Agricultural Water Use in the Mississippi Delta

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ABSTRACT

Agricultural water use from the Mississippi River Valley Alluvial Aquifer exceeds long term recharge rates and is resulting in declines of aquifer water levels. Understanding agricultural water use is essential to developing plans to reduce groundwater use to match the long term recharge of the aquifer. This paper reports the amount of ground water pumped on to the major crop types and the irrigation methods of the Mississippi Delta. Water use numbers have been gathered by YMD staff over the past 15 years in an effort to determine annual water use per acre. Major crop types studied include: Cotton, corn, soybeans, rice and catfish. Water used on individual sites is determined by obtaining flow rates for each well in the study, then determining each well's time of operation. By multiplying the flow rate by the time the wells ran, the amount of water pumped can be obtained. Field size is determined through the use of aerial photos and site inspection. The total water pumped is then divided by the acres receiving water to get water used per acre. Irrigation methods are recorded for each site. Different irrigation methods observed include pivot, furrow, contour levee, straight levee, straight levee multiple inlets, and zero grade. The per acre water use numbers are shown in three different ways: 1.) Annual water use across all crop types, 2.) Average water use per acre for each crop type, 3) Where it is relevant, water use per crop type by different irrigation methods. In 2006 results showed cotton use an average of .84 acre feet per acre over the course of the growing season. Soybeans used an average of 1.00 acre feet per acre, corn used an average of 1.16 acre feet per acre, catfish used an average of 2.40 acre feet per acre, and rice used an average of 3.34 acre feet per acre. These numbers represent the highest amount water used since 2000.

Keywords: Agriculture, Ground Water, Water Use

Introduction

Agricultural water use from the Mississippi River Valley Alluvial Aquifer currently exceeds long term recharge rates and is resulting in declines in aquifer levels across the Delta. Understanding agricultural groundwater use is essential to the development and implementation of plans aimed at reducing groundwater use to levels matching that of the long term recharge rate of the aquifer. In an effort to better understand irrigation requirements of the different crops of the Delta, YMD conducts a water use survey throughout each growing season. This survey is designed to reveal the amount of groundwater used per acre on Delta crops.

YMD's Annual Water Use Survey was started in 1991 as a means of determining the amount of groundwater used per acre on catfish farms in the Delta. The original survey consisted of twelve sites all of which were located in Humphreys, Leflore, and Tunica counties. The Water Use Survey's focus remained on catfish groundwater use until 1994 at which time it was expanded to encompass rice and row crops as well as catfish.

While the basic goals of the Water Use Survey have remained the same, over the years, data collection and analysis techniques have continually evolved. This evolution has allowed YMD to generate more accurate and useful groundwater use numbers each year. While early surveys included only a minimal number of sites, with a focus on catfish, more recent surveys have grown to include well over 100 sites focusing on all the major crop types of the Delta. Sites now range from the Mississippi River to the West, to Leflore County in the east, south to Yazoo County, North to Tunica County and all areas between. Through this layout, results are influenced less by localized rainfall events and are more representative of the Delta as a whole.

Survey sites are currently broken down and compared based on crop type as well as the irrigation methods used on each site. This analysis reveals the most water efficient methods of irrigating each crop. These groundwater use numbers play a vital role in the planning and implementation of water efficient management practices across the Mississippi Delta. By implementing these practices groundwater withdraws can be reduced to levels more closely matching the recharge rate of the aquifer, thereby cutting our overdraft significantly.

Purpose and Scope

The purpose of this study is to determine the amount of irrigation water applied to the crops grown in the Mississippi Delta and to reveal the most water efficient means of irrigating each crop. Crops included in the study are cotton, corn, soybeans, rice, and catfish. Early groundwater use numbers were divided into three primary categories: Rice, row crops, and catfish, but subsequent groundwater use numbers are divided into the five distinct categories breaking row crops down to cotton, corn, and soybeans.

Along with groundwater applied per crop type, the groundwater applied for each irrigation method under specific crop types is also recorded and compared. Irrigation methods and land contours observed in the study include zero grade, multiple inlet, straight levee, and contour levee irrigation for rice sites. Furrow, straight levee, and contour levee irrigation were used for soybean irrigation. Furrow and pivot irrigation were used for cotton irrigation, and furrow irrigation was used for corn irrigation. Each of the irrigation methods represents different groundwater use characteristics among individual crop types, some of which use more groundwater while others use significantly less.

Methodology

Site Selection

The first step in each survey is site selection. Each year sites are added in an effort to generate more accurate and representative numbers. Typically the survey begins with between 250 and 300 sites, but through equipment failure, supplemental irrigation, or meter removals and changes the number falls to between 100 and 150 by the season's end. Sites are selected at random across the Delta based on three primary factors: Accessibility, availability of a dedicated utility meter, and crop type (when evident).

Sites must be accessible for YMD staff, meaning wells behind lockable gates or across low lying fields are generally kept out of the survey. Also sites close to growers' headquarters are kept to a minimum because YMD's influence on the irrigation practices of those growers is likely to increase as contact with the growers increases. Electric wells are the primary wells observed in this study. This is because their utility meters are a simple and effective way to keep up with their run time. If the electric well lacks a dedicated utility meter it will not be used unless a time totalizer is installed. Due to totalizer failure this is not a viable option for the majority of survey sites. Lastly crop type may be used in site selection late in the planting season in order to elevate numbers of a certain crop that may have been of a smaller sample size compared to the other crops.

Runtime Measures

Once sites have been selected, an initial reading is taken from either the utility meter running the pumping mechanism of the well, or a time totalizer installed by YMD staff before the irrigation season begins. After the initial reading, readings are taken at the end of every month throughout the growing season in order to get a monthly groundwater use number. A final reading is then taken at the end of the season in order to get the total kilowatts used on the electric wells and the total hours of operation displayed on the time totalizers.

Kilowatts used per hour are figured during the growing season while the well is running. This figure is obtained by taking a reading while the well is running and recording this number down to the smallest practical unit of measure (hour/minute/seconds), then returning between 3 and 24 hours later to record a second measurement. The number of units used can then be divided by the elapsed time to give kilowatt usage per hour. This figure can then be used to figure hours of operation by dividing total kilowatts used by the kilowatts used per hour by the well. The time totalizers are mounted on diesel wells or electric wells lacking a dedicated utility meter. These devices calculate the total hours of operation by monitoring vibrations made while the wells are operating. The hours are then displayed on a LED screen negating the need for any further calculation in order to obtain total hours of operation.

Flow Rates

The flow rate of each well is measured during the growing season; this is done through the use of an ultrasonic flow meter. Flow meter sensors are attached to the outside of the pipe wall and use ultra sonic waves along with manually entered pipe parameters in order to calculate flow. Flow rates are recorded in gallons per minute and later are converted to gallons per hour to be used in groundwater use calculations. The ultrasonic flow meter is noninvasive meaning it is mounted to the outside of the pipe wall and does not inhibit flow in any way. The gallons pumped per hour can then be multiplied by the hours of operation to get the gallons pumped from the well. A Cross-Correlation flow meter was used for the 1991 and select sites for the 1992 survey. However ultra sonic flow meters were used to determine how many gallons per minute each groundwater well pumped from the 1992 survey until the present. Ultrasonic models used include a Tyme-Flyte portable flow meter, a Controlotron 1010 portable flow meter, and most recently a Fuji Ultrasonic Portaflow flow meter.

Acreage Calculation

Acreage receiving the water can be determined through three primary methods: Through the use of YMD's GIS database, physical land inspection, or through grower consultation. Most common is a combination of the GIS database information accompanied by physical inspection. Growers are only contacted if riser placement is ambiguous or supplementary irrigation from a surface water source or other groundwater well look likely. Gallons pumped are then divided by irrigated acres in order to get the gallons used per acre. This number is then divided by 325,900 to get the acre feet used per acre on each site. The per acre groundwater use numbers are displayed in three different ways: 1.) Annual average groundwater used across all crop types studied, 2.) Average groundwater used for each crop type studied, 3.) Where it is relevant, groundwater used per crop type by different irrigation methods.

Equations

Utility Meter Method

1. Flow Rate (GPM) X 60= Gallons Per Hour (GPH)
2. Total utility meter units / Utility meter rate (unit/unit per hour) = Total Hours of Operation
3. Total Hours of Operation x GPH= Total Gallons Used
4. Total Gallons Used / Acres Irrigated = Gallons Per Acre (GPA)
5. GPA / 325,900 (gallons per acre foot) = Total Acre Feet of Water Used Per Acre

Time Totalizer Method

1. Flow Rate (GPM) X 60= Gallons Per Hour (GPH)
2. Total Hours of Operation x GPH= Total Gallons Used
3. Total Gallons Used / Acres Irrigated = Gallons Per Acre (GPA)
4. GPA / 325,900 (gallons per acre foot) = Total Acre Feet of Water Used Per Acre

Table 1. Average acre feet of groundwater applied per acre per crop type.

Year	Catfish	Row Crops	Rice	Cotton	Corn	Soybeans	Yearly Average
1991	2.1						2.1
1992	1.8						1.8
1993	2.1						2.1
1994		1.0	3.0				2.0
1995		1.1	3.5				2.3
1996		0.7	2.5				1.6
1997		1.0	3.0				2.0
1998		1.1	3.5				2.3
1999		1.0	3.3	0.6	0.9	1.4	1.6
2000		1.2	3.6	0.7	1.2	1.6	1.8
2001							
2002		0.7	3.1	0.5	0.9	0.7	1.3
2003		0.6	2.7	0.5	0.6	0.6	1.1
2004	1.5	0.4	2.5	0.3	0.4	0.4	0.9
2005		0.7	3.0	0.5	1.0	0.6	1.3
2006	2.4	1.0	3.3	0.8	1.2	1.0	1.6
Average	2.0	0.9	3.1	0.6	0.9	0.9	1.4

Results

Yearly groundwater application (use) averages for individual crop types ranged from a high of 3.6 acre-feet per acre for rice during the 2000 growing season to a low of 0.3 acre feet per acre for cotton during the 2004 growing season. Average groundwater applied per crop type across all of the years included in the survey ranged from 3.1 acre feet per acre in rice to 0.6 acre feet per acre in cotton (Table 1).

Irrigation method analysis revealed that pivot irrigation was the most water efficient way to irrigate cotton, straight levee flooding was the most water efficient way to irrigate soybeans, and zero grade irrigation was the most water efficient means to irrigate rice (table 2). The differences in row crop irrigation practices show less of an impact on their irrigation groundwater use characteristics than do the differences in rice irrigation. The 2006 survey highlighted the fact that a well managed multiple inlet site can approach the water efficiency of a zero grade field without the problems associated with zero grade land forming.

The 2006 Water Use Survey compared the groundwater use of catfish farmers receiving EQIP funds to practice the 6/3 method of water conservation with the groundwater use of farms not receiving funding. It was found that the groundwater use of both parties was nearly identical. Better educated farmers along with skyrocketing energy costs are thought to be the key reasons for the water use similarities. EQIP farms applied an average of 2.5 acre feet per acre, while farms not receiving EQIP funds applied 2.2 acre feet of groundwater per acre (table 3). It should also be noted that there were only seven sample sites compared in catfish water use, and numbers could have been influenced by localized rain events.

Differences in the irrigation groundwater use of individual row crops in the Delta have been shown to remain similar regardless of irrigation method. Rice, however, has shown

Table 2. Average acre feet applied per acre for different irrigation methods 2004-2006.

	Furrow	Pivot	Contour	Straight Levee	Multiple Inlet	Zero Grade
Cotton	0.7	0.5				
Corn						
Soybeans	0.9		0.9	0.8		
Rice			3.8	3.1	2.3	1.6

greater irrigation groundwater use differences among the irrigation methods used. Therefore, the widespread implementation of more water efficient irrigation practices in rice production represents a promising opportunity to generate groundwater savings. Savings of only one acre foot per acre in rice irrigation could save the aquifer nearly 250,000 acre feet of water per year. This savings would approach the average overdraft and help to bring groundwater withdrawals closer to the recharge rate of the aquifer.

Table 3. Catfish average acre feet applied per acre 2006.

EQIP	Non-EQIP
2.5	2.2