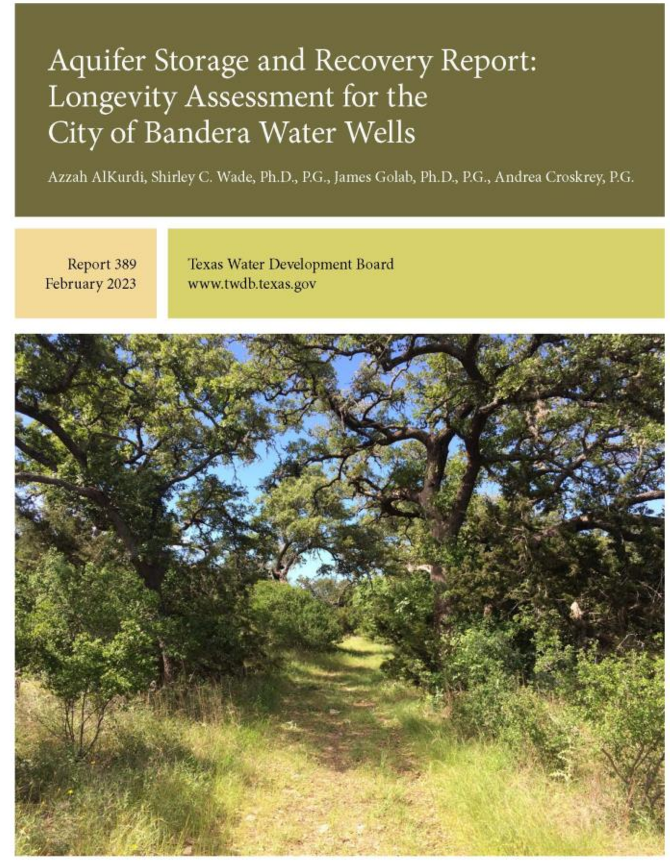
Longevity Assessment for the City of Bandera Water Wells


Aquifer Storage and Recovery Report: Longevity Assessment for the City of Bandera Water Wells

Azzah AlKurdi, Shirley C. Wade, Ph.D., P.G., James Golab, Ph.D., P.G., Andrea Croskrey, P.G.

Report 389
February 2023

Texas Water Development Board
www.twdb.texas.gov

Public Webinar (March 30th,10am - 12pm)

https://www.twdb.texas.gov/innovativewater/asr/projects/Bandera/index.asp

Speakers

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TWDB IWT manager

Dave Mauk

BCRAGD general manager

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TWDB ASR discipline lead and a coauthor

Webinar reminders and format

TURN OFF YOUR CAMERAS

TYPE QUESTIONS IN THE CHAT SO WE CAN QUEUE THEM UP

TOPIC-RELATED QUESTION TIME AFTER SECTIONS

QUESTION TIME AT THE END TOO!

WEBINAR IS BEING RECORDED

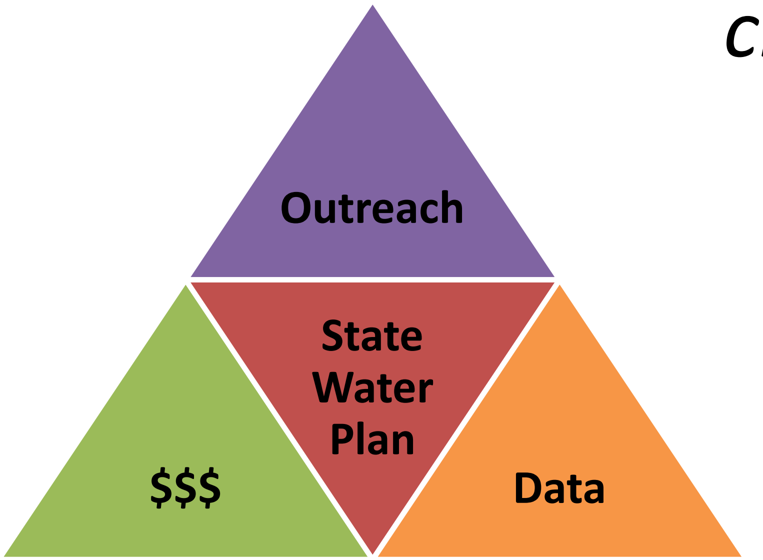
Outline

- Background
  - Texas Water Development Board
  - Aquifer Storage and Recovery (ASR)
  - The City of Bandera Water Management Strategies
  - Trinity aquifer geology
- Bandera well longevity study
  - Objective
  - Methodology and results
    - Well operation
    - Long-term planning
  - Conclusions

Texas Water Development Board

Mission Statement:

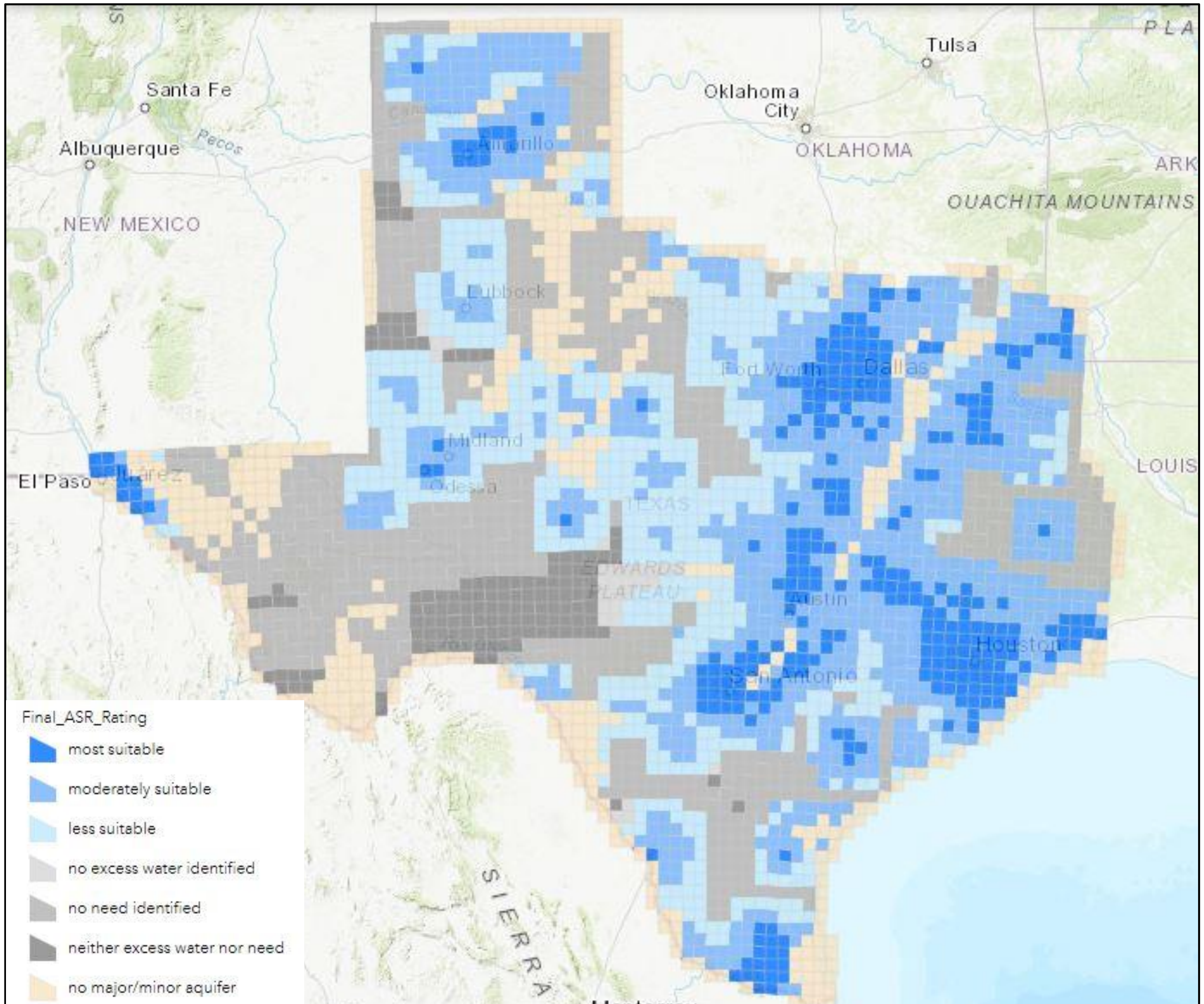
"To lead the state's efforts in ensuring a secure water future for Texas and its citizens"



50-year State Water Plan updated every 5 years

Texas Water Code § 11.155

Statewide survey of aquifer suitability for Aquifer Storage and Recovery (ASR) or Aquifer Recharge (AR) projects in Texas

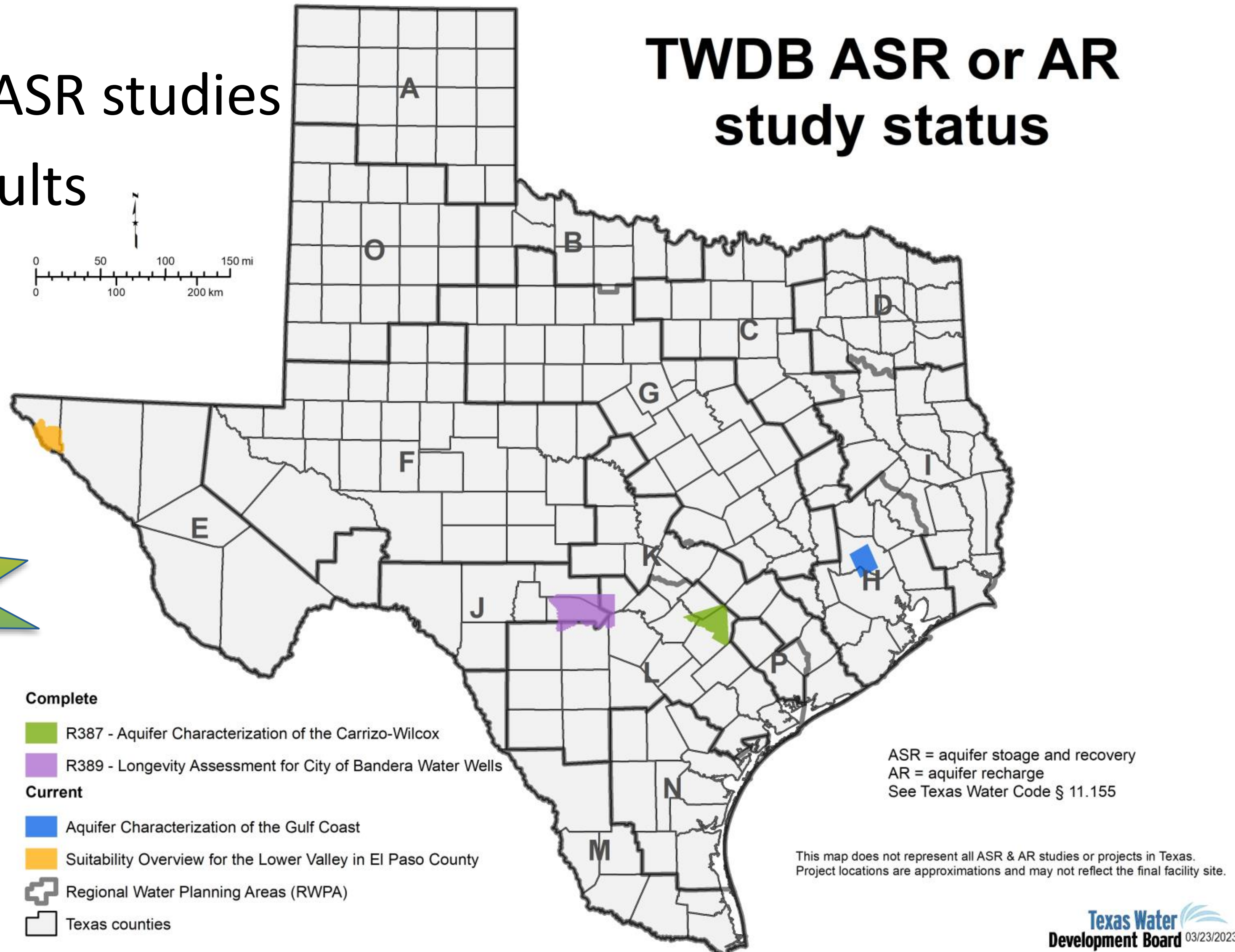


Project web page:

Story map:

Texas Water Code § 11.155

- Conduct ASR studies
- Share results



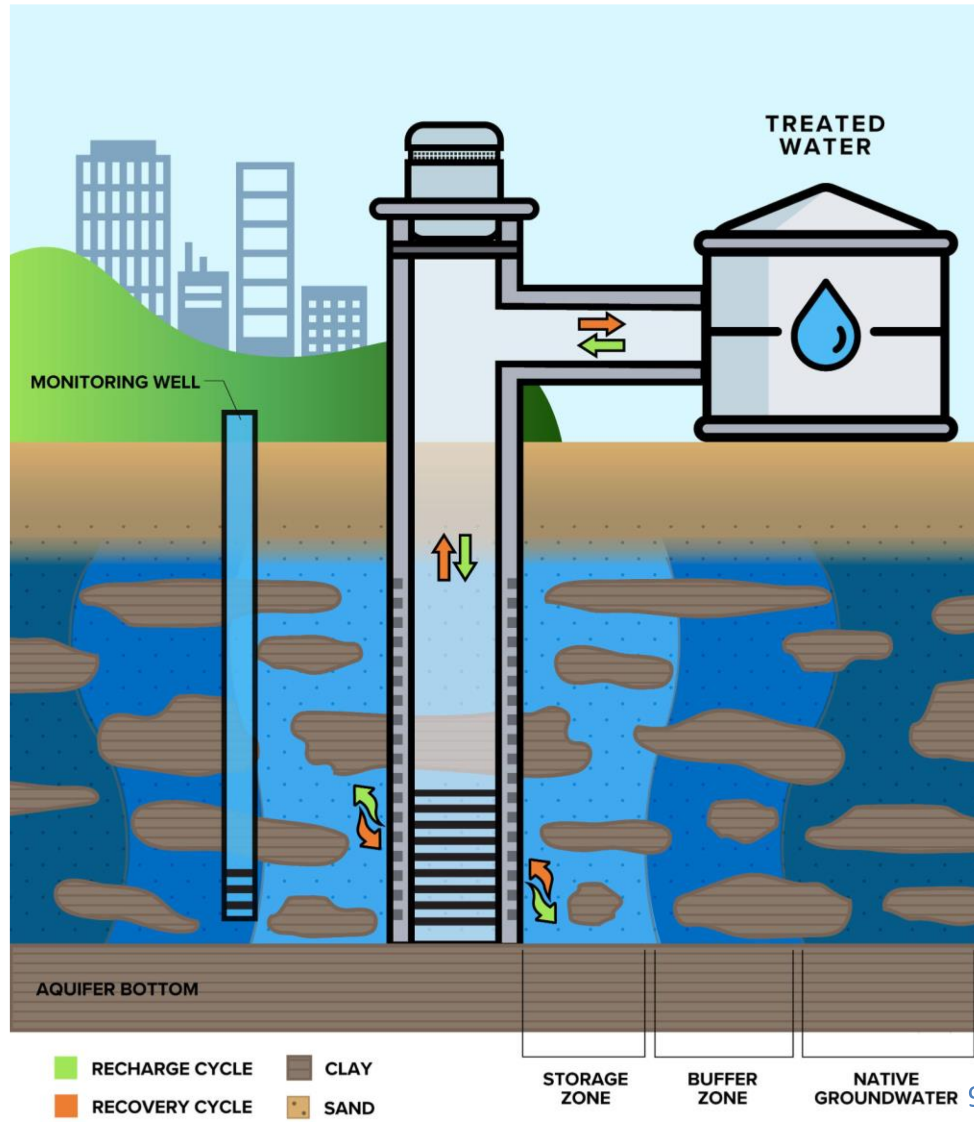
Aquifer Storage and Recover (ASR)

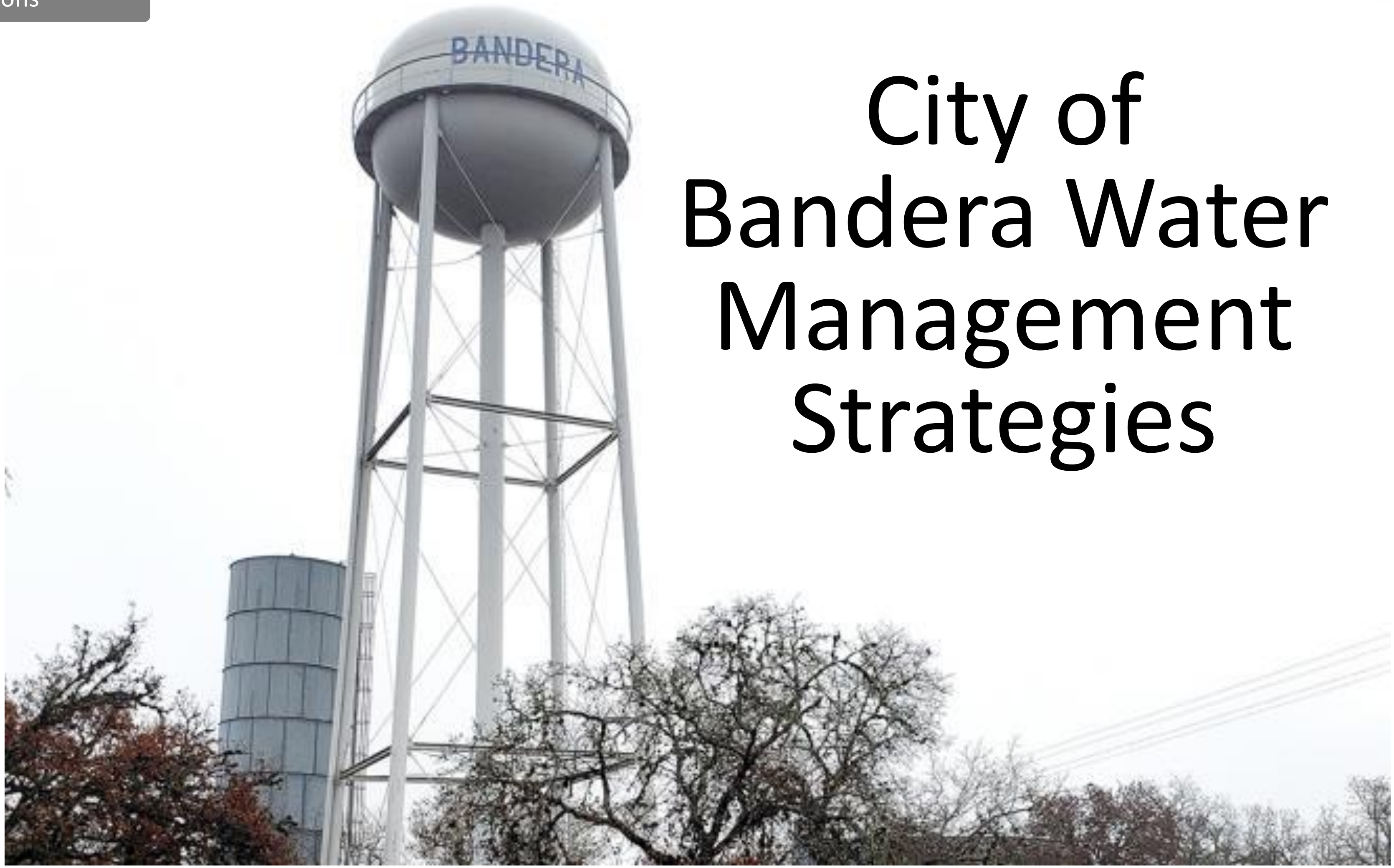
An underground water supply savings account

Texas Water Code

"...a project involving the injection of water into a geologic formation for the purpose of subsequent recovery and beneficial use by the project operator."

- Drought and emergency supply
- Seasonal storage
- Reduce subsidence
- Benefits over surface reservoirs





City of Bandera Water Management Strategies

The City of Bandera surface water acquisition, treatment and ASR

(2022 State Water Plan)

Phase 1: new water supply

- Medina River
- Storm water
- Water reuse

Other options:

- Water reuse for irrigation purposes
- Rainwater harvesting systems
- Drill additional middle Trinity aquifer wells
- Drill an additional lower Trinity aquifer well

Phase 2: ASR

- Store some of the new supply in the lower Trinity aquifer
- Use existing public supply wells initially
- Future plan: add 2 new wells

Water Reuse

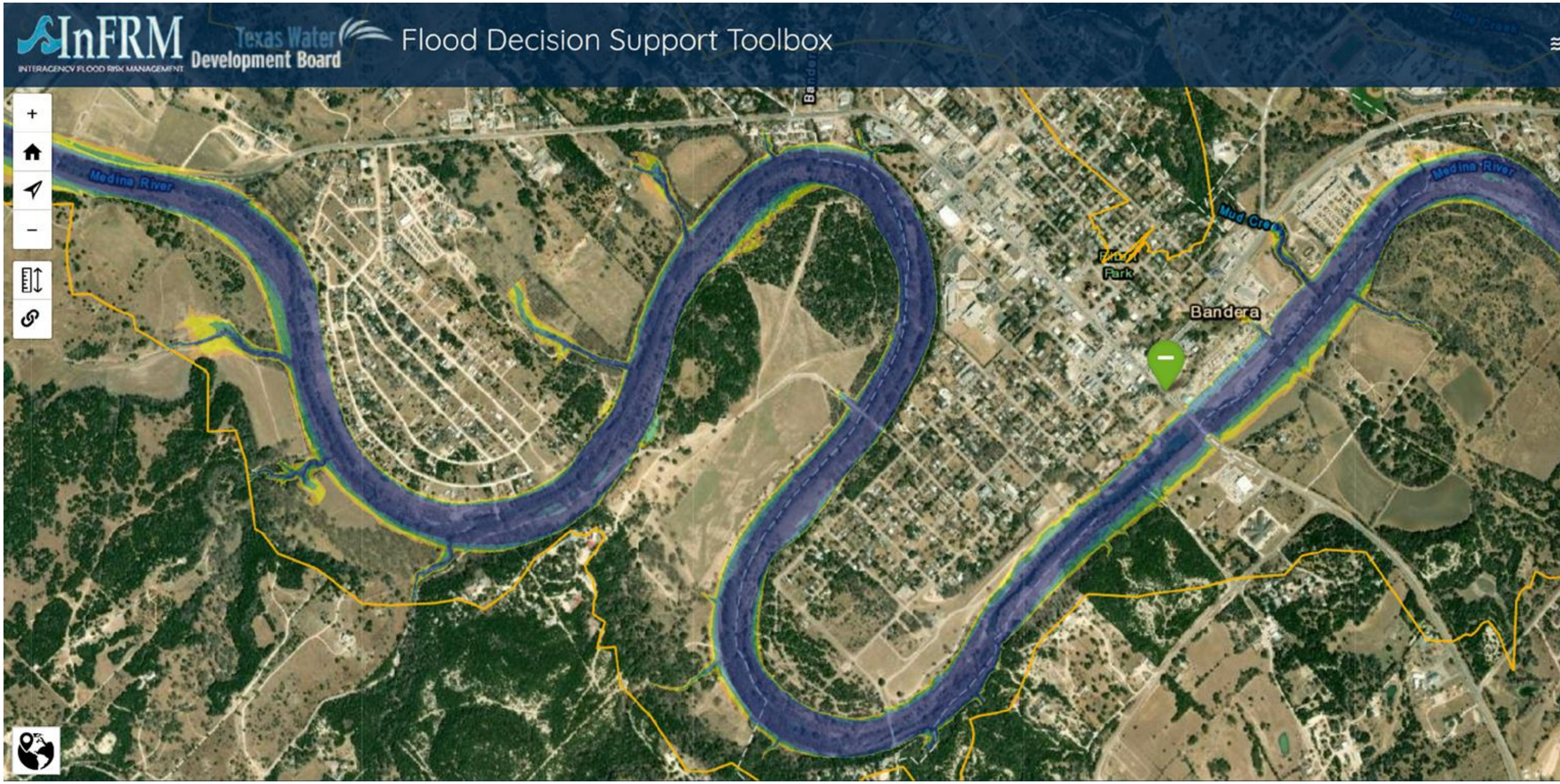
- Treating wastewater (reclaimed water) for direct reuse or indirect reuse.
  - High degree of treatment.

Stormwater

- Treating storm water for direct reuse or indirect reuse. – High degree of treatment.

Texas Minimum Water Quality Guidelines for Indoor Use of Rainwater in Public Water Systems	
Rainwater Quality for Non-Potable Indoor Use	Rainwater Quality for Potable Uses
Total coliforms < 500 CFU/100 ml Fecal coliforms < 100 CFU/100 ml Water testing recommended annually	Total coliforms – 0 Fecal coliforms – 0 Protozoan cysts – 0 Viruses – 0 Turbidity ≤ 0.3 NTU Water testing required monthly *In addition, the water must meet all other public water supply regulations and water testing requirements per Texas Administrative Code Title 30, Chapter 290.*
Texas Rainwater Harvesting Evaluation Committee, 2006, Rainwater Harvesting Potential and Guidelines for Texas - Report to the 80th Legislature: URL http://www.twdb.state.tx.us/iwt/rainwater/docs/RainwaterCommitteeFinalReport.pdf	

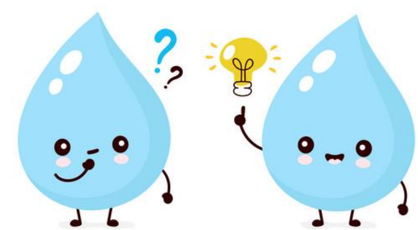
Construction of the Parafield Stormwater Harvesting Facility



Supplemental Water Supply from Cow Creek Wells

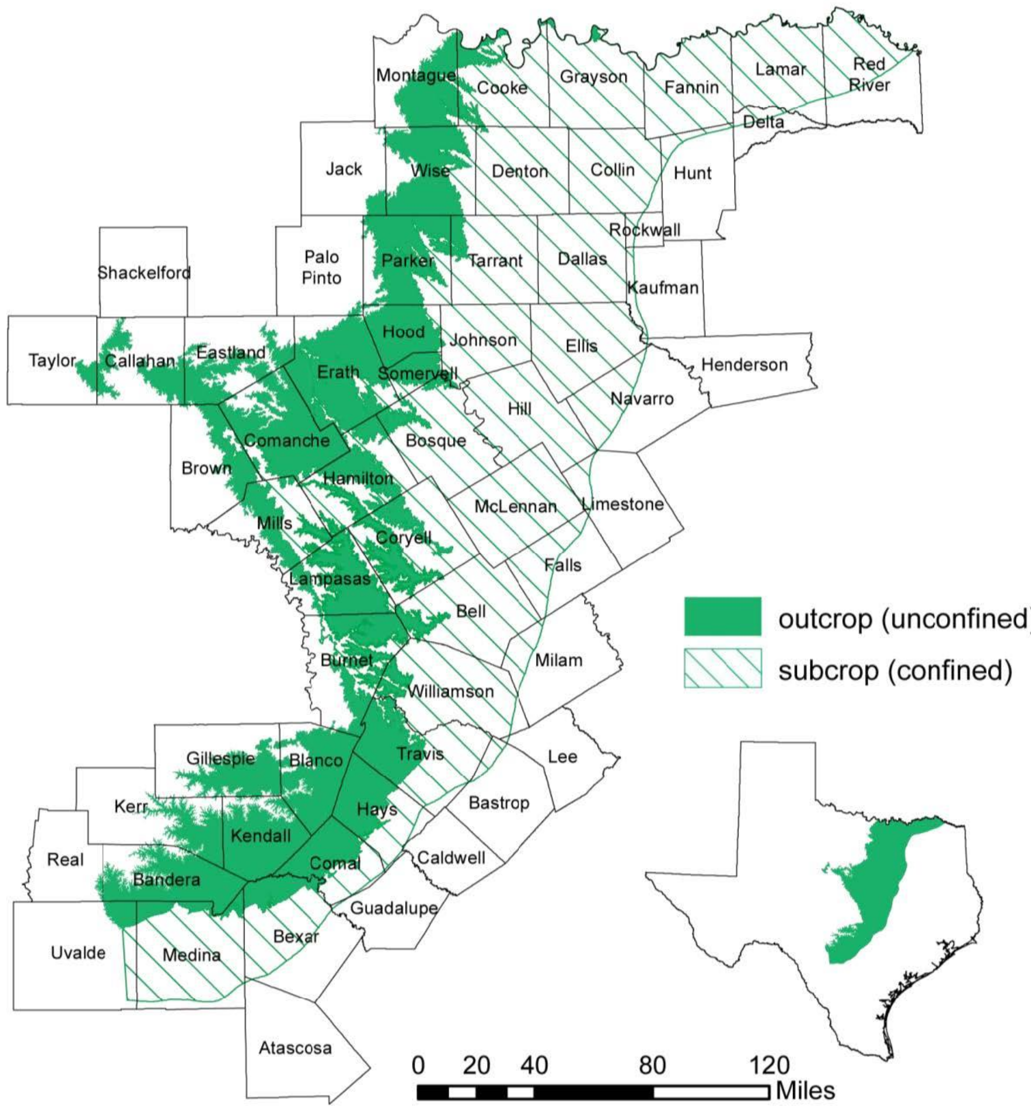
Friday May 22, 2015

https://webapps.usgs.gov/infrm/fdst/?region=tx



Trinity Aquifer

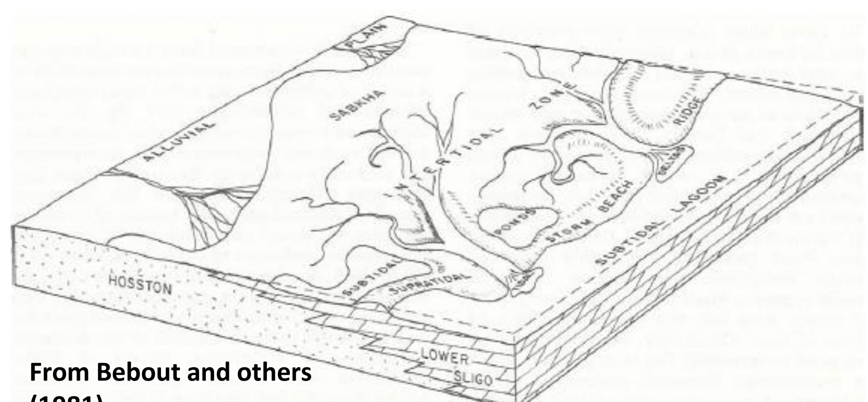
- Found across most of south-central Texas
- Complex and contains limestone, sandstone, and shale
- Subdivided into three hydrogeological units
  - Lower Trinity aquifer
  - Middle Trinity aquifer
  - Upper Trinity aquifer



ASR target aquifer: lower Trinity Aquifer

- The lower Trinity aquifer is contained within the Hosston and Sligo formations
- The Hosston Formation is primarily coarse-grained sandstone and conglomerates
- The Hosston Formation is ~280 ft thick in southern Bandera County and thins northward
- The Sligo Formation is dolomitic and ~80 ft thick in southern Bandera County. It pinches out near the center of the county
- The Hammett Shale overlies the lower Trinity and limits interaction with the middle Trinity aquifer

Epoch	Age	Group	Formation	Member	Hydrostratigraphic unit	Aquifer
Lower Cretaceous	Aptian		Pearsall	Hammett Shale	Hammett *Confining*	Confining unit
			Sligo			
	Barremian		Hosston		Lower Trinity *Transmissive*	Lower Trinity
	Hauterivian					



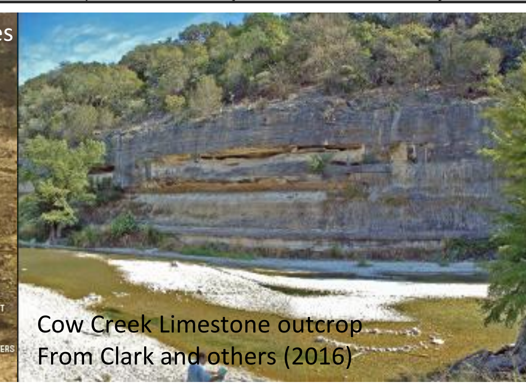
From Bebout and others (1981)

Upper and Middle Trinity aquifers

- Middle Trinity aquifer
  - Contained within the Lower Glen Rose Limestone and the upper portion of the Pearsall Formation
  - Contains both carbonate units with fracture and karstic porosity as well as the sand and dolomite
  - Primary source of groundwater for most residential and municipal entities in the county
- Upper Trinity aquifer
  - Contained in the Upper Glen Rose Limestone
  - Primarily argillaceous limestone and carbonate mud with evaportites
  - Fluid flow is directed through faults and factures and is particularly high within evaporite beds
  - Unconfined across much of the county
  - Primarily used for residential and local irrigation in Bandera County

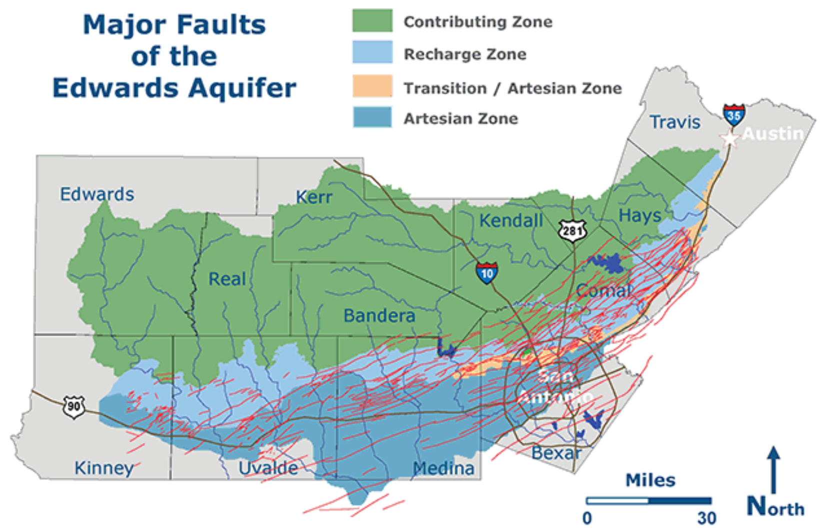
Epoch	Age	Group	Formation	Member	Hydrostratigraphic unit	Aquifer
Lower Cretaceous	Albian	Edwards	Fort Terrett	Basal Nodular	VIII *Transmissive*	Edwards
		Trinity	Glen Rose Limestone	Upper Glen Rose Limestone	Cavernous *Transmissive*	Upper Trinity
					Camp Bullis *Semi-confining*	
					Upper Evaporite *Transmissive*	
					Fossiliferous *Semi-confining*	
					Lower Evaporite *Transmissive*	
				Lower Glen Rose Limestone	Bulverde *Semi-confining*	Middle Trinity
					Little Blanco *Transmissive*	
	Aptian				Twin Sisters *Confining*	
					Doeppenschmidt *Transmissive*	
					Rust *Confining*	
					Honey Creek *Transmissive*	
			Pearsall	Hensell Sand	Hensell *Confining*	
				Cow Creek Limestone	Cow Creek *Transmissive*	

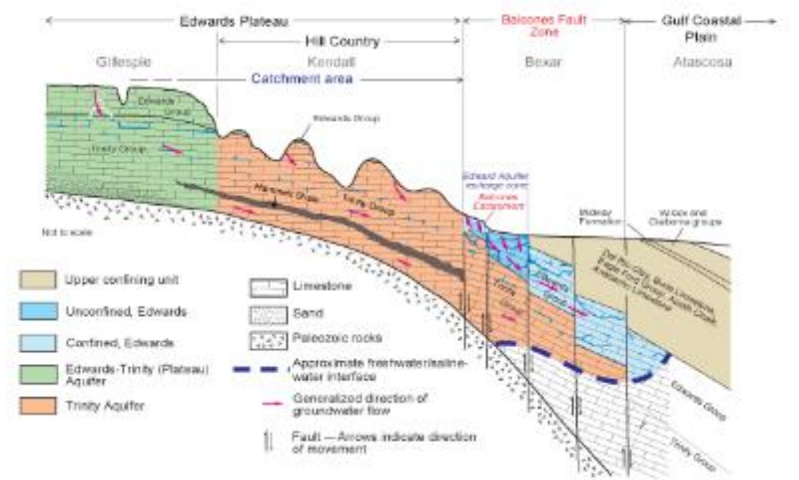
Upper Glen Rose LS evaporites
From Clark and others (2020)


Cow Creek Limestone outcrop
From Clark and others (2016)

Balcones Fault Zone

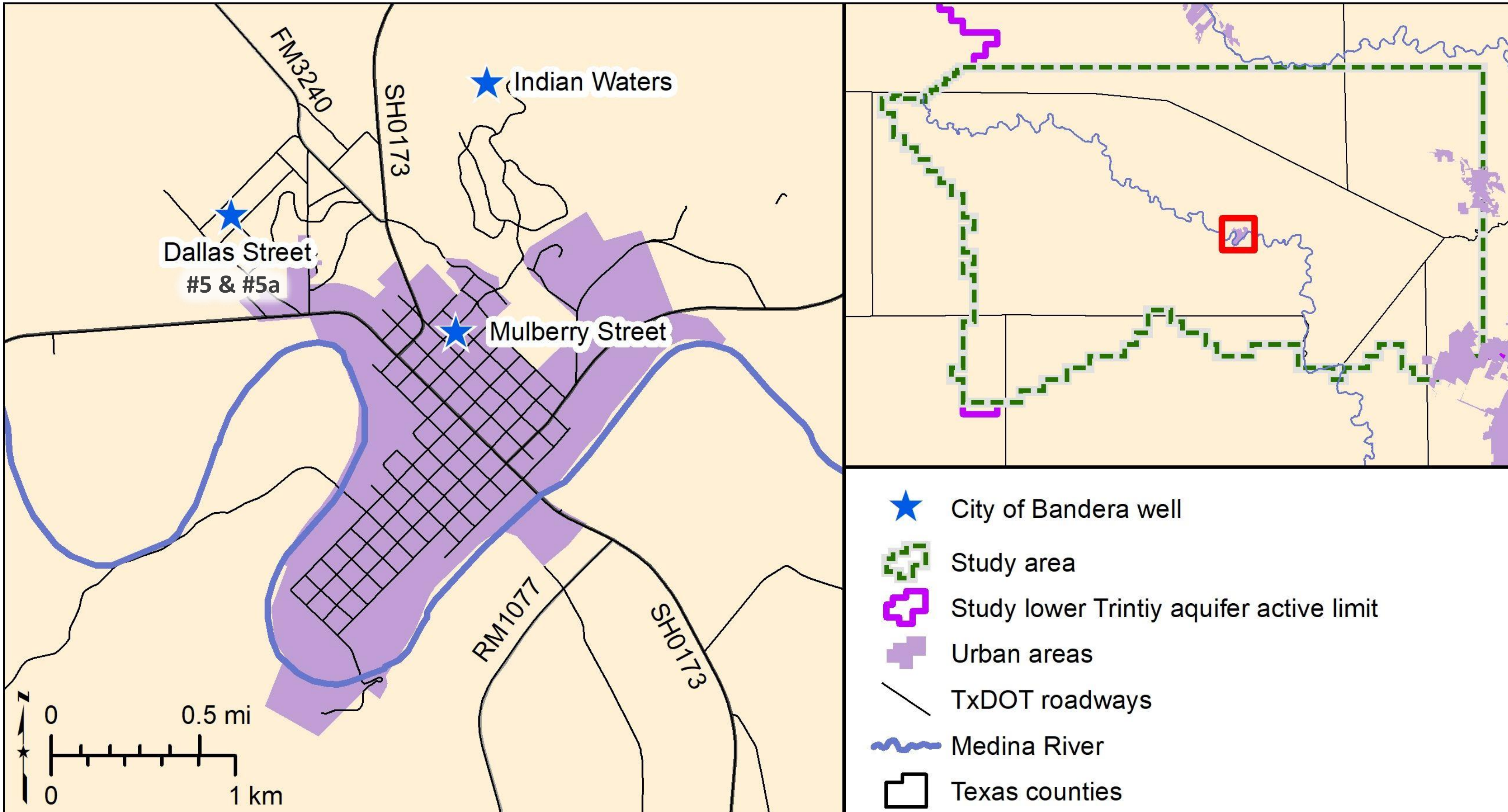
- The Trinity Group was faulted during the Miocene
- The Balcones Fault Zone is a northeast–southwest trending zone of near-vertical faults extending from central to north Texas
- The hydrogeology in the Trinity aquifer is highly affected by faults, fractures, and geologic structures
- Recent studies show that there are likely more faults in Bandera County than previously mapped
- Some faults in Bandera County may have over 100 feet of offset, which may displace confining units such as the Hammett Shale



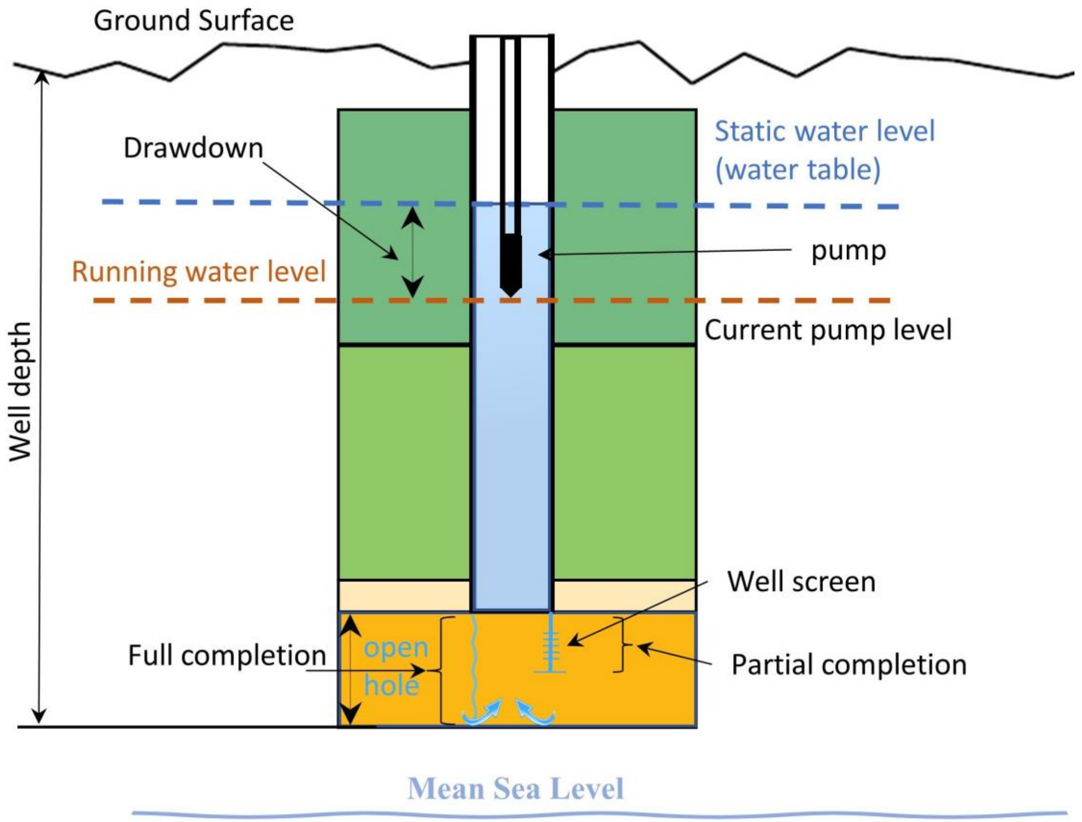


Modified from Barker and Ardis, 1996; Lindgren and others, 2004

The City of Bandera water wells



The City of Bandera water wells



Well Name	Well #5a or Dallas St. (SWN 6924116)	Well #5 or Dallas St. (SWN 6924102)	Well #4 or Mulberry St. (SWN 6924202)	well #6 or Indian Waters (SWN 6924221)
Drill year	2017	1967	1953	1998
Well depth	480	805	842	770
Screen intervals	221-480	533-805	740-842	610-710
Well completion	Open Hole. Middle Trinity	Open Hole. Lower Trinity	Open Hole. Lower Trinity	Screened. Lower Trinity
Static water depth (ft)	257	468	444	444
Running water depth (ft)	268	581	490	494
Drawdown (ft)	11	113	46	50

The City of Bandera water wells

Total production = **274** Acre-foot per year

#5a or Dallas St.
7%
2.4 hrs

#5 or Dallas St.
29%
2.4 hrs

#4 or Mulberry St.
42%
3.6 hrs

#6 or Indian Waters
22%
3.1 hrs

Percentage of City of Bandera production

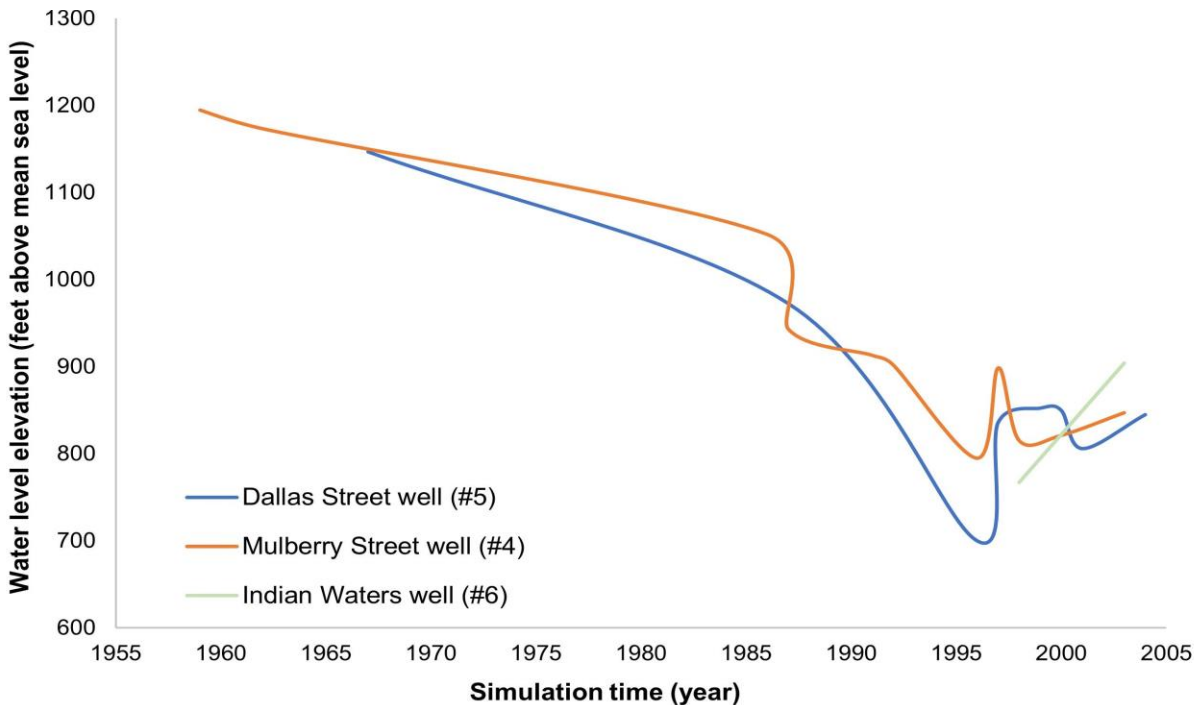
Average daily run time

Longevity assessment for the City of Bandera water wells

- Water supply challenges
- Investigation methods
  - Daily operations
  - Long-term planning
- Results

The City of Bandera water supply challenges

- Projected population growth
- Trinity Aquifer is the sole supply source currently
- Lower Trinity aquifer historic water level declines



- City of Bandera wells already near production capacity
- There is very little redundancy in case of failure

Investigation

Predict the longevity of the city's lower Trinity wells, based on water levels and well configuration, to aid future water supply planning

Daily Operation

- **Current operation (run time and water level)**
- **Capacity of existing wells (configuration of well)**
- **Minimum operational requirements**

Long term planning

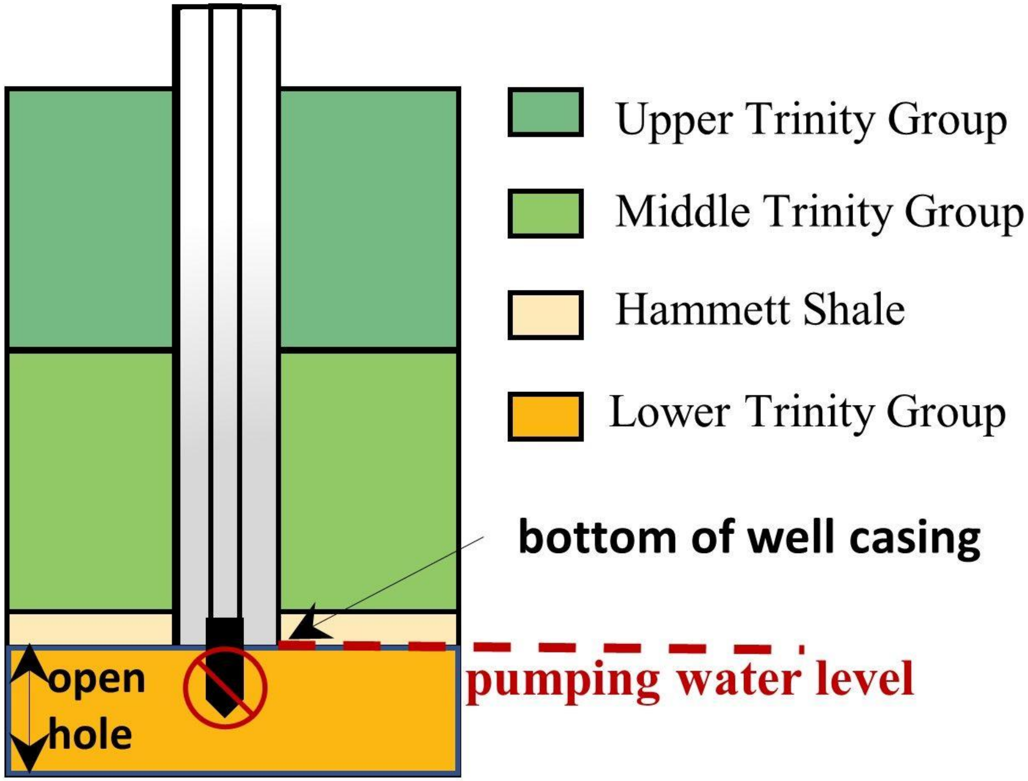
- **Lower Trinity aquifer historic and current water levels**
- **Projected levels based on planned use**

Well operational limit

Well Configuration

What would be the end of life for a well?

When water levels reach the bottom of the casing

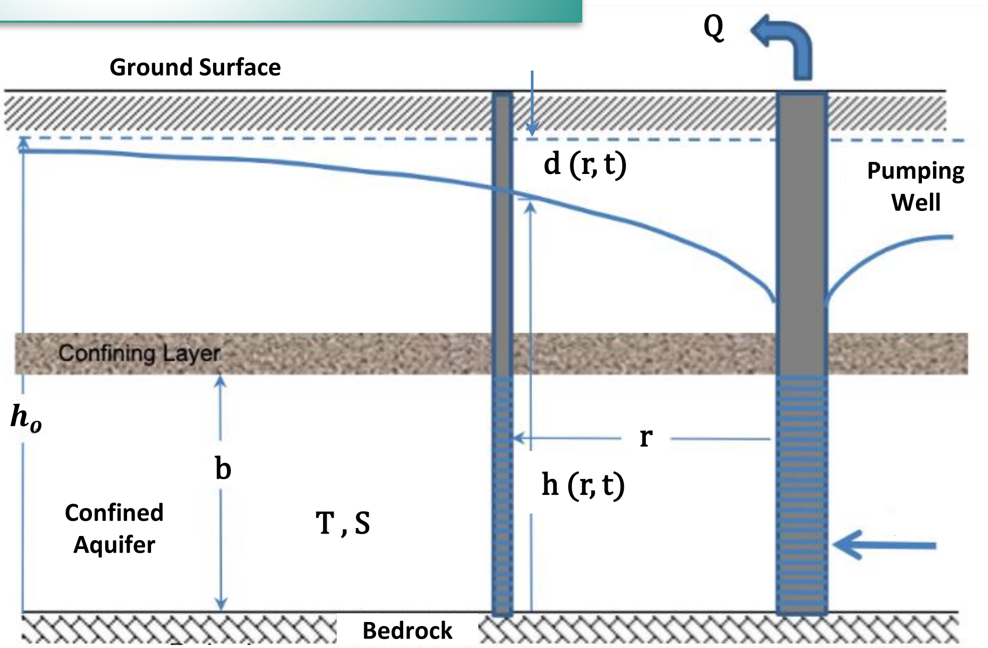


Analytical solution

- simple groundwater flow equation
- solve for drawdown at a point in time and space (fine resolution)
- has many assumptions

- Theis (1935) equation

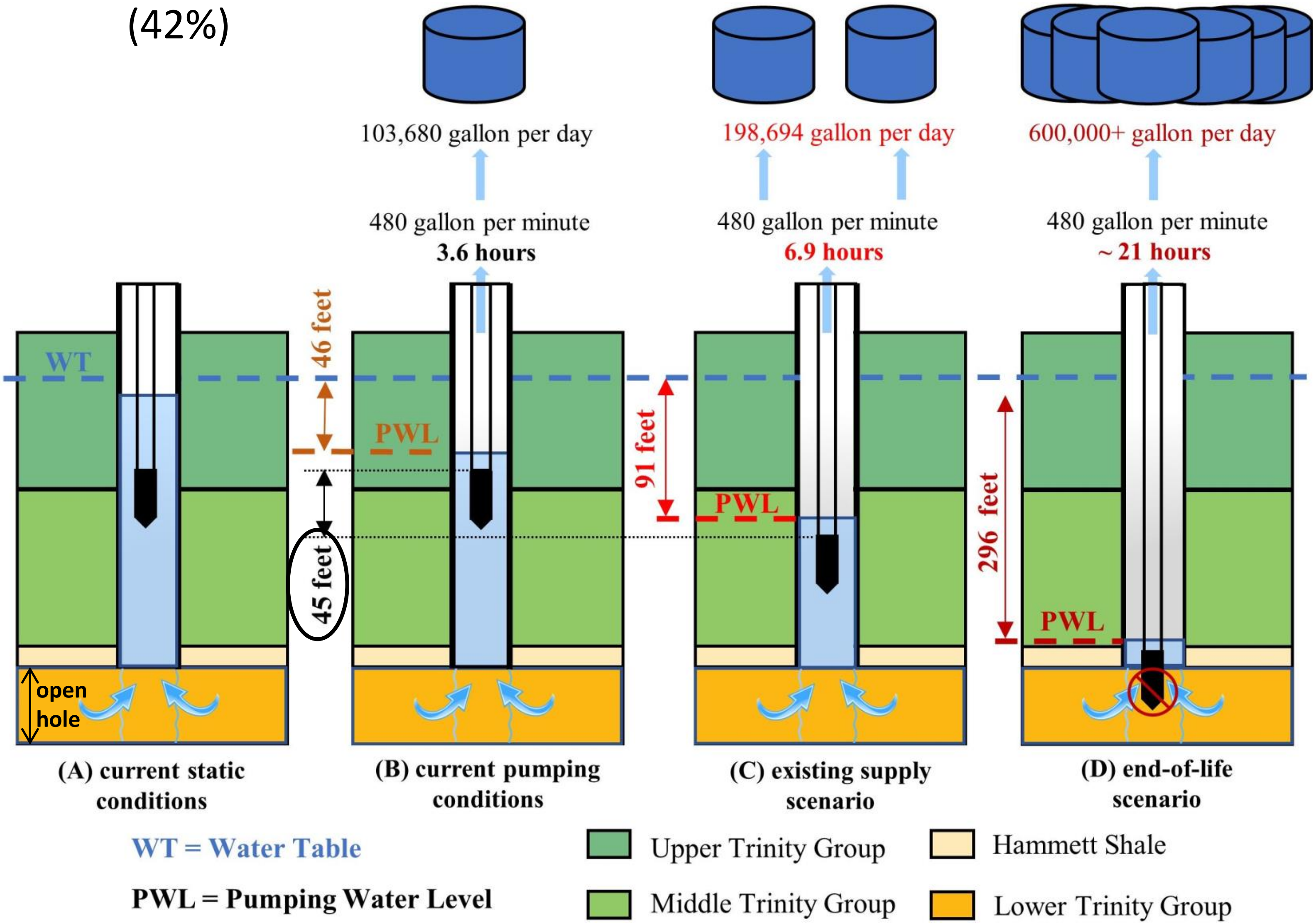
$$d(r,t) = \frac{Q}{4\pi T} W\left(\frac{r^2 S}{4Tt}\right)$$



Operational analysis results

The Mulberry Street well

Max available Trinity Aquifer supply for City of Bandera = **534 AFY (476,726 gpd).** The Mulberry Street well = 198,694 gpd (42%)

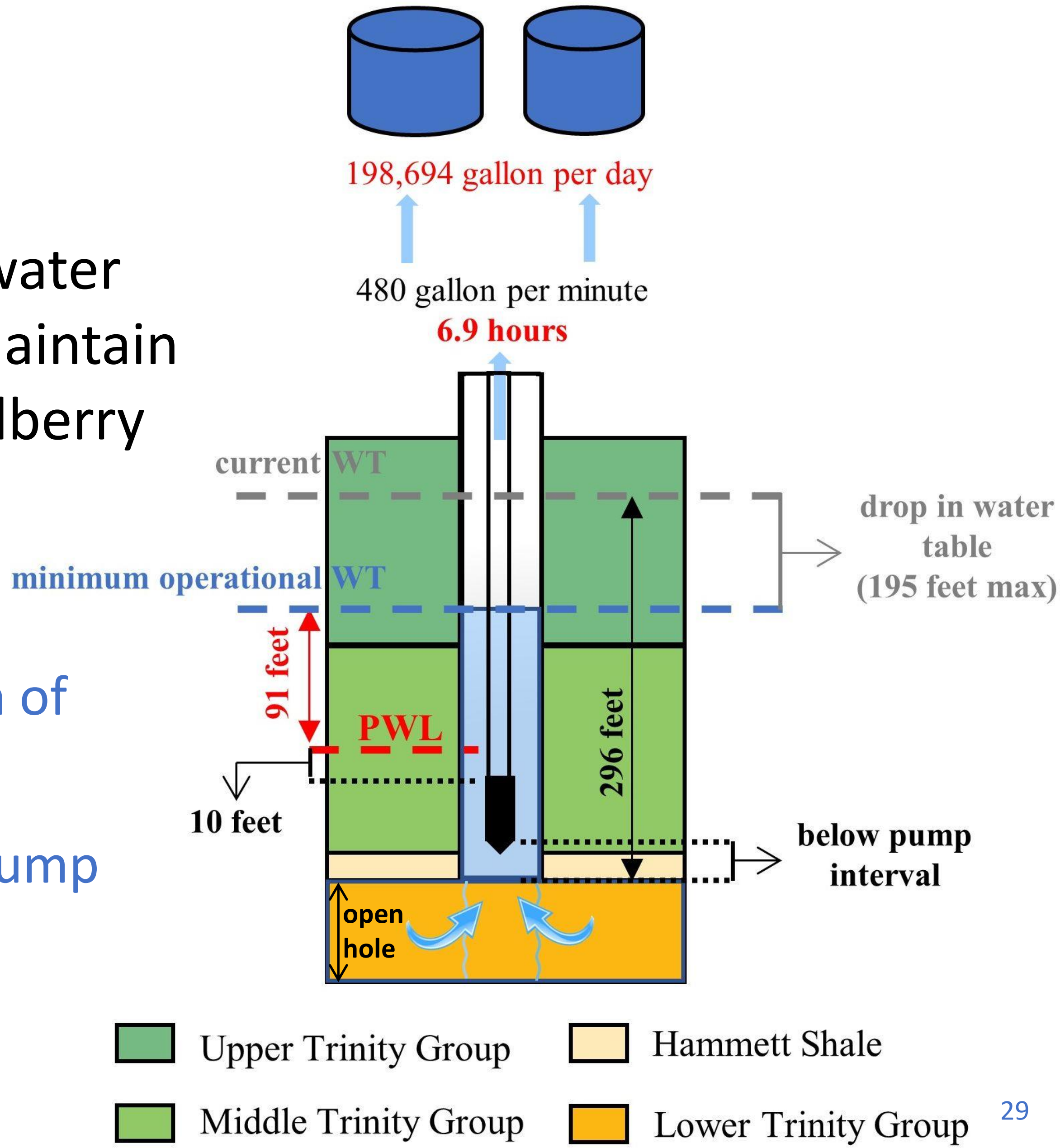


Minimum operational requirement

Then, what would be an approximate minimum water table level required to maintain the operation of the Mulberry Street well?

Criteria:

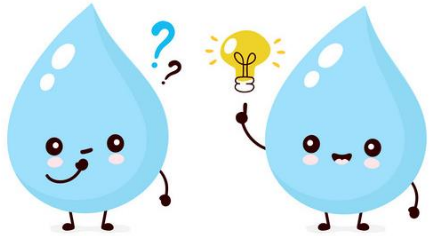
- Pump above the bottom of the well casing
- Water level above the pump
- Full recovery between pumping sessions



Analytical solution limitations

- Complicated and difficult to solve for:
  - multiple wells
  - long simulation time
  - complex aquifer system

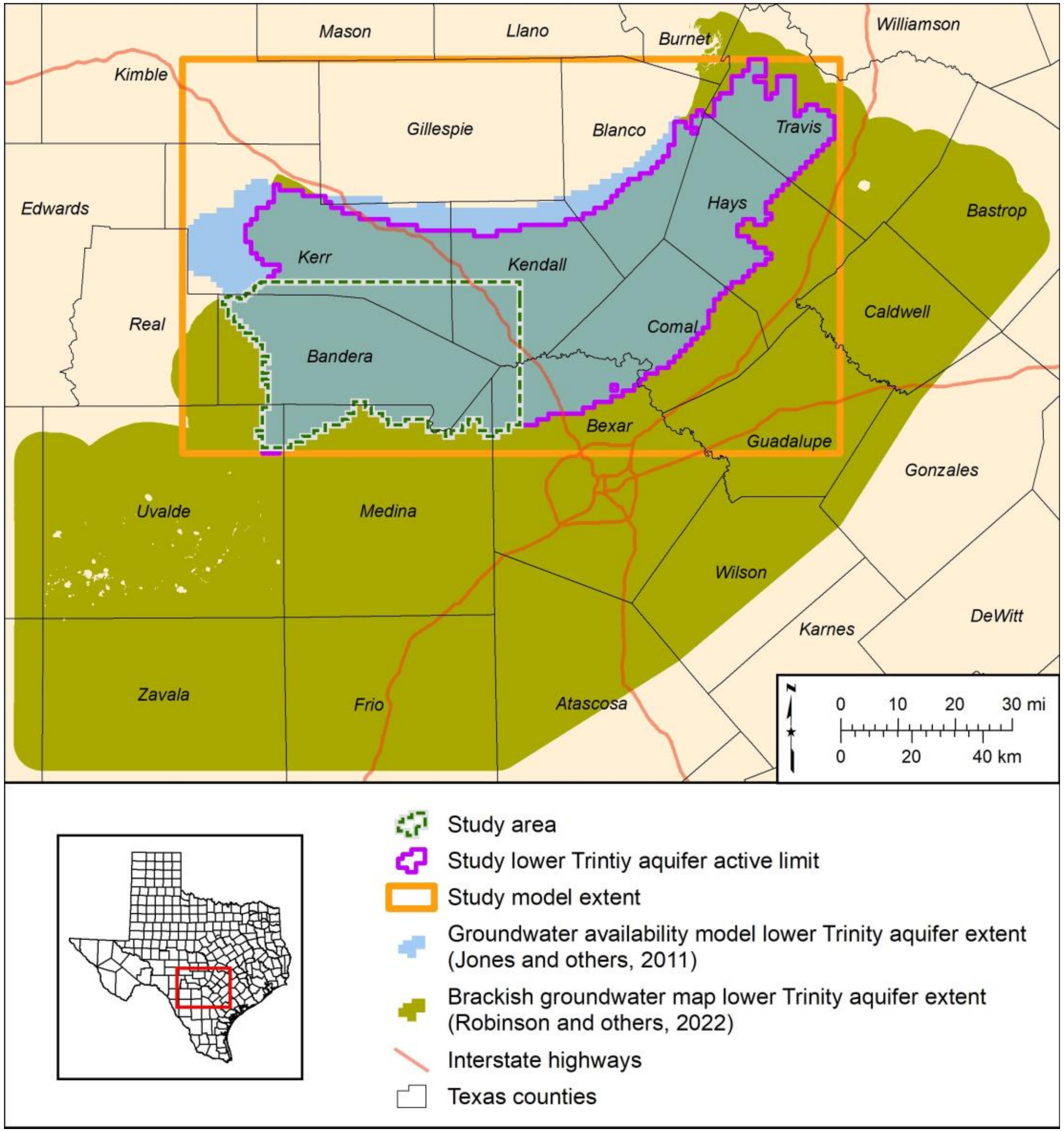
- Does not project future water table levels



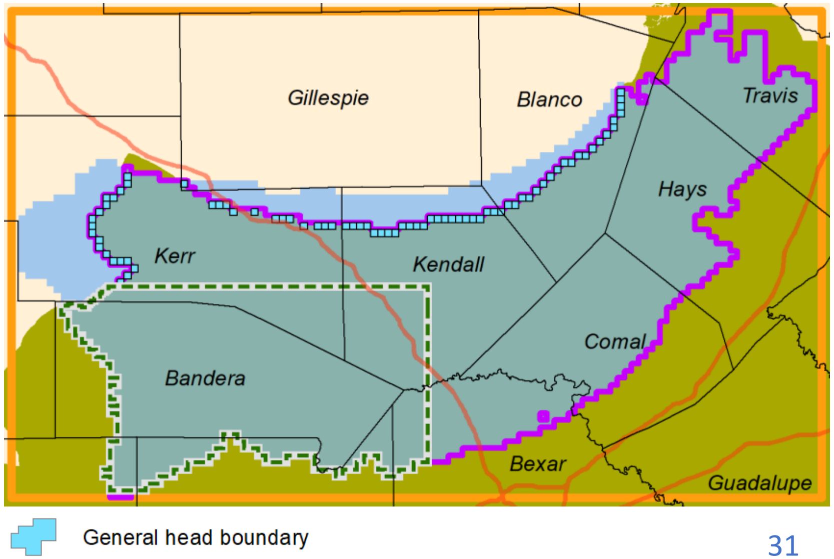
- Background
- Study objective
- Method and results
- Conclusions

Long-term planning

Created the Bandera Well Longevity Model



- used existing GAM model frame
- updated layers with most recent BRACS aquifers surfaces



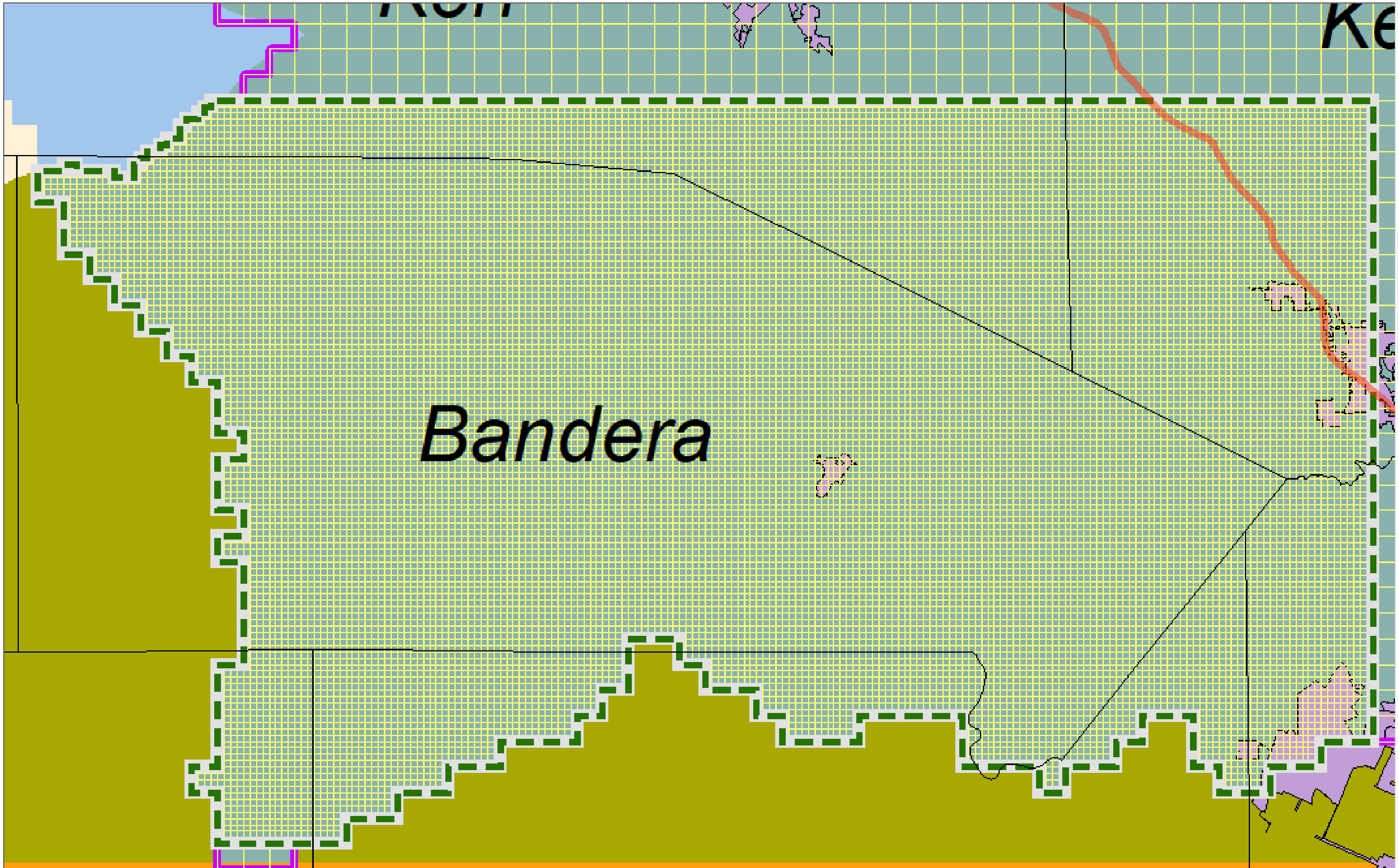
Long-term planning

Bandera Well Longevity Model layers

Era	System	Group	Stratigraphic unit		Hydrologic unit		Model layer
Cenozoic	Quaternary		Alluvium		Alluvium		
Mesozoic	Cretaceous	Edwards	Segovia Formation		Edwards Group		Layer 1
			Fort Terrett Formation				
		Trinity	Glen Rose Limestone	Upper Member	Trinity Aquifer System	Upper Trinity	Layer 2
				Lower Member		Middle Trinity	Layer 3
			Hensel Sand/Bexar Shale				
			Cow Creek Limestone				
			Hammett Shale			Confining unit	
			Sligo Formation			Lower Trinity	Layer 4
			Sycamore Sand/Hosston Formation				
Paleozoic			Undifferentiated Pre-Createaceous rock				

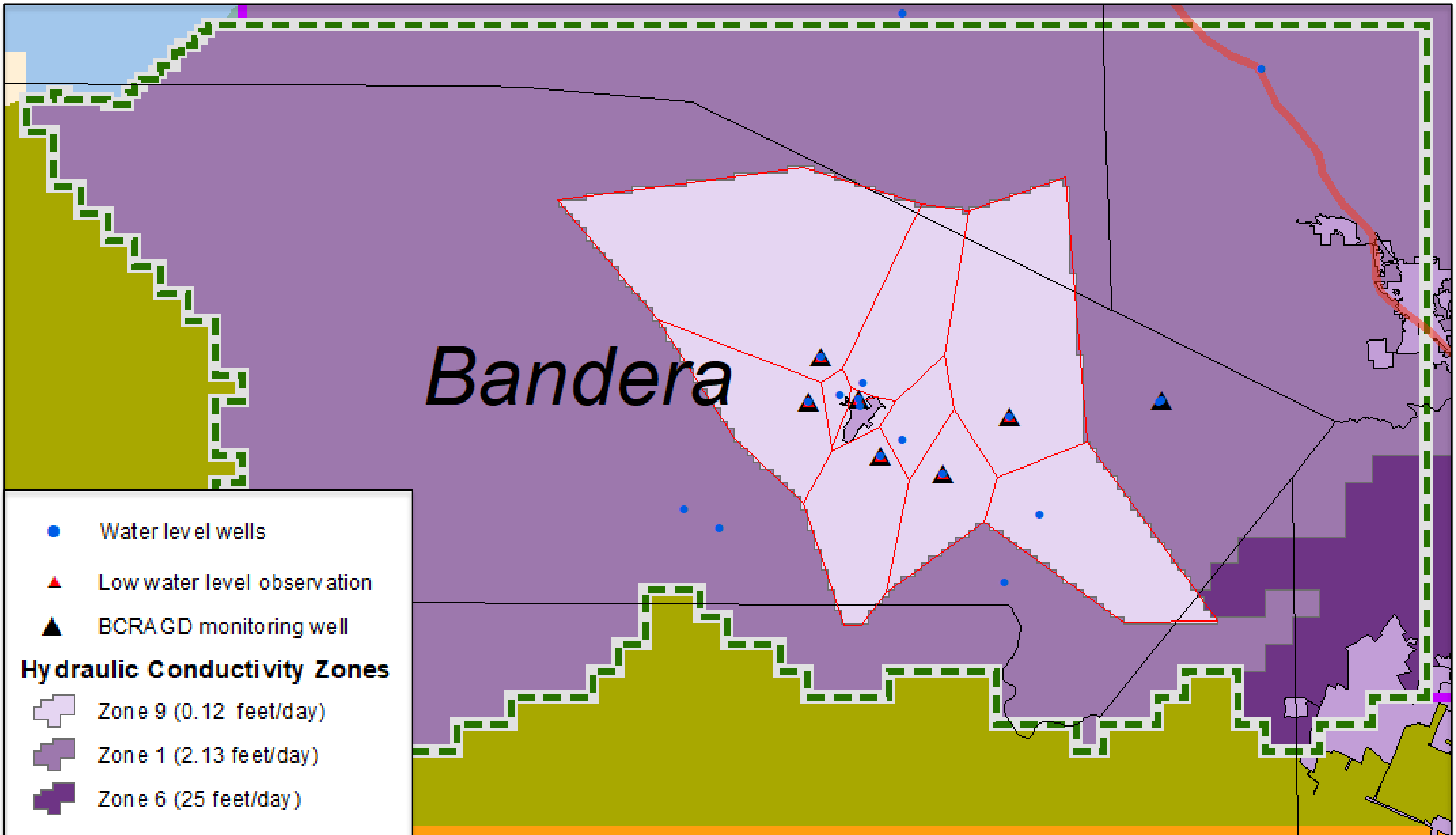
Long-term planning

Refined mesh from 1-mile to 0.25-mile in Bandera County area (MODFLOW-USG)

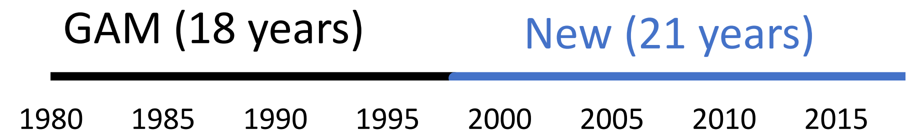


Long-term planning

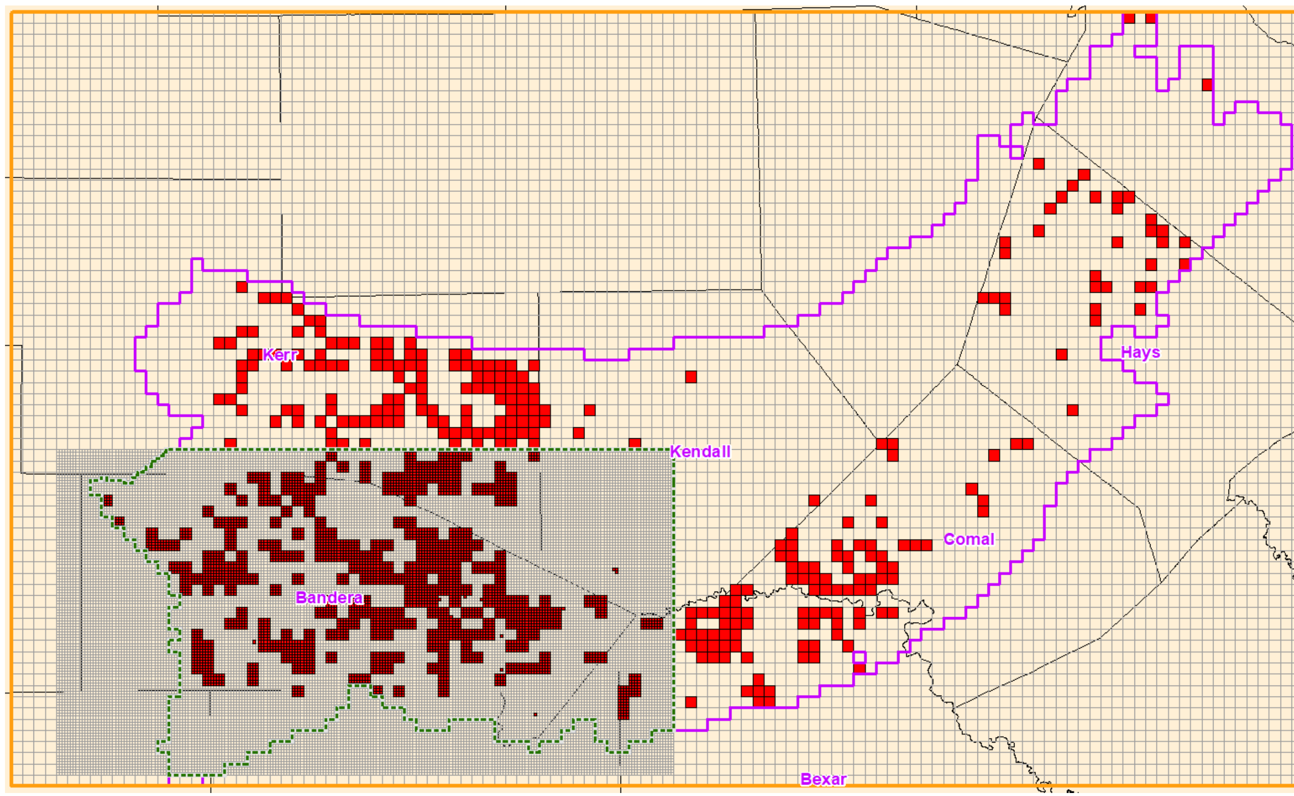
Added a new hydraulic conductivity zone in Bandera county



Long-term planning



- Timeline: added new stress periods (years)
- Added pumping (1998-2018) in 6 counties
- Use and Well Data Quality Assurance
- Sources:
  - TWDB Groundwater Database
  - TWDB historic use information
  - TCEQ Database
  - GCD Database
  - City of Bandera records



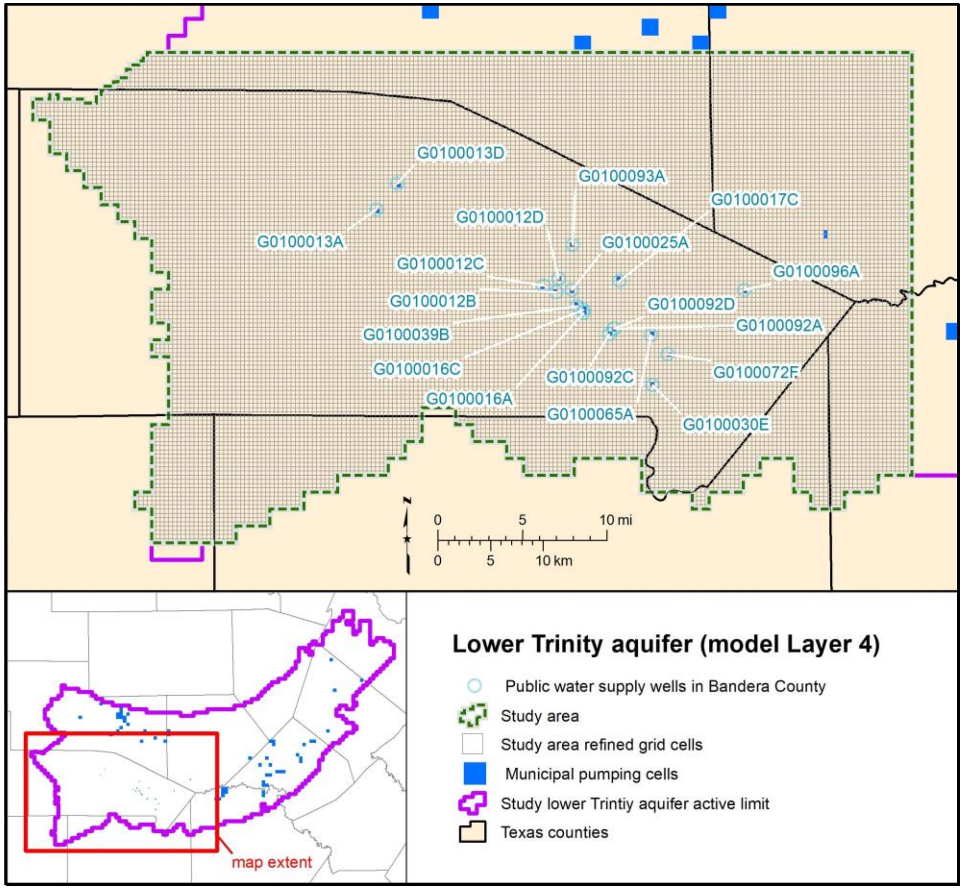
Model cells with pumping activity

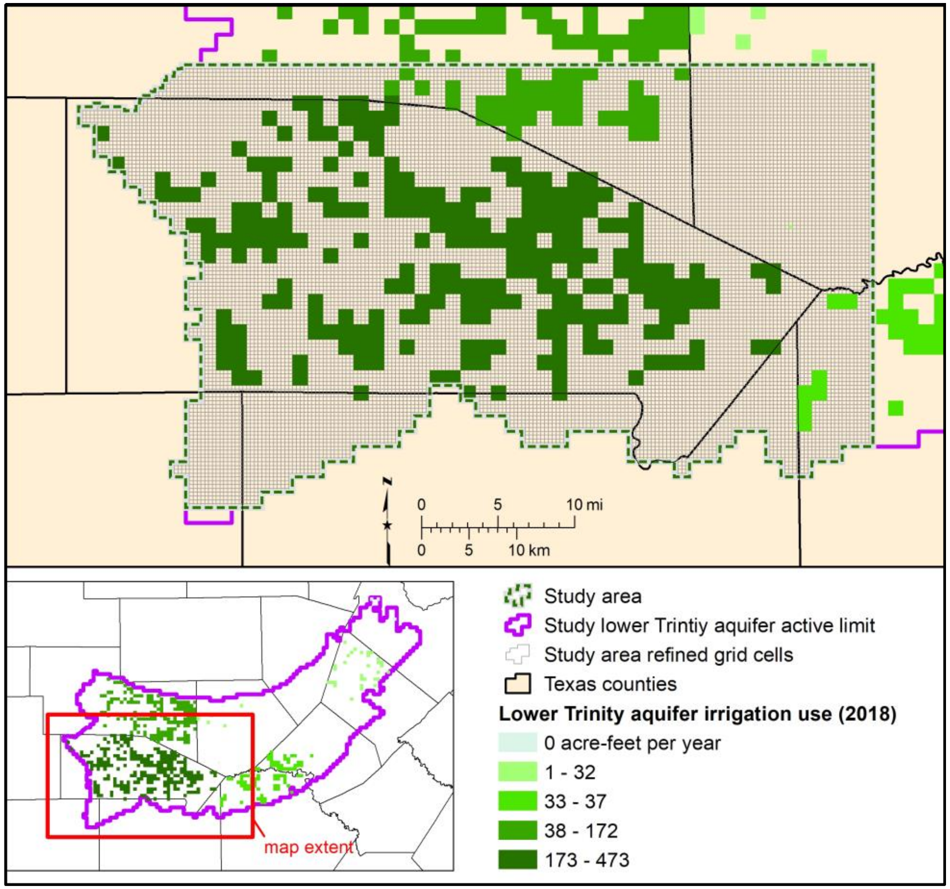
Long-term planning

- Use: Municipal and Irrigation use

GAM (18 years) New (21 years)

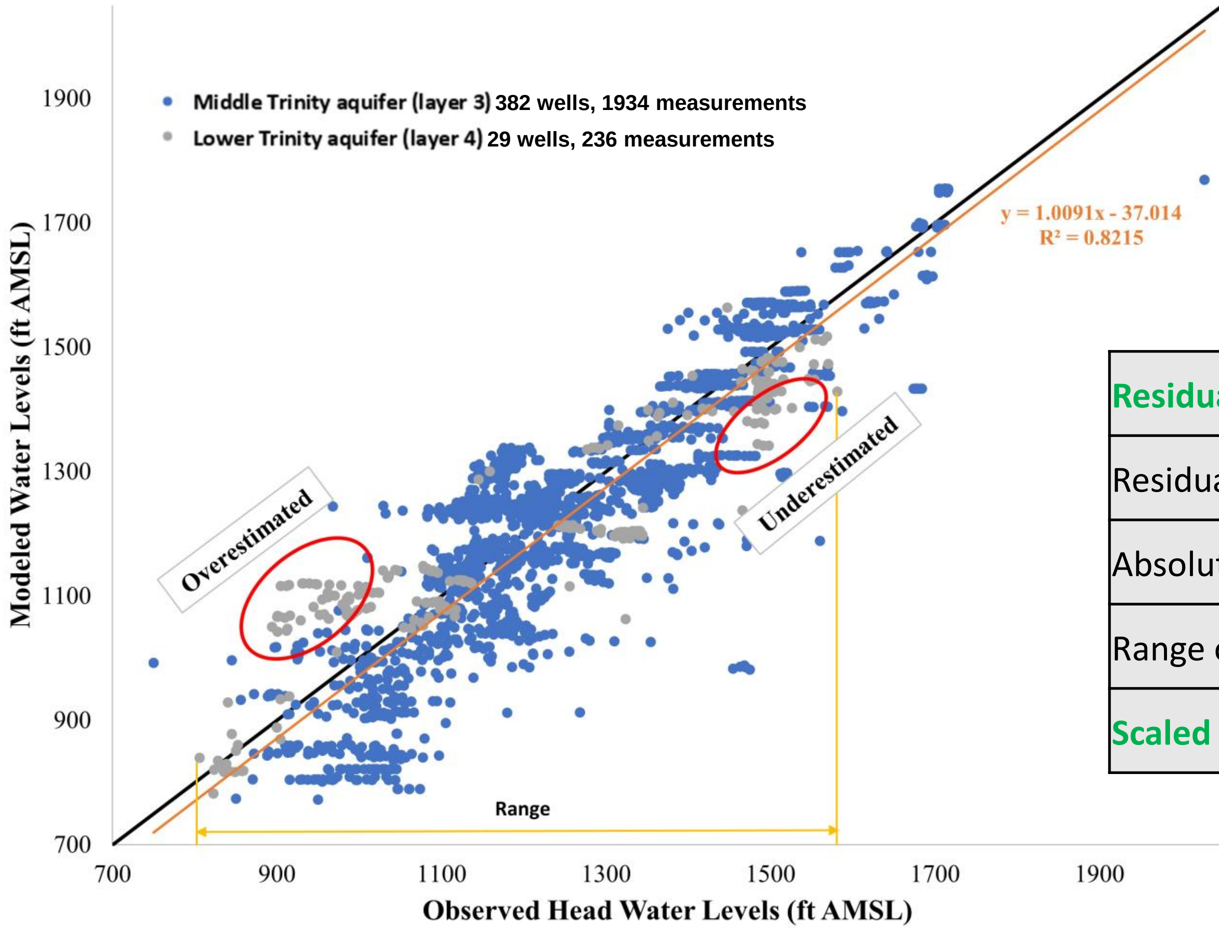
1980 1985 1990 1995 2000 2005 2010 2015





Results: Historic Match

- Evaluate how well the model matched the observed water levels
- Residual = Observed (water level measurements) - Modeled



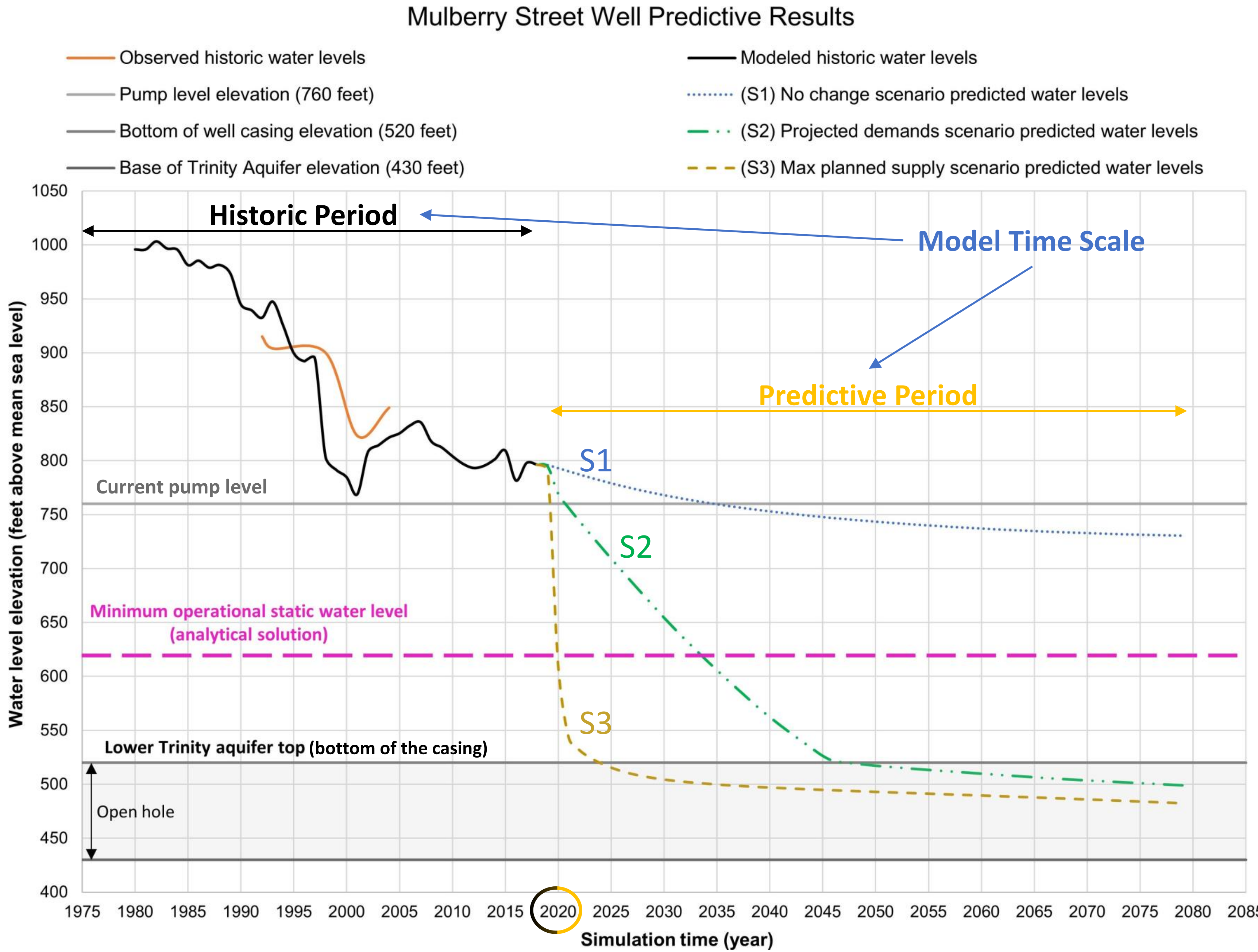
Residual Mean (ft)	2.52
Residual Standard Deviation (ft)	91.41
Absolute Residual Mean (ft)	74.56
Range of Observations (ft)	775.4
Scaled Residual Standard Deviation	0.096

Prediction scenarios

The model was used to forecast future conditions based on three scenarios:

No change scenario	Projected use scenario	Max supply use scenario
No increase in pumping	Pumping will increase to match the projected demands in the 2022 State Water Plan	Pumping will increase to produce all groundwater listed as available to the City of Bandera in the 2022 State Water Plan

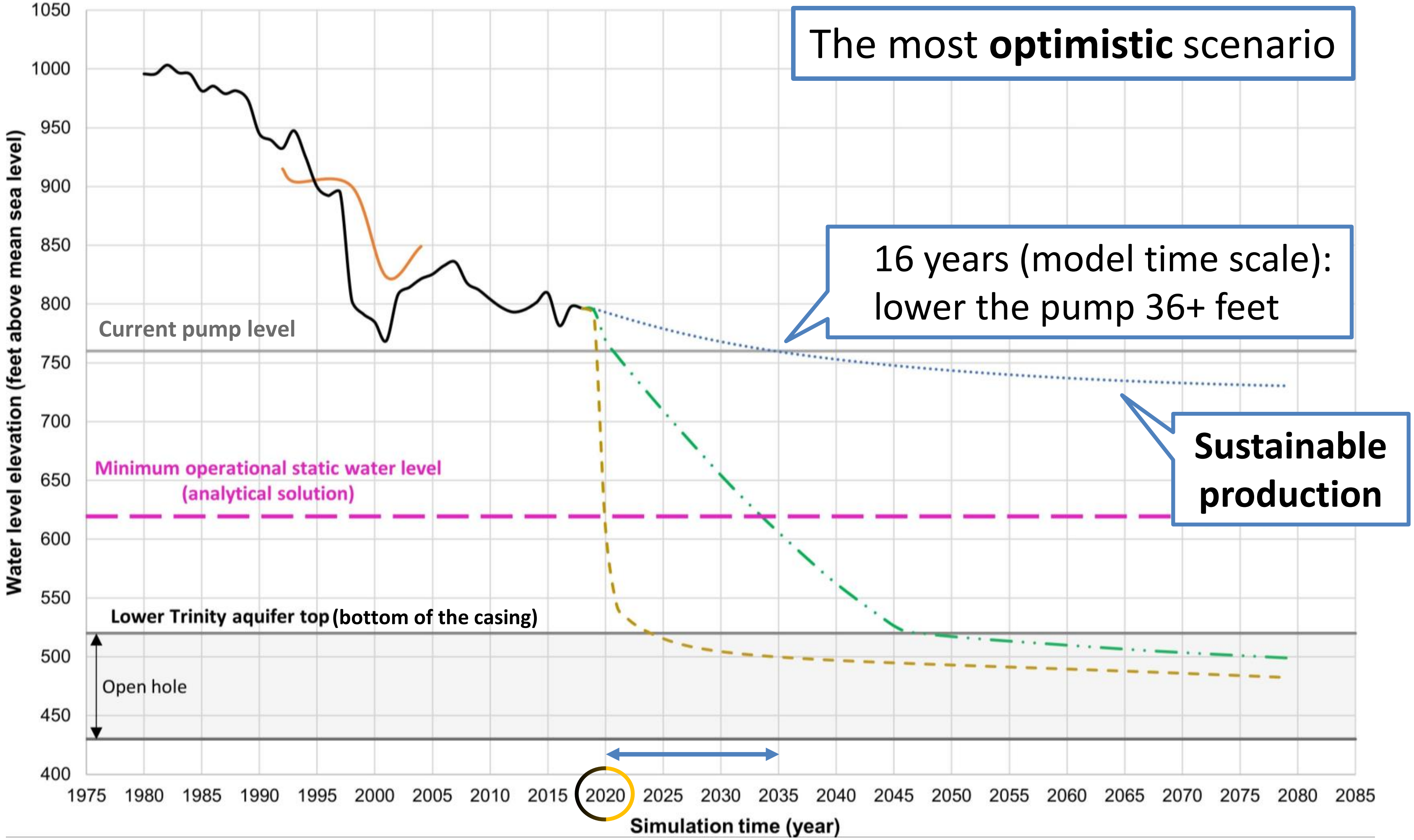
Predictive model results



Predictive model results

The Mulberry Street Well

Scenario 1: No change

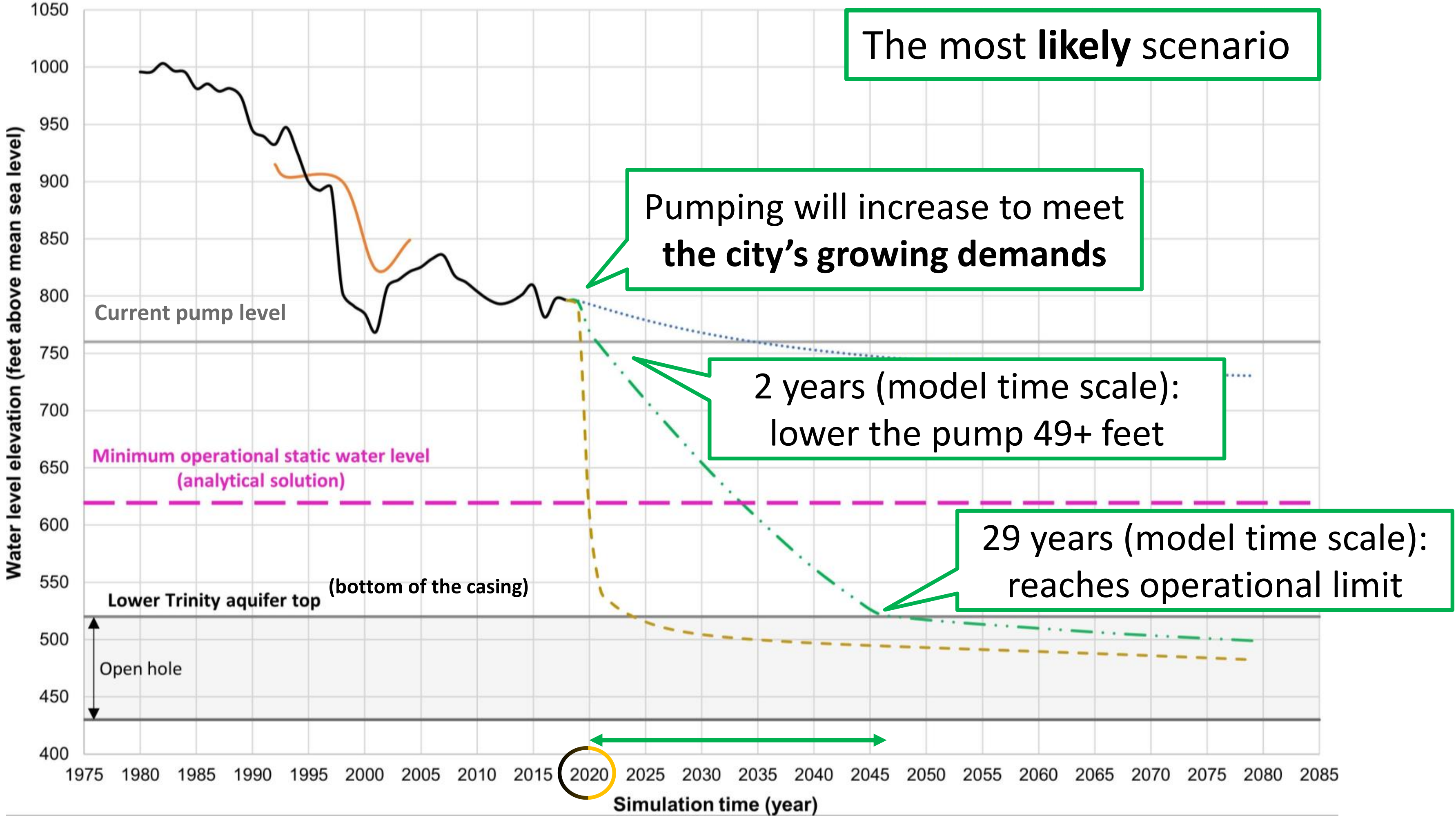


The City of Bandera has plenty of time to implement new water supply strategies

Predictive model results

The Mulberry Street Well

Scenario 2: Projected demands

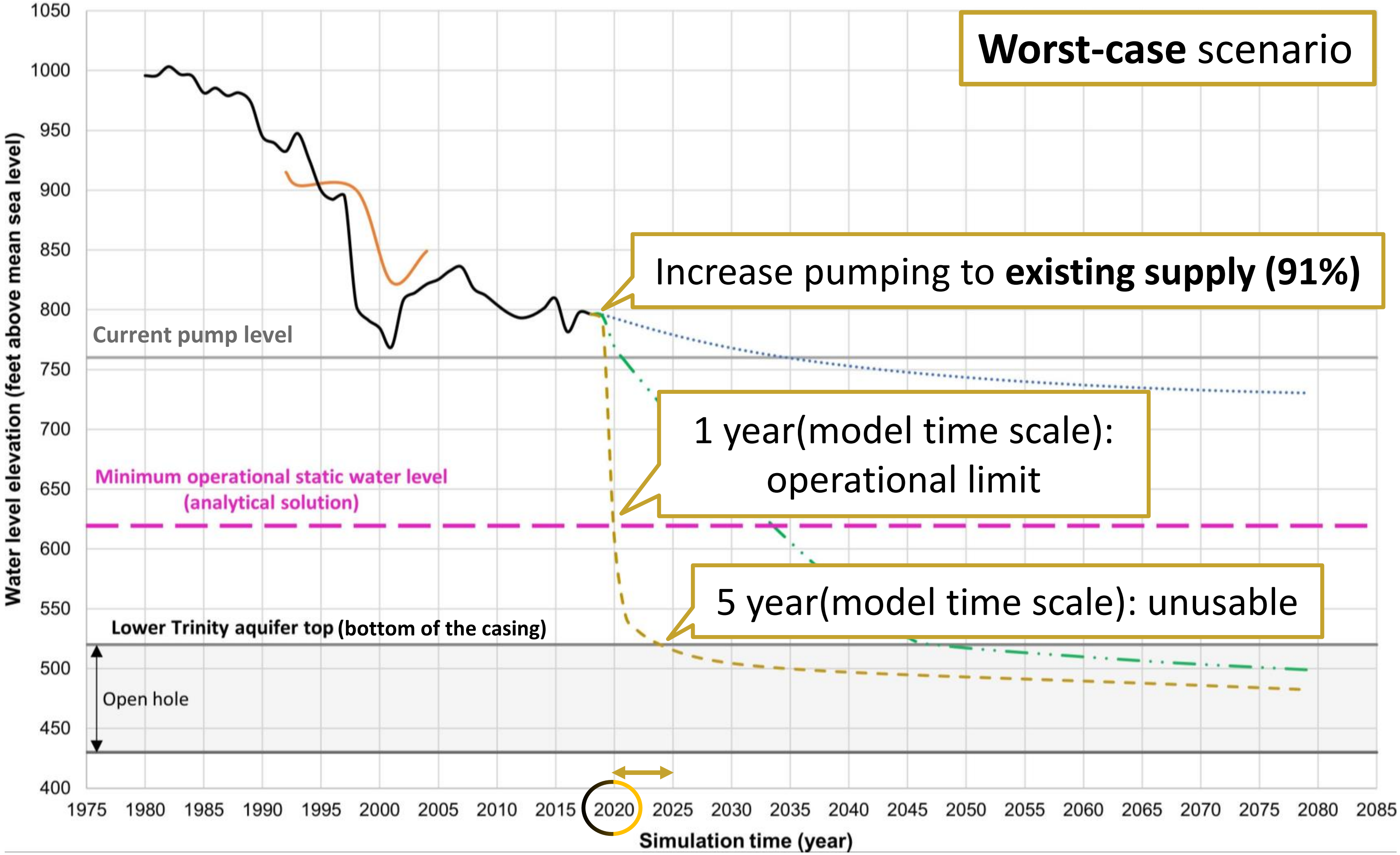


The City of Bandera has less than 29 years margin to implement new water supply strategies

Predictive model results

The Mulberry Street Well

Scenario 3: Maximum existing supply



The City of Bandera would need to implement new strategies before considering this scenario

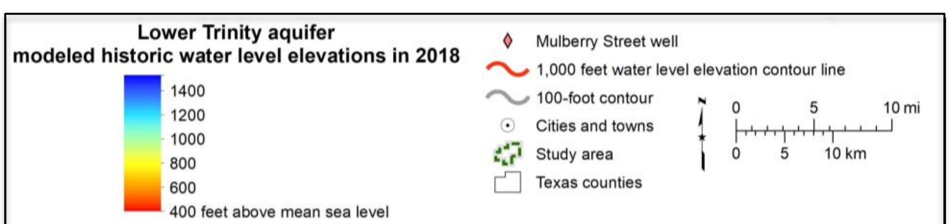
Predictive model results

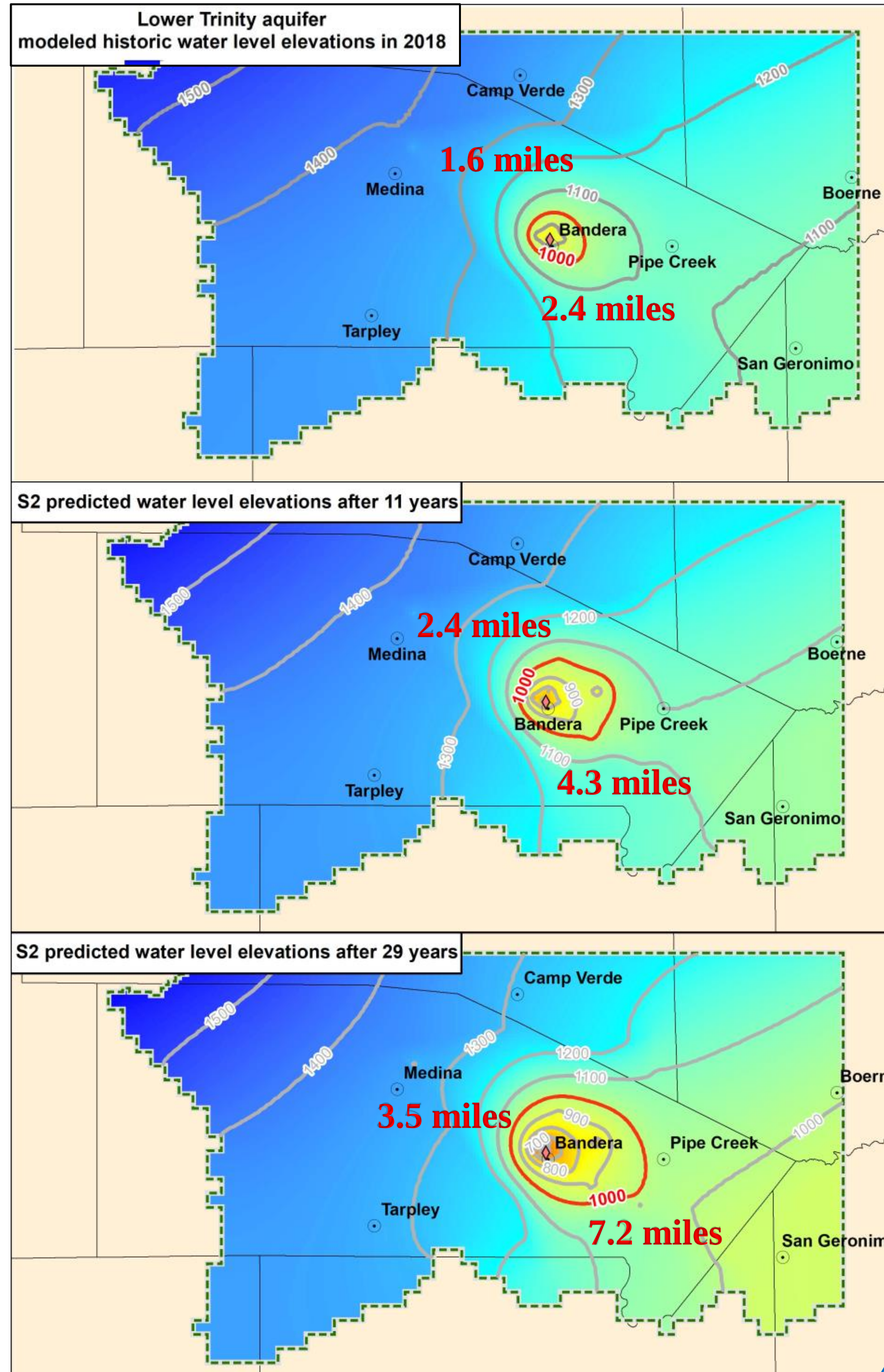
Alternative management strategy:
new lower Trinity well

- outside of current cone of depression
- 4 miles north of the city
- online by 2030

BWLM simulated cone of depression:

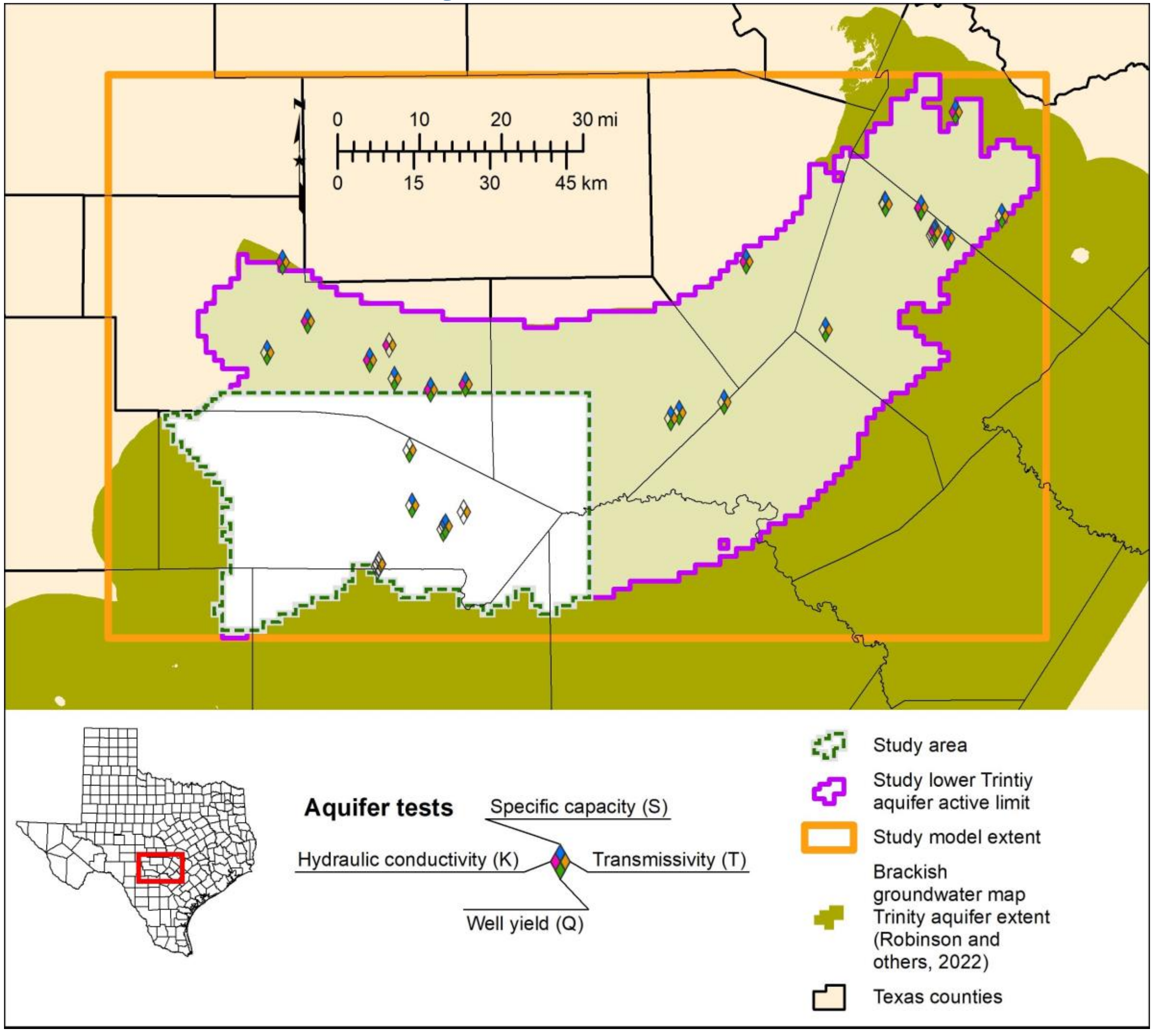
- 1000 feet AMSL: model threshold
- less than average observed water level



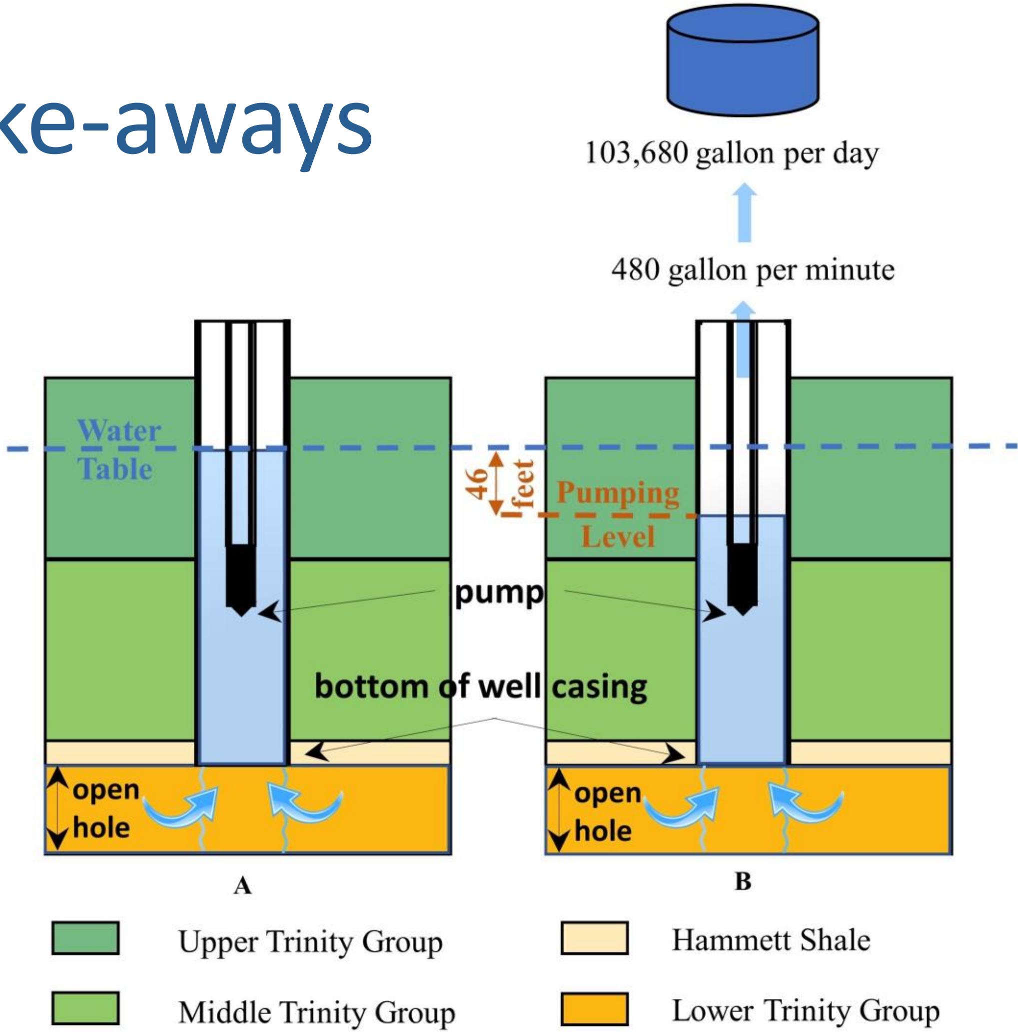


Lower Trinity aquifer in Bandera County

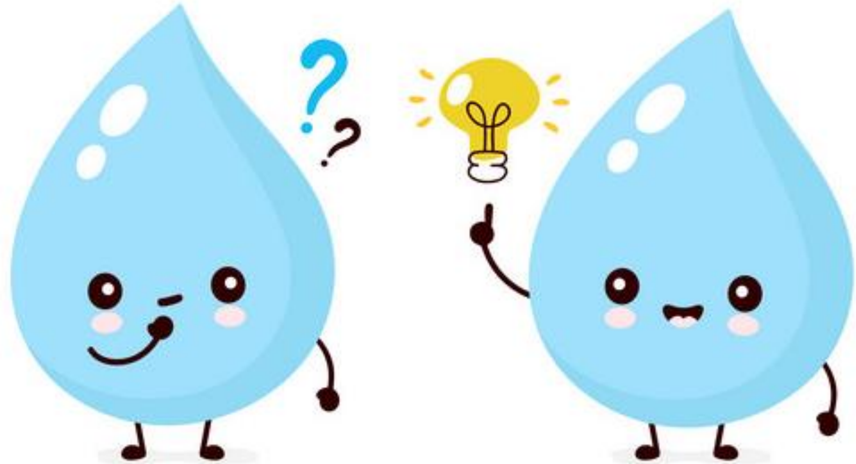
- Has limited data availability
- Very different from City of Kerville to City of Bandera



Key take-aways



- The City of Bandera lower Trinity aquifer wells:
  - Currently meet the city's needs but are reaching pumping limits
  - Pumps can be lowered to meet some increased demand but vulnerable to single well failures
- The City of Bandera
  - Has an estimated groundwater supply that is almost twice the current use
  - Has 30% projected population growth by 2070
  - Has less than 29 years to implement new water management strategies to meet increasing demands



Questions?

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