Integrated Research Projects:
Managed Aquifer Storage and Recovery in Coastal Louisiana

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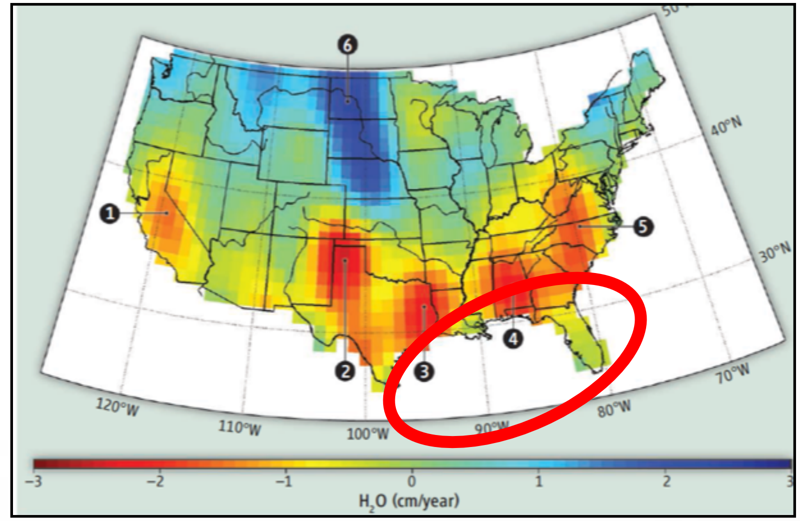
Problem

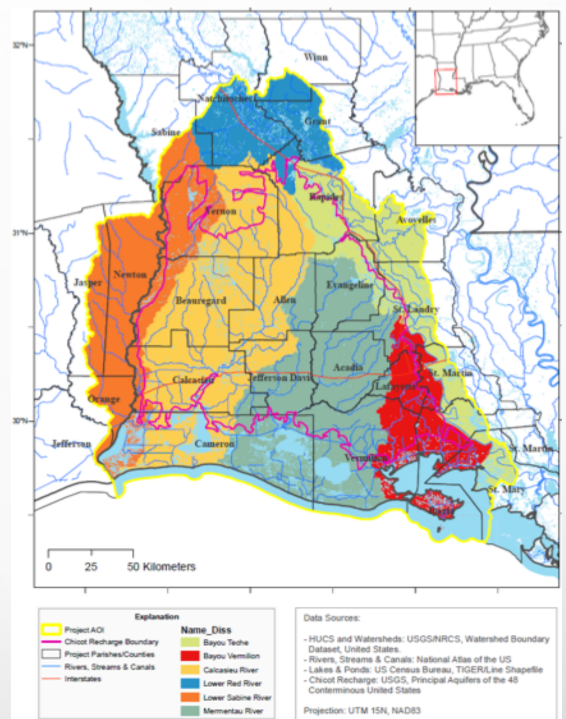
Despite relatively abundant rainfall and surface water, groundwater is being overused across the Southeastern United States. Coastal Louisiana is no exception.



GRACE satellite estimates of changes in terrestrial water storage over the last decade. (Famiglietti and Rodell, 2013, Science).

Consequences

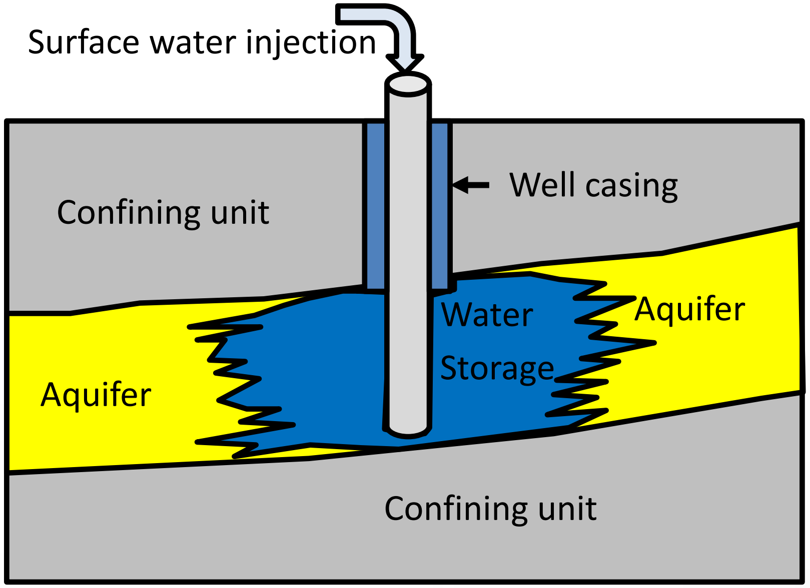
Overuse of coastal aquifers leads to **subsidence** and **salt water intrusion,** accelerates **coastal land loss,** and devastate coastal communities through the **loss of available freshwater** for drinking and economic activities.



Chicot Aquifer: Overdraft of ~350 million gallons per day (MGD); Projected overdraft of 420 MGD by 2030; Saltwater intrusion near the coast

Possible Solution

During high-flows (e.g., floods), clean surface water is pumped into aquifer for storage and later use during droughts and peak demands ..... combat subsidence and provide freshwater buffer to keep salt water intrusion at bay.



ASR Wells, City of Cocoa, FL

Operational ASR Sites in the US in 2013 (Source: FEMA)

Background: NSF Water Sustainability Project

Overarching Question

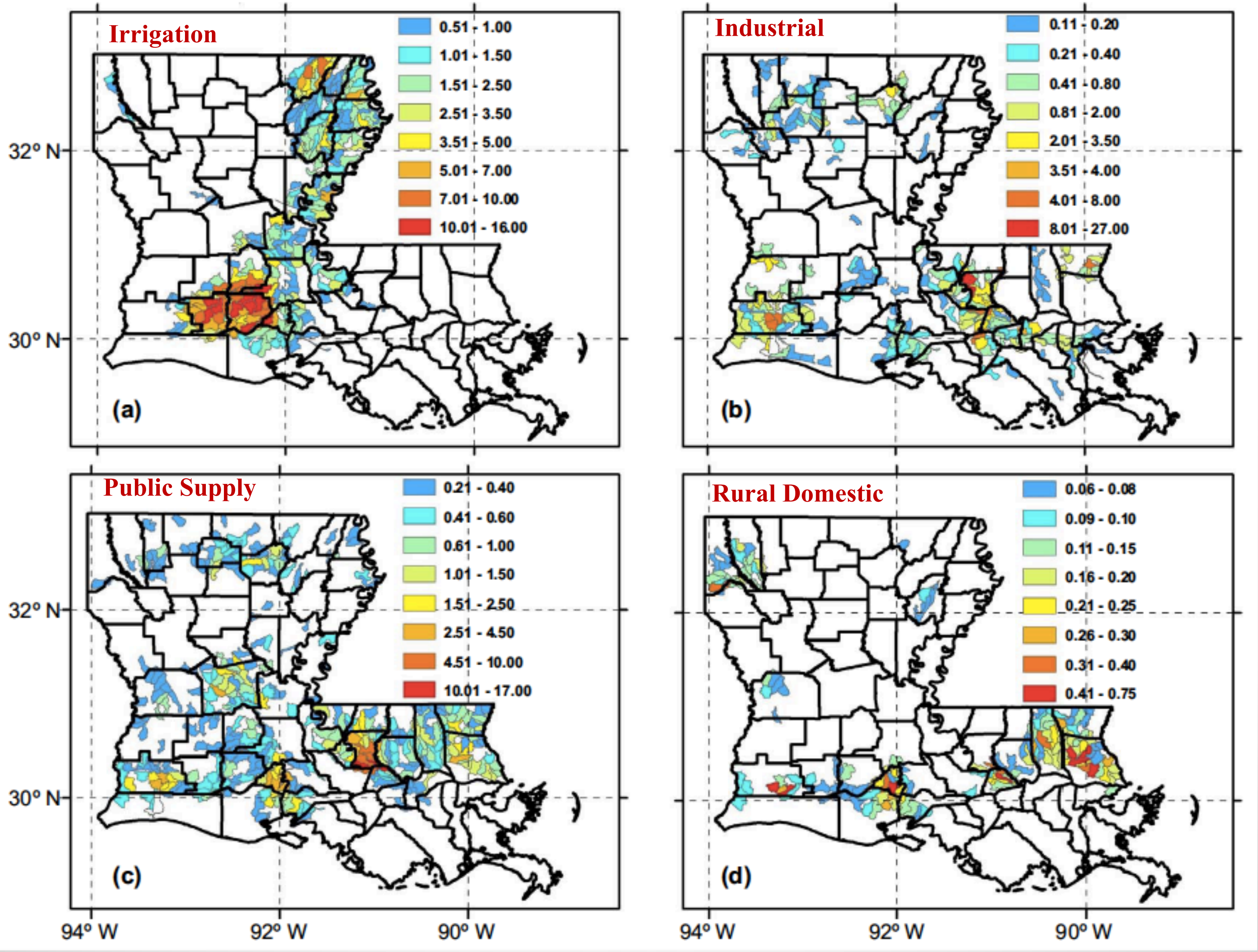
Is there enough "excess" surface water available in these regions to address groundwater supply gaps without harming coastal ecosystems?

Objectives

- Develop a framework to quantify water stress on fine spatial and temporal scales.
- Understand social dynamics that underpin water usage decisions in south LA.
- Identify opportunities for implementing new water management strategies.
- Educate students and provide community outreach.

Irrigation and water quality sampling at a rice farm in southwest Louisiana

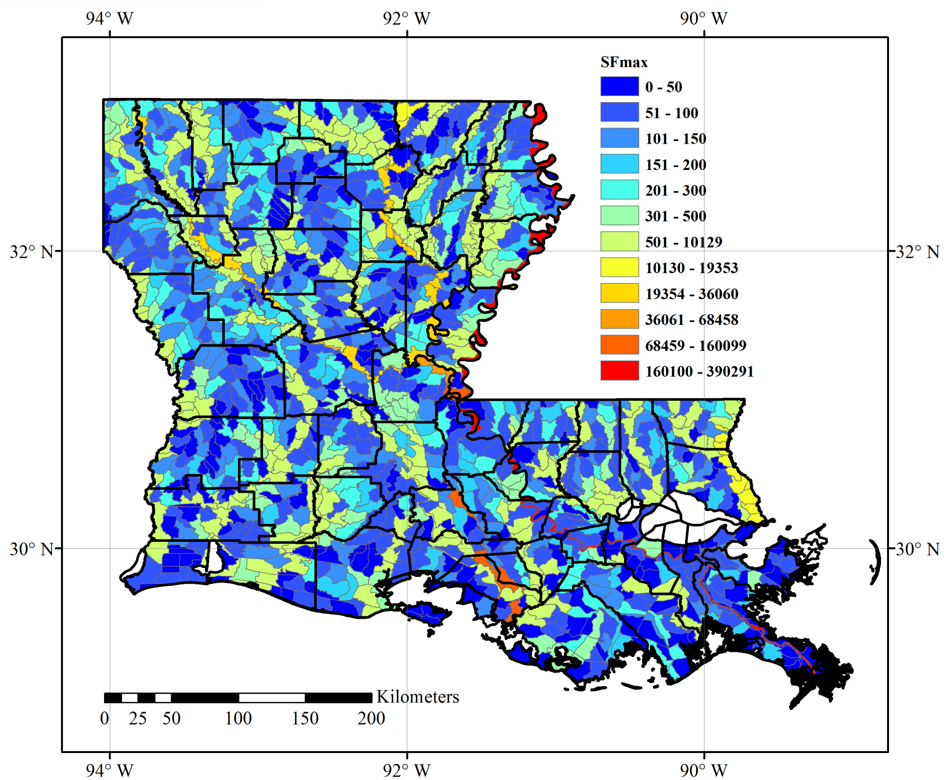
Groundwater Demand



Disaggregation of GW Withdrawals based on casing diameter of wells.

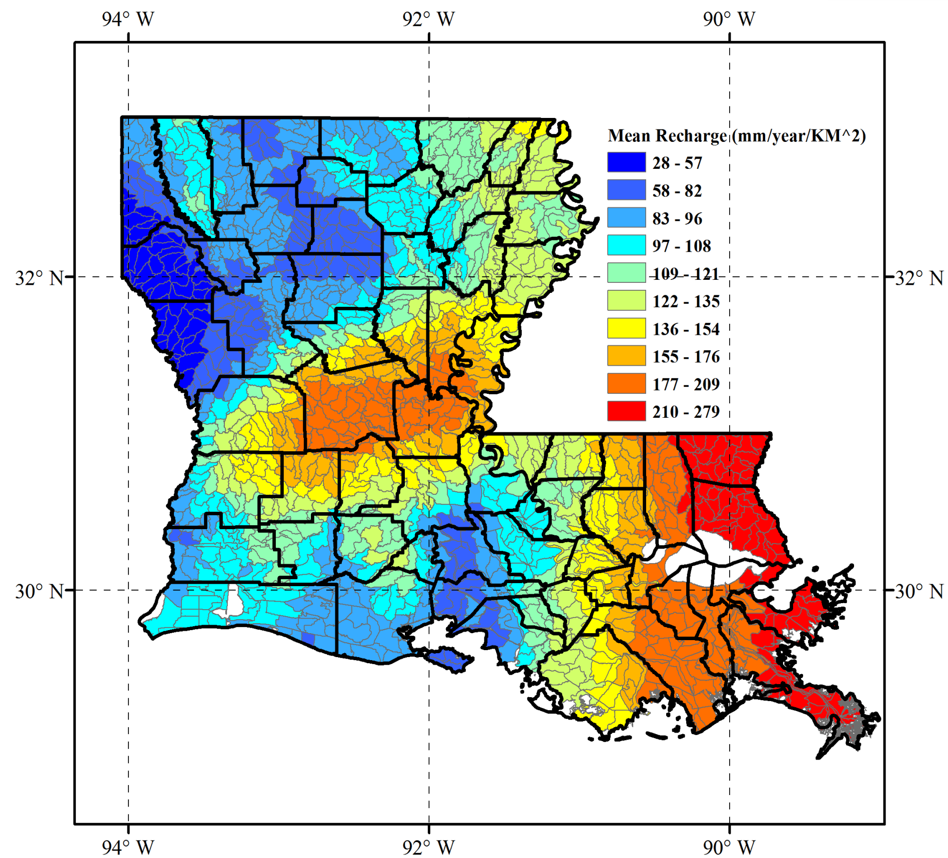
Water Availability Data

Surface Water



<u>National Hydrography Dataset (NHDPlus)</u>, represents 25 year average (annual and monthly) climatological conditions of water availability.

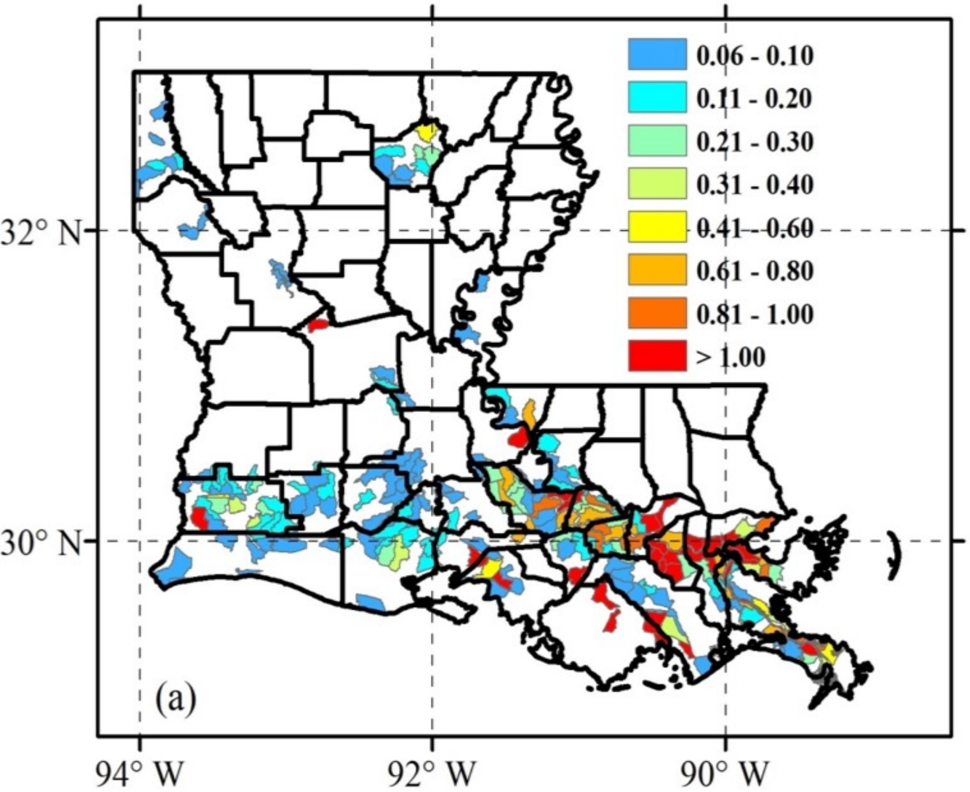
Groundwater



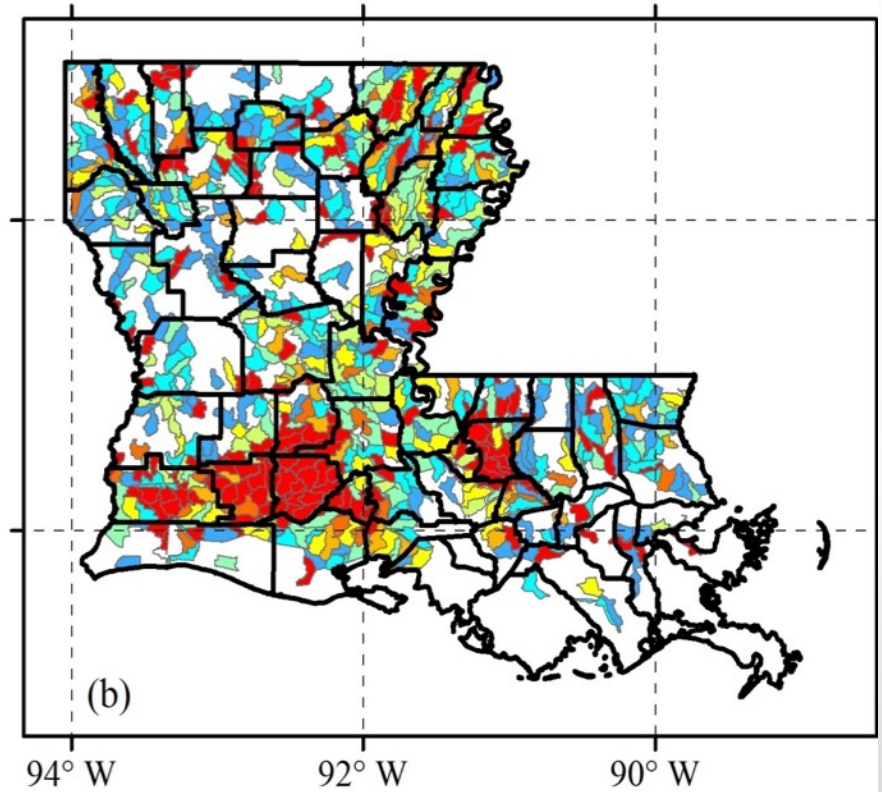
<u>USGS Groundwater recharge estimates</u>
mean annual recharge (mm/yr/km²)

Water stress in Louisiana

Annual Surface Water Stress



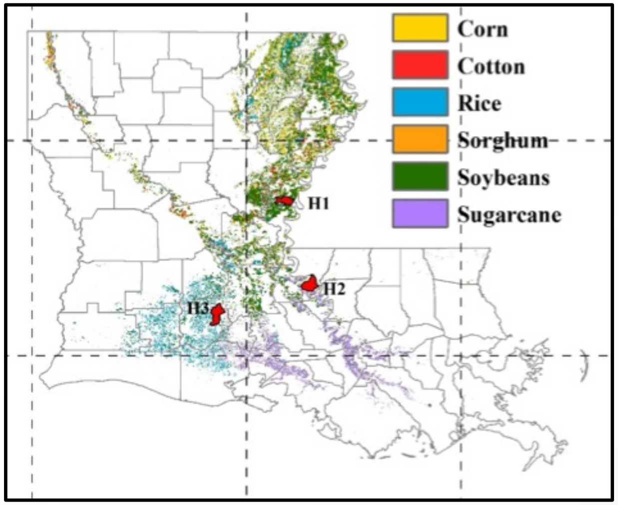
Annual Groundwater Stress



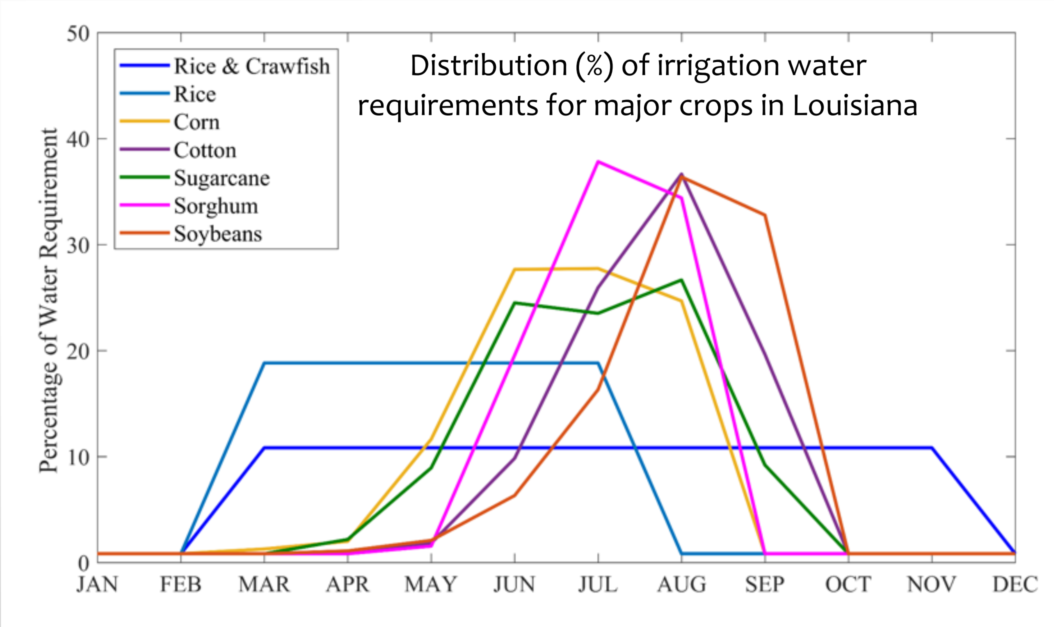
Areas in red indicate water deficits. For groundwater that implies water is being mined faster than it is replaced through natural recharge processes.

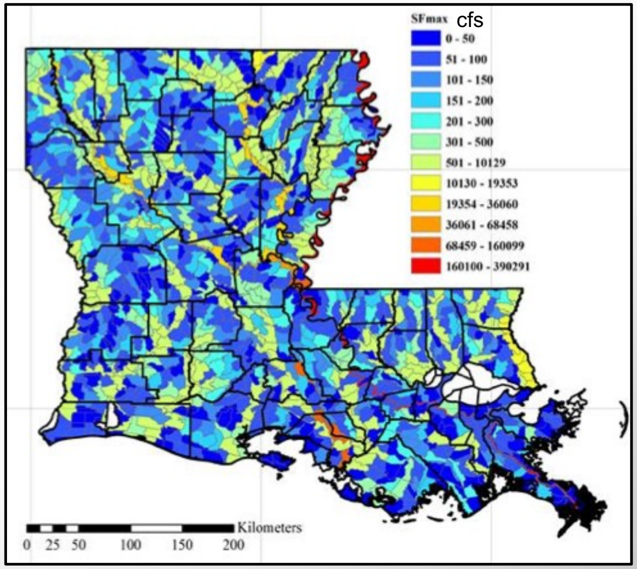
Impact of Climate Variability

- Inter-annual and intra-annual variability in water supply
- Seasonal variability in water demands



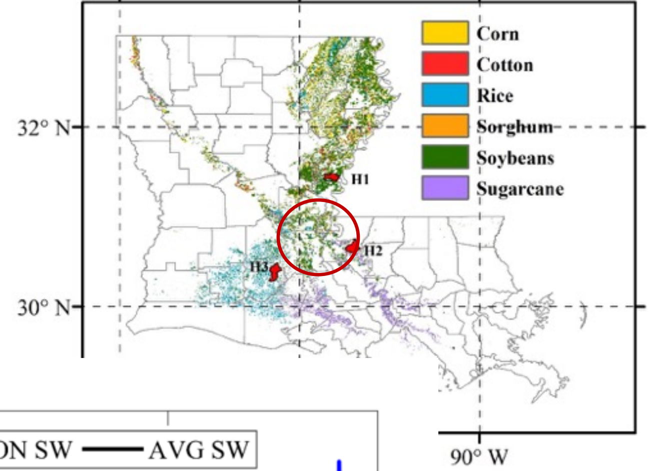
Spatial distribution of dominant crops in Louisiana (Source: USDA/NASS).

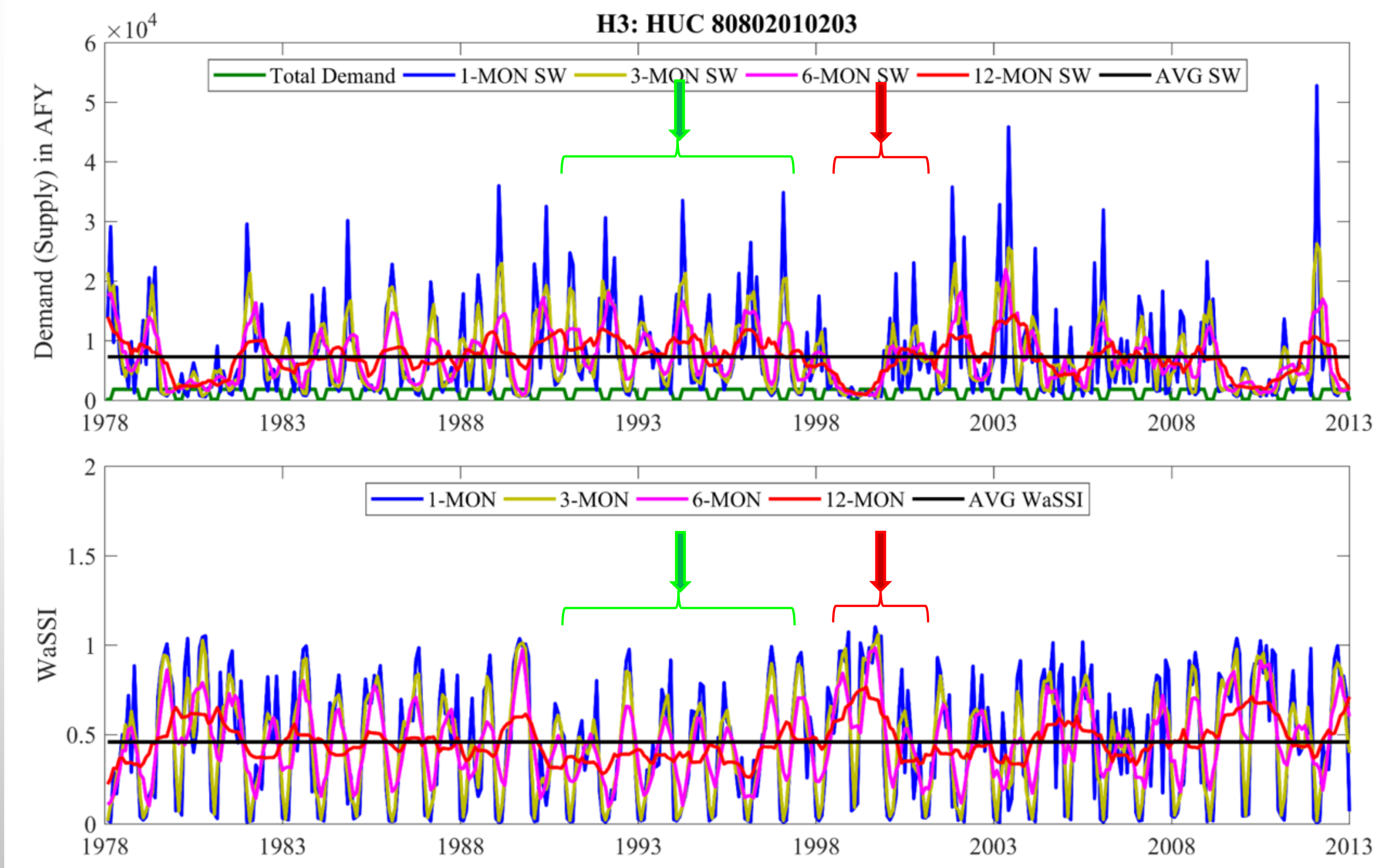




Time series of monthly (1979-present) streamflow estimates (Source: NASA/NLDAS)

Seasonal Variability: Results from Example HUCs



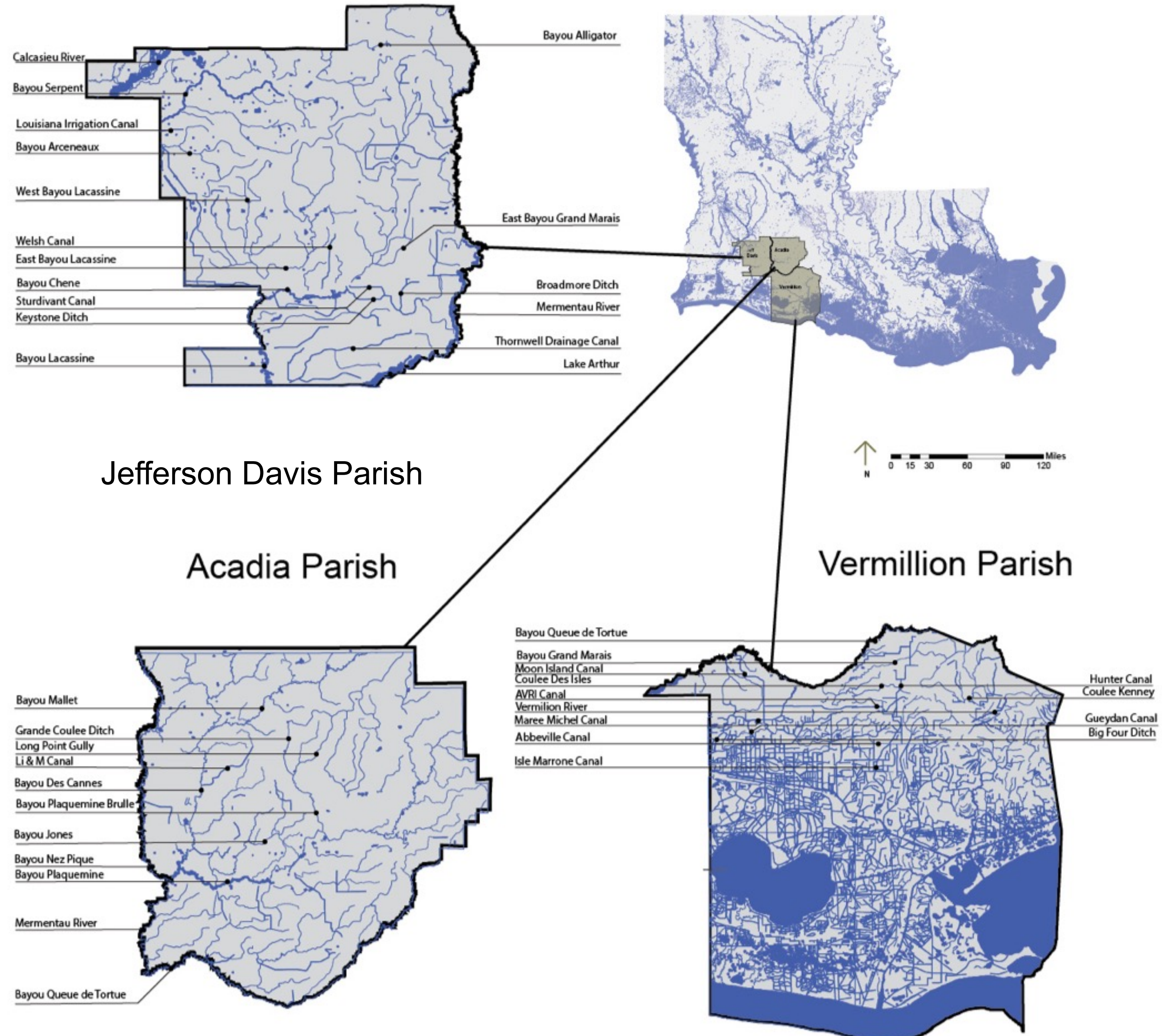


Key Insights & Implications for Water Management

- Abundance of surface water on an average annual basis is sufficient to offset groundwater demand.
- However, there is substantial seasonal and inter-annual variability that is hidden by annual averages.
- This suggests there is a strong probability of surface water not being available in a given year/season. Hence, "**reliability**" is a primary factor why farmers choose groundwater over surface water.

What drives the decision making?

- Completed interviews of 68 farmers.
- In-person, on-site, interviews.



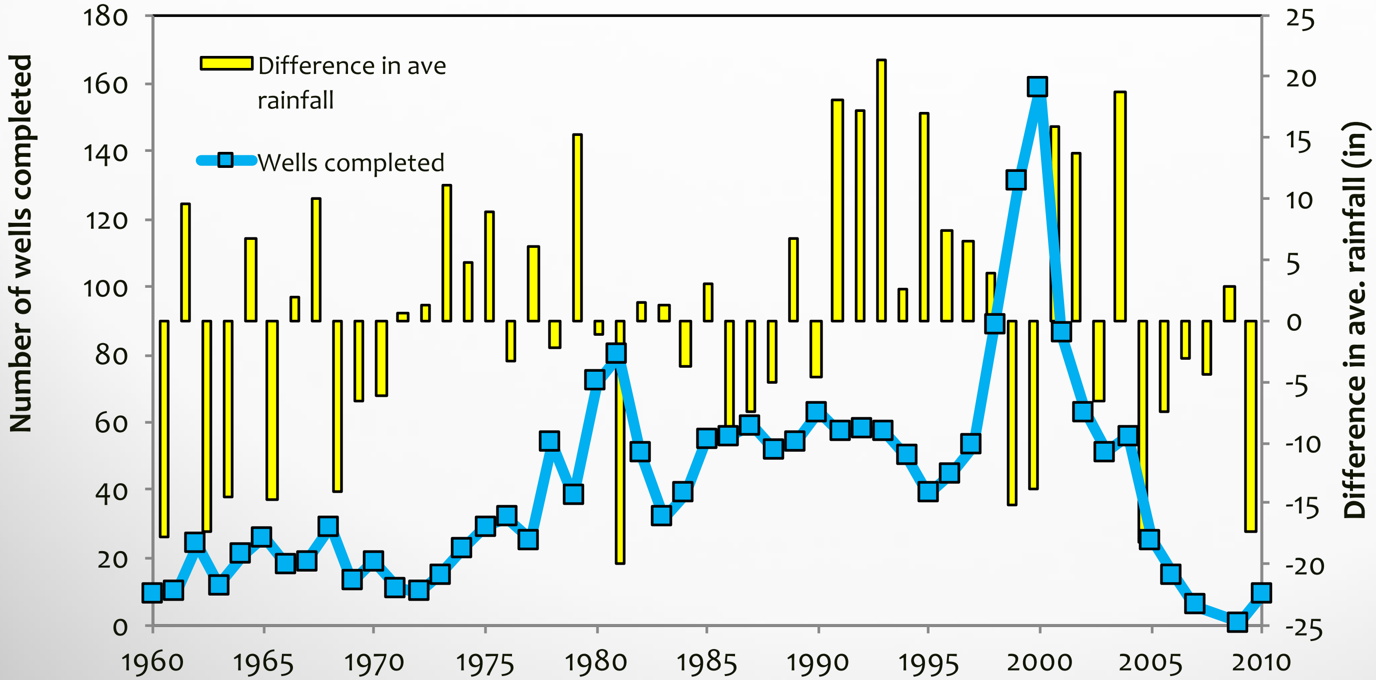
How our results were corroborated by field interviews

- Farmers who owned the majority of the acreage they farmed and who had experienced extended or repeated drought had multiple deep-water wells.
- There is practically no investment in water storage infrastructure for dealing with the "reliability" problems for surface water on a local or larger scale.
- Less than 20% of farmers stored surface water for future use. Those who did store surface water had a naturally occurring pond area, or had identified areas of their property that were not viable for farming.

Water storage site

Farmers adapt to climate variability by drilling more wells!

- Farmers invested in groundwater wells instead of surface water infrastructure in response to seasonal deficits and drought.



Working with Community Stakeholders

We worked with community stakeholders to examine solutions for surface water storage.

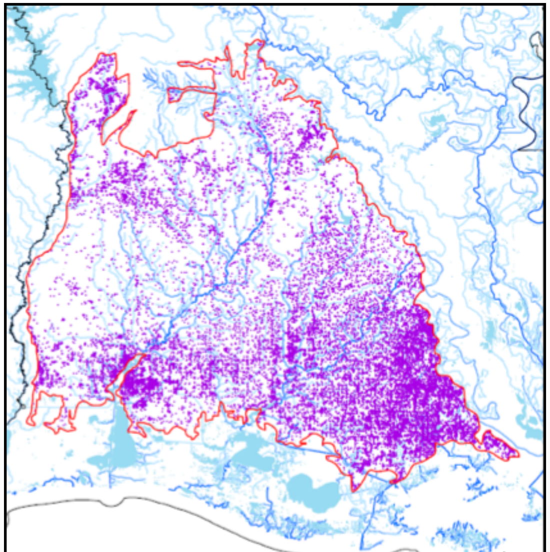
A combination of our GIS framework, hydrologic models, and architectural design concepts were used to find opportunities for construction of temporary surface water storage sites.

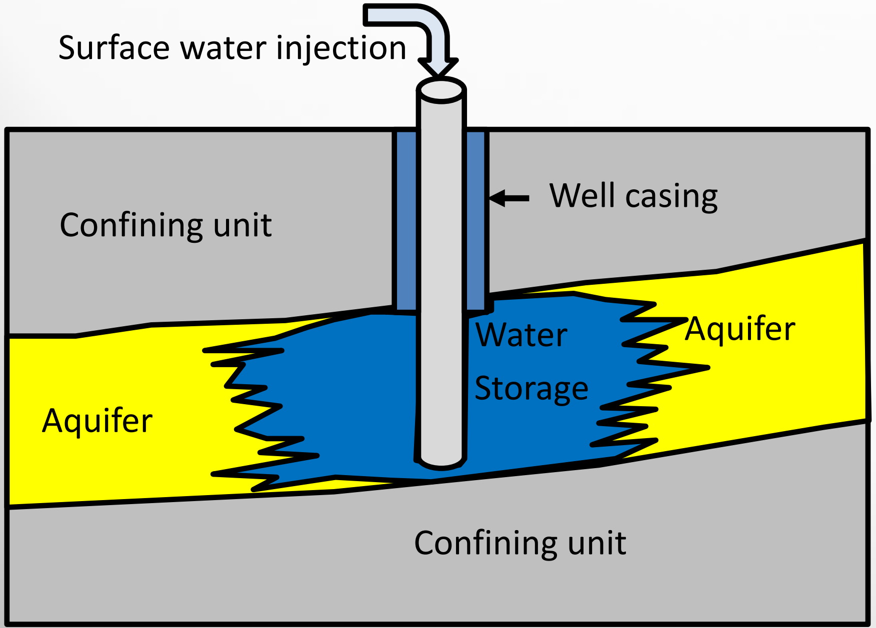
Community stakeholder involvement-real world implications

Our new project: Integrated water management solutions

<u>Developing storage capacity</u>

Can we identify opportunities for building surface water storage capacity to benefit farmers during irrigation season but also mitigate flooding during emergencies?


Well distribution in Chicot Aquifer



<u>Managed aquifer recharge (MAR)</u>

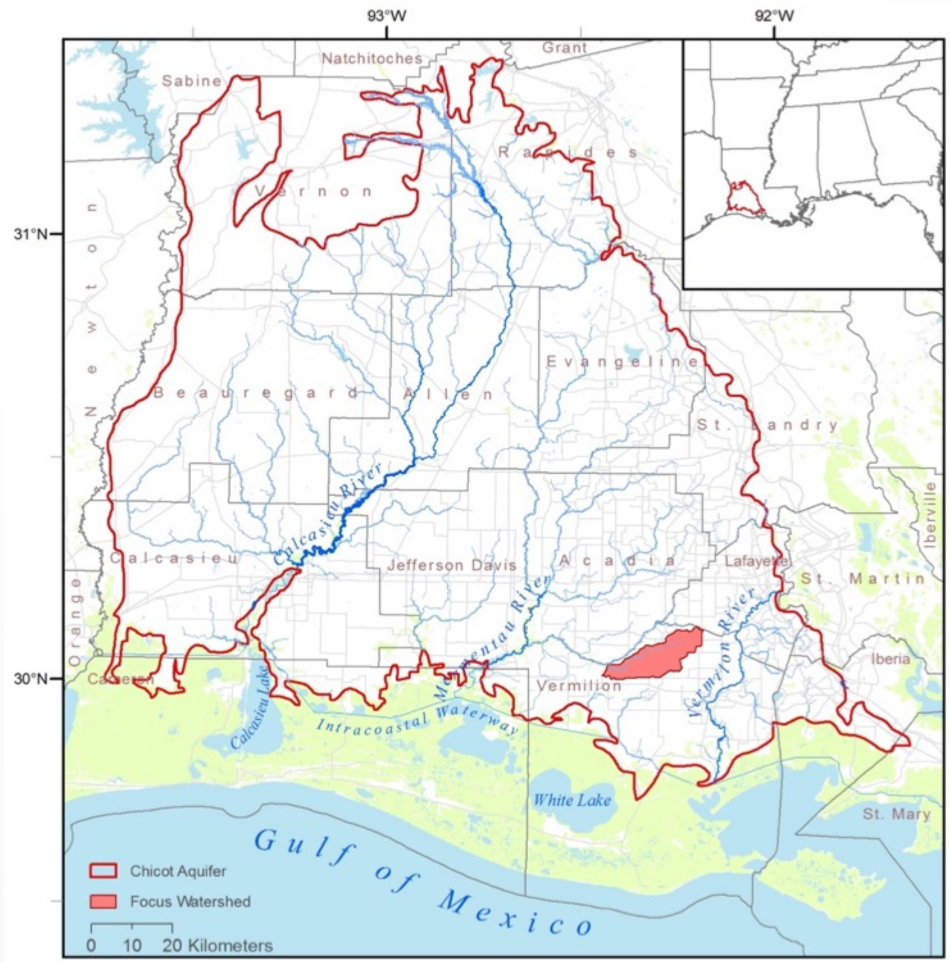
Can we identify locations where we reverse pumping and effectively recharge the groundwater system with excess (flood) water?

Research Objective

Investigate **feasibility** of implementing an **innovative water management design solution** using small reservoirs and engineered wetlands or water treatment centers in combination with Aquifer Storage and Recovery (ASR).

Approach

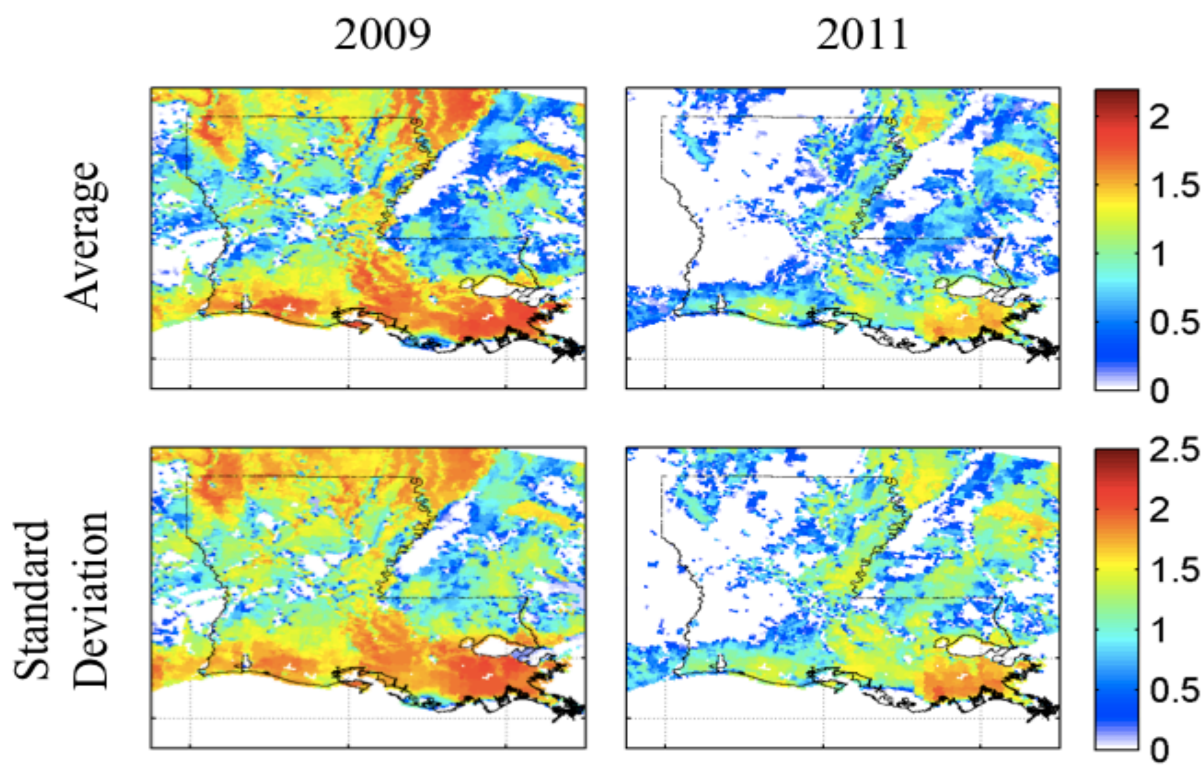
A) Surface water hydrology
B) Groundwater hydrology
C) Social and economic expectations
D) Outreach and Education



Site map of the project area showing the freshwater boundary of the Chicot aquifer and the pilot study watershed.

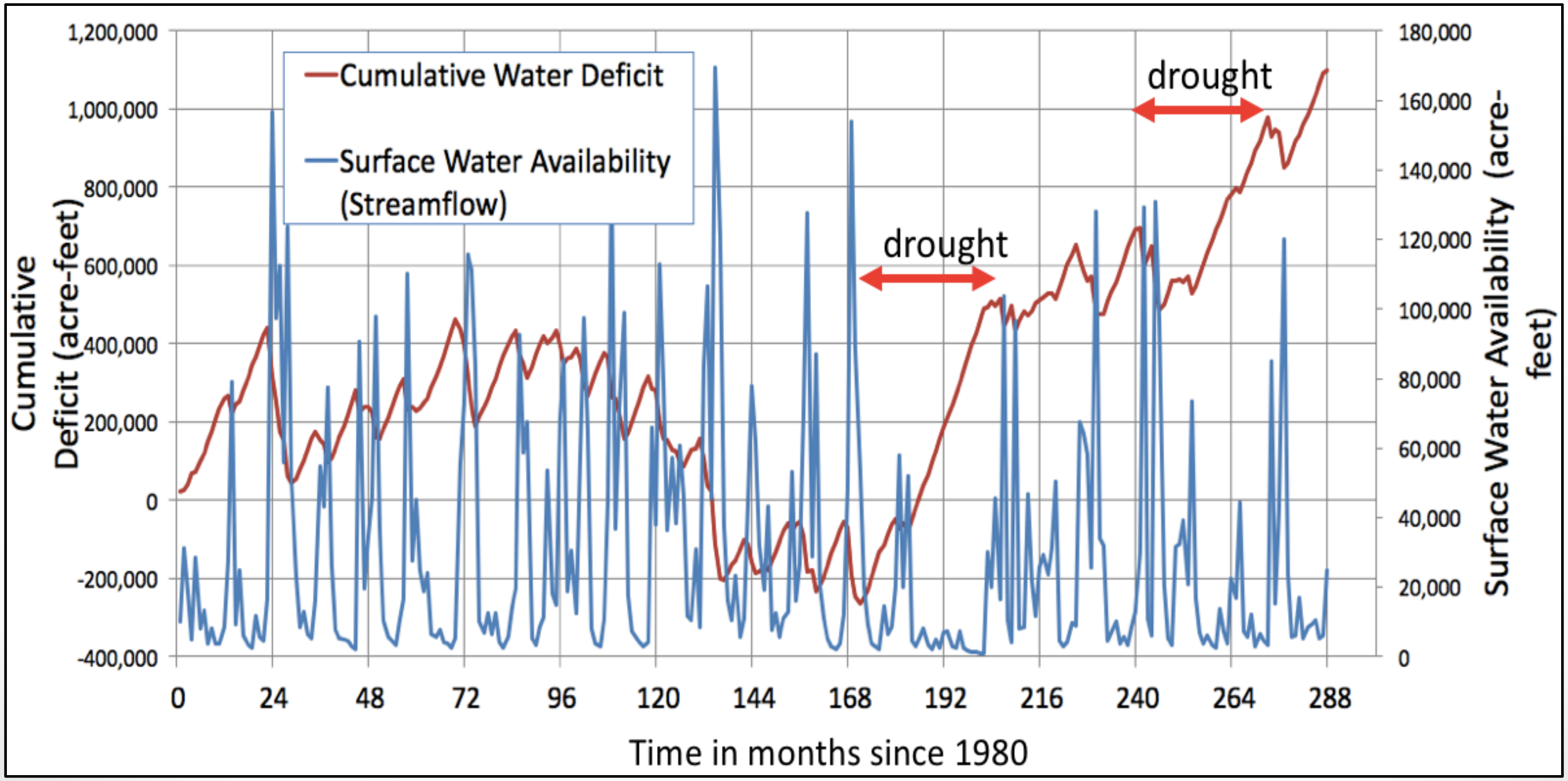
Surface Hydrology:

A) Analysis of Water Availability for ASR



Mean and variability of monthly surface runoff over Louisiana using the NLDAS system for two example years. Units are in logarithmic scale of mm/month.

Surface Hydrology:
B) Analysis of Water Deficit/Surplus with and without ASR

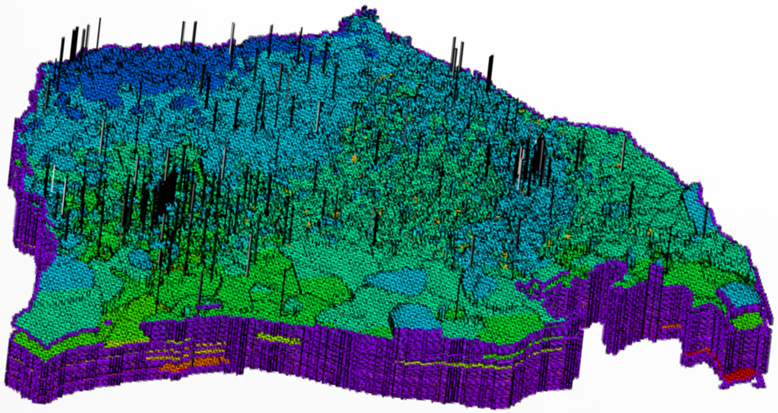


Cumulative water deficit using monthly streamflow and water demands in an irrigation-dominated catchment in southwest LA. Similar analysis will be conducted after the addition of ASR to examine potential benefits for capturing water during wet years and alleviating water stresses during droughts.

Groundwater Hydrology (LSU Team):

A) Development of a localized groundwater model

211 USGS groundwater observation wells

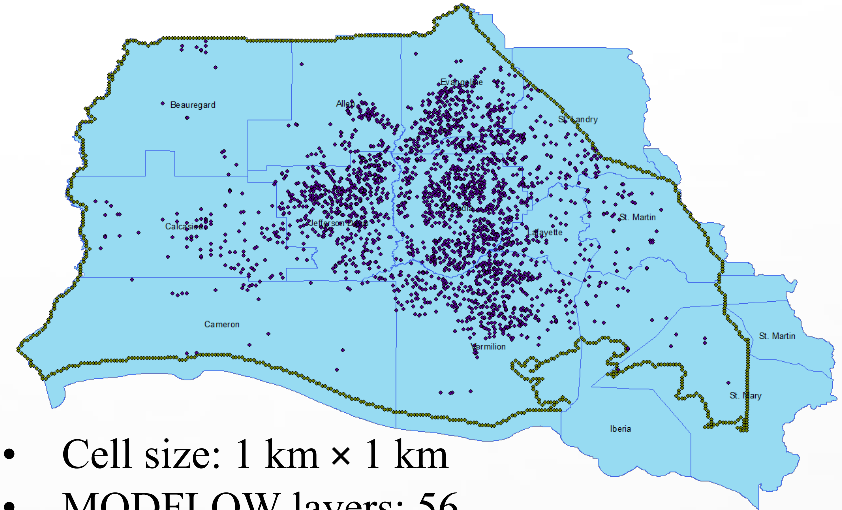


Side plane view at west of Chicot aquifer

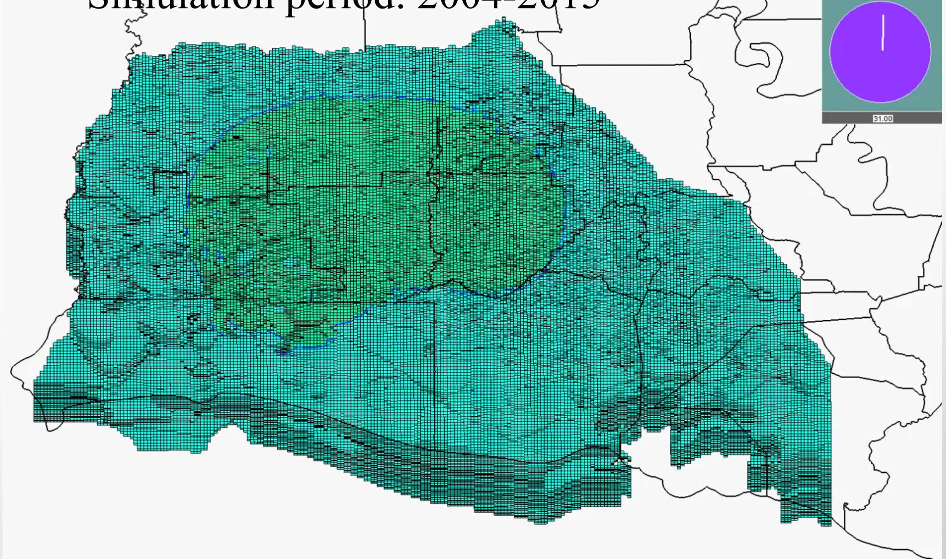
North-south cross section at the middle of Chicot aquifer

Side plane view at east of Chicot aquifer

2680 Pumping wells



- Cell size: 1 km × 1 km
- MODFLOW layers: 56
- Simulation period: 2004-2015



Groundwater Hydrology:

B) Development of an ASR management model

A simulation-optimization approach to evaluate and optimize potential ASR operation efficiency.

Bolivar Recycled Water ASR Trial site on the Adelaide Plains, SA. 2002

Objectives:

(1) maximizing surface water stored in aquifer,

(2) minimizing injection time,

(3) minimizing excessive GW level increase during recharging,

(4) minimizing excessive GW level decrease during recovery.

Potential Applications:

(1) provide recommendations to stakeholders on where, how many wells, well spacing, pumping rates, and operation time.

(2) provide information on influence zone of each ASR well, change in GW level over a cycle of operation, and % of injected water captured during recovery.

Social & Economic Aspects:

(A) Interviews with people currently using ASR systems

- Gather experiences on implementation challenges; risks, costs and benefits; changes to aquifer conditions
- acceptance/rejection by community; unanticipated consequences.

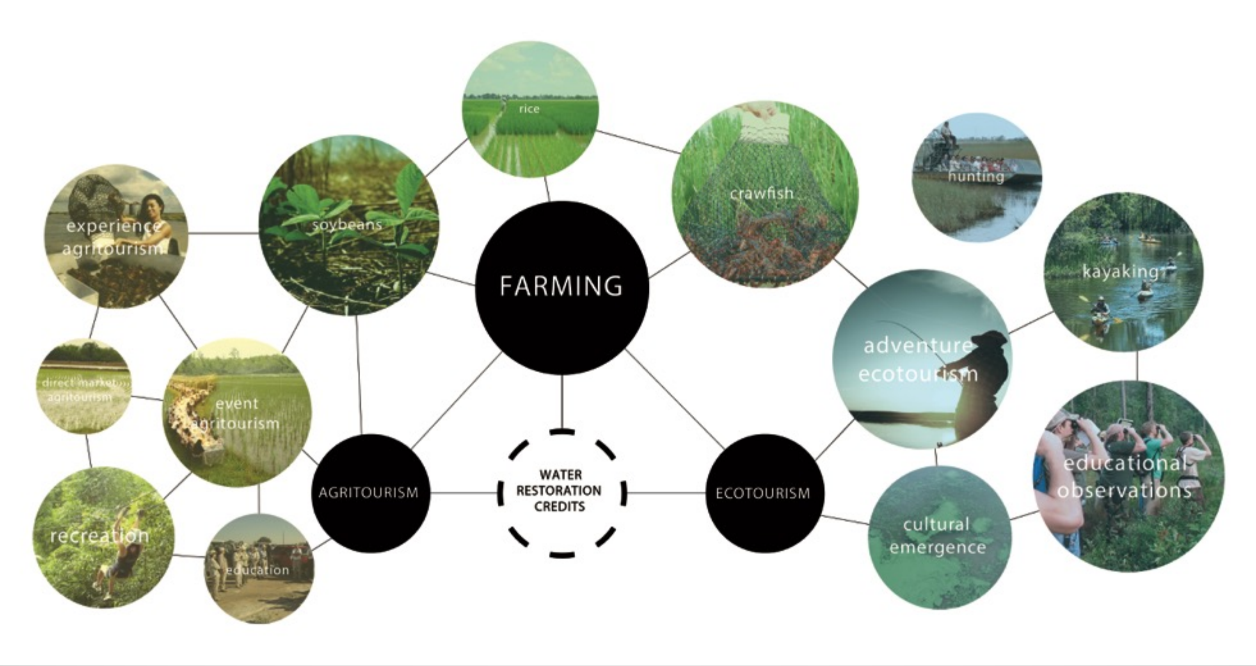
(B) Focus groups with local stakeholders

- determine potential support for ASR; how support may depend on actual use of water (e.g., irrigation, industrial or drinking).
- explore feasibility of implementation from technical, economic and regulatory perspectives:
  - How might an ASR impact property values?
  - How might an ASR impact land-use patterns?
  - What are the energy costs associated with ASR?
  - What monitoring will be required to avoid unforeseen water-quality problems on groundwater resources?
  - What concerns about implementation are likely to result in resistance?

Social & Economic Aspects:

(C) Research into economic opportunities

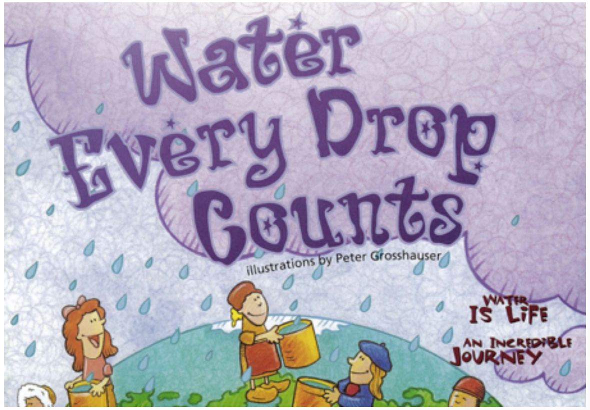
- identify revenue options for farmers to offset cost of ASR units.
  - *Water Restoration Certifications* for freshwater restoration projects
  - *Environmental Quality Incentives Program (EQUIP)*
    - Master Farmer Program, National Water Quality Initiative (NWQI), Gulf of Mexico Initiative (GoMI)
  - Ecotourism/Agritourism for supplemental incomes



Conceptual Designs & Visualizations

Develop pilot-site renderings, analytical diagrams and visualizations, and use it disseminate to engage policy makers and stakeholders in ASR discussion

Outreach & Education



- We want to engage stakeholders in creating and implementing a more sustainable water-management plan for coastal Louisiana.
- Begin by assessing knowledge base on wetland filtering and storage, and ASR topics among stakeholders.
- Recruit experts (researchers, consultants, water managers) to speak to public about water storage alternatives
- Provide resources such as fact sheets, graphics, web resources, and visualizations to public, utilities, municipalities, and other water officials.
- Work Office of Conservation, Parish boards and commissions, LA Water Resources Commission, Louisiana State Law Institute

Partnerships

- LSU AgCenter Marine Extension Agent
- Louisiana Sea Grant Law & Policy Program
- LSU AgCenter Master Farmer Program Coordinator
- Ground Water Management Advisory Task Force for the state of Louisiana
- Vermilion Soil and Water Conservation District.
- Cypress Engineering and Development Group
- Chenier Plain Coastal Protection and Restoration Authority
- Rockefeller Wildlife Refuge
- State Conservationist with NRCS
- Local non-profit organizations
- Vermilion Soil and Water Conservation District