2017

Mississippi Water Resources Conference

Jackson Hilton

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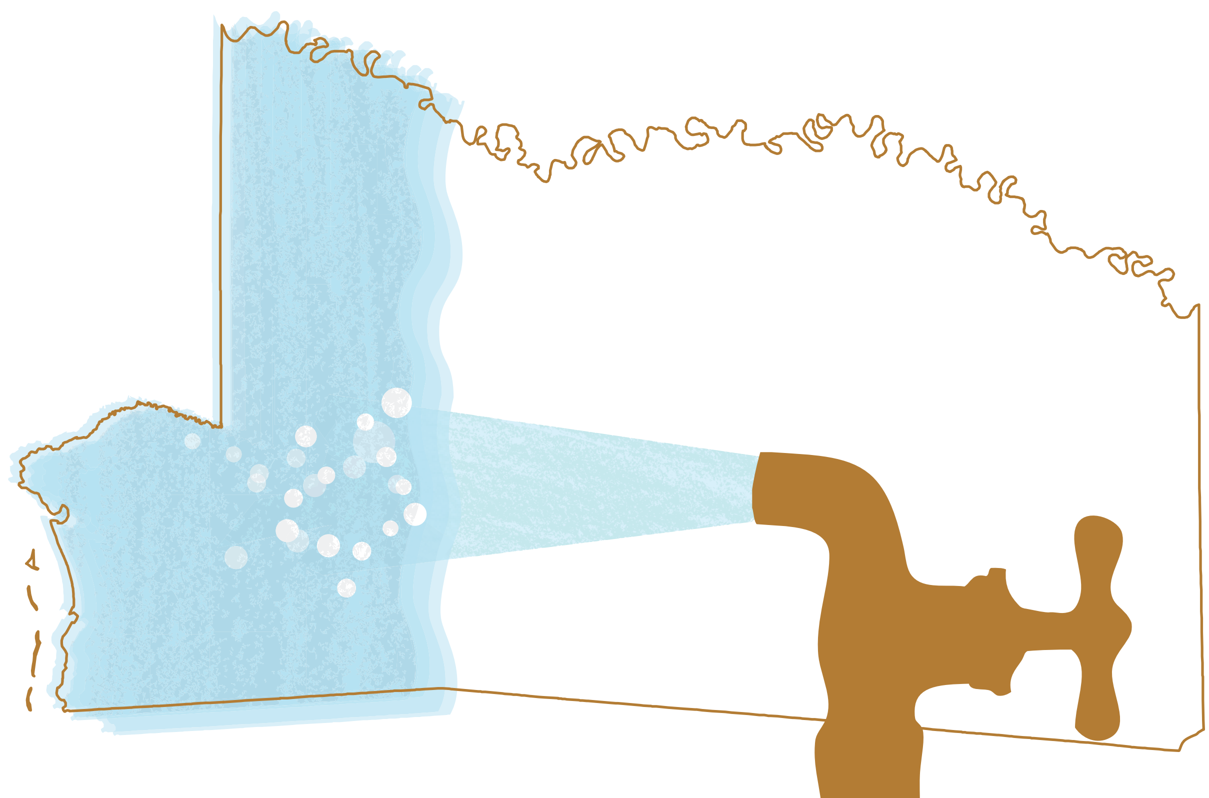

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Hilton Jackson Jackson, MS

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Can one hundred-year precipitation record produce patterns allowing seasonal weather prediction?

Buka, H.; Pote, J.; Wax, C.; Linhoss, A.

Rainfall prediction remains a scientific and technical challenge, since rainfall is the most difficult element of the hydrological cycle to forecast. Precipitation predictions as produced by the weather services are frequently poor beyond a few days. Using historical precipitation data to predict future rainfall is possible, as rainfall tends to follow previous patterns that can be easily explained through statistical and mathematical procedures. Rainfall is the most important climatic variable on which most crops are dependent. In Mississippi, however, certain climatic phenomena such as El Nino – Southern Oscillation (ENSO) comprised of the warm phase (El Nino) and the cold phase (La Nina) can be responsible for irregular climatic changes such as uneven distribution of rainfall, thereby making predictions using past patterns challenging. This study attempted to determine the extent to which rainfall received during six months (September -February) prior to the growing season can be used to predict rainfall during the growing season (March - August). The assumption is that certain patterns might be good indicators of climatic oscillations that could persist. One hundred years of previous precipitation data from the Delta Research and Extension center will be used and statistical equations and analysis will be performed to provide three outputs useful to producers. The outputs include normal climate, average growing season for the closest ten years matching pre-growing season, and the single year that closely matches the current growing season. The results will be shown as 20, 50 and 80 percent probability brackets. This study will address issues such as i) can the second six months' variations be low enough to consider it as a good predictive tool and ii) can established patterns be tied back to teleconnection to make predictions based on those.

Chitosan Nanoparticle Applications for Water/ Wastewater Treatment

Cook, C.; Gude, V.

Chitosan is an abundant naturally occurring biopolymer originating from several microbial species as well as crustacean species, such as shrimp and lobster. This biodegradable polymer has been the subject of research for water treatment applications for more than three decades due to its excellent physical and chemical properties; however, modern processes have allowed for the creation of new, novel materials. Chitosan presently offers a myriad of potential through chemical coagulation and flocculation, antimicrobial properties, adsorption capabilities, nanofiltration, and more. Such new applications as chitosan gelations, membranes, grafted nanoparticles, and other functionality-driven variations allow greater efficiency and broader implications than ever before. This presentation will discuss some of the recent developments in chitosan nanoparticle research for potential applications in water and wastewater treatment.

Application and validation of STWAVE in the nearshore of Deer Island, MS

Dillon, C.; Linhoss, A.

Waves are the driving force for many coastal processes. The process of sediment transport along a beach face is highly tied to the presence and action of waves. Therefore, due to the constant sediment transport occurring along Deer Island in Harrison County, MS, and the costly procedures required to maintain the sediment budget of the area, an accurate and full understanding of the wave parameters in the area is important. To date, no validation of a local model or any other published data on the waves for the area exists. Therefore, the purpose of this study is to validate a local model which will be able to be used to forecast or hindcast wave information for present or future work done on Deer Island. To quantify wave parameters of the area a wave model is the best option for its ability to generate high resolution information. For this study, the STWAVE model was chosen because of the mild and uniform conditions of the area and for STWAVE's fast computational efficiency. Field data of recorded wave information was taken from a Nortek Vector which recorded wave and current data between the months of June and September, 2016. The raw data of the Vector will be processed using the PUV method to produce wave height, wave period, and wave direction information. Wave data was also taken during this same time period through littoral environmental measurements (LEM) made at the shoreline. Both sets of gathered wave information will be used to validate the STWAVE model.

Evaluating the effects of irrigation management practices on groundwater recharge and storage in Mississippi Delta

Gao, F.; Feng, G.; Han, M.; Jenkins, J.

The Lower Mississippi River alluvial plain (refers to MS Delta), which is located in the northwest part of Mississippi in the U.S. It is a highly productive agricultural region, groundwater was considerably pumped for irrigating major row crops such as corn, cotton, soybean, and rice. As a result, the groundwater table has decreased dramatically, which threaten the sustainability of irrigated agriculture in the MS Delta. The objectives of this study were: 1) quantifying the amount of groundwater recharge as well as the groundwater storage from precipitation and irrigation return flow; 2) simulating the groundwater recharge and storage as affected by a) conventional irrigation scheme; b) water-saving irrigation scheduling for exactly satisfying crop water requirement using all groundwater; c) water-saving irrigation scheduling using different percentages of surface and ground water. The Soil and Water Assessment Tool (SWAT) was calibrated by the SUFI-2 auto-calibration algorithm in the SWAT-CUP package using observed daily streamflow data from 2003 to 2006,then was validated using measured streamflow data from 2007 to 2010. The model performed well during the calibration period (R2 ranged from 0.70 to 0.93 and Nash-Sutcliffe efficiency varied from 0.41 to 0.62) for daily streamflow. This study suggested that the conjunctive use of surface and ground water as irrigation sources is a sustainable way for future generations to continuously grow those major row crops in MS Delta.

Social Indicators: A Tool to Measure Change Among Hypoxia Stakeholders

Guzman, S.; Cossman, R.; Ingram, R.

Water quality problems that have accumulated over many decades similarily take decades to correct. This is the case when considering the complexity, scale, causes, and impacts of Gulf of Mexico hypoxia. Social dimension plays a key role because it is "people" who dictate interactions with the environment. Every individual (functionalized as "stakeholders"), community and culture has a set of beliefs and attitudes that guide decision-making and influence behavior. The success of nutrient reduction strategy implementation in state-designated priority watersheds depends upon a large percentage of watershed stakeholders understanding both the water quality impacts of their land use activities and the importance of conservation. Thus, an important social-environmental metric must include confirming that awareness and attitudes are changing, and behaviors are being adopted. Social indicators can inform planners and managers of modifications needed to their nutrient reduction strategies to increase their effectiveness. These social metrics such as input and feedback from stakeholders can supplement environmental metrics. In this poster we present the concept of social indicators as a viable metric for agricultural and water management. The ultimate goal is to increase the adoption of standardized social indicators as best practices for measuring watershed interventions.

Groundwater dynamic modeling and sustainable management in Big Sunflower River Watershed

Han, M.; Feng, G.; Ouyang, Y.; Gao, F.

Groundwater resource in Mississippi Delta is under a serious threat due to overdraft by agricultural pumpage, and showing a decreasing trend since 1970s. Groundwater management strategies are needed for the sustainable development of agriculture in Delta. This study analyzed groundwater dynamics in Big Sunflower River Watershed (BSRW) from 2000 to 2009 using MODFLOW model. The MODFLOW model was set up to quantify the changes in groundwater storage, level, and balance during this simulation period. The model was first calibrated with measured data and compared with the results from previous modeling studies in BSRW with a good agreement. Two scenarios were then chosen to evaluate groundwater management: 1) different crop rotation/sequence, and 2) coupled use of surface water and groundwater for irrigation. The results revealed that the annual change in groundwater storage was highly correlated to the annual amount of precipitation in this region. As the annual precipitation was larger than 60 inch, the groundwater storage increased due to receiving more rainwater recharge and pumping less groundwater for irrigation. Coupling use of surface and ground waters is a sustainable way for water resources management in this region. Appropriate percentages of utilizing groundwater and surface waters were determined under current weather conditions and future climate change scenarios.

Dynamic mechanism and simulation of soil and water conservation practices in restraining runoff, sediment and nutrient losses on slopes

Han, Y.; Feng, G.

Rainfall is a major dynamic driving factor of soil erosion and nutrient loss on different slopes. Soil and water conservation practices can change the dynamic process of soil and water losses, it is an important measure to reduce erosion and nutrient loss. In this study, four types of soil and water conservation practices, i.e., fish-scale pits, narrow terrace, shrub cover and agricultural landuse, were tested from 2001 to 2010. The results showed that all of these practices for soil and water conservation can significantly reduce soil erosion and nutrient losses. Compared with other practices, fish-scale pits most effectively reduced runoff, sediment and nutrient losses (the total losses of runoff, sediments, TP and TN were 20%, 2%, 10% and 36%, respectively, from the bare land in the same area), followed by 30% shrub coverage, narrow terrace and agricultural landuse. These soil and water conservation practices decreased shear stress, stream power, cross-section specific energy and soil detachment rate as well as reduced surface disturbances and soil erosion. The mechanisms of restraining soil and water loss by those conservation practices were quite different. In this study, rain intensity and erosion dynamic parameters (flow rate, Reynolds number, Froude numbers, Darcy resistance coefficient, Manning coefficient, shear stress, stream power, unit runoff power and cross-section specific energy) were considered as major factors in the empirical models for estimation of runoff, sediments, TP and TN at different runoff experiment sites. Statistical models were developed through stepwise linear regression analysis, correlation coefficient R of the models ranged from 0.65 to 0.99, indicating that simulated results were in good agreement with measured values.

Species-Specific Environmental Factors that Influence Sap Flow Rates of Nine Bottomland Hardwood Species

Kassahun, Z.; Renninger, H.

Climate change models predict an increase in prolonged drought events in the southeastern United States. Due to these climate alterations, bottomland hardwood forests could experience a drastic shift in their established hydrological patterns. Individual water consumption of hardwood trees vary by species and can be influenced by environmental factors such as solar radiation, soil water availability, temperature, and atmospheric vapor pressure deficit. These environmental factors are expected to shift in intensity and availability as climate change persists. As these environmental factors shift, certain tree species could be more negatively affected over more resilient species, ultimately leading to a shift in species composition in the forest. The rate of sap flow described as the transport of water that occurs in the xylem of a tree, is indicative of a tree's water use strategy. Sap flow rates can convey how much water a tree is using as well as how the tree copes with limited water resources. By using sap flow measurements to study the species-specific factors that influence physiological response, we can better understand how species specific water use will shift under drought conditions. Sap flow rates were measured using heat dissipation sensors on nine deciduous hardwood species found in a seasonally flooded hardwood forest. Simultaneously, temperature, relative humidity and soil moisture were measured and vapor pressure deficits were calculated. We found that cherrybark oak uses the most water during the growing season, using ~45% more water than the next highest consumer, swamp chestnut oak. Shagbark and pignut hickory use the least amount of water during the growing season, roughly 2% of cherrybark oaks' water consumption. Sap flow rates also exhibited a linear correlation with soil moisture and vapor pressure deficit for American elm, pignut hickory, swamp chestnut oak, and willow oak in order of correlation strength. Response to changes in vapor pressure deficit were also directly linked to the soil moisture conditions for these species. These findings suggest that as drought conditions increase, leading to a decrease in soil moisture, these species will respond with a reduction in sap flow, with American elm and pignut hickory showing the greatest reduction in water use and winged elm exhibiting the least response. This information will be useful in accurately estimating forest water budgets based on future climate change predictions.

Research Program at the USDA-ARS National Sedimentation Laboratory: Addressing Agricultural and Natural Resource Management

Locke, M.

The USDA-ARS National Sedimentation Laboratory, Oxford, MS, ("Sed Lab") has served for 50 years as a center for research on sediment and erosion issues and is currently the lead USDA-ARS facility addressing (1) watershed erosion and sedimentation processes, and (2) watershed ecological functions as impacted by agricultural practices. The Sed Lab consists of two research units: (1) Water Quality and Ecology, and (2) Watershed Physical Processes. The research program emphasizes interdisciplinary studies dealing with physical, chemical, and biological processes related to natural resources in agricultural watersheds, and assessing strategies for sustaining and enhancing the integrity and function of agro-ecosystems. Specific topics of study include: (1) soil erosion, transport and deposition of sediment in watersheds including stream stability and bank protection; (2) agricultural practice and stream structure impacts on water quantity, water quality, and ecosystem services; (3) movement and fate of chemicals within the landscape; (4) ecosystem integrity of streams and adjacent riparian zones, lakes and wetlands; and (5) processes controlling surface and groundwater movement. The NSL also serves as the lead research facility in the Lower Mississippi River Basin for the USDA-ARS Long Term Agro-ecosystem Research (LTAR) network.

Simulating cotton water use and yield under rainfed and full irrigation conditions using RZWQM2 model in the Lower Mississippi Delta Region

Ma, X.; Feng, G.; Sui, R.; Jenkins, J.

Sustainable agricultural water management requires knowledge of crop water use and productivity under both rainfed and Irrigation conditions. Our objective was to determine the yield and water use of both nonirrigated and fully irrigated cotton in the Lower Mississippi Delta Region. The CSM-CROPGRO-Cotton v4.6 model within the Root Zone Water Quality Model (RZWQM2) were applied. The model was calibrated and validated using measured data at Stoneville Experimental Station in 2015 and 2016 Results suggested that the calibrated model simulated cotton yield and water use had good agreement with measured data in field. Simulation study discovered that the lowest rainfed yield was less than 2500 kg ha^{-1}, and the highest irrigated yield were more than 3600 $kgha^{-1}$.

Estimating Impacts of Future Rainfall Change on Stream Flow and Sediment Load in Lower Yazoo River Watershed Using BASINS-HSPF-CAT Modeling System

Ouyang, Y.; Feng, G.; Parajuli, P.B.

Climate change over the past several decades has resulted in shifting rainfall pattern and modifying rainfall intensity, which has, in turn, exacerbated stream flow and sediment load and imposed uncertainties to these processes. This study projected impacts of potential future rainfall variations on stream flow and sediment load from the Lower Yazoo River Watershed (LYRW) in Mississippi using the BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)-HSPF (Hydrological Simulation Program-FORTRAN)-CAT (Climate Assessment Tool) modeling system. Several simulation scenarios were performed to investigate impacts of different future rainfall rates on stream discharge and sediment load in the LYRW. Results showed that over a ten-year simulation period, an increase in the rainfall rate by 10% and 20%, respectively, resulted in increasing discharge by 8.1% and 7.4% as well as in increasing sediment load by 1.1 and 1.2 times. A potential future wet climate had discernable impacts on stream flow and sediment load in the LYRW. The BASINS-HSPF-CAT modeling system is a useful tool to modify historical rainfall data to project future rainfall impacts on watershed hydrological processes and sediment load due to climate change.

Introduction

Climate change over the last several decades has resulted in modifying precipitation pattern and intensity (Bates et al., 2008). Precipitation change has resulted wetting in the Northern Hemisphere mid-latitudes, drying in the Northern Hemisphere subtropics and tropics, and moistening in the Southern Hemisphere subtropics and deep tropics in recent decades as detailed by Zhang et al. (2007) and Bates, et al. (2008). Bates et al. (2008) reported that heavy rainfall has increased over most areas, whereas the very dry land area has increased more than double globally since 1970s. Tank et al. (2009) stated that air temperature in 2100 is expected to be 1.1- 6.4ºC higher than that in 1900, accompanied by changes in rainfall intensity and amount. Each of the past three decades has been successively warmer than any previous decades based on instrumental records and the decade of the 2000s has been the warmest (Tank, et al., 2009).

Estimate of stream flow is central to water resource management, water supply engineering, environmental protection, and ecological restoration (Ouyang et al., 2015). In climate vulnerability assessment, stream flow is an important indicator of water response to the climate change. To mitigate the likelihood of future climate impact on stream flow, water resource managers must be able to assess potential risks and opportunities, and where appropriate, implement practices for adapting to future climatic conditions (Pielke & de Guenni 2004). Sediments in rivers are increasingly recognized as both a carrier and potential source of contaminants in aquatic environments due to their adsorption of toxic chemicals (Ouyang et al., 2002). Significant changes in river discharge, stage, and morphology as a result of sediment deposition have become an issue of concern due to the broad impacts upon terrestrial and aquatic life as well as river hydrology (Simon et al., 2002).

Changes in agricultural and forest practices, clearcutting in bottomland hardwood forests, and conversions from forests to agricultural lands are largely responsible for the increases in flooding, low stream flow, and sediment load in the Lower Mississippi River Alluvial Valley (LMRAV) (Zhang and Schilling 2006). Despite great efforts have devoted to investigating the impacts of agricultural, forestry, industrial, and urban activities on stream flow and sediment load in the LMRAV (Simon et al., 2002; Zhang and Schilling 2006; Shields et al., 2009; Ouyang et al., 2013), our literature search revealed that studies on the impacts of future climate change upon these issues in this region are fragmented and poorly documented.

The goal of this study was to assess the impacts of future rainfall variations due to climate change upon stream flow and sediment load from the LYRW in the LMRAV, using the US-EPA (Environmental Protection Agency)'s BASINS-HSPF-CAT modeling system. Our specific objectives were to: (1) develop a BASINS-HSPF-CAT model for the LYRW; and (2) apply the resulted model to investigate daily and annual stream flow and sediment load in the LYRW as affected by potential rainfall variations due to climate change.

Materials and Methods

Study sites

The LYRW is located in south Yazoo River Basin (YRB), Mississippi (Fig. 1). This watershed consists of 61 % forest land and 31% agriculture land with soil types of sand, loam, and clay. Surface water pollution within the YRB includes excess nutrients, sediments, heavy metals, and herbicides, which are the results of storm water runoff, discharge from ditches and creeks, groundwater seepage, aquatic weed control, naturally-occurring organic inputs, and atmospheric deposition (Nett et al., 2004; Pennington, 2004). An elaborate description of the study site can be found in Ouyang et al. (2013).

Model description

The US-EPA watershed modeling system, BASINS-HSPF-CAT, was selected for this study. BASINS is a multipurpose environmental analysis system for use by regional, state, and local agencies, research institutes and universities to perform watershed hydrology and water quality studies. HSPF is a comprehensive model developed by Aqua Terra Inc. through US-EPA for simulating water quantity and quality in watersheds of almost any size and complexity (Bicknell et al. 2001). The CAT model was first incorporated into US-EPA's BASINS modeling system in 2007 with the goal of increasing the capacity of BASINS users to conduct watershed based studies due to potential climate variability and change on water resources (US-EPA, 2009). CAT provides flexible capabilities for creating climate change scenarios, allowing users to quickly assess a wide range of "what if" questions about how weather and climate could affect watershed systems using the HSPF, SWAT, and SWMM models. A post-processing capability is also provided for calculating management targets to water resource managers. Climate change scenarios can be created with CAT by selecting and modifying an arbitrary base period of historical temperature and precipitation data to reflect any desired future changes.

Model development

Development of a HSPF model in the BASINS starts with watershed delineation. The processes include to setup a digital elevation model, create the stream networks, and select watershed inlets or outlets. The HSPF model also requires land use and soil data to determine the area and the hydrologic parameters of each land use pattern. This was accomplished by using the land use and soil classification tool in BASINS (version 4.2). The major steps in watershed modeling with HSPF are the mathematical description of the watershed, the preparation of input meteorological and hydrological time series, and the estimation of input parameter values through model calibration and validation. The time series are fed to the model by utilizing a standalone program called the Watershed Data Management program (WDM) provided in BASINS. The hydrologic and sediment components of the HSPF model have been calibrated and validated previously (Ouyang et al., 2013 and 2015).

Simulation scenarios

To gain a better understanding of potential future rainfall impacts on stream flow and sediment load in the LYRW, three simulation scenarios were performed in this study. The first scenario (base scenario) was chosen to predict daily and annual stream flow and sediment load with historical rainfalls. The second and third scenarios were the same as the first scenario except that the rainfall rate was increased by 10% for the second scenario and by 20% for the third scenario. Comparison of simulation results from the three scenarios allowed us to evaluate the potential impacts of future rainfall variations due to climate change upon the daily and annual stream flow and sediment load. The reason for selecting the wet climate with an increasing rainfall rate in this study was that the historical data have shown an increasing trend of rainfall through the years in this region.

Results and Discussion

Daily variations of stream discharge for the three rainfall settings (i.e., base rainfall, increased by 10%, and increased by 20%) in the LYRW are shown in Fig. 2. The base rainfall data were obtained from the local weather station and further computed to fill the gaps for representing the average rainfall condition at the LYRW, whereas the other two sets of rainfall data were attained by increasing 10 and 20% of base rainfall data to account for wet climate through the CAT model. Simulation results showed that an increase in rainfall rate boosted stream discharge although the percent increase in rainfall rate was not necessary proportional to the percent increase in stream discharge (Fig. 2). Analogous to the case of stream discharge, the daily stream sediment concentration in the LYRW increased with the rainfall rate (Fig. 3). Therefore, a potential future wet climate had great impacts on daily stream flow and sediment concentration in the LYRW.

Annual stream discharge and sediment load through the LYRW for the three rainfall settings are shown in Figs. 4 and 5. Over a 10-year simulation period, an increase in rainfall rates of 10% and 20%, respectively, resulted in increasing stream discharge by 8.1% and 7.4%. Similarly, over a 10-year simulation period, an increase in rainfall rates of 10% and 20%, respectively, resulted in increasing sediment load by 1.1 and 1.2 times. Therefore, a potential future wet climate could have discernable impacts on stream flow and sediment load at the LYRW watershed. The BASINS-HSPF-CAT modeling system is a useful tool to modify historical rainfall data to project future rainfall impacts on watershed hydrological processes and sediment load due to climate change.

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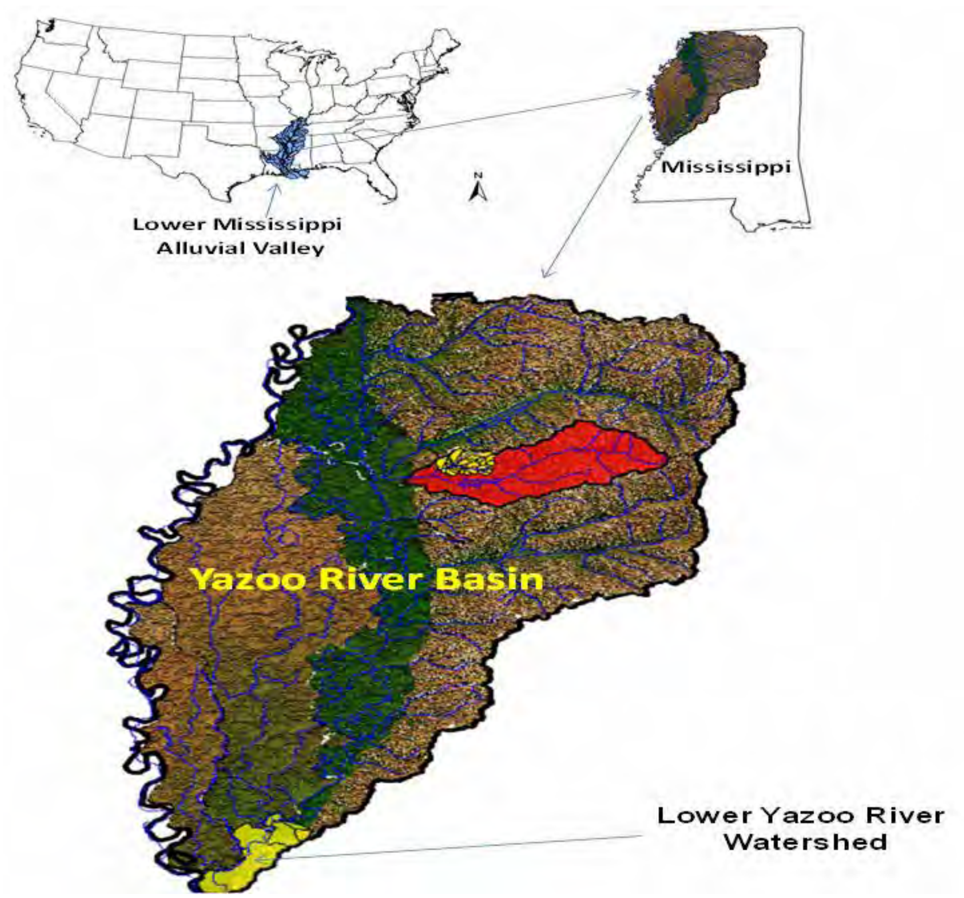

Figure 1. Location of the Lower Yazoo River Watershed.

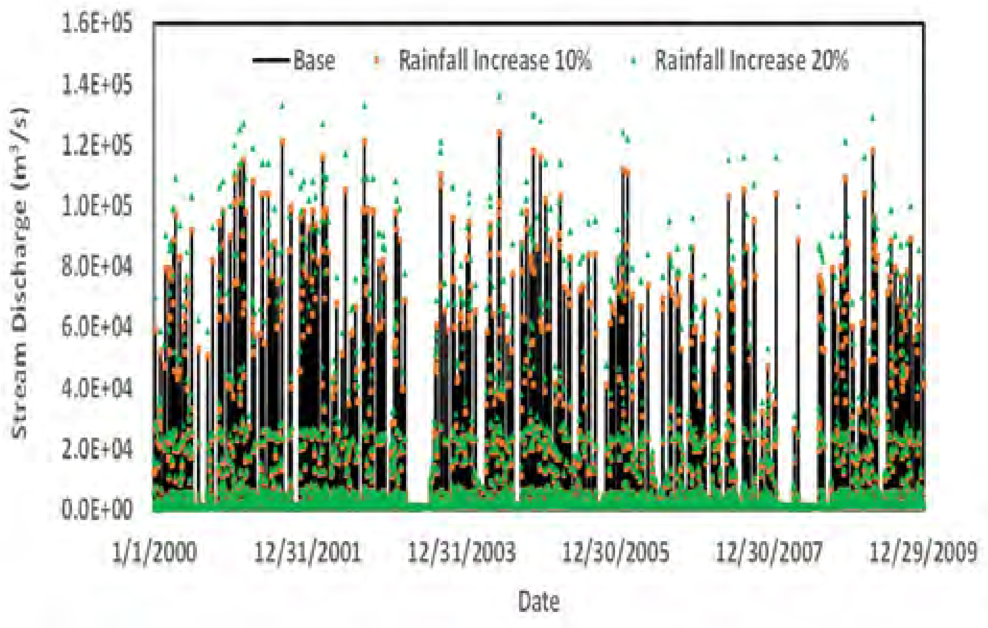

Figure 2. Daily stream discharge as rainfall rate increased.

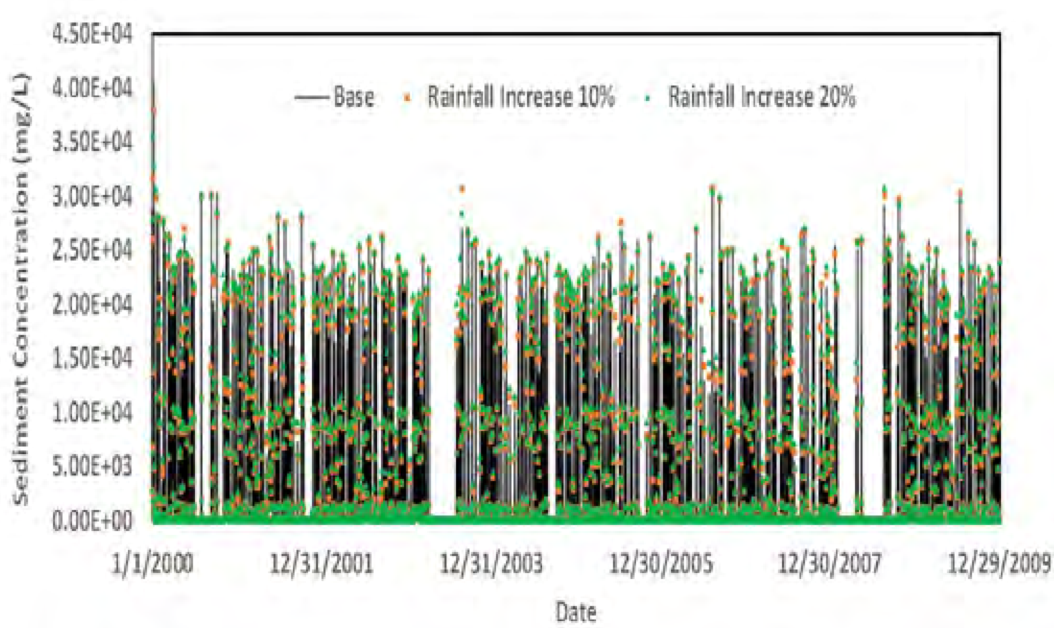

Figure 3. Daily sediment concentration as rainfall rate increased.

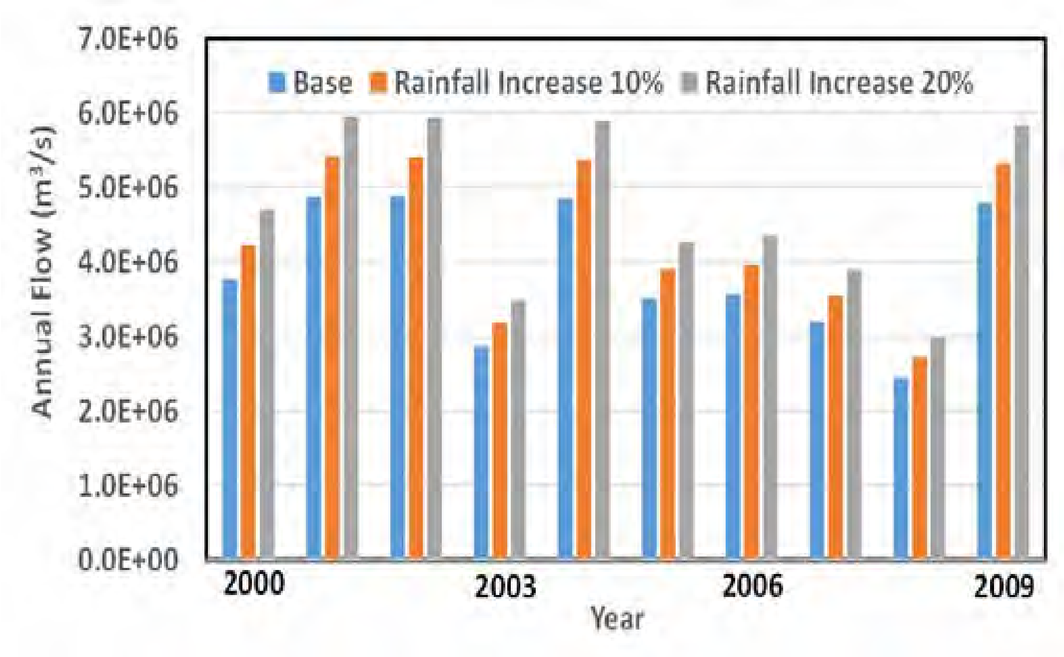

Figure 4. Annual stream discharge as rainfall rate increased.

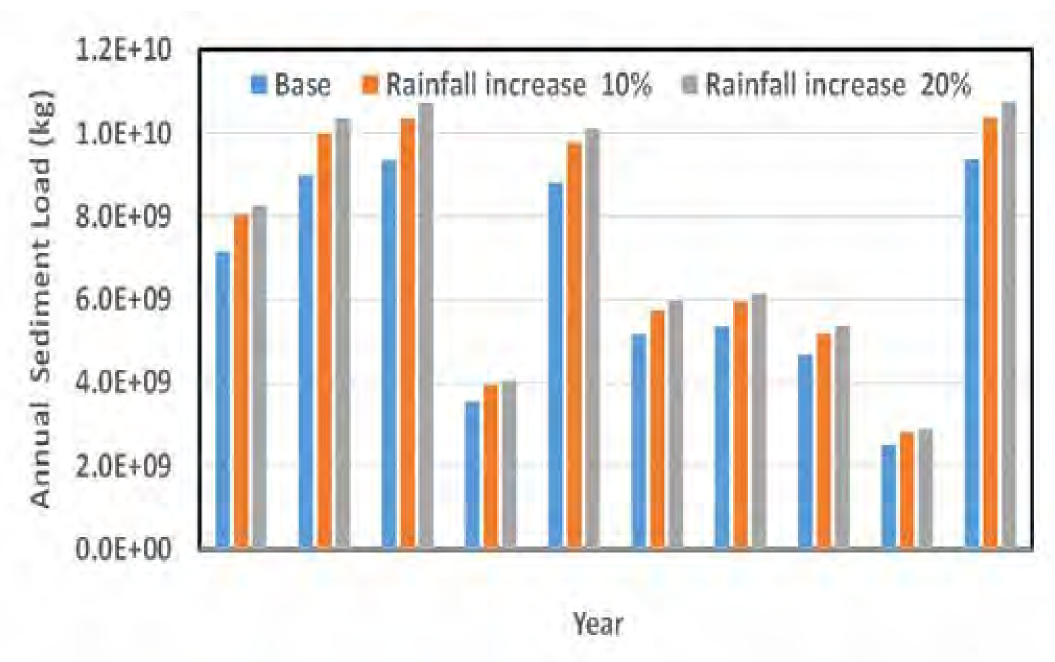

Figure 5. Annual sediment load as rainfall rate increased.

Grazing Cattle Preference for Automated Water Troughs and Shade Trees versus Pond Use for Drinking and Heat Stress Mitigation

Parish, J.; Rutherford, W.; Best, T.; Stewart, C.

British breed heifers aged 19 to 21 months and 4 to 6 months pregnant were grazed on a 25-acre pasture of 'Kentucky-31' toxic endophyte-infected tall fescue starting May 18, 2015 at the Prairie Research Unit in Prairie, MS. They were fitted with global positioning system collars that recorded position within the pasture at 5-minute intervals until July 28, 2015. Heifers had free-choice access to a surface pond, automated open-faced water trough supplied by well water, and shade trees. Heifers spent 73.9 ± 0.12% of time away from water and shade sources, 23.8 ± 0.12% of time in shade, 1.4 ± 0.03% of time at the water trough, and 1.0 ± 0.03% of time at or in the pond. Comparing time spent at drinking water sources directly, heifers were 1.4 times more likely to be at the water trough than the pond. In a direct comparison of shade use versus pond use for heat stress mitigation, heifers were 23.9 times more likely to be in the shade than the pond. Ambient temperature affected ($P < 0.01$) animal location within the pasture. Mean temperatures for the different location classifications were: shade (84.5°F), water trough (82.6°F), pond (81.8°F), and other (77.6°F). At greater ambient temperatures, heifers were more likely ($P < 0.01$) to be located under shade than at water sources or out grazing. Likewise, heifers were more likely ($P < 0.01$) to be grazing or otherwise away from shade and water sources at lesser ambient temperatures. These results suggest a strong preference by cattle for shade over pond use during late spring and summer as well as a preference for water trough use over pond use. Thus, by providing shade and an alternate drinking water source, pond use by cattle for drinking and heat stress mitigation purposes may be lessened.

Using Deuterium and Oxygen-18 Isotopes to Understand Stemflow Generation Mechanisms

Siegle-Gaither, M.; Siegert, C.

Stemflow is a nutrient-enriched type of rain partitioning that redirects intercepted water from the forest canopy down tree trunks, creating biogeochemical hotspots at tree bases. Few studies have examined species-specific effects of bark structure and storm meteorological conditions on stemflow generation via stable hydrogen (δD) and oxygen ($\delta^{18}O$) isotopic tracers. This study explores these relationships in an oak-hickory stand in central Mississippi. Species were chosen based on their unique bark characteristics and variable effects on rain partitioning. Stemflow volume and isotopic composition were measured over one year with objectives to determine (i) origins and pathways of stemflow water using stable isotopes, (ii) differences in stemflow generation mechanisms between tree species, and (iii) differences in stemflow generation mechanisms between storm events.

Stemflow collars were installed on 18 trees of six species. Water samples were collected within 24 hours of individual storm events. Laser ablation spectroscopy was used to analyze δD and $\delta^{18}O$ in collected water samples. Results show that isotopic composition (δ^2H) of stemflow (-20.08±10.18‰) is distinct from that of throughfall (-21.25±9.09‰) and precipitation (-15.49±10.03‰). The difference in isotopic composition of stemflow relative to throughfall and precipitation signifies evaporation, suggesting that this pathway is composed of both pre-event and event water. Bark thickness measurements were greatest in *Quercus alba*, followed by *Q. stellata, Q. shumardii, Q. pagoda, Carya glabra*, and *C. ovata*. Stemflow volumes per basal area followed a similar trend. Greater bark thicknesses correlate with lower stemflow volumes per basal area, advocating that interspecific bark characteristics play an intricate role in stemflow generation. A bark-wetting experiment showed bark water storage capacity (BWSC) per tree stem to be greatest in red oaks (*Q. shumardii*: 87.4±21.5 L and *Q. pagoda*: 85.4±21.5 L), then white oaks (*Q. alba*: 57.2±41.7 L and *Q. stellata*: 45.5±20.0 L), and hickories (*C. ovata*: 26.7±24.9 L and *C. glabra*: 18.6±6.5 L), respectively. Oak species with thick, continuous bark surfaces generate lower stemflow volumes and have higher BWSC; whereas hickory species tend to have thinner, irregular bark structures that lead to higher stemflow volumes and lower BWSC. Specifies-specific BWSC is therefore not only a determining factor for stemflow generation during an event, but also for how much pre-event water is contributing to this flux, both in terms of volume and chemistry. Thus these results show how stemflow significantly impacts forest hydrology and microclimate based on interspecific differences in bark thickness.

Delta Sustainable Water Resources: Monitoring and Modeling

and Modeling

Delta Sustainable Water Resources: Monitoring and Modeling

Kay Whittington *(Mississippi Department of Environmental Quality)*	Delta Sustainable Water Resources Task Force update
Wade Kress *(U.S. Geological Survey)*	Coupling modeling with monitoring to assess water availability in the Mississippi Alluvial Plain
Jeannie Barlow *(U.S. Geological Survey)*	Water availability in the Mississippi Delta: Initial assessment of alternative water-supply scenarios
Larry Falconer *(Mississippi State University)*	Cost analysis of water management scenarios for the Mississippi Delta

Delta Sustainable Water Resources Task Force Update

Whittington, K.

Groundwater levels in the aquifer used for irrigation in the Mississippi Delta are declining as irrigation demands have increased. By law, the Mississippi Department of Environmental Quality (MDEQ) is charged with conserving, managing, developing, and protecting the state's water resources. MDEQ is working with those in the Delta through the Delta Sustainable Water Resources Task Force to identify solutions. A Voluntary Metering Program is being implemented to get accurate withdrawal information and irrigation water management practices proven to save water, time, and money are being promoted. Progress must be made now with voluntary measures while all options continue to be investigated.

Coupling Modeling with Monitoring to Assess Water Availability in the Mississippi Alluvial Plain

Kress, W.; Clark, B.; Barlow, J.

The Mississippi Alluvial Plain (MAP) is one of the most important agricultural regions in the United States, and crop productivity relies on groundwater irrigation from a system that is poorly understood. Groundwater use from the Mississippi River Valley alluvial aquifer has resulted in substantial groundwater-level declines and reductions in baseflow in streams within the MAP. These impacts are limiting well production and threatening future water availability for irrigation in the region.

Accurate and ongoing assessments of water availability in the MAP region are critically important for making well-informed management decisions about sustainability, establishing best practices for water use, and identifying predicted changes to the regional water system over the next 50-100 years. To provide stakeholders and water-resource managers with information and tools to better understand and manage available water resources within the MAP, the U.S. Geological Survey (USGS) initiated a regional water availability project funded by the Water Availability and Use Science Program (WAUSP). The MAP project couples modeling with monitoring to improve the characterization of the alluvial aquifer system in an existing numerical-groundwater-simulation model. The premise of the investigation is to evaluate the existing groundwater model and produce an estimate of the uncertainty of the model inputs, such as hydraulic conductivities, storage, streams, recharge, and water use. Based on the uncertainty results, additional data are collected (monitoring) to improve the model. After which, the uncertainty will be estimated again, and the process will be repeated as necessary. For example, initial uncertainty results indicated that better knowledge of streambed conductances could improve the precision of simulated groundwater levels. In response to this data need, waterborne geophysical data were collected along 180 km of streams in the Mississippi Delta. The geophysical data identified areas of coarse- and fine-grained material in the streambed that may control the amount of water passing between the alluvial aquifer and the stream. The results of the geophysical investigation can be used to adjust the relative streambed conductance (increase for coarse-grained sediment and decrease for fine-grained material) and input into the numerical model to determine if the precision of simulated water levels improve. Through this iterative method of modeling and monitoring, a more dynamic 'living' numerical model will be available to more accurately represent groundwater flow in the system. The MAP groundwater model can then be used to help manage the water resource evaluate potential future effects of water-use changes, conservation practices, construction of diversion-control structures, or climate change.

Water Availability in the Mississippi Delta: Initial Assessment of Alternative Water-Supply Scenarios

Barlow, J.; Haugh, C.

In an effort to better understand the impacts of different water-management scenarios on water availability and to identify additional monitoring needs in the Mississippi Delta, the U.S. Geological Survey and the Mississippi Department of Environmental Quality are collaborating to update and enhance an existing regional groundwater-flow model. As a result of this collaboration, the model has been updated through 2013 with the most recent water-use data, precipitation and recharge data, and streamflow and water-level observation data. The updated model has been used to evaluate selected alternative water-supply scenarios in order to assess relative impacts to the alluvial aquifer and identify data needs for future groundwater management modeling. Alternative water-supply options assessed to date include: 1) irrigation efficiency; 2) tailwater recovery and on-farm storage; 3) weirs for surface-water augmentation; 4) inter/intra-basin transfers; and 5) groundwater transfer and injection. A relative comparison approach was used to calculate the simulated water-level response due to each scenario. Water-level response is the difference between water-levels simulated by the alternative-supply scenario and those simulated by a base case or "no action" scenario. Water-level response in the alluvial aquifer varied for each scenario based on the location and magnitude of the implemented alternative-supply option. These initial model results will serve as a starting place to develop and assess conjunctive water-management-optimization scenarios as well as improve and enhance current and future monitoring activities within the Delta.

Cost Analysis of Water Management Scenarios for the Mississippi Delta

Falconer, L.; Tewari, R.; Johnson, J.

The objective of this study is to provide the Mississippi Department of Environmental Quality with a report comparing the cost of reduced pumping or increase in recharge per acre-foot in the Mississippi River Valley Alluvial Aquifer as a result of 5 proposed groundwater management alternatives with scenarios. It is important to note that the cost data available for some of the alternatives are more detailed and current than the data for others. The cost data for the RISER and the Tailwater Recovery and Onfarm Storage scenarios are detailed, current, and based on recently implemented projects and practices. The cost estimates for the Enhanced Aquifer Recharge scenario are detailed and based on research on current materials and construction and ancillary costs for a project with similar components, but no comparable project has actually been built. The cost estimates for the Tallahatchie-Quiver Intra-basin Transfer scenarios are based on a U.S. Army Corps of Engineers (USACE) report issued in September, 2016. The cost estimates for the Instream Weir scenarios are based on itemized costs provided by USACE personnel.

Preliminary results indicate that at 33%, 66% and 100% adoption rates in the service area for the Instream Weir alternative scenarios, this alternative provides the lowest cost per acre foot per acre-foot in reduced pumping from the aquifer.

Introduction

For more than three decades, groundwater levels in the Mississippi River Valley Alluvial Aquifer (MRVA) have been declining. Although declines in water levels have been greatest in the central Delta, the problem is spreading. Because of declines in the MRVA, in 2014 Governor Phil Bryant issued Executive Order No. 1341, establishing the Governor's Delta Sustainable Water Resources Task Force (Task Force), thereby formally instituting a process begun by the Mississippi Department of Environmental Quality (MDEQ) in 2011 to assure that the Delta will have the water it needs to sustain its economy and environment. The Task Force members are MDEQ, Delta Council, Delta F.A.R.M., Mississippi Farm Bureau Federation, the Mississippi Soil and Water Conservation Commission, the Natural Resources Conservation Service (NRCS), the Vicksburg District of the U.S. Army Corps of Engineers (USACE), and the Yazoo-Mississippi Delta Joint Water Management District (YMD).

In 2014, MDEQ signed a multi-year agreement with the United States Geological Survey (USGS). Under the agreement, the USGS will cooperate with MDEQ to enhance the USGS regional groundwater model and then use the model to help MDEQ and the Task Force evaluate the effects on the aquifer of potential alternative actions and strategies. The first phase of USGS modeling compared the effects of various scenarios to the effects of a no-action base scenario. Some of the scenarios would reduce the amount of groundwater pumped relative to the base no-action scenario. One scenario would potentially enhance groundwater recharge.

Objective

The objective of this study is to provide MDEQ with a report comparing the cost of reduced pumping or increase in recharge per acre foot in the Mississippi River Valley Alluvial Aquifer as a result of 5 proposed groundwater management alternatives with scenarios.

Methodology

The USGS and MDEQ collaborated with the following organizations to develop scenarios that were modeled using the

USGS groundwater model:

1. Mississippi State University (MSU) Delta Research and Extension Center (DREC) for scenarios for implementation of water use efficiency practices to reduce groundwater pumping;
2. NRCS for scenarios for construction and operation of tail water recovery systems and on-farm water storage systems to reduce groundwater pumping;
3. USDA Agricultural Research Service (ARS) for scenarios for a proposed groundwater-to-groundwater transfer project to enhance aquifer recharge;
4. YMD for scenarios for the proposed Tallahatchie River-Quiver River intra-basin surface water transfer to reduce groundwater pumping;
5. USACE for scenarios for proposed in-stream weirs to provide additional surface water to reduce groundwater pumping.

After the alternatives were defined, the above organizations prepared preliminary cost estimates for implementation of the scenarios. For all alternatives to be modeled, the USGS provided DREC personnel with estimates of reduced groundwater pumping or enhanced aquifer recharge.

The calculations made by DREC personnel are based on construction, operation and maintenance cost estimates provided by each organization. These cost estimates were normalized using a consistent methodology, and the costs per acre-foot of groundwater saved or recharged by each scenario were compared using appropriate capital budgeting methods consistent with the planning horizon utilized in the USGS modeling. Where appropriate, opportunity costs were calculated for productive land that is designated for use in a water conservation scenario based on MSU Extension Service survey data (Parman, 2016). These costs were adjusted for future input price changes utilizing appropriate discount rates. The 3.125% discount rate used for net present value calculations in this study is the federal interest rate for USACE projects for fiscal year 2016 (U.S. Army Corps of Engineers, 2016).

The reduced pumping costs for each scenario were derived using the Calculating and Comparing Irrigation Pumping Costs Excel Spreadsheet (Tacker, 2005). It was assumed that all water pumped will use an electrical, vertical line shaft pump. The heights for water lift for the Delta and the Central Delta regions were assumed to be at 75 feet and 120 feet respectively. Irrigation well operating and maintenance costs derived using the Calculating and Comparing Irrigation Pumping Costs Excel Spreadsheet were estimated to be $1.23/ac-in Delta-wide and $1.90/ac-in for the central Delta.

Future electricity costs were adjusted based on projections made by the US Energy Information Administration (EIA, 2016). Future equipment costs, labor costs, and changes in land opportunity cost adjustments were based on projections made by the Food and Agricultural Policy Research Institute of the University Missouri (FAPRI, 2016).

Results and Discussion

Cash Flows: Riser (Irrigation Efficiency)

The cash flow estimates in the RISER (IRRIGATION EFFICIENCY) scenario are based on detailed information provided by MSU personnel for irrigation efficiency, capital equipment and supplies used in application of the RISER irrigation water conservation program. The initial costs of capital equipment and operating supplies were updated and verified by the authors.

RISER Scenario cash flows were calculated for two Sub-scenarios (Delta-wide and the Central Delta areas). The RISER Scenario is expected to increase irrigation efficiency and reduce the total water pumped by 4.38 ac-in/ac/year Delta wide and 4.80 ac-in/ac/year in the central Delta. The Sub-scenarios were assumed to be implemented on 1,453,074 acres across the entire Delta region, and on 91,590 acres in the Central Delta region. The amount of change in water withdrawals on account of the RISER Scenario is expected to be 530,647 acre-feet annually, or 0.37 acre-feet/acre of project area for the entire Delta region, and 36,710 acre-feet annually, or 0.40 acre-feet/acre of project area for the Central Delta region respectively.

Based on the above projections, costs per acre-foot of groundwater pumping reduced were calculated using capital budgeting for a planning horizon of 50 years. For the RISER Scenario, cost savings were calculated for reduced pumping costs for both scenarios. The reduced pumping costs were arrived at by multiplying the reduction in water

Table 1. RISER Scenario Investment Cost Estimate[1]

Depreciable Items	Quantity	Initial Cost (each)	Useful Life	Initial Investment
Surge Valve - 10"	2	$3,483.00	50	$6,966.00
Pipe Elbows	4	$127.00	50	$508.00
Soil Moisture Sensors	3	$39.00	3	$117.00
Irrometer Datalogger (package)	1	$450.00	10	$450.00
				$8,041.00

[1] The initial cost of implementation estimates of the depreciable items as part of the RISER Scenario for a 160 acre tract with 148 irrigated acres. This estimate includes two 10" surge valves at an initial investment of $6,966. The surge valves will be overhauled at 10-year intervals at a cost of $1,146 each. These overhauls will extend the life of the surge valve to the total length of the project. In addition, four pipe elbows at an initial purchase cost of $127 each (assumed to last the life of the project), 3 moisture sensors ($39 for each, and replaced every 3 years), and an Irrometer Datalogger (package) at $450 (replaced every 10 years), will be required. Total initial investment amounts to $8,041 for an average initial investment of $54.33 per irrigated acre.

pumped (4.38 ac-in/ac/year Delta wide and 4.80 ac-in/ac/year central Delta) by the number of irrigated acres, and the operating costs associated with pumping an acre-inch of water. This amounted to a reduction in water pumped costs of $5.39 per acre per year, and $9.12 per acre per year for the Delta and the Central Delta regions respectively.

Table 3 describes the costs per acre foot associated with the RISER Scenario in the project regions. The total discounted cash flow per acre for a 50 year planning horizon was estimated at $244.25 for the entire Delta region, and at $101.49 for the Central Delta region. The total reduction in water pumped over a 50 year planning horizon was found to be 26,532,350 acre-feet, and 1,835,500 acre-feet for the entire Delta region, and the Central Delta region respectively. The estimated total Net Present Value (NPV) cost of the project was found to be $354,913,325, and $9,295,469 for the entire Delta region, and the Central Delta region respectively. The cost per acre-foot for the RISER Scenario was estimated by multiplying the NPV of the costs by the acres in the project, and dividing by the total reduction

Table 2. RISER Scenario Direct Cost Estimate[2]

Direct Expenses	Unit	Quantity	Price	Total Cost
Batteries	Each	4	$35.00	$140.00
Transfer Pipe - 15 mil	Ft	2640	$0.405	$1,069.20
				$1,209.20

[2] Table 2 presents the direct cost items associated with the RISER Scenario. 4 batteries for the controller costing $35 each amount to a total of $140, and last 2 years (personal communication with L. Jason Krutz, June 9, 2016). Transfer pipe priced at $0.405 per feet for a total of 4 at 660 feet (2,640 feet total) amount to $1,609.20 leading to total annual direct costs of $1,209.20. Assuming that out of a land parcel of 160 acres where 148 acres are irrigated, the annual direct costs per acre amount to $8.17. The reduction in water pumped by implementing the RISER Scenario is expected to be 4.38 ac-in/ac/year Delta wide and 4.80 ac-in/ac/year central Delta.

Table 3. Estimated Cost per Acre-Foot Not Pumped from the Aquifer for the RISER Sub-scenarios.

	Delta Wide RISER	Central Delta RISER
Acres in Project	1,453,074	91,590
Estimated Total NPV Cost of Project	$354,913,324.50	$9,295,469.10
Amount of Change (acre ft/year)	530,647	36,710
Total Amount of Change	26,532,350	1,835,500
Cost of Change per Acre Foot	$13.38	$5.06

achieved over the 50 years, which amounted to $13.38 and $5.06 for the entire Delta region, and the Central Delta region respectively.

Cash Flows: Tail Water Recovery (TWR) And Onfarm Storage (OFS)

The cash flow estimates in the Tail Water Recovery (TWR) and Onfarm Storage (TWR+OFS) scenario are based on detailed information provided by NRCS personnel for irrigation efficiency, capital equipment and operating supplies used in application of the Tail Water Recovery (TWR) and Onfarm Storage (TWR+OFS) program. The initial costs of capital equipment and operating supplies were updated and verified by the authors.

Table 4. TWR System Investment Cost Estimate[3]

TWR (160 Acre Project)	Unit	Amount	Cost/ Unit	Initial Cost
TWR Excavation	cuyds	22,000	$1.50	$33,000.00
Pumping Plant (30 HP)	each	1	$21,000.00	$21,000.00
Underground line - 12"	lnft	1,320	$7.00	$9,240.00
Stand (w/ flow meter)	lnft	8	$243.75	$1,950.00
2 acres lost for storage Annual	ac	2	$176.00	$352.00

[3]Table 4 describes the initial investment cost of implementation estimates for the TWR Scenario for a 160 acre tract. The excavation cost at $1.50 per cubic yard for 22,000 cubic yards amounts to $33,000. In addition, a 30 HP pumping plant will be installed at $21,000, and 12" underground lines at $7/lnft will cost $9,240 for a total length of 1,320 feet. One pump stand (including a flowmeter) costing $1,950 will also be required. The opportunity cost for the 2 acres lost for storage annually is calculated based on current Delta region average lease rate of irrigated land of $176/acre (Parman, 2016) at a total cost of $352 per year.

The TWR Scenario and the TWR+OFS Scenario cash flows were calculated for 3 Sub-scenarios: Delta-wide OFS+TWR (250 systems) leading to a 75% reduction in groundwater withdrawals from baseline, Delta-wide TWR (250 systems) leading to a 25% reduction in groundwater withdrawals from baseline and Delta-wide OFS+TWR and TWR mix (in a 50/50 ratio) leading to a 50% reduction in groundwater

Table 5. TWR+OFS System Investment Cost Estimate[4]

TWR + OFS (160 Acre Project)	Unit	Amount	Cost/ Unit	Initial Cost
TWR Excavation	cuyds	22,000	$1.50	$33,000.00
Reservoir Levees	cuyds	30,000	$1.50	$45,000.00
Pumping Plant (2-30hp)	each	2	$21,000.00	$42,000.00
Underground line - 12"	lnft	1,320	$7.00	$9,240.00
Stand (w/ flow meter)	lnft	8	$243.75	$1,950.00
14 (12+2) acres lost for storage Annual	ac	14	$176.00	$2,464.00

4 Table 5 presents the initial cost of implementation estimates for the TWR Scenario in combination with the on farm storage (OFS) for a 160 acre tract. The TWR pit excavation cost at $1.50 per cubic yard for 22,000 cubic yards amounts to $33,000.00. The project will also require the construction of reservoir levees at an excavation cost at $1.50 per cubic yard for 30,000 cubic yards amounting to $45,000.00 in total costs. In addition, two 30 HP pumping plants will be installed at $21,000.00 each leading to a total cost of $42,000.00, and 12" underground lines at $7/linear foot (installed) will cost $9,240.00 for a total length of 1,320 feet. One stand with flowmeter will also be required at a total cost of $1,950.00. Finally, the opportunity costs for the 14 acres lost for storage annually (2 acres for the TWR, and 12 acres for the OFS) are calculated at a current Delta region average lease rate of $176.00/acre for a total land opportunity cost of $2,464.00.

withdrawals from baseline.

The Sub-scenarios will be implemented on the acreages shown in Table 6, and will lead to the following respective changes in water withdrawals. Sub-scenario 1 (Delta-wide, OFS+TWR) will be implemented on 40,000 acres leading to an annual change in water withdrawals of 55,297 acre-feet or 1.38 acre-feet/acre of project area. Sub-scenario 2 (Delta-wide, TWR only) will be implemented on 40,000 acres leading to an annual change in water withdrawals of 18,432 acre-feet or 0.46 acre-feet/per acre of project area. Sub-scenario 3 (Delta-wide, OFS+TWR, and TWR mix) will be implemented on 40,000 acres leading to an annual change in water withdrawals of 36,865 acre-feet or 0.92 acre-feet/acre of project area.

Costs per acre-foot of change in water pumped from the aquifer were calculated using capital budgeting over a planning horizon of 50 years. For the TWR Scenario as well as for the TWR+OFS Scenario, cost savings were calculated in the form of reduced pumping costs for each Sub-scenario. It is assumed that 49 acre-feet of water will be pumped from the TWR ditch, and 145 acre-feet will be pumped from the TWR ditch into the OFS, and then from the OFS on to the field. It was assumed that all water pumped will use an electrical, vertical line shaft pump. The heights for water lift for pumping water from the TWR system into the OFS, and then from the OFS on to the field were both assumed to be 15 feet. Pump operating and maintenance costs to lift water from the aquifer were estimated to be $14.76/ac-ft for the Delta region. The operating and maintenance costs for pumping water from the TWR system into the OFS, and then from the OFS on to the field were both calculated at $2.76/ac-ft.

Table 6. Estimated Cost per Acre-Foot Not Pumped from the Aquifer for TWR and OFS Sub-scenarios

	Delta Wide TWR +OFS	Delta Wide TWR	Delta Wide 50% OFS +T WR / 50% TWR mix
Acres in Project	40,000	40,000	40,000
Annual Reduction (amount of change in ac-ft)	55,297	18,432	36,865
Total Reduction in acre-feet (50 years)	2,764,850	921,600	1,843,250
Cost per acre foot ($/ac-ft)	$19.76	$24.13	$20.85

The reduced pumping costs for each system were arrived at by multiplying the acre-feet of water pumped using the respective systems by the operating costs associated with pumping an acre-foot of water. This amounted to an annual reduction in water pumped costs of $723.24 for every TWR system for the Delta-wide region, and $2,140.20 for the TWR+OFS system for the Delta-wide region. The NPV of costs of each TWR System were calculated at $88,956 for the Delta-wide region, and the NPV of costs of each TWR+OFS system were calculated at $218,514 for the Delta-wide region.

Table 6 shows the comparisons in costs per acre-foot associated with the TWR, TWR+OFS, and the OFS+TWR and TWR mix Sub-scenarios. The total reduction in water pumped over a 50 year planning horizon was found to be 2,764,850 acre-feet for Delta-Wide TWR +OFS, 921,600 acre-feet for the Delta-Wide TWR, and 1,843,250 acre-feet for the Delta-Wide 50% OFS+TWR/50% TWR mix Sub-scenarios respectively. The annual cost per acre-foot for each Sub-scenario was estimated by dividing the NPV of the costs for the total number of systems installed for each scenario by the total reduction achieved over the 50 years. This amounted to $19.76, $24.13, and $20.85 per acre- foot of reduced pumping for the Delta-Wide TWR +OFS, Delta-Wide TWR, and the Delta-Wide 50% OFS+TWR/50% TWR mix scenarios respectively.

Cash Flows: Enhanced Aquifer Recharge

The cash flow estimates in the Enhanced Aquifer Recharge scenario are based on detailed information provided by ARS personnel for capital equipment and operating supplies used in application of the Enhanced Aquifer Recharge

Table 7. Enhanced Aquifer Recharge Scenario Investment and Maintenance Cost Estimate[5]

Component	Total cost
Extraction / Injection Wells	$5,400,000.00
Booster Pumps	$10,034,000.00
Piping	$55,908,265.00
Miscellaneous	$15,268,453.00
Monitoring & Assessment	$1,000,000.00
Electricity	$2,744,683.00
Redevelopment	$46,394.60
Well Maintenance	$160,000.00
Pipeline Maintenance	$20,000.00
Monitoring & Assessment	$30,000.00

[5] Table 7 presents the cost of implementation estimates for the components required as part of the enhanced aquifer scenario. This estimate includes Extraction / Injection Well costs of $5,400,000, booster pump costs of $10,034,000 (replaced every 15years), and piping costs of $55,908,265. Extraction/ Injection wells will also require replacement of well pumps with electric motors (every 10 years), down-hole flow control valve (to be replaced every 25 years), and SCADA System (to be replaced every 25 years). Initial monitoring and assessment costs were estimated at $1,000,000, and annual monitoring costs for site visits and sample analysis were estimated at $30,000. Annual electricity expenditures were estimated at $2,744,683. Redevelopment charges were estimated at $46,395. Well maintenance is projected to cost $160,000, assuming total work hours at 3,200 for 2 employees working 2 days per well, and being paid $50/hour. Pipeline maintenance was estimated at $20,000 assuming the requirement of 400 work hours being paid at $50/hour.

program. The initial cost of capital equipment and operating supplies was provided by ARS personnel and Eley-Barkley Engineering and Architecture, Cleveland, MS.

The enhanced aquifer recharge Scenario will be implemented on 16,640 acres across the East-Central Delta region and the amount of change in water recharge on account of the Scenario is expected to be 120,976 acre-feet annually, or 7.27 acre-feet/acre of project area. Based on the above projections by the USGS, costs per acre-foot of groundwater recharge were calculated using capital budgeting for a planning horizon of 50 years.

Table 8 shows the costs per acre-foot associated with the enhanced aquifer recharge Scenario in the project region. The NPV for a 50 year planning horizon was estimated at $263,810,846, the annual change in aquifer was 120,976 acre-ft, and the total reduction in water pumped over a 50 year planning horizon was calculated to be 6,048,800 acre-feet. The cost per acre-foot for the scenario was estimated by dividing the NPV of the costs by the total reduction achieved over the 50 years, which amounted to $43.61 for the East-Central Delta region.

Cash Flows: Tallahatchie-Quiver Intra-Basin Transfer

The cash flow estimates in the Tallahatchie-Quiver Intra-basin Transfer scenario are based on data provided by USACE and YMD personnel. Detailed information for capital equipment and operating supplies is available in a USACE report titled "Big Sunflower River Watershed (Quiver River), Mississippi Draft Feasibility Report with Integrated Environmental Assessment", issued in September, 2016.

Net cash flow estimates were made for 6 Tallahatchie-Quiver Intra-basin Transfer Sub-scenarios in the East-Central Delta location. The Scenarios will be implemented on 51,933 acres assuming a ½ mile distribution area around the Quiver River in the East-Central Delta region, and the second scenario will be implemented on 95,893 acres assuming a 1 mile distribution area around the Quiver River across the East-Central Delta region. Three Sub-Scenarios will be calculated assuming 100% adoption, 66% adoption and 33% adoption rates for each Scenario. The amount of change in water withdrawals on account of the scenario implemented over a ½ mile distribution area is expected to be 36,289 acre-feet annually, or 0.70 acre-feet/acre of project area for a 100% adoption rate, 23,951 acre-feet annually, or 0.46 acre-feet/acre of project area for a 66% adoption rate, and 11,975 acre-feet annually, or 0.23 acre-feet/acre of project area for a 33% adoption rate respectively. Additionally, the amount of change in water withdrawals on account of the scenario implemented over a 1 mile distribution area is expected to be 71,917 acre-feet annually, or 0.75 acre-feet/acre of project area for a 100% adoption rate, 47,465 acre-feet annually, or 0.49 acre-feet/acre of project area for a 66% adoption rate, and 23,733 acre-feet annually or 0.25 acre-feet/acre of project area for a 33% adoption rate respectively.

Table 8. Estimated Cost per Acre-Foot of Increased Recharge to the Aquifer for the Enhanced Aquifer Recharge Scenario				
	NPV of Total Cost	**Annual Change in Aquifer (acre-ft)**	**Total Change in Aquifer (acre-ft)**	**Average Cost Change in Aquifer ($/acre-ft)**
Enhanced Aquifer Recharge Scenario	$263,810,846	120,976	6,048,800	$43.61

Table 9. Tallahatchie-Quiver Intra-basin Transfer Scenario Construction Cost Estimate[6]	
Construction Item	**Cost/Unit**
Lands and Damages	$489,000
Relocations	$13,750
Channels	$5,495,491
Pumping Plant	$6,249,012
Main Pump Motors & Pumps	$3,264,064
Engineering Design & Construction Management	$4,724,823
Total	$20,236,140

[6] Table 9 describes the initial investment cost estimates for the components required as part of the Tallahatchie-Quiver Intra-basin Transfer Scenario. The Pumping Plant is assumed to have a life of 25 years. Total annual operating costs are assumed to $550,000 per year.

Table 10. Tallahatchie-Quiver Intra-basin Transfer Scenario Relift Equipment Investment Cost Estimate (1/2 mile distribution area) [7]				
		Adoption Rate		
Tallahatchie- Quiver Project 1/2 Mile Distribution Area	**Cost/Unit**	**100%**	**66%**	**33%**
Pumping Plant (30 HP)	$21,000.00	$6,489,000	$4,284,000	$2,142,000
Underground line - (12")	$7.00	$2,855,160	$1,884,960	$942,480
Stand (w/ flow meter)	$1,950.00	$602,550	$397,800	$198,900
Total Systems		309	204	102

[7] Relift equipment cost estimates required for the Tallahatchie-Quiver Intra-basin Transfer Scenario developed for ½ distribution area is shown above in Table 10 for the East-Central Delta region, for three specific adoption rates (100%, 66%, and 33%) based on Sub-scenario runs provided by the USGS. The number of systems to be used in a ½ mile distribution area assuming 100%, 66%, and 33% adoption rates were 309, 204, and 102 respectively. Initial investment costs associated with 30 HP relift pumping plants at a unit cost of $21,000 for a total of 309 systems was estimated at $6,489,000, $4,284,000, and $2,142,000 for 100%, 66%, and 33% adoption rates respectively. Relift pumps are projected to be replaced every 20 years. Total cost of underground lines at $7.00 per unit for 12" (installed) was estimated at $2,855,160, $1,884,960, and $942,480 for 100%, 66%, and 33% adoption rates respectively. The total costs for stands at $1,950 per unit were estimated at $602,550, $397,800, and $198,900 for 100%, 66%, and 33% adoption rates respectively.

Table 11. Tallahatchie-Quiver Intra-basin Transfer Scenario Relift Equipment and Right of Way Investment Cost Estimate (1 mile Distribution Area) [8]				
		Adoption Rate		
Tallahatchie- Quiver Project 1 Mile Distribution Area	Cost/Unit	100%	66%	33%
Pumping Plant (30 HP)	$21,000.00	$13,755,000	$9,072,000	$4,536,000
Underground line - (12"/15")	$7.00/$12.00	$19,297,080	$12,719,520	$6,359,760
Stand (w/ flow meter)	$1,950.00	$1,277,250	$842,400	$421,200
Right of Way	$10,460.00	$3,619,160	$2,384,880	$1,192,440
Total Systems		655	432	216

[8] Relift equipment cost estimates required for the Tallahatchie-Quiver Intra-basin Transfer Scenario for the 1 mile distribution area is shown above in Table 11 for the East-Central Delta region, for three specific adoption rates (100%, 66%, and 33%) based on Sub-scenario runs provided by the USGS. For a 1 mile distribution area, the number of systems to be used under 100%, 66%, and 33% adoption rates were 655, 432, and 216 respectively. Costs associated with 30 HP relift pumping plants at a unit cost of $21,000 for a total of 655 systems was estimated at $13,755,000, $9,072,000, and $4,536,000 for 100%, 66%, and 33% adoption rates respectively (to be replaced every 20 years). Total cost of underground lines at $7.00 per unit for 12" pipe (installed) for relift systems servicing the ½ mile distribution area and $12.00 per unit for 15" pipe (installed) for relift systems servicing the ½ mile to 1 mile distribution area was estimated at $19,297,080, $12,719,520, and $6,359,760 for 100%, 66%, and 33% adoption rates respectively. The total costs for stands at $1,950 per unit were estimated at $1,277,250, $842,400, and $421,200 for 100%, 66%, and 33% adoption rates respectively. Right of way costs are calculated for the number of systems outside the half-mile distribution area, based on a per system cost of $10,460 for a half mile of right of way (Eley, 2016). Right of way costs were estimated at $3,619,160, $2,384,880, and $1,192,440 for 100%, 66%, and 33% adoption rates respectively.

Table 12. Estimated Cost of Change per Acre-Foot in Reduced Pumping from the Aquifer for the Tallahatchie-Quiver Intra-basin Transfer Scenario (1/2 mile Distribution Area)

	NPV of Total Cost	Annual Change (acre-ft)	Total Change in Aquifer (acre-ft)	Average Cost of Change ($/acre-ft)
Tallahatchie/ Quiver- 100%	$40,369,190	36,289	1,814,450	$22.25
Tallahatchie/ Quiver - 66%	$42,559,883	23,951	1,197,550	$35.54
Tallahatchie/ Quiver - 33%	$44,680,714	11,975	598,750	$74.62

Table 13. Estimated Cost of Change per Acre-Foot of Reduced Pumping from the Aquifer for the Tallahatchie-Quiver Intra-basin Transfer Scenario (1 mile Distribution Area)

	NPV of Total Cost	Annual Change (acre-ft)	Total Change in Aquifer (acre-ft)	Average Cost of Change ($/acre-ft)
Tallahatchie/ Quiver- 100%	$53,868,434	71,917	3,595,850	$14.98
Tallahatchie/ Quiver - 66%	$51,427,291	47,465	2,373,250	$21.67
Tallahatchie/ Quiver - 33%	$49,113,657	23,733	1,186,650	$41.39

Transfer channel construction costs, initial costs of pumping plants installation (useful life of 25 years), engineering design and construction management costs, annual water lift cost to the field, annual operation and maintenance costs were combined to estimate total project cash flow. For the Tallahatchie-Quiver Intra-basin Transfer Scenario savings in pumping costs that result from relifting water from the river as opposed to pumping from the aquifer were calculated for the different adoption rates and distribution areas. The reduced pumping costs for different adoption rates and distribution areas were arrived at by multiplying the number of systems and the operating costs associated with pumping an acre-foot of water. Based on the above assumptions, estimated cost of change per acre-foot of reduced pumping from the aquifer was calculated using capital budgeting for a planning horizon of 50 years.

Table 12 describes the estimated cost of change per acre-foot in reduced pumping from the aquifer associated with the Tallahatchie-Quiver Intra-basin Transfer Sub-scenarios (1/2 mile distribution area). The NPV for a 50 year planning horizon was estimated at $40,369,910, $42,559,883, and $44,680,714 for 100%, 66% and 33% adoption rates respectively, and the corresponding total reduction in water pumped over a 50 year planning horizon was found to be 1,814,450 acre-feet, 1,197,550 acre-feet, and 598,750 acre-feet respectively. The cost per acre-foot for each Sub-scenario was estimated by dividing the NPV of the costs by the total reduction achieved over the 50 years, which amounted to $22.25, $35.54 and $74.62 under 100%, 66% and 33% adoption rates respectively.

Table 13 describes the estimated cost of change per acre-foot in the aquifer associated with the Tallahatchie-Quiver Intra-basin Transfer Sub-scenarios (1 mile distribution area). The NPV for a 50 year planning horizon was estimated at $53,868,434, $51,427,291, and $49,113,657 for 100%, 66% and 33% adoption rates respectively, and the corresponding total reduction in water pumped over a 50 year planning horizon was found to be 3,595,850 acre-feet, 2,373,250 acre-feet, and 1,186,650 acre-feet respectively. The cost per acre-foot for each Sub-scenario was estimated by dividing the NPV of the costs by the total reduction achieved over the 50 years, which amounted to $14.98, $21.67, and $41.39 under 100%, 66% and 33% adoption rates respectively.

Cash Flows: Instream Weirs For Surface-Water Availability
The cash flow estimates in the Instream Weirs for Surface-Water Availability scenario are based on detailed information provided by USACE personnel for capital equipment used in development of the Instream Weirs for Surface-Water Availability program. The relift cost estimates related to moving water from the weirs to the fields are based on estimates made by DREC personnel.

Cash flows were calculated for 2 Sub-scenarios for the Instream Weirs, one for a ½ mile distribution area and the second for a ¾ mile distribution area around select locations on the Big Sunflower River, Quiver River, Bogue Phalia and Clear Creek. The amount of change in water withdrawals on account of the three ½ Mile Distribution Area Sub-scenarios is expected to be 73,290 acre-feet annually for a 100% adoption rate, 48,372 acre-feet annually for a 66% adoption rate, and 24,186 acre-feet annually for a 33% adoption rate respectively. The amount of change in water withdrawals on account of the ¾ Mile Distribution Area Sub-scenarios is expected to be 108,859 acre-feet annually for 100% adoption, 71,847 acre-feet annually for a 66% adoption rate, and 35,923 acre-feet annually for a 33%

Table 14. Instream Weirs Scenario Construction Cost Estimates

Item	Total
Mobilization/Demobilization	$400,000
Filter Fabric	$247,806
R200	$1,053,000
R400	$4,613,752
Filter Stone	$1,648,272
42"/36"/30" Pipe	$214,480
Earth for Weir	$1,217,050
Earth for Cofferdam	$3,806,600
Erosion Control	$46,750
PZ22	$832,200
Mob/Demob Piling Crew	$150,000
Clearing and Grubbing	$98,000
Control of Water	$2,000,000
Total - All Weirs	$16,327,910

Table 15. Instream Weirs Sub-scenario Relift Equipment Investment Cost Estimate for the 1/2 mile Distribution Area[9]

In Stream Weir Project 1/2 Mile Distribution Area	Cost/Unit	Number of Systems - 100%	Number of Systems – 66%	Number of Systems - 33%
Pumping Plant (30 HP)	$21,000.00	$12,642,000.00	$8,337,000.00	$4,179,000.00
Underground line - 12"	$7.00	$5,562,480.00	$3,668,280.00	$1,838,760.00
Stand (w/ flow meter)	$1,950.00	$1,173,900.00	$774,150.00	$388,050.00
Total Systems		602	397	199

[9] Relift equipment cost estimates for the Instream Weirs Project for Surface-water Availability Scenario were developed for the ½ mile distribution area for three adoption rates (100%, 66%, and 33%) based on Sub-scenario runs provided by the USGS. The number of relift systems to be used in a 1/2 mile distribution area assumed for the 100%, 66%, and 33% adoption rates were 602, 397, and 199 respectively. Total relift equipment investment costs associated with 30 HP pumping plants respectively (to be replaced every 20 years) at a unit cost of $21,000 for a total of 602 relift systems was estimated at $12,642,00, $8,337,000, and $4,179,000 for 100%, 66%, and 33% adoption rates respectively. Total cost of underground lines at $7.00 per unit for 12" pipe (installed) was estimated at $5,562,480, $3,668,280, and $1,838,760 for 100%, 66%, and 33% adoption rates respectively. The total Stand costs were estimated at $1,173,900, $774,150.00, and $388,050 for 100%, 66%, and 33% adoption rates respectively.

Table 16. Instream Weirs Sub-scenario Relift Equipment Investment Cost Estimate for the 3/4 mile Distribution Area[10]

In Stream Weir Project 3/4 Mile Distribution Area	Cost/Unit	Number of Systems - 100%	Number of Systems – 66%	Number of Systems - 33%
Pumping Plant (30 HP)	$21,000.00	$19,698,000.00	$12,999,000.00	$6,510,000.00
Underground line - 12" & 15"	$7.00/$12.00	$16,206,960.00	$10,701,240.00	$5,355,240.00
Stand (w/ flow meter)	$1,950.00	$1,829,100.00	$1,207,050.00	$604,500.00
Right of Way	$10,460.00	$3,514,560.00	$2,322,120.00	$1,161,060.00
Total Systems		938	619	310

[10] Table 15 describes the total cost estimates for relift equipment needed for implementation in a ¾ mile distribution area under the Instream Weirs sub-scenario. For a total 3/4 mile distribution area, the number of systems to be used under 100%, 66%, and 33% adoption rates were 938, 619, and 310 respectively. Total relift equipment investment costs associated with 30 HP pumping plants at a unit cost of $21,000 for a total of 938 systems was estimated at $19,698,000, $12,999,000, and $6,510,000 for 100%, 66%, and 33% adoption rates respectively (to be replaced every 20 years). Total cost of underground lines at $7.00 per unit for 12" pipe (installed for ½ mile distribution area) and $12.00 per unit for 15" pipe (installed for systems past the ½ mile distribution area and in the ¾ mile distribution area) was estimated at $16,206,960, $10,701,240, and $5,355,240 for 100%, 66%, and 33% adoption rates respectively. The total Stand costs were estimated at $1,829,100, $1,207,050, and $604,500 for 100%, 66%, and 33% adoption rates respectively.

Table 17. Estimated Cost of Change per Acre-Foot Pumped from the Aquifer for Instream Weirs Sub-scenario (1/2 mile distribution area)

	NPV of Total Cost	Annual Change (acre/feet)	Total Change (acre/feet)	Average Cost of Change ($ per acre/feet)
In Stream Weir – 100%	$1,811,916	73,290	3,664,550	$0.49
In Stream Weir – 66%	$6,724,753	48,792	2,436,600	$2.76
In Stream Weir – 33%	$11,560,932	24,186	1,209,300	$9.56

adoption rate respectively.

Construction costs provided for the Instream Weirs Scenarios includes estimates for 10 weirs located at selected locations on the Big Sunflower River, Quiver River, Bogue Phalia and Clear Creek. The construction cost estimate used in the study was $16,327,910. Itemized construction costs provided by USACE are shown in Table 14.

Weir construction costs and annual water lift cost to the field costs were used to develop the cash flow estimates calculations. For the Instream Weirs Scenario savings in pumping costs that result from relifting water from the weir as opposed to pumping from the aquifer were calculated for the different adoption rates and distribution areas. The reduced pumping costs different adoption rates and distribution areas were arrived at by multiplying the number of systems and the operating costs associated with pumping an acre-foot of water.

Table 17 describes the cost of change per acre-foot in reduced pumping from the aquifer associated with the Instream Weirs Sub-scenario (1/2 mile distribution area). The NPV for a 50 year planning horizon was estimated to provide a savings across all adoption rates due to low initial investment and no specified maintenance costs for the weirs. The total reduction in water pumped over a 50 year planning horizon was found to be 3,664,500 ac-feet, 2,436,600 ac-feet, and 1,209,300 ac-feet respectively. The cost per acre-foot for the sub-scenario was estimated by dividing the NPV of the costs by the total reduction achieved over the 50 years, which amounted to costs of $0.49, $2.76 and $9.56 per acre foot under 100%, 66% and 33% adoption rates respectively.

Table 18 describes the cost of change per acre-foot in reduced pumping from the aquifer associated with the Instream Weirs Sub-scenario (3/4 mile distribution area). The total reduction in water pumped over a 50 year planning horizon was found to be 5,442,950 acre-feet, 3,592,350 acre-feet, and 1,796,150 acre-feet respectively. The cost of change per acre-foot in reduced pumping from the aquifer for each of the sub-scenarios was estimated by dividing the NPV of the costs by the total reduction achieved over the 50 years, which amounted to $1.63, $3.17and $7.74 under 100%, 66% and 33% adoption rates respectively.

Conclusion And Discussion

This study evaluated the costs of implementing five water management alternatives in the Mississippi Delta over a planning horizon of 50 years. Specifically, these were the RISER (Irrigation efficiency) Scenario, the Tail Water Recovery (TWR) and the Onfarm storage (OFS) Scenario, the Enhanced Aquifer Recharge Scenario, the Tallahatchie-Quiver Intra-basin Transfer Scenario, and the Instream Weirs for Surface-water Availability Scenario. In considering the study results, it should be noted that the cost data available for some of the alternatives are more detailed and current than the data for others. The cost data for the RISER and the Tail Water Recovery and Onfarm Storage scenarios are detailed, current, and based on recently implemented projects and practices. The cost estimates for components of the Enhanced Aquifer Recharge scenario are detailed and based on research of current materials and construction and ancillary costs for a project with similar components, but no comparable project has actually been built. Detailed information for capital equipment and operating supplies for the Tallahatchie-Quiver Intra-basin Transfer scenario is available in a USACE report titled “Big Sunflower River

Table 18. Estimated Cost of Change per Acre-Foot Pumped from the Aquifer for the Instream Weirs Sub-scenario (3/4 mile Distribution Area)

	NPV of Total Cost	Annual Change (acre/feet)	Total Change (acre/feet)	Average Cost of Change ($ per acre/feet)
In Stream Weir – 100%	$8,854,799	108,859	5,442,950	$1.63
In Stream Weir – 66%	$11,397,970	71,847	3,592,350	$3.17
In Stream Weir – 33%	$13,897,922	35,923	1,796,150	$7.74

Table 19. Cost of change per acre-foot in reduced pumping from the aquifer comparison of water management scenarios for the Mississippi Delta.

Water management Scenario	Type of change	Amount of change (ac-ft/ year)	Cost ($/ac-ft)
RISER (Irrigation efficiency)	Decrease groundwater withdrawal		
Delta-wide		530,647	13.38
Central Delta		36,710	5.06
Tail Water Recovery (TWR)	Decrease groundwater withdrawal		
TWR only			
Delta-wide		18,432	24.13
TWR + OFS			
Delta-wide		55,297	19.76
50% TWR-OFS/50% TWR			
Delta-wide		36,865	20.85
Enhanced Aquifer Recharge	Increase recharge to alluvial aquifer	120,976	43.61
Quiver/Tallahatchie Intra-basin	Decrease groundwater withdrawal		
1/2 mile distribution area			
100% adoption		36,289	22.25
66% adoption		23,951	35.54
33% adoption		11,975	74.62
1 mile distribution area			
100% adoption		71,917	14.98
66% adoption		47,465	21.67
33% adoption		23,733	41.39
Instream Weirs (Surface water)	Decrease groundwater withdrawal		
1/2 mile distribution area			
100% adoption		73,290	0.49
66% adoption		48,732	2.76
33% adoption		24,186	9.56
3/4 mile distribution area			
100% adoption		108,859	1.63
66% adoption		71,847	3.17
33% adoption		35,923	7.74

Watershed (Quiver River), Mississippi Draft Feasibility Report with Integrated Environmental Assessment", issued in September, 2016. The cost estimates for the instream weirs project was provided by the USACE, which has previously implemented weir construction in the Mississippi Delta region.

Overall results suggest that the instream weirs program resulted in the lowest costs of implementation measured as cost in dollar per-acre foot of reduced pumping from the aquifer among all scenarios, followed by the RISER program. The other alternatives resulted in various levels of implementation costs depending on the location of the project, and/or adoption rates by producers.

The results from this project provide an initial estimate of the costs associated with the different water management alternatives, and builds the groundwork for future in-depth studies addressing the feasibility of implementation, and the associated cost-benefit trade-offs for the proposed water management strategies in the Mississippi Delta.

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Water Treatment and Management

Jason Barrett *(Mississippi State University)*	Mississippi private well owner demographics and characteristics
Catherine Janasie *(University of Mississippi)*	Drinking water supplies- How is your tap water regulated?
Mary Alexandra Fratesi *(University of Mississippi)*	Community-based research strategies to analyze risk of lead contamination in public water supplies in the Mississippi Delta
Aaron Collier *(Collier Consulting, Inc.)*	Essential components for custom water management software utilizing modern web standards and the Amazon cloud

Mississippi Private Well Owner Demographics and Characteristics

Barrett, J.

Mississippi citizens who acquire their drinking water from private wells do not have the luxury of knowing the quality of their drinking water on a regular basis unless they are making the effort to have their water screened and tested. Approximately 90% of Mississippi citizens are served by one of the over 1,200 public water systems which provide safe reliable water under the regulatory enforcement of the Mississippi State Department of Health-Bureau of Public Water Supply. Private well owners are free to operate and maintain their wells because there is no regulatory oversight. For some private well owners, this freedom is welcome but others want to know the quality of their drinking water.

No demographic data about private well owners has been compiled since the 1990 census. At Mississippi State University Extension workshops for the Mississippi Well Owner Network in which private well owners were able to have their well water screened for bacteria, demographic data was collected. This presentation will compare demographic data and characteristics of current private well owners with those from the 1990 census as well as compare to overall Mississippi demographic data. The concluding data can be utilized to better understand and serve Mississippi private well owners.

This study should be of interest to representatives of local municipal water systems, local communities, and rural water associations for potential expansion of their water systems. The expansion of a public water system may achieve multiple goals. Additional customers generate more revenue for the public water system, as well as provide a larger customer base in which to spread costs. The regulatory oversight of public water systems should promote and produce a safer drinking water supply for Mississippi residents.

Drinking Water Supplies- How is Your Tap Water Regulated?

Janasie, C.

In the past, many Americans took the safety of their drinking water for granted. However, recent national news stories about the quality of drinking water have brought water quality to the forefront of many people's minds. Most noteworthy have been the stories of lead contamination in the drinking water supplies in cities like Flint, MI and Jackson, MS. In addition to lead contamination, additional issues with drinking water supplies have also appeared. For instance, in 2014 a harmful algal bloom forced Toledo, OH to issue a two-day ban on the use of the city's tap water, which had tested positive for the toxin microcystin. Further, lawsuits have emerged concerning the drinking water supplies in cities such as New York, NY and Des Moines, Iowa. Litigants in those cases claim there are Clean Water Act violations in the delivery of water to households in the respective cities.

This talk will focus first on how drinking water supplies are regulated in the United States. Next, the talk will review the requirements of the Safe Drinking Water Act, as well as what happens when a drinking water supply exceeds a contaminant level under the Act, such as when the lead level was exceeded in Jackson, MS. In addition, the talk will discuss the role that other environmental statutes, like the Clean Water Act, play in the regulation of our drinking water supplies. Finally, the talk will consider what changes may be coming to the regulation of drinking water in the United States.

Community-Based Research Strategies to Analyze Risk of Lead Contamination in Public Water Supplies in the Mississippi Delta

Fratesi, M.; Woo, L.; Green, J.; Otts, S.; Janasie, C.; Rhymes, J.; Thornton, C.; Avula, B.; Willett, K.

This project includes community-based participatory research and an assessment of residential drinking water supplies and water supply infrastructure in the Mississippi Delta. Additionally, we aim to assess multiple social science approaches to engage stakeholders and influence policy on the current state of lead contamination in drinking water in Mississippi. The 2016-2017 cohort of students enrolled in the Tri-County Workforce Alliance and their parents served as our initial community partners. The participants came from four counties (primarily Coahoma) and 14 municipalities and all reported being on public water systems (e.g. not wells). Participants collected their home drinking water (first catch of the day from kitchen sink, cold water) and samples were analyzed for pH and lead concentrations. Sixty-eight of the 87 distributed bottles (78%) were returned. The pH of the drinking water samples ranged from 7.04-8.23. Notably, lower pH is associated with higher potential to leach lead. Of the samples tested so far from the Delta cohort, only 20 of the samples had lead concentrations above the detection limit, with the highest concentration being 3.45 ppb. All concentrations were well below the EPA 15 ppb action level. Letters were sent to each participant notifying them of their water results. The study is ongoing: demographic data is being analyzed for risk factors associated with lead detects; water sampling data from public water systems is being collected and analyzed; and additional community cohorts are being engaged. For example in the cohort, 85% of the residences were houses (vs. apartments or mobile homes) and 47% of the respondents who estimated the age of their home indicated that it was built before 1985. Ultimately, this project has the potential to help safeguard public health because survey and sampling results will help assess the risks of lead contamination in the Mississippi Delta, assist with the identification of lead service lines and lead plumbing within the distribution systems, and design and guide scalable research and outreach efforts to minimize lead exposure through use of filters and/or behavioral changes.

Essential Components for Custom Water Management Software Utilizing Modern Web Standards and the Amazon Cloud

Gartrell, B.; Bailey, J.; Collier, A.

This talk will discuss the components necessary for custom water management software that utilizes modern web and cloud technology, as well as spatial enterprise Relational Database Management Systems (RDBMS) and the latest NoSQL databases in the Cloud. Water managers need their information capture and display methods modernized to keep pace with today's technology. If your workflow involves paper forms, it is time to modernize. However, don't simply settle for where the industry was a decade ago (e.g. antiquated technologies such as Access and Silverlight).

Utilizing modern technology will realize the following advances:

- The database is no longer fragmented into multiple pieces of outdated software and data repositories.
- Cloud-based enterprise RDBMS eliminates costly infrastructure and time spent doing backups, upgrades, and maintenance of hardware and software.
- Data are readily available and backed up across multiple data centers, so local disaster recovery is instantly achieved.
- With web mapping tied to dashboard and reporting systems, all information is connected.
- Having paper forms integrated as web forms means that all data is collected directly in the Cloud database, resulting in cleaner data and real-time utilization.
- The latest web technology is used to give the most performant and standards based approach.
- The system can be scaled and load balanced to achieve a consistent experience given a small or large number of concurrent users.
- Content can be accessible across mobile/tablet/PC platforms.
- The open architecture of the software is maintainable for years to come.

Delta Sustainable Water Resources: Irrigation Efficiency and Alternative Water Supplies

James I. Palmer, Jr. *(Yazoo-Mississippi Delta Joint Water Management District)*	Those who say it can't be done are often interrupted by somebody doing it
J.R. Rigby *(USDA-ARS)*	Groundwater transfer & injection: Progress toward a managed aquifer recharge option for sustainable groundwater supply
Dave Johnson *(U.S. Army Corps of Engineers)*	Use and benefits of weirs for irrigation water supply, ecological stream restoration, and aquifer recharge
Jason Krutz *(Mississippi State University)*	Irrigation water management strategies that improve crop yield and/or on farm profitability

Those who say it can't be done are often interrupted by somebody doing it

Palmer, Jr., J.

The Yazoo-Mississippi Delta Joint Water Management District (YMD) was established in 1989 by the Boards of Supervisors of the seventeen counties or partial counties comprising the Mississippi Delta physiographic region. The members of the YMD Board of Commissioners (Board) are appointed by the member counties, and the headquarters office of the agency is located in Stoneville, Mississippi. The Executive Director, Deputy Director, and Financial Officer serve as the senior leadership team

> Mississippi law recites:
> It is the policy of the Legislature that conjunctive use of groundwater and surface water shall be encouraged for the reasonable and beneficial use of all water resources of the state. The policies, regulations and public laws of the State of Mississippi shall be interpreted and administered so that, to the fullest extent possible, the ground and surface water resources within the state shall be integrated in their use, storage, allocation and management.

Thus, the principal mission of YMD is to develop water resources management policies, plans, and projects that promote and ensure sustainable surface water and groundwater supplies for the Delta's expanding agricultural economy. In the planning arena, YMD operates under delegation of authority from the Mississippi Commission on Environmental Quality, which approved YMD's current water resources management plan in 2006. In the permitting arena, YMD operates under delegation of authority from the Environmental Quality Permit Board to receive and review applications for permits to utilize surface water and groundwater and make recommendations, through the Board, to the Mississippi Department of Environmental Quality regarding the issuance, denial, revocation, or modification of such permits.

Over the twenty-eight years since its formation, YMD has sponsored the construction of a number of surface water and groundwater projects to maintain and enhance agricultural water supplies, support fisheries, waterfowl, and wildlife habitat, and achieve environmental restoration, in general. The largest of these projects, built in 2005, is a well field that provides groundwater for low flow augmentation in the upper Sunflower River watershed during the irrigation season in the dry weather months of the year from late Summer through late Fall. This presentation will cover both the YMD projects that have been completed over the years and others that the YMD Board is now actively supporting, promoting and pursuing.

Groundwater Transfer & Injection: Progress toward a managed aquifer recharge option for sustainable groundwater supply

Rigby, J.

Sustainable use of the Mississippi River Valley Alluvial Aquifer (MRVAA) for irrigation will require increased efforts to manage and enhance aquifer recharge to meet demand. One scenario for aquifer management involves the development of a groundwater transfer and injection project to move water from the Tallahatchie River to the central Delta. Such a project relies fundamentally on adequate hydraulic connection between the Tallahatchie River and the MRVAA to supply the required water. This presentation will review the conceptual model of the groundwater transfer and injection option and the research necessary to determine its feasibility. Preliminary data on stream-aquifer interactions and groundwater injection from Leflore and Sunflower Counties collected in collaboration with U.S. Geological Survey and Mississippi Department of Environmental Quality will be discussed with implications for larger pilot studies.

Use and benefits of weirs for irrigation water supply, ecological stream restoration, and aquifer recharge

Johnson, D.

Currently groundwater is the primary source of irrigation water supply in the Mississippi Delta, and aquifer levels are declining. In-stream weirs offer a relatively inexpensive means to increase surface water supply. Several factors which affect the cost of weirs will be examined. In addition, the potential benefits of weirs for stream restoration and aquifer recharge will be addressed. Finally, permitting issues will be briefly addressed.

Irrigation Water Management Strategies that Improve Crop Yield and/or on Farm Profitability

Krutz, L.; Pickelmann, D.; Atwill, R.; Leininger, S.; Bryant, C.; McNeal, J.; Wood, W.; Henry, M.; Roach, D.

The Row-crop Irrigation Science Extension and Research (RISER) program has demonstrated how Irrigation Water Management (IWM) practices including computerized hole selection, surge irrigation, soil moisture sensor (SMS) technology, and alternate wetting and drying (AWD) reduces irrigation water use up to 40% while improving profitability by $40/acre. However, very few Mid-South irrigators are using IWM practices. The objectives of this session are to 1) illustrate how computerized hole selection and surge irrigation improves irrigation application efficiency; 2) describe how SMS technology improves irrigation scheduling decision for initiation and termination; 3) inform practitioners how AWD impacts water use, yield, weed control, and N uptake 4) examine on-farm case studies where IWM practices significantly improved corn, soybean and rice yield/profitability.

Statewide Management of Water Resources: MDEQ Office of Land and Water Resources

John Banks *(Mississippi Department of Environmental Quality)*	Monitoring and characterization of water resources in priority areas throughout Mississippi
Kristen Sorrell *(Mississippi Department of Environmental Quality)*	Office of Land and Water Resources: Overview of Mississippi's participation in the National Ground-Water Monitoring Network
Dusty Myers *(Mississippi Department of Environmental Quality)*	Overview of recent dam failures and incidents
Chris Hawkins *(Mississippi Department of Environmental Quality)*	Office of Land and Water Resources: Permitting, certification and compliance division initiatives

Monitoring and Characterization of Water Resources in Priority Areas throughout Mississippi

Banks, J.

The Office of Land and Water Resources is charged with conserving, managing, and protecting the water resources of Mississippi. To help achieve this mission, the Monitoring Branch of the Water Resources Division was created in 2015 to monitor the quantity of the state's ground water and surface water resources. A primary goal for the Monitoring Branch is to characterizing the available water resources in prioritized areas throughout the state each fiscal year. Study areas vary in extent and are prioritized based on factors such as population, demand, and historical record. Prioritized areas are characterized based on the collection and compilation of data from multiple sources regarding current and historical ground water levels, base line water quality, and geology, among other things. The prioritized areas being studied for state fiscal year 2017 are Clarksdale, Starkville, Flowood/Brandon, and McComb.

Office of Land and Water Resources: Overview of Mississippi's Participation in the National Ground-Water Monitoring Network

Sorrell, K.

Water is a vital resource, and water resource management is a high priority concern at both the state and federal level. The National Ground-Water Monitoring Network (NGWMN) was established by the Subcommittee on Ground Water (SOGW) in 2007 to monitor ground-water availability in major aquifers and aquifer systems across the United States. The goal of this network is to collect and compile groundwater level and quality data in a common shareable format so that long term trends can be identified and used to aid in current and future water-resource management decisions. The Office of Land and Water Resources (OLWR), a division of the Mississippi Department of Environmental Quality (MDEQ), has maintained a network of observation wells in the state of Mississippi with recorded water level data dating back to 1930. In 2015, the OLWR began work to incorporate its existing observation well network into the NGWMN database. Participation in this program has allowed the OLWR an opportunity to consider new approaches to data collection, data management, and water resource management by collaborating with other states to develop the network.

Overview of Recent Dam Failures and Incidents

Myers, D.

The goal of the Dam Safety Program is to protect people and property from the damaging consequences of catastrophic dam failures. Each year, there are several dam failures in Mississippi and many other dams are breached under controlled conditions to avoid the possibility of a sudden failure. Some dam failures in the state have caused significant property damage, but there have been no fatalities in Mississippi attributable to a dam failure. Our goal is to provide sufficient oversight of the operational safety and structural integrity of dams in Mississippi to minimize the possibility of a life threatening catastrophic failure occurring at a dam that falls under our jurisdiction.

Since the start of the Mississippi Dam Safety program in 1978 there have been approximately 111 reported dam failures and incidents. This presentation will provide a general overview of dam failure modes, a review of recent dam failures and incidents, and lessons learned.

Office of Land and Water Resources: Permitting, Certification and Compliance Division Initiatives

Hawkins, C.

The Office of Land and Water Resources (OLWR) is responsible for the management of the water resources in Mississippi. § 51-3-1 of the Mississippi Code requires that "…the water resources of the state be put to beneficial use to the fullest extent of which they are capable, that the waste or unreasonable use, or unreasonable method of use, of water be prevented, that the conservation of such water be exercised …" To achieve this requirement, the Permitting, Certification, and Compliance Division administers several programs and is undertaking several initiatives to improve our services. These initiatives include revision of the minimum conservation practices required to obtain a permit from the alluvial aquifer in the delta; expanded water use surveys and reporting tools; improved software for the review and processing of applications for issuance, modification and enforcement of surface and ground water use permits; monitoring of a ground water well network within national framework; and improved licensing and regulating water well contractors operating in Mississippi. OLWR strives to ensure that the use, storage, allocation, and management of water resources of the state be accomplished to the fullest yet sustainable extent possible and that water used in Mississippi complies with applicable permit regulations.

Agricultural Water Storage and Reuse

Mary Love Tagert *(Mississippi State University)*	Multiple benefits provided by an on-farm water storage system in East Mississippi
Domena Agyeman *(Mississippi State University)*	On-farm water storage (OFWS) as a tool to reduce risk
Austin Omer *(Mississippi State University)*	Summary of tailwater recovery system efficiencies as a conservation practice
Austin Omer *(Mississippi State University)*	Economic analyses of tailwater recovery systems

Multiple Benefits Provided by an On-Farm Water Storage System in East Mississippi

Tagert, M.; Paz, J.; Karki, R.; Perez-Gutierrez, J.

A growing number of farmers in East Mississippi have been interested in implementing irrigation to increase yields and reduce risk during periods of infrequent rainfall. However, it is not economically feasible, or even possible in some areas, to use groundwater for irrigation in East Mississippi. Farmers must instead rely solely on surface water for irrigation. Some farmers are able to obtain a permit to withdraw surface water from a nearby stream, but this source also carries the risk of being inadequate in times of sparse rainfall during the growing season. On-farm water storage (OFWS) systems are a better solution for providing water for irrigation in East Mississippi, and these systems are being implemented by producers in this region. After installation of an OFWS system, the pond is commonly gravity-fed by rainfall-runoff collected throughout the year, and fields are typically irrigated using sprinkler irrigation. Storage ponds in East Mississippi are larger than those used conjunctively with groundwater, because they must hold enough water to irrigate a given area throughout the entire growing season. This presentation will discuss the multiple benefits provided by an OFWS system in the Middle Tombigbee–Lubbub watershed (HUC 0316106) in East Mississippi, including reduction of downstream nutrient and sediment runoff and the quantity of surface water provided for irrigation which subsequently increased crop yields.

On-Farm Water Storage (OFWS) as a Tool to Reduce Risk

Agyeman, D.; Williams, B.; Coble, K.; Tagert, M.; Parman, B.

Though irrigation can offer producers many advantages such as reducing potential losses due to uncertain rainfall, in some areas of the Southeast irrigation options for agricultural crops are limited. For example, in East Mississippi access to groundwater resources is impractical, with well depths often exceeding 1,000 feet and prohibitively high drilling costs. As a result, producers are gradually resorting to the use of on-farm water storage systems (OFWS) to recapture irrigation runoff and rainfall for later use for irrigation. Previous research has confirmed reduced groundwater withdrawal and downstream flow of nutrients are some advantages that come with OFWS, but few studies have focused on the economic profitability of this system. This article employs a stochastic benefit-cost analysis to analyze the net returns of irrigating from an OFWS using a center pivot irrigation system (CPIS) compared to a rain-fed production system for corn and soybean in the Southeast while also incorporating risk in the form of stochastic prices and yields. Preliminary findings indicates that investing in an OFWS for irrigating purposes can increase producers returns significantly compared to depending on rainfall. As expected increase in interest rates reduces the net present value of making such an irrigation investment and this is more evident when interest rates are above 7%. The use of OFWS becomes more attractive when revenue generated is protected under crop insurance. As coverage levels increases the net present value of investing in an OFWS increases well above that rain-fed production at lower interest rates, however there's over 60% chance of rain-fed production been more profitable than irrigating at 70%, 75%, 80% and 85% coverage levels when discount rates are over 9%.

Summary of tailwater recovery system efficiencies as a conservation practice

Omer, A.

Water conservation practices are being widely implemented to alleviate sediment and nutrient losses from agricultural land and unsustainable groundwater use for irrigation. Tailwater recovery (TWR) systems are conservation practices being implemented to collect and store runoff to reduce nutrient losses and provide a source of irrigation water. This research is focused on evaluating TWR systems through the following actions: 1) investigate ability to reduce solids and nutrients delivery to downstream systems; 2) determine the potential to irrigate water containing solids and nutrients; and 3) quantify a water budge for TWR systems. Tailwater recovery systems did not significantly reduce concentrations of solids and nutrients; however, loads of solids, P, and N were significantly reduced by 43%, 32% and 44%, respectively. Mean nutrient loads per hectare available to be recycled onto the landscape were 0.20 kg ha^{-1} P and 0.86 kg ha^{-1} N. Water budget analyses show these systems save water for irrigation, but were inefficient. Mechanistically, TWR systems retain runoff on the agricultural landscape, thereby reducing the amount of sediment and nutrients entering downstream waterbodies and provide an additional source of water for irrigation; however, more cost-effective practices exist for nutrient reduction and providing water for irrigation.

Economic analyses of tailwater recovery systems

Omer, A.

Tailwater recovery (TWR) systems are being implemented on agricultural landscapes to reduce nutrient loss and save water on the landscape for irrigation. These systems are a large financial investment for both government agencies (United States Department of Agriculture Natural Resources Conservation Service) and private producers with total costs ranging from $400,000-900,000. Although economic analyses of TWR systems have been modeled, analyses of implemented TWR systems have yet to be completed. Economic studies are necessary to guide adaptive management of conservation funding for appropriation in methods with the greatest return. Therefore, an analysis was conducted on the costs and benefits of TWR systems. Net present values (NPV) and benefit to cost ratios (BCR) of TWR systems were used to compare the benefits to the costs. Three discount rates of 3, 7, and 10% were used on both rented and owned land schemes. Five TWR system scenarios were used in the investigation including dryland, irrigated, irrigation improvements, TWR systems, and TWR systems with external benefits of sediment loss mitigation. NPV and BCRs were positive and greater than one for TWR systems if producers owned the land but remained negative or less than one if land was rented. Beyond improvements to irrigation infrastructure, farms with a TWR system installed lost NPV of $51 to $328 per ha. The range of mean total cost to reduce solids using TWR systems was $0 to $0.77 per kg; P was $0.61 to $3,315.72 per kg; and N was $0.13 to $396.44 per kg. The range of mean total cost to retain water using TWR systems was $189.73 to $628.23 per ML, compared to a range of mean cost of groundwater of $13.99 to $36.17 per ML. Compared to other conservation practices designed to reduce solids and nutrients, TWR systems are one of the least expensive ways to reduce solid losses from the landscape but remain an expensive way to reduce nutrient losses. Using TWR systems to provide an additional source of irrigation water yields a wide range in costs from less expensive than water efficiency conservation practices to similar to the high costs of practices such as desalination. Therefore, TWR systems may be a more expensive conservation practice to retain nutrients and water on the agricultural landscape than other solutions.

Modeling Applications

D. L. Hendon *(GarverUSA)*	Change is coming: An introduction to the next generation of hydraulic modeling
Xiaobo Chao *(University of Mississippi)*	Numerical modeling of flow circulation and chlorophyll concentration in an oxbow lake in the Mississippi Delta
Brian Clark *(U.S. Geological Survey)*	Groundwater availability of the coastal lowlands aquifer system - refinement of a regional-numerical model

CHANGE is Coming: An Introduction to the Next Generation of Hydraulic Modeling

Hendon, D.

Recent developments in hydraulic modeling and 3D computer visualization provide engineers, scientists, CFMs and other users with the tools for a more comprehensive understanding of complex flow patterns that are commonly associated with river crossings and in coastal environments. These tools help locate and illustrate patterns of flow, water surface elevations, depth, velocity, and shear stress. The proper use of these tools allows a more realistic estimation of hydraulic conditions (e.g., scour); floodplain impacts (e.g., FEMA floodplain); aquatic and terrestrial habitat impacts; and extreme weather event scenarios. There is a shift coming in our professions to move from one-dimensional models, such as HEC-RAS, to two-dimensional models. This presentation will cover the differences, applications, and visualizations that are associated with this change. Attendees will be provided an introduction to these new tools so they may have a better understanding of what they look like, what they can do, how they work, and how to use the results.

Numerical Modeling of Flow Circulation and Chlorophyll Concentration in an Oxbow Lake in the Mississippi Delta

Chao, X.; Jia, Y.; Locke, M.; Lizotte, R.

The Mississippi Delta is one of the most intensively farmed agricultural areas of the United States. The quality of surface water resources in this area are particularly vulnerable due to excessive sediment, nutrients, and pesticides transported from upland watershed.

Beasley Lake watershed (BLW) located in Sunflower County of the Mississippi Delta, was selected as one of the Conservation Effect Assessment Project (CEAP) benchmark watersheds to assess environmental benefits derived from implementing USDA conservation programs. The loads of flow, sediment and water quality from the upland watershed were measured by the USDA-ARS National Sedimentation Laboratory (NSL). The weekly or biweekly samples of suspended sediment, nutrients, chlorophyll, bacteria, and other selected water quality variables in the lake were also collected and analyzed. Field measurements show that the concentrations of nutrients and sediment of the lake are greatly affected by the loads of upland watershed.

A water quality model, CCHE_WQ has been developed by National Center for Computational Hydroscience and Engineering, and applied for predicting the distributions of nutrient, phytoplankton, dissolved oxygen, etc., in natural lakes. In Beasley Lake, wind shear is the major driving force for flow hydrodynamics. The flow circulations were simulated using CCHE hydrodynamic model, and the CCHE_WQ model was applied to simulate the concentration of chlorophyll in the lake. The simulated results were generally in good agreement with field measurements. The sensitivity scenarios show that the lake primary productivity is mainly limited by suspended sediment concentration, while it is less sensitive to concentrations of nitrogen and phosphorus

Groundwater availability of the Coastal Lowlands aquifer system - refinement of a regional-numerical model

Clark, B.; Duncan, L.; Foster, L.; Kress, W.

The Coastal Lowlands Aquifer System (CLAS), a large, regional aquifer comprised of multiple hydrogeologic units, is located along the Gulf of Mexico from the Texas/Mexico border through the Florida panhandle. Groundwater withdrawals from the aquifer system are primarily for public supply, irrigation, and self-supplied industry. As withdrawals from the system have increased, some areas along the Gulf have experienced water-level declines, saltwater encroachment, and land subsidence. The U.S. Geological Survey (USGS), as part of the Water Availability and Use Program, is developing a regional groundwater-flow model (~99,000 square miles) to simulate past, present, and projected conditions and to improve understanding of groundwater availability in the CLAS. The model incorporates a refined hydrogeologic framework, as well as improved estimates of aquifer recharge, water use, and groundwater-surface water exchange.

The refined hydrogeologic framework builds on work from the 1980s and 1990s for the USGS Gulf Coast Regional Aquifer System Analysis, and our agency is working with other locate, state, and Federal agencies to integrate data and knowledge gained since the original model was created. Improved land-surface-altitude data and methods to estimate recharge, additional driller's log information, and data extracted from multiple smaller-scale models are a few of the sources for new information. After incorporation of these data and other model parameters, initial estimates of uncertainty will be calculated to help guide additional model refinement as an iterative process. The resultant model (or model ensemble) will quantify groundwater resources in the system and provide uncertainty ranges to better evaluate the predictive capability of future simulations.

Coastal Restoration Projects

Marc Wyatt *(Mississippi Department of Environmental Quality)*	Hancock County marsh living shoreline project
Alina Young *(Mississippi Department of Environmental Quality)*	Oyster restoration and management
Sarah Tracy *(Mississippi Department of Environmental Quality)*	Round Island marsh restoration
Bailey N. Rainey *(Mississippi State University)*	Identification and evaluation of potential impacts of onsite wastewater treatment systems in decentralized communities within the Jourdan River watershed

Hancock County Marsh Living Shoreline Project

Wyatt, M.

The Hancock County Marsh Living Shoreline project will provide for construction of up to 5.9 miles of living shoreline. In addition, approximately 46 acres of marsh will be constructed to protect and enhance the existing shoreline, and 46 acres of subtidal oyster reef will be created in Heron Bay to increase secondary productivity in the area. Located between Bayou Caddy and the mouth of the East Pearl River, the project area falls within the 20,909-acre Hancock County Marsh Preserve. This complex, one of the largest in Mississippi, is part of the Pearl River estuary in the western Mississippi Sound and managed as part of the Mississippi Coastal Preserves Program. Anticipated outcomes for the project include shoreline erosion reduction, creation of habitat for oysters and other secondary productivity, and the protection and creation of marsh habitat. The National Oceanic and Atmospheric Administration (NOAA) is partnering with the State of Mississippi on this project which has been funded by the Natural Resource Damage Assessment (NRDA) Trustee Council.

Oyster Restoration and Management

Young, A.

The Oyster Restoration and Management project was funded by the National Fish and Wildlife Foundation (NFWF) in November 2015. Oyster restoration is a major priority for the state of Mississippi due to oysters' importance to the area's ecology and to the state's economy. The project consists of five components: experimental cultch development, contaminated cultch assessment of the Mississippi Sound, environmental characterization including water quality and benthic mapping, oyster gardening, and a hydrodynamic model of the Lower Pearl River/West Mississippi Sound. These studies will contribute to the technical due diligence that will inform oyster restoration in Mississippi and help to ensure sustainability and success of future investments.

Round Island Marsh Restoration

Tracy, S.

The Utilization of Dredge Material for Marsh Restoration in Coastal Mississippi Project was funded by the National Fish and Wildlife Foundation (NFWF) in November 2014. Over many decades, priority bays on the Mississippi Gulf Coast have experienced significant impacts due to shoreline erosion, storm damage, and alterations to sediment transport, contributing to the loss of thousands of acres of tidal marsh habitat. In the past, most dredge material has been disposed of offshore or in upland dredge disposal areas. This project advances Mississippi's beneficial use program to facilitate a cost-effective, sustainable approach to restoring and protecting significant coastal marsh and bay shorelines. An example of one of these restoration efforts is located in Pascagoula, MS at the Round Island Coastal Preserve. Over 200 acres of marsh were created using dredge material provided by the U.S. Army Corps of Engineers from the Pascagoula Channel. This marsh will create habitat for living coastal and marine resources, reduce erosion along bay shorelines, and improve water quality.

Identification and evaluation of potential impacts of onsite wastewater treatment systems in decentralized communities within the Jourdan River watershed

Rainey, B.; Gude, V.; Truax, D.; Martin, j.

Assessment of water and wastewater quality is crucial to safeguard public health and the environment. However, water quality data on fresh and marine waters in the Mississippi coastal region, especially in the Jourdan River watershed, are still sparse and uncoordinated. Therefore, monitoring these parameters is important for the assessment of the environmental and public health impacts on these water bodies. This research is concerned with the water quality of tributaries in the Jourdan River watershed that could be potentially impacted by wastewater discharges from onsite treatment systems in the surrounding small communities. The tributaries monitored during this study (Orphan Creek, Bayou Bacon, and Bayou La Terre) are not currently monitored by the Mississippi Department of Environmental Quality (MDEQ), but feed directly into the Jourdan River. Seven small communities surrounding these tributaries were identified to evaluate any possible contribution to the water quality impairment in the Jourdan River. Eight sampling locations were selected to evaluate these water quality parameters at upstream and downstream points of these communities. The water quality parameters being monitored during the study were defined on the basis of total maximum daily load (TMDL) reports for monitored waters in the watershed and common nutrient contaminants present in wastewater effluent. Current wastewater treatment and management practices and their impacts on these receiving water bodies were assessed for the representative communities. This presentation will discuss the preliminary evaluation of the water quality parameters and a present perspective on the local water quality issues of the watershed.

Nutrient Reduction

Jason M. Taylor *(USDA-ARS)*	Enhancing ditch denitrification with rice cutgrass: Experimental evidence for a simple nitrate runoff mitigation tool
Matt Hicks *(U.S. Geological Survey)*	Evaluating change in intermittent streams monitored by the Mississippi Delta's nutrient reduction strategy efforts: Successes and challenges
Jao-Young Ko *(Jackson State University)*	Policy dimension of adopting wetlands assimilation to increase the NPDES compliance rates for municipal wastewater plants in Mississippi
Daniel S. Spencer *(Mississippi State University)*	An economic analysis of agricultural crop production in the Mississippi Delta under alternative nutrient management strategies

Enhancing ditch denitrification with rice cutgrass: experimental evidence for a simple nitrate runoff mitigation tool

Taylor, J.; Speir, S.; Moore, M.; Scott, J.

Widespread implementation of best management practices (BMPs) that mitigate nitrogen (N) runoff are needed to reduce significant environmental impacts including eutrophication of fresh and coastal waters. Denitrification is a biologically-mediated mechanism that converts $NO_{3-}N$ to N_2 gas and reduces N transport to downstream waterbodies. We investigated $NO_{3-}N$ mitigation and denitrification potential in ditch sediments vegetated with rice cutgrass (L*eersia oryzoides*). An initial study was conducted to quantify differences in N retention and denitrification during experimental runoff events between three different vegetation treatments: unvegetated, rice cutgrass, and common cattail (Typha latifolia L.). Vegetated mesocosms removed significantly more $NO_{3-}N$ from the water column than unvegetated systems. However, sediments planted with cutgrass had significantly higher average denitrification rates (5.93 mg m^{-2} h^{-1}) than cattails and unvegetated sediments (0.2 mg and 0.19 m^{-2} h^{-1}). Whole mesocosm mass balance indicated that denitrification accounted for as much as 56% of the immobilized nitrate over a 48 hr period. A follow up study examined the effects of nitrate availability on uptake and denitrification in sediments planted with cutgrass over four seasons. Michaelis-Menten models described the relationship between nitrate concentration and N_2 flux rates for spring, summer, and fall seasons. Summer denitrification models exhibited the highest V_{max} and K, with maximum N_2 fluxes of approximately 20 mg m^{-2} h^{-1}. Denitrification rates were strongly correlated with $NO_{3-}N$ uptake by vegetated sediments in spring and summer, but low uptake in fall and winter resulted in virtually no net denitrification during these seasons. Whole mesocosm 48 hr denitrification was estimated using models from study 2 applied to data from study 1. The predicted contribution of denitrification to N mitigation based on Michaelis-Menten kinetics was slightly higher, less variable, but within one standard error of original estimates based on applying average denitrification rates to mass balance estimates for the same data set (310.80 ± 5.03 vs 284.48 ± 29.69 mg). Our results indicate that ditch sediments vegetated with cutgrass not only immobilize a significant fraction of nitrate, but also permanently remove significant amounts of immobilized nitrate through microbial denitrification. Ditches vegetated with cutgrass can provide an important tool for mitigating N runoff from agricultural landscapes, particularly during the growing season when ditches receive irrigation tailwater.

Evaluating Change in Intermittent Streams Monitored by the Mississippi Delta Nutrient-Reduction Strategy Efforts: Successes and Challenges

Hicks, M.

Evaluating the effectiveness of on-field implementation of agricultural best management practices (BMPs) to improve downstream water quality is a challenge due to seasonal and temporal fluctuations in streamflow and water chemistry and to the limited resources available to monitor these two variables. Yet consistent monitoring and evaluation of collected data is the ideal way to document water-quality changes. In 2010, the U.S. Geological Survey began monitoring in several small drainages in northwestern Mississippi as part of nutrient-reduction strategy efforts in the Mississippi Delta. Various BMPs were implemented to reduce sediment and nutrient runoff in the drainages. Water quality and streamflow were monitored for 5-10 years and data were evaluated and then correlated with observed changes in BMPs. Data analysis progressed in a two-step approach. First, exploratory analyses were completed to evaluate the general hydrologic and water-quality conditions of each site. Then, inferential analyses including tests of differences and equivalences were completed using bootstrapping or an assumed distribution based on the available data. Finally, a power analysis was completed to evaluate the minimum detectable change in water quality possible based on the collected data and to determine the ideal number of samples that need to be collected in the future for similar studies. An example of these data-analysis results will be presented for an intermittent tributary that drains into Bee Lake. This particular tributary has had several BMPs installed over the study period. The results of the analysis and "lessons learned" during monitoring, summarized as successes and challenges presented by this approach, will provide relevant information for forthcoming analyses and similar future studies in this area.

Policy dimension of adopting wetlands assimilation to increase the NPDES compliance rates for municipal wastewater plants in Mississippi

Ko, J.; Day, J.

The Clean Water Act has been contributing to water quality improvement and enhanced ecological integrity of natural ecosystem in the United States. However, water pollution driven by poorly treated municipal wastewater still has been significant deterrent factor in achieving the goals of the Clean Water Act, especially in the economically depressed Southern Region, causing harms to the human health, and the aquatic ecosystems. Academicians and government officials have advocated incorporating ecosystem services as a tool to increase compliance rates of the environmental regulation.

Economically poor communities across the Southern Region show poor compliance records of the NPDES regulation. For example, as of 2008, the compliance rate among the 1,437 NPDES permits of the wastewater treatment plants in State of Mississippi was below 50%, and so far, no significant compliance improvements have been reported. Wetlands assimilation is one of the Best Available Technology (BAT), allowed by the EPA. However, the State of Mississippi has not adopted the wetlands assimilation as a policy tool. On the contrary, the State of Louisiana has adopted policy guidelines of using natural wetlands to assimilate nutrients in secondarily treated municipal effluent, thus utilizing ecosystem services of natural wetlands, and improving the EPA regulation with reduced financial burdens to local communities.

We reviewed the state policy formulation process of wetlands assimilation in Louisiana by analyzing the implementation of the Clean Water Act from an inter-governmental relation among federal, state, and local governments for expansion of wetlands assimilation, and we found that the communities which have adopted the wetlands assimilation method have complied their NPDES permits successfully, with reduced financial burdens.

Local communities in Mississippi have been under serious financial burdens, resulting from declining residential population, and declining property tax base. In addition, increasing regulations and unfunded mandates, compounded with political pressures of no-property tax increase have been declining local government's capacity to comply with the environmental regulations.

State of Mississippi may need more active and trustworthy dialogues among State and local governments, scientists, and local community leaders, with results from science-based field studies, and the case studies available from neighboring states. We believe that the wetlands assimilation method is a strong alternative for cost-effective ways in increasing the NPDES compliance in Mississippi.

An Economic Analysis of Agricultural Crop Production in the Mississippi Delta Under Alternative Nutrient Management Strategies

Spencer, D.; Barnes, J.; Coatney, K.; Parman, B.; Coble, K.

Several recent studies have examined how excess nutrient runoff from nitrogen and phosphorous have caused environmental damage in the United States. Perhaps the most significant is the hypoxia zone in the Gulf of Mexico. As a result, regulation of these nutrient levels has emerged as an important step toward environmental stewardship, yet this has been an uneven process. Some states have developed strict regulations to decrease nutrient runoff, but the majority of states have favored broader goals of reducing nutrient runoff using best management practices (BMPs) instead of strict regulations.

This presentation will showcase the empirical results and methodology used to examine the economics of alternative nutrient management strategies that can be used at the farm level to meet alternative standards for nitrogen and phosphorous runoff. We explain how we used a new methodological approach to understand alternative production practices and nutrient management strategy economics from a farm level perspective. The Agricultural Policy and Environmental eXtender (APEX) biophysical simulation model is used along with enterprise budgets to understand the cost impacts of alternative management practices and water quality standards in the Mississippi Delta.

Surface Water-Groundwater Interaction

Surface Water-Groundwater Interaction

Benjamin V. Miller *(U.S. Geological Survey)*	Surface-geophysical surveys to characterize lithological controls on aquifer recharge and surface water–groundwater exchange
Courtney Killian *(Mississippi State University)*	Characterizing groundwater and surface-water interaction throughout the Mississippi Delta using hydrograph-separation techniques combined with near-stream geophysical and groundwater-level data
Michael Gratzer *(University of Mississippi)*	Quantifying recharge to the Mississippi River Valley Alluvial Aquifer from oxbow-lake-wetland systems
Meredith Reitz *(U.S. Geological Survey)*	Estimating water budget components of evapotranspiration, recharge, and runoff for Mississippi and the Mississippi Alluvial Plain

Surface-Geophysical Surveys to Characterize Lithological Controls on Aquifer Recharge and Surface Water–Groundwater Exchange

Miller, B.; Kress, W.; Ladd, D.

The U.S. Geological Survey (USGS) developed a groundwater-flow model of the Mississippi Embayment Regional Aquifer System (MERAS) that incorporated multiple aquifers including the Mississippi River Valley alluvial (MRVA) aquifer. In addition to groundwater withdrawal, two major fluxes in the model are recharge from precipitation and surface water-groundwater exchange. In order to determine appropriate values for recharge to the MERAS model, the USGS has utilized two published datasets- the geomorphology of Quaternary deposits and local soil surveys. At a regional scale, recharge in the MERAS model correlate well with large-scale geomorphological features. However, there is little spatial variability, so local-scale variations in recharge are not adequately represented. Higher resolution data such as soil coverages provide a more spatially-variable estimates of recharge, but, soil-survey data often characterize the shallow soil horizon and do not reflect the generalized geomorphological features in which the horizon lies. In addition, streambed sediments may differ greatly from the mapped geomorphologic areas and shallow soils due to alteration from stream mechanics. Thus, geomorphologic maps and soil information are both types of surficial information that may not accurately reflect the underlying hydrogeology that controls infiltration of recharge water or the composition of streambed sediments.

In 2016, the USGS conducted a surface-geophysical survey to characterize the near-surface (<15 m) lithology that controls recharge to the MRVA aquifer and surface water-groundwater exchange at selected locations in northwestern Mississippi. Two-dimensional vertical profiles of resistivity identified differences in geoelectrical properties of the streambed for reaches of the Tallahatchie (60 km), Quiver (50 km), and Sunflower (70 km) Rivers. Resistivity profiles of each stream were able to detect boundaries of individual geomorphic features. In addition, terrestrial-based resistivity surveys identified variations in geoelectrical properties from Money to Steiner, Mississippi, a distance of approximately 68 km. The terrestrial-resistivity survey showed distinct differences in surface soil resistivity based on lithology. Drilling logs of wells along the Sunflower River confirmed that lithologic descriptions correlated positively with the resistivity profiles.

Characterizing groundwater and surface-water interaction throughout the Mississippi Delta using hydrograph-separation techniques combined with near-stream geophysical and groundwater-level data

Killian, C.; Barlow, J.; Barlow, P.; Kress, W.; Schmitz, D.

The Delta, an area dense in agriculture, is situated between the Mississippi and Yazoo Rivers in northwest Mississippi. Stream and groundwater levels in the Delta have shown declines with the increase in irrigation to support agricultural production. In 2016, the U.S. Geological Survey (USGS) began a study to better understand the effects of pumping on groundwater and its availability in the Mississippi River Valley alluvial (MRVA) aquifer. The alluvial aquifer is the uppermost hydrologic unit in the Delta and supplies most of the groundwater used for agricultural irrigation. Understanding the relation between withdrawals and groundwater response in the alluvial aquifer could allow for the estimation of changes in groundwater availability over time and can help to determine the best water-resource-management practices for the study area. A spatially-distributed network of paired groundwater and surface-water streamgage sites provided hydrologic data to characterize groundwater/surface-water interaction throughout the Delta. Baseflow, the amount of groundwater that contributes to streamflow, was estimated for each site using hydrograph-separation methods. The USGS Groundwater Toolbox open-source software provides several techniques for hydrograph separation and was used for this study. Recently collected geophysical data along selected streams in the Delta provided insight to the hydraulic conductivity, or ease with which water moves through the soils and unconsolidated sediments, was coupled with the hydrograph-separation results. This combination of techniques allowed for better characterization of groundwater/surface-water interaction at the selected sites. Characterizing and defining these types of hydrologic relations will help USGS scientists refine a regional model of the Delta that will be used to aid water-resource managers in future decisions pertaining to the alluvial aquifer.

Quantifying Recharge to the Mississippi River Valley Alluvial Aquifer from Oxbow-Lake-Wetland Systems

Gratzer, M.; Davidson, G.; O'Reilly, A.; Rigby, J.

Irrigation-related groundwater withdrawals have caused declining water levels in the Mississippi River Valley Alluvial Aquifer (MRVAA) since the late 1920s. To manage this resource, recharge sources must be quantified. This study examines recharge through oxbow lakes, which are numerous in the Mississippi Delta. Previous investigations at Sky Lake, an ancient Mississippi River oxbow with an associated wetland, near Belzoni, Mississippi, suggest that oxbow wetlands may contribute significant recharge to the MRVAA. Multiple methods using geologic, hydrologic, and temperature data are being employed to identify and quantify recharge from the Sky Lake oxbow lake-wetland system. Two wetland soil cores were collected to depths of approximately 7 m, encountering 6 m of clay and silt before penetrating into sands and gravels. Monitoring of MRVAA water levels in two piezometers in the wetland and nine monitoring wells in Sky Lake's vicinity began during the 2016 drought and will continue through the rainy season to track groundwater responses. The potentiometric surface will be mapped to identify possible groundwater mounding beneath the lake, which would indicate vertical recharge. Preliminary results from mid-December, 2016, indicate a general groundwater flow direction to the west beneath the lake. Wells are outfitted with temperature-recording data loggers at specific depth intervals. The groundwater temperature profiles have the potential to differentiate localized wetland-recharge from regionally distributed infiltration, or from recharge from the nearby Yazoo River. Soil temperatures 30 and 60 cm below ground at ten points in the wetland are also being monitored over time to characterize small-scale variations in downward flux. Preliminary results are consistent with earlier work indicating preferential flow pathways through the fine-grained bottom sediments due to an abundance of buried trees and limbs in various stages of decomposition.

Estimating water budget components of evapotranspiration, recharge, and runoff for Mississippi and the Mississippi Alluvial Plain

Reitz, M.; Sandord, W.; Senay, G.; Kress, W.

As water resources become increasingly strained in the US and globally, the development of reliable water availability estimates is needed for making informed water use management decisions. Here we present new 800m annual estimates of water budget components of evapotranspiration (ET), surface runoff, and recharge, produced using various data sources such as soil properties, surficial geology type, stream gage and climate data for 2000-2013. Groundwater-sourced irrigation is included as a component in the local water budget, using data from USGS county-level compilations. The ET and recharge estimates compared favorably when checked against independent field data, and against other ET estimation methods. We show results for the state of Mississippi, and also for the focus area of the Mississippi Alluvial Plain, which has seen significant impacts on water resources due to irrigation and groundwater pumping. Comparisons with USGS groundwater withdrawal data indicate regions where rates of water use may be unsustainable. We summarize results of the water budget estimates for the 2000-2013 timespan for both the state of Mississippi and the Mississippi Alluvial Plain. Finally, we show preliminary results of current work to estimate water budgets on a monthly timescale, through a combination of remote sensing and ground-based data.

Ecological Studies

Anna Linhoss *(Mississippi State University)*	Calibration and comparison of forest canopy interception models
Richard Lizotte *(USDA-ARS)*	Drawdown II: Water quality and ecological responses to a managed hydrologic drawdown during autumn
Clay Mangum *(Weyerhaeuser Company)*	Multi-species environmental DNA screen of aquatic species in the Sipsey River in Alabama
Yafei Jia *(University of Mississippi)*	Numerical Simulations of Spilled Coal-Ash in The Dan River and The Environment Impact of the Incident

Calibration and comparison of forest canopy interception models

Linhoss, A.; Siegert, C.; Levia, D.

Rainfall interception by the forest canopy plays an important role in the water budget by removing water from the terrestrial hydrologic cycle. Effective models of canopy interception are critical for simulating the water budget and river flows. Over the years, several models have been developed to simulate canopy interception. Few comparative studies have been conducted that assess how well these models simulate measured interception. The objective of this study was to compare five mechanistic canopy interception models including the Rutter, Rutter Sparse, Gash, Sparse Gash, and Liu models. Each model was calibrated independently using PEST, and automatic parameter estimation routine. The five models were calibrated for American beech and yellow-poplar stands as well as under leafed and unleafed conditions. Overall, the models behaved somewhat similarly. Cumulative error ranged between 0.0% and 14.9%. The models were also assessed for their ability to accurately simulate interception during individual rainfall events. The coefficient of determination (R^2) between measured and modeled interception events ranged between 0.21 and 0.48. An important reason for the low R^2 values is the fact that the models were unable to simulate very low or very high levels of interception. Measured interception ranged between 0.2 and 12.2 mm while modeled interception only ranged between 1.2 and 6.9 mm. These results indicate an important gap in our ability to simulate a substantial portion of the water budget.

Drawdown II: Water quality and ecological responses to a managed hydrologic drawdown during autumn

Lizotte, R.; Jenkins, M.

A water drawdown of Roundaway Lake, a tributary of the Big Sunflower River, was initiated in mid-autumn to alleviate critical low river flow. While water releases have been demonstrated to alleviate critical low flows, effects of these releases on water quality in contributing tributaries is necessary to improve water resource management decisions. The purpose of the present study was to assess the responses of lake surface water chemical and ecological components including nutrients, phytoplankton and ecoenzyme activities. Lake drawdown began on October 17, 2016 and finished after 14 days when outflow was <0.1% of peak flows and shallowest depths occurred 35 days after drawdown with decreased depths of 56%, 23% and 90% at upstream, lake, and downstream sites, respectively, relative to pre-drawdown depths. Control pond depths during the study period ranged from 82-113% relative to pre-drawdown depths with changes due to evaporation and rainfall. Water samples were collected on days -3, 0, 1, 2, 3, 7, 14, 21, 28, 35, and 42 at the three drawdown sites and an adjacent control pond site (no drawdown) to account for natural seasonal variations. Chemical analyses included soluble nutrients ($PO_{4\text{-}}P$, $NH_{4\text{-}}N$, $NO_{2\text{-}}N$, $NO_{3\text{-}}N$), total nutrients (TP, TN) and organic carbon. Ecological analyses included algal chlorophyll, phycocyanin and photosynthetic efficiency as well as a suite of five ecoenzyme activities. Nutrient changes were greatest at sites with the largest changes in water depth. Upstream dissolved organic nitrogen ($NH_{4\text{-}}N$, $NO_{2\text{-}}N$, $NO_{3\text{-}}N$) increased by >100%, while organic carbon exhibited bimodal changes. Downstream $PO_{4\text{-}}P$, C:N ratios, and C:P ratios all increased by >100%, organic carbon increased by 50% and TP decreased by 45%. Lake nutrients exhibited modest bimodal changes in $NH_{4\text{-}}N$, $NO_{2\text{-}}N$ and organic carbon while control pond $NO_{2\text{-}}N$ decreased by 50%. Similar to nutrients, algal responses were strongest upstream and downstream. Upstream phycocyanin concentrations increased by >70% while photosynthetic efficiency decreased by 75-80%. Downstream chlorophyll and phycocyanin concentrations decreased by 75-85% and photosynthetic efficiency decreased by 66-90%. Lake and control algal responses were modest with chlorophyll concentrations decreasing by 22-30% and photosynthetic efficiency decreasing by 25-45%. Ecoenzyme activity responses were modest at most sites with bimodal changes to Β–glucosidase:alkaline phosphatase ratios upstream and leucine aminopeptidase in the lake. Greatest changes occurred downstream where Β–N-acetylglucosaminidase, fluorescein diacetate and alkaline phosphatase decreased by 76%, 77% and 98%, respectively. The study contributes valuable information supporting water resource management goals to sustain river and lake ecosystem integrity.

Multi-species environmental DNA screen of aquatic species in the Sipsey River in Alabama

Mangum, C.; Homyack, J.; Atkinson, C.

The Southeastern U.S. is rich in biodiversity with over 1000 species of fish, mussels and crayfish alone Aquatic species are often cryptic, found in low densities, and their current geographic distribution not well-described. Environmental DNA (eDNA) is an emerging technique to detect and identify species-specific DNA fragments in water and soil samples. Modern genome sequencing technology can obtain millions of DNA sequences from a single sample, making it possible to identify organisms by the residual DNA (e.g., feces, urine, skin cells) they shed in their environment. A pilot project was conducted to use data and samples from a freshwater mussel study for eDNA analysis, to evaluate both the effectiveness of the technology to identify known species and to refine field methods. Dr. Carla Atkinson, University of Alabama, is conducting a field study examining abundance and diversity of freshwater mussels in the Sipsey River, Alabama. The Sipsey River is one of the last free flowing rivers in Alabama and it is considered one of "Alabama's Ten Natural Wonders." The river has a 37 mussel species and 102 fish species reported and represents one of the best remaining and most intact mussel communities left in the United States. Water samples were collected in the vicinity of identified mussel species, and submitted for eDNA analysis. An overview of the mussel study and year one data collection will be presented, as well as eDNA field methodology. This non-invasive screening tool has many uses ranging from verifying presence or absence of threatened and endangered species to monitoring of invasive species. Collecting information on aquatic species is difficult and labor intensive with federal permits need for threatened and endanger species. This method is fast, cost effective, and does not require a permit.

Numerical Simulations of Spilled Coal-Ash in The Dan River and The Environment Impact of the Incident

Jia, Y.; Altinakar, M.; Chao, X.; Zhang, Y.

39,000 ton of coal ash and 27 million gallons of waste water were released accidentally into the Dan River from the Dan River Steam Station on 2/2/2014. The chemicals brought with the coal-ash and the waste water into the Dan River caused serious concerns of the residents along the river and government agencies because the river is an important source of water supply. Studies supported by the Duke Energy using a 2D numerical model, CCHE2D, were carried out. This is a general free surface flow model with sediment transport, pollutant transport and bed change simulation capabilities. The Dan River from the spill site to the downstream School Field Reservoir, a 40km curved channel stretch was simulated. The channel morphologic change due to sediment transport and coal ash transport were simulated for allocating the coal ash deposition in the alluvial system. Both bed load sediment and suspended sediment transport were both simulated. The coal ash is of very fine particles, most of them are treated as suspended sediments. Transport of Arsenic and Selenium brought by the incident are simulated to evaluate the environment impact. The simulation results are comparable to the data measured in emergency.

Innovative Studies and Applications

Ryan F. Adams *(U.S. Geological Survey)*	Enhanced characterization of the Mississippi River Valley Alluvial aquifer using surface-geophysical methods: A pilot study near Money, Mississippi
Kaitlin Voll *(University of Mississippi)*	Variable pathways and geochemical history of seepage under the Mississippi River Levee: Observations from the 2011, 2015, and 2016 floods
Benjamin Runkle *(University of Arkansas)*	Rice irrigation strategies: Alternate wetting and drying and methane reductions
Ruixiu Sui *(USDA-ARS)*	Variable rate irrigation technology for improving water use efficiency
Hughbert Collier *(Collier Consulting, Inc.)*	Integrating hydrogeology, well design and drilling techniques to maximize production and minimize problems
Clifford A. Ochs *(University of Mississippi)*	The Mississippi Water Security Institute: Report on year 1; plans for year 2
Cory Gallo *(Mississippi State University)*	The Rainworks Challenge Bioretention Demonstration Project

Enhanced Characterization of the Mississippi River Valley Alluvial Aquifer Using Surface-Geophysical Methods - a Pilot Study near Money, Mississippi

Adams, R.; Kress, W.; Minsley, B.; Kass, M.

The Mississippi River Valley alluvial (MRVA) aquifer is a complex and poorly understood near-surface aquifer system used to supply irrigation for agriculture across the alluvial plain of the Lower Mississippi River basin. The thickness and extent of the aquifer units are typically determined by evaluating geophysical and driller logs from test holes at spatially discrete points. Surface-geophysical data, along with borehole-geophysical and lithologic data from test holes, can be used to provide high-resolution three-dimensional characterization of the aquifer system. In 2016, the U.S. Geological Survey (USGS) conducted a pilot study to demonstrate the use of surface-geophysical methods for delineation of near-surface geologic features, characterization of alluvial aquifer properties, and evaluation of surface water/groundwater exchange in the MRVA. The area chosen for this pilot was a 100-acre plot in Money, Mississippi. The study approach integrated waterborne and terrestrial resistivity and nuclear magnetic resonance (NMR) surveys to develop a three-dimensional geoelectrical model of the site. This integrated approach helped define the 100-150 feet of sand aquifer and the contact of the clay-confining unit beneath it. Shallow terrestrial-resistivity surveys confirmed that the clay-rich loam at the land surface continues as a clay-rich alluvial deposit approximately 25-50 ft thick beneath the study area. The presence of this relatively impermeable layer above the alluvial aquifer has the potential to limit vertical recharge from precipitation or irrigation. The NMR survey was used to determine that the aquifer volume consists of 30% water with two-thirds of that available for use. Comparisons of the waterborne- and terrestrial-resistivity surveys were used to identify that a hydraulic connection or potential for water exchange, between the Tallahatchie River and the MRVA is possible. These geophysical observations provide a more accurate understanding of the local hydraulic properties and hydrology of the MRVA aquifer at this site, and will contribute new data to constrain a regional, numerical groundwater model.

Variable pathways and geochemical history of seepage under the Mississippi River Levee: Observations from the 2011, 2015, and 2016 floods

Voll, K.; Davidson, G.; Kelley, J.; Corcoran, M.; Borrok, D.; Ma, L.

Seepage beneath levees during flood stage becomes a concern when piping occurs, opening up channels beneath the levee and forming sand boils where transported sediments discharge. Along the lower Mississippi River, the pathway beneath the levee varies with surface geology, following deeper paths where the levee sits on channel fill deposits, and shallower paths where it sits on sand bar deposits. A preliminary investigation north of Vicksburg, MS, during the 2011 flood, demonstrated the potential for using aqueous geochemistry to differentiate sand boils forming at the end of deep and shallow flow pathways. Deeper flow through the geochemically stratified Mississippi River Valley Alluvial Aquifer (MRVAA) produces discharge low in oxygen and high in redox sensitive elements such as iron and arsenic. Shallow flow contains measureable oxygen and much lower iron and arsenic concentrations. Sampling during the 2015 and 2016 events for bulk chemistry, trace metals, tritium, and stable isotopes of oxygen, hydrogen, iron, and strontium, is enhancing our understanding of the nature of flow and the geochemical evolution of the local groundwater.

Oxygen and hydrogen isotopes suggest that river water experiences significant evaporation before recharging to the MRVAA. Shallow flow pathways beneath the levee are characterized by lower iron isotope ratios, and higher strontium isotope ratios, reflecting interaction with unique mineral phases and distinct reaction pathways. Sand boil discharge following deeper flow pathways group isotopically and geochemically with relief wells, or between relief-well and river end-members. Boil discharge following shallow pathways does not just plot closer to river water. River water passing through the shallow aquifer is altered in ways that will require installation and sampling of dedicated shallow wells to fully understand. Tritium results reveal a dynamic system, where flow paths may vary over between floods or within a continuous flooding event.

Rice irrigation strategies: Alternate wetting and drying and methane reductions

Runkle, R.; Suvocarev, K.; Reba, M.

Approximately 11% of the global 308 Tg CH4 anthropogenic emissions are currently attributed to rice cultivation. In this study, the impact of water conservation practices on rice field CH_4 emissions was evaluated in Arkansas, the leading state in US rice cultivation. While conserving water, the Alternate Wetting and Drying (AWD) irrigation practice can also reduce CH_4 emissions through the deliberate, periodic introduction of aerobic conditions. Seasonal CH_4 emissions from a pair of adjacent, production-sized rice fields treated with continuous flood (CF) and AWD irrigation were estimated and compared during the 2015 and 2016 growing seasons using the eddy covariance (EC) method on each field. The seasonal cumulative carbon losses by CH_4 emission significantly less for the AWD treatment. The substantial decrease in CH_4 emissions by AWD supports previous chamber-based research and offers strong evidence for the efficacy of AWD in reducing CH4 emissions in Arkansas rice production. Plans for the 2017 measurement season will be discussed, including a mixture of EC and surface renewal micrometeorological techniques on 16 adjacent 40-acre fields under various irrigation practices in northeast Arkansas. The AWD practice is incentivized by several USDA-NRCS conservation programs and is used for carbon offsets trading, so reductions of both water use and CH_4 emissions are encouraged on a regional scale.

Variable Rate Irrigation Technology for Improving Water Use Efficiency

Sui, R.

VRI technologies allow the producers to site-specifically apply irrigation water at variable rates within the field to adjust the temporal and spatial variability in soil and plant characteristics. Adoption of VRI has the potential to improve water use efficiency. VRI technologies are normally implemented on self-propelled center-pivot and linear-move sprinkler irrigation systems. VRI practices require specialized hardware and software. The hardware requirements include a GPS receiver to determine the spatial position of the irrigation system and an intelligent electronic device to control individual sprinklers or groups of sprinklers to deliver the desired amount irrigation water on each specific location within the field according to the VRI prescription. The software required includes the algorithms to calculate the water application rates and the computer programs to create VRI prescription maps. This proposed presentation will introduce the VRI technology and provide a case study on VRI application in Mississippi Delta for improving water use efficiency.

Integrating hydrogeology, well design and drilling techniques to maximize production and minimize problems

Collier, H.

Constructing a water well that maximizes its production rate, efficiency, and lifespan requires integrating hydrogeology, well design, and drilling techniques. Unfortunately, this is not always the case. When engineering a well, it is critical that both the initial and final design be based on site specific geology. The initial well design should be based on a hydrogeologic study, with pilot or test hole data (e.g. geologic description of drill cuttings, sieve analyses, borehole geophysical logs, water analyses) used to finalize the well design.

Well specifications are a second critical component for successful well construction. They serve three functions: protect the client, assist the drilling contractor, and ensure a quality well. This talk will discuss items that should be included in well specs (e.g. drilling fluid properties, testing procedures, guarantees), along with case histories of what happens when they are deficient.

Daily, onsite monitoring throughout drilling and well construction is a third critical component. It serves the same three functions: protect the client, assist the drilling contractor, and ensure a quality well. A high capacity water well is a significant financial investment warranting professional, third party monitoring. Partnering with the drilling contractor minimizes problems and helps insure the success of the project. Case studies vouch for the wisdom of this approach.

An orchestration of hydrogeology, engineering design, and construction oversight is imperative to deliver to the client a well project that ensures quality construction and maximizes production and infrastructure lifespan.

The Mississippi Water Security Institute: Report on Year 1; Plans for Year 2

Ochs, C.; Young, D.; Sullivan-Gonzalez, D.

Earth, Air, Fire, and Water. Ancient Greeks considered these the essentials to support life on earth - a wise observation. From Earth, nourishment is derived. From Air are provided the gases of respiration. From the Fire of our Sun we are bathed in the catalytic energy necessary for complex organization. But only where there is also Water can we "live long and prosper." In May 2016, we completed the first workshop of the Mississippi Water Security Institute (MS WSI). Our purpose was to introduce undergraduate honors students to the challenges and complexities of how we use and manage the state's water resources to meet present and future needs. The 2016 MS WSI involved 16 students from four Mississippi universities. The regional focus in our first year was on the Mississippi Delta, a place of great importance to the state's economy but also of striking contrasts – high agricultural production at the expense of enormous resource use; an historically wet wilderness with only remnants remaining outside the levees; islands of economic prosperity in a sea of rural poverty; where water seems inexhaustible but in fact can be consumed faster than it is replenished. Over our two-week Institute, we investigated the means by which we might use water in this vast region to jointly promote broad economic development, and human community health, while supporting ecosystem health. We were visited by numerous speakers representing different areas of expertise related to water use and management, from farming to law to conservation, and we made several field trips to sites of interest in the Mississippi Delta. In this talk, we will present outcomes of student learning from the 2016 workshop, and discuss plans for the upcoming 2017 MS WSI workshop on urban water systems in Mississippi.

The Rainworks Challenge Bioretention Demonstration Project

Gallo, W.

Raingardens and bioretention facilities are being explored for their application in urban environments all across the United States. However, each location is unique, requiring specific soil, climate, rainfall, and even political responses. Over the past year, MSU faculty and students have designed and built a demonstration facility on MSU's Starkville campus that is designed to meet the specific requirements of an urban site in central Mississippi.

Funded by an EPA grant, the demonstration facility captures water from a campus building for reuse in a 2,000 gallon cistern and manages the remaining rainfall in an engineered bioretenation basin. The facility is designed to be seamlessly integrated into the surrounding site and offers educational kiosks that explain the various layers and design considerations that go into a bioretenation basin. The facility uses adapted and native species to reduce irrigation demands in summer. The plants thrive in eighteen inches of biorentention soil mix that filters pollutants and absorbs rainfall. Due to the heavy clay soils of central Mississippi, a gravel layer was installed below the soil to allow for storage over a longer period of time and move water out of the facility in larger events.

The project was designed and built through a collaborative process by students from Landscape Architecture, Graphic Design and Civil Engineering. At each step students were able to make real world decisions that impacted the final outcome of the demonstration facility. This process has helped to prepare them to be leaders in bioretention design after graduation and to influence the sustainable design of our cities.

Climate and Agronomics

Lindsey Yasarer *(USDA-ARS)*	A century of precipitation trends in the Mississippi Delta region and implications for agroecosystem management
Courtney Siegert *(Mississippi State University)*	Weather map classification as a tool for the hydroclimatological community
Saseendran S. Anapalli *(USDA-ARS)*	Quantifying crop water requirements in the MS Delta using eddy covariance and energy balance methods
Gary Feng *(USDA-ARS)*	Water consumption and yield variability of nonirrigated and irrigated soybeans in Mississippi dominant soils across years

A century of precipitation trends in the Mississippi Delta region and implications for agroecosystem management

Yaserer, L.; Bingner, R.; Locke, M.

With nutrient-rich soils and a humid climate, the Mississippi Alluvial Plain (i.e. the Delta) within the Lower Mississippi River valley is a productive region for agriculture and a critical contributor to the national agricultural economy. Irrigation plays a large role in the fecundity of this region; however, precipitation patterns also have a significant impact on yield, crop choice, management practices, and ambient water quality. In this study precipitation trends in the Delta for over 100 years are explored. The average annual rainfall from 1901 to 2000 in the Delta was approximately 52 inches. However, precipitation has increased an average of 0.5 inches per decade in the region. Using the NOAA nClimDiv dataset and the network of USDA-NRCS SCAN weather stations, regional precipitation trends for the entire Delta and location-specific patterns are analyzed. Projected precipitation estimates from the CMIP5 dataset (provided by the World Climate Research Program's Working Group on Coupled Modeling) are used to provide insight on future precipitation patterns and implications for agroecosystem management planning within the Delta.

Weather map classification as a tool for the hydroclimatological community

Siegert, C.

Weather map classification, also known as synoptic classification, is a tool used to simplify diverse atmospheric variables into a single weather type, which allows researchers to relate large-scale atmospheric circulation to regional- and small-scale surface environments. Synoptic classification has many applications for understanding the response of the surface environment to atmospheric forcings as evidenced in the range of atmospheric pollutant studies. However, full applicability has been under-utilized to date, especially in disciplines such as hydroclimatology, which are intimately linked to atmospheric inputs. Using a combination of principal components analysis and cluster analysis, a daily synoptic calendar can be developed from readily available atmospheric measurements including temperature, sea level pressure, wind, and cloud cover. These methods are not site specific and may serve as guidance for researchers who wish to employ synoptic classification techniques in their own region of interest.

Case studies are presented to demonstrate the utility of synoptic techniques in hydroclimatological applications including precipitation characteristics, soil moisture, and stream discharge. These examples illustrate how synoptic typing can be used (1) to quantify direct relationships between atmospheric patterns and precipitation characteristics or (2) to quantify relationships further removed in the hydrologic cycle such as atmospheric patterns and stream discharge. The cascade of processes in the hydrologic cycle are complex and considerable effort has been made to understand, model, and predict these relationships. As such, synoptic classification may be applied to a broad array of hydrological research questions and warrants further consideration by the hydroclimatological community.

Quantifying crop water requirements in the MS Delta using eddy covariance and energy balance methods

Anapalli, S.; Fisher, D.; Reddy, K.; Ruixiu, S.

With competing demands for fresh water from human, urban, and industrial sectors, water available for irrigated agriculture is rapidly declining; this calls for a more judicious use of the limited share of water available for crop irrigations. Accurately quantifying crop water requirements and providing crops with the right amount of water at the right time to optimize crop water productivity holds the key to addressing this challenge. While large field lysimeters allow us to grow crops for quantifying ET directly from the crop-field, they are expensive and time-consuming to install successfully and maintain for long-term data collection for analyzing climate variability impacts on crop water requirements. Eddy covariance (EC) and energy balance (EB) methods are easier to install in crop fields and are portable, and provide two scientifically sound methods for indirect, accurate measurements of water requirements (ET; evapotranspiration) of cropping systems. Nonetheless, the EC method has been widely known to have energy balance closure problems — imbalance in matching energy inputs to the outputs. In the evolving scenario, we embarked on a research program for monitoring ET from corn and soybean crops using both EC and EB approaches, for comparison with each other and accounting for energy balance non-closure artifacts on the EC data generated. In the EB method for quantifying ET, a surface energy balance equation is applied to a soil-plant surface using ground-based and remote-sensing measurements of the system variables, and ET (expressed as latent heat flux) is estimated as the residual term of the energy balance equation when other fluxes in the equation are either measured or calculated. The EC system consists of an omnidirectional sonic anemometer and an open-path infrared gas analyzer with data recorded at a frequency of 10 Hz on a data logger and analyzed with Smartflux software (LiCor, Lincoln, NE, USA). In this project, crops were grown in 40-ha fields planted to soybean and equipped with the EC and EB systems in 2016. In general, computed daily values of ET from EB and EC methods deviated from the computed short grass (ET_o) and alfalfa (ET_r) reference crop ET. However, total seasonal ET from both EB and EC methods were comparable with ET_r and ET_o. The EC and EB methods tested show high potential for quantifying crop ET in cropping systems in the MS Delta region.

Water consumption and yield variability of nonirrigated and irrigated soybeans in Mississippi dominant soils across years

Feng, G.; Ouyang, Y.; Reginelli, D.; Jenkins, J.

Soybean is the most important crop in Mississippi in both acreage and value. In 2015, the Mississippi soybean harvested area was 2.27 million acres and a total value of $1.04 billion, surpasses other major crops combined. Approximately one-half of Mississippi soybeans are grown under rainfed conditions and another half are irrigated. In order to stabilize dryland soybean yield and improve yield by irrigation, it is essential to determine yield, water requirement and consumption of both non-irrigated and irrigated soybeans in Mississippi dominant soils under different climate conditions over years.

Field experiments were conducted in Noxubee county for those objectives on Vaiden clay, Okolona silty clay, and Demopolis clay loam at a private Good Farm in 2014 and on the Brooksville silty clay at Mississippi State University Black Belt Branch experiment station in 2015 and 2016.

During the entire soybean growing season from 1895 to 2014, the average long-term reference evapotranspiration and crop water requirement (ETc) were 720 and 542 mm, mean rainfall was 432 mm, rainfall of wet, normal and dry category years was 597, 421 and 280 mm.

During soybean season in 2014, 2015 and 2016, rainfall were 365, 388 and 284 mm, soybean water requirement were 428, 455, and 504 mm. In 2014, 2015 and 2016, rainfed soybeans consumed 402, 417, and 347 mm water and produced 5672, 2736, and 1806 kg ha^{-1} grain, in contrast, irrigated soybean consumed 440, 526, and 478 mm water and yielded 6264, 3109, and 3031 kg ha^{-1} grain.

The APEX (Agricultural Policy/Environmental eXtender) model was applied on nine soil types (Vaiden clay, Catalpa, Okolona, Griffith, Sumter, Kipling and Brooksville silty clay, Demopolis clay loam, and Leeper sandy loam) in Eastern Central Mississippi from 2002 to 2014.

APEX simulated grain yield of rainfed soybean ranged broadly from 2.24 to 6.14 Mg ha^{-1} on nine soil types over the 13 years. The average yield in wet, normal and dry years was 4.88, 4.51 and 3.74 Mg ha^{-1}, respectively. Simulated yield potential without water stress due to irrigation varied from 4.47 to 6.51 Mg ha^{-1}. Compared with rainfed soybean, the average increase in yield by irrigation ranged from 0.34 to 1.60 Mg ha^{-1} among the nine soils. Griffith, Sumter and Demopolis had the highest average yield gap (difference between yield potential and the rainfed yield), ranged from 1.37 to 1.60 Mg ha^{-1}. Average irrigation amount required to achieve potential yield ranged from 16 to 377 mm across the nine soil types. High variability of water consumption as well as grain yield was observed for both nonirrigated and irrigated soybeans on different soils and on a given soil over different years. Therefore, it is necessary to explore production/management options for different soils that will increase opportunities for consistent yields and profits across years without irrigation.

Mississippi River Basin

Beth Baker *(Mississippi State University)*	Role of SERA-46 in fostering collaboration and improvement toward nutrient reduction goals in the Mississippi/Ohio River Basin
Sandra Guzman *(Mississippi State University)*	Social indicators: A new metric to guide, measure, and accelerate implementation of state-level nutrient reduction strategies
Doug Daigle *(Lower Mississippi River Sub-basin Committee)*	Overview of Gulf of Mexico Hypoxia Policy in 2017

Role of SERA-46 in fostering collaboration and improvement toward nutrient reduction goals in the Mississippi/Ohio River Basin

Baker, B.; Burger, W.; Ingram, R.

The Southern Extension and Research Activities committee number 46, is one of a group of formal USDA Nation Institute of Food and Agriculture (NIFA) and Land Grant University funded committees designed to promote multistate research and extension activities. SERA-46 was created to provide a framework for collaboration and advancement of priorities with the Mississippi River Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force). Land Grant Universities (LGU) throughout the Mississippi/Ohio River basins are uniquely positioned to assist state agencies and the Hypoxia Task Force in the development and implementation of state level nutrient reduction strategies. Researches as these universities participate in interdisciplinary research ranging from soil science, nutrient transport, water quality, and human behavior, which offer support toward the mitigating nutrient pollution to the Gulf of Mexico to secure water quality for environmental and economic enterprises. In addition to a diversity of scientists, LGUs each have expansive extension units that can assist in disseminating innovative best management practices and solutions to farmers across the basins. Recent strides made by SERA-46 in support of state and Hypoxia Task Force nutrient reduction goals include securing extramural funds to develop a framework for tracking progress toward nutrient reduction goals via reductions in nonpoint sources of pollution, securing funds for watershed capacity building, developing social indicators related to nutrient reduction, and a large-scale transforming drainage project in the Midwest. Mississippi State University has contributed significantly toward advancement of priorities within the state through a semantic analysis of all Mississippi/Ohio River basin Nutrient Reduction Strategies to develop a guideline for optimizing plans toward goals of the Hypoxia Task Force, leading the social indicator development efforts, farmer engagement, farm system sustainability trainings, and BMP efficiency investigations.

Social Indicators: a New Metric to Guide, Measure, and Accelerate Implementation of State-Level Nutrient Reduction Strategies

Guzman, S.; Cossman, R.; Ingram, R.

Major barriers in water conservation are the development of effective strategies to improve the quality of freshwaters, and management of the current nutrient loads released by agricultural production. Decision makers require a set of technical, environmental, landscape, and social measurements to restore the quality of their watersheds. Social metrics contribute to the understanding of how individuals and communities perceive, and incorporate, nutrient management plans in their agricultural processes. They are also short term metrics in which change (i.e., delta) can be quantified quickly. Individual producers and users have a set of beliefs and attitudes that make them respond differently to a specific situation. In this project we refine social indicator metrics for agricultural and water management with an emphasis on nutrient reduction, promote an expansion of the existing Social Indicators Planning & Evaluation Systems/Social Indicators Data Management & Analysis Tool (SIPES/SIDMA) throughout the Mississippi Atchafalaya River Basin, and lay the groundwork for an active social indicators users community among policy researchers and regulatory agencies. The overall goals of this project include 1) identifying social science experts and potential users of social indicators in the existing Hypoxia Task Force (HTF) states to build the foundation for establishing a community of practice at the state-wide and Mississippi/Atchafalaya River Basin (MARB)-wide scales, 2) incorporate a fully developed suite of social indicators that are tested, standardized and, most importantly, can be compared across watersheds and at varying spatial scales through the expansion of SIDMA, and 3) expand the use of social indicators to guide, and accelerate implementation of state-level nutrient reduction strategies. Social indicators provide consistent measures of social change and can be used by planners and managers to assess change in attitudes towards the implementation of water conservation practices. Social indicators can also accelerate the effective implementation of nutrient reduction strategies.

Overview of Gulf of Mexico Hypoxia Policy in 2017

Daigle, D.

Doug Daigle, Coordinator of the Lower Mississippi River Sub-basin Committee, will give an overview of current policy to address the Gulf of Mexico hypoxic zone, focusing on the national Action Plan and Task Force that Mississippi and other lower river states are participants on. The revised Goal and Interim Target of the Action Plan will be explained, since they set the direction for joint action among Task Force states and agencies for the next decade, and provide the broader context for the work of SERA-46 and state and federal agencies described by other speakers in this session.

Doug Daigle has coordinated the Lower Mississippi River Sub-basin Committee, part of the national Mississippi River/ Gulf of Mexico Watershed Nutrient Task Force, since organizing it in 2003. The Sub-basin Committee consists of Arkansas, Louisiana, Mississippi, Missouri, and Tennessee, along with federal partner agencies, researchers, and stakeholders in the region. He also coordinates the Louisiana Hypoxia Working Group, a monthly forum held at Louisiana State University.

Introduction

2017 marks an important point for the national policy response to the spread of hypoxia (low oxygen) in the northern Gulf of Mexico, with both ongoing progress and significant uncertainties about the prospects for success in reaching federal-state goals to address this problem.

Background and History

It's helpful to remember that the science documenting and recording the trend of hypoxia in the northern Gulf goes back several decades, with initial measurements of a large area of low oxygen being recorded in the 1970s, and annual mapping of the hypoxic zone beginning in 1985. During that time the measured size of the mid-summer Gulf Hypoxic zone has gone from 9,774 square kilometers (3,775 square miles) in 1985 to 16,760 square kilometers (6,474 square miles) in 2015. The 30 year average for the hypoxic zone's size is 13,752 square kilometers (5,312 square miles.)

The national policy response to the Gulf Hypoxia problem is now over 20 years in the making. An initial Clean Water Act petition by several non-governmental organizations in 1995 led to a White House level response by the Clinton administration, with organization of special science committees and the eventual formation of a federal-state Task Force involving key agencies and states along the main stem Mississippi River.

Legislative authorization came from the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) in 1998, which required an integrated assessment of the science by 1999 and an action plan for addressing Gulf Hypoxia by 2000. The Mississippi River Gulf of Mexico Watershed Nutrient Task Force reached agreement on an Action Plan in late 2000, and the final version was submitted to Congress in January 2001.

The *Action Plan for Reducing Hypoxia in the Gulf of Mexico* continues to be the national policy vehicle for addressing this problem. Three central, co-equal goals formed the core of the 2001 (and subsequent) versions of the Action Plan:

1. A Coastal Goal of achieving a 5 year average annual aerial extent for the Gulf Hypoxic Zone of less than 5000 square kilometers (1950 square miles) by the year 2015;
2. A Within-Basin Goal of improving water quality across the entire Mississippi River Basin;
3. A Quality of Life Goal of improving communities and economic conditions through these efforts.

The Coastal Goal, the centerpiece of the Action Plan, focused on "practical… and cost-effective voluntary actions" to address "all categories of sources and removals within the [basin] to reduce the annual discharge of nitrogen and phosphorus into the Gulf." An underlying goal, articulated since the beginning of the process, was also to protect the fishery resources of the Gulf before pervasive negative impacts were seen in the system. The 2001 version of the Action Plan anticipated a coordinated, tightly phased implementation process using an adaptive management approach. Unfortunately, the Integrated Budget proposed at the federal level to drive the effort was never adopted.

The 2008 Revision of the Action Plan kept all 3 goals, including the 2015 target date for reaching the central or coastal goal of achieving a 5000 square kilometer average annual size. The 2008 Revision also utilized the findings of a special U.S. Environmental Protection Agency (EPA) Science Advisory Board, which concluded that a dual reduction of 45% of the main nutrients nitrogen and phosphorus entering the Gulf was necessary for achieving the Action Plan's Coastal Goal.

The 2008 Revision of the Action Plan shifted the focus of implementation efforts from the sub-basin level to states, and from Sub-Basin Committees to State Nutrient Reduction Strategies. The Plan called for states to "complete and implement comprehensive nitrogen and phosphorus reduction strategies… encompassing watersheds with significant contributions of nitrogen and phosphorus to the surface waters of the Mississippi/Atchafalaya River Basin [MARB], and ultimately the Gulf of Mexico."

Mississippi was the first Hypoxia Task Force state to develop a nutrient reduction strategy following the 2008 Revision of the Action Plan. The state convened/organized 11 Work Groups to formulate the details for 11 strategic elements of the strategy:

1. Stakeholder awareness, outreach, and education;
2. Watershed characterization;
3. Current status and historical trends;
4. Analytical tools;
5. Water Management;
6. Input Management;
7. Best management practices;
8. Point source treatment;
9. Monitoring;
10. Economic incentives and funding sources;
11. Information management.

The Mississippi Nutrient Reduction Strategy focused on the state's Delta region, responding to dual needs for addressing interior water quality issues and nutrient loading to the river. Seven watersheds with completed total maximum daily load (TMDL) plans were selected for the Strategy: Harris Bayou, Porter Bayou, Coldwater River, Bee Lake, Lake Washington, Steele Bayou, and Wolf/Broad Lake.

A central challenge for the Gulf Hypoxia Action Plan has been that of funding. The 2001 and 2008 versions of the *Action Plan* both stated that reducing or making significant progress toward reducing the five year running average areal extent of the hypoxic zone was "subject to the availability of additional resources." Implementation of the Action Plan has never been fully funded, though particular components have been.

During the time between the first and second versions of the Action Plan, the conservation and management programs in the Farm Bill provided funding for projects in many of the tributary watersheds of the Mississippi River. These were focused on achieving broad conservation and water quality benefits, some of which occurred in watersheds contributing to the Gulf Hypoxia problem. The first targeted federal funding for implementation of the Gulf Hypoxia Action Plan came in 2009 from the USDA Natural Resource Conservation Service's (NRCS) Mississippi River Basin Healthy Watersheds Initiative (commonly known as MRBI).

MRBI has continued and expanded cooperative efforts with landowners and producers in watersheds that stakeholders help select in each state. Project sites in Mississippi include Beaver Bayou-Mound Bayou, Burrell Bayou, Tommie Bayou/Brook Bayou, Christmas Lake Bayou, Stillwater Bayou and Long Lake in Bolivar, Washington and Sunflower Counties.

Latest Revision of the Action Plan

As 2015 approached and it was clear that the Coastal Goal of the Action Plan was not going to be met, the Task Force convened an assessment committee. After a year-long process of discussion and evaluation, the Task Force decided to revise the Action Plan Goal. The size of the Goal – less than 5000 square kilometers – was kept, but the end date was pushed out to the year 2035.

An Interim Target was added to the Goal: achieving a 20% reduction of nitrogen and phosphorus loading to the Gulf by the year 2025. This Interim Target was identified as a milestone for immediate planning and implementation actions. The Action Plan directs federal agencies, States, Tribes, and other partners to "work collaboratively to plan and implement specific, practical, and cost-effective actions to achieve both the Interim Target and the Updated Coastal Goal."

The 2015 Revision of the Action Plan Goal was clear that "reaching this final goal will require a significant commitment of resources to greatly accelerate implementation of actions to reduce nutrient loading from all major sources of nitrogen and phosphorus in the [MARB]…" and reinforced this point by stating that a "significant scaling up of action [is] needed to reach to reach the Interim Target and the Goal".

The Interim Target and Revised Coastal Goal are the Action Plan's main directives now, with the Interim Target being the initial focal point for action. What do they mean? Both are non-binding, and represent the cumulative result of all actions taken throughout the Mississippi and Ohio River basins. In terms of reaching the Target and ultimately the Revised Goal, specific reduction targets are not allocated by state, but states and agencies on the Task Force have all made a commitment to help. The Interim Target represents a key milestone of progress for achieving the Goal – if the Target is reached, then the Goal can be seen as both possible and feasible.

The 2015 Action Plan Framework lists a series of Near-Term Actions that can be used to achieve the Interim Target and Revised Goal:

State Nutrient Reduction Strategies: The 2015 Framework called for both implementation and updating of the state strategies as needed so that they could aid in documenting, tracking, and reporting on action, including quantifying nutrient load reductions, so that their contribution to meeting the Interim Target can be assessed.

Federal Programs: In addition to the Farm Bill programs and the MRBI, a number of interagency initiatives have been working at a basin scale, including the Regional Conservation Partnership Program (RCPP), the Landscape Conservation Cooperative (LCC) Partnership, and the U.S. Fish and Wildlife Service's Mississippi River Habitat Initiative.

Quantitative Measures: The 2015 Framework emphasizes the importance of verifying actions to reduce nutrient loadings with improved tracking, and watershed monitoring and modeling tools." Key partners in this effort include the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration, along with a number of state gauge stations on the rivers and tributaries.

Modeling plays a key role in the annual Gulf Hypoxic Zone forecast developed by NOAA and partners that include the Louisiana Universities Marine Consortium (LUMCON). The LUMCON annual summer mapping cruise has been carried out since 1985, providing a key baseline of data and 30 years of information. It is a central means of measuring success in achieving the Action Plan Goals, i.e., reducing the trend of growth along with the average annual size of the zone. The cruise has only been cancelled twice, once in 1989 for lack of funds, and in 2016 when the federally selected vessel broke down. The funding and future of the summer mapping cruise are uncertain at this point.

Funding: The 2015 Framework also states explicitly that achieving the Interim Target and Revised Goal will not be possible without additional resources. The level of resources that will be available at the federal and state levels remains highly uncertain. At the federal level, agencies such as NOAA and EPA are facing significant proposed budget cuts, along with bedrock programs like the 319 Grant Program, initiatives like the Landscape Conservation Cooperative (LCC), and long-term sources like the Land and Water Conservation Fund.

While state budgets are facing challenges as well, several Task Force states (Iowa, Minnesota, and Missouri) have utilized funding mechanisms such as state taxes or legislative appropriations to apply funding to their nutrient reduction strategies. The states of Louisiana and Mississippi can draw on a funding source unavailable to other Task Force states, the settlement monies from the 2010 BP Oil Disaster, codified in the RESTORE Act.

Partnerships: Partnerships bring additional capacity and resources that can help significantly in reaching the Action Plan goals. The SERA 46 Land Grant University Consortium is one of the most prominent partners to align with the Task Force. The Land Grant Universities in the Mississippi-Ohio River states signed a Memorandum of Understanding with the Task Force, and are working aggressively on a set of research and extension goals tied to the Action Plan.

Several NGO partners are also working at a basin scale on projects that complement the Action Plan. The Nature Conservancy has launched a Mississippi River Initiative explicitly tied to the Action Plan's Interim Target of a 20% reduction in nitrogen and phosphorus loading from the river to the Gulf by 2025.

Research: The 2015 Framework also elevates the role that research will play in improving current efforts and developing new techniques for nutrient reduction and water quality improvement. Some partners such as the SERA 46 Consortium will play a role in this area, along with agency programs like the USDA Agricultural Research Service (ARS). When fully funded, the annual LUMCON Gulf Hypoxia mapping cruise utilized that opportunity carry out related research, working with partner agencies and universities.

A final near-term action in the Revised Action Plan is a Biennial Report to Congress required by the 2014 Revision of the HABHRCA law, which could be utilized to build Congressional support.

Future Prospects

A key question facing the Gulf Hypoxia effort is whether can the Action Plan can work. The 2015 Framework lays out a series of Near Term Actions that are necessary but not sufficient steps to reach the Interim Target and Revised Coastal Goal. Final success is conditional - achieving the Interim Target by 2025 will indicate (but not guarantee) that the Coastal Goal can be reached by 2035.

Background Information:

Gulf Hypoxic Zone Mid-Summer Mapping Cruise reports www.gulfhypoxia.net

Harmful Algal Bloom and Hypoxia Research and Control Act https://coastalscience.noaa.gov/research/habs/habhrca

Action Plan for Reducing Hypoxia in the Gulf of Mexico (2001, 2008, 2015) https://www.epa.gov/ms-htf

EPA Science Advisory Board Report on Hypoxia in the Northern Gulf of Mexico https://yosemite.epa.gov/sab/sabproduct.nsf/95eac6037dbee075852573a00075f732/6f6464d3d773a6ce85257081003b0efe!OpenDocument&TableRow=2.3#2.

Mississippi Delta Nutrient Reduction Strategies Implementation Projects https://www.deq.state.ms.us/mdeq.nsf/page/WMB_MDNRSIP?OpenDocument

Gulf Hypoxia Action Plan New Goal Framework https://www.epa.gov/ms-htf/hypoxia-task-force-new-goal-framework

USDA NRCS Landscape Initiatives https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/initiatives/

Hypoxia Task Force – Land Grant Universities statement on collaborative work https://www.epa.gov/ms-htf/htf-lgu-priorities-collaborative-work

Nature Conservancy Mississippi River Basin Initiative https://www.nature.org/ourinitiatives/urgentissues/water/protecting-rivers/mississippi-river.xml

Year	Square kilometers	Square miles
1985	9,774	3,775
1986	9,592	3,705
1987	6,688	2,583
1988	40	15
1989	n.d.	n.d
1990	9,420	3,638
1991	11,920	4,604
1992	10,804	4,173
1993	17,520	6,767
1994	16,680	6,443
1995	17,220	6,651
1996	17,920	6,922
1997	15,950	6,161
1998	12,480	4,820
1999	20,000	7,725
2000	4,400	1,699
2001	19,840	7,663

n.d. = no data, entire area not mapped

Year	Square kilometers	Square miles
2002	22,000	8,497
2003	8,320	3,214
2004	14,640	5,655
2005	11,800	4,558
2006	16,560	6,396
2007	20,480	7,910
2008	21,764	8,406
2009	8,240	3,183
2010	18,400	7,107
2011	17,680	6,829
2012	7,480	2,889
2013	15,120	5,840
2014	13,080	5,052
2015	16,760	6,474
Goal	**5,000**	**1,991**
30-yr Ave.	**13,752**	**5,312**
5-yr Ave.	**14,024**	**5,543**

Figure 1. Record of Mid-Summer Gulf Hypoxic Zone Measurements, 1985-2015. (Source: Dr. Nancy Rabalais, c/o GulfHypoxia.net)

Figure 2. Mississippi Delta projects with drainage weirs, reservoirs.

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