

# Longevity Assessment for the City of Bandera Water Wells

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

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Texas Water Development Board  
[www.twdb.texas.gov](http://www.twdb.texas.gov)



Public Webinar (March 30<sup>th</sup>, 10am - 12pm )  
<https://www.twdb.texas.gov/innovativewater/asr/projects/Bandera/index.asp>



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# Speakers



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# Webinar reminders and format



TURN OFF YOUR  
CAMERAS



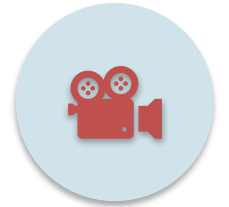
TYPE QUESTIONS IN  
THE CHAT SO WE CAN  
QUEUE THEM UP



TOPIC-RELATED  
QUESTION TIME  
AFTER SECTIONS



QUESTION TIME AT  
THE END TOO!



WEBINAR IS BEING  
RECORDED

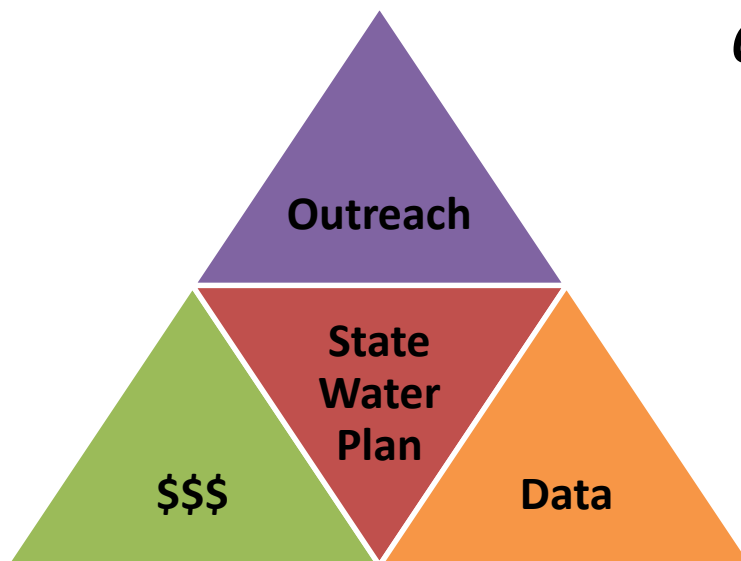
# Outline

- 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”*



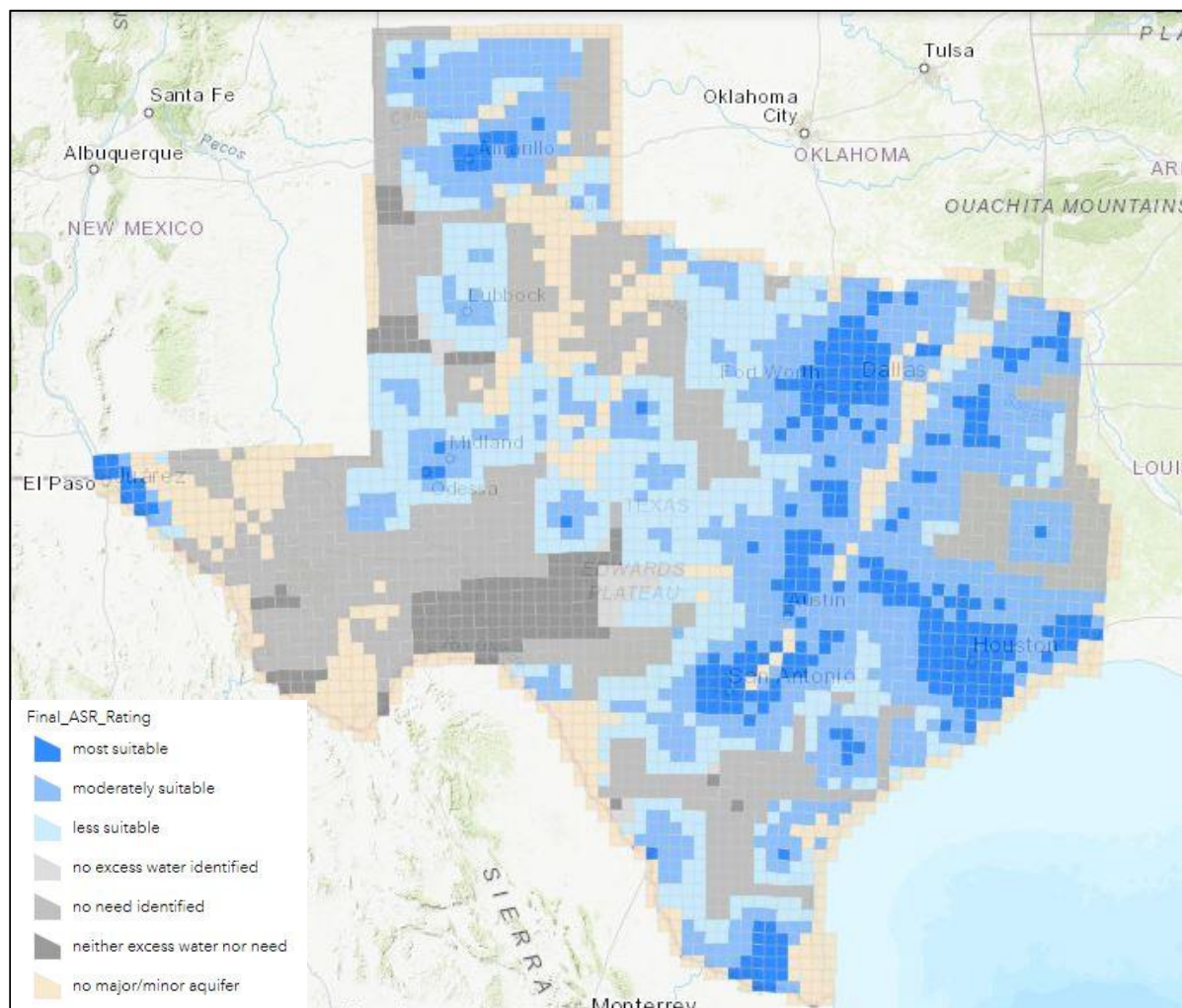
**50-year State Water Plan  
updated every 5 years**



Background
Study objective
Method and results
Conclusions

# 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:



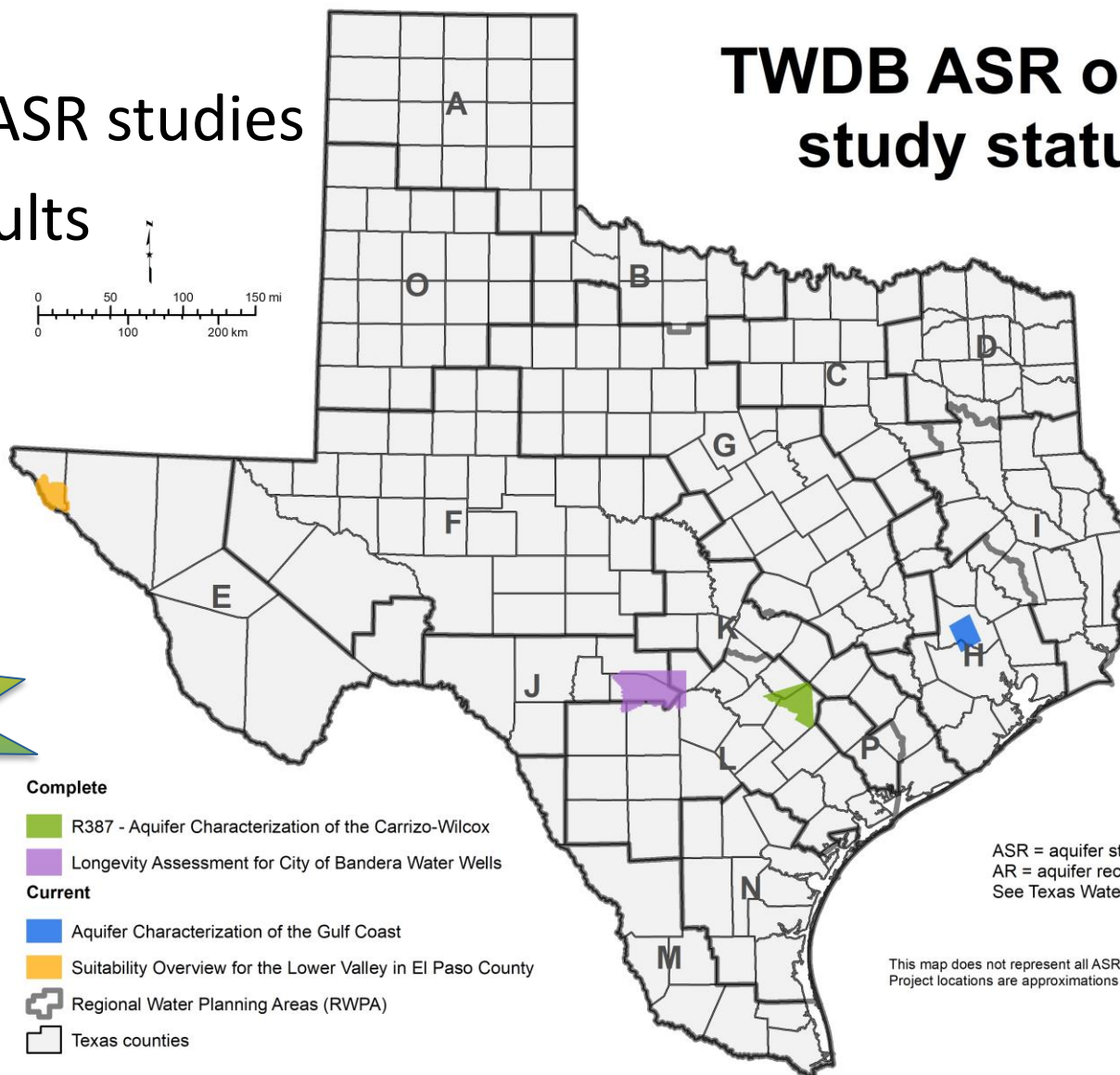
Story map:



# Texas Water Code § 11.155

- Conduct ASR studies
- Share results

## TWDB ASR or AR study status





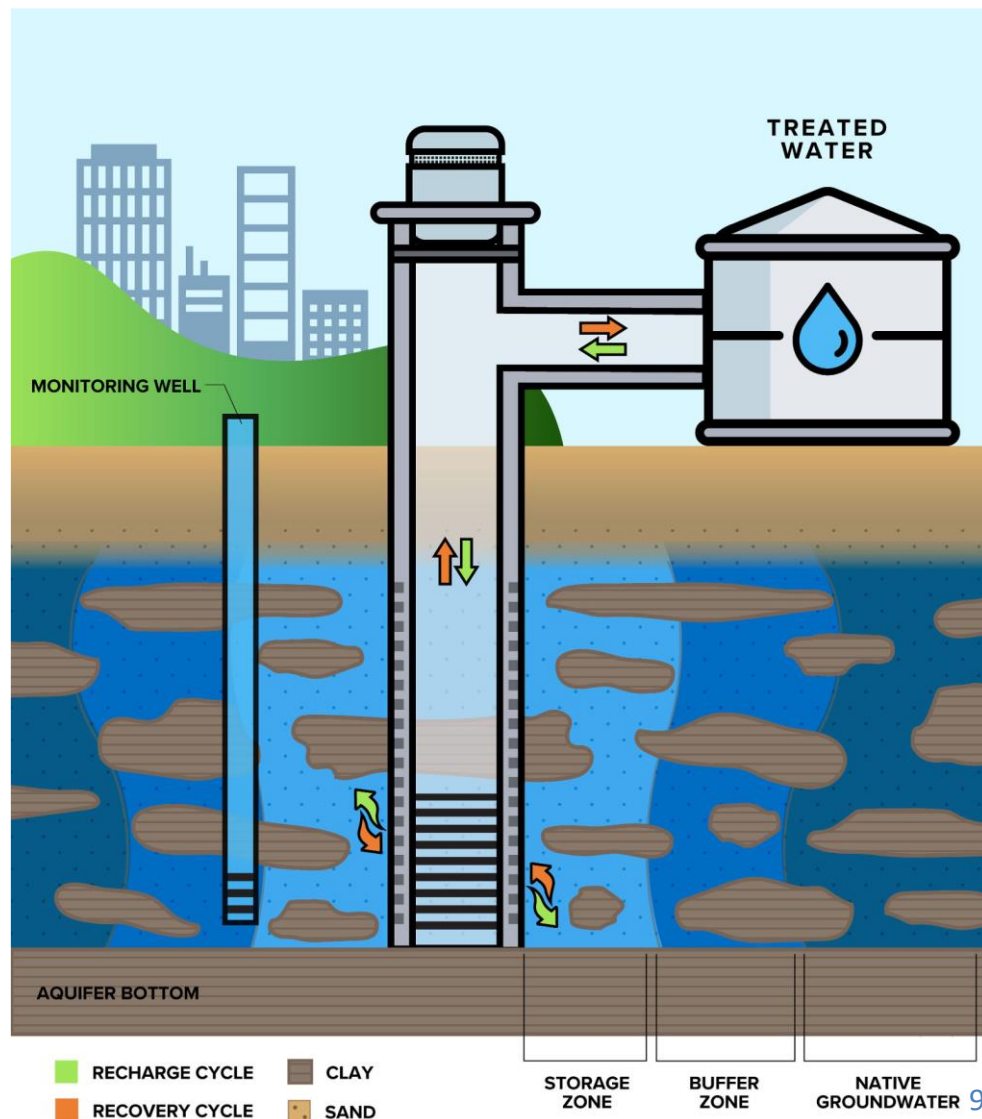
# Aquifer Storage and Recover (ASR)

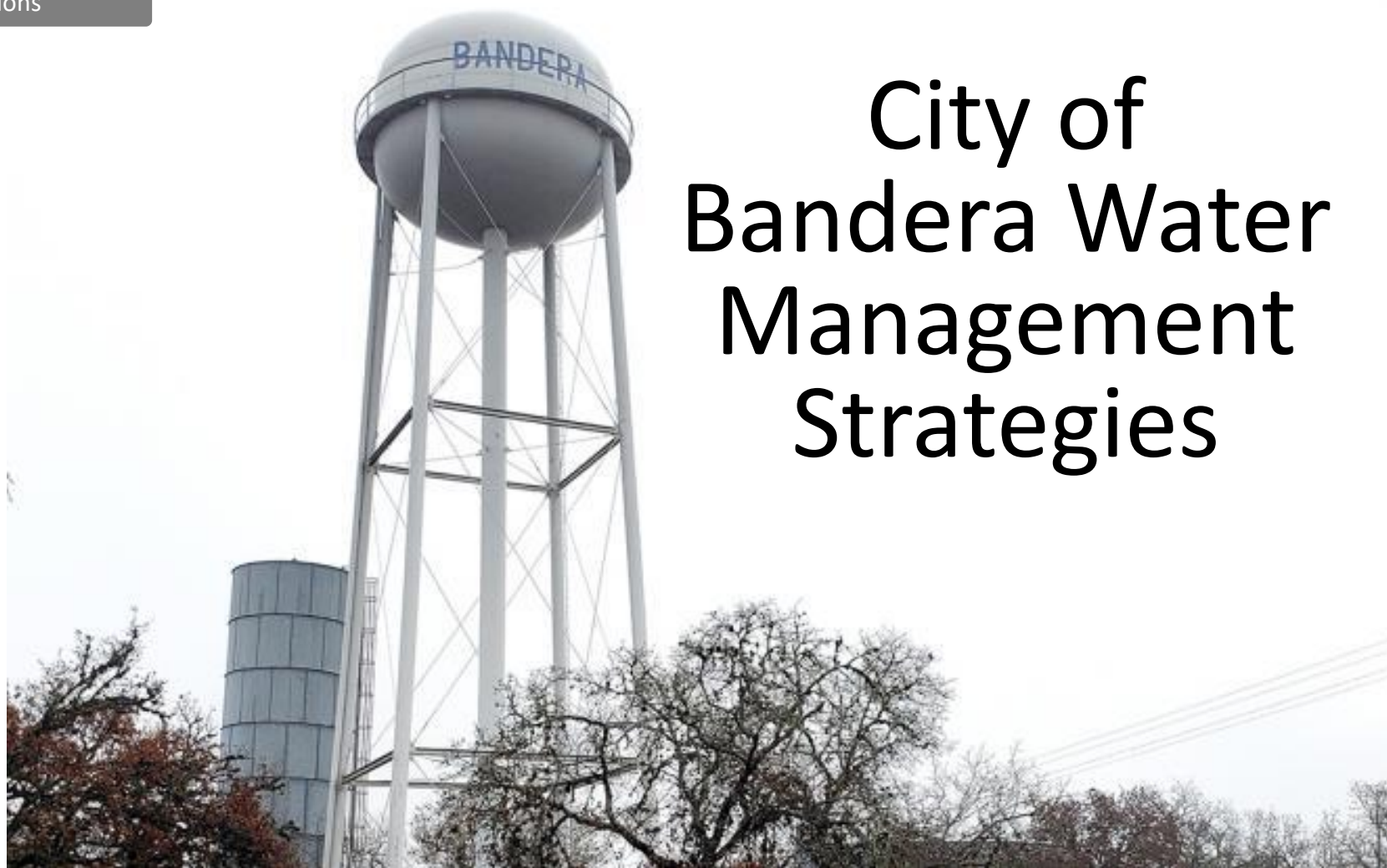
An underground water supply savings account

## 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.

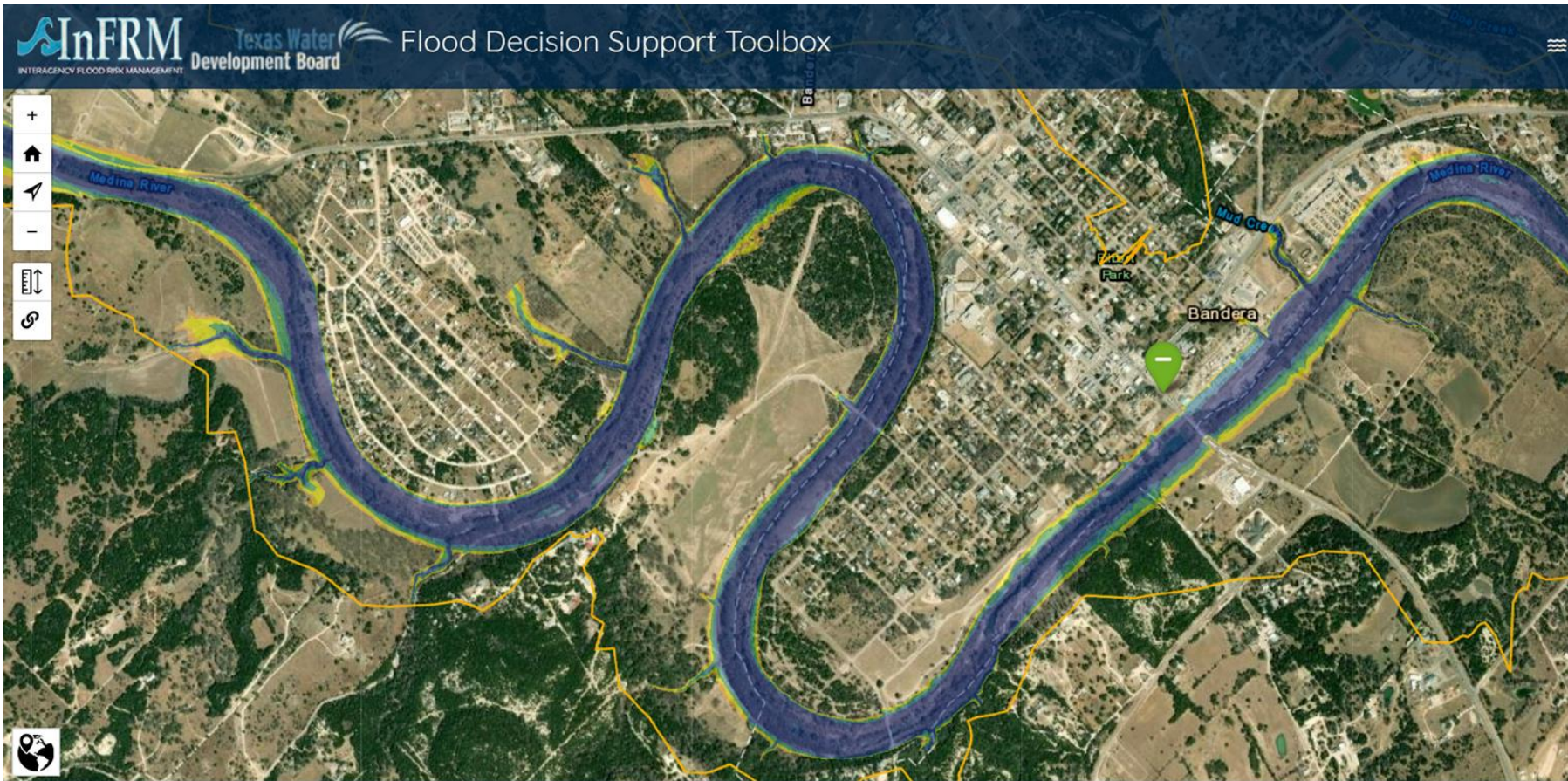
Texas Minimum Water Quality Guidelines for Indoor Use of Rainwater in Public Water Systems	
Rainwater Quality for Non-Potable Indoor Use	Rainwater Quality for Potable Uses
Total coliforms < 500 CFU/100 ml Fecal coliforms < 100 CFU/100 ml Water testing recommended annually	Total coliforms – 0 Fecal coliforms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



# Construction of the Parafield Stormwater Harvesting Facility



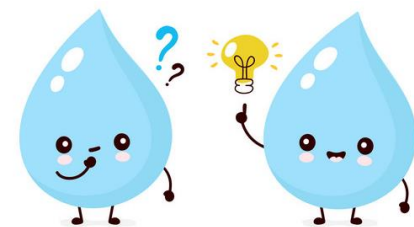




## Supplemental Water Supply from Cow Creek Wells

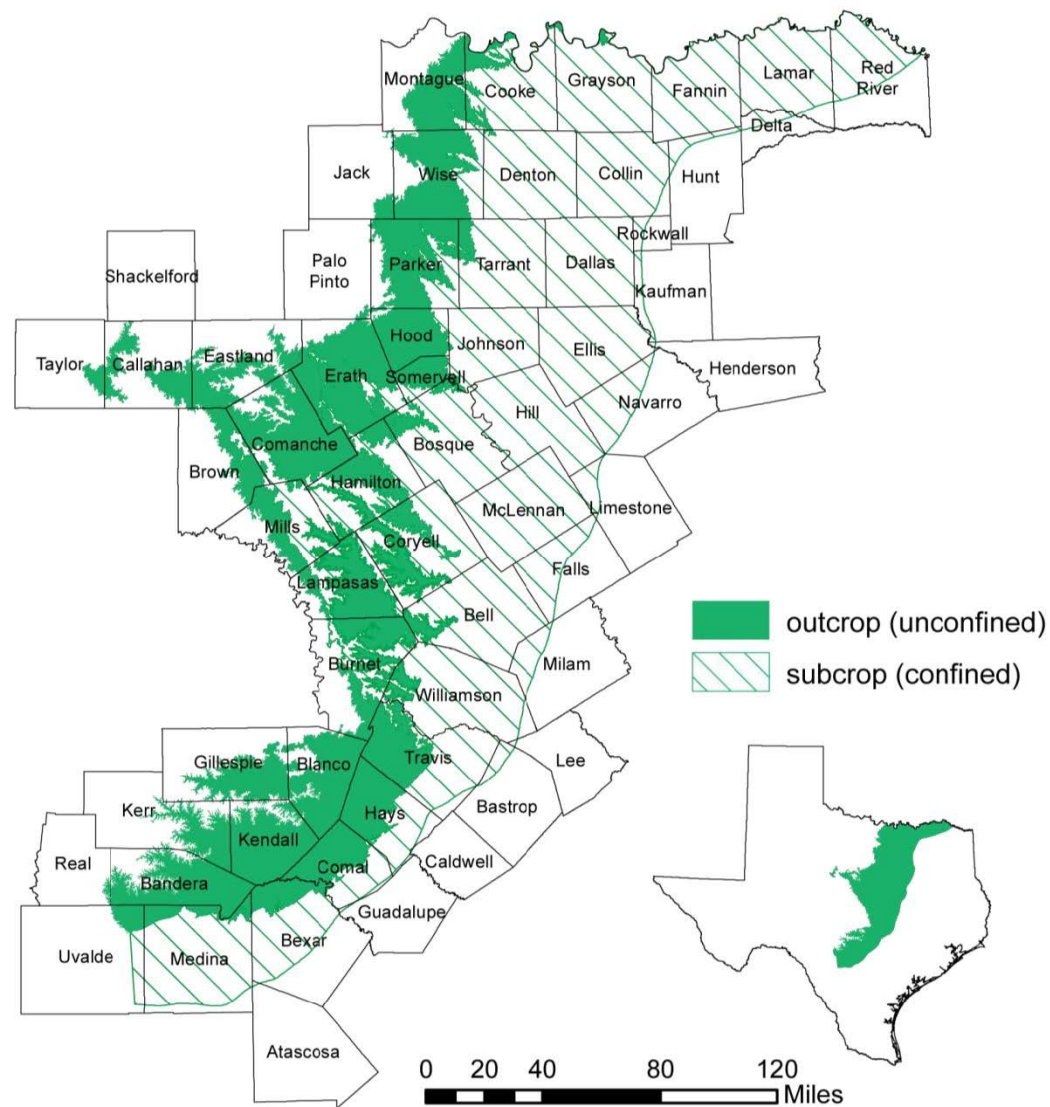
Friday May 22, 2015

<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

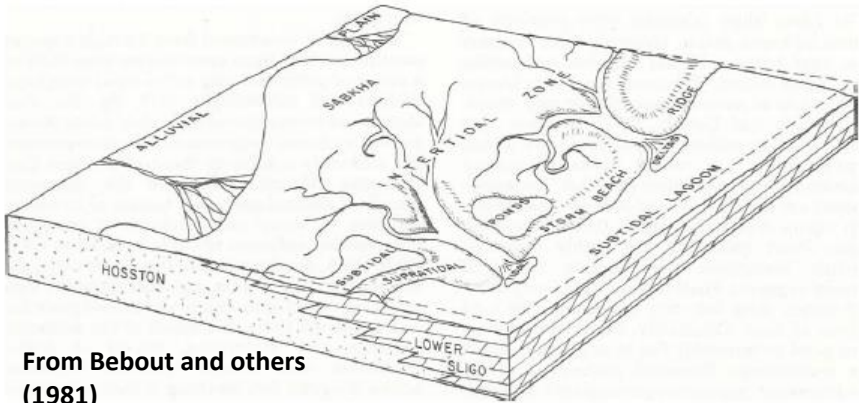




# ASR target aquifer: lower Trinity Aquifer

- 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					
	Hauterivian		Hosston			



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 evaporites
  - 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

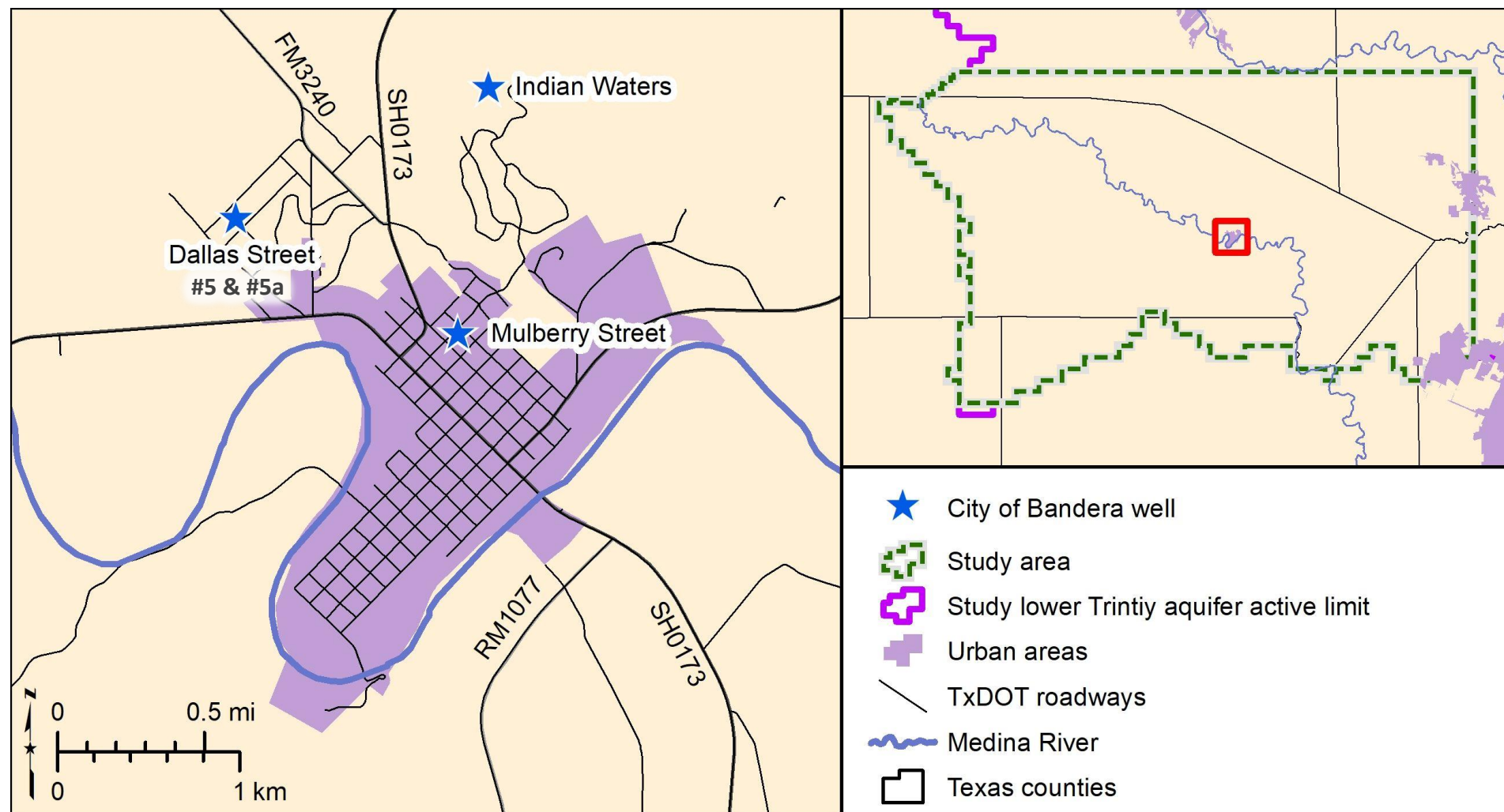
Epoch	Age	Group	Formation	Member	Hydrostratigraphic unit	Aquifer
Lower Cretaceous	Albian	Edwards	Fort Terrett	Basal Nodular	VIII <i>Transmissive</i>	Edwards
		Trinity	Glen Rose Limestone	Upper Glen Rose Limestone	Cavernous <i>Transmissive</i>	Upper Trinity
					Camp Bullis <i>Semi-confining</i>	
			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







# The City of Bandera water wells



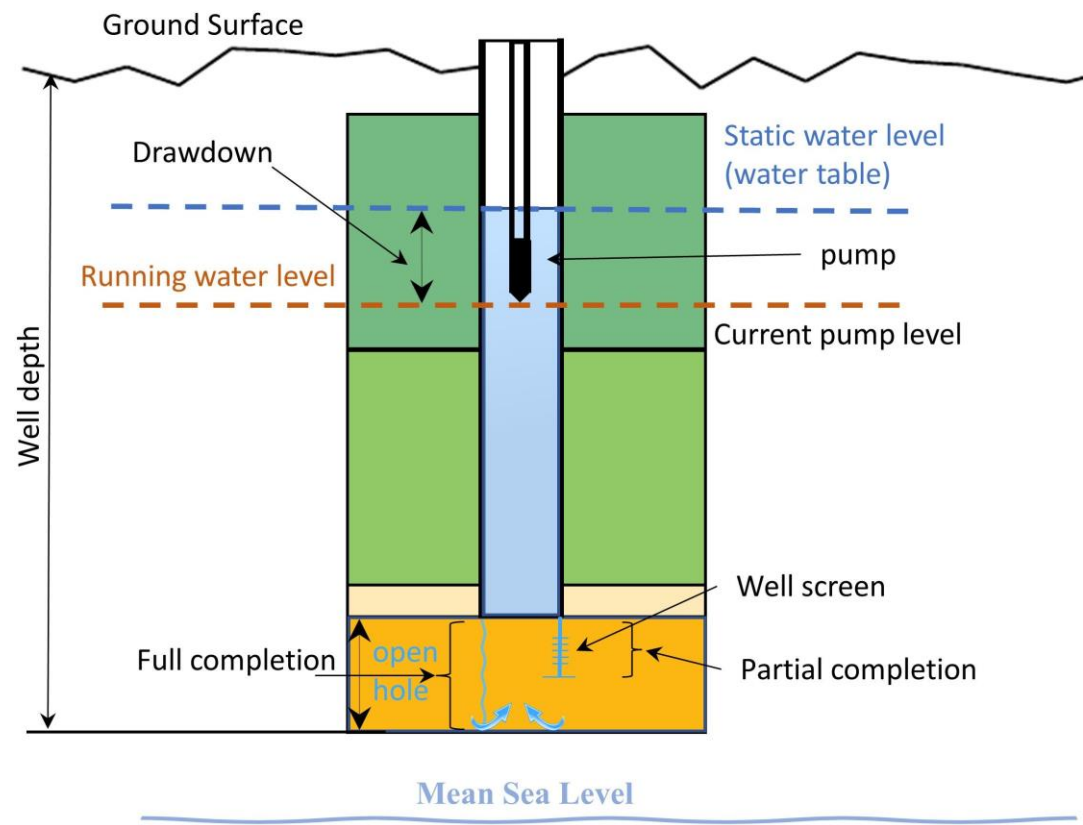
Background

Study objective

Method and results

Conclusions

# The City of Bandera water wells

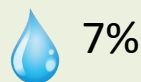


Well Name	Well #5a or Dallas St. (SWN 6924116)	Well #5 or Dallas St. (SWN 6924102)	Well #4 or Mulberry St. (SWN 6924202)	well #6 or Indian Waters (SWN 6924221)
Drill year	2017	1967	1953	1998
Well depth	480	805	842	770
Screen intervals	221-480	533-805	740-842	610-710
Well completion	Open Hole. Middle 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



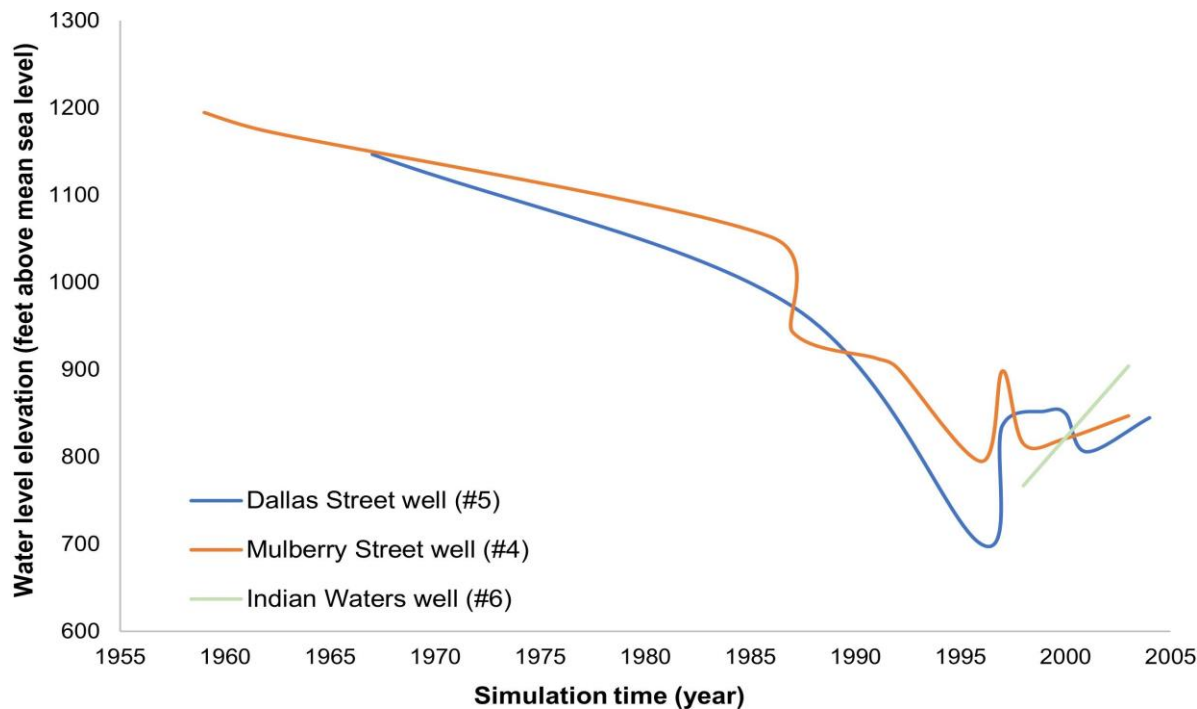
# Longevity assessment for the City of Bandera water wells

- 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

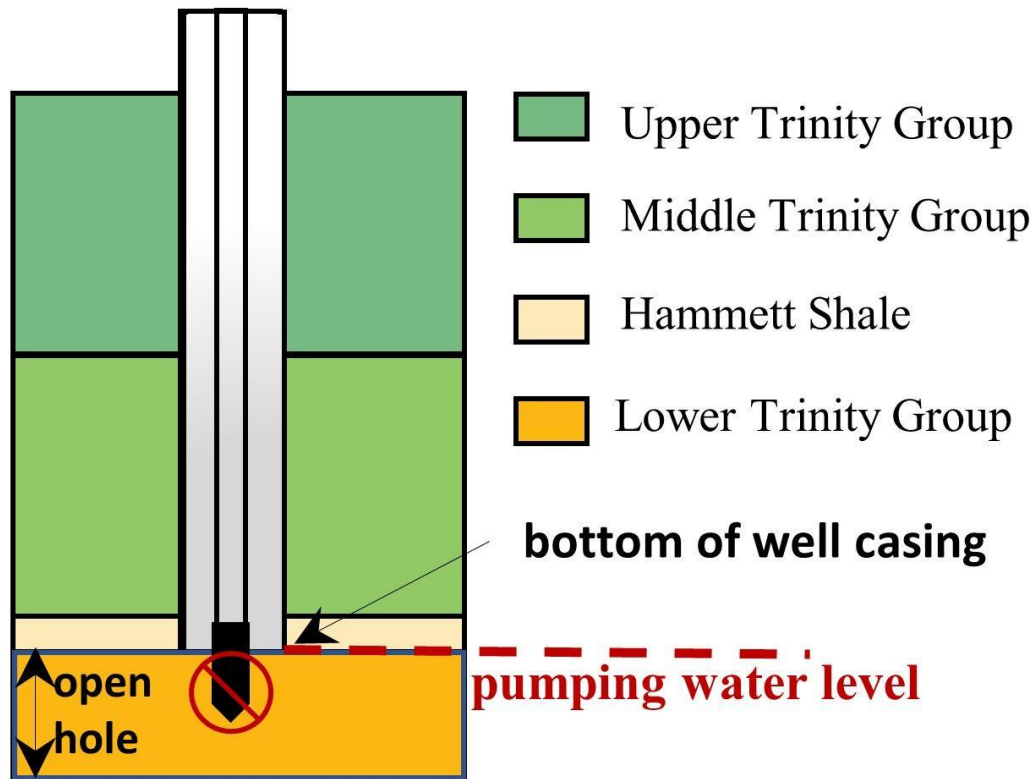
- **Lower Trinity aquifer historic and current water levels**
- **Projected levels based on planned use**

# Well operational limit

## Well Configuration

What would be the end of life for a well?

When water levels reach the bottom of the casing

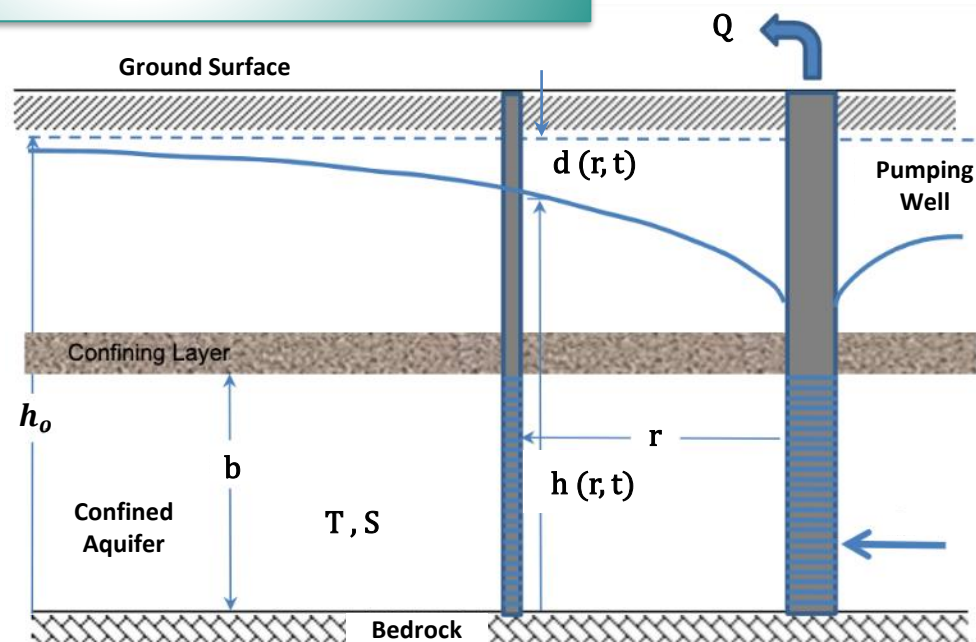


# Analytical solution

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

- Theis (1935) equation

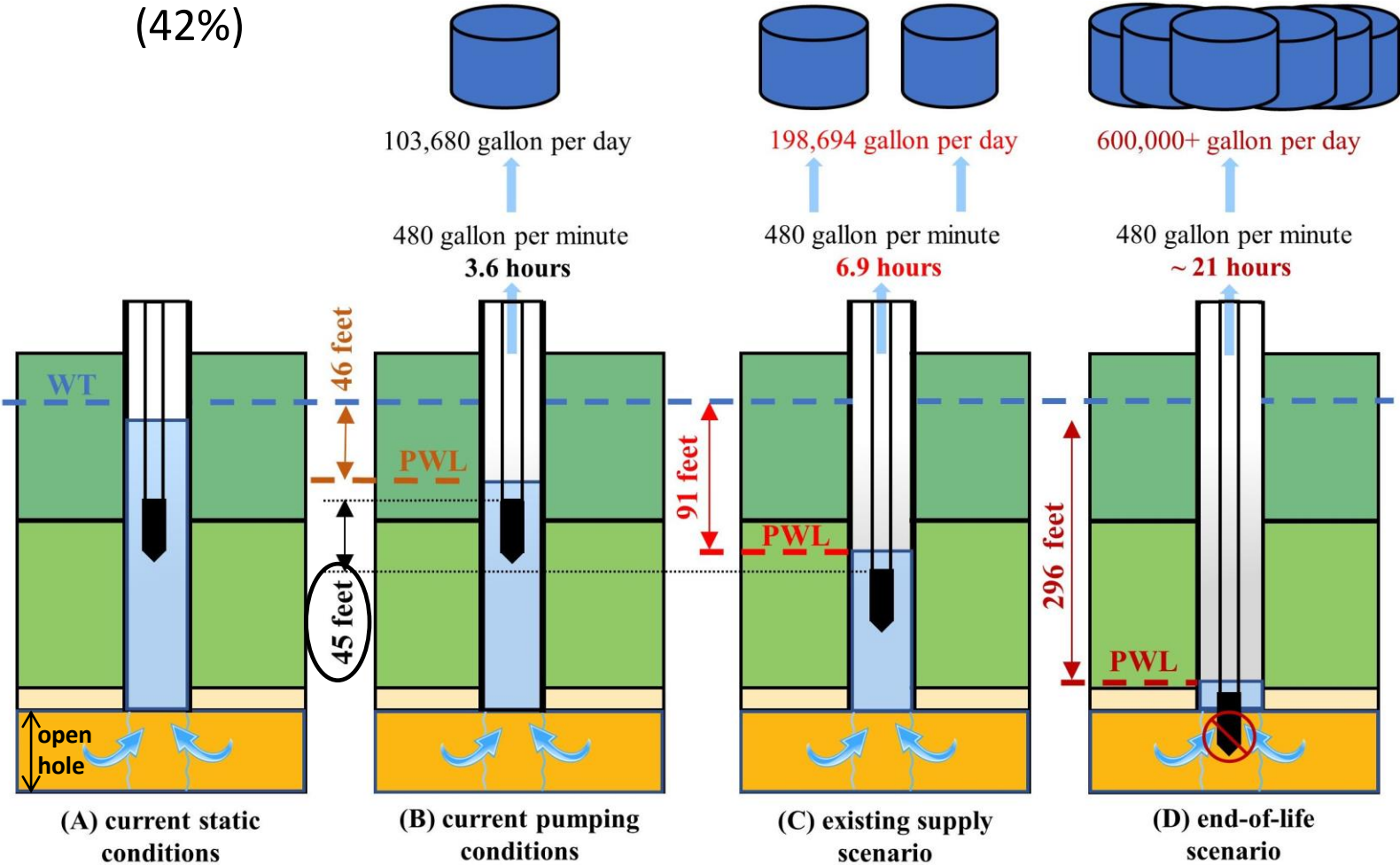
$$d(r, t) = \frac{Q}{4\pi T} W \left( \frac{r^2 S}{4Tt} \right)$$



# 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%)



WT = Water Table

PWL = Pumping Water Level

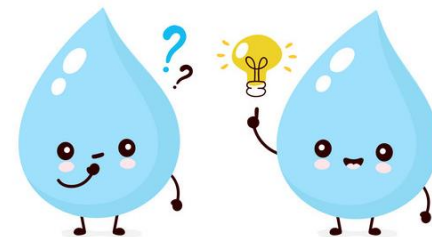
Upper Trinity Group	Hammett Shale
Middle Trinity Group	Lower Trinity Group





# Analytical solution limitations

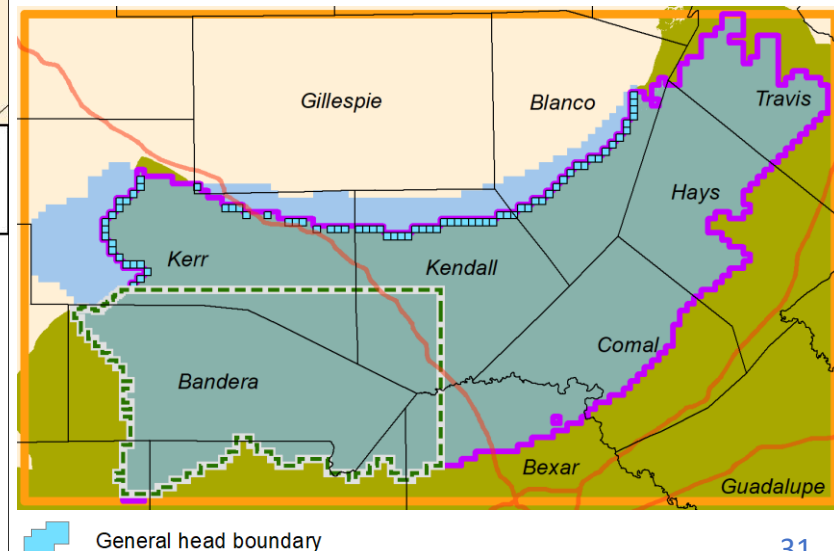
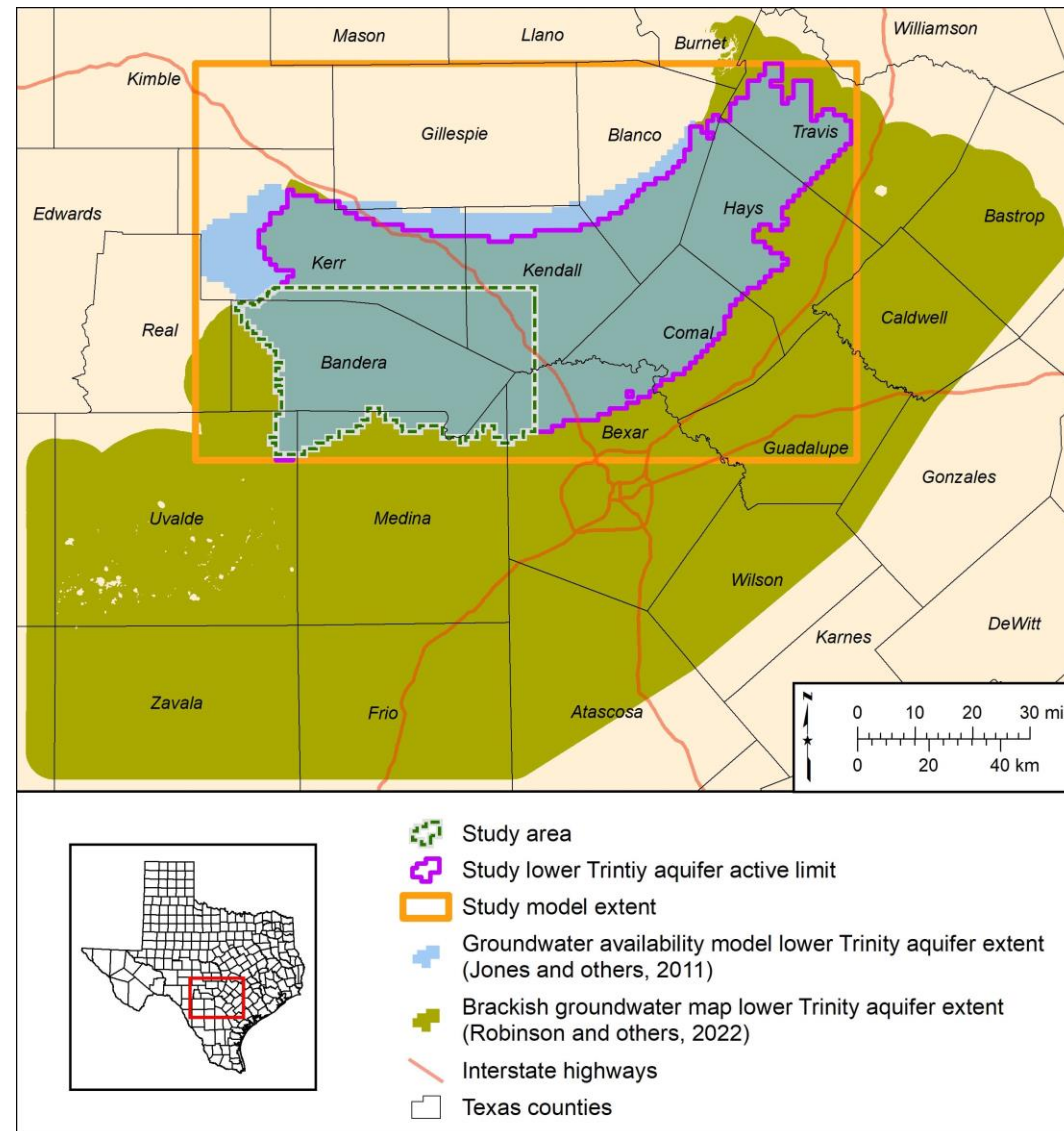
- Complicated and difficult to solve for:
  - multiple wells
  - long simulation time
  - complex aquifer system
- Does not project future water table levels



# Long-term planning

## Created the Bandera Well Longevity Model

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



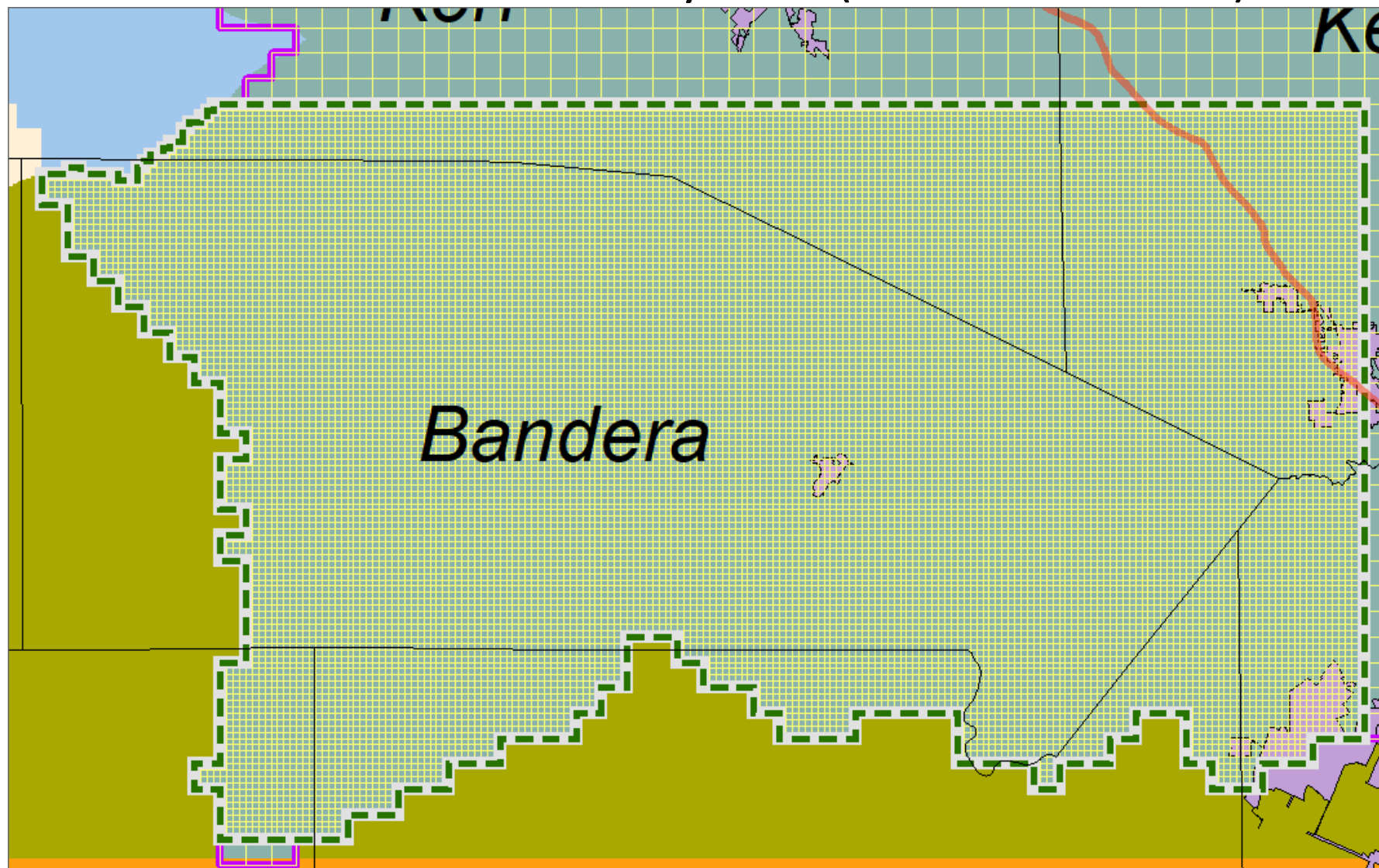
# Long-term planning

## 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-Creataceous rock				

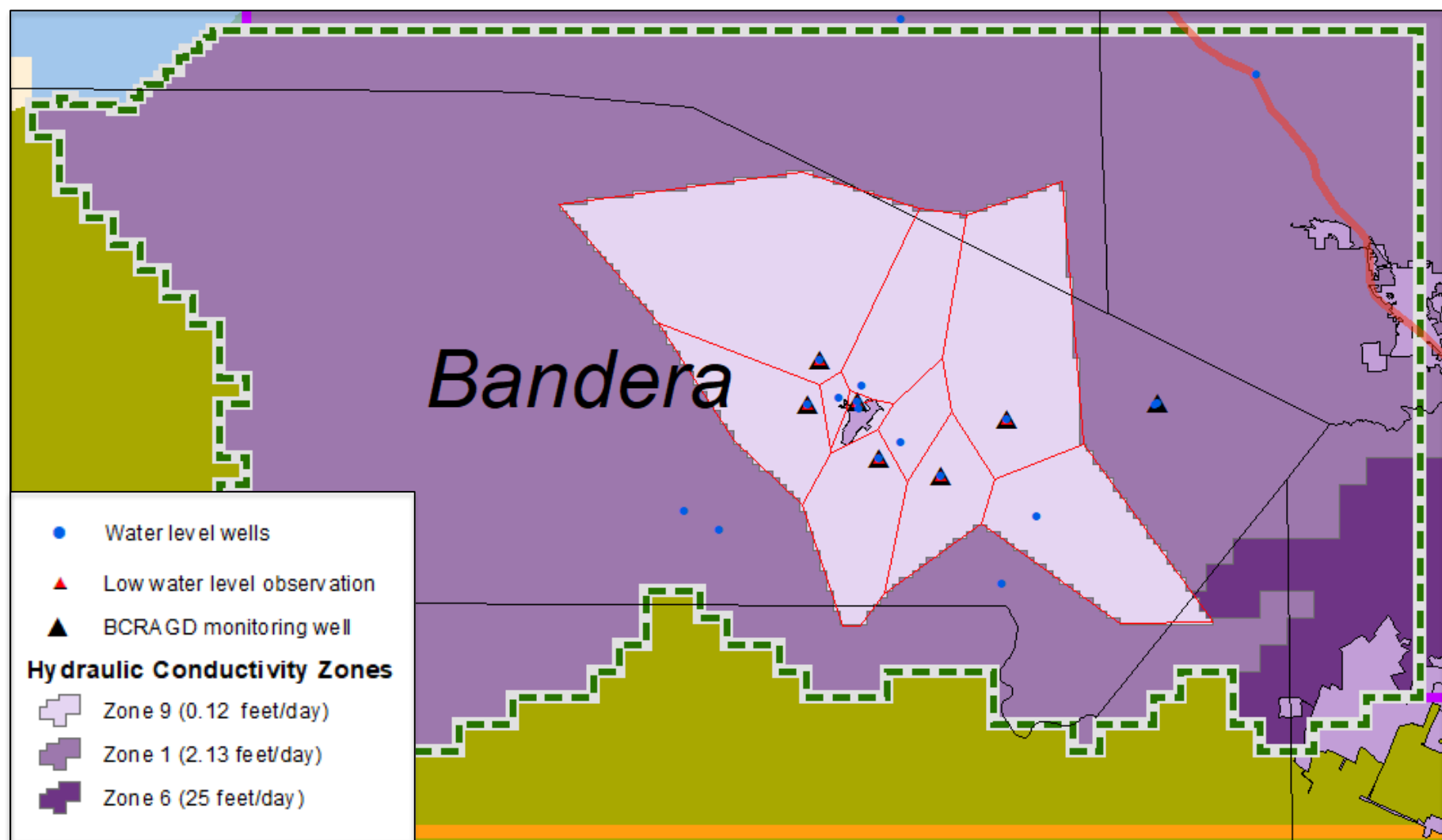
# Long-term planning

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





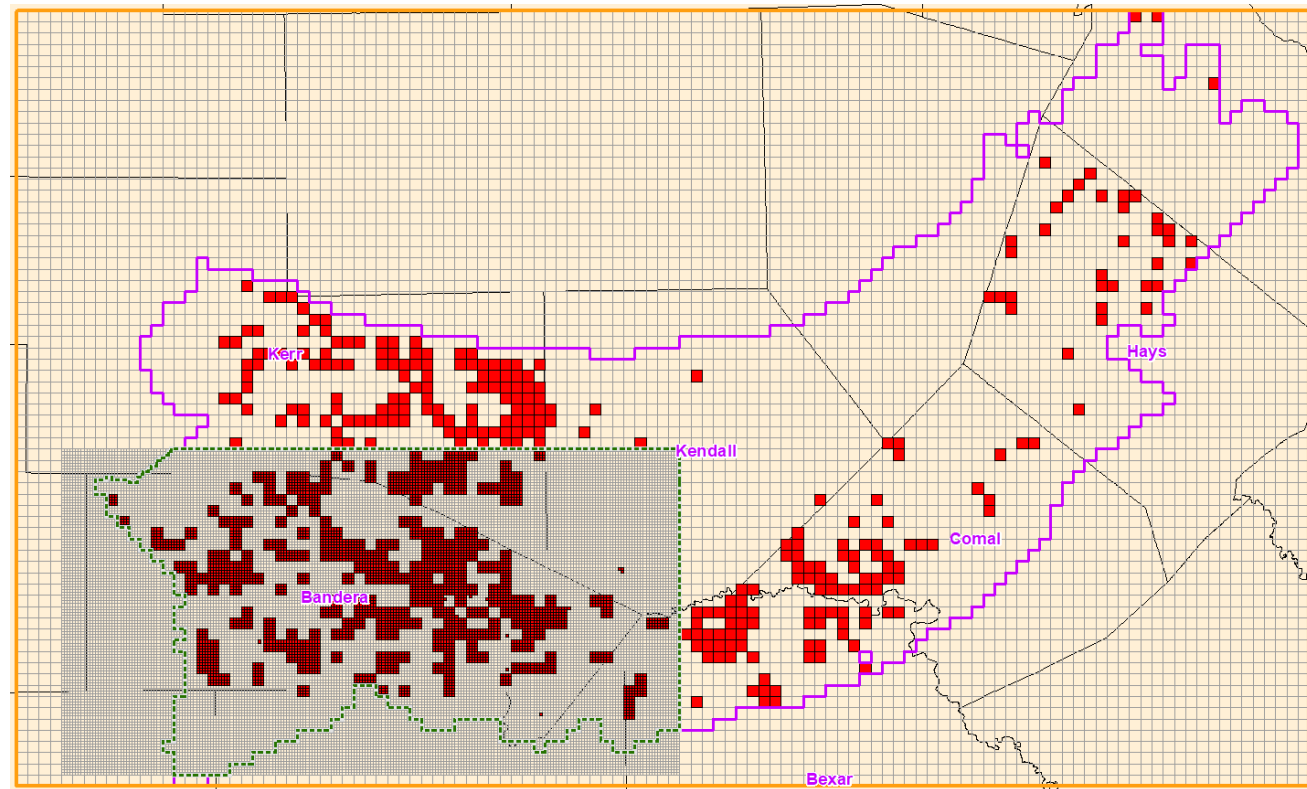
# Long-term planning

GAM (18 years)

New (21 years)

1980 1985 1990 1995 2000 2005 2010 2015

- 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

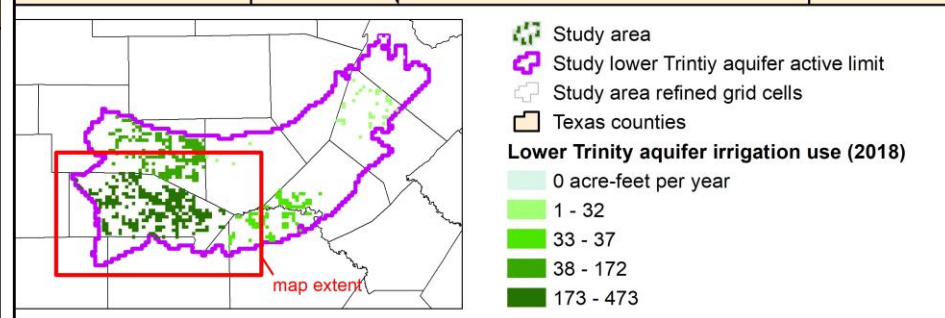
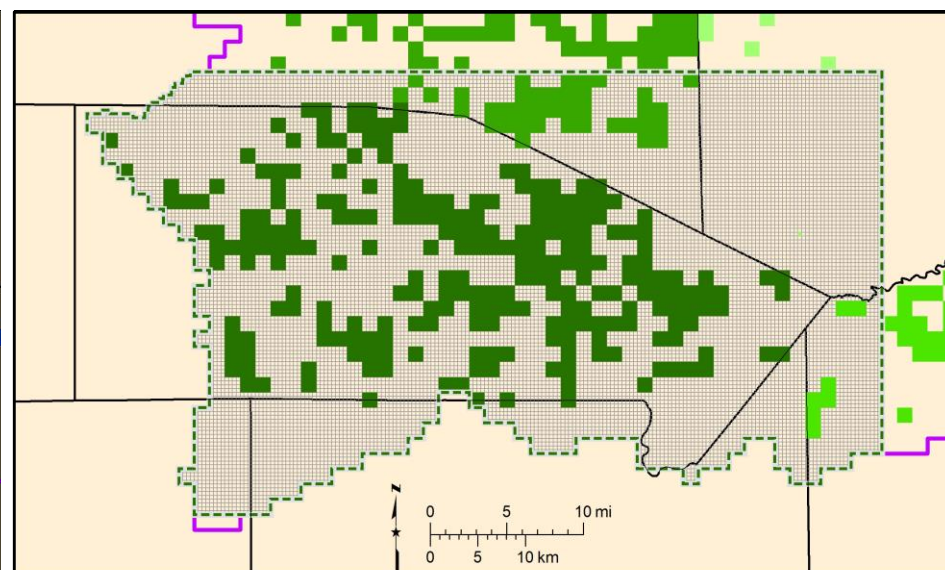
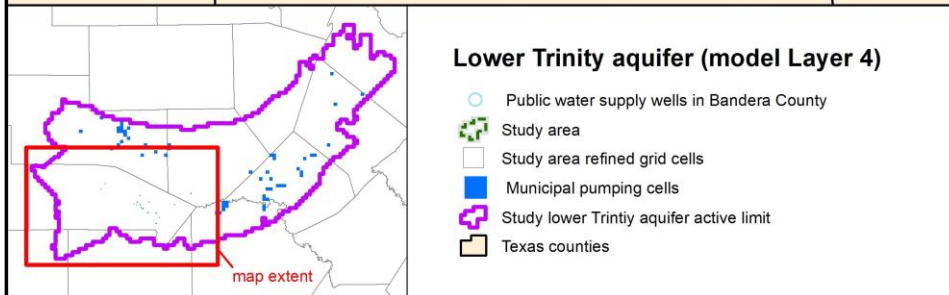
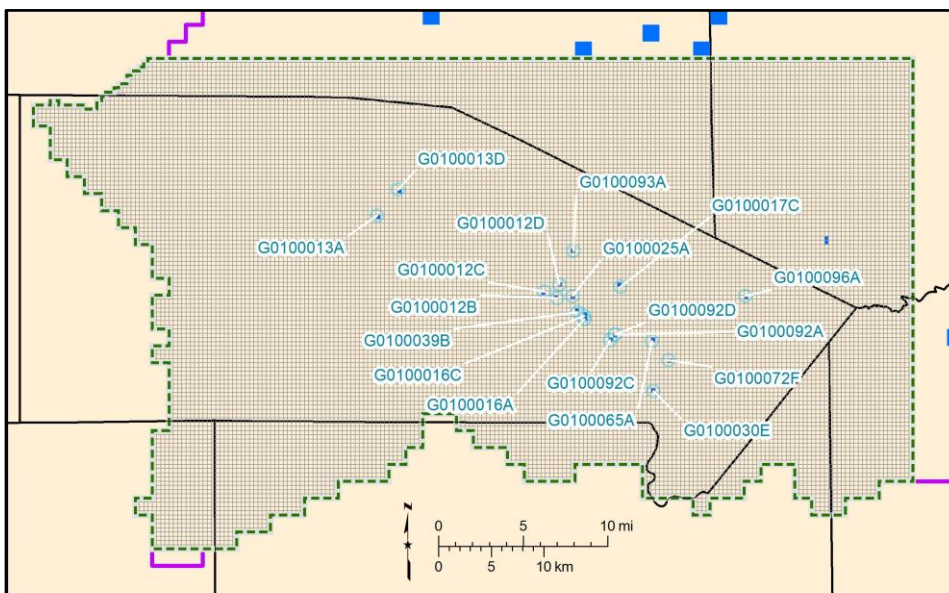
# Long-term planning

- Use: Municipal and Irrigation use

GAM (18 years)

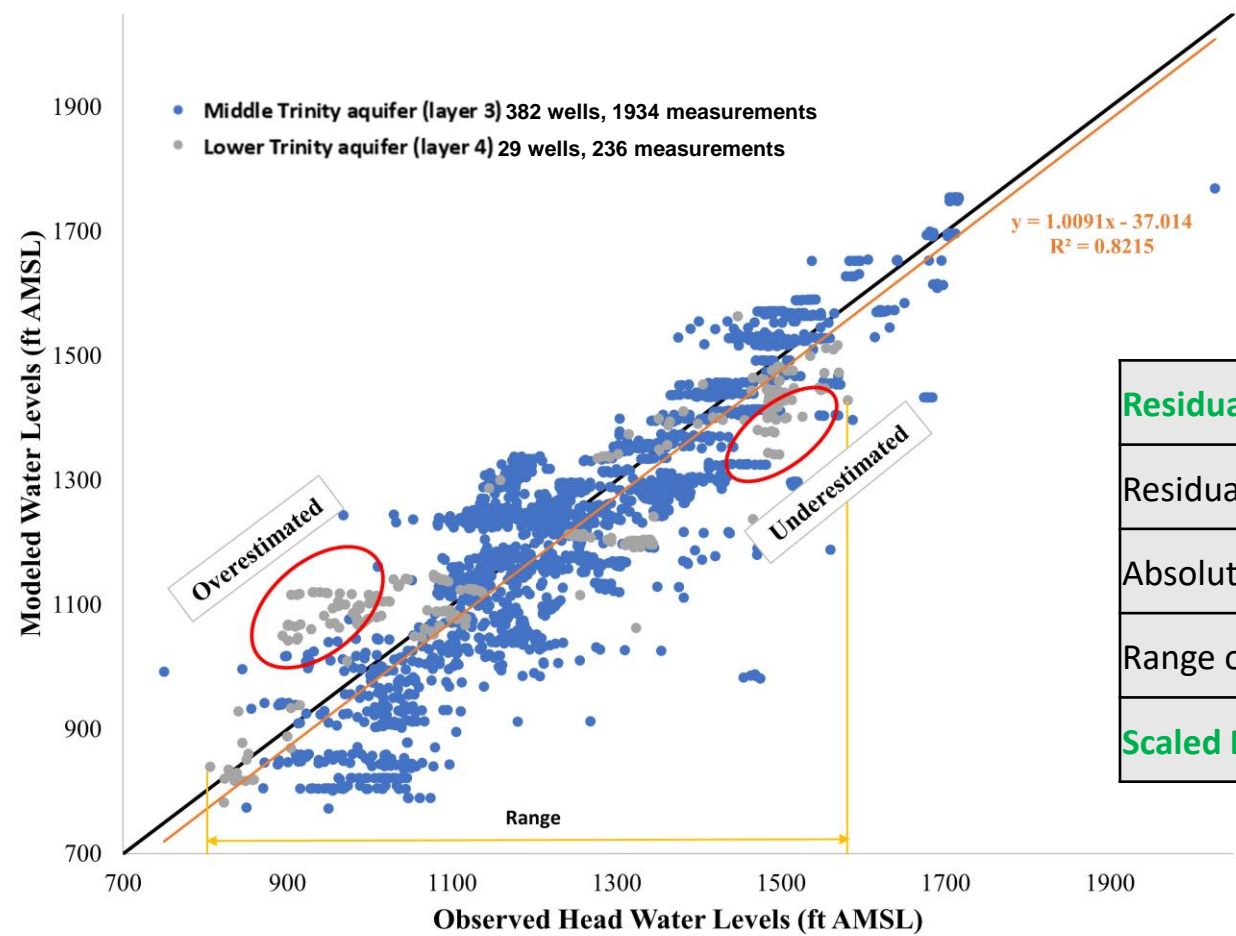
New (21 years)

1980 1985 1990 1995 2000 2005 2010 2015



# Results: Historic Match

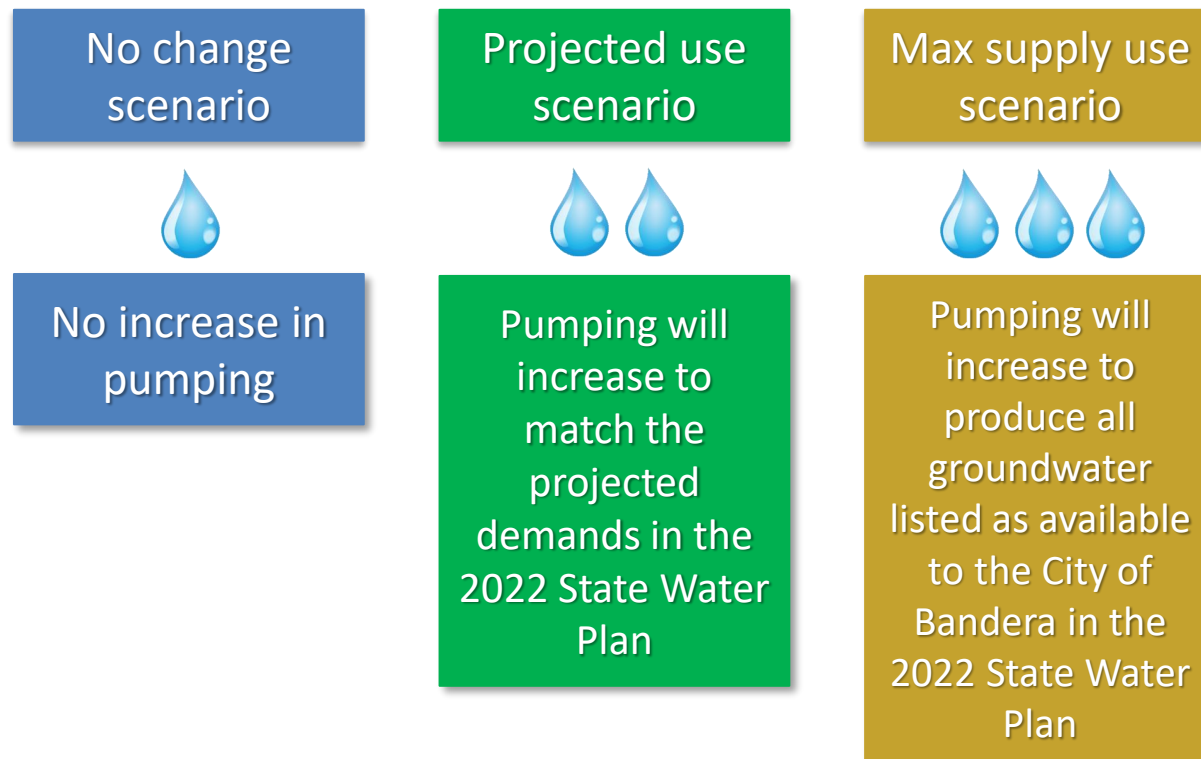
- Evaluate how well the model matched the observed water levels
- Residual = Observed (water level measurements) - Modeled



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

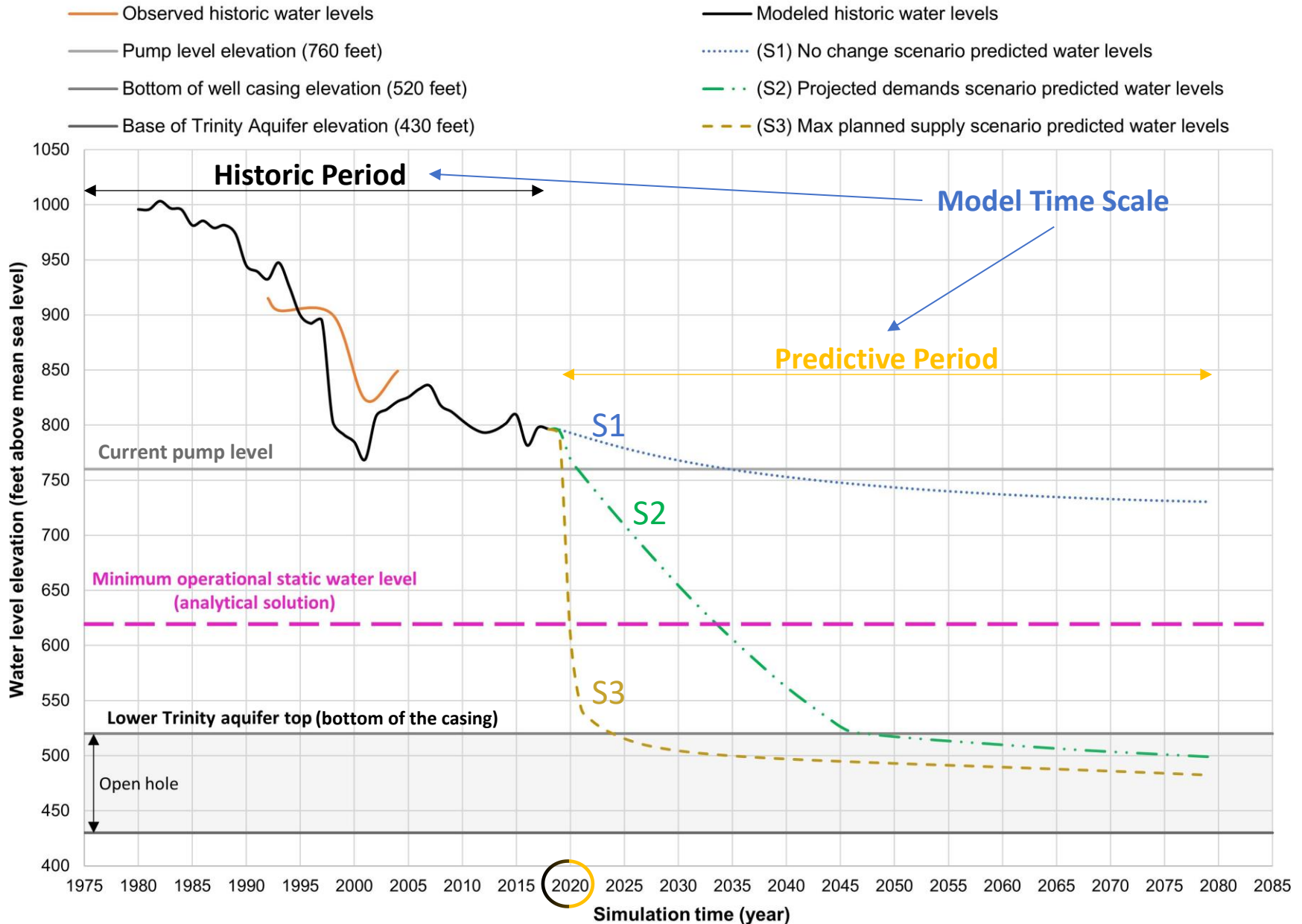
The model was used to forecast future conditions based on three scenarios:





# Predictive model results

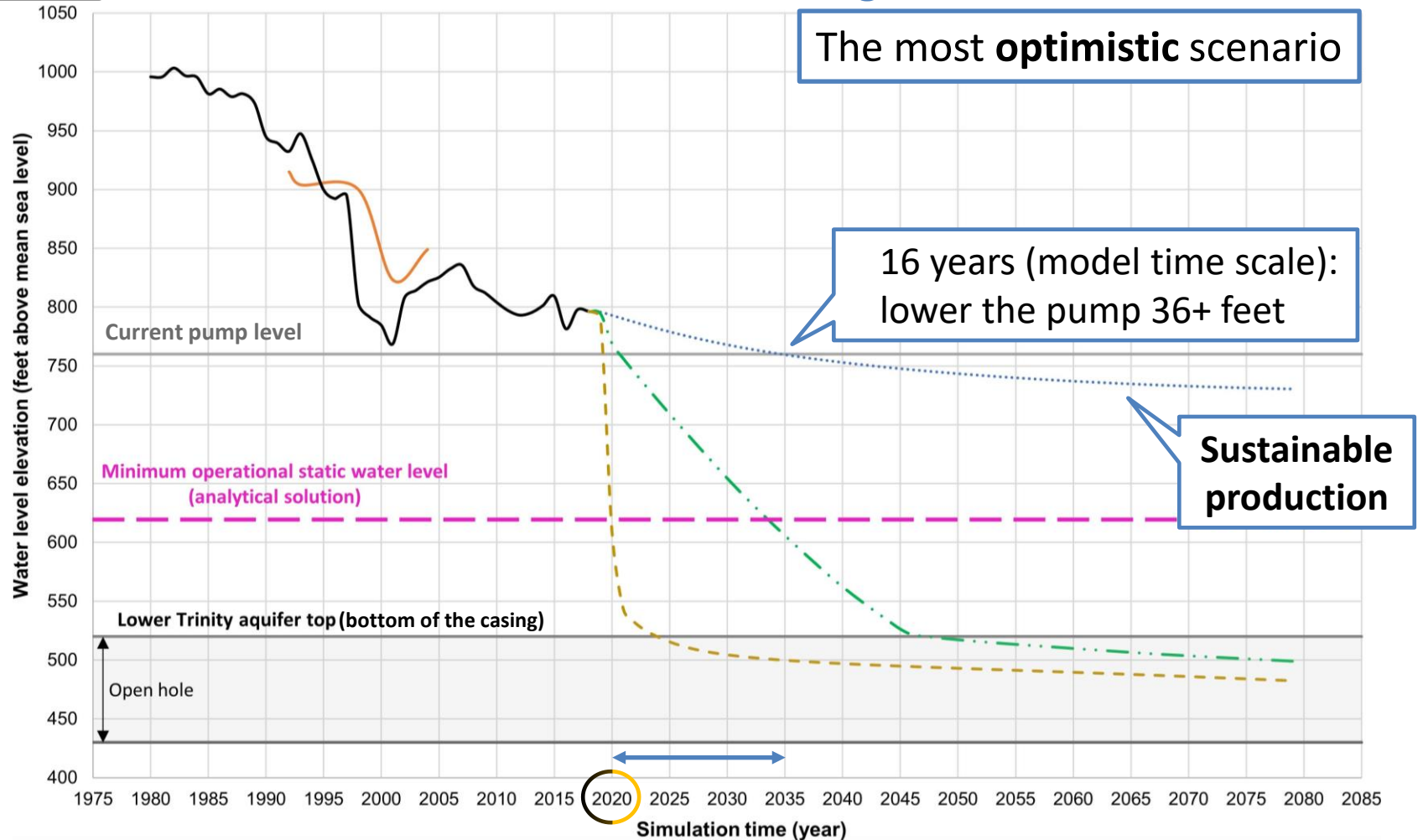
## Mulberry Street Well Predictive Results



# Predictive model results

## The Mulberry Street Well

### Scenario 1: **No change**



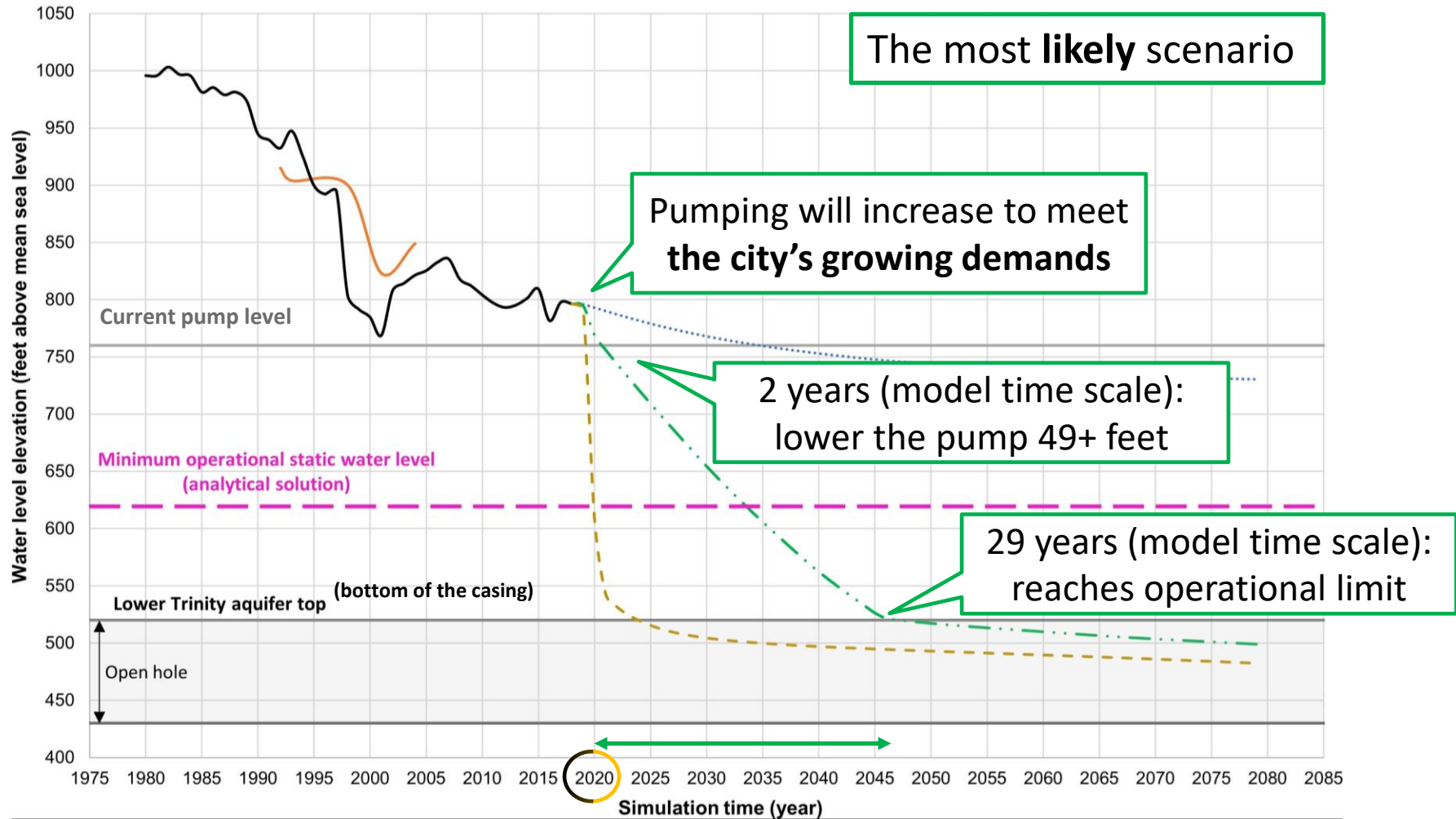
The City of Bandera has plenty of time to implement new water supply strategies



# Predictive model results

## The Mulberry Street Well

### Scenario 2: **Projected demands**

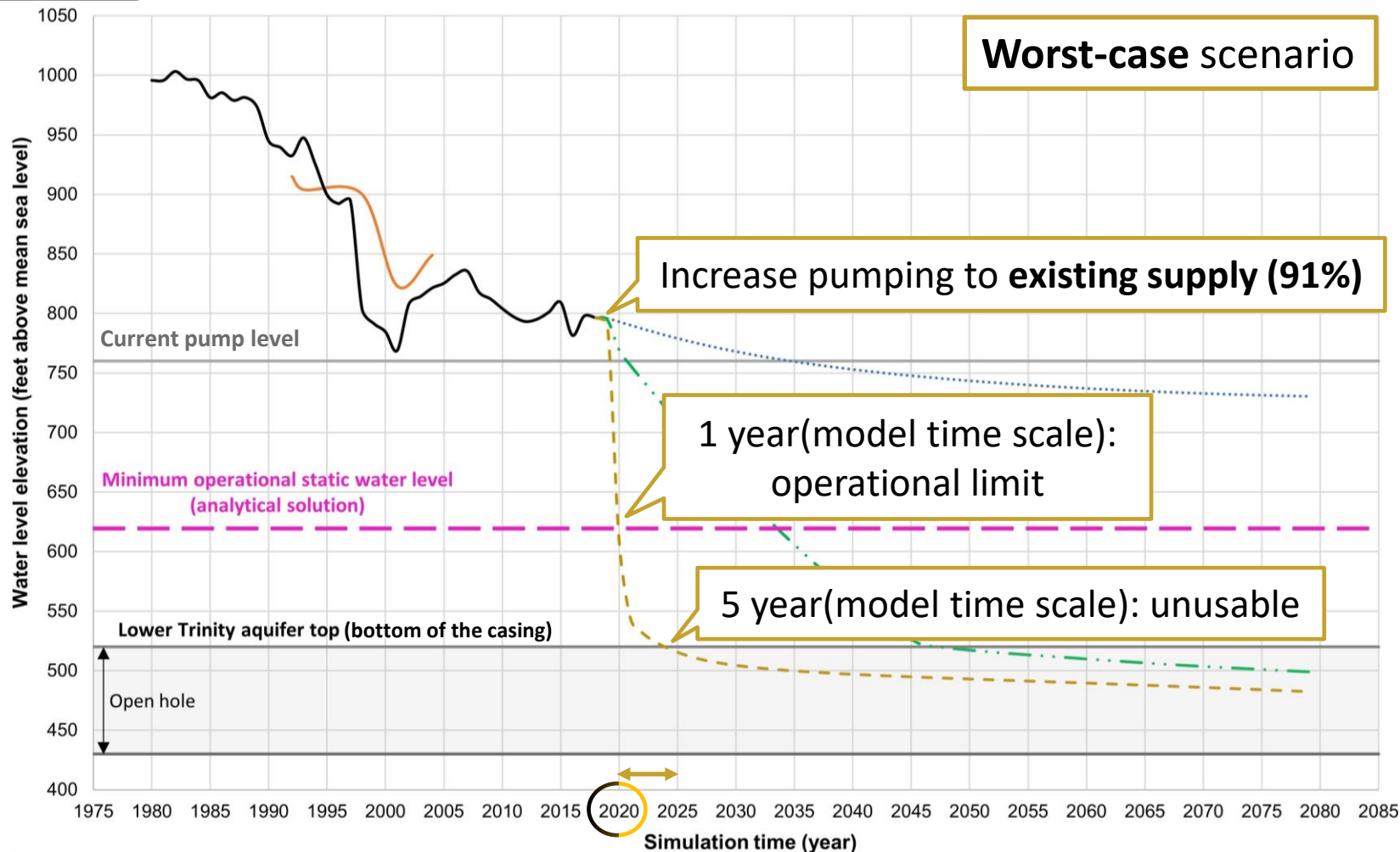


**The City of Bandera has less than 29 years margin to implement new water supply strategies**

# 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

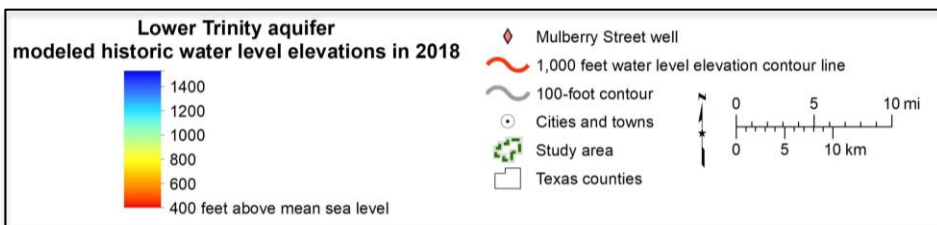
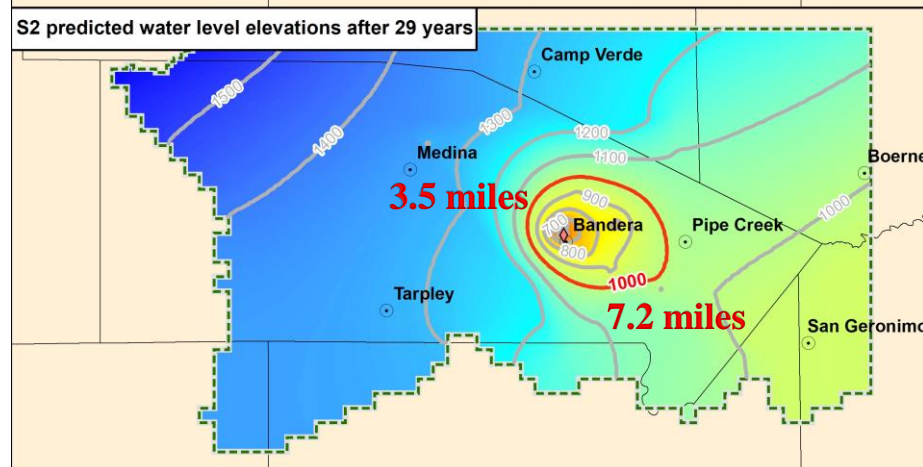
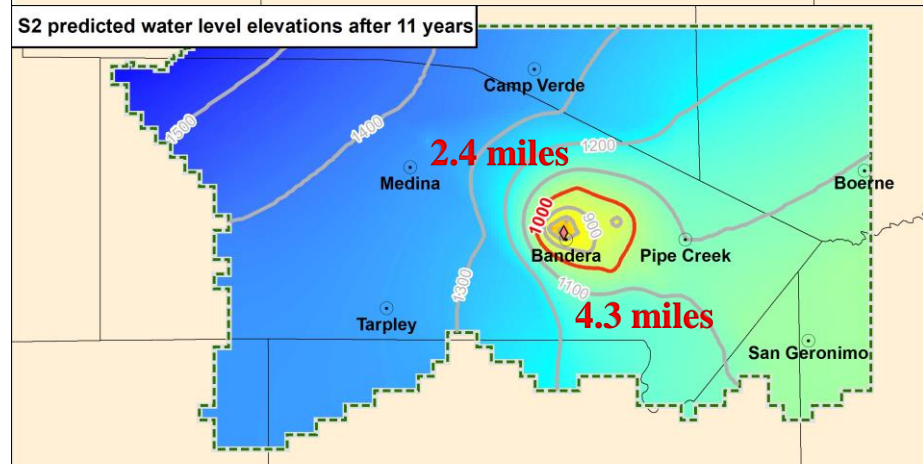
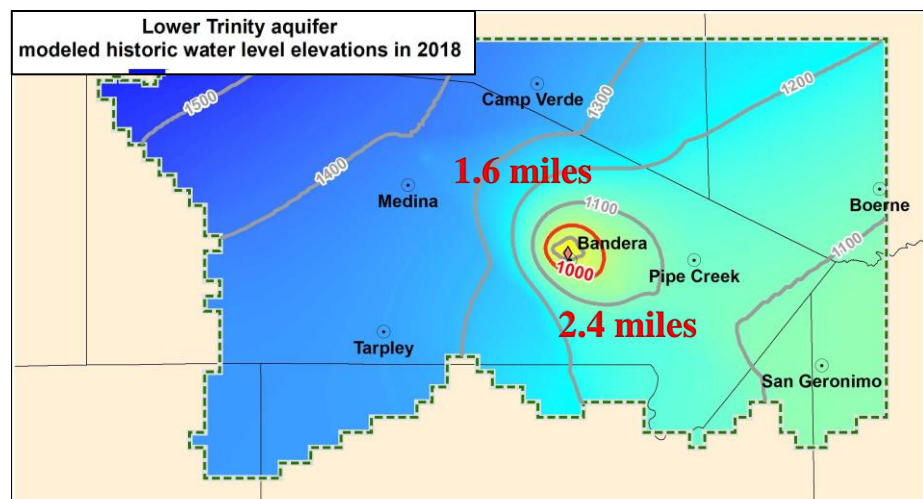
Alternative management strategy:

## new lower Trinity well

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

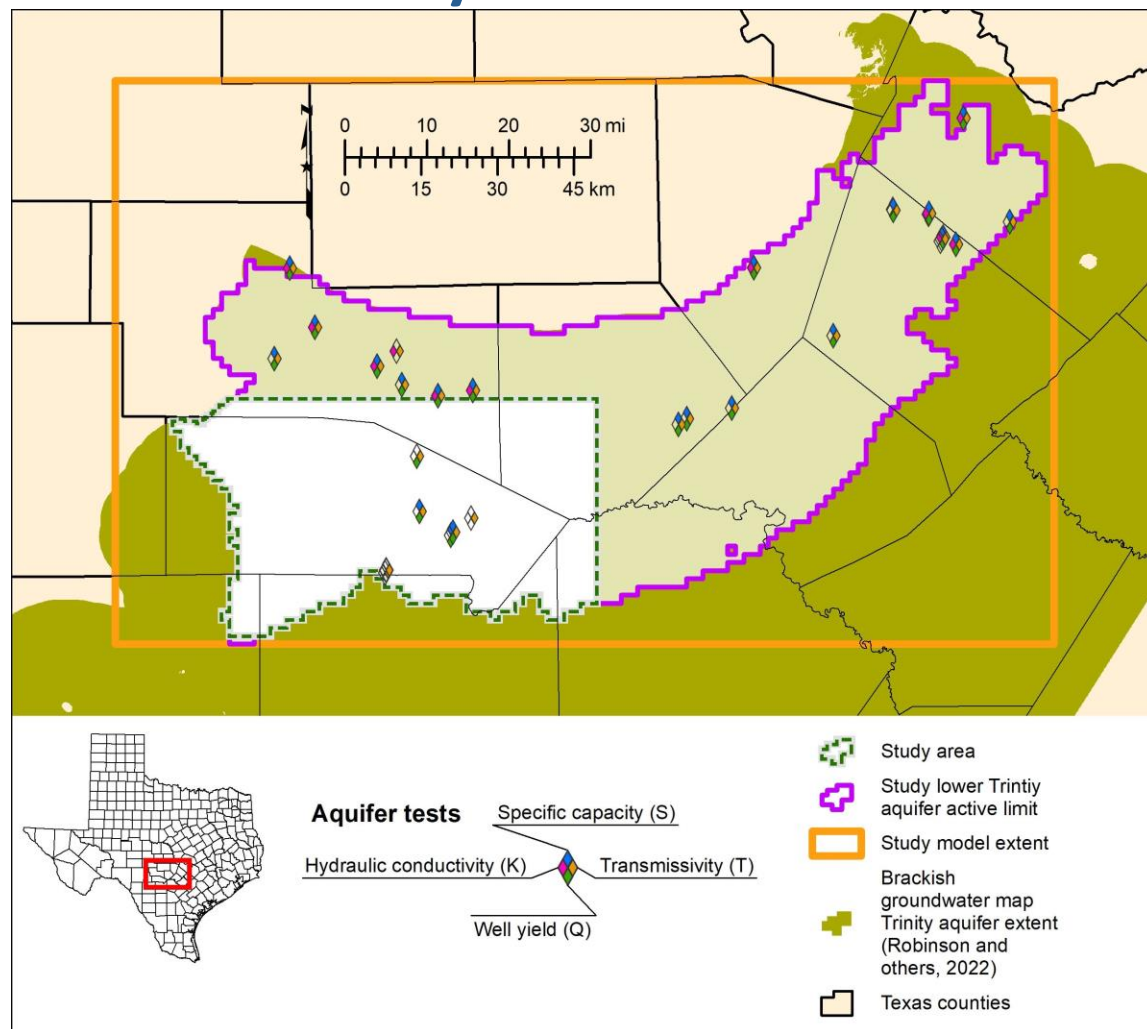
BWLM simulated cone of depression:

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



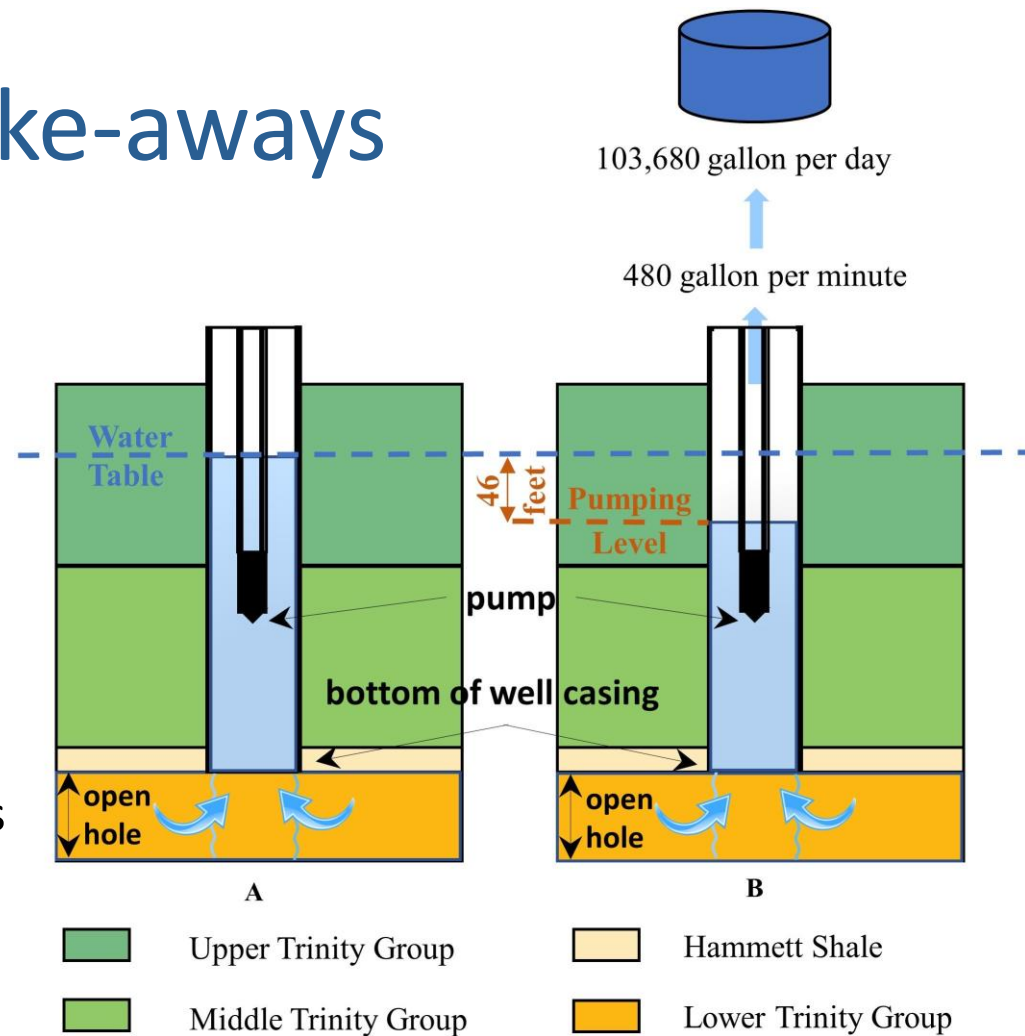
# Lower Trinity aquifer in Bandera County

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



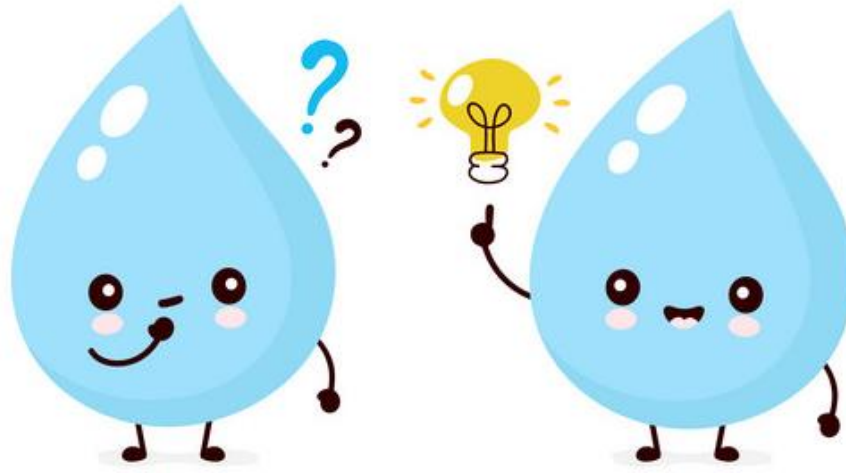
# Key take-aways

- 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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