Priority Areas for Managed Aquifer Recharge by Infiltration Galleries in Eastern Arkansas

Sarah Houston[1], Heather Mullenax[1], Allegra Pieri[1,2], Jarod Przybylski[1], Michele Reba[2], and Deborah Leslie[1]

[1]Department of Earth Sciences, University of Memphis, Memphis, TN; [2]USDA-ARS Delta Water Management Research Unit, Jonesboro, AR

ABSTRACT

The Mississippi River Valley alluvial (MRVA) aquifer is one of the main shallow aquifers for agriculture in the United States. The MRVA supplies over 90% of irrigation water in the Lower Mississippi River Basin, due to its accessibility and high yield. Irrigation demand has increased since the early 1900s with continued expansion and inequitable recharge contributions. The overdraft of the MRVA in Arkansas has resulted in the designation of critical groundwater areas. Managed aquifer recharge (MAR) methods intentionally replenish stressed groundwater resources while emphasizing the protection and improvement of groundwater quantity and quality. MAR using infiltration galleries (IG) is being tested in the Cache River Critical Groundwater Area (CRCGA) of eastern Arkansas. These IG are shallow, gravel-filled trenches excavated to the upper unsaturated MRVA sand sediments. Recharge source water from a nearby on-farm storage reservoir will flow through the gravel fill as well as through 30 m of unsaturated MRVA sands and gravels before reaching the water table. The IG appears to be a promising MAR method to enhance recharge and store surface water within the MRVA. Identification of other priority areas to install IG is needed to determine the adoptability. As part of a class group project, students analyzed and interpreted available geospatial and hydrological data to identify and support ideal IG locations. Prioritized IG sites will have the following conditions: thin confining unit, large depth to groundwater, and areas near an on-farm storage reservoir.

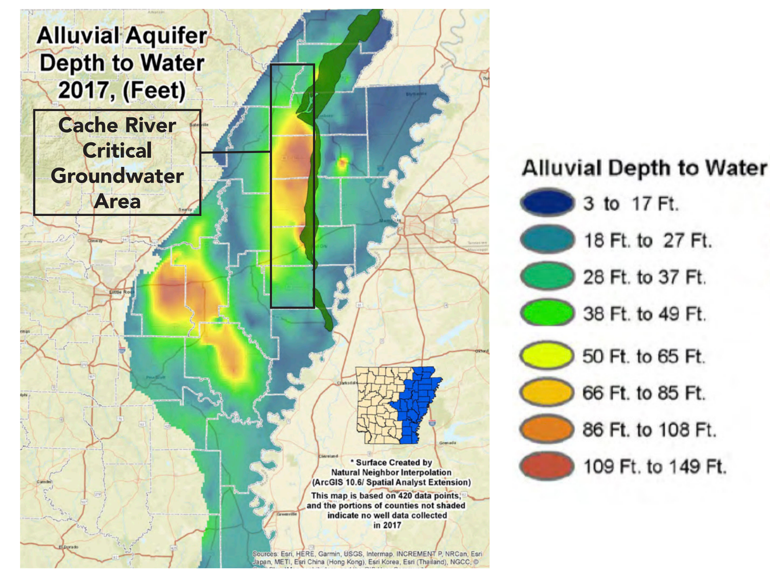

Fig. 1: MRVA aquifer cones of depression (ANRC, 2018).

BACKGROUND

Critical groundwater areas were designated in Arkansas in 2009 as a result of overpumping from the MRVA aquifer (ANRC, 2009). A confining clay layer near ground surface greatly limits recharge, and large-scale cones of depression have formed (Fig. 1). This investigation focuses on using infiltration galleries (IG) for managed aquifer recharge (MAR) in the CRCGA. These IG are built in connection with the unsaturated zone and use on-farm storage reservoirs as the injection source water during the non-growing season (Fig. 2). IG are being tested by the U.S. Department of Agriculture (USDA) - Agriculture Research Service (ARS) Delta Water Management Research Unit (DWMRU) (Godwin, 2020). This project aims to determine the viability of IG as a conservation practice for producers. The IG appears to be a promising MAR method to store surface water underground with minimal operational expense. Consideration of more sites to test IG is needed to determine the adoptability of this practice. Site selection is a critical aspect of the process.

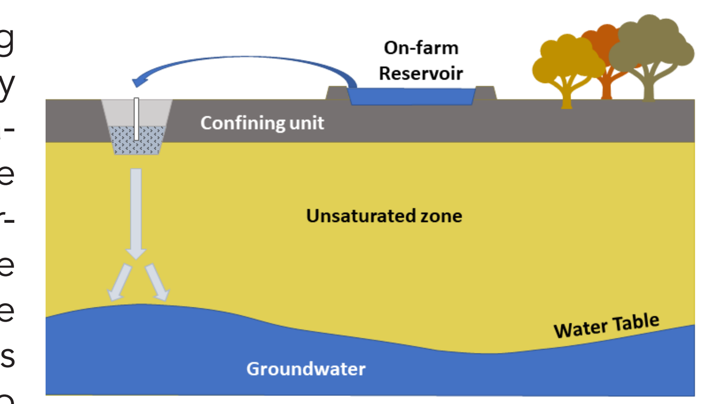

Fig. 2: Infiltration gallery conceptual drawing.

DATA & METHODS

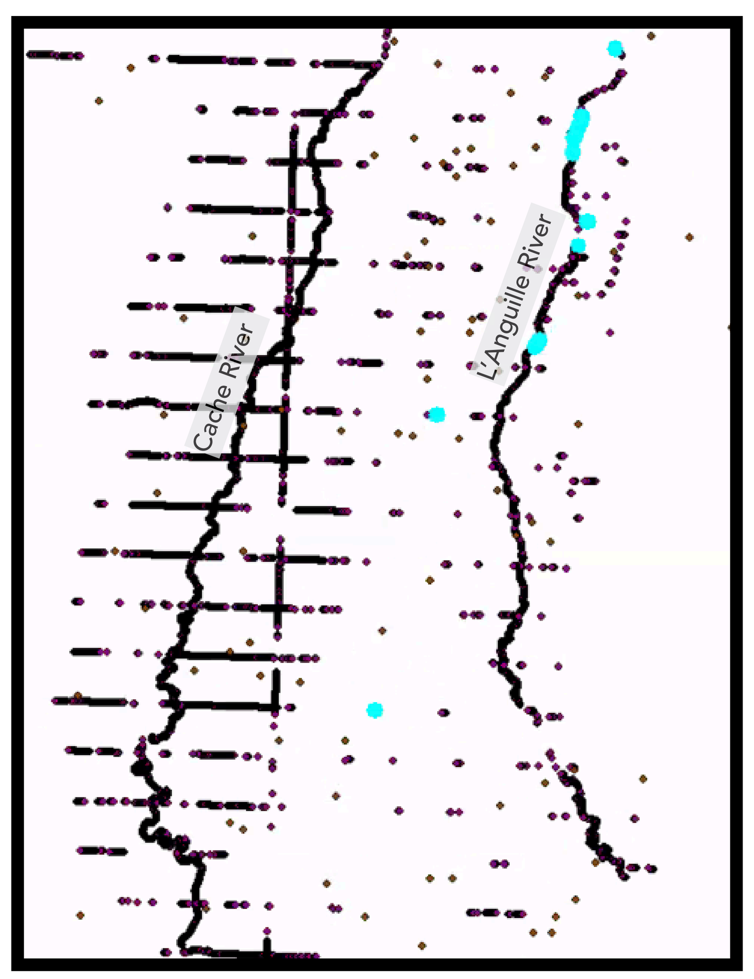

Fig. 3: AEM & waterborne survey lines loaded into ArcGIS. Blue indicates all locations that met parameters (http://arcg.is/01nraa).

Airborne electromagnetic (AEM) data from the U.S. Geologic Survey flyover survey (Fig. 3) quantified the thickness of shallow confining material using the high resolution Resolve instrument. The subsurface mapping included the first 3 model layers (0-3.2 m depth) and the vertically integrated conductance (VIC) from the next 7 model layers (3.2-15.1 m depth) (USGS, personal communication). Fig. 4 gives a visual representation of the subsurface through resistivity, VIC and clay thickness. These datasets including the locations of on-farm storage reservoirs were uploaded to ArcGIS ArcMap (Yaeger et al., 2017). Utilizing the Query tool, potential IG sites containing the following conditions were prioritized:

1. Thin confining unit (<4 m) for ease of construction
2. Low vertically integrated conductance (VIC) (<0.2) for materials with high permeability near the surface
3. Locations within 60 m of on-farm storage reservoirs

Then, the discrete groundwater depth measurements were interpolated into a groundwater surface map in ArcGIS using the Natural Neighbor method. These data were integrated to generate the selected sites map (Fig. 5).

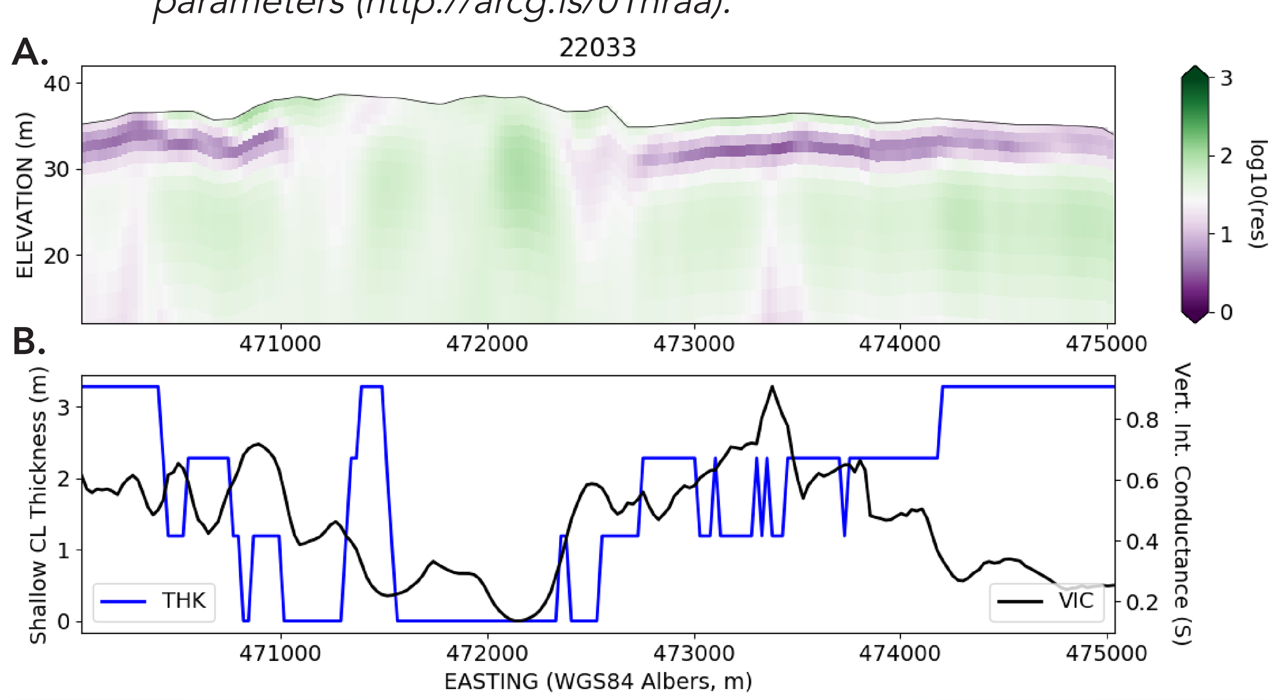

Fig. 4: A) Shallow subsurface cross-section at USGS flight line 22033. Fine materials are in purple, and coarse materials are in green. B) VIC higher values are fine materials, and lower values are coarse materials.

SELECTED SITES

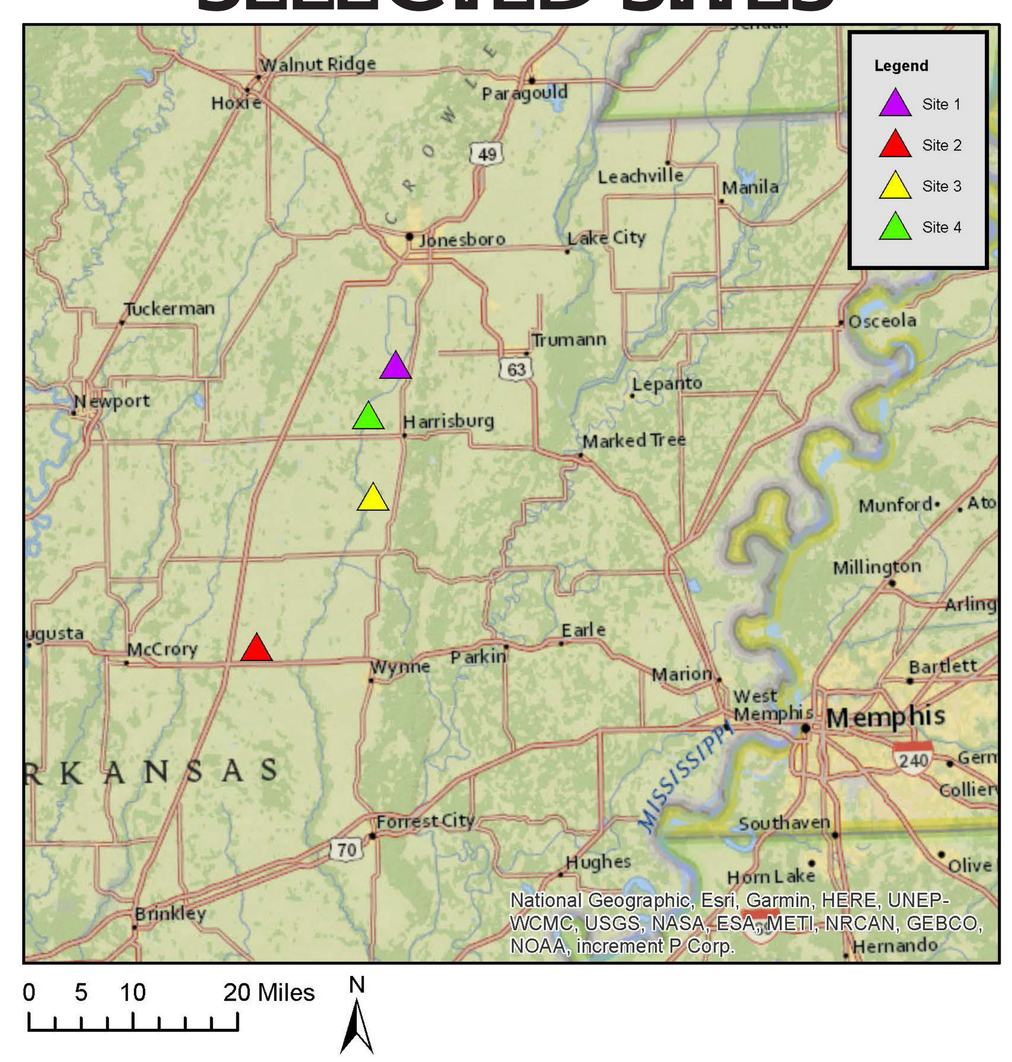

Fig. 5: Top sites within CRCGA that fit parameters.

RESULTS & CONCLUSIONS

Nine out of the 143 reservoirs available within the CRCGA met these very specific parameters described in the Data & Methods section (Yaeger et al, 2017). Many sites were located near the L'Anguille River (Fig. 3) and it is hypothesized that the river eroded the confining unit in those areas. Sites were then narrowed to four locations that best matched the criteria. Each selected site has a thin confining clay layer, depth to groundwater greater than 25 m, and low VIC (<0.2) (Fig. 5).

In Figures 6-9 the four selected IG locations differed slightly. It is ideal for land to not be taken out of production. The IG locations at the selected sites were placed in forested areas near the on-farm reservoir. Additionally, parameter results that were in or near agricultural ditches were relocated.

- Site 1 (Fig. 6): Poinsett County, Arkansas, with a depth to groundwater water of 31.8 m.
- Site 2 (Fig. 7): Cross County, Arkansas, with a depth to groundwater of 26.0 m.
- Site 3 (Fig. 8): Poinsett County, Arkansas, with a depth to groundwater of 37.1 m.
- Site 4 (Fig. 9): Poinsett County, Arkansas, with a depth to groundwater of 34.6 m.

Producer collaboration and land access are key to IG implementation. Contact and agreement with the landowners are necessary for further investigation and construction. The next step is to refine and determine the feasibility of the selected sites. Ground-based geophysical surveys would affirm the AEM survey data. Site-specific soil collection and analysis would validate the subsurface materials. Ongoing reservoir water quality should be initiated to establish annual and seasonal conditions. Additional site-specific investigations could change the parameters of clay thickness, depth to groundwater, and vertical integrated conductance modeled at the prioritized sites.

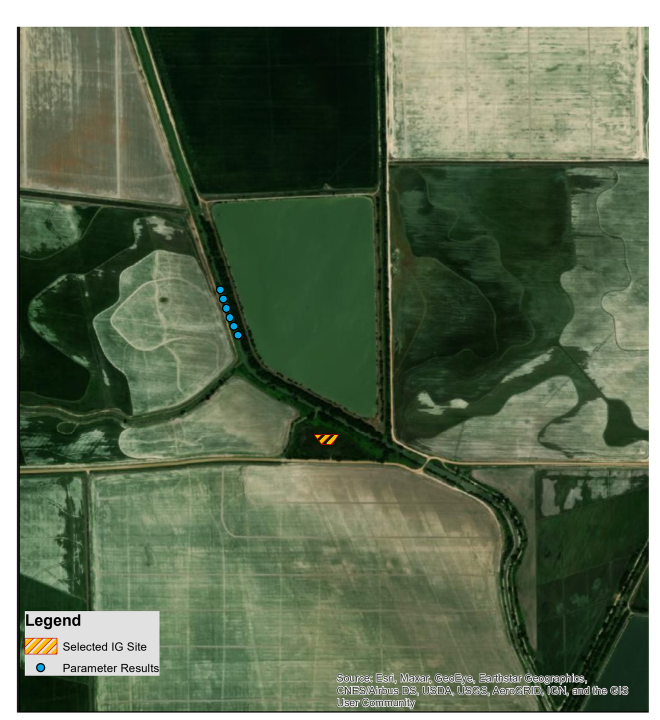

Fig. 6: Site 1

Fig. 7: Site 2

Fig. 8: Site 3

Fig. 9: Site 4

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