On-Farm Water Storage Systems and Surface Water for Irrigation

What Is an OFWS System?

An on-farm water storage (OFWS) system is a structural best management practice that captures and stores surface water runoff so that it can be used at a later time for irrigation. These systems can capture runoff both from rainfall and tailwater from furrow irrigation, and they can be constructed with only a storage pond, with an enlarged tailwater recovery (TWR) ditch, or with a TWR ditch and a storage pond (**Figure 1**). The pond is typically constructed on an area of the farm that is less productive, such as a low-lying area that does not drain well. The TWR ditch and pond are positioned where they can capture adequate runoff yet remain accessible to fields that will be irrigated using the stored water. The designs of the systems vary depending on where in Mississippi they are installed. It is important to note that Section 404 of the Clean Water Act (CWA) requires a permit for the discharge of dredged or fill material into waters of the United States, which includes wetlands.

Figure 1. An on-farm water storage system typically consists of a pond and a tailwater recovery canal.

History of OFWS Systems

In Mississippi, irrigation first began in the Delta area in the 1970s and has steadily increased. This increase in irrigation is mostly a result of easy access to the shallow groundwater in the Mississippi River Valley (MRV) alluvial aquifer, low energy costs, and the availability of pumps and power plants. Unlike in the western United States, where the federal government helped implement major infrastructure projects such as dams and reservoirs to support irrigation, the expansion of irrigation in the southeastern United States has been primarily due to private investment by farm owners. No large federal projects have been implemented to date.

In 1982, Mississippi had 430,901 irrigated acres. In 1992, that number had more than doubled to 882,976 irrigated acres, moving Mississippi into 19th in the country for states with the greatest number of irrigated acres. In 2012, Mississippi moved to ninth in the country with 1,651,978 irrigated acres (NASS, 2004; NASS, 2014). Conversely, the number of irrigated acres in most western states has decreased. This is due to the increasing demands for water resources from growing urban populations and over-allocation of water resources.

Increased dependence on irrigation has become an issue. Current irrigation systems are expected to reduce risk, withstand periodic droughts, and maintain or increase profits. However, these expectations have caused the groundwater in the MRV alluvial aquifer to be pumped at a faster rate than it is being refilled, resulting in declining aquifer levels in the Delta over the past three decades.

The Mississippi Department of Environmental Quality (MDEQ) is responsible for managing all of the state's waters and has recognized and responded to this growing concern. In November 2011, the executive director of MDEQ established the Delta Sustainable Water Resources Task Force, which is led by MDEQ's executive director and includes representatives from Delta Council, Delta Farmers Advocating Resource Management (Delta F.A.R.M.), Mississippi Farm Bureau, the Mississippi Soil and Water Conservation Commission, the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture, the Vicksburg District of the U.S. Army Corps of Engineers, and the Yazoo-Mississippi Delta Joint Water Management District. The task force was formalized by Executive Order No. 1341, signed by the governor of Mississippi on August 26, 2014. The task force aims to manage water as efficiently as possible, store water when it is plentiful to use at times when it is not, and pursue all feasible alternative water supplies.

While concerns over aquifer declines and the availability of water for irrigation were escalating, there was also growing concern about the issue of hypoxia (oxygen deficiency) in the Gulf of Mexico. The Mississippi River Basin contains approximately 65 percent of the United States' harvested cropland, and the Mississippi and Atchafalaya Rivers contribute over 85 percent of the total nutrient load to the Gulf (Dunn, 1996; Kolpin, 2000). Excess nutrient runoff increases aquatic primary production, which is often indicated by algal blooms (Dubravko et al., 2005). When this plant material dies and is degraded by bacteria, oxygen is consumed, depleting oxygen levels in the water column. Hypoxic conditions occur when oxygen levels in the water reach 2 milligrams per liter or less. The northern Gulf of Mexico contains one of the largest hypoxic "dead" zones in the world (Renaud, 1986; Rabalais et al., 2002).

The Mississippi River Gulf of Mexico Watershed Nutrient Task Force, formed in 1997, set a goal to reduce the size of the Gulf hypoxic zone to less than 5,000 square kilometers by the year 2015. The average size of the Gulf hypoxic zone in 2005–2010 was 17,300 square kilometers, and the size in 2010 covered 20,000 square kilometers (Rabalais and Turner, 2010). The size of the hypoxic area fluctuates from year to year, depending on the amount and timing of spring and summer rainfall, the associated discharge from the Mississippi River, and wind speed and wind direction, among other factors. The most recent mapping of the Gulf in July 2017 recorded a hypoxic area of 22,720 square kilometers, the largest size measured to date since mapping began in 1985 (LUMCON, 2017).

In 2009, the USDA-NRCS launched the Mississippi River Basin Healthy Watersheds Initiative (MRBI). This initiative provided additional funds to support voluntary conservation practices in selected focus area watersheds in participating states to reduce nutrient loading and improve water quality in the Basin and Gulf of Mexico. When the MRBI program first began, there were 12 participating states, including Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin.

When the MRBI was first implemented, there were three focus area watersheds in Mississippi: Big Sunflower (08030207), Upper Yazoo (08030206), and Deer-Steele (08030209) (**Figure 2**). In 2011, the Coldwater Creek Watershed (08030204) in northwest Mississippi was added. South Dakota began participating in 2012.

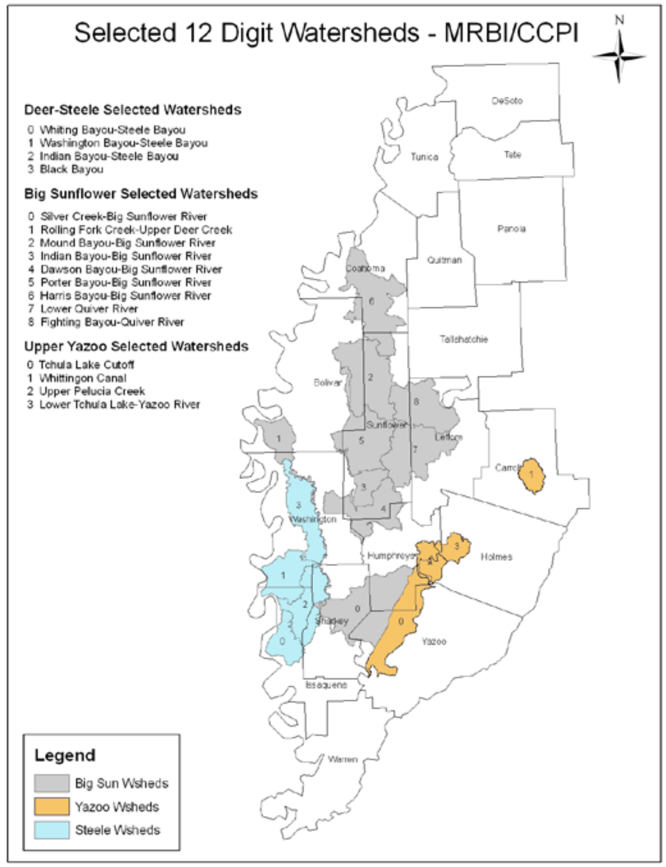

Figure 2. Original MRBI focus area watersheds in Mississippi. Source: Rodrigue, P. 2017. MRBI Watersheds Mississippi. Personal Communication, December 7, 2017.

Since its inception, the MRBI has used several Farm Bill programs to improve water quality, restore wetlands, enhance wildlife habitat, and install conservation practices on agricultural lands in high-priority watersheds. In addition, states in the Mississippi River Basin, including Mississippi, have developed state nutrient reduction strategies, and the MRBI projects support these strategies.

As a result of financial assistance provided through the MRBI, decreasing aquifer levels, and producer concerns over the availability of water for irrigation, the first OFWS system was installed in the Mississippi Delta in 2010. Since that time, there have been 180 projects installed over 14 Delta counties under NRCS Practice Code 436, which includes both TWR ditches and storage ponds.

An OFWS system is defined by NRCS as "an irrigation water storage structure made by constructing a dam, embankment, pit, or tank" (NRCS, 2012). Approximately 70 percent of these projects have included OFWS ponds, while the remaining 30 percent were only for TWR. In addition, 124 of these projects were installed in the two counties where the declines in the MRV alluvial aquifer have been most severe—95 projects in Sunflower and 29 projects in Bolivar. There are also producers in other regions of the state who are installing OFWS systems, without cost assistance, to have a source of water for irrigation.

OFWS System Differences

Due to the flat terrain in the Mississippi Delta, fields are usually precision-leveled, and pads and pipes are installed to ensure that runoff from surrounding fields drains into the TWR ditch. From there, it is pumped into the storage pond, where it is held until needed for irrigation. The storage pond is typically built up from soil captured through the land-leveling process, with minimal excavation. OFWS systems that are constructed with financial assistance from the NRCS are usually designed by an NRCS engineer to have a ratio of 1 acre storage for every 16 irrigated acres. Storage ponds are usually around 8 feet deep with a 4-foot berm and a minimum 6-inch overflow pipe (**Figure 3**).

Figure 3. On-farm water storage pond.

OFWS systems designed by NRCS in the Mississippi Delta ideally have ponds with a storage capacity to apply 6 inches of water per acre per season if the pond is full at the beginning of the growing season. OFWS systems are designed to meet irrigation requirements 8 out of 10 years. If the system is a combined TWR ditch and storage pond, the ditch is designed to hold 12 acre-feet of water, providing additional storage for irrigation water. Systems installed in the Delta usually have a minimum 32 acre-feet of storage. Depending on the weather conditions during a growing season, how much rainfall is received, and the planting date of the crop, producers are sometimes able to irrigate entirely with stored surface water. At other times, producers can use a combination of surface and groundwater.

In addition, in the Mississippi Delta, OFWS systems use furrow irrigation after installation. Even though more water is applied through furrow irrigation, any excess water that runs off will be captured by the TWR ditch and recycled through the OFWS system. When OFWS systems are installed, the TWR ditch is originally constructed with a trapezoidal shape, and native grasses are planted on the banks of the ditch and pond to help reduce erosion. Many systems now have an automatic shutoff switch, so that when water in the storage pond reaches a designated height, the pump that is pumping water from the ditch to the pond will automatically shut off. If there is excess rainfall during the winter when the pond is full, the overflow would move through the outlet of the TWR ditch.

There is also a growing interest in irrigation in northeast Mississippi, where more producers are opting to move acres previously under dryland production into irrigation. The reasons for doing so are mostly the same as in other areas of the state, but, in northeast Mississippi, there is no easy access to shallow groundwater. Producers who want to reduce risk and have greater yield stability from year to year are making private investments in OFWS systems. There is more topography in the northeastern region of the state, so rather than land leveling, systems are designed so that rainfall runoff is gravity-fed into storage ponds, sometimes with the help of constructed terraces.

Ponds constructed for irrigation in northeast Mississippi are usually deeper than 8 feet and use center pivot irrigation. All water captured is from rainfall and rainfall runoff with no contribution from tailwater runoff. Thus, OFWS systems in northeast Mississippi are usually designed with only a storage pond and no accompanying TWR ditch. In this region of the state, accessing groundwater is not cost efficient due to the drilling depth required to reach sufficient groundwater. Since OFWS systems here are typically the sole source of water for irrigation, they must be designed to hold enough water for the producer to irrigate the desired number of acres for an entire growing season.

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