LSU SHREVEPORT

USEPA Hydraulic Fracturing Study Water Management Workshop

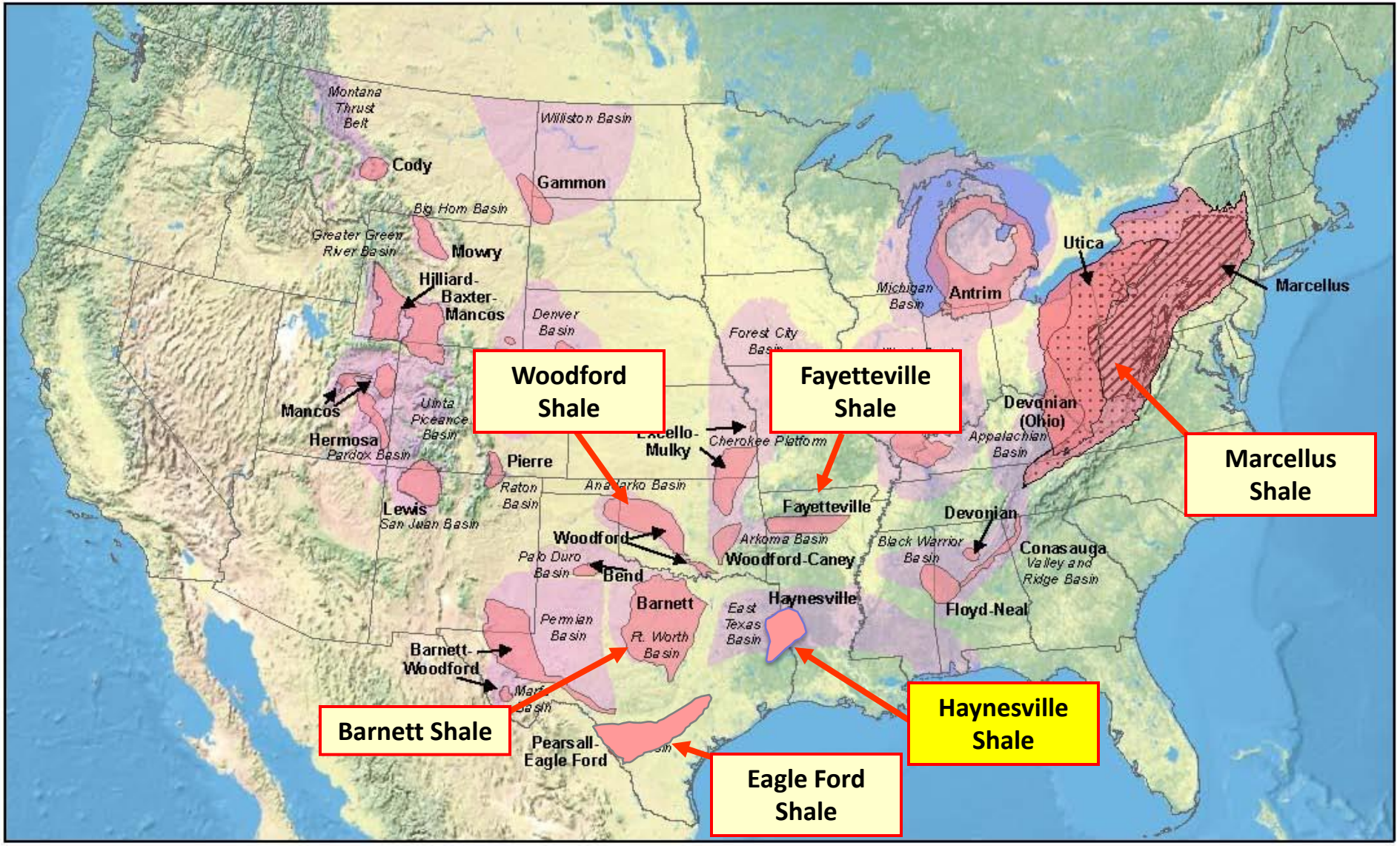
March 29, 2011

How are Appropriate Water Sources for Hydraulic Fracturing Determined? Pre-development Conditions and Management of Development Phase Water Usage

Red River Watershed Management Institute - LSU Shreveport

Gary Hanson, Director

Amanda Lewis, Assistant to Director



United States Shale Gas Plays

www.eia.doe.gov
Energy Information Administration
Office of Oil and Gas

Shale Gas Plays
Basins

Stacked Appalachian Plays
Marcellus
Utica
Devonian (OH shale)

November 2008
Miles
0 150 300 600

N

Appropriate water sources of hydraulic fracturing (fracing) in shale gas plays

- Groundwater (potable)
- Groundwater (non-potable)
- Surface water
- Treated wastewater
- Produced brackish or saltwater
- No water - LPG

LSUS Red River Watershed Management Institute

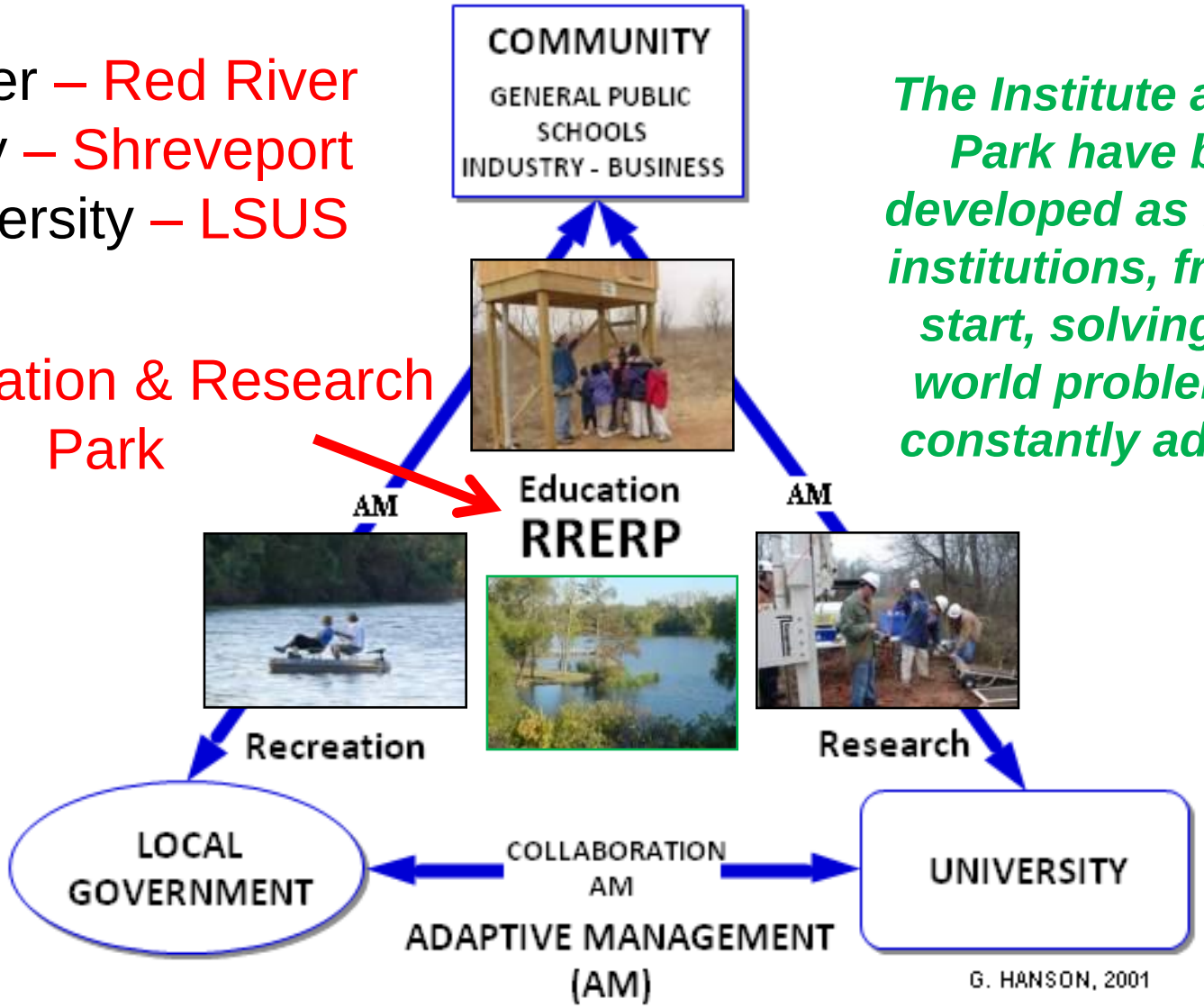
LSU Shreveport and Red River Education & Research Park

Evolving Community-based Nature Education & Research Park Model (Red River Education & Research Park)

A River – Red River
A City – Shreveport
A University – LSUS

An Education & Research Park

The Institute and the Park have been developed as flexible institutions, from the start, solving real-world problems by constantly adapting



An adaptive model - Based on "Sense of Place" institution building

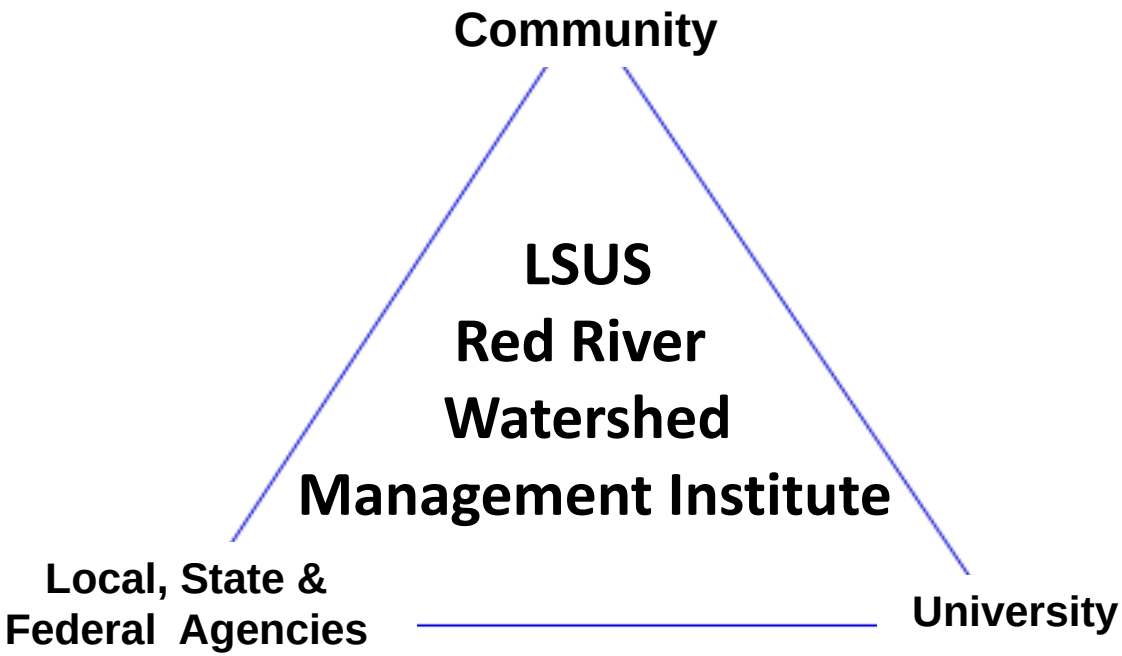
Red River Education & Research Park

"Not scared of dirt, willing to work"

Using a suite of borehole logs to evaluate Red River Alluvial Aquifer & Carrizo-Wilcox Aquifer

LSUS students using Geoprobe to develop monitoring well in Red River Alluvial Aquifer

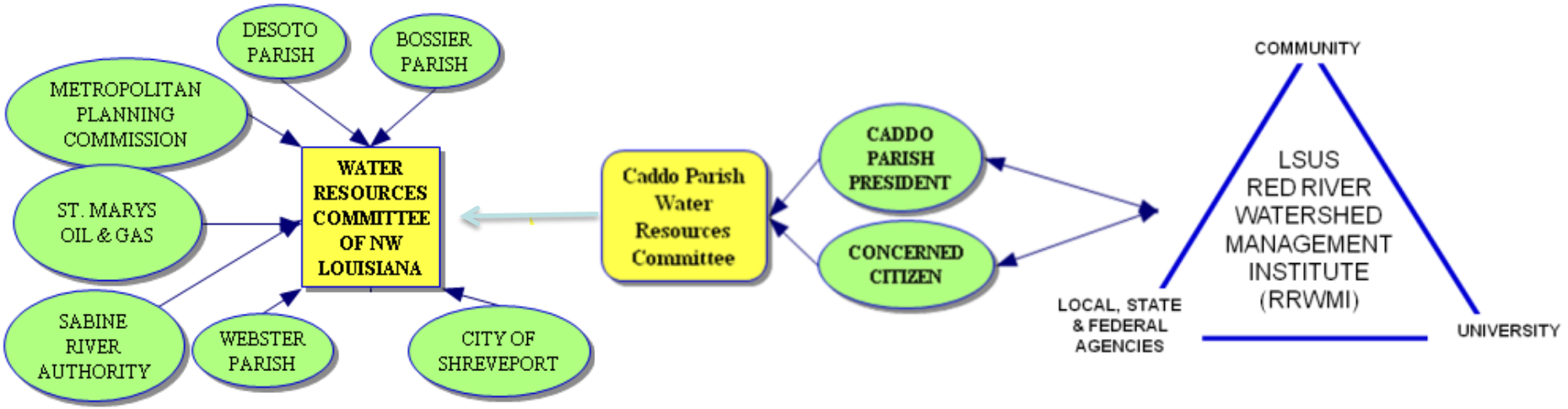
Institute Model
A Watershed Approach



A NEUTRAL ENTITY

Water Availability

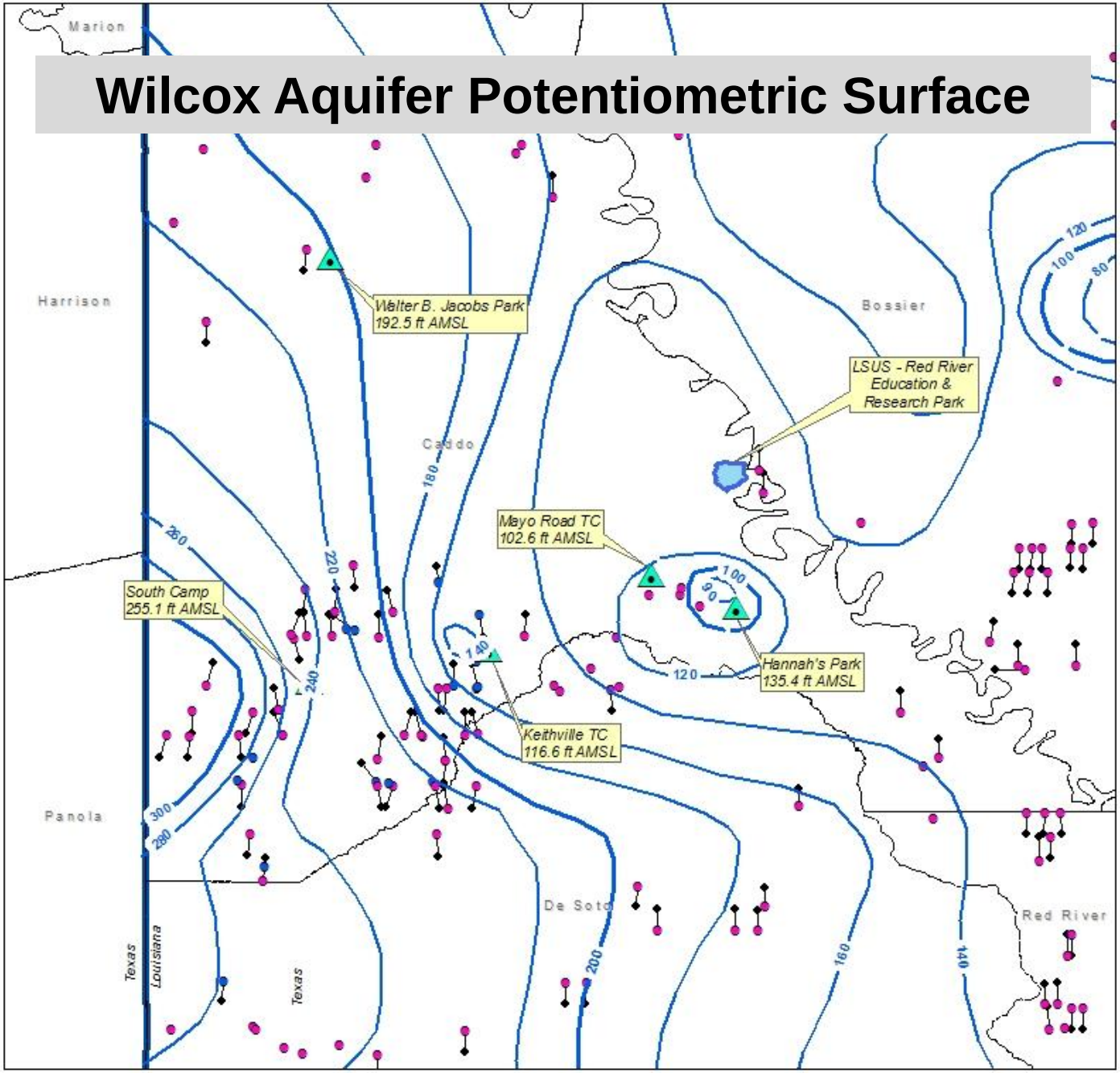
CADDO PARISH COMMITTEE EVOLVED INTO A REGIONAL *"WATER RESOURCES COMMITTEE OF NW LOUISIANA"*

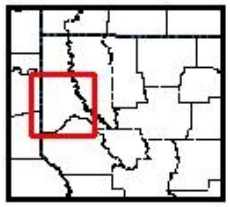


Water Resources Committee of Northwest Louisiana
Watershed Based - Volunteer Committee

The Committee was formed by the Caddo Parish President, a concerned citizen & Director of the RRWMI. As WRCNL evolved, more issues arose, & it became more flexible & adapted to solve new challenges.

Wilcox Aquifer Potentiometric Surface





Legend

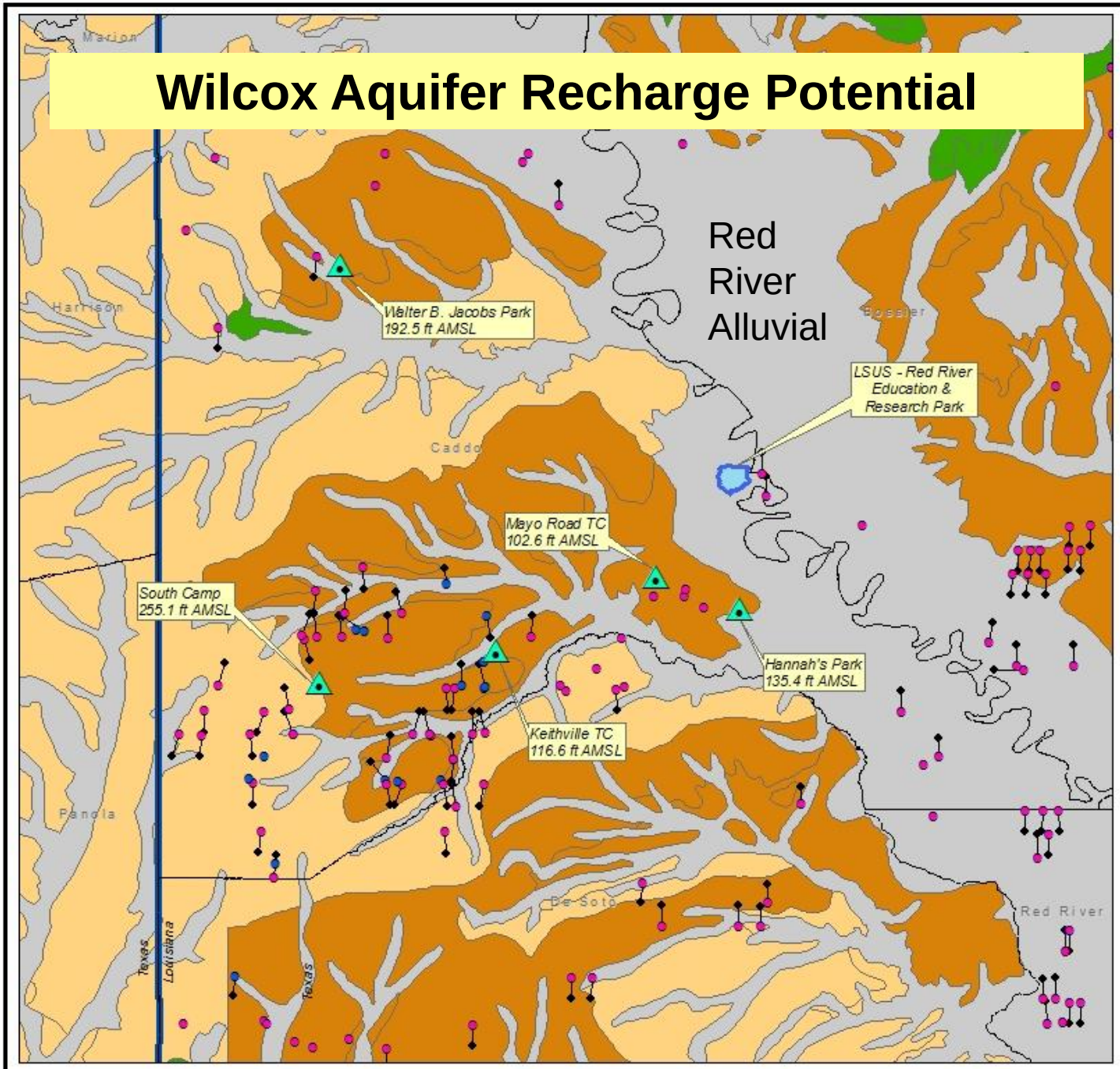
- GW Monitor Wells
- Permitted Well
- Producing Well
- Bottom Holes
- Bores
- RRERP Boundary
- County
- States
- USGS 1991 Potentiometric Contour*

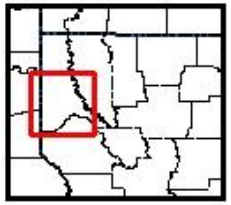
* Source: USGS

Miles

0 4 8

Wilcox Aquifer Recharge Potential





Legend

- GW Monitor Wells
- Permitted Well
- Producing Well
- Bottom Holes
- Bores
- RRERP Boundary
- County
- States

Recharge Potential

- No
- Low
- Moderate
- High

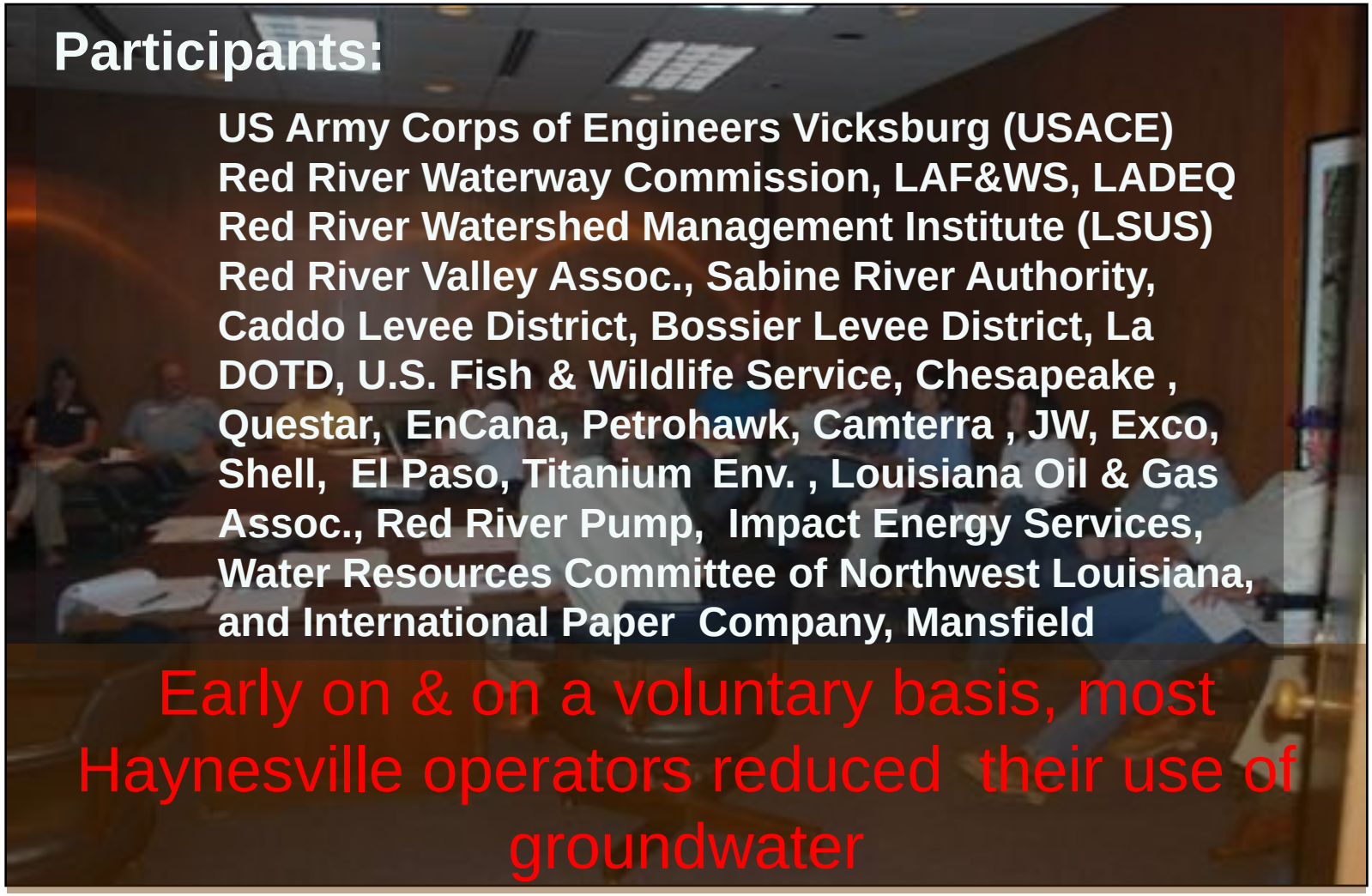
* Source: USGS

Miles

0 4 8

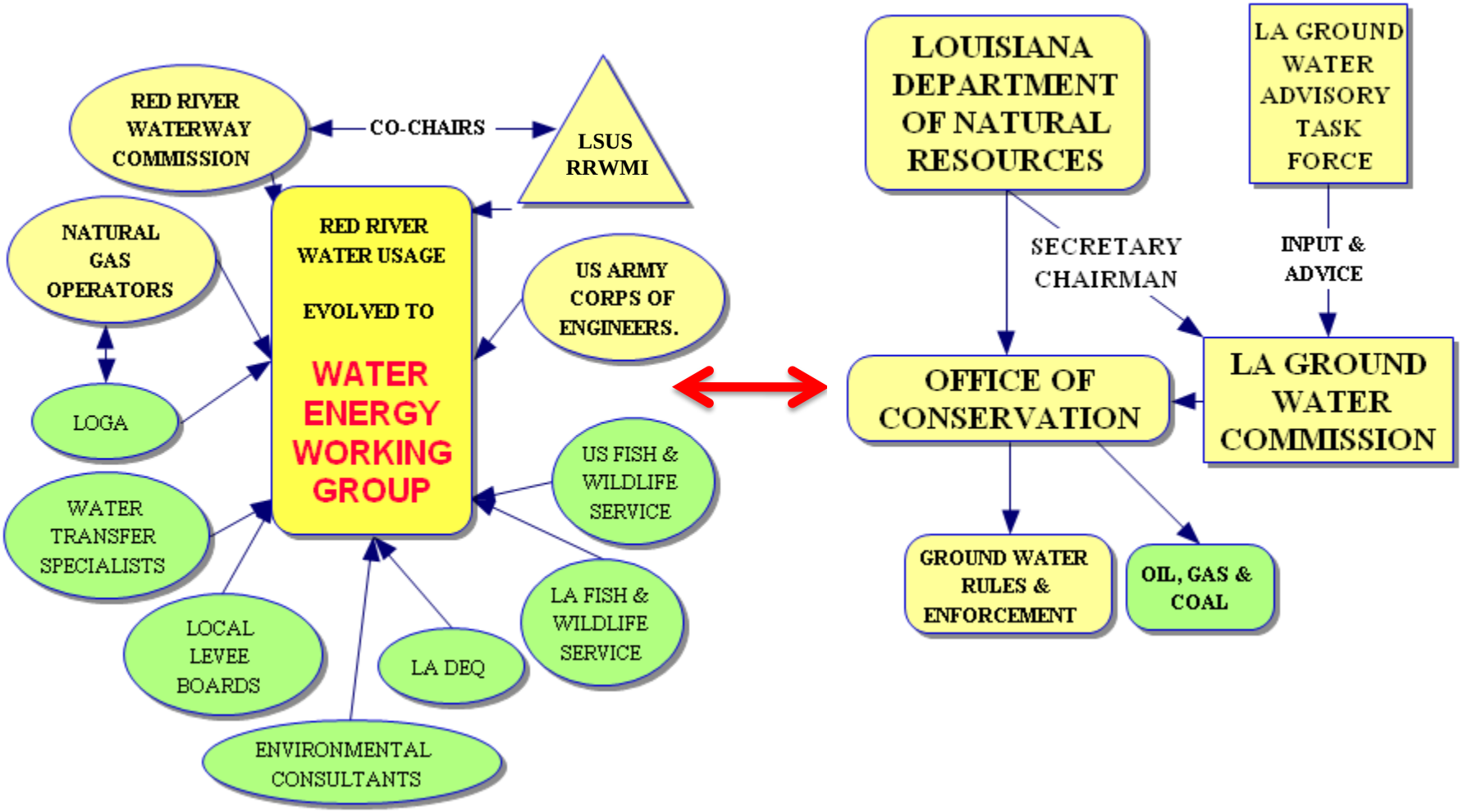
Water Energy Working Group – Meeting at LSU Shreveport

WG became more flexible & adapted to issues before or as they arose

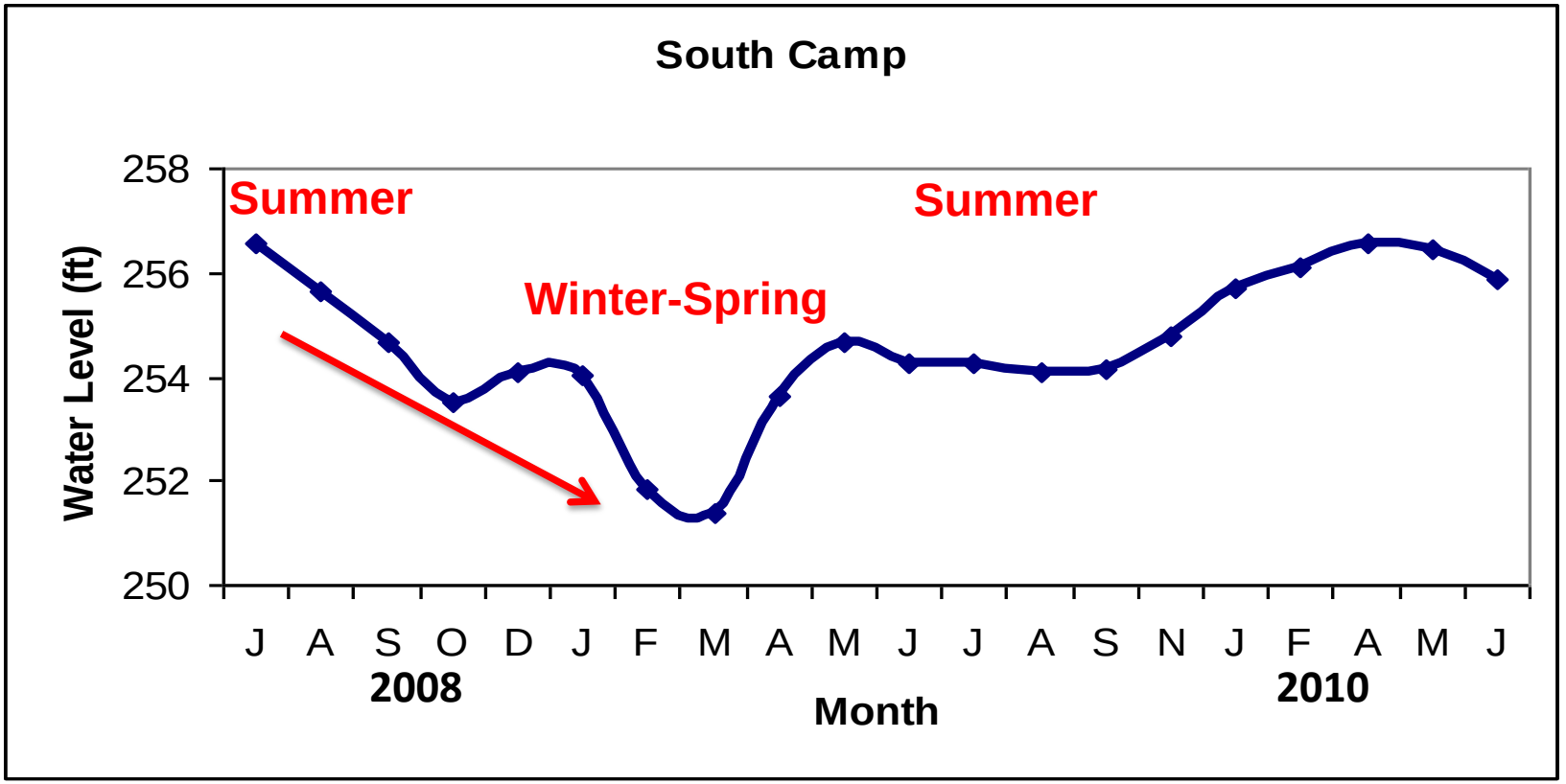


Co-chairs: Directors of Red River Watershed Management Institute & Red River Waterway Commission

CLOSE COORDINATION BETWEEN WATER ENERGY WORKING GROUP & OFFICE OF CONSERVATION HAS BEEN CRITICAL FOR SUCCESS



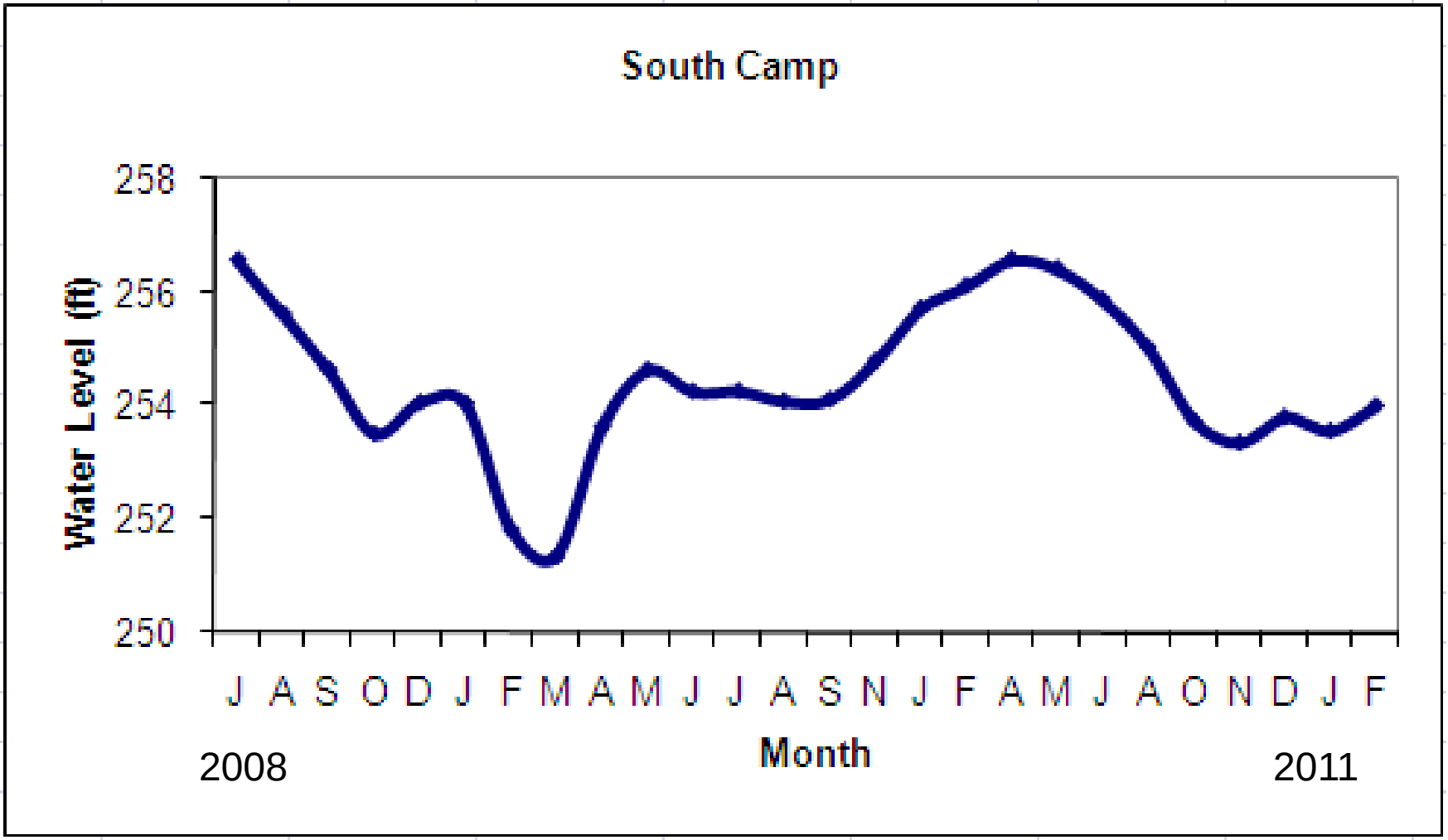
Caddo Parish/LSUS GW Monitoring



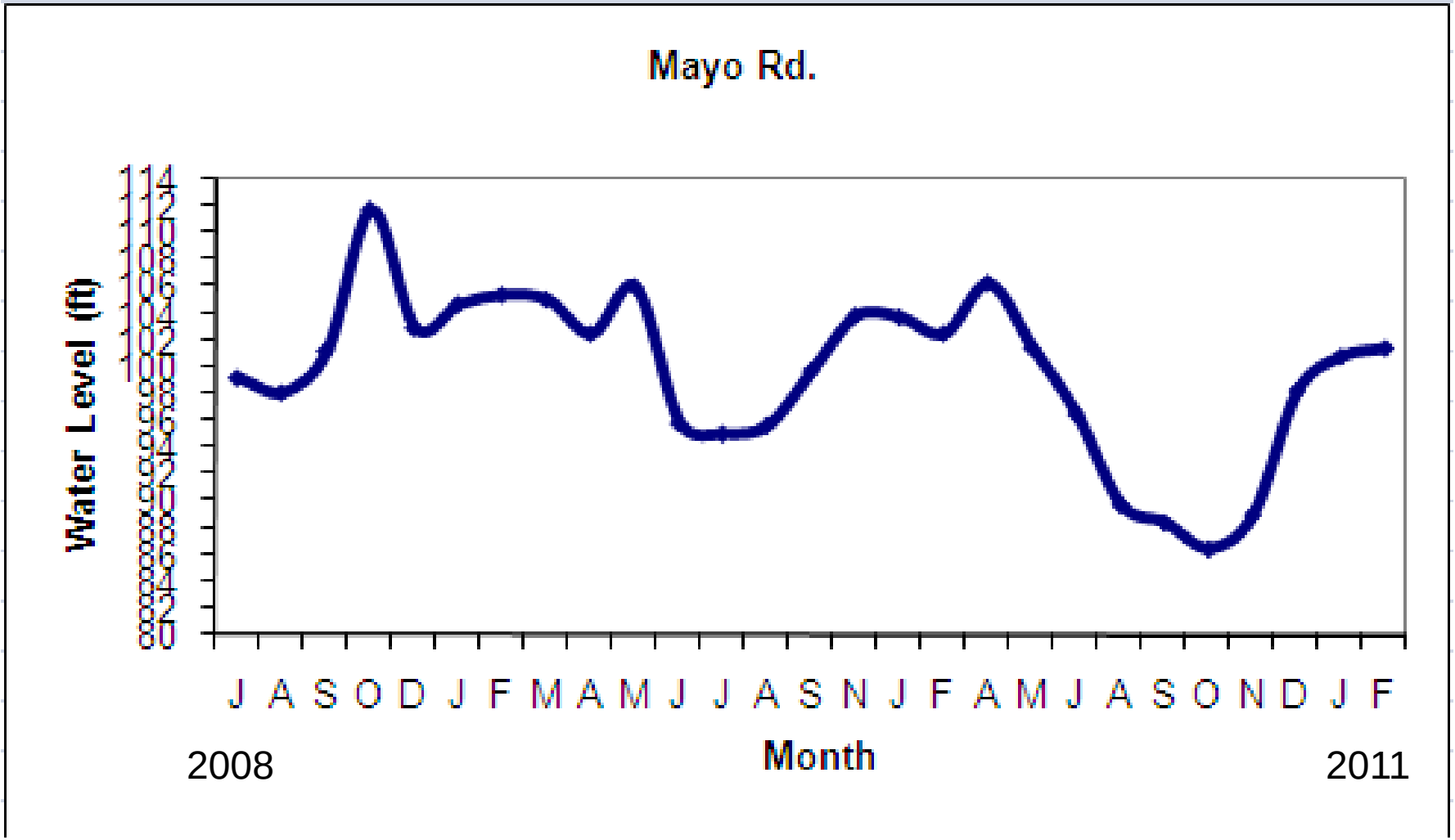
Water level appeared to be dropping rapidly in this area of heavy drilling & hydraulic fracturing

Lewis and Hanson, 2010

Caddo Ph/LSUS Wilcox Monitoring Well Project



Caddo Ph/LSUS Wilcox Monitoring Well Project



The Times (Shreveport) - This article is a good example of how the press can inform and educate the public

Water: Red River Alluvial is plentiful water supply

■ Continued from 1A

panies) are trying to do the right thing, and the public needs to know they have definitely shifted and are concerned that they do not hinder the local water supply if at all possible."

Hanson is in a position to witness the change since by default the geologist has become a liaison of sorts between the state agenc and industry operators. His pho rings constantly as industry ope tors are directed by the Louisia Department of Natural Resour to seek his advice on the best lo tions for water sources that will ke them away from the Carrizo-Wil Aquifer.

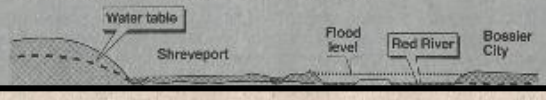
The aquifer sits under the nor west corner of Louisiana and p vides drinking water to thousan of people who either depend up their own wells or wells connect to rural water systems. It's also p

River Parish, estimated that abo 85 percent of its water for well completions comes from surface sources. But when grou water has been used, it has b from the Red River Alluvial, s Dennis Degner, EnCana's g lead completions.

Surfac water supplies come thro arrangements with land ers to use their creeks, bayous or ponds. Doing so can be time con-

Red River Aquifer System

A number of Haynesville Shale operators are heeding the advice of the Louisiana Department of Natural Resources in using the Red River Aquifer System, or Red River Alluvial, as a water source for fracing operations. The goal is to have the companies utilize alternate sources to lessen the impact on the Wilcox Aquifer. The Red River also is being eyed as another water source.



"We have a lot of recycling learnings. We've been recycling in west Colorado for the past several years. The difference is the water chemistry there is very fresh; whereas, it

ings. We've been recycling in west Colorado for the past several years," Degner said.

"The difference is the water chemistry there is very fresh; whereas, it has a higher chemical composition in north Louisiana."

But overcoming challenges are encouraged by EnCana through an environmental innovative fund that finances technology developments.

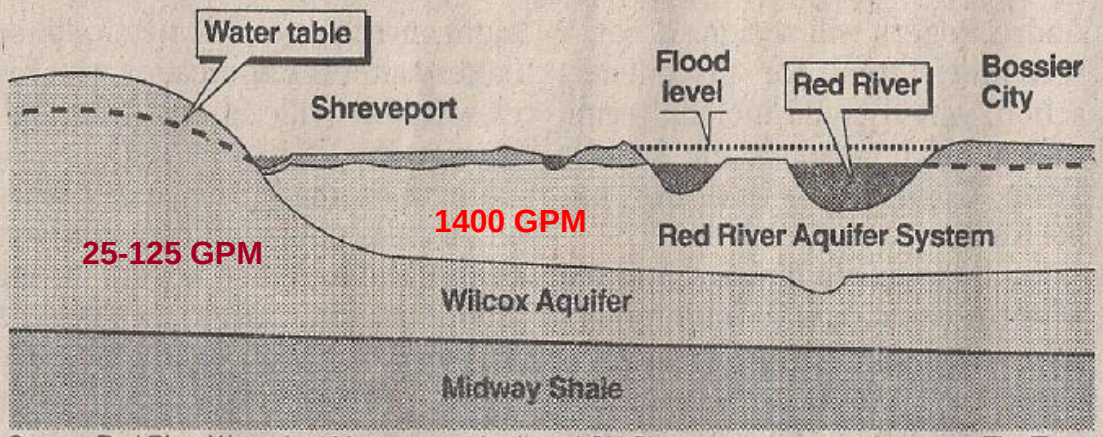
"We applied for it when we were the Barnett. ... Two years ago, didn't know we'd be on the verge this activity in the Haynesville," gner said.

Understanding how much water going to be needed for future ling is something Shell also is ploring.

"The completion design for the lls is something you want to stan-rdize the best you can. We're still the learning mode," op de Weegh id.

Red River Aquifer System

A number of Haynesville Shale operators are heeding the advice of the Louisiana Department of Natural Resources in using the Red River Aquifer System, or Red River Alluvial, as a water source for fracing operations. The goal is to have the companies utilize alternate sources to lessen the impact on the Wilcox Aquifer. The Red River also is being eyed as another water source.



Source: Red River Watershed Management Institute, LSU-Shreveport The Times

Vickie Welborn, 2009

Solutions - Alternative surface water frac sources

EXCO has built a 9 mile pipeline in order to use treated wastewater from International Paper Co. at Mansfield, La.

HAYNESVILLE SHALE

Drilling's environmental IMPACT

Jim Hudelson/The Times

Birds fly near a collection pond containing treated water that is being pumped through a pipe for use at a nearby natural gas-drilling well site. International Paper's Mansfield Mill is in the background.

IP, EXCO test water source union

By Vickie Welborn
vwelborn@gannett.com

NEAR MANSFIELD — International Paper Company's Mansfield Mill is testing a partnership with the region's burgeoning natural gas business through an environmentally friendly move that could have a long-range positive impact on both industries.

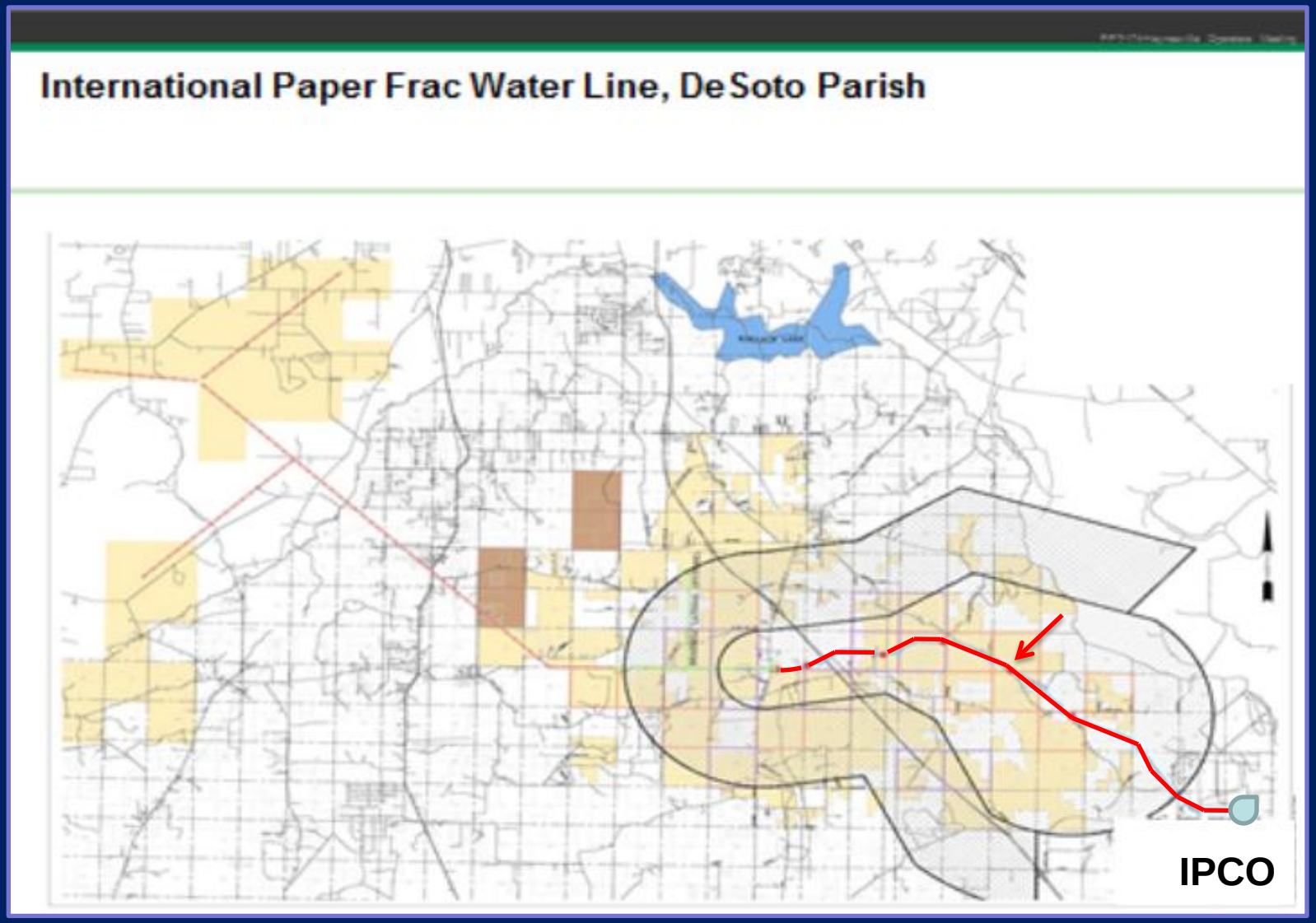
IP and EXCO Resources Inc. are in a trial to reuse the papermaker's treated processed water to aid EXCO in its hydraulic fracturing process. The trial run, which has been approved by the Louisiana Department of Environmental Quality, will go through Sept. 30, allowing EXCO to complete two Haynesville Shale natural gas wells.

The end result is that millions of gallons of treated processed water that normally would be discharged into the Red River will be diverted through pipelines to EXCO's drilling loca-

The Times, 2010

12 million gallons/day

Solutions - Alternative surface water frac sources



EXCO's 9-mile wastewater pipeline

Louisiana Geological Survey

NewsInsightsonline

Summer 2010 • Volume 20, Number 1

Baseline Water Quality Study of Aquifers in Bossier, Caddo and De Soto Parishes

Douglas Carlson

Starting this summer and lasting through December of 2011, Professors Douglas Carlson and Thomas Van Biersel of Louisiana Geological Survey will in collaboration with Gary Hanson, Director of Red River Watershed Management Institute and a LSU-Shreveport graduate student will work on an extensive groundwater quality study of the Carrizo-Wilcox and Red River Alluvial aquifers in southern Caddo (Townships 14 north to 18 north) and Bossier (Townships 15 north to 17 north) Parishes, and northern De Soto Parish (Townships 13 north to 16 north). The study will include the collection of groundwater samples from approximately 1,000 domestic water supply wells. Each sample will be analyzed for Arsenic, Boron, Bromide, Cadmium, Calcium, Chloride, Chromium, Copper, Fluoride, Iron, Lead, Magnesium, Manganese, Nickel, Nitrate, Nitrite, Potassium, Phosphates, Phosphorus, Rubidium, Sulfate, Silicon, Sodium, Strontium, and Zinc, as well as pH and specific conductance in the field. Water levels will be collected where the well construction allows. This project is receiving $216,596 of support from the Bossier, Caddo, and De Soto Parish Police Juries.

This study seeks to develop a regional baseline water quality data set prior to major groundwater resource development associated with drilling and hydrofracking activity related to the resource development of Haynesville Formation Shale natural gas play, which underlies the study area (Figure 1).

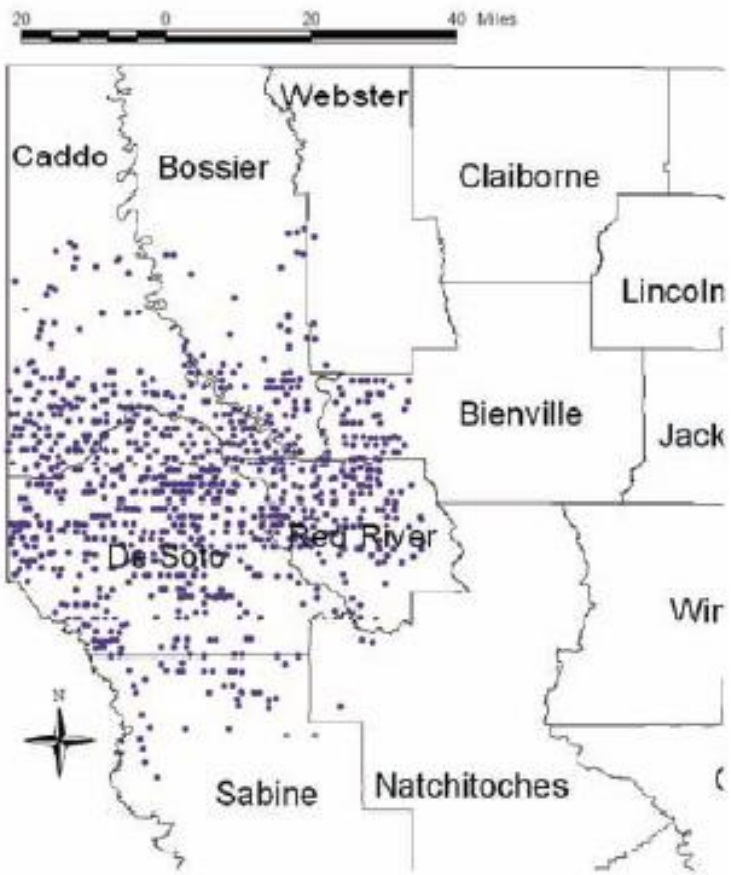
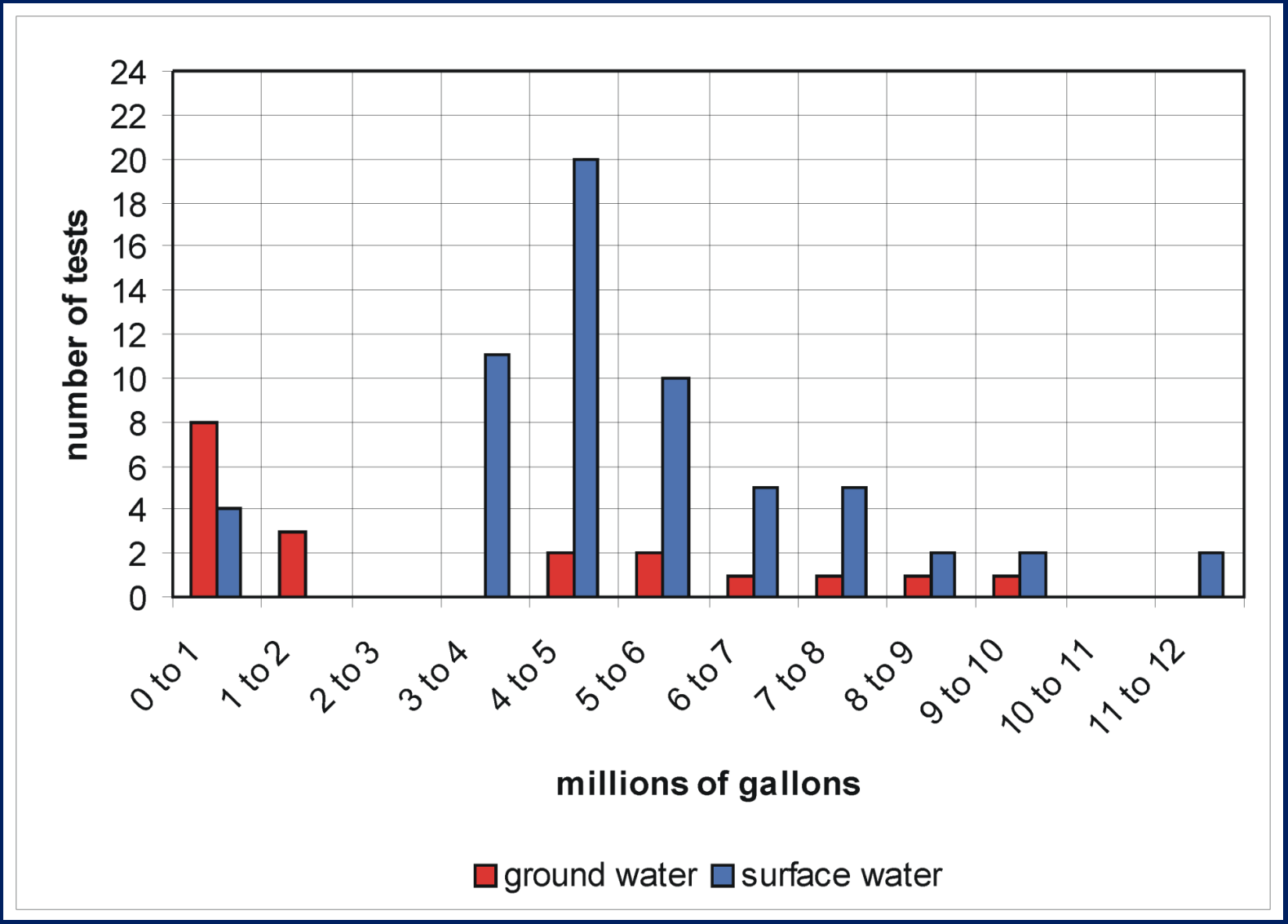


Figure 1. Location of current drilling associated with development of the Haynesville Formation, blue dots are well sites (Source of data Louisiana Department of Natural Resources, 2010b).

Baseline Water Quality Study of Aquifers in Bossier, Caddo & De Soto Parishes

Louisiana Geological Survey Hydrologist/Geologist Doug Carlson (right) & Marty Horn (middle) and Gary Hanson (left), LSU Shreveport

Frac Water Use – Haynesville Shale



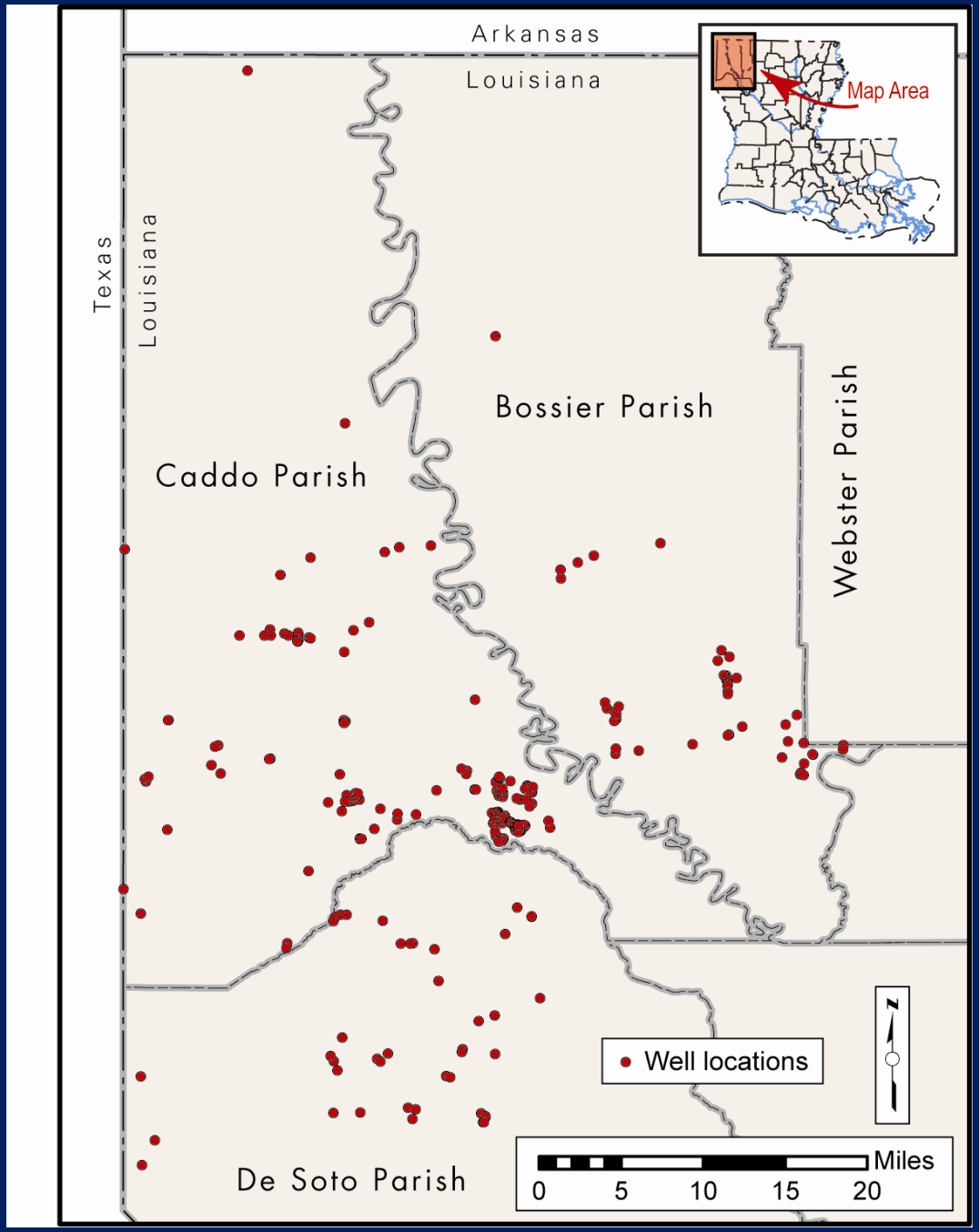
Source Louisiana Department of Natural Resources (2010)

After D. Carlson et al, 2011

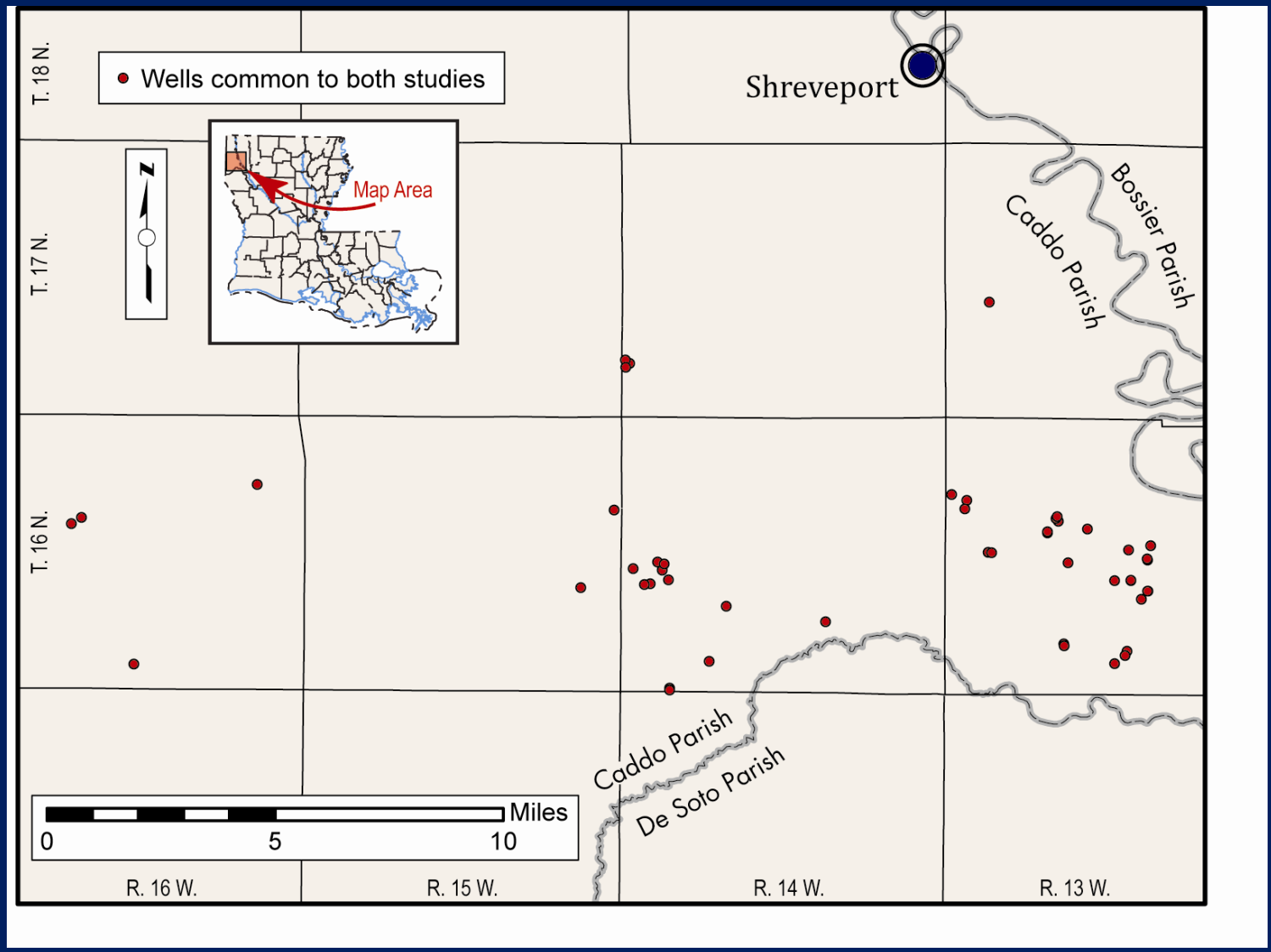
Has Wilcox Aquifer Water Quality Changed in the Past Three Years in Response to Haynesville Hydraulic Fracturing Activity?

Douglas Carlson & Marty Horn
Louisiana Geological Survey
&
Thomas Van Biersel
Louisiana Department of Natural Resources

Location of this study's first 450 wells



Location of Caddo Parish wells previously sampled



Location of current match set of wells ~75

D. Carlson et al, 2011

June 1, 2010 to December 31, 2011

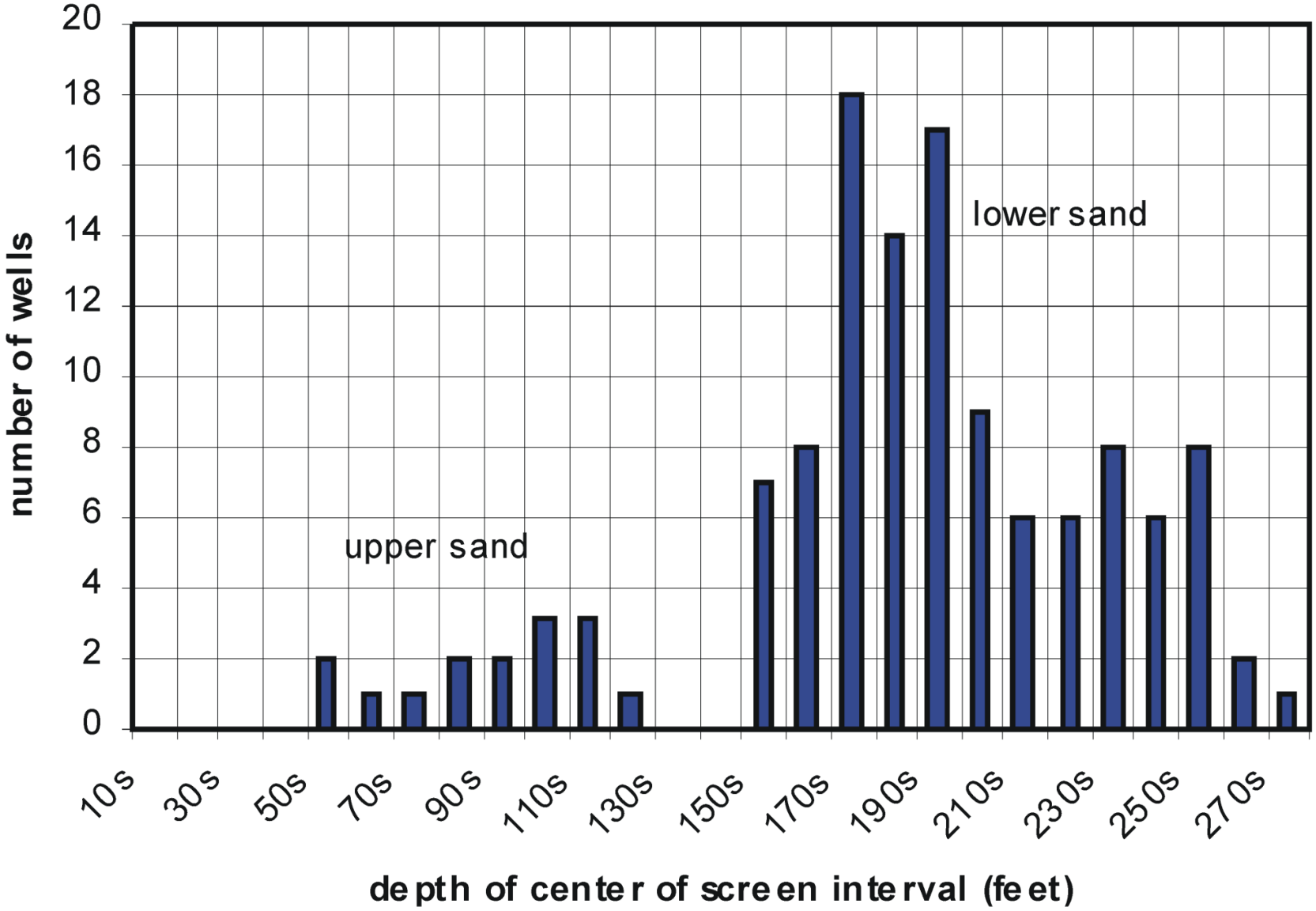
This study will create a base data set of water quality that will include 950-1,050 samples analyzed for: Arsenic, Boron, Bromide, Cadmium, Calcium, Chloride, Chromium, Copper, Fluoride, Iron, Lead, Magnesium, Manganese, Nickel, Nitrate, Nitrite, Potassium, Phosphorus, Phosphate, Rubidium, Sulfate, Silicon, Sodium, Strontium, TDS, and Zinc. The number of values of chloride is approximately five times larger than those in Rapp's (1996) and even larger for other parameters when compared to Rapp's study which was the largest study previously.

D. Carlson et al, 2011

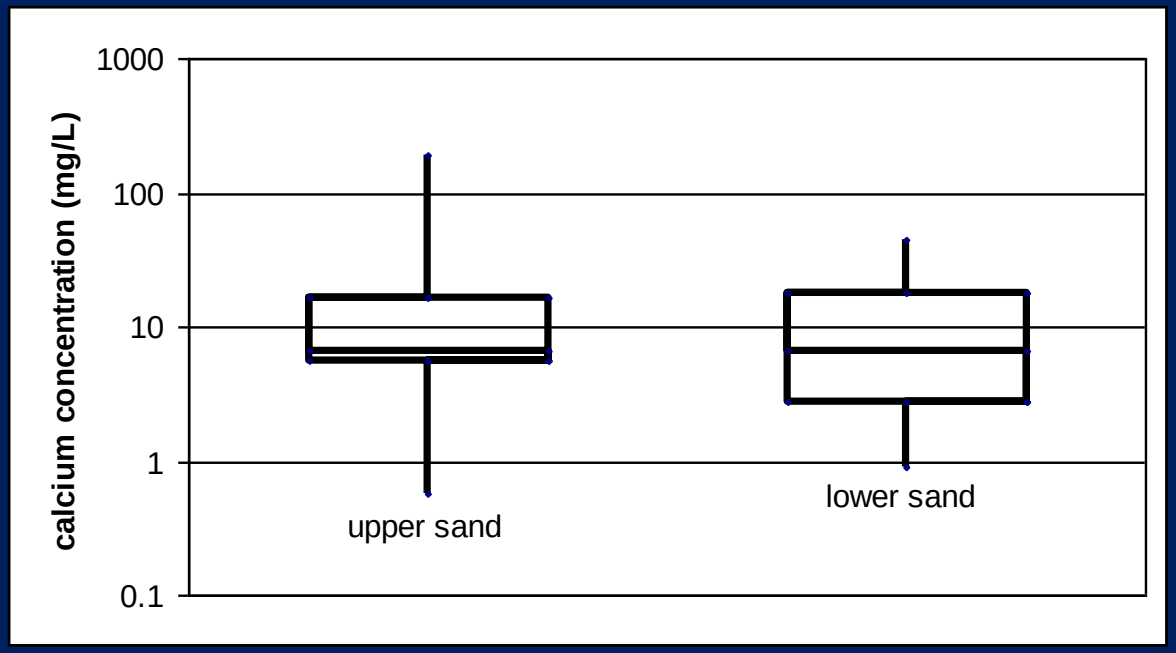
Stratigraphy

Difference of chemistry among Wilcox sands

D. Carlson et al, 2011

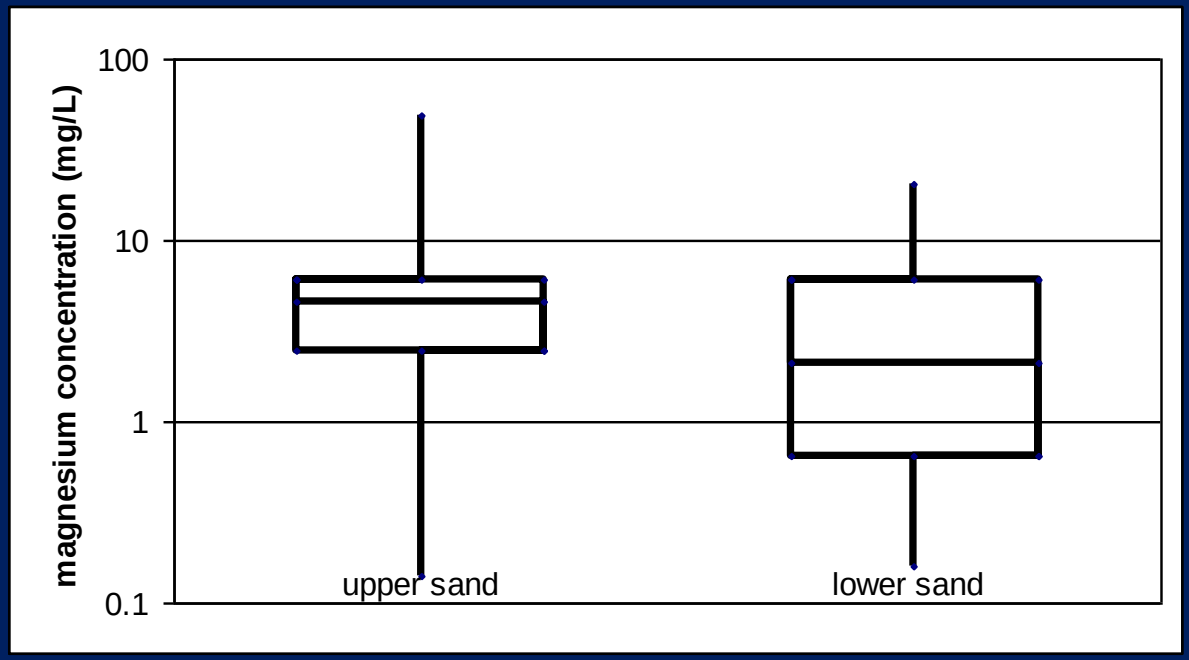


D. Carlson et al, 2011

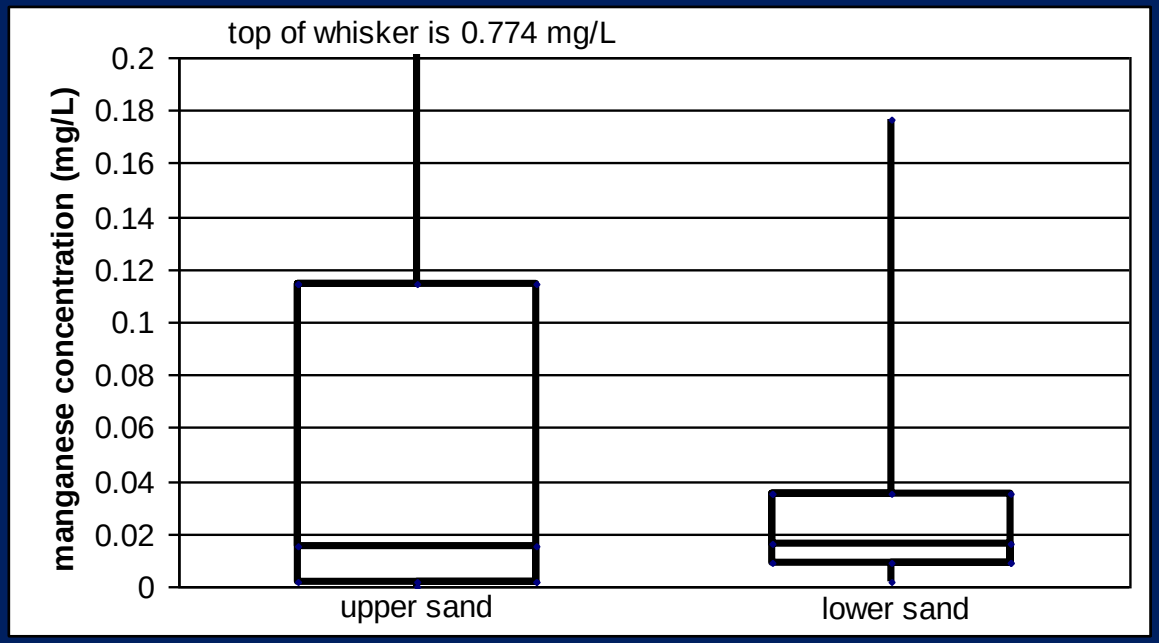


Calcium

Magnesium

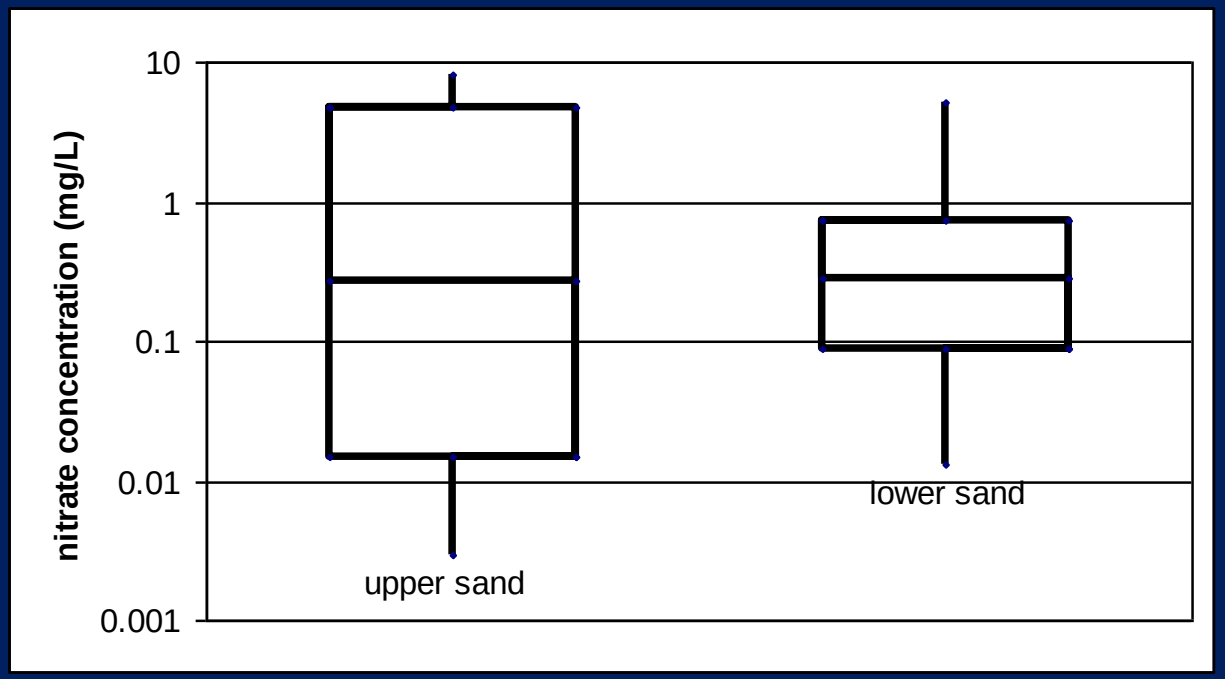


D. Carlson et al, 2011

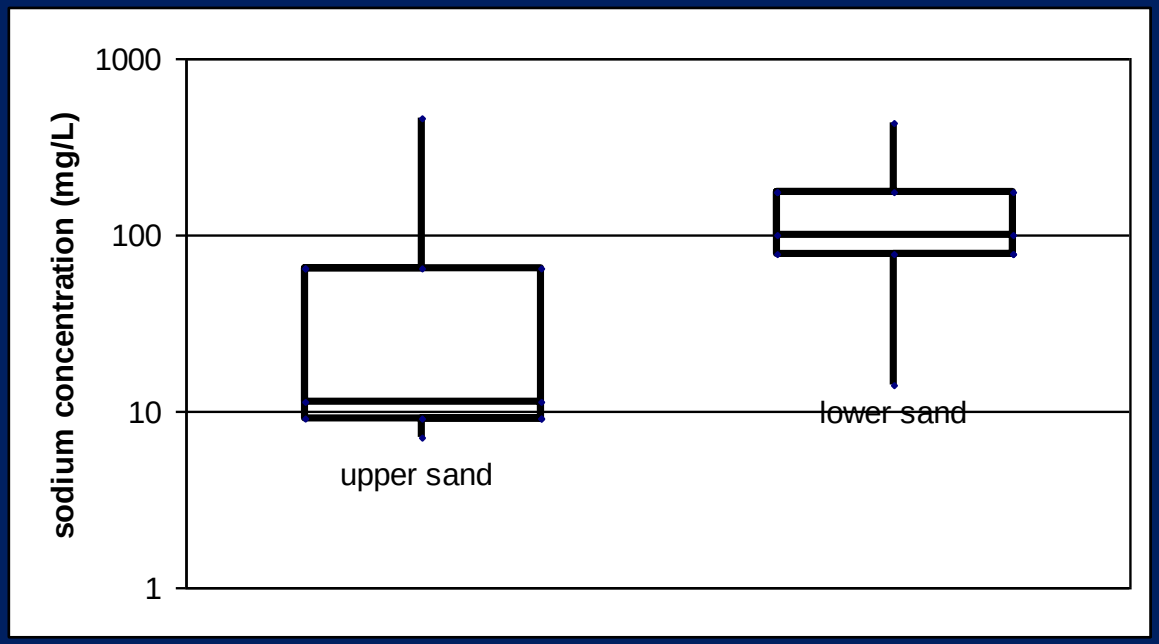


Manganese

Nitrate

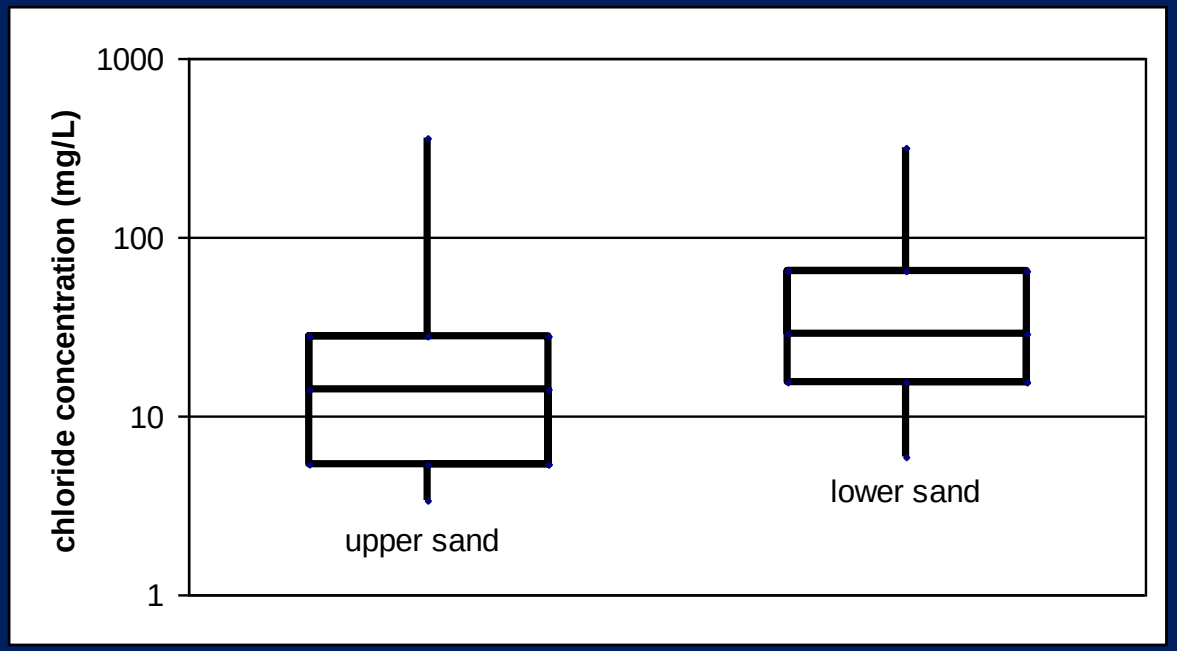


D. Carlson et al, 2011



Sodium

Chloride



D. Carlson et al, 2011

Summary – Interim Report

1. There have been generally small changes in water chemistry

2. Uncertainty of change tends to increase with decreasing ion concentration

3. Changes are mixed, 6 indicate downward flow of water and 3 indicate upward flow of water

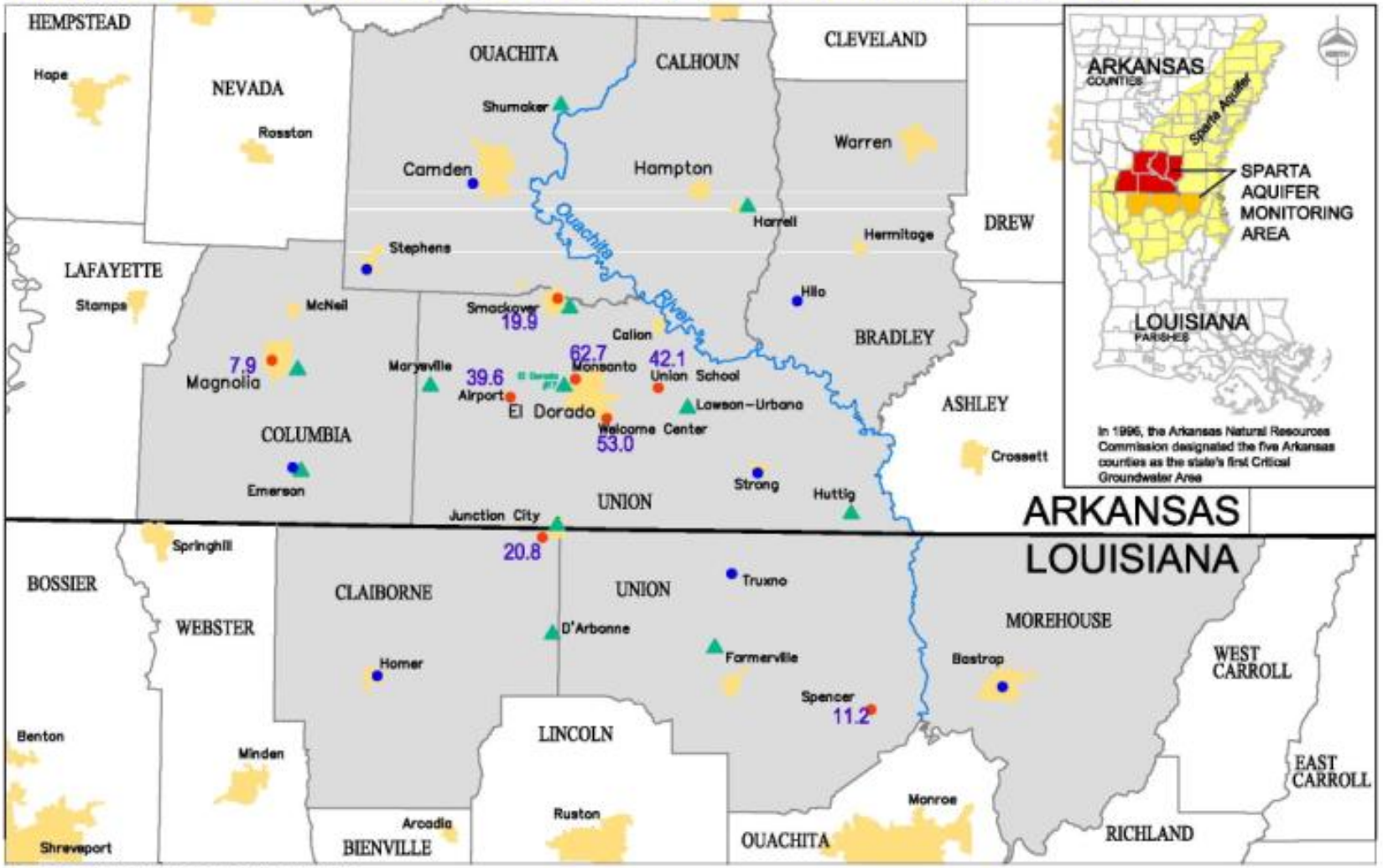
4. Only 4 changes are significant, 2 indicate upward flow and 2 indicate downward flow

5. These mixed results appear to support the idea of downward flow

6. Possible candidates of wells causing downward flow are public supply and other domestic wells, NOT rig wells

D. Carlson et al, 2011

South Arkansas Sparta Aquifer Recovery Initiative - *Monitoring Well Network*

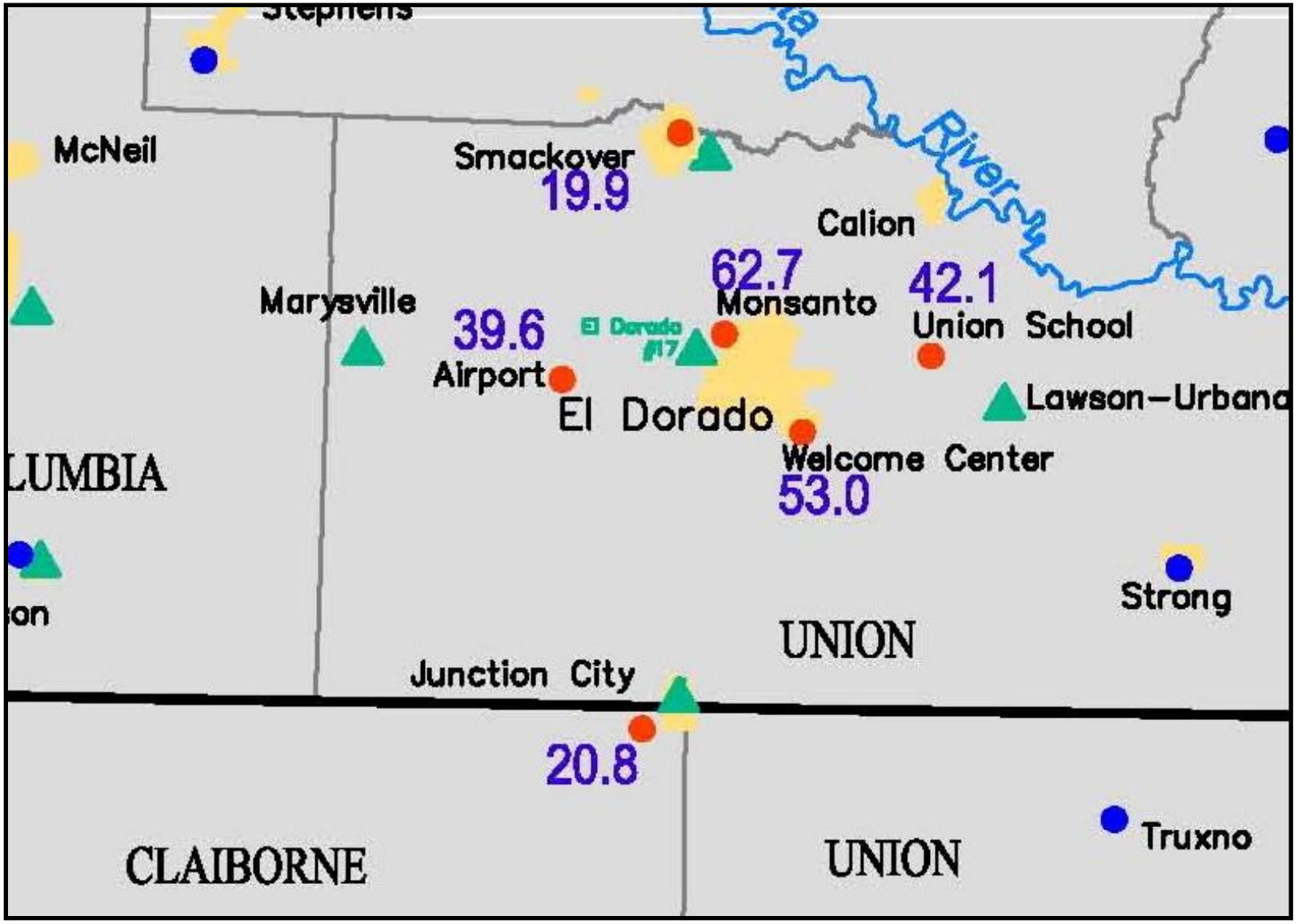


62.7 RISE IN SPARTA AQUIFER GROUNDWATER LEVEL IN FEET BETWEEN OCTOBER 2004* AND APRIL 2010, USGS REAL-TIME WELLS

* THREE MAJOR UNION COUNTY (ARKANSAS) INDUSTRIES BEGAN CONVERSION GROUNDWATER TO SURFACE WATER OCTOBER 2004

UNION COUNTY WATER CONSERVATION BOARD • 441 W Cedar • El Dorado, Arkansas 71730 • 870 814-2871 • www.ucwcb.org

MAY 2010


McNeil
Smackover
19.9
Calion
62.7
Monsanto
42.1
Union School
Marysville
39.6
Airport
El Dorado
#17
El Dorado
Lawson-Urbana
Welcome Center
53.0
LUMBIA
Strong
UNION
Junction City
20.8
Truxno
CLAIBORNE
UNION

Acknowledgements:

US EPA Region 6
City of Shreveport
AEP SWEPCO
LSU Shreveport & LSU System
Halliburton
Anderson Oil & Gas
Louisiana Department of Natural Resources &
Office of Conservation
The Parishes of Caddo, DeSoto, Bossier &
Webster, Sabine River Authority & Red River
Waterway Commission & Metropolitan
Planning Commission
Members of the Water Energy Working Group
Louisiana Geological Survey
Union County Conservation Commission

Thank you!

How are Appropriate Water Sources for Hydraulic Fracturing Determined? Pre-development Conditions and Management of Development Phase Water Usage

Gary Hanson
Louisiana State University Shreveport

The statements made during the workshop do not represent the views or opinions of EPA. The claims made by participants have not been verified or endorsed by EPA.

Historically the determination of water sources for hydraulic fracturing has typically been left up to the oil or gas operator or their drilling contractor. Fresh water, although only one component of frac fluids in tight gas sand stimulation, was the source of choice and ease of access would determine whether surface or groundwater was used. Prior to multistage horizontal fracing of gas shales, use of ponds or nearby streams provided sufficient water to drill and frac a typical tight sand well in most areas of the country. However as the unconventional shale plays arrived on the scene using "slick-water" fracing technique and horizontally drilled wells that required multiple stages in order to effectively stimulate the reservoir, water demands increased dramatically. Groundwater, which had been only used periodically in the past, became the source of choice in many areas. Groundwater use for fracing increased in northwest Louisiana after the discovery of the massive Haynesville Shale. The public and rural water utilities saw this activity as a threat to "their" source of water, so from their perspective a water source (groundwater) that was previously considered an appropriate source for fracing, became an inappropriate source, as drilling and fracing continued.

Prior to the onset of the Haynesville Shale gas boom in northwest Louisiana, two critical actions were taken by local government and a university. First, a voluntary water committee called the Water Resources Committee of Northwest Louisiana (WRCNL) was formed and second, one of the member parishes (counties) worked with the local LSU Shreveport University to set up a groundwater monitoring system. Both actions were taken prior to the Haynesville Shale discovery and because there was a perceived need that groundwater and surface water resources were in jeopardy. In some cases, as operators moved into the area multiple Wilcox aquifer water wells were drilled to not only supply water for drilling, but also for fracing. Rig supply wells are considered exempt wells (no notification to Office of Conservation prior to developing) in Louisiana, but groundwater wells used for fracing are considered industrial wells and there is a 60-day pre-drilling notice required. Groundwater use for fracing is not specifically deemed unlawful. As stated earlier, operators have always used groundwater as an appropriate water source for fracing, but with the onset of the Haynesville high volume (5 million gallons), multistage, horizontal well development program, other groundwater users (district water systems, domestic & agriculture) became concerned. For them, groundwater was not an appropriate water source for fracing. The Office of Conservation stepped in and advised that surface water or non-potable aquifer alternatives should be used as a source of water.

In 2001, the Red River Watershed Management Institute (Institute) was formed at LSU Shreveport and the Red River Education & Research Park (RRERP) was developed adjacent to the campus in the floodplain of the Red River. Faculty and students developed monitoring wells in the Red River Alluvial Aquifer (RRAA), an aquifer that had been studied historically by the USGS and other agencies. The RRAA is considered non-potable, but exhibits high deliverability due to its' high porosity and high hydraulic conductivity and was a good candidate for alternative groundwater supply for fracing. The RRAA became an appropriate water source for fracing, and although there exists some competition from agriculture, it is deemed sustainable because it is sourced by the overlying Red River which has been impounded for navigation.

In the early stages of the Haynesville development, a sub-committee of the WRCNL was formed and met at the Institute. Co-chaired by the Director of the Institute and the Executive Director of the Red River Waterway Commission, the Water Energy Working Group (WEWG) was comprised of federal and state regulators, operators and water transfer specialists. Although many Haynesville Shale operators had become convinced that they needed to reduce their dependence on the Wilcox Aquifer, appropriate alternatives could not be used without some kind of approval process. The WEWG worked to establish USACE permits for access to the Red River. Following formal opinions by the Louisiana Attorney General and legislation that would allow for the states "running" surface water, including the Red River, to be withdrawn legally, operators were given surface water alternative. Private ponds became an easy and appropriate source of surface water in areas remote from large waterbodies. If landowners filled the ponds using groundwater wells, however, the pond is not considered an appropriate water source for fracing by the state.

Has the Wilcox aquifer been changed by Haynesville Shale drilling activity in northwest Louisiana? A study of up to 1000 domestic wells located in the areas of gas shale development, was undertaken by the Louisiana Geological Survey /LSU in cooperation with the watershed Institute at LSU Shreveport. Over one-third of the wells have been sampled and analyzed. About 75 domestic wells that were used in a previous study have been included (re-sampled and analyzed). No significant change in water quality has been observed at this point in the project.

A project in nearby south Arkansas has been challenged to develop a recovery plan for Sparta Aquifer, historically the main source of water for pubic and industrial use. This successful project, which funded the construction of a 20-mile pipeline to a large river in order to supply water for industrial needs, allowed industry to stop drawing water from the aquifer and should be a model for the nation. A potential unconventional gas play is in the early stages of development in South Arkansas/North Louisiana and the Union County Water Conservation Board has the potential to supply about 20 million gallons of surface water as an appropriate water source for fracing.