of an irrigation organization's conveyance infrastructure—including reservoir storage capacity, canal flow capacity, and turnout technology—may constrain an organization's ability to meet peak water demand, even under normal water supply conditions (Yoo and Busch, 1985). Other legal and regulatory considerations, such as water allocation rules and environmental flow requirements, may also constrain an organization's ability to meet water demand.

[6] Turnouts are also commonly referred to as offtakes, delivery gates, or head gates.

[7] A ditch rider is hired by an irrigation organization to maintain irrigation canals and laterals and open turnouts as appropriate to divert water for water deliveries through the water conveyance system. The ditch rider may also calculate the volume of water deliveries and oversee ditch operations (Palmer et al., 1991; Waskom et al., 2007).

Table 1
Types of irrigation system turnouts and definitions

Turnout	Definition
Manual metergate	A turnout that uses circular gates to control water flow into a downstream pipeline. Flow measurement is taken downstream from a stilling well that is tapped into the top of the pipeline.
Calibrated slide gate	A turnout that uses a built-in rectangular slide for flow regulation and measurement. The gate position paired with the water level drop across the gate are used to compute the flow rate using either a table or formula.
Crested weir	A small dam built across canals or natural waterways where water flows over the crest of the structures that are used to control upstream water levels and measure water flow based on weir characteristics, including length, the height of the water level above the crest of the weir, and the geometry of the weir.
Pump	A turnout that uses energy inputs to convey water under pressure from organization conveyance infrastructure to on-farm canals, ditches, or pipelines.
Automated flow control	A turnout system to determine the water flow parameters of an open channel and automatically adjust the size of a gate opening accordingly. The system includes a flow measurement structure (e.g., weir or flume), a water level sensor, a flow control gate, and an actuator for adjusting the inflow gate.
Siphon tube	A basic turnout that conveys water over a barrier, such as the bank of a raised irrigation canal. Siphon tubes rely on the water level in the canal being higher than the water level in the field being irrigated to function.

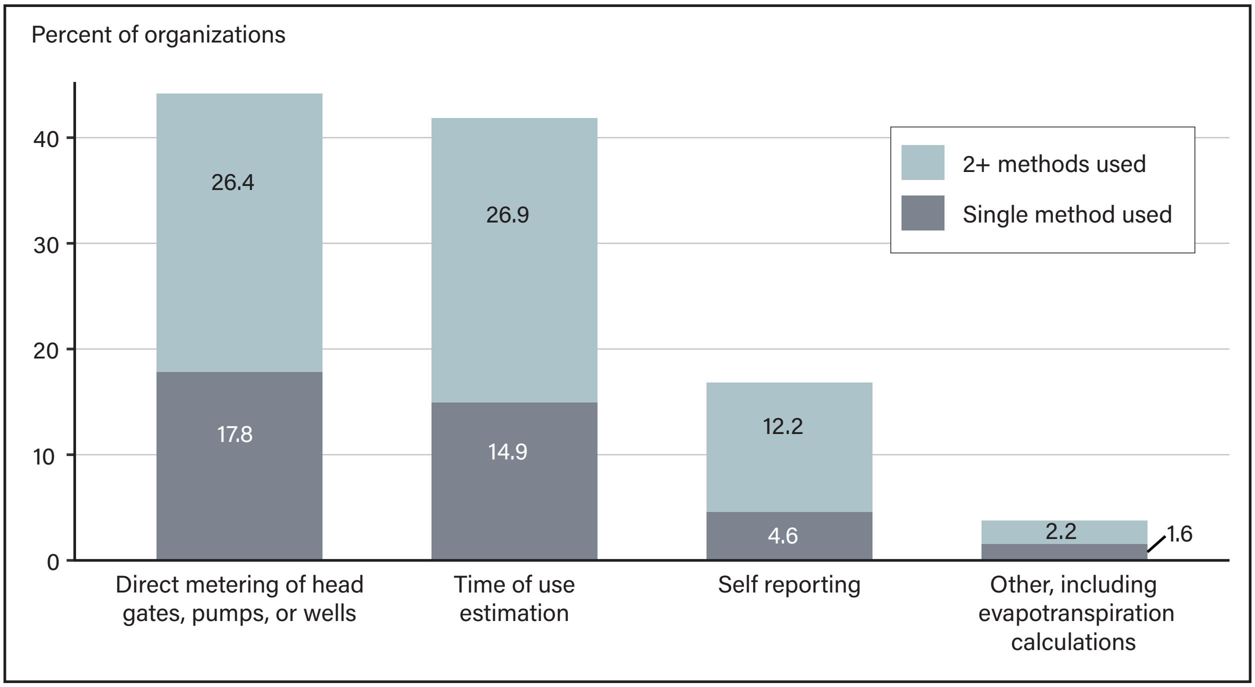
Sources: USDA, Economic Research Service using data from U.S. Department of the Interior, Bureau of Reclamation (2001) and Howes and Burt (2015).

Irrigation organizations use a variety of methods to calculate on-farm water use

- Direct metering of head gates, pumps, or wells is the most common means water delivery irrigation organizations use to determine water use. Approximately 44 percent of water delivery irrigation organizations use direct metering methods to calculate water use, with more than half of these organizations using at least one other method.
- Time of use estimation is the second most common method for determining water use. This method uses information on the duration of water deliveries, canal size, and flow rate to estimate the volume of water delivered. More than 41 percent of water delivery irrigation organizations use time of use estimations to calculate on-farm water use. Most of these organizations use time of use estimation in tandem with at least one other method to track water use.
- Self-reporting and "other" methods, including evapotranspiration-based calculations, are less commonly employed to calculate water use. Approximately 17 percent and 4 percent of organizations use self-reporting and "other" methods, respectively.
- More than 20 percent of water delivery organizations report their organization does not use any means to calculate on-farm water use.

Figure 5

Methods used by irrigation organizations to calculate water use by farms and ranches served by their conveyance infrastructure



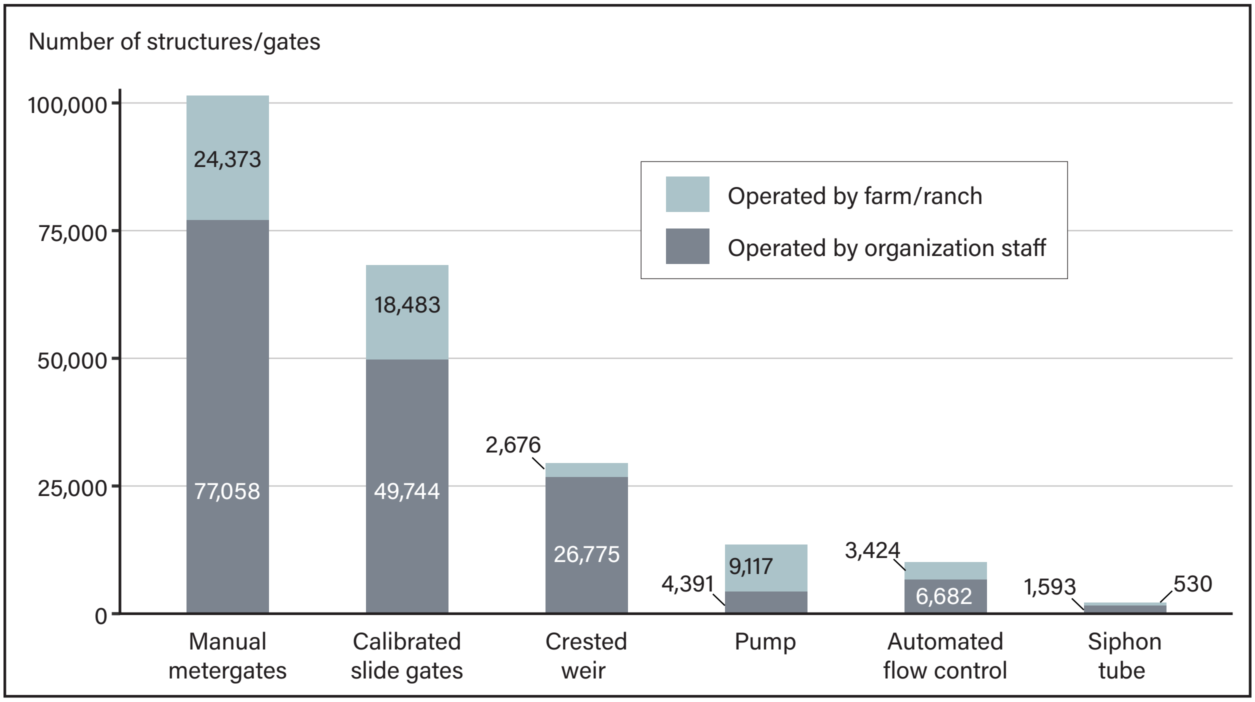
Notes: Organizations can cite multiple methods for tracking on-farm water use. As such, aggregating percentages across methods results in a total of more than 100 percent. This figure represents only those organizations that identified as water delivery organizations and answered at least one of the four relevant water calculation questions in the survey. The category "Other, including evapotranspiration calculations" includes all other means organizations may use to calculate water use by farms and ranches. Evapotranspiration calculations are a common means to estimate water use. These calculations use information on the water uptake (evapotranspiration) of differing crops to estimate the amount of water consumptively used by the crop.

Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Manually operated irrigation system turnouts are the most used turnout technologies

- Manual metergates are the most common type of turnout in irrigation organization conveyance systems. Across the United States, there are more than 101,000 manual metergates used in irrigation organization conveyance systems. Approximately 24 percent of these metergates are operated by the irrigator rather than organization staff.
- Calibrated slide gates are the second most common turnout used in irrigation organization conveyance systems. There are approximately 68,000 calibrated slide gates in irrigation organizations' conveyance systems, with 27 percent of these turnouts operated by farms and ranches.
- The third most common turnout in irrigation organization conveyance systems is crested weirs. There are nearly 30,000 crested weirs used by irrigation organizations, with less than 10 percent of these turnouts operated by farms and ranches.
- Pumps, automated flow control, and siphon tube turnouts are all relatively less common, with approximately 14,000, 10,000, and 2,000, respectively, used in irrigation organization conveyance systems. Farms and ranches operate 67 percent of pumps, 34 percent of automated flow control systems, and 25 percent of siphon tubes.
- More than 75 percent of manual metergates within small water delivery irrigation organization conveyance systems are operated by farms and ranches, while less than 10 percent of manual metergates within large water delivery irrigation organization conveyance systems are operated by farms and ranches. See appendix A for more details on organization size classifications.

Figure 6
Number and operation of irrigation system turnouts



Note: Figure represents only those organizations that identify as water delivery organizations.

Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

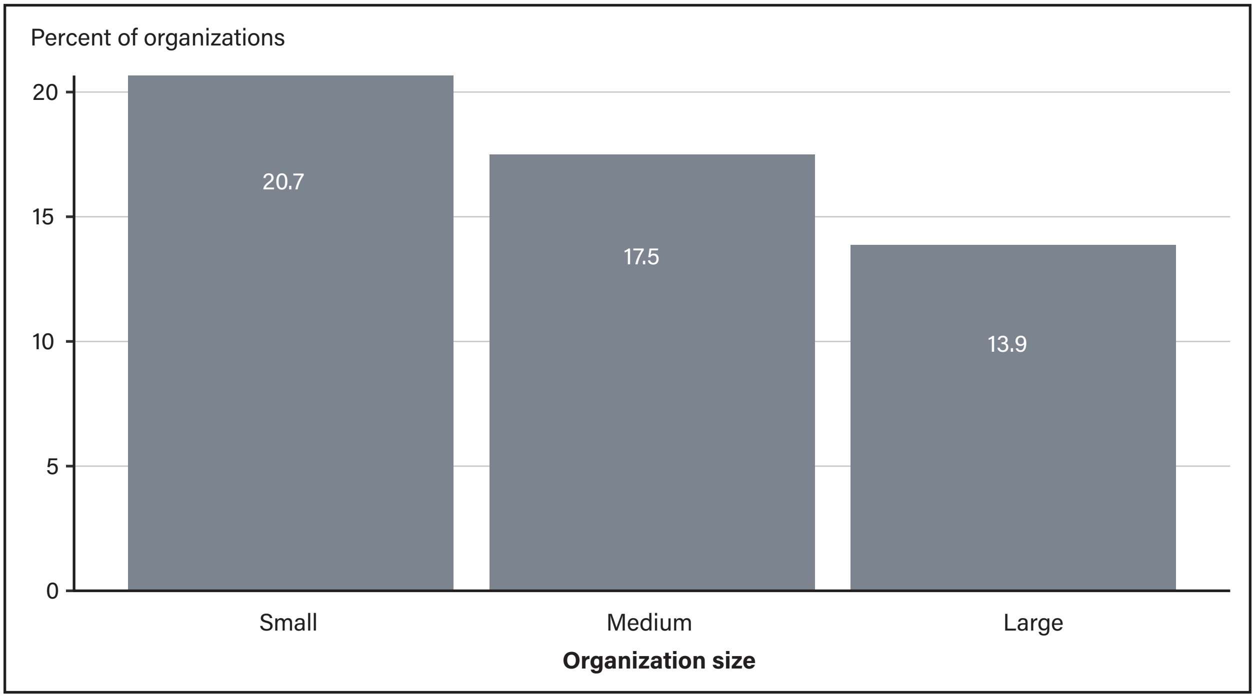
Small organizations face the most significant water conveyance system constraints in delivering water to farms and ranches

- Less than 20 percent of large and 20 percent of medium water delivery organizations are unable to meet irrigation water demand at least 80 percent of the time under normal water supply conditions. Water supply shortfalls because of drought would further reduce the ability of water delivery organizations to meet water demand. Several components of an irrigation organization's system can contribute to these delivery constraints, including diversion reservoir storage capacity, canal flow capacity, turnouts, and water allocation rules.

- Large water delivery organizations are the least likely to experience delivery capacity constraints. Conversely, small water delivery organizations are the most likely to experience delivery capacity constraints. See appendix A for more details on organization size classifications.

Figure 7

Percent of organizations unable to meet irrigation peak water demand (required flowrate and volume) at least 80 percent of the time under normal water supply conditions



Notes: Figure represents only those organizations that identify as water delivery organizations. Large organizations serve more than 10,000 acres; medium organizations serve 1,000 to 10,000 acres; and small organizations serve less than 1,000 acres. Irrigable acres are farmland that could have received water in 2019.

Source: USDA, Economic Research Service using data from the USDA 2019 Survey of Irrigation Organizations.

Conclusion

The infrastructure owned and managed by irrigation organizations is vital to the irrigated agricultural sector. The ability of irrigated farms to manage on-farm water supplies is connected to the capacity of irrigation water delivery organizations to provide sufficient water. Data collected in the 2019 Survey of Irrigation Organizations suggest that, in many cases, water delivery organizations may not be able to supply all water demands, even under normal water supply conditions. This is particularly true for smaller organizations that serve relatively fewer irrigated acres.

The effects of climate change on water resources are expected to become more prevalent (USGCRP, 2018). Climate change may alter seasonal water flow regimes, increasing the importance of water storage capacity across the Western United States (USDI, Reclamation, 2015; Evan and Eisenman, 2021). Projected surface temperature increases are also expected to intensify evaporative losses of water stored in reservoirs and diminish irrigation return flows as more water applied evaporates before returning to waterways (Helfer et al., 2012; Malek et al., 2018). The increasing frequency of drought throughout the United States, particularly in the Southwestern United States, amplifies the need to store and convey water efficiently (Seager et al., 2013; Dettinger et al., 2015).

Investments in irrigation infrastructure upgrades can help develop resiliency to drought, climate change, and long-term water scarcity in the irrigated agricultural sector. Section 2304 of the Agriculture Improvement Act of 2018 (P.L. 115-334), commonly known as the 2018 Farm Bill, extends eligibility for financial assistance under the USDA, Natural Resources Conservation Service's Environmental Quality Incentives Program (EQIP), historically targeted to farms and ranches, to include irrigation water-delivery and groundwater management organizations. Irrigation organizations can leverage EQIP funds to enhance the capacity and efficiency of their storage and conveyance systems, including the upgrading of system turnouts. Investments in regulating reservoirs and canal flow capacity allow greater flexibility in managing water demands by farmers and ranchers.

Lining conveyance canals or converting to piped systems presents a significant opportunity to increase the efficiency of water transport, particularly since most main and lateral canals owned by irrigation organizations remain unlined. However, lining canals may be prohibitively costly for some organizations and reduces rates of aquifer recharge that many water delivery organizations cite as a reason to leave canals unlined. An organization's ability to meet irrigators' water demand may be constrained by the turnout technology used to divert water within organizations' conveyance systems and deliver water to farms and ranches. Many organizations rely on more traditional turnout technologies that potentially affect the precision of water metering. Irrigation system turnout upgrades have the potential to deliver water and track water use more efficiently within an organization's conveyance system.

This report provides a national-scale overview of infrastructure owned by water delivery organizations. Despite the importance of irrigation infrastructure, relatively little is known about how characteristics of irrigation organizations and their service areas (e.g., portfolio of water rights, mix of crops grown, precipitation patterns) affect infrastructure investment and vice-versa. Future research is needed describing the causal mechanisms that determine infrastructure investment decisions and how those decisions affect the profitability and resilience of irrigated agriculture.

Appendix A: Irrigation Organization Size Categories

This report groups water delivery organizations according to the number of irrigable acres served by the organization. Irrigable acres are farmland served by irrigation organizations that could have received water in 2019. Large organizations serve more than 10,000 acres. Medium organizations serve between 1,000 and 10,000 acres. Small organizations serve less than 1,000 acres.

- Large delivery organizations make up 16 percent of all delivery organizations. While these organizations constitute a small portion of the total number of organizations, they provide most of the off-farm water used for irrigation. In 2019, they served 78 percent of irrigable acres and delivered 80 percent of the total off-farm water delivered to farms and ranches.
- Medium delivery organizations represent 40 percent of all delivery organizations. They served 20 percent of irrigable acres and delivered 17 percent of total off-farm water delivered to farms and ranches in 2019.
- Small delivery organizations represent 44 percent of all delivery organizations. They served 2 percent of irrigable acres and delivered 2 percent of total off-farm water delivered to farms and ranches in 2019.

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