Institute for Energy Innovation
Assessing CO$_2$ Geologic Storage Impacts on Louisiana’s Water Resources and Environment

Progress Update

Frank Tsai, PhD, PE, PG
Professor, Department of Civil and Environmental Engineering
Director, Louisiana Water Resources Research Institute
Louisiana State University

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Outline

• Motivation
• Project overview
• Large-scale geological and groundwater model development
• CO$_2$ transport simulation and baseline information collection for understanding carbon budget and land-surface deformation
• Next steps
CO₂ Geologic Storage in the Gulf Coast Region

- The Coastal Plains region has the most storage potential for CO₂, accounting for 65% of the national total.
- The Gulf Coast region of the United States has a large storage capacity for carbon dioxide (CO₂) through geologic sequestration. It accounts for 59% of the national CO₂ storage capacity. (USGS Circular 1386, 2012).

Geologic Carbon Storage Potential in the United States (Blondes et al. 2019)

Gulf Coast Aquifer System (Grubb, 1998)

Lower Mississippi Gulf Region (LMGR)
Concerns of CO₂ Geologic Storage

Potential leakage pathways and consequences (Benson and Hepple 2005)

Major geological structural features in southeast Louisiana (Gagliano 2005)
Project Overview

• Funding Source: LSU Institute for Energy Innovation
• Funding Program: Research for Energy Innovation 2023-I (Phase I)
• Project Title: Assessing CO$_2$ Geological Storage Impacts on Louisiana's Water Resources and Environment (Experimental)
• Project Period: 10/9/2023 – 10/8/2025 (2 years)
• Project Team:
  • Frank Tsai, Professor, Department of Civil and Environmental Engineering
  • Christopher Kees, Associate Professor, Department of Civil and Environmental Engineering
  • Yi-Jun Xu, Professor, School of Renewable Natural Resources
  • Ahmed Abdalla, Assistant Professor, Department of Civil and Environmental Engineering
Project Goal: Develop baseline information on geology, groundwater, carbon budget, land-surface deformation, and scenario-based CO₂ transport simulation to assess potential impacts of CO₂ storage in Louisiana's porous rocks on drinking water, water supplies, and the environment.
Seismic survey was finished.
Two Class V test wells were approved for drilling
Class VI well permit is under review
Expected to have 12 to 16 CO₂ injection wells on the Lake
Expected to start CO₂ injection in 2026
Where Are Freshwater Zones and Potential CO₂ Injection Zones?

- Upper Ponchatoula Aquifer
- Lower Ponchatoula Aquifer
- Big Branch Aquifer
- Lower Ponchatoula Aquifer
- Slidell Aquifer
- Covington Aquifer
- Gonzales-New Orleans Aquifer
- Norco Aquifer

Freshwater Zones:
- Lake Maurepas
- 1000’
- 2700’
- 3100’
- 3650’
- 8050’

Saltwater Zones:
- 3650’

Where are Freshwater Zones and Potential CO₂ Injection Zones?
Groundwater Pumping Wells – Depth (ft)
Module 1: Workflow for Large-Scale High-Resolution Groundwater Model Development

- Multi-state well log data compilation
- Multi-state groundwater use data compilation
- Hydrogeologic framework development
- Horizon restoration
- Lithofacies modeling
- MODFLOW 6 unstructured grid and model split
- Techniques for model calibration
- MODFLOW 6 Packages development
- High-fidelity groundwater models
- Groundwater analysis and management
## Compilation of Driller’s Logs and Electrical Logs

<table>
<thead>
<tr>
<th>State</th>
<th>Driller’s Logs</th>
<th>Electrical Logs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>3,106</td>
<td>702</td>
<td>3,808</td>
</tr>
<tr>
<td>Arkansas</td>
<td>34,278</td>
<td>1,191</td>
<td>35,469</td>
</tr>
<tr>
<td>Florida</td>
<td>152</td>
<td>16</td>
<td>168</td>
</tr>
<tr>
<td>Illinois</td>
<td>79</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>Kentucky</td>
<td>3,028</td>
<td>6</td>
<td>3,034</td>
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<tr>
<td>Louisiana</td>
<td>114,472</td>
<td>4,556</td>
<td>119,028</td>
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<tr>
<td>Mississippi</td>
<td>4,561</td>
<td>9,584</td>
<td>14,145</td>
</tr>
<tr>
<td>Missouri</td>
<td>15,368</td>
<td>11</td>
<td>15,379</td>
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<tr>
<td>Tennessee</td>
<td>11,933</td>
<td>145</td>
<td>12,078</td>
</tr>
<tr>
<td>Texas</td>
<td>8,071</td>
<td>10,804</td>
<td>18,875</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>195,048</strong></td>
<td><strong>27,016</strong></td>
<td><strong>222,064</strong></td>
</tr>
</tbody>
</table>

### Number of well logs

![Number of well logs chart](chart.png)

- **Drillers Logs**
- **Electrical logs**
Lower Mississippi-Gulf Hydrogeologic Framework

Around 156,000 driller’s logs & 8,400 E-logs
-1 : Unknown Lithofacies
0 : Clay Lithofacies
1: Sand Lithofacies
2: Limestone Lithofacies
Lower Mississippi-Gulf Lithologic Model

Sand probability model
Louisiana Lithologic Model
(Provisional Result)

- Clay
- Sand
- Soil group A
- Soil group B
- Soil group C
- Soil group D
Louisiana Lithologic Model (Provisional Result)

- Clay
- Sand
- Soil group A
- Soil group B
- Soil group C
- Soil group D

Lake Maurepas

Gonzales-New Orleans Aquifer
Upper Ponchatoula Aquifer
Covington Aquifer

MRVA

LSU
Department of Civil and Environmental Engineering
Louisiana Groundwater Model

- Parallel MODFLOW 6 – Unstructured Grid
- Nearly 4.4 million 3D cells
- 2004-2021
- 9 sub-models
- 16 EXG files
- Single core: 15 hr 44 min
- 9 cores: 1 hr 50 min
- Speedup: 8.6

Pumping wells > 24,500
Simulated Groundwater Level

Simulated groundwater level on 12/2021

Depth to water level, feet below land surface

USGS 362745091092401 EB-90

300 ft

Period of approved data
Module 2 (Kees) – CO$_2$ Transport (Computational Modeling)


• Building on existing multiphase flow models and numerics for unstructured mesh representations of subsurface geology

• Extending recently developed high-resolution Finite Element Methods based on Flux Corrected Transport (FCT)
Module 2 (Kees) – CO₂ Transport (Computational Modeling) (provisional result)

Unstructured FEM mesh extracted from benchmark data (above) under soil/rock properties, and water flood.
Module 3 (Xu) – Understand the Carbon Budget of Lake Maurepas

Objectives:

• To determine levels and fluctuations of dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), and partial pressure of dissolved carbon dioxide (pCO₂) in Lake Maurepas, the Amite River, and water wells near the lake;

• To quantify total mass inputs and/or exchange of DIC and DOC from the river and groundwater into Lake Maurepas, and investigate seasonality of the inputs;

• To estimate hourly, daily, and monthly outgassing rates of CO₂ from the lake and river water surface; and

• To assess the factors affecting dissolved carbon mass transport and CO₂ outgassing in the Amite-River-Lake-Maurepas continuum.
Field measurements and sampling conducted in the Amite River at Port Vincent and Lake Maurepas at Pass Manchac north and south.
• Preliminary survey over Lake Maurepas assessed 25 InSAR images in 2017
• Sentinel-1 Satellite images produced every 12 days
• Good SAR coverage exists at the boundary of Livingston and St. John the Baptist Parish Parishes.
• Low SAR signal is shown in the vegetation area.
Module 4 (Abdalla) - Monitoring Land Surface Displacement around Lake Maurepas (provisional result)

Displacement per image
2/27/2017 to 12/24/2017

Average velocity of 2017
Uplift 0.5 to 0.8 mm
Next steps

• Analyze geological structure and groundwater flow for the Lake Maurepas area
• Post-process the MODFLOW 6 mesh and model results for high-resolution Finite Element Methods for CO₂ simulation
• Continue CO₂ concentration monitoring and analysis
• Continue land surface displacement analysis with satellite data
Thanks for your attention!

Questions?