MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 10-2015 (YEAR 2)
2015 Annual Report

Title: Costs and Benefits of On-Farm Water Storage Systems (OFWS)

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Co-PIs: Joel O. Paz and Brian Williams

Objective 1: Perform a cost-benefit analysis of implementing OFWS systems

An Agricultural Economics master's student was recruited to work on this project, and he began working in August 2015. Co-PI Dr. Brian Williams has been analyzing needed datasets and determining what data can be obtained from the literature or county averages (estimated yields for irrigated vs. non-irrigated) vs. what data should be obtained from the local site (cost of constructing pond).

Cost for construction of the OFWS system storage pond and establishment of the irrigation system at the Noxubee County study area were acquired. As the entire field is not irrigated, the yield difference between irrigated and non-irrigated acres after the establishment of the OFWS system was also acquired (Fig. 1). These data are being utilized to perform a cost-benefit analysis of implementing OFWS systems.

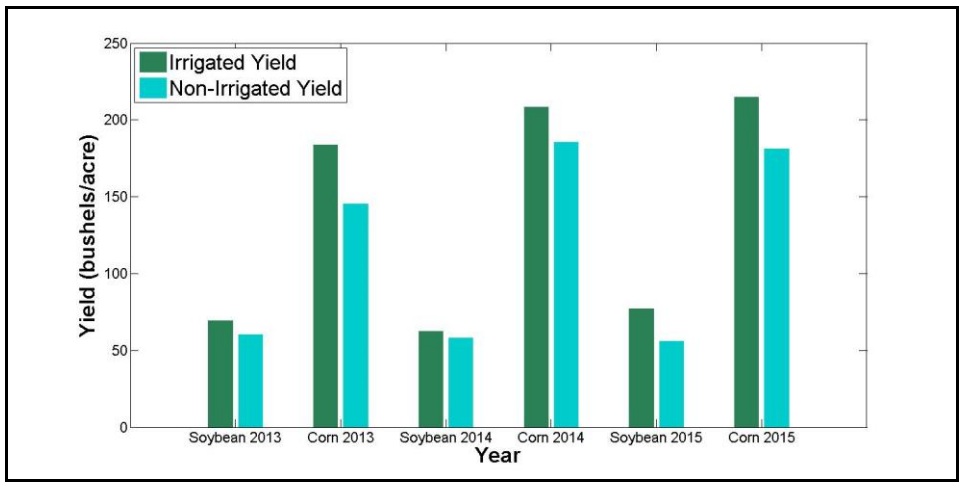


Figure 1: Average yield between irrigated and non-irrgated acres in the research field.

Dr. Williams has constructed preliminary budgets in which cost, yield, and other data can be easily input. Additional budgets have been constructed for a corn/soybean crop rotation, and net present values have been calculated under various price scenarios. Additional analysis is in progress. Preliminary results suggest that at soybean prices below $13.50/bu, an on-farm water storage system will not pay for itself (Figure 2.). However, several assumptions were made to reach those results, and we are currently working on relaxing some of those assumptions and incorporating year-to-year price and yield variability into the analysis.

Price, county yield, and weather data have also been gathered to be used in the analysis. The next step will be to determine any additional data that are needed and to begin working on the model.

Future plans include looking at various cost scenarios, scenarios involving weather and yield risk, and additional price scenarios.

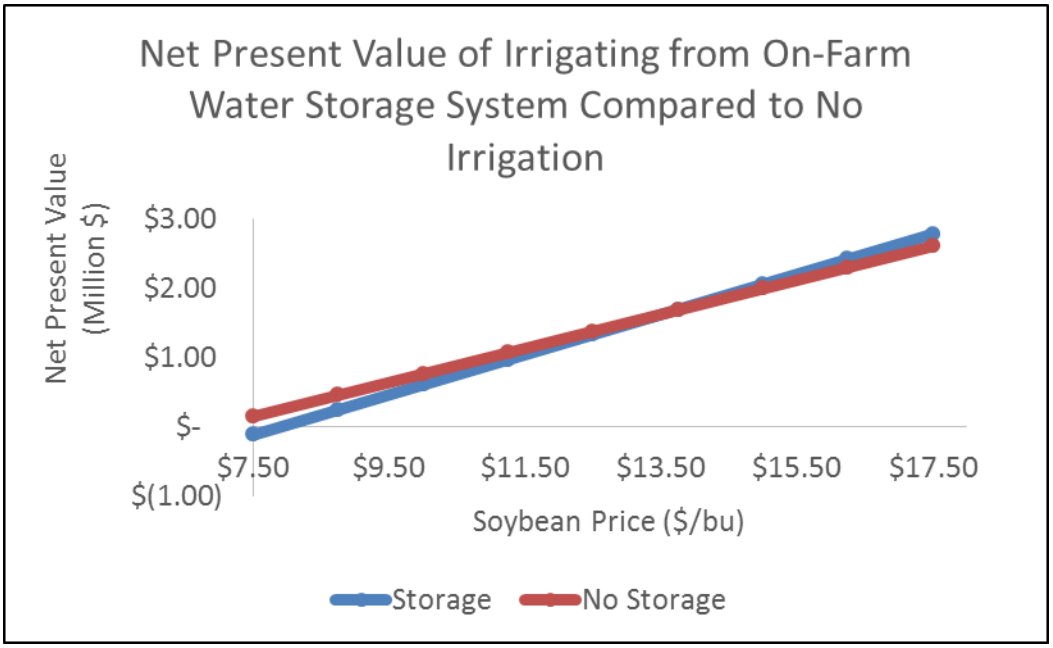


Figure 2. Net present value of OFWS system to compared to no irrigation for soybeans.

Dr. Williams plans an extension fact sheet as a result of this objective. The fact sheet would give what-if scenarios with different yield and price estimates in a table, such as "If you can construct an on-farm water storage system for less than $XX and improve yields by Z bu/acre, the system should pay for itself in Y years." In addition, a Master's Thesis proposal, including a complete literature review, will be finished and defended by the end of May 2017 and will focus on how on-farm water storage can be used to manage risk.

Objective 2: Quantify the nutrient load in recycled water that is reapplied to the crop

A Rugged Troll 100 depth sensor was deployed in the OFWS storage pond to record water level change throughout the growing season. A YSI 6600 V2-2 sonde was used to take and record various in situ measurements in the pond at 15-minute time intervals. The YSI water quality sonde was removed in late fall 2015 when the water level in the pond dropped significantly.

Copper screens were ordered for the probes on the sonde and were applied to prevent fouling, and the sonde was re-deployed after the water level began to rise again during the winter. Weather data are also being continuously collected from the Watchdog 2900 ET for analyzing environmental conditions. Grab samples are continuously being collected every 3 weeks during the growing season and every 6 weeks during the off-season from the Brooksville site and the two Delta sites. Samples are analyzed for total and reactive phosphorus (TP), nitrate (NO_3), ammonia (NH_3), total nitrogen (TN), TSS, Total Kjeldahl Nitrogen, and dissolved orthophosphate concentrations.

An ISCO automated water sampler was also installed at the site to collect samples from storm runoff events. Samples were collected from the first runoff event following the fall fertilizer application after harvest of the 2015 growing season. Nitrate concentrations in the captured

runoff were as high as 179 mg/L, and the highest recorded dissolved orthophosphate concentration was 0.690 mg/L (Figures 3 and 4). Additional runoff events were captured during the off-season of 2015 – 2016 to analyze the nutrient concentration in the rainfall events captured by the OFWS system pond. Monitoring data over two off-seasons indicate that these systems can be effective in reducing downstream nutrient and sediment loading as demonstrated by the nutrient and sediment concentrations in the captured runoff events.

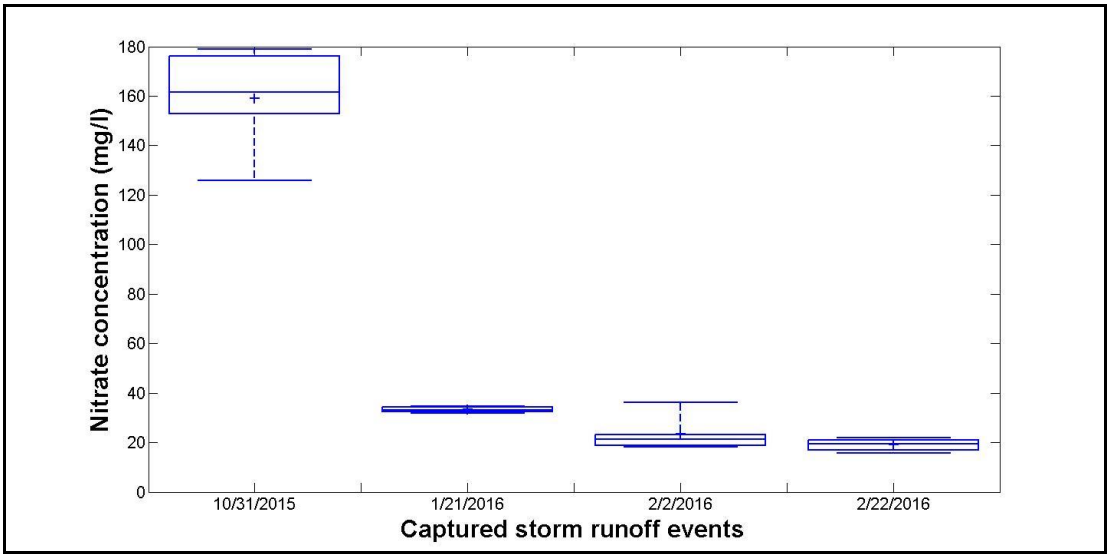


Figure 3: Nitrate concentration in storm runoff events captured in fall 2015 – spring 2016 non-growing season.

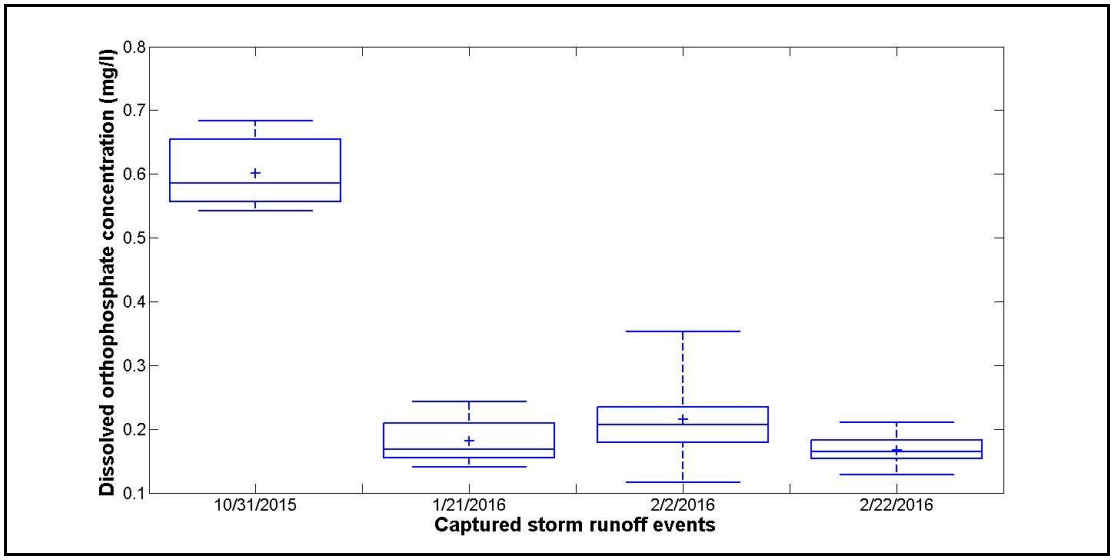


Figure 4: Orthophosphate concentrations in storn runoff events captured in fall 2015 – spring 2016 non-growing season.

Water samples were also collected directly from the center pivot during irrigation and analyzed for the aforementioned nutrient constituents to get better estimates of nutrients being recycled after the application of OFWS storage water. Grab samples from the OFWS storage pond were collected concurrently to look at variations between the two samples. Analysis of the center pivot

sample showed that the water being applied for irrigation has a lower nitrate and a higher ammonium concentration than the grab sample collected from the pond (Figure 5).

It was also observed that the nutrient concentration in the water applied for irrigation varied with each event. This finding could be significant in that the grab sample of the pond may not provide a true representation of the nutrient load that is recycled to the field through the OFWS system. It is important to note that grab samples are taken from near the surface of the pond, whereas the water intake for the center pivot is located near the bottom of the pond. Soil sampling was also conducted at the Brooksville site to analyze soil nitrate and phosphorus conditions before the growing season. Soil sampling was again conducted after irrigation events at selected sampling points to analyze potential nutritional change in soil after the application of OFWS storage water.

The total watershed area that contributes runoff water to the OFWS storage pond was identified. This was used in the Annualized Agricultural Non-Point Source Pollution Loading Model (AnnAGNPS), a non-point source pollution model, to help evaluate the effectiveness of OFWS systems. Flow data, weather data, and TSS concentration data collected over the monitoring period were used to model the research field using AnnAGNPS. The model was validated for runoff and sediment loading from the agricultural field. The validated model estimated that the OFWS system was able to capture 53.3 tons of sediment in 2014 and 2015 and prevent it from going downstream. The model is currently being calibrated and validated for total nitrogen (TN) and total and reactive phosphorous (TP) to estimate the amount of nutrients captured by the system.

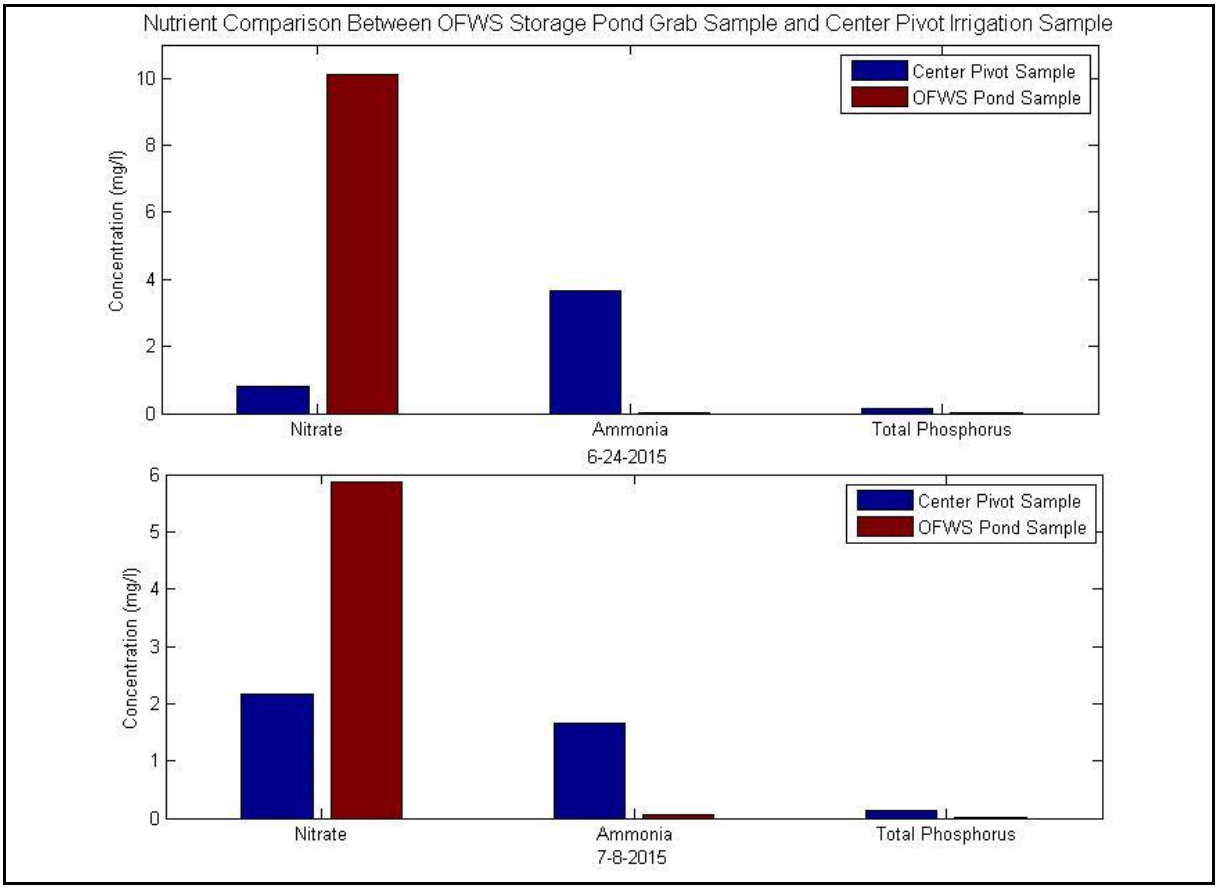


Figure 5. Nutrient concentrations from pond grab samples as compared to samples from center pivot.

Objective 3: Quantify surface water supplied by OFWS under various scenarios

Three Lindsey Growsmart IM3000 magnetic flow meters were installed at the Brooksville site before the 2015 growing season on the three pivots being supplied by the OFWS pond. The magnetic flow meters record the volume of water used from the OFWS storage pond throughout the growing season. The Flownet software allows us to monitor irrigation events remotely, enabling better timing for water and soil sampling.

Water use data from the flowmeters during the 2015 growing season have shown that 1,239.53 acre-inches (33,658,655 gallons) of water was used from the OFWS storage pond for irrigation (Figure 6). The AnnAGNPS agricultural watershed model will be used to analyze the capacity of the OFWS system to provide water for irrigation under different scenarios. The three flow meters on the center pivots will continue to be monitored.

The two Delta OFWS systems are also being monitored. Readings are regularly taken for the flowmeters on the pumps pumping water from the OFWS pond, as well as on the flowmeters on the groundwater wells at both sites. Water use for the two Delta OFWS systems can be seen in Figure 7.

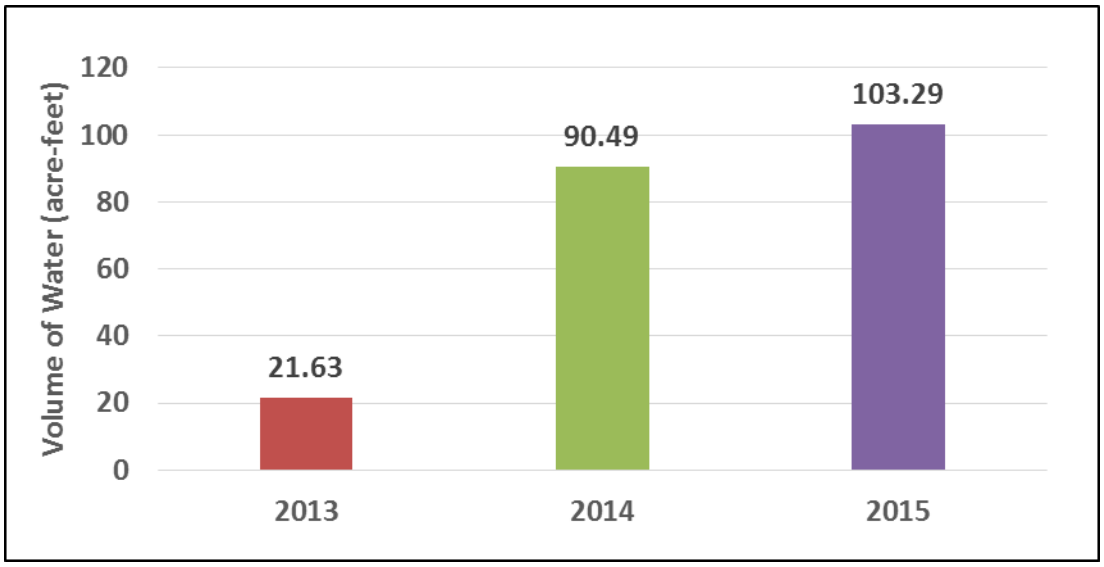


Figure 6. Surface water supplied by an OFWS system in East MS, under pivot irrigation and as the sole water supply for irrigation.

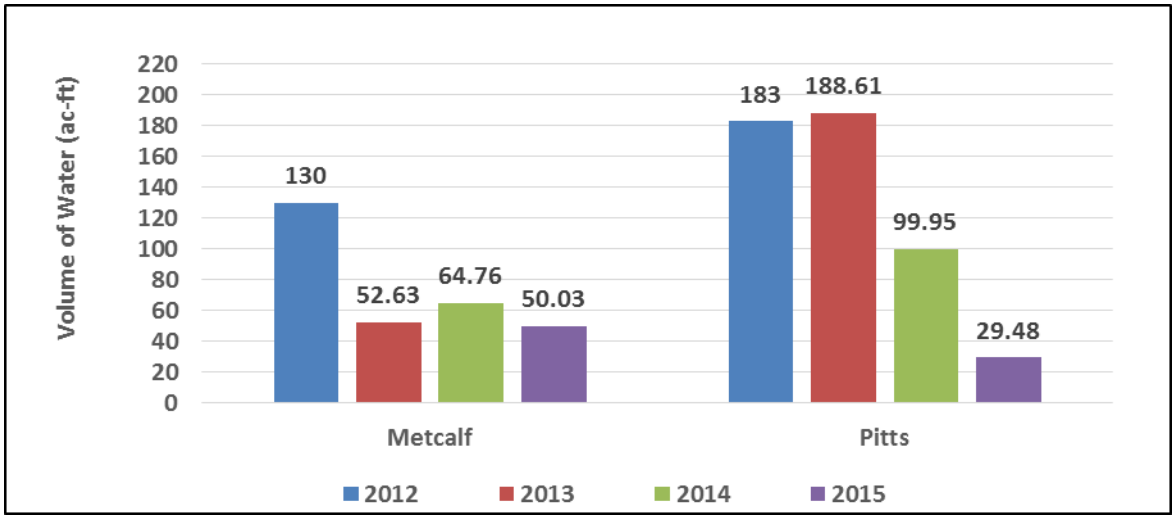


Figure 7. Surface water supplied by two OFWS systems in the MS Delta, under furrow irrigation, in conjunction with groundwater.

Objective 4: Share project results with various stakeholder groups and at specific meetings

This year's outreach activities began with a presentation by M.S. student Ritesh Karki at the 2015 Mississippi Water Resources Project, held in Jackson, MS on April 7-8. Next, this project was featured on the June 24th Summer Agronomy Tour organized by the MS Chapter of the American Society of Agronomy and included a tour of the Brooksville site and a brief description of the project.

A poster was presented on site, and copies (attached) were distributed to participants. A presentation was made and a conference paper was submitted to the 2015 American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting held in New Orleans, LA, from July 26-29. A poster and an oral presentation were also given on the results of the project at the 2015 AWRA Annual Conference in Denver, CO on November 16-19.

We had the opportunity to share information about the project with four Cochran Fellows visiting Mississippi from Bosnia Herzegovina in August 2015. An invited presentation was made by Dr. Tagert at the 19th Annual National Conservation Systems Cotton and Rice Conference and the Delta States Irrigation Conference, which was held on January 12-14, 2016 in Memphis, TN. In addition, an abstract has been accepted to present research findings from the project at the ASABE 2016 Annual International Meeting to be held in Orlando, FL from July 17-20, 2016. Ritesh Karki is writing his M.S. thesis and is expected to graduate in August 2016. Finally, a manuscript is in preparation to be submitted to a peer-reviewed journal, and a minimum of one or two Extension bulletins are planned.

Assessment of On-Farm Water Storage (OFWS) Systems as a BMP for Sustainable Irrigation and Nutrient Loading Control from Agricultural Fields

Ritesh Karki, Mary Love M. Tagert, Joel O. Paz, and Brian Williams

Introduction

Research has demonstrated the importance of supplemental irrigation in increasing crop productivity and yields. In East Mississippi, accessing groundwater is expensive and impractical in most areas, leaving surface water as the only viable option. Mississippi receives an average 56 inches of rainfall annually, but roughly 70% of it is received during the winter and spring months. In addition, there are water quality impairments from nutrient and sediment loading in the Middle Tombigbee Watershed in East Mississippi (http://www.deq.state.ms.us/mdeq.nsf/page/TWB_tombigbeestatrep?OpenDocument).

What is an OFWS System?

An On-Farm Water Storage (OFWS) system is a planned irrigation system that allows producers to collect nutrient rich irrigation tail water and storm runoff for storage in an onsite reservoir and reuse for irrigation. Systems in the Delta typically consist of fields that are padded and piped and drain runoff to a tail water recovery (TWR) ditch, where water is then pumped to a shallow storage reservoir. In East MS, ponds are typically deeper and are filled with storm runoff, which is often guided to the pond by terraces. There is less tail water runoff from sprinkler-irrigated fields in East MS.

Objectives

1. Quantify surface water provided by the OFWS system for irrigation.
2. Determine the effectiveness of OFWS systems as a source for irrigation in East Mississippi.
3. Quantify nutrient loading reduction from agricultural watersheds by OFWS systems.
4. Quantify nutrient load in recycled irrigation water from OFWS systems.
5. Perform a cost:benefit analysis of OFWS systems (Dr. Brian Williams).

Study Area

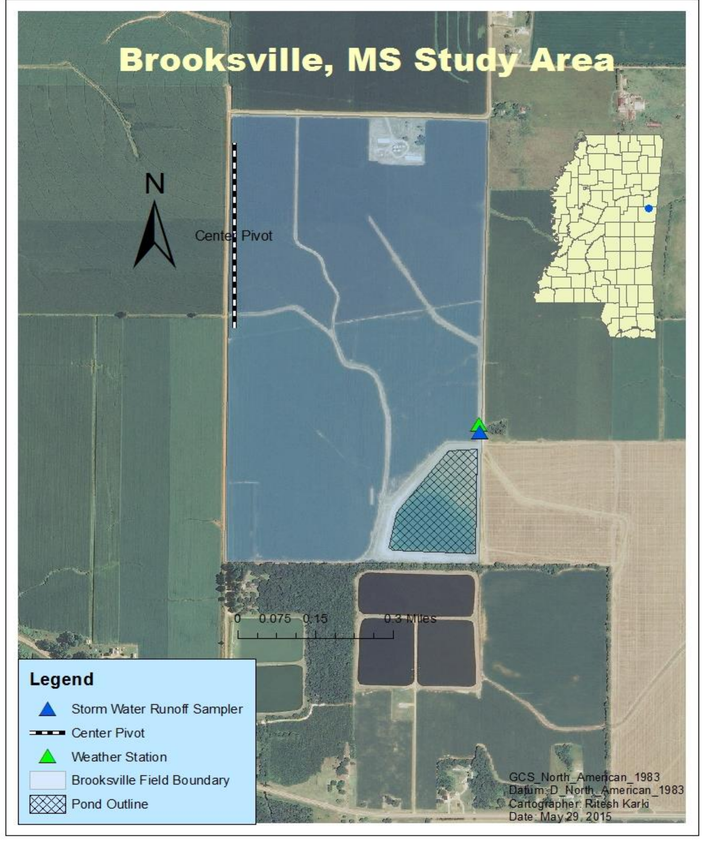


Figure : Brooksville, MS Study Area

The irrigated field is about 249 acres, and is located in the Middle Tombigbee – Lubbub Watershed (HUC 03160106). An OFWS system with a storage pond of approximately 17 acres and 25 feet in depth was constructed in 2012.

Methodology

Grab Samples:

Grab samples are being collected every 21 days from the pond. In-situ measurements for temperature, dissolved oxygen, and conductivity are taken using an ORION STAR A329 portable multiparameter probe, and samples are transferred to the lab for further analysis.

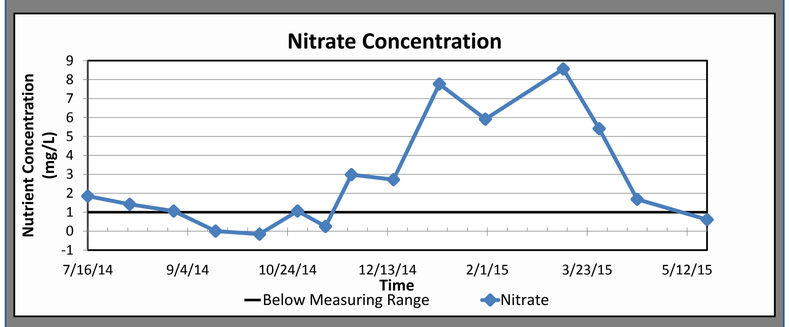
Storm Runoff Samples:

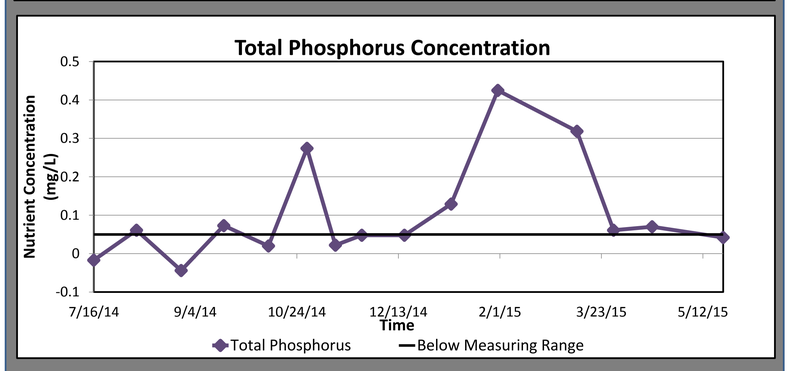
Collection of storm runoff samples is event-based using the ISCO 6712 portable sampler. The sampler collects water samples every half an hour and is triggered based on the flow depth of the channel.

Acknowledgements: We are grateful for the funding provided by the Mississippi Soybean Promotion Board (MSPB). We would like to thank the MSPB, Mr. Paul Good, Mr. Dale Weaver, Dr. Dennis Reginelli, and Mr. Juan D. Pérez-Gutiérrez for their support in this research.

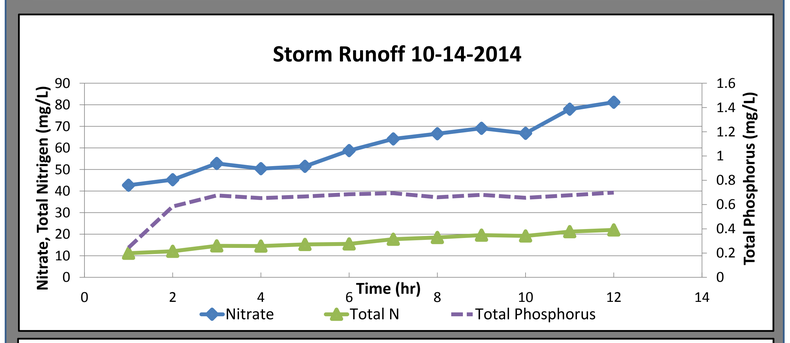
Preliminary Results

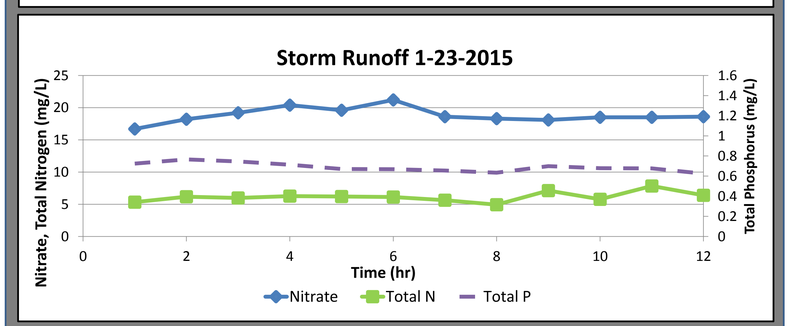
Time series for grab samples in OFWS pond:

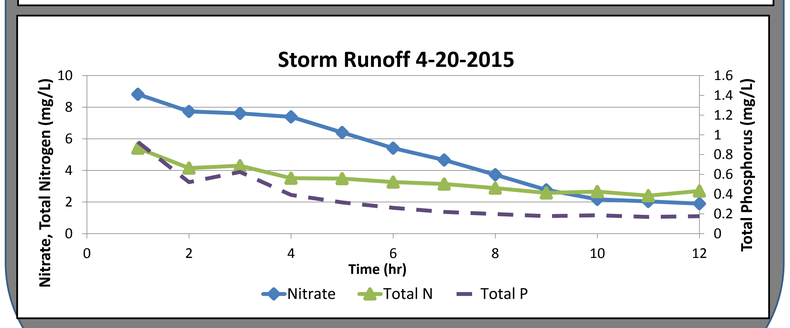




Nutrient concentrations in storm runoff :







Summary

Nitrate concentrations of more than 80 mg/L in the early winter storm water runoff demonstrate the importance of OFWS systems in reducing downstream nutrient loading. The time series nutrient concentrations in the OFWS pond show that the pond can act as a sink for nutrient removal.