Ag WATER PUMPING

Project Report 52

Executive Summary

Statewide Irrigation Monitoring

EPD Cooperative Agreement Number: 764-890147
UGA ID 25-21-RF327-107

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EXECUTIVE SUMMARY

Agricultural irrigation systems used on Georgia farms, orchards, nurseries, and certain golf courses are estimated to cover over 1.5 million acres, mostly in the Coastal Plain region that lies in the southern part of the state. These systems are supplied with water from ground and surface water resources that fall under permitting requirements of the Georgia Environmental Protection Division (EPD). Most of the wells, surface water pumping stations and ponds used in these systems were constructed and paid for by individual land owners. Each individual water source usually supplies only one or two of the estimated 16,500 irrigation systems in the state. In the 1988 statutes that required permits for agricultural withdrawals, these privately owned pumping and delivery systems were specifically exempted from water metering, record keeping, and reporting to EPD. Consequently, Georgia water planners have lacked systematic enumeration of water quantities applied for irrigation in agricultural production. In 1998, EPD requested that the Georgia Cooperative Extension Service (CES) establish a statewide system for measurement of water application by producers and conduct a multi-year study of those water amounts.

Approach

Engineers, researchers and statisticians of the University of Georgia (UGA) designed a statewide irrigation monitoring program that met the dual needs of rapid startup and modest budget. The basic design included repeated monthly visits to selected irrigation sites by UGA personnel. Water application amounts were calculated from equipment use time and calibrated flow rates for most irrigation systems. Electric timers were installed on irrigation application equipment when possible or on pumps or generators that supplied unique irrigation systems and had uniform flow rates. When flow rates varied over time, totalizing flow meters were used. At each monthly visit, crops that were in the irrigated fields were noted, and the proportion of water that was applied on each was estimated.

A stratified, random sampling was used to identify potential participants for a voluntary monitoring program. A statewide 2% random sample was taken of the Agricultural Water Withdrawal Permits issued by EPD between 1988 and 1998. The sample was stratified to assure proportionality of sampling by county and water source. A secondary stratification was made in an attempt to represent types of irrigation systems and choices of crops as identified by separate CES surveys. The randomly selected permit holders were asked to participate in the monitoring program that became known as Ag Water Pumping (AWP). A large majority, 78%, of producers agreed. When a producer could not or would not participate, a potential replacement was randomly selected from among others who used the selected water source type in that county.

Once a withdrawal site was selected, all wells, surface water sources, pumps and irrigation systems connected to that site were characterized. Multiple water sources and multiple irrigation systems were common. Flow points in the system that supplied fixed

"wetted" field areas with water were selected as metering sites. Flow rates were measured with the pumps and application system operating under normal conditions and under control of the producer. Portable "strap-on" digital flow meters provided flow rates. These did not require modification of the irrigation system for the measurement and follow-up flow checks could easily be made. A systematic follow-up of flow rates was made during the 2001 to evaluate changes in producers' systems over time.

The state was divided into four reporting areas based on special water planning needs. The 24-county Coastal Zone had been previously identified by EPD as a special area based on salt water intrusion concerns for the Upper Floridan aquifer. Similarly, a 26-county area in Southwest Georgia had been delineated because most of its area included river basins involved in tri-state water compact studies and negotiations. Setup and monitoring of AWP sites was initiated during 1999 for both of these reporting regions. On average, 93 irrigation systems were monitored in the Coastal zone; 221 in Southwest Georgia. The 34 remaining Coastal Plain counties were grouped into a third reporting area. Likewise all 75 counties that lay north of the physiographic Fall Line that separates the flatter Coastal Plain from the upland Piedmont were grouped into a fourth reporting area. Setup and monitoring of AWP sites was initiated in 2000 for these last two regions. On average, 249 irrigation systems were monitored in the Central Coastal Plain, while 15 were monitored in North Georgia. A total of approximately 43,000 acres of irrigated land was included in these sampled systems statewide. Monthly monitoring was continued through 2004. This report details water application amounts made for agricultural irrigation for the period 2000 to 2004.

Results

Statewide mean annual application depths were 9.4, 7.8, 8.7, 4.8 and 8.6 in. for 2000, 2001, 2002, 2003, and 2004, respectively. The 2000 through 2002 data reflect water application during a period of drought considered one of the worst in Georgia's history. During 2003 normal to above-normal in-season rainfall returned and significant periods of recharge occurred, as evidenced by state and US Geological Service reporting of groundwater levels in the region. Although 2004 also had total rainfall above normal, it occurred in a few months of excessive rainfall. The remainder of that year rainfall was below normal. This was reflected in decreases in irrigation depths.

Irrigation depths were weighted by field sizes to minimize the influence of small fields of specialty crops that received high irrigation depths. When applied on a statewide basis, area weighting made little difference among the 585 monitoring sites. Weighted mean annual application depths were 9.6, 7.5, 8.4, 4.2, and 8.2 in. for 2000 through 2004, respectively. However, when applied on smaller areas or when comparing irrigation among water sources or system types, it provides for a more reasonable value for use in water planning. Application volumes could be computed directly from area weighted means, and this value will be used in the remaining comparisons in this summary.

In each year, producers at some of the metered systems made the decision not to irrigate. These varied from 5 to 7% during the drought years and increased to 17% during 2003.

At times the decision to withhold irrigation was based upon limited water supplies; at others it reflected rotation of more valuable crops among a producer's irrigation systems.

Producers who used groundwater for irrigation applied more water on average than those who relied upon surface water sources. In 2000, statewide mean application was 11.3 in. when irrigation was from groundwater versus 7.2 in. when it was from surface water. Similarly, for 2001 through 2003 groundwater versus surface withdrawals were 8.6 vs. 6.1, 9.9 vs. 7.1, 4.8 vs. 3.4, and 7.7 vs. 6.1 in., respectively.

In talking with producers about this difference, several explanations were offered. During the 1998 through 2002 drought, many producers found that their surface water supplies dried up. While they might have planned to apply more water, dry ponds and streams prevented it. Other producers suggested that in order to produce higher value, more water intensive crops they had to drill wells to obtain a reliable water source. Conversely, others said that because they were located in areas where reliable groundwater could readily be obtained, they were able to grow higher value crops. Still others indicated that their surface water supplies were used primarily to fill-in when rainfall was below normal to help their crops survive. These uses often meant setting up temporary, labor-intensive irrigation systems like travelers that discouraged frequent irrigation. Thus for a variety of reasons, surface water users applied less irrigation during our study.

Faced with inadequate runoff to refill ponds just when it was needed for irrigation, many producers drilled wells adjacent to the ponds to supplement them during peak use periods. In some cases, the choice of a well-to-pond system was made because wells of sufficient pumping capacity to directly supply the irrigation system were too expensive or impossible, given the local geology. Wells of smaller capacity could be drilled and operated longer, while water would be pumped at higher rates with separate pumps during irrigation. Other times a well is used to ensure an adequate supply when runoff or stream flows were inadequate to maintain pond water volume. The higher costs associated with pumping from groundwater and again from the pond made this a less desired option than using surface water whenever it was available.

EPD who issued permits by water source recognized well-to-pond systems as a separate category in its permitting. It was included among our random selections in proportion to those permits and counties. On a statewide basis, mean annual application depths were 8.5, 7.3, 7.0, 3.7, and 6.3 in. for 2000 to 2004, respectively. These values were in between the amounts applied when groundwater or surface supplies were used alone.

Irrigation depths differed by regions. In the drought years, more water was applied to fields in Southwest Georgia than in other regions, but in 2003, more water was applied to fields in North Georgia. This was primarily an observation that water application decreased in the Southwest region in 2003, while water application remained constant in North Georgia. Irrigation in this region was affected by the number of golf courses, plant nurseries and sod farms. These make up smaller portion of fields in the Coastal Plain. Less water was applied to fields in the Coastal Zone and Central Coastal Plain than in Southwest Georgia in every year.

Irrigation systems in Georgia include center pivots, traveler systems like hose reel and cable tow, solid set sprinklers, and microirrigation systems including surface drip, drip under plastic and subsurface drip. Irrigation depths for center pivot systems were close to overall statewide means. This was expected since 80% of the state's systems were center pivots. Of these 40% were supplied by groundwater. Almost 97% of these were in use in each year. In contrast, only 6% of systems were travelers, and of those only 9% were using groundwater. Even during drought, only 40 to 75% were in use. Irrigation depths with travelers were generally less than 4 in./yr.

Producers used solid set systems primarily for pecan and other orchards, nurseries, and athletic fields. These uses resulted in mean annual application depths of 29 to 57 in./yr between 2000 and 2004 when supplied from groundwater. When supplied from surface sources, solid set systems had much lower annual application depths, 7.5 to 11.2 in./yr.

Drip systems were also in use on specialty crops including pecan orchards and vegetables. About 87% of these were supplied with groundwater. Mean annual application depths varied from 8.0 to 13.7 in./yr in this period.. The systems were almost always used each year.

Means for irrigation depths are useful in reporting observed water application and in calculating volumes withdrawn. However, for anticipating future water withdrawals, it is important to recognize that annual means were computed from individual applications that varied from 0 to over 300 in./yr. When the full range of observations was ranked, application depths associated with the 50^{th} (median), $75^{th,}$, 90^{th} and 95^{th} percentiles could be determined. Statewide, median irrigation application depths, the values separating the upper and lower half of all applications, were 8.3, 6.2, 6.7, 2.8 and 5.8 in. for 2000 through 2004, respectively. The 75^{th} percentile varied between 10 and 13 in./yr in the 2000 to 2002 drought years. Similarly, the 90^{th} percentile varied between 14 and 18 in./yr, and the 95^{th} percentile between 19 and 21 in./yr in those drought years. Thus, even in severe drought 95% of producers applied less than 20 in./yr.

From CES Irrigation Surveys that have been conducted every three years, estimates of land area used for irrigation showed that the Flint and Ochlocknee river basins each had more than 10% of their land area under irrigation. Additionally, the Suwannee basin had almost 7% of its area under irrigation. The Altamaha, Chattahoochee, Ocmulgee, Ogeechee, Satilla and Savannah basins had 1 to 5% under irrigation. Sensitivity of Georgia's river basins to agricultural irrigation should be related to the percent of the basin under irrigation, as well as to its geology.

More specific examination of the amounts of irrigation by basin was made by computing withdrawals by water source within each. Area-weighted mean annual application depths were computed from AWP sites located in each basin by water sources. These were multiplied by area under irrigation by source within each basin.

Surface water withdrawal volumes were greatest in the Flint, Suwannee, and Ocmulgee basins where 29, 17, and 9 billion gal/yr, respectively, were withdrawn from ponds and streams in 2002. Additionally, 8, 7, and 6 billion gal/yr were taken from ponds that were at least partially refilled by wells. Other basins with surface withdrawals exceeding 2 billion gal/yr in 2002 included Altamaha, Chattahoochee, Ochlocknee, Oconee, Ogeechee, Satilla, and Savannah.

Groundwater withdrawals within basin boundaries were greatest in the Flint basin where 123 billion gal/yr were withdrawn in 2002. The Ochlocknee, Ocmulgee, Ogeechee, and Suwannee each had groundwater withdrawals exceeding 10 billion gal/yr that year.

Georgia's basins vary in size, so that smaller withdrawals in smaller basins could actually represent a higher proportion of that basins resources. To normalize these, the volumes of water withdrawn per year from all sources were divided by the area of the basin. That value was converted to a basin-wide mean application depth. These varied from 1.97 in./yr for the Ochlocknee basin to less than 0.02 inches in the St. Mary's, Tennessee, and Tallapoosa basins. Other basins with higher basin-wide rates included the Flint, 1.02 in./yr, Suwannee, 0.60 in./yr, Ochmulgee, 0.31 in./yr, and Ogeechee, 0.26 in./yr. These basin-wide application depths can be compared with basin-wide rainfall depths that usually exceed 36 in./yr even in drought years.

A similar computation of withdrawals was made for the politically delineated 24-county Coastal Zone. Annual withdrawals from groundwater sources in that basin were 24, 19, 21, 7 and 16 billion gal/yr for 2000 through 2004, respectively. Additionally, about 4 billion gal/yr was removed from ponds partially refilled by groundwater and 10 billion gal/yr from streams and ponds during the 2000 to 2002 drought years.

Irrigation does not occur uniformly throughout the year. Producers apply water in response to crop needs, and those crops have different growing periods. Irrigation demand is also related to net difference between evapotranspiration and effective rainfall. Patterns of monthly withdrawals were prepared for each region and source, but common to all were peak use periods of May through September. In the Southwest region, little water was applied outside of this peak use area. In the Coastal Zone and Central Coastal Plain, a diversity of vegetables and pastures results in proportionally higher application depths in winter months than seen in the Southwest Georgia region.

Summary

The Agricultural Water Pumping program has provided the state with a comprehensive examination of water application amounts for irrigation by Georgia agricultural producers during the 2000 to 2002 drought, in a recovery year 2003 and a normal year 2004. Irrigation amounts were seen to vary by year, region, water source, irrigation system, and month of the year. Many of these variations were related to the type of crop produced with various systems and water sources. Application volumes for irrigation were large, particularly in Georgia's basins that predominantly lie in the Coastal Plain. However, when those amounts were compared with annual rainfall resources, these withdrawals were quite small.