ASSESSING AGRICULTURAL GROUNDWATER NEEDS FOR THE FUTURE: IDENTIFYING IRRIGATED AREA AND SOURCES

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Abstract. State water plans require an assessment of agricultural water demand with enough specificity that regional water planners can anticipate when, where and how much will be needed to support irrigation. Planning for withdrawals with this level of detail begins with an assessment of current withdrawals. While several efforts have been made to identify irrigated areas, each has fallen short of defining a comprehensive map. Widely conflicting estimates and maps have created uncertainty and mistrust. As part of Georgia Environmental Protection Division-led efforts to conduct assessments of water use for regional planning groups, we sought to pull together results from past efforts into a common irrigation area baseline. Additionally, using 2007 aerial imagery, we have identified additional irrigation systems that were not included on either record set. Each irrigated area was connected with a water source allowing determination proportion of withdrawals from surface and groundwater supplies by watershed and county. The comprehensive mapping shows Georgia farmers currently irrigate about 1,400,000 acres of land, mostly in the Coastal Plains.

BACKGROUND AND PROBLEM

Taken collectively, agriculture water use in Georgia is estimated to equal or exceed municipal and commercial water use or total industrial water use (Hutson et al., 2004). In rural areas where irrigation supports production of food, feed, and fiber crops, irrigated fields dominate the landscape (Fig 1.). Seasonal withdrawals of both ground and surface water exceed all other human uses. Regional water planners need to anticipate when during the year that water will be needed, what water sources will be used, and how much water will likely be withdrawn. For this level of detail agricultural water use assessment must begin with accurate records of current withdrawals. The purpose of this study was to identify all active agricultural irrigation fields and determine their water source.

The Georgia Environmental Protection Division (EPD), and what is now its Agricultural Permitting Unit, have been responsible for permitting agricultural withdrawals since 1988. While applications for permits have require location information, no resources were available to verify those locations or to accurately pinpoint them on high resolution maps. During the 1988 to 1991 'grandfathered' period, more than 17,000 applications were received for existing agricultural uses – more than all other water permits issued to date. These requests, nearly all of which received permits, make up 80% of currently permitted withdrawals.

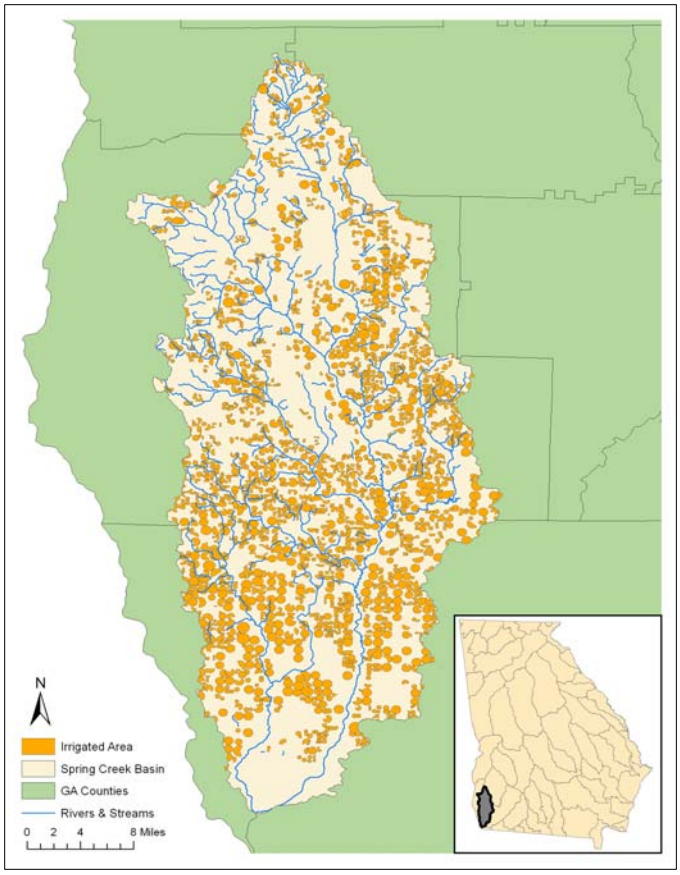

Figure 1. Delineated, irrigated field areas in the Spring Creek sub-basin in Southwest Georgia.

Applications also required an estimate of irrigated field area supplied by the permitted source. They do not specify the location of those irrigated areas. The area of the irrigation is placed as a condition on the permit, but

irrigated field areas have always been viewed as flexible by farmers. Over the years since permits were issued, farmers have eliminated sources, replaced original pumps, moved or replaced irrigation systems and reconfigured irrigated fields as sound management decisions within their farm businesses. All of these changes are viewed as allowed under their existing permits. Thus at best, this leaves EPD with a record that is never up to date. Permit records report how many permits were issued for various sources and counties, what pumping rate were allowed for each source, and an estimate of area that could be irrigated.

Since permit records cannot accurately reflect irrigation area or amount of withdrawal, EPD has commissioned a number of studies to capture a point-in-time snapshot of existing irrigation. One of the first of these was actually done before permitting was initiated. In 1980, the Georgia Geologic Survey worked to locate each well that was being used for irrigation (William McLemore, former State Geologist, personal communication). Along with the well data and its location, they gathered information on the irrigation system itself – location, wetted area, type, even brand. A map was prepared, but it has never been digitized.

During the data gathering period for the ACT-ACF Interstate Compacts, i.e. the Comprehensive Study, estimates of irrigated area were collected from the three states for watersheds of the compact. These were derived from statistical, not mapped sources (USDA-SCS, 1994). Following initial Compact discussions, EPD sought an independent survey of irrigated area from the Georgia Center for Remote Sensing and Mapping Science (Litts et al., 2001). The University of Georgia research group used GIS techniques with USGS digital orthoquad images, images that they had to digitize from raw photogrammetric images. Pivot circles were generally discernable in the images, but temporary irrigation (travelers, big guns) and drip irrigation were not. Their work used the tedious techniques of visual examination of images while mapping irrigated fields into separate data layer. (Blood et al., 1999). For the less visible irrigation systems Litts and his colleagues used estimates of non-pivot acres in each county based on input from several expert sources (Litts et al., 2001). That ACF River Basin study set that resulted became one of the first GIS-based data layers for irrigated areas in the state.

While the aerial image-based mapping identified wetted areas, at least those irrigated by pivots, it provided little information on water sources used or connections of those fields to their permitted sources. During 1999 and 2000, Hook and Blood (2001) were contracted to locate all permitted withdrawals in the 17-counties of the lower Flint River Basin. Cooperative Extension Agents contacted permit holders individually and asked them to meet with a team of GIS specialists who would map the permitted surface pump and well locations, and the fields that were currently or that had been irrigated from those sources. Response to the voluntary participation was overwhelming, and over 90% of permits were mapped in the Lower Flint Basin. Participants were provided with maps confirming the location of their sources and fields now registered with the agricultural permit data base (Hook, et al., 2003).

Lower Flint mapped permits included areas where irrigation had been discontinued for one reason or another. It also included fields that were irrigation in a multi-year rotation, but not every year. As such, permit mapping over-estimated the area that would receive water in any given year. It did, however, allow withdrawal locations and types to be connected with the fields they supplied. Through the direct contact with users, this approach gave EPD insight to the complexities of modern irrigation as practiced in Georgia. Often more than one field was supplied by a single well or pump. In other cases more than one pump or well was used to supply water to a single irrigated field. Still other cases had several sources providing backup supplies for each of several fields. Rotation of crops among fields and irrigation systems, splitting single pivot fields into several crop areas, sequential cropping of a field for spring and fall crops, and changing land ownership were all common among the 7000 mapped permits.

The GIS-based permit mapping system became the geographic management tool for EPD agricultural permitting following that contract. EPD added irrigated fields and sources in the Middle and Upper Flint as it prepared for the 2001 and 2002 implementations of the Flint River Drought Protection Act. EPD needed to verify the permitted activity of existing permit holders before they could allow participation. In addition to this area EPD assisted various counties with 'mapping days' where permit holders could map their irrigation systems and receive permit assistance. Water planning also prompted EPD efforts in separate efforts to map in the 24-county Coastal Zone and surrounding counties. EPD's Geologic Survey employees built upon McLemore's records, identifying wells and fields on paper orthoquad sheets. Depending upon accessibility of fields and pumps, farmers were not always involved in identifying these permitted sources used in Coastal Zone planning. Eventually most of these sources and fields made their way into EPD's GIS-based permit management system.

During 2006, EPD reorganized the units responsible for managing agricultural permits and formed the Agricultural Permitting Unit which they moved to offices in Tifton. At that time, EPD was implementing the Flint River Basin Water Conservation and Development Plan (EPD, 2006b) and the Coastal Georgia Water and Wastewater Permitting Plan (EPD, 2006a), both of which were adopted in 2006. At that time there were more than 3000 agricultural withdrawal permits pending. Terms of those

plans called for selective location permitting. It became essential that locations of all proposed wells and surface water pumps be closely identified before evaluation of the application could proceed (Hook et al., 2007). The GIS-based permit system was fully implemented with pending applications added along with known existing pumps and wells. A geodatabase and geoprocessing tools were put in place to assist hydrologists and geologists charged with evaluating permits (Alfonso, 2006). Follow-up field visits were made and GPS tools used to accurately determine installed locations before permits were issued.

While the GIS system enabled accurate mapping of new withdrawals, the thousands of withdrawals installed prior to 2005 were not well defined. Further, because EPD permits still do not specify where or how water is to be used, their ability to record or track irrigated area was still limited. That task remained an essential part of the water use planning, but passage of the Agricultural Water Metering law in 2003 created a means for the state to gather measured data on most farm water users. All permitted surface and groundwater withdrawals used for irrigation were required to be metered by July 2009. The Georgia Soil and Water Conservation Commission (SWCC) was given the charge of locating those and installing water flow meters on existing systems. For newly permitted withdrawals (applications made after July, 2003), the farmers were responsible for the installation, but SWCC would be responsible for reading and maintaining the meters.

The task of actually locating the tens of thousands of permits proved daunting. In areas where some mapping had been done – Flint River Basin and Coastal counties – SWCC started with those mapped permit locations. Many proved inaccurately located; even more permitted sites were inactive or only occasionally used with portable pumps. Communications with permit holders proved difficult. Most counties had implemented E-911 addressing since permits were issued, land had changed ownership, rented lands had distant or uninvolved owners, and with conversion to mobile phones even phone records in EPD permit records were inaccurate. Still SWCC located many of the existing systems, installed meters, and used GIS to document where they installed them. Subsequently they contracted with the Flint River Water Planning and Policy Center at Albany State University (ASU) to revisit the metered sites and actually map the wetted areas of the irrigation systems that were metered. They also recorded locations of wells and pumps connected with metered irrigation. With irrigated area and total volumes as recorded by water meters, SWCC could estimate farmers water application depths, data that would be needed in any regional water plan. Unfortunately, personnel mapping fields after meters were installed did not have access to permit information, so cross-checking permitted, and sometimes mapped, irrigation between SWCC and EPD records became a challenge. Each agency reported different irrigated area estimates.

To eliminate some of the communication problems with farmers and pre-screen sites for meter installation, in 2007 and 2008 SWCC contracted Albany State University and The University of Georgia to update EPD's permit records. The effort focused on 52 Coastal Plain counties where SWCC meter installation was not already completed or underway. UGA's Cooperative Extension Service agents in those counties communicated or attempted to communicate with all farmers and land owners who held EPD permits. Where some previous mapping or application location records were in EPD files, those maps were added to permit information sheets. Farmers and agents confirmed those mapped locations or used GoogleEarth® tools to locate and record the coordinates of the permitted pumps and wells. They also updated contact information and recorded activity status.

Subsequently, ASU field mapping personnel visited the updated locations provided by farmers and agents, and recorded GPS coordinates as confirmation. Actively irrigated field areas were likewise delineated by GPS, and GIS specialists at Flint River Water Planning and Policy Center created comprehensive coverage as well as individual images for each permitted system to guide SWCC meter installations. The two stage mapping effort identified many duplicate permits (two permits for the same withdrawal), as well as those that had never been installed. In the counties of this mapping effort, a large percentage (up to 30%) of permitted sites were no longer in use. Farmers could chose to terminate their use of those permits, or, under Georgia law, retain them for future use. In the latter case, the locations of the inactive permitted withdrawals were mapped for future use. Each permit is valid only for the location permitted.

METHODOLOGY AND RESULTS

Because EPD primarily mapped locations of permitted withdrawals and SWCC mapped sites where meters were installed, there were two overlapping irrigation maps. As we quickly recognized, there were many irrigation systems that did not appear on either map. Thus, we created a comprehensive coverage of irrigated field areas from the two overlapping coverages. SWCC's mapping of metered sites plus its mapping of sites to be metered contained the most accurate data on existing irrigated fields. That is, for any site that was drawn, an accurate perimeter was created of the system as present at the time of mapping in 2007 and 2008. The use of GPS, and overlaying it on modern NIAP aerial imagery created confidence in these mapped areas. A few hundred mapped fields required redrawing because of errors in drawing GPS maps or because irrigation equipment had been modified since

field mapping one to three years earlier. Since pivots were mapped by hardware length, some adjustment were needed to get the full wetted areas since 99% of existing pivots have end guns that spray water 50 to 100 ft beyond the outer circumference created by the end of the pipe. We added 10% area as and average based on the geometry of systems that extend 75 ft from a 100 acre pivot circle. In total 13,700 mapped irrigated fields in the SWCC records total 856,000 acres. These included 10,450 center pivots that irrigated 725,000 acres.

As we overlaid the SWCC mapped and metered fields on NIAP images for 2006 and 2007, we noticed that numerous irrigated areas, as evidenced by visible pivot hardware, plastic mulch, or orchard and nursery rows were not included yet in the SWCC irrigated maps. In addition, SWCC had not yet mapped irrigation in the 75 counties of North Georgia. Although agricultural irrigation in the latter is sparsely scattered among the areas, it is needed for comprehensive projections of water use.

When we overlaid the EPD mapped areas we found that many of these remaining pivots were included in their maps, or the point records for withdrawals fell within those suspected irrigation systems. To create a single coverage, we first selected and then removed all EPD-mapped irrigated areas whose centroids fell within a SWCC mapped irrigated area. The process accepted all SWCC map areas as accurate, but it added EPD identified areas not included on SWCC maps. As with SWCC mapped fields, changes since the original mapping, some initiated as early as 2000, were evident. Farmers had converted traveler-irrigated fields to center pivots. Other irrigated areas were abandoned. We corrected all EPD shapes to reflect the current irrigation field configuration and area.. At that point there were 8,900 fields remaining in the EDP data laid that added 370,000 acres to the state's total. Center pivots (2,410 un-metered systems) covered 152,000 acres of that land.

Even with addition of EPD records, high resolution NIAP imagery revealed that many center pivots and other obvious irrigated areas remained. As a result, we undertook an extensive visual examination of every area in all 159 counties looking for signs of agricultural irrigation, mostly center pivot and linear hardware and tire tracks from them. In the 2007 imagery, pivot pipes and tires, as well as pump well heads and other signs of irrigation are visible. In many cases EPD permitted withdrawal records showed a well in the center of a previously unmapped pivot or a pump on a nearby pond that was not yet assigned to an irrigated field. We drew in previously unmapped systems, pecan and peach orchards, blueberry and grape fields, drip irrigated fields, plant nurseries, and other visible irrigated fields. In all, this painstaking process identified 4,700 previously unmapped irrigated areas covering a combined center pivots. Together they had a combined area of 224,000 acres. There were almost 3,000 previously unmapped, and presumably un-metered center pivots covering 150,000 acres of that land. Drip systems were found in another 620 mapped areas.

After adding the 10% overthrow area to SWCC and our mapped pivots, our total of mapped agricultural irrigation currently stands at 1,450,000 acres. Some cross checking and verification remains to be done. Some areas identified as irrigated by EPD mapping have been confirmed as inactive in later field assessments by ASU. Some orchards, drip fields, may have been overlooked in all efforts since presence of irrigation can only be confirmed on the ground. Likewise many fields that may have a portable irrigation set up periodically might be in use in some dry years but not average or wet years. Finally verification must confirm if EPD and SWCC have assigned the same permits for the same withdrawal points and associated fields.

Since most installed irrigation in Georgia is done with systems that have a 20 to 30 year lifespan, these areas represent the most likely areas for future irrigation withdrawals. For planning purposed we broke the data into counties and into sub-watersheds. Within each, predominant irrigated soils and irrigation sources were identified. Onto this baseline, future cropping patterns and probable irrigation amounts were projected for agricultural water demand forecasts of the State Water Plan. The data is now under review by EPD.

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