A Stakeholder driven approach to optimize modeling and monitoring of water resources in the Mississippi Alluvial Plain

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Jeannie Barlow, Wade Kress, Kathy Knierim, Connor Haugh

USGS, Lower Mississippi-Gulf Water Science Center
The Mississippi Alluvial Plain Aquifer: An Engine for Economic Activity

Agriculture in the MAP region
• $6.56 billion total revenue
• $11.88 billion total economic impact

2017 agricultural gross domestic product (GDP)
• 84% Arkansas
• 71% Mississippi

USGS Science and Decisions Center
Water Budgets of the 3 most used aquifers, all for irrigation

- **ET**: evapotranspiration
- **RO**: surface runoff (quick flow)
- **RC**: recharge (base flow)

**ET + RO + RC = Ppt + Irr**

- **Central Valley**: 95% ET, 5% RO, no RC
- **High Plains**: 95% ET, 4% RO, 1% RC
- **MRVA**: 63% ET, 26% RO, 11% RC

Sources: Esri, USGS, NOAA, Sources: ESRI, Garmin, USGS, NRCS
Water Budgets by State

MO
- ET: 60
- RO: 21
- RC: 19

AR
- ET: 61
- RO: 26
- RC: 13

LA
- ET: 71
- RO: 26
- RC: 3

TN
- ET: 69
- RO: 21
- RC: 10

MS
- ET: 65
- RO: 29
- RC: 6
A. Precipitation

EXPLANATION
Precipitation, in meters per year
- 1.00 to 1.03
- 1.04 to 1.07
- 1.08 to 1.12
- 1.13 to 1.17
- 1.18 to 1.22
- 1.23 to 1.24
- 1.25 to 1.27
- 1.33 to 1.37
- 1.38 to 1.42
- 1.43 to 1.46
- 1.47 to 1.51
- 1.52 to 1.61
- 1.62 to 1.98

GULF OF MEXICO

Base from U.S. Geological Survey digital data.
Universal Transverse Mercator projection, zone 15N
North American Datum of 1983

A. Evapotranspiration

EXPLANATION
Evapotranspiration, in meters per year
- 0.704 to 0.719
- 0.720 to 0.751
- 0.752 to 0.782
- 0.783 to 0.797
- 0.798 to 0.813
- 0.814 to 0.844
- 0.845 to 0.876
- 0.877 to 0.891
- 0.892 to 0.922
- 0.923 to 0.954
- 0.955 to 0.985
- 0.986 to 1.02
- 1.03 to 1.06
- 1.07 to 1.13
- 1.14 to 3.99

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B. Quickflow

EXPLANATION
Quickflow, in meters per year
- 0.141 to 0.169
- 0.170 to 0.226
- 0.227 to 0.282
- 0.283 to 0.339
- 0.340 to 0.409
- 0.410 to 0.480
- 0.481 to 0.550
- 0.551 to 0.621
- 0.622 to 0.677
- 0.678 to 0.748
- 0.749 to 0.804
- 0.805 to 0.875
- 0.876 to 0.945
- 0.946 to 1.016
- 1.017 to 1.087

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0 50 100 MILES
0 50 100 KILOMETERS
How do we take advantage of these water budget opportunities? →

*Integrated water availability assessment*
Water availability in the Mississippi Delta: optimized monitoring and modeling for water management
Water Use Monitoring and Mapping Efforts
Water-Use Network

usgs.gov/centers/lmg-water
Measuring Water Use

Real-Time Water Use

Real-Time GW Levels
Hydrogeologic Efforts

Mapping Framework

Hydrogeologic

GW Flow Model

Uncertainty Data Worth

Geophysical Mapping

Surface-Groundwater Exchange

Groundwater Levels
Medical Imaging

MRI

Geophysical Imaging

EMI
AEM Survey

Largest AEM effort for water resource mapping in the CONUS

Total planned +40,000 line-km

Feb-March 18: 2,500 ln-km
• High-res survey of Shellmound, MS
• 250m & 1km line spacing

Nov 18-Feb 19: 17,000 ln-km
• Regional flight grid over MAP
• 6-12 km line spacing + river lines

Summer 2019: 10,000 ln-km
• Regional flight grid with Tempest fixed wing system

More 2020-2021

http://arcg.is/01nraa
Resistivity Color Scale for EM data

- Resistivity (ohm\*m)
  - Low
  - High
- Grain Size
  - Fine
  - Coarse
- Sed. Type
  - Clay
  - Sand
- SW/GW Exchange Potential
  - Lower Potential
  - Higher Potential
Medical Imaging

Geophysical Imaging

2D Profile

Depth slice
Water quality for availability
Groundwater Quality Goals

- Groundwater Age Tracers
- Estimate Recharge Rates
- MERAS Model
- Salinity (Specific Conductance & Chloride)
- Airborne Electromagnetic Geophysical Survey
2018 Sampling

Explanation

Mississippi Embayment Regional Aquifer Study (MERAS) model extent
Mississippi River Valley alluvial aquifer (MRVA) within the MERAS model extent
MRVA well sample locations
CLB well sample locations

Preliminary information - Subject to revision. Not for citation or distribution.
Spatial Variation of Chloride Over Time

Explanation

Mississippi Embayment
Regional Aquifer Study (MERAS) model extent

Mississippi River Valley
alluvial (MRVA) aquifer within the MERAS model extent

Groundwater Quality Parameter
Chloride (mg/L)
- 0 - 132
- 628 - 1,177
- 1,178 - 2,390
- 2,390 - 6,000
- 6,001 - 12,500

Selected Sites

USGS Station Number 322605091301101

USGS Station Number 322623091294901

Preliminary information - Subject to revision.
Not for citation or distribution.
Next Steps

Tracer Lumped Parameter Model (LPM)

Mississippi Embayment
Regional Aquifer Study (MERAS) model extent
Mississippi River Valley alluvial (MRVA) aquifer within the MERAS model extent

Groundwater Quality Parameter
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- 628 - 1,177
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Explanation

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628 - 1,177
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Alternative Water-Supply Scenarios

- Irrigation efficiency
- Instream weirs to increase surface-water availability
- Tailwater recovery and onsite farm storage
- Inter/intra-basin transfer(s)

Decrease GW Withdrawals

Irrigation efficiency in the Mississippi Delta; photo credit: Jason Krutz, MSU-DREC

Mundaring Water Treatment Plant, Australia; photo credit: http://www.watertechnology.net
Alternative Water-Supply Scenarios

Decrease GW Withdrawals

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Increase Recharge to the Alluvial Aquifer

- Enhanced aquifer recharge

Groundwater transfer and injection schematic

*Image from Dr. J.R. Rigby, USDA-ARS*
How much will water levels decline within the area of the Delta with the highest rate of water-level declines?
Average water level decline within the area of interest at the end of 50 years

Key Findings

1. Irrigation efficiency practices implemented outside of the “cone of depression” positively benefit water levels within the cone of depression, and when combined with irrigation efficiency practices implemented within the “cone of depression”, result in greater water-level response than implementing irrigations practices within the “cone of depression” alone.
2. The groundwater transfer and injection scenario was the only one that resulted in “recovery” after 50 years. Water-levels within the “cone of depression” were on average 1 ft higher than initial conditions at the end 50 year simulation.
How much will it cost?
Connect water and economic models to estimate anticipated cost for each scenario.

Land Surface

Base Scenario

Water Level Response

Alternative Scenario

Economic Model for each scenario

Cost per acre foot of water level response due to each scenario
## Economic Analysis: Most Realistic Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Estimated Total NPV</th>
<th>Average Water Level Increase at Year 50 in Feet</th>
<th>Cost of Change - Average Foot of Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigation Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta Wide</td>
<td>$354,913,325</td>
<td>15</td>
<td>$23,660,888</td>
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<tr>
<td>Central Delta</td>
<td>$9,295,469</td>
<td>10</td>
<td>$929,547</td>
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<tr>
<td><strong>In Stream Weirs 1/2 Mile Service Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66% Adoption Rate</td>
<td>$6,724,753</td>
<td>8</td>
<td>$840,594</td>
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<tr>
<td>33% Adoption Rate</td>
<td>$11,560,932</td>
<td>4</td>
<td>$2,890,233</td>
</tr>
<tr>
<td><strong>Tallahatchie- Quiver 1/2 Mile Service Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66% Adoption Rate</td>
<td>$51,427,291</td>
<td>4</td>
<td>$12,856,823</td>
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<tr>
<td>33% Adoption Rate</td>
<td>$49,113,657</td>
<td>2</td>
<td>$24,556,829</td>
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<tr>
<td><strong>Enhanced Aquifer Recharge</strong></td>
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<td></td>
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<tr>
<td>10 Abstraction Wells</td>
<td>$52,762,173</td>
<td>8</td>
<td>$6,595,272</td>
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<td>20 Abstraction Wells</td>
<td>$105,524,338</td>
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<td>30 Abstraction Wells</td>
<td>$158,286,513</td>
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<tr>
<td>40 Abstraction Wells</td>
<td>$211,048,680</td>
<td>35</td>
<td>$6,029,962</td>
</tr>
</tbody>
</table>
Future efforts will involve optimizing multiple solutions.
Questions?

- Wade H. Kress, wkress@usgs.gov
- https://www2.usgs.gov/water/Img/map
- Twitter: @USGS_LMG