**Western Tennessee Water Resources**

*Leveraging High Resolution Remotely Sensed Data to Assess Water Availability and Vulnerability in the Memphis Aquifer Area in West Tennessee.*

**Project Team**

***Project Team:***

Lauren Webster (Project Lead)

Elena Pilch

Katera Lee

Michael Pazmino

***Advisors & Mentors:***

Kerry Cawse-Nicholson (NASA Jet Propulsion Laboratory, California Institute of Technology)

Madeleine Pascolini-Campbell (NASA Jet Propulsion Laboratory, California Institute of Technology)

Benjamin Holt (NASA Jet Propulsion Laboratory, California Institute of Technology)

***Past or Other Contributors:***

Lauren Mahoney

Brenna Hatch

Lauren Webster

Claire-Villanueva-Weeks

***Fellow:***

Kathleen Lange (JPL)

***Team Contact:*** Lauren Webster, lauren.webster@ssaihq.com

***Partner Contacts:*** Sarah Houston, sarah@protectouraquifer.org, Brian Waldron bwaldron@memphis.edu

**Project Overview**

***Project Synopsis:***

The Memphis Aquifer (MA) is the primary water supply for Tennessee residents; however, with new developments in West Tennessee, aquifer recharge may be compromised. Through an expanded partnership with Protect Our Aquifer and the University of Memphis, this project assessed water availability and vulnerability in the West Tennesse portion of the MA by utilizing high-resolution evapotranspiration data from ECOSTRESS, precipitation data from GPM IMERG, and land cover data from Landsat 8 OLI. The project mapped hydrological and land cover trends to locate areas that are not water stressed so that the partners can prioritize these areas for conservation and additional groundwater monitoring.

***Abstract:***

The Memphis Aquifer (MA) is located in the Mississippi Embayment that extends 250,000 square kilometers across nine states. Fayette and Haywood counties in West Tennessee are situated within the recharge zone of the MA and include the soon-to-be-built Ford “mega campus” named Blue Oval City (BOC), which will consist of a vehicle-production facility and battery assembly division. Increased water demand and land cover change from urban development, such as BOC, in the MA’s narrow recharge zone, threaten the aquifer’s groundwater storage and recharge rate. Groundwater recharge factors that influence the narrow recharge zone of the MA include precipitation, evapotranspiration, runoff, and land cover type. In partnership with Protect Our Aquifer (POA) and the Center for Applied Earth Science and Engineering Research (CAESAR) at the University of Memphis, the team used data from the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS), Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (GPM IMERG), and Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The team also used ancillary data from the National Land Cover Database (NLCD) and the North American Land Data Assimilation System (NLDAS) Noah Land Surface Model. These results identified thriving recharge locations in Fayette County, which the partners may use to prioritize specific areas in need of protection before they become susceptible to the effects of urbanization and industrialization.

***Key Terms:***

precipitation, evaporative stress, remote sensing, evaporative stress index, thriving index, land cover change, runoff

***National Application Area Addressed:*** Water Resources

***Study Location:*** Hatchie-Obion Watershed, with special focus on Haywood and Fayette Counties TN

***Study Period:*** March 2019 to August 2022

***Community Concerns:***

* With the construction of BOC and signs of suburbanization of the area above the Memphis aquifer, there may be long lasting impacts to the quantity and quality of the water in the Memphis aquifer, which is a resource around 1 million residents rely on.
* Tennessee does not have a system in place to directly monitor groundwater depletion and recharge rates. In order to continue providing long-term access to groundwater for agricultural, industrial, and domestic purposes, it is necessary to investigate the current health of recharge zone areas within the Mississippi Embayment.
* Increased urban development makes it difficult for water to infiltrate into the soil, affecting groundwater recharge rate, and therefore may decrease the clean water supply to its residents.
* Haywood County is a financially vulnerable community, with a median income of $38,994 in 2021. The development of BOC atop the Memphis Regional Mega Site in Haywood County is estimated to create close to 6,000 jobs to the region; however, the potential negative environmental impacts to the aquifer would directly affect the residents.

***Project Objectives:***

* Expand on the previous term’s analysis of water availability and water stressed areas by incorporating higher resolution data
* Zoom in on a smaller portion of the Memphis aquifer by focusing on thriving areas in West Tennessee
* Visualize changes in evapotranspiration, precipitation, and land cover which are influential to groundwater recharge
* Identify areas in the aquifer recharge zone that are the least water stressed to prioritize for protection
* Quantify the variation of recharge potential in West Tennessee

***Previous Term:***

* Spring 2022 (JPL) – Mississippi Embayment Water Resources

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Protect Our Aquifer** | Sarah Houston, Executive Director; Ward Archer, President; Jim Kovarik, Board Member | End User |
| **University of Memphis, Center for Applied Earth Science and Engineering Research** | Brian Waldron, Director; Scott Schoefernacker, Associate Director; Youngsang Kwon, Associate Professor | Collaborator |

***Decision-Making Practices & Policies:***

POA is a decision-making group that monitors groundwater supply and use of the aquifers within the Mississippi Embayment (ME). POA is aware of products that utilize NASA Earth observations but has yet to use these products directly in their monitoring. They currently do not have a system to process remotely sensed data. In addition to building the BOC, the ME will likely experience increased pumping for agricultural use and other infrastructural development. POA is interested in how these changes will affect groundwater recharge potential, especially in areas of the recharge zone. While POA is not a regulatory group, they have advised the Tennessee Governor to create a statewide water management plan for future water availability.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **ISS ECOSTRESS** | Evapotranspiration, Evaporative Stress Index | ECOSTRESS data were used to assess areas experiencing water stress and calculate water balance.  |
| **GPM IMERG** | Precipitation | Precipitation data were used to evaluate water availability and calculate water balance. |
| **Landsat 8 OLI and TIRS** | Land cover | Landsat 8 data were used to detect change in land cover classifications. |

***Ancillary Datasets:***

* USGS National Water Information System – Used to validate surface water and groundwater availability
* National Land Cover Database (NLCD) – Used to identify changes in land cover, specifically impervious and pervious land cover types to create a thriving index
* North American Land Data Assimilation System (NLDAS) Noah Model – Runoff parameters were used to understand patterns of excess water in the study area
* USA National Atlas Water Feature Lines Rivers and Streams – Used as a Reference layer on land cover maps to visualize waterways in the study area

***Software & Scripting:***

* Esri ArcGIS Pro 2.9.3 – Rescaled and clipped GPM-IMERG data to match ECOSTRESS data, calculated water balance, visualized data, and created final maps
* Python 3.9.12 – Collected and preprocessed ECOSTRESS
* GIOVANNI v 4.37 - Generated time averaged maps from GPM-IMERG data
* Google Earth Engine – Classified Landsat 8 imagery to NLCD land cover types

***End Product:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Evaporative Stress Index Time Series** | ECOSTRESS | This time series map depicted spatiotemporal anomalies in evapotranspiration. End users can use this to identify water stressed areas. |  N/A |
| **Water Balance Time Series** | ECOSTRESSGPM IMERG | This time series showed monthly changes in water balance. This product can help partners identify areas that require additional monitoring of water resources.  | N/A |
| **Thriving Areas Map** | ECOSTRESSGPM IMERGLandsat 8 OLI and TIRS | This map identified areas that were not water stressed and should be protected from future development.  | N/A |
| **Land Cover Maps** | Landsat 8 OLI and TIRS | These maps visualized change in land use to understand where water can infiltrate to the aquifer. | N/A |

***Product Benefit to End User:***

POA is interested in protecting the areas within the MA to ensure long-term water availability to the residents and industries dependent on the water resources. The team’s comparison of water balance, evaporative stress, runoff, and land cover patterns within West Tennessee will offer insight into thriving areas of the aquifer. The identified thriving areas will help POA assess areas that are the least water-stressed stressed and most suitable for groundwater recharge potential.

**References**

CAESER - University of Memphis. (2021, October 6). *The Memphis Aquifer.* <https://caeser.memphis.edu/resources/memphis-aquifer/>

Mahoney, L., Hatch, B., Villanueva-Weeks, C., & Webster, L. (2022). *Mississippi Embayment Water Resources: Utilizing NASA Earth Observations to Understand Groundwater Recharge in the Mississippi Regional Aquifer System.* NASA DEVELOP National Program, California – JPL.

https://ntrs.nasa.gov/api/citations/20220005934/downloads/2022Spring\_JPL\_MississippiEmbaymentWater\_TechPaper\_FD\_v4.docx

TNH2O. (2018). Tennessee’s Roadmap to Securing the Future of Our Water Resources. https://cumberlandrivercompact.org/wp-content/uploads/2019/10/TN\_H2O\_REPORT.pdf

TN Office of the Governor. (2021, September 27). *Memphis Regional Megasite Lands $5.6 Billion Investment from Ford Motor Company and SK Innovation* https://www.tn.gov/governor/new/2021/9/27/memphis-regional-megasite-lands--5-6-billion-investment-from-ford-motor-company-and-sk-innovation.html

*U.S. Census Bureau Quickfacts: Haywood County, Tennessee*. United States Census Bureau. (n.d.). <https://www.census.gov/quickfacts/fact/table/haywoodcountytennessee/PST045221>