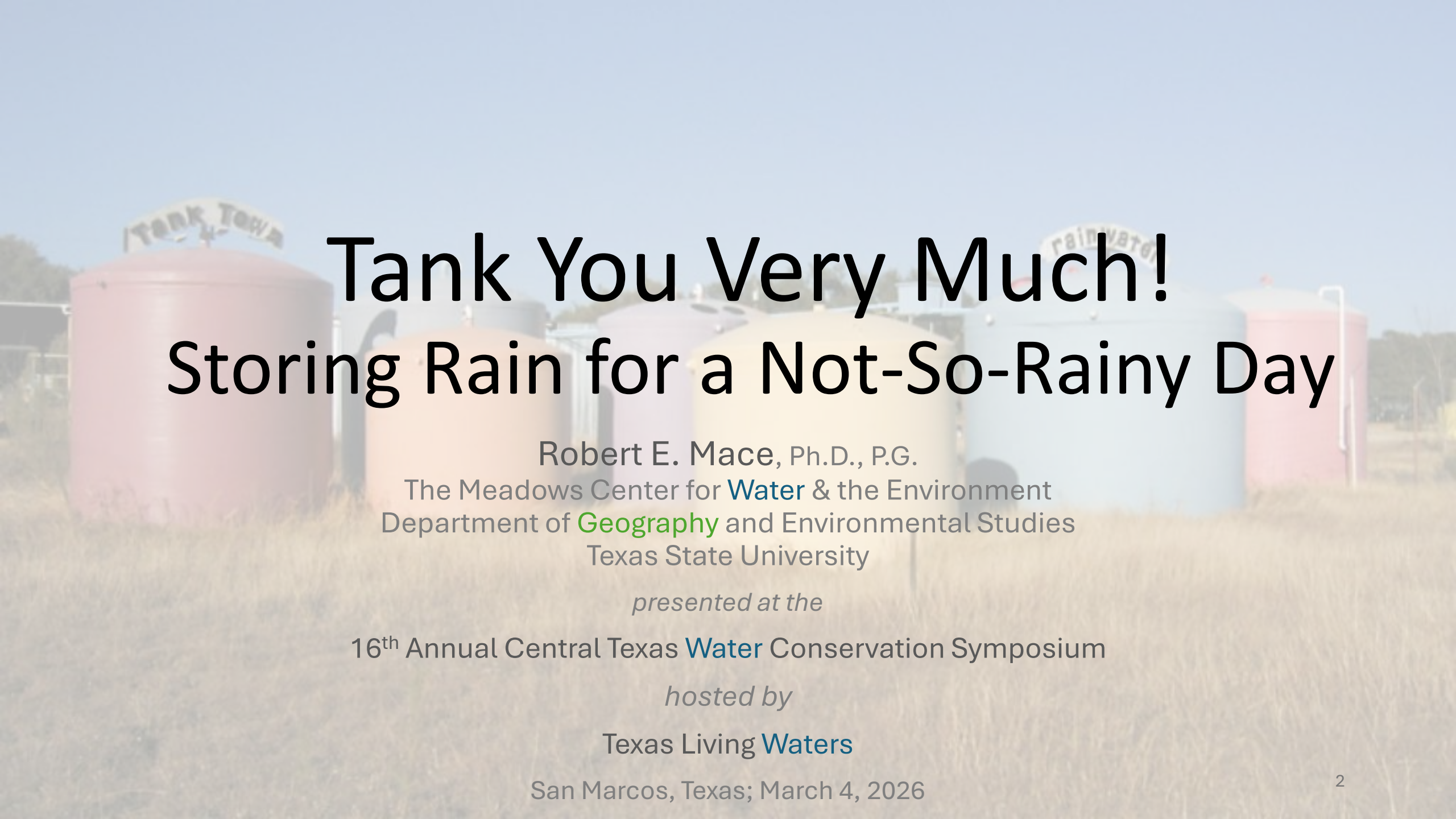
Rainwater as a New Supply: What's the Potential?



Tank You Very Much!
Storing Rain for a Not-So-Rainy Day

Robert E. Mace, Ph.D., P.G.
The Meadows Center for Water & the Environment
Department of Geography and Environmental Studies
Texas State University

presented at the

16th Annual Central Texas Water Conservation Symposium

hosted by

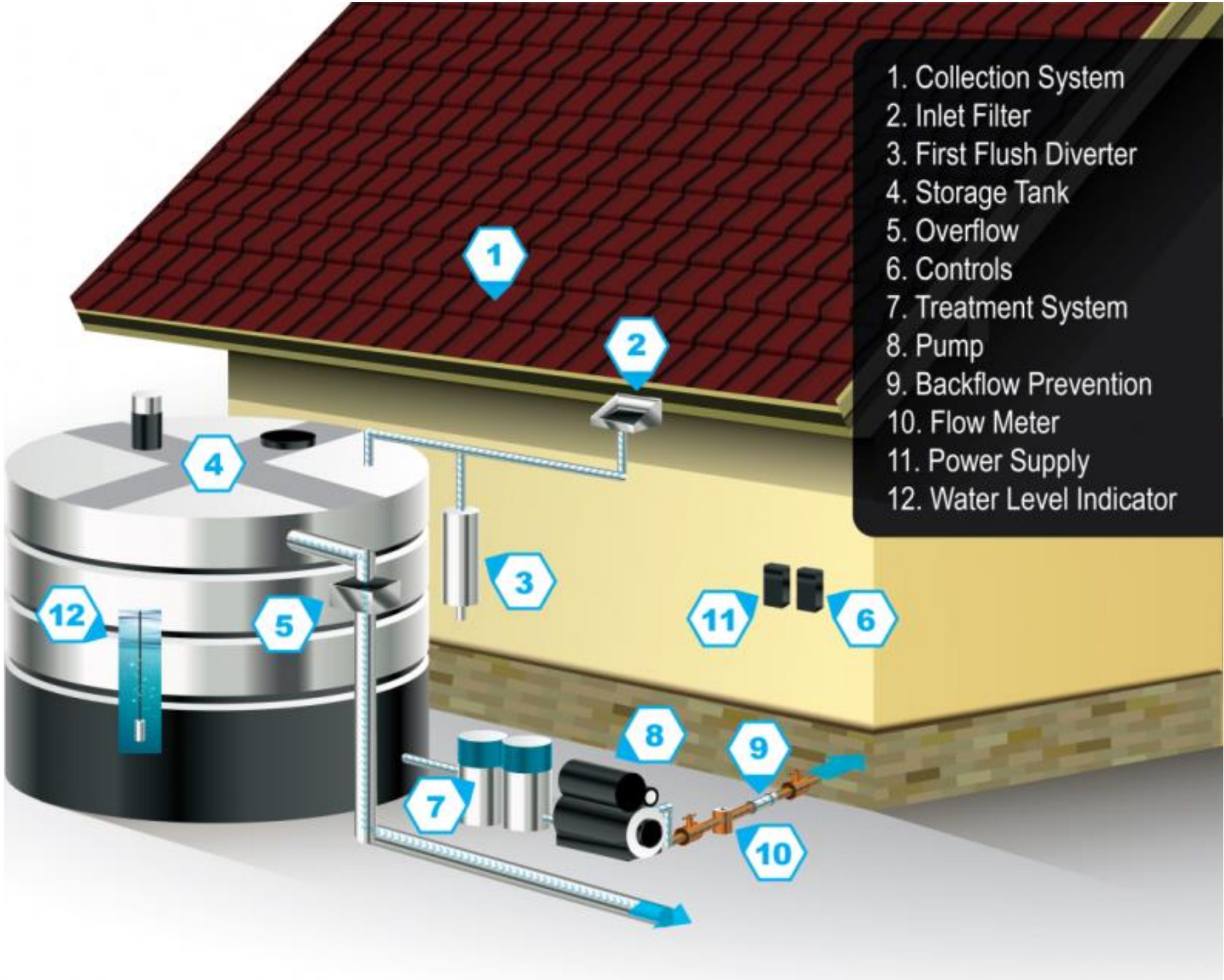
Texas Living Waters

San Marcos, Texas; March 4, 2026


RAINWATER
OR
BUST!!!

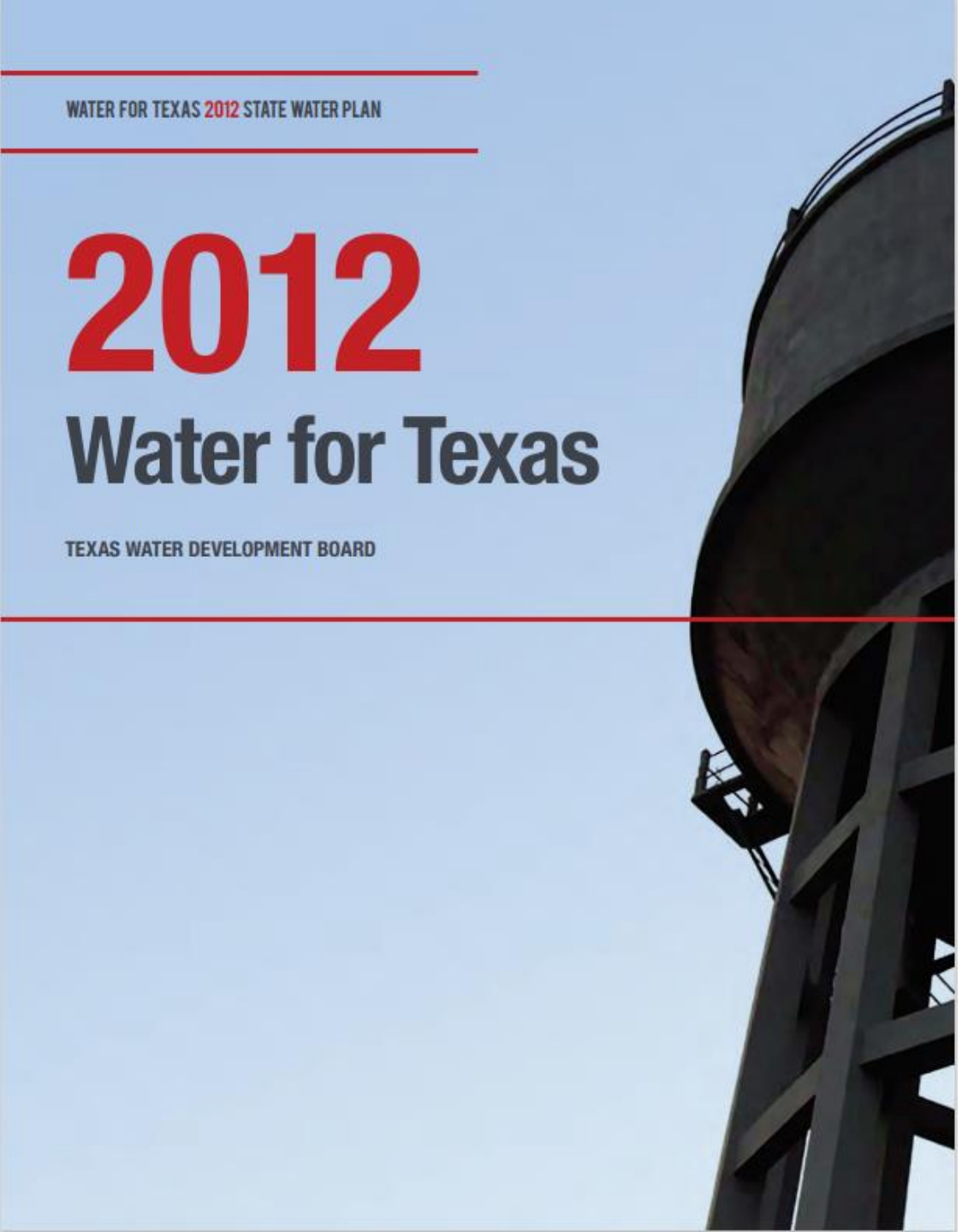
acknowledgments

- Meadows Foundation Endowment to support Graduate Fellows and Research Assistants
- Meadows Foundation Endowment for the Water Policy Program
- National Oceanic and Atmospheric Administration


1. Collection System
2. Inlet Filter
3. First Flush Diverter
4. Storage Tank
5. Overflow
6. Controls
7. Treatment System
8. Pump
9. Backflow Prevention
10. Flow Meter
11. Power Supply
12. Water Level Indicator
1
2
3
4
5
6
7
8
9
10
11
12

why rainwater?

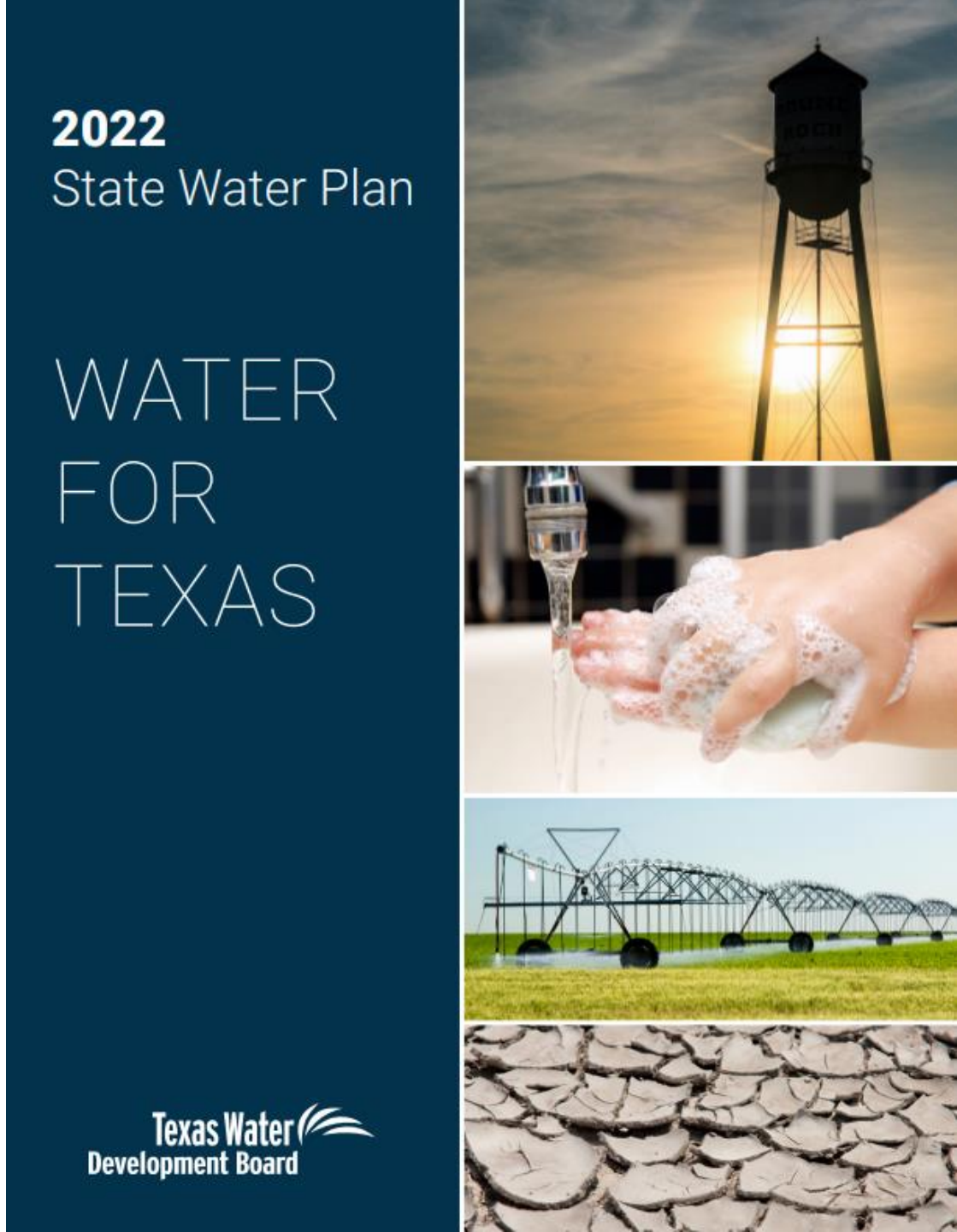
- may be the only option
- reduce the use of source supplies
- better quality
- may be cheaper than drilling a well
- plants like it better
- self/back-up supply
- builds resilience
- may be required
- it’s fun!



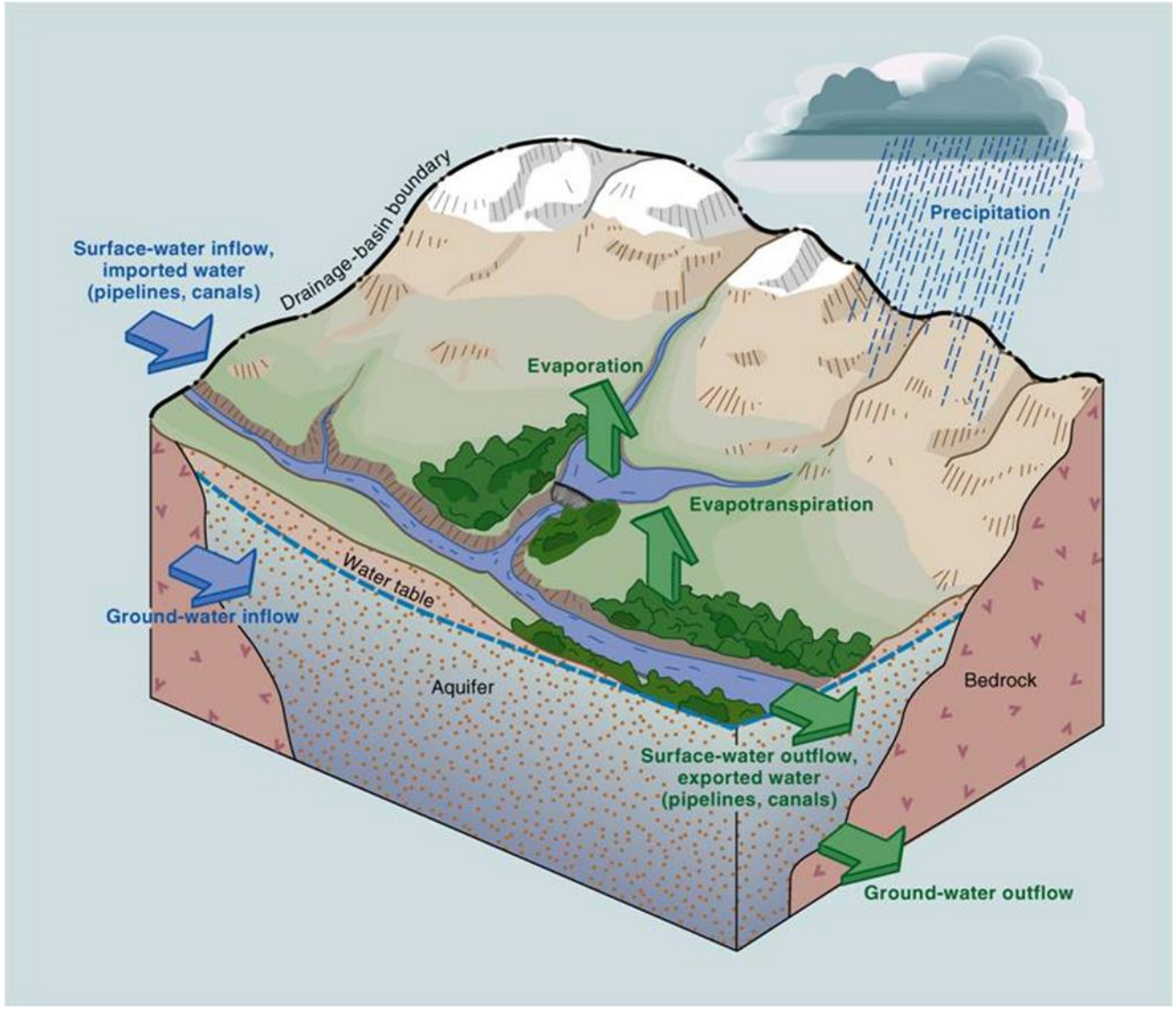
"While it is often a component of municipal water conservation programs, rainwater harvesting was not recommended as a water management strategy to meet needs since, like brush control, the volume of water **may not be available during drought conditions**."

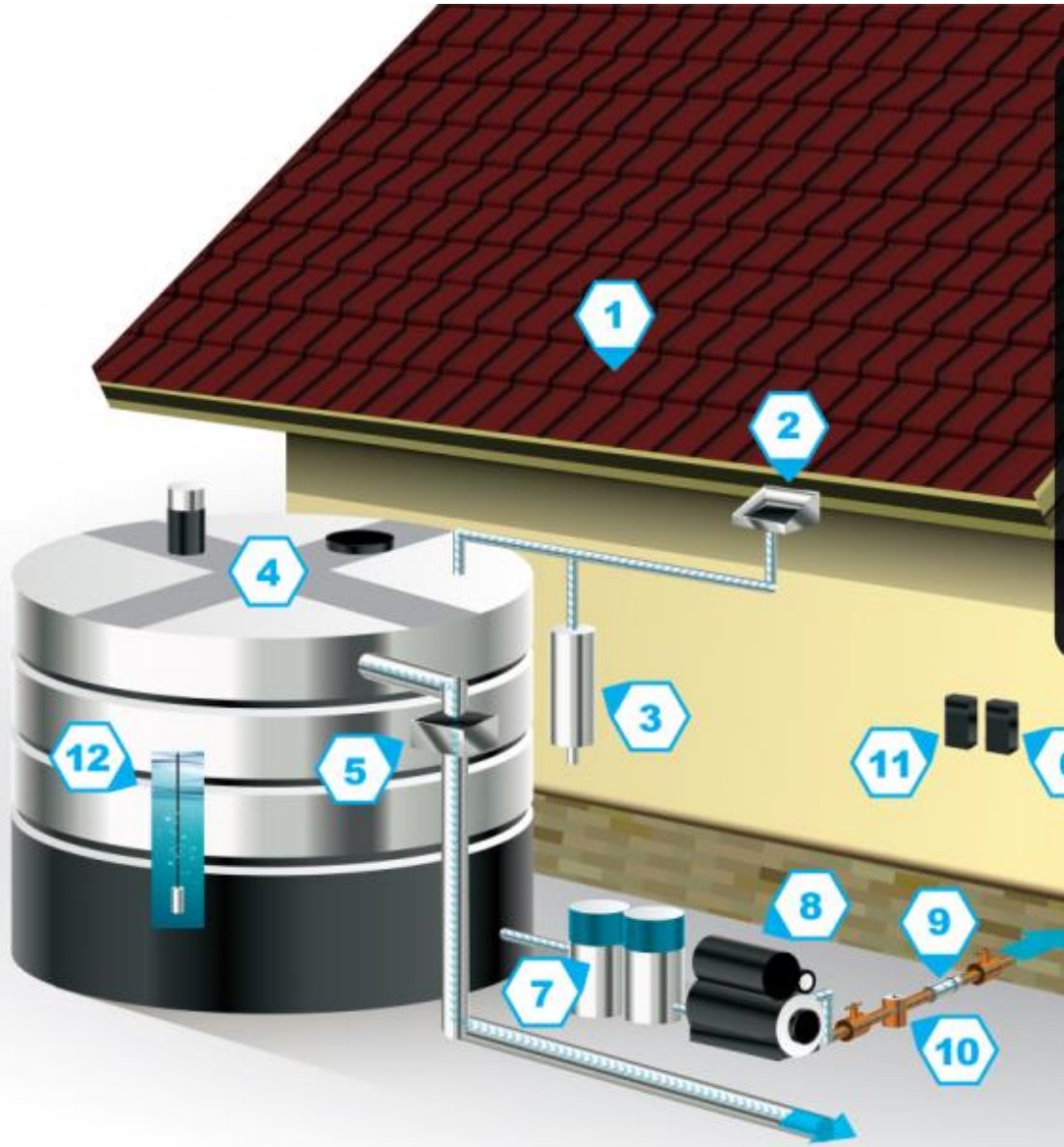
Firm Yield

- 2022 State Water Plan definition:
  - “Maximum water volume a reservoir can provide each year under a repeat of the drought of record using anticipated sedimentation rates and assuming that all senior water rights will be totally utilized and all applicable permit conditions met.”
- Generalized definition:
  - Maximum volume of water a source can reliably provide under a repeat of the drought of record



analogous (but different [but the same {but better}])





why firm yield?

- “100%” reliable
- avoid tank anxiety
- the cost of a firm system may minimize “overall cost”
- increase site, local, and regional resilience

volume of tank today

volume of tank yesterday

precipitation

catchment area

runoff coefficient

volume first flush

volume of use

$$V_t = V_{t-1} + R * A * C - V_{ff} - V_u$$

unless

$V_{ff} > R * A * C$ in which case $V_{ff} = R * A * C$ (2) not enough rain

$V_t > V_{tot}$ in which case $V_t = V_{tot}$ (3) tank full

total storage of tank

$V_t < 0$ in which case $V_t = 0$ (4) tank empty

governing equation

RAINFAL (Rainwater Assessment and Interactive eNumator for Firm-yield Analysis Limits)

items in **red** *are user-assigned; items in* **black** *are calculated*

version: 2025-0528

Austin

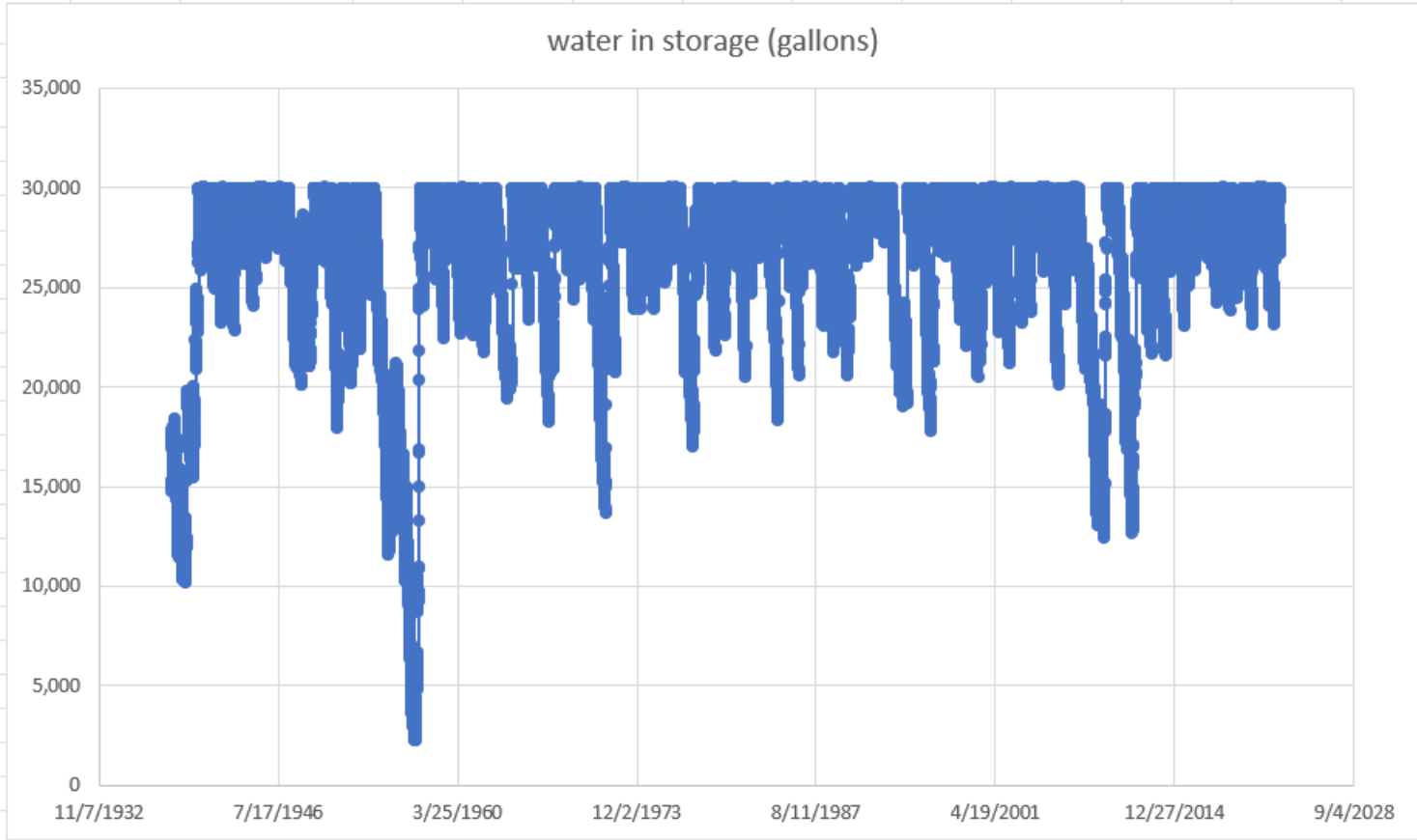
Weather station: **Camp Mabry**

user-adjusted parameters:

Ar	**3,000**	ft*ft
Vt	**30,000**	gallons
daily demand	**94**	gallons per day
runoff coefficient	**0.92**	unitless
precip adjuster	**1**	unitless

conversions & calculations:

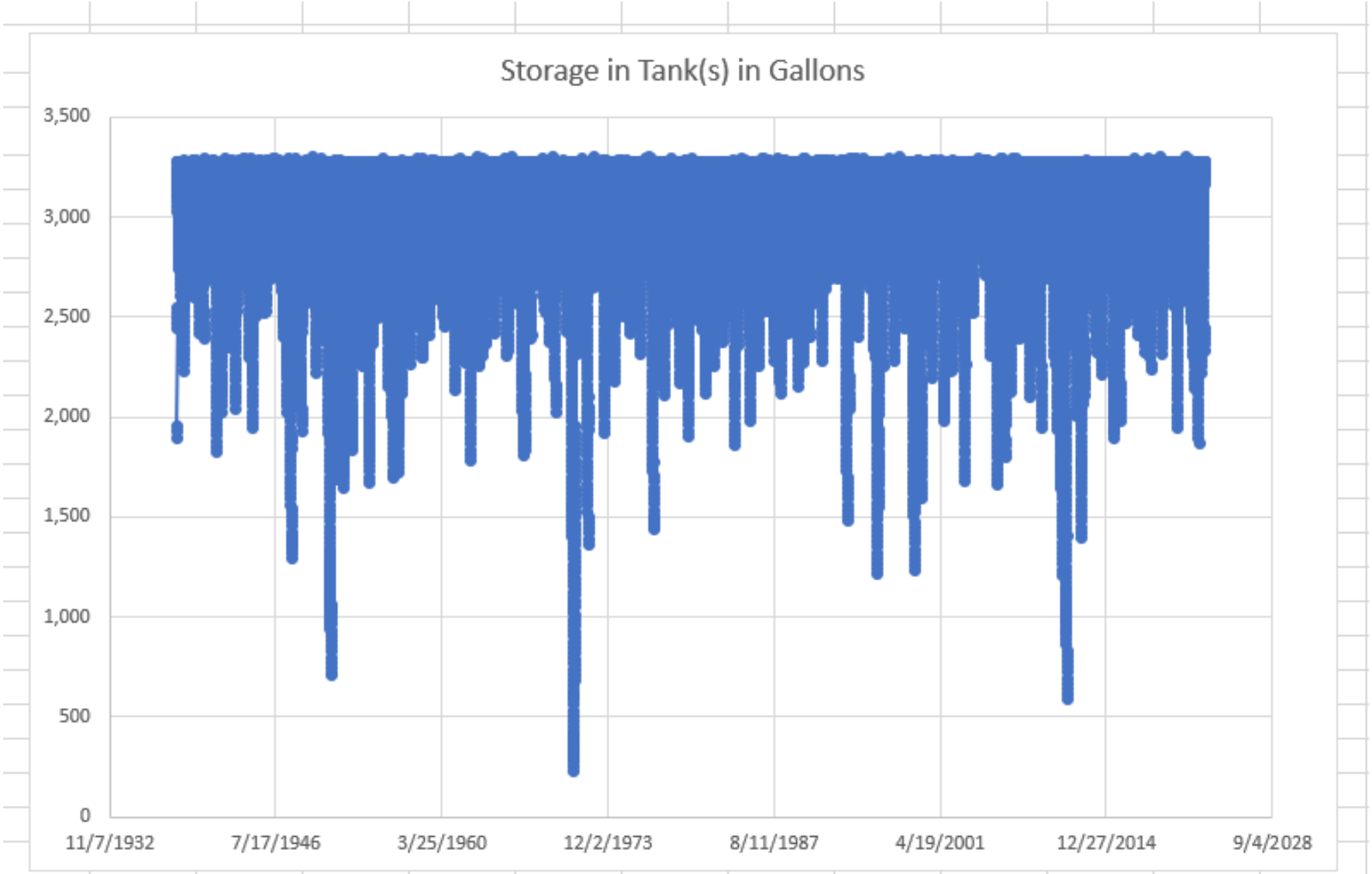
Vt	**4010.4**	ft*ft*ft
Vff	**4.01**	ft*ft*ft
daily demand	**12.57**	ft*ft*ft per day
starting tank storage	**50**	percent full
starting tank storage	**2005.2**	ft*ft*ft
dead pool	**5**	percent full



dead pool storage:	**1500**	gallons
lowest storage:	**2224**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**1,602,338**	gallons

date	**precipitation**	**adjusted precipitation**
	inches	inches

3.1 million gallons used!

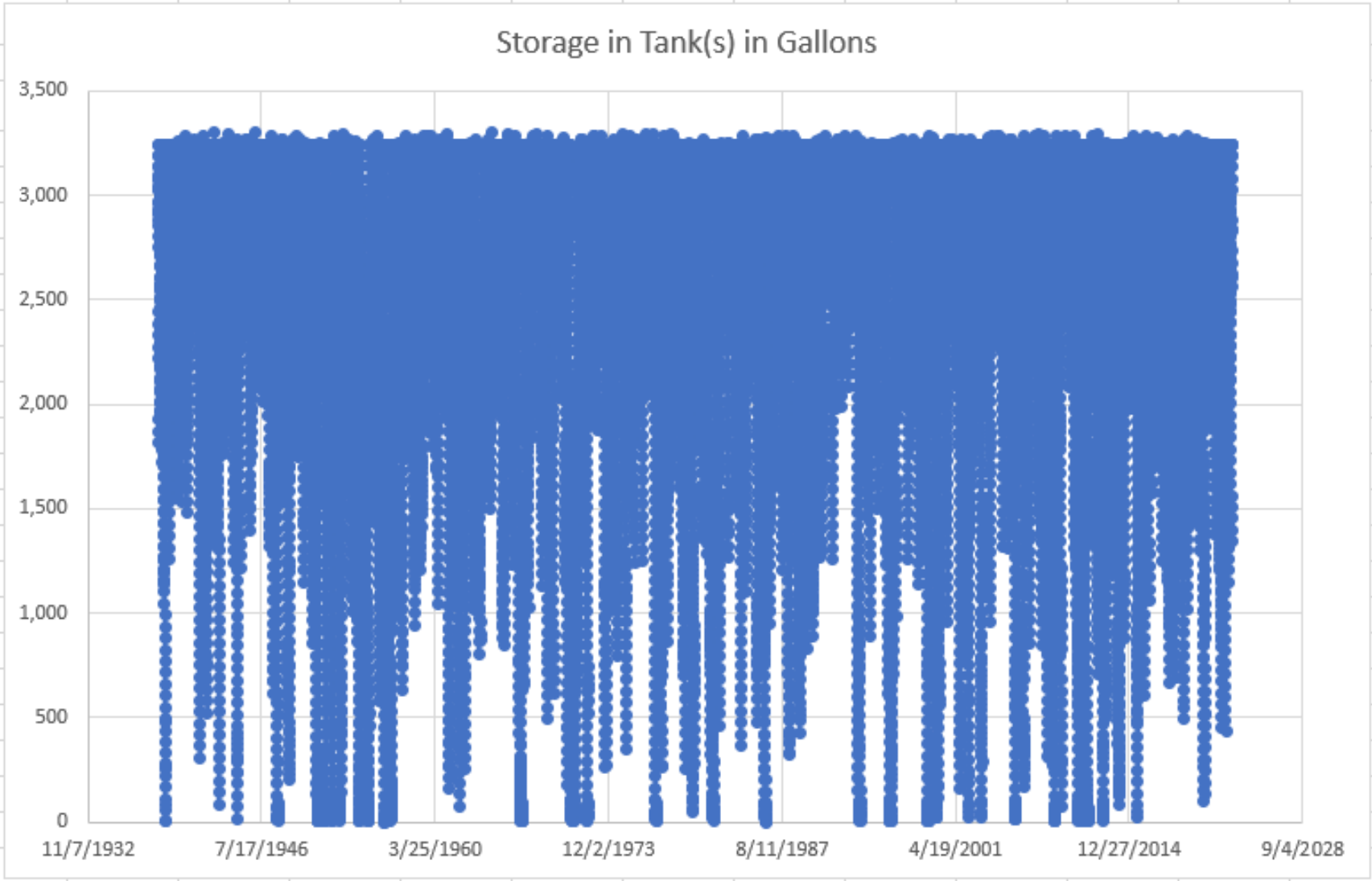


5% of storage:	165	
lowest storage:	228	gallons
reliability:	100.00	percent

Austin

Vt = 3,300 gallons

U = 10*2.76 gpd



5% of storage:	165	
lowest storage:	0	gallons
reliability:	99.81	percent

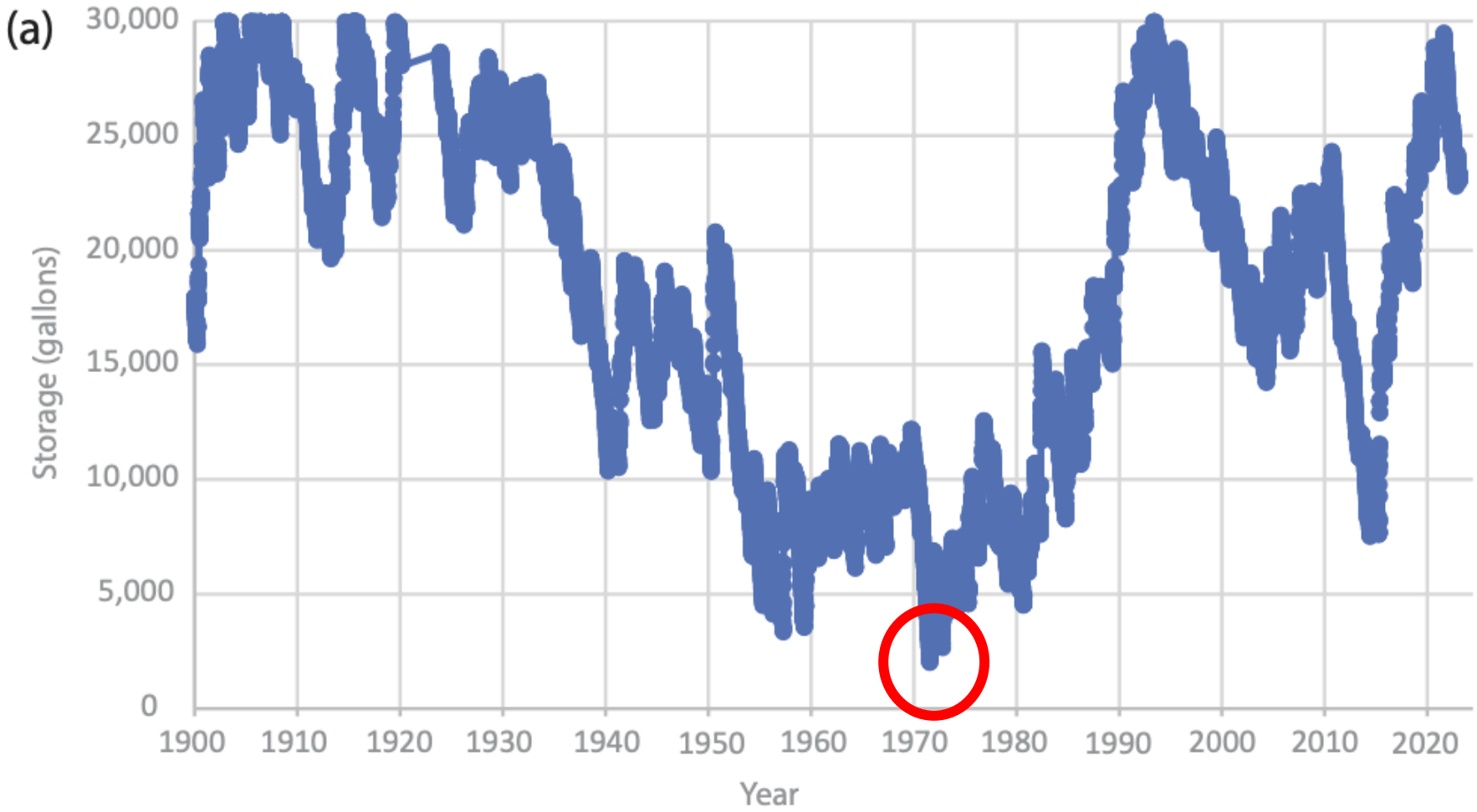
Austin

Vt = 3,300 gallons
U = 20*2.76 gpd

60 dry days

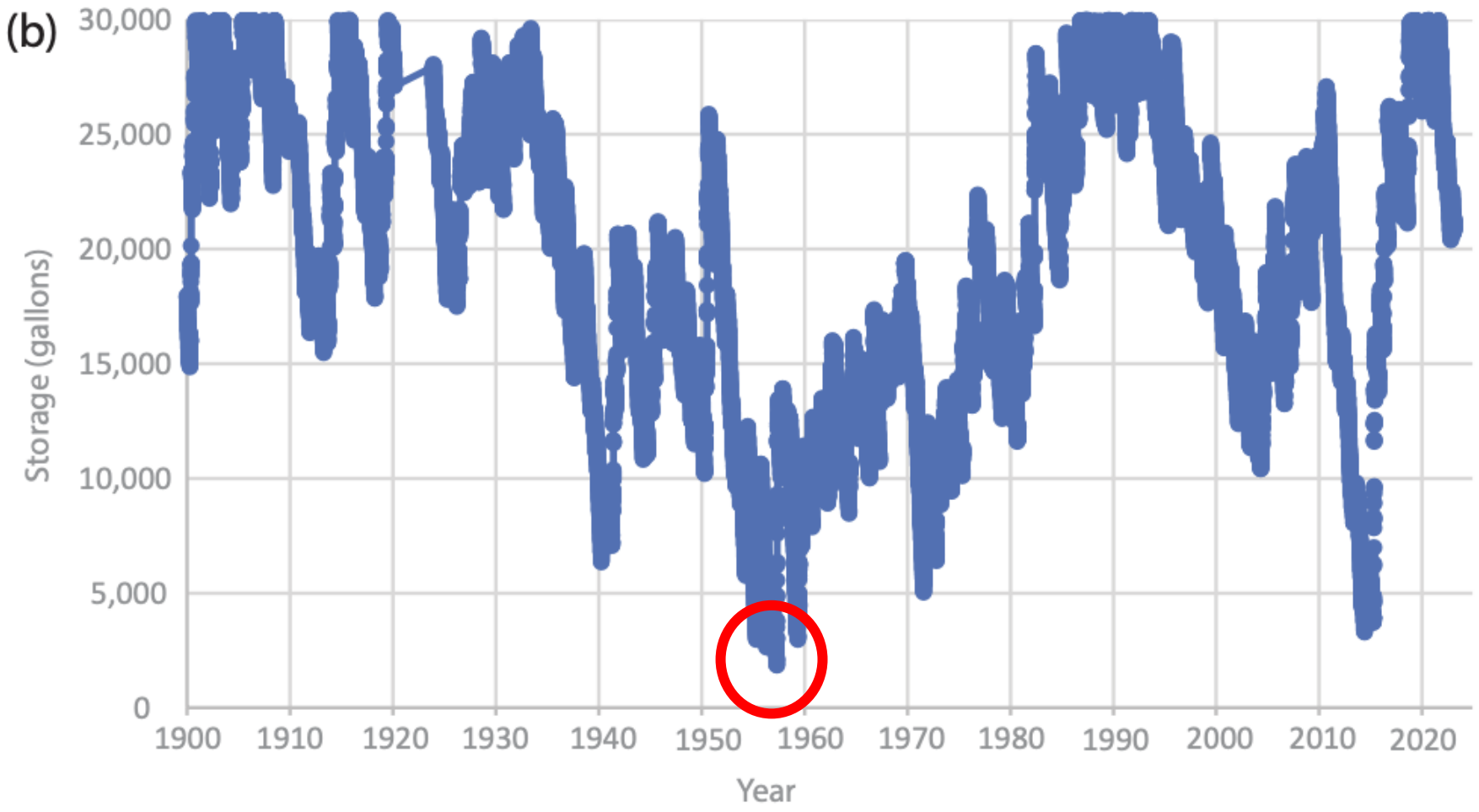
7,340 gallon tank
for firm yield
at 20*2.76 gpcd
(0 dry days)

different droughts for different spouts!



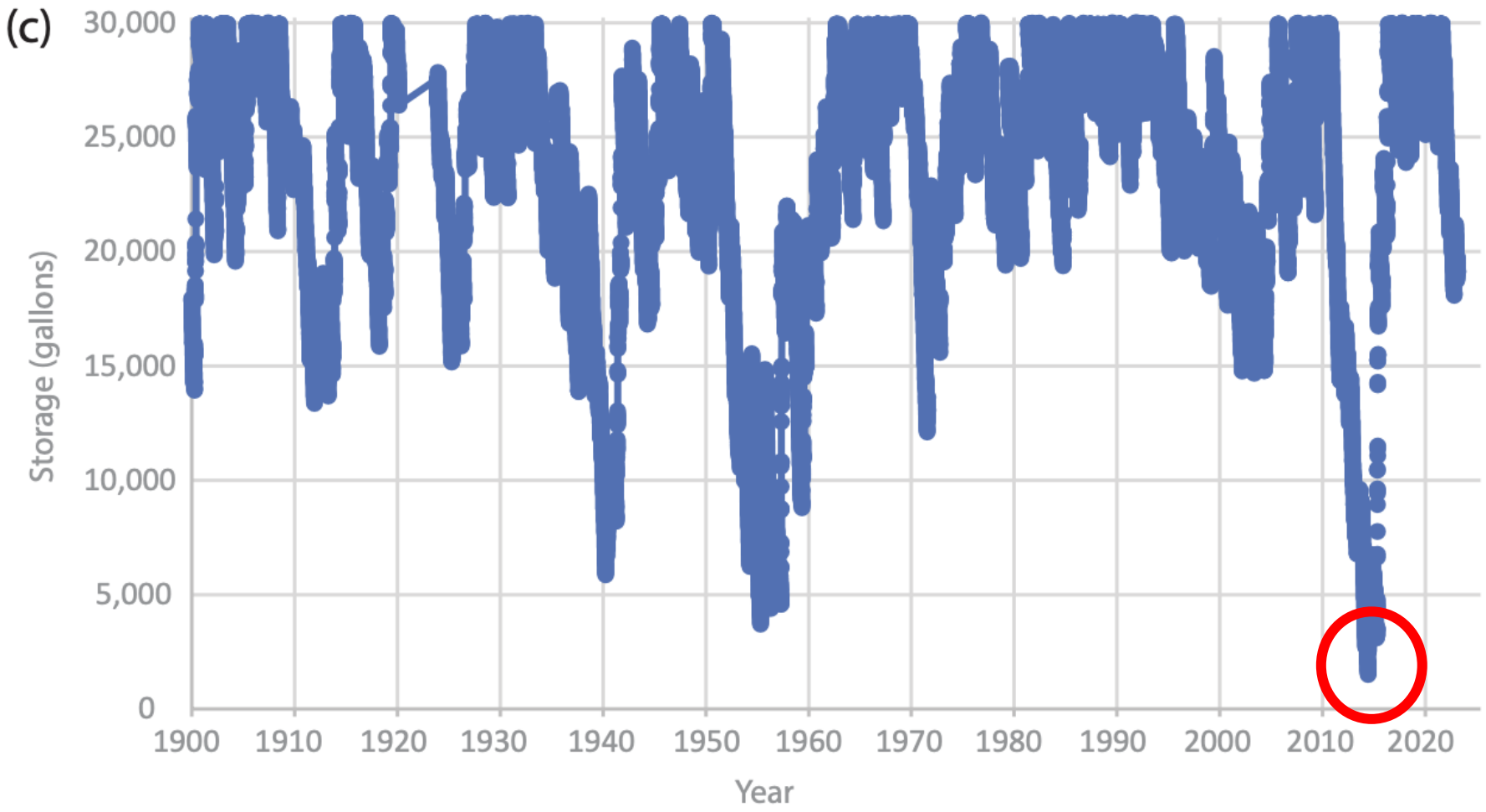
location: Wichita Falls
daily use: 27.6 gallons
(10 gallons per person per day times multiplied by 2.76 people)
catchment: 804 square feet
maximum storage: 30,000 gallons

different droughts for different spouts!

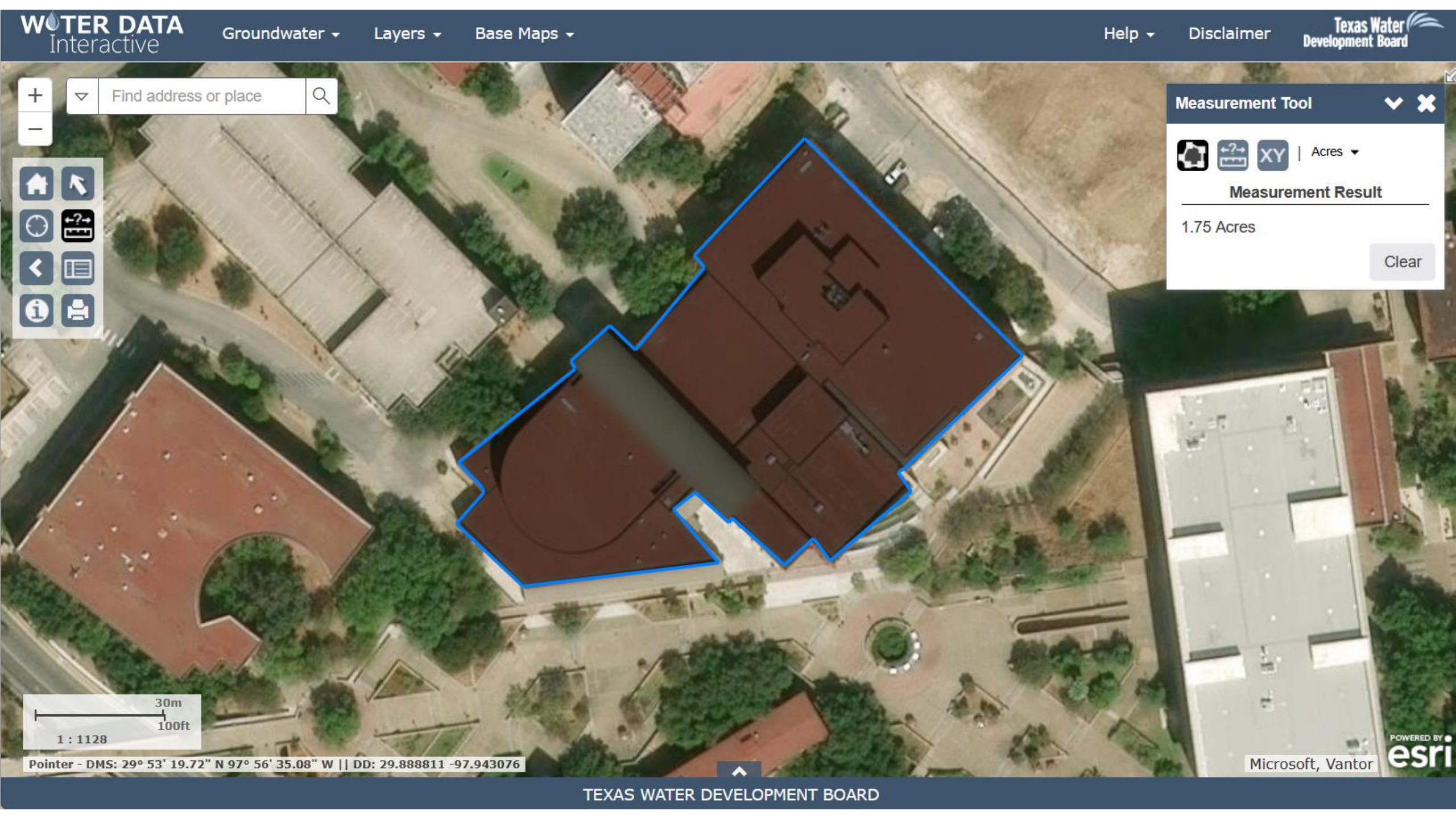


location: Wichita Falls
daily use: 41.4 gallons
(15 gallons per person per day times multiplied by 2.76 people)
catchment: 1,156 square feet
maximum storage: 30,000 gallons

different droughts for different spouts!



location: Wichita Falls
daily use: 55.2 gallons
(20 gallons per person per day times multiplied by 2.76 people)
catchment: 1,570 square feet
maximum storage: 30,000 gallons


WATER DATA Interactive
Groundwater
Layers
Base Maps
Help
Disclaimer
Texas Water Development Board
Find address or place
Measurement Tool
XY
Acres
Measurement Result
1.75 Acres
Clear
30m
100ft
1 : 1128
Pointer - DMS: 29° 53' 19.72" N 97° 56' 35.08" W || DD: 29.888811 -97.943076
Microsoft, Vantor
POWERED BY esri
TEXAS WATER DEVELOPMENT BOARD

RAINFAL (Rainwater Assessment and Interactive eNumator for Firm-yield Analysis Limits)

items in **red** *are user-assigned; items in* **black** *are calculated* *version: 2025-0528*

Austin

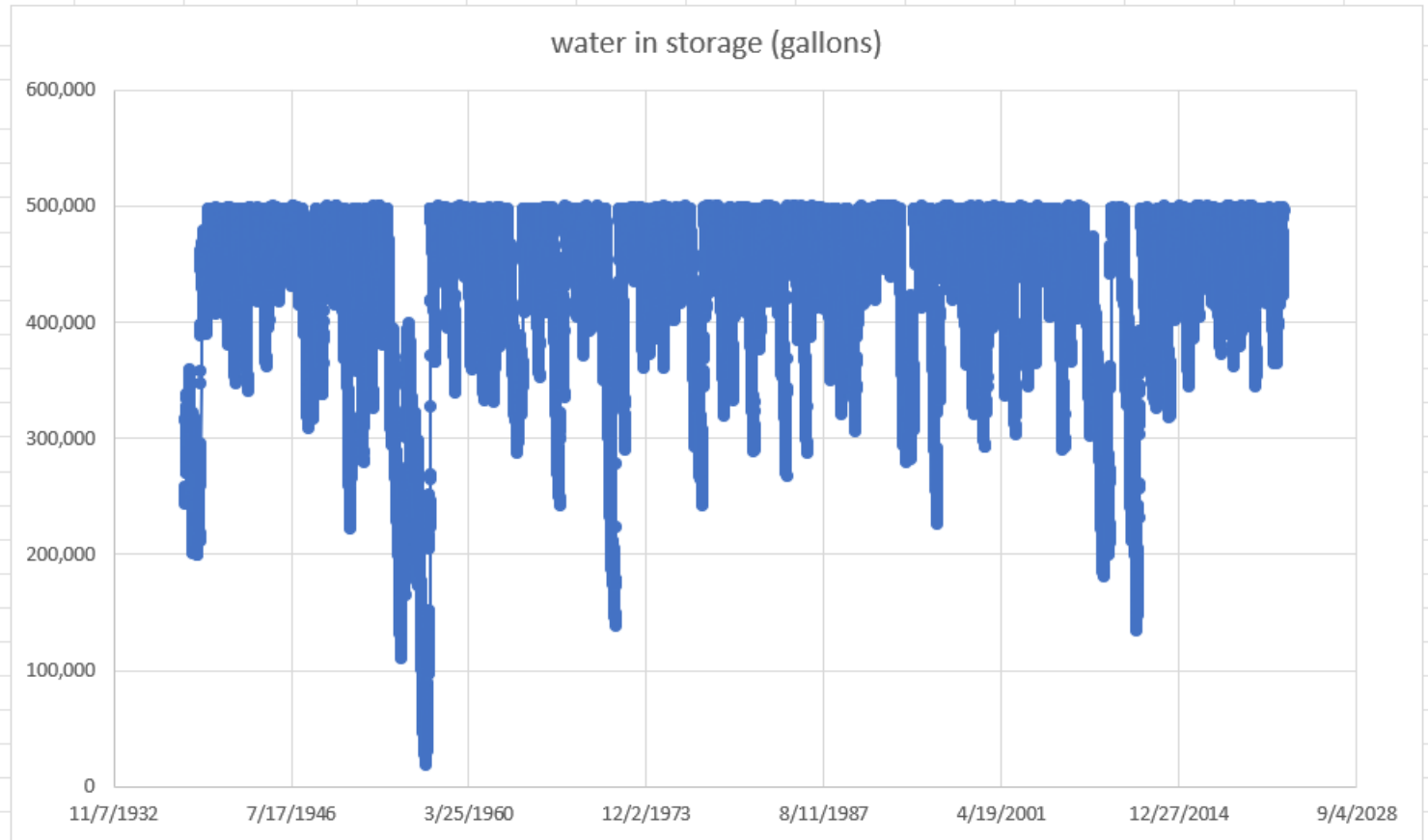
Weather station: **Camp Mabry**

user-adjusted parameters:

Ar	**76,230**	ft*ft
Vt	**500,000**	gallons
daily demand	**2200**	gallons per day
runoff coefficient	**0.92**	unitless
precip adjuster	**1.00827**	unitless

conversions & calculations:

Vt	**66840.5**	ft*ft*ft
Vff	**101.91**	ft*ft*ft
daily demand	**294.12**	ft*ft*ft per day
starting tank storage	**50**	percent full
starting tank storage	**33420.3**	ft*ft*ft
dead pool	**5**	percent full

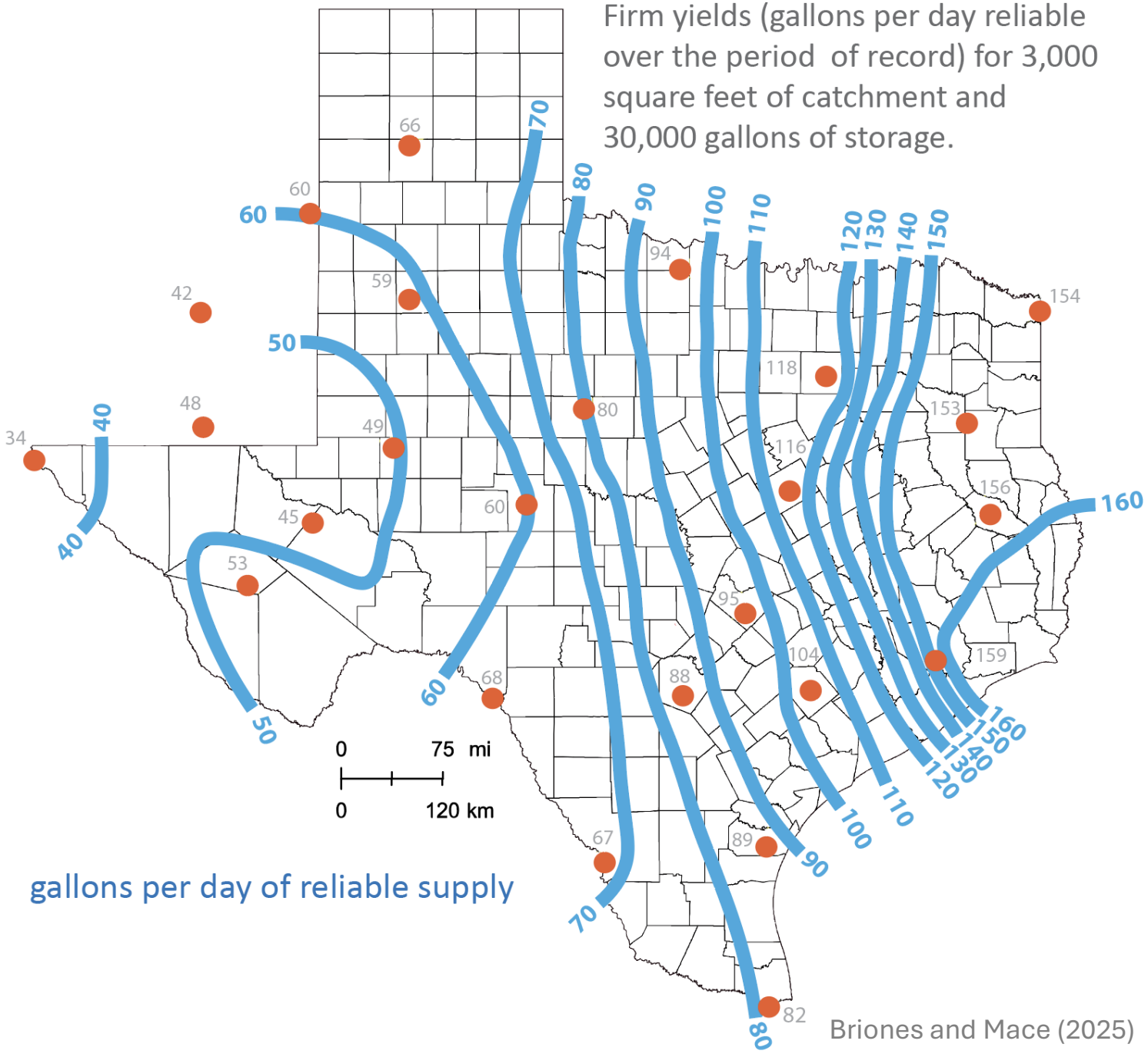


dead pool storage:	**25000**	gallons
lowest storage:	**18721**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**47,496,293**	gallons

date	**precipitation** inches	**adjusted precipitation** inches
6/1/1938	0	0


WATER DATA Interactive
Groundwater
Layers
Base Maps
Help
Disclaimer
Texas Water Development Board
Find address or place
Measurement Tool
XY
Acres
Measurement Result
1.75 Acres
Clear
- 500,000-gallon tank
- 2,200 gpd
- 1m-gallon tank
- 2,600 gpd
30m
100ft
1 : 1128
Pointer - DMS: 29° 53' 19.72" N 97° 56' 35.08" W || DD: 29.888811 -97.943076
Microsoft, Vantor
POWERED BY esri
TEXAS WATER DEVELOPMENT BOARD

reliable rainwater harvesting



conclusions

- It’s ‘easy’ to achieve a firm yield for rainwater harvesting in most of Texas
- there’s a larger swath of the state that could employ reliable rainwater harvesting than understood
- the drought of record for a rainwater system depends on the rainwater system in addition to rainfall
- high reliability (<100%) may mean frequent water hauling

Meadows Report 25-003

Reliable Rainwater Is Only a Roof Away: The Firm Yield of Rainwater Harvesting in Texas

Storm over a Texas field along Route 66 © David Smith

Prepared by

Ricardo O. Briones and Robert E. Mace, Ph.D., P.G.

September 2025

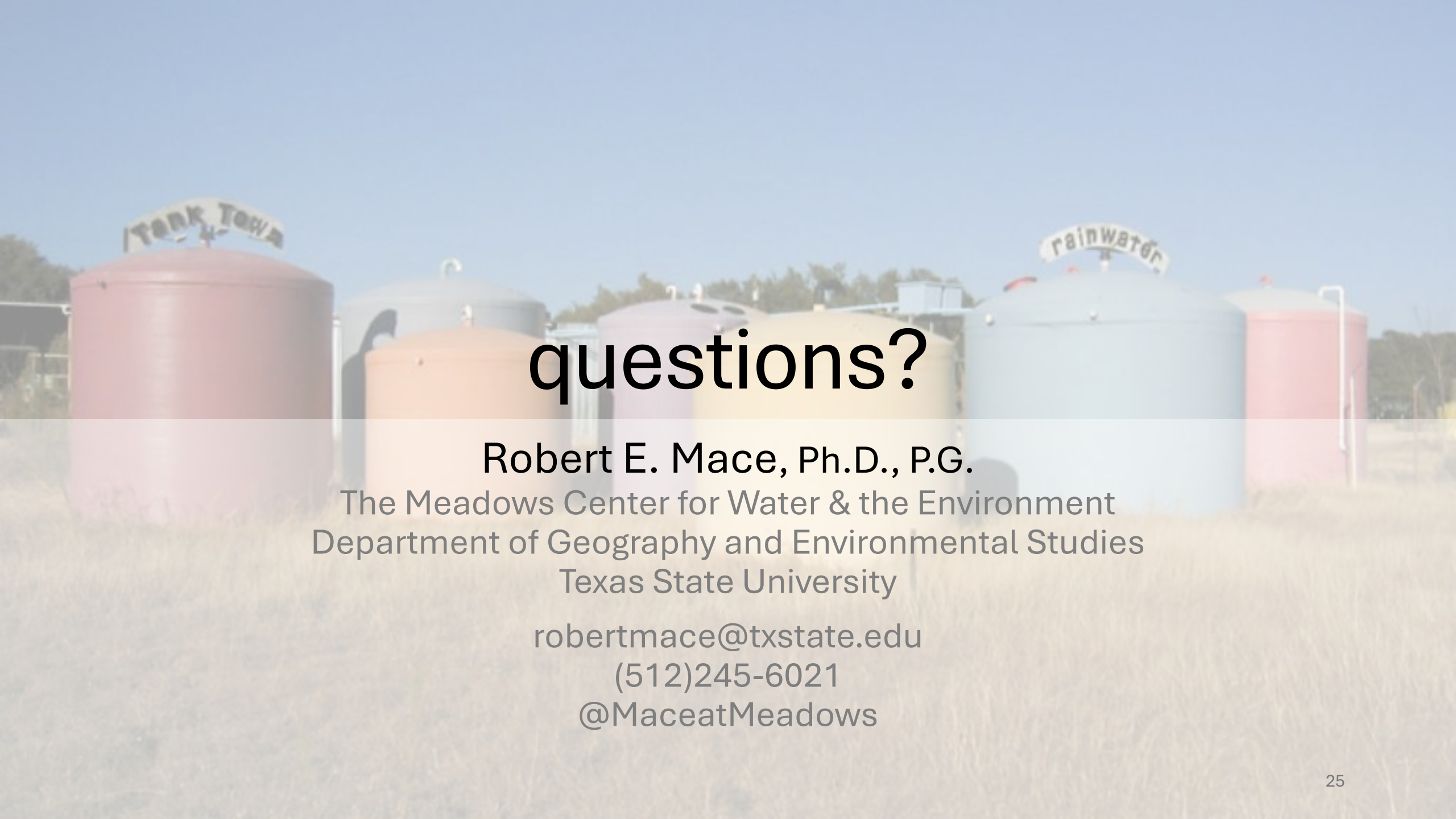
The Meadows Center for Water and the Environment
Texas State University

MEMBER THE TEXAS STATE UNIVERSITY SYSTEM

RAINFAL Tool Downloads

Location	Regional Planning Area
Abilene (XLSX, 6.03MB)	Region G (Brazos)
Amarillo (XLSX, 5.74MB)	Region A (Panhandle)
Austin (XLSX, 6.2MB)	Region K (Lower Colorado)
Brownsville (XLSX, 5.76MB)	Region M (Rio Grande)
Corpus Christi (XLSX, 5.66MB)	Region N (Coastal Bend)
Dallas (XLSX, 6.09MB)	Region C (Upper Trinity)
Del Rio (XLSX, 4.75MB)	Region J (Plateau)
El Paso (XLSX, 6.14MB)	Region E (Far West Texas)
Fort Davis (XLSX, 7.11MB)	Region E (Far West Texas)
Hallettsville (XLSX, 9.07MB)	Region P (Lavaca)
Houston (XLSX, 5.72MB)	Region H (Lower Trinity)
Laredo (XLSX, 4.52MB)	Region M (Rio Grande)
Lubbock (XLSX, 5.69MB)	Region O (Llano Estacado)
Lufkin (XLSX, 5.65MB)	Region I (East Texas)
Midland (XLSX, 7.76MB)	Region F (North Central Texas)
San Angelo (XLSX, 5.77MB)	Region F (North Central Texas)
San Antonio (XLSX, 5.62MB)	Region L (South Central Texas)
Texarkana (XLSX, 8.37MB)	Region D (North East Texas)
Waco (XLSX, 6.07MB)	Region G (Brazos)
Wichita Falls (XLSX, 8.36MB)	Region B (Red River)

https://bit.ly/RAINFAL



questions?

Robert E. Mace, Ph.D., P.G.
The Meadows Center for Water & the Environment
Department of Geography and Environmental Studies
Texas State University

robertmace@txstate.edu
(512)245-6021
@MaceatMeadows

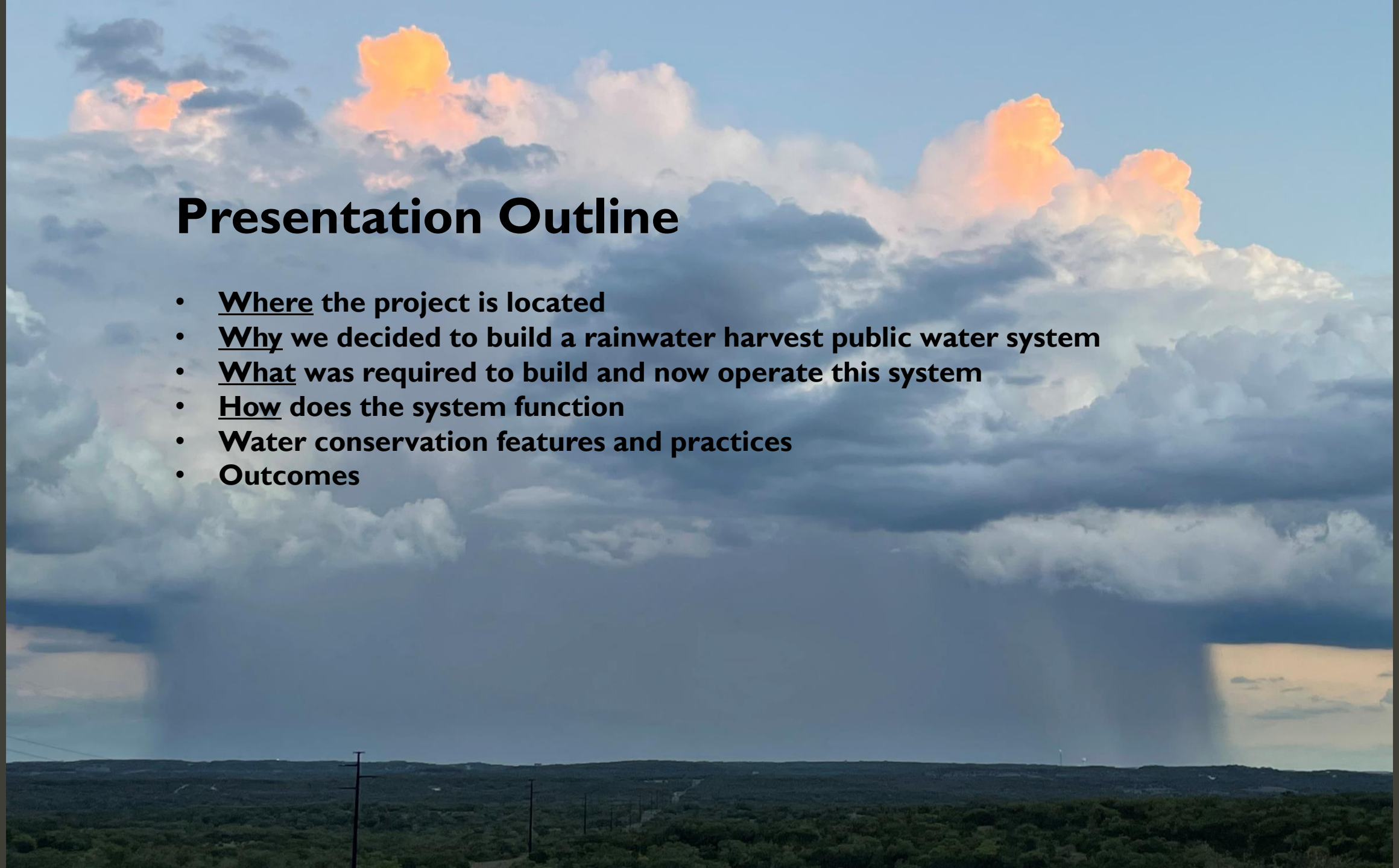
Rainwater as a New Supply: What's the Potential?

Sky to Supply: Texas' First Rainwater Public Water System

Blake Murden
Shield Land Stewardship Group

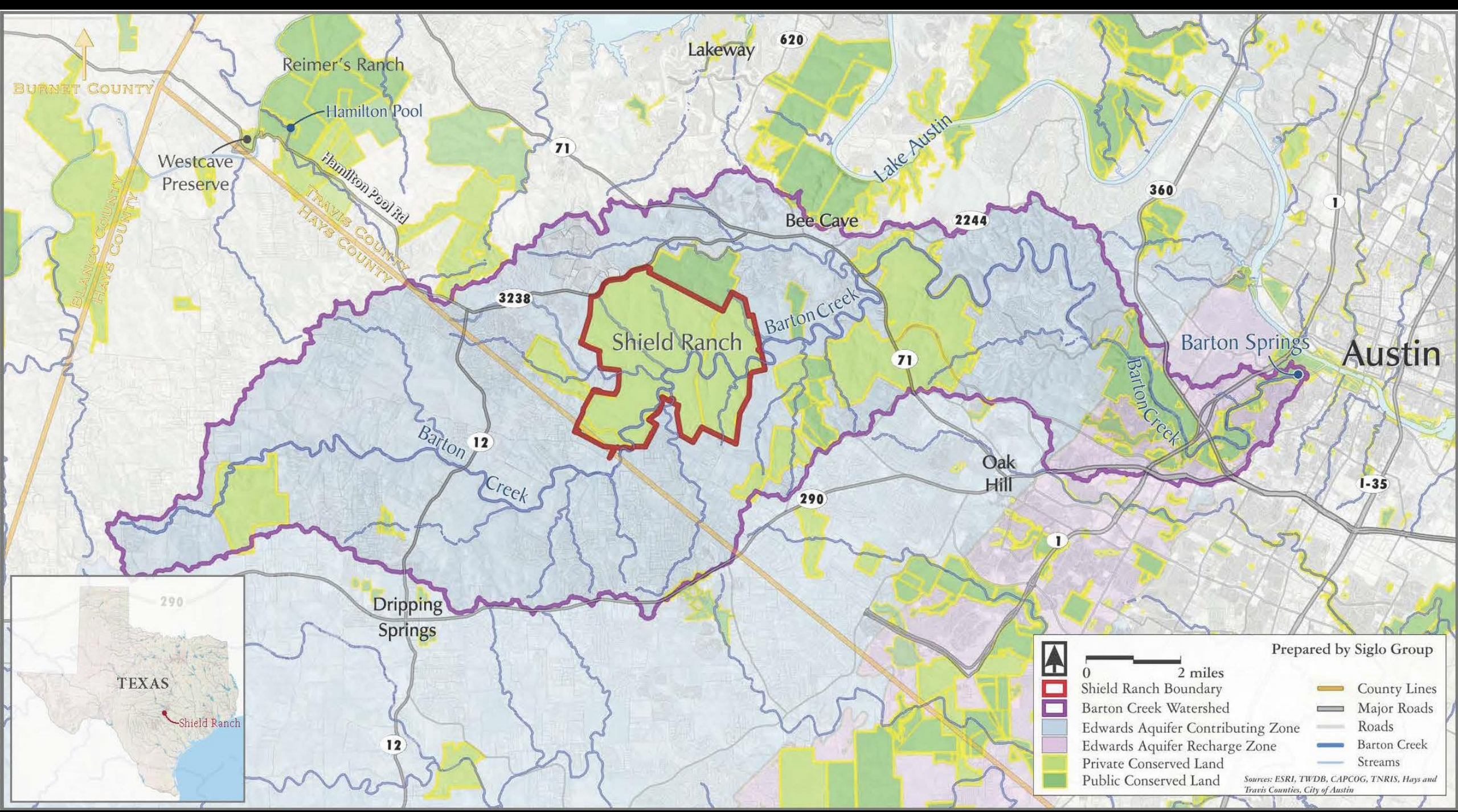
March 4, 2026
Central Texas Water Conservation Symposium

SHIELD RANCH



Presentation Outline

- **Where** the project is located
- **Why** we decided to build a rainwater harvest public water system
- **What** was required to build and now operate this system
- **How** does the system function
- Water conservation features and practices
- Outcomes


Burnet County
Reimer's Ranch
Hamilton Pool
Westcave Preserve
Hamilton Pool Rd
Lakeway
620
71
Lake Austin
360
1
Bee Cave
2244
Travis County
Hays County
Blanco County
Hays County
3238
Shield Ranch
Barton Creek
Barton Springs
Austin
71
Barton Creek
12
Barton Creek
Oak Hill
290
I-35
1
Dripping Springs
12
290
TEXAS
Shield Ranch
Prepared by Siglo Group
0
2 miles
Shield Ranch Boundary
Barton Creek Watershed
Edwards Aquifer Contributing Zone
Edwards Aquifer Recharge Zone
Private Conserved Land
Public Conserved Land
County Lines
Major Roads
Roads
Barton Creek
Streams
Sources: ESRI, TWDB, CAPCOG, TNRIS, Hays and Travis Counties, City of Austin

Shield Ranch Foundation's
Camp El Ranchito

The Campsite at Shield Ranch

100% Off Grid – "power from the sun, water from the clouds"

- **Why rainwater?**
  - 3.5 miles from municipal water source
  - groundwater unreliable

- **Why a public water system?**
  - serves at least 25 people at least 60 days out of the year

Public Water System Permitting Process for The Campsite

Regulated by Texas Commission on Environmental Quality (TCEQ)

January 2020
TCEQ receives permit request

April 2020
TCEQ issues conditional permit for construction

July 2020
TCEQ receives updates system plans

September 2020
TCEQ approves construction plans

September 2022
Campsite construction is complete

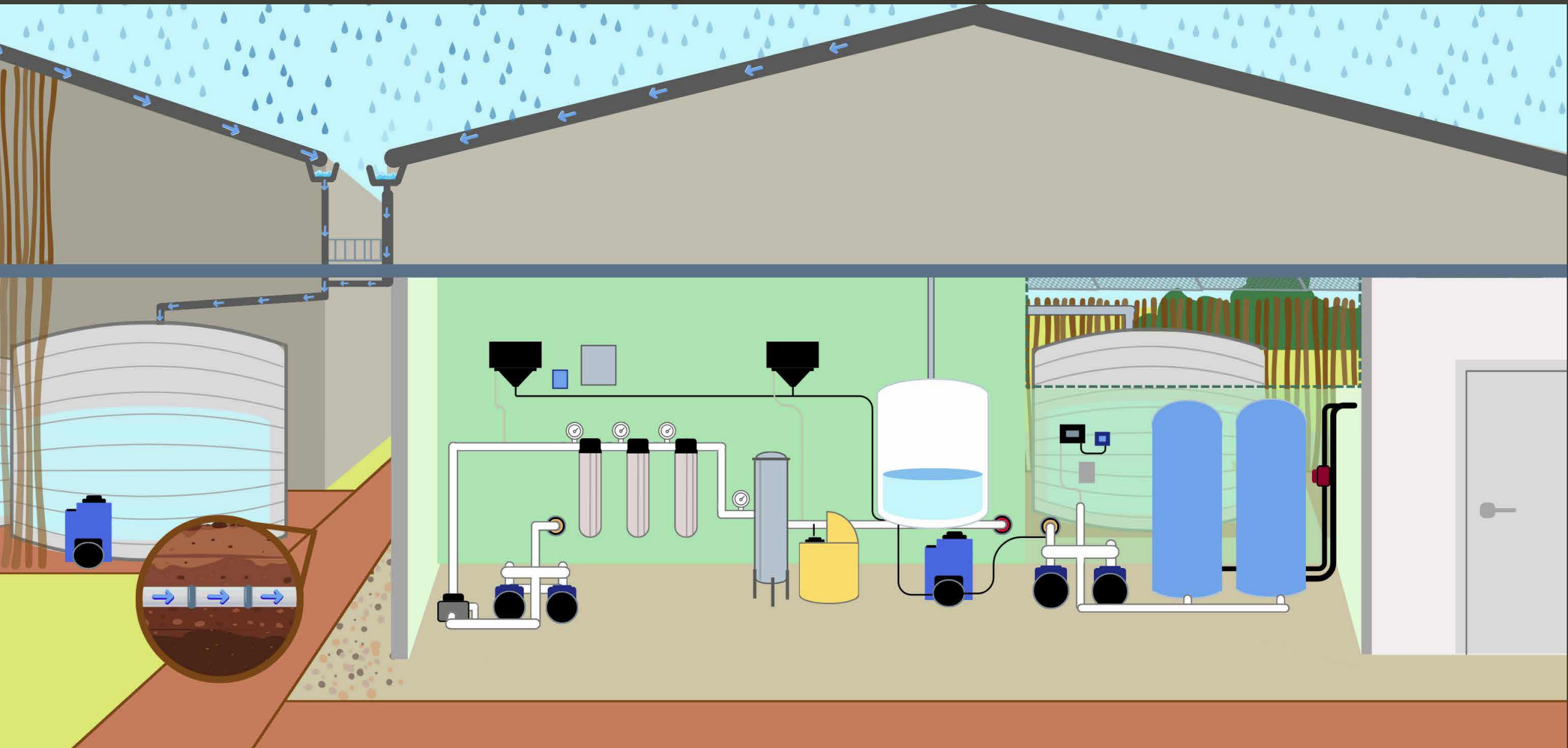
August 2023
TCEQ grants condition permit to operate & requires corrosivity study

May 2024
TCEQ approves corrosivity study & requires system changes

February 2025
TCEQ approves & designates facility as an active public water system

Rainwater Harvest Public Water System

Collection – Storage – Treatment - Distribution



Rainwater Collection

- 7,340 sq. ft. roof area
- 1” rain = 4,575 gallons

Rainwater Storage

- Two 30,500-gallon tanks and two 3,400 tanks
- 67,800 gallons total

Treatment

- pH balancing
- Sediment filtration
- Pathogen filtration
- Chlorination

Distribution

DISTANCE FROM PAVILION	
PARKING VIA GREEN TRAIL	5 MIN
ADA PARKING VIA GREEN TRAIL	4 MIN
OVERFLOW PARKING VIA RED TRAIL	5-6 MIN
OWL SHELTER	5 MIN

DISTANCIA DESDE EL PABELLÓN	
ESTACIONAMIENTO VÍA SENDERO VERDE	5 MIN
ESTACIONAMIENTO ADA VÍA SENDERO VERDE	4 MIN
ESTACIONAMIENTO ADICIONAL VÍA SENDERO ROJO	5-6 MIN
REFUGIO DE BÚHO	5 MIN

Water Conservation

Metered-faucets

Recycled test water

Recycled flush water

Evaporative Waterless Toilets

No water, electricity, or sewer connection needed

Uses wind and sun (solar radiation and air flow)

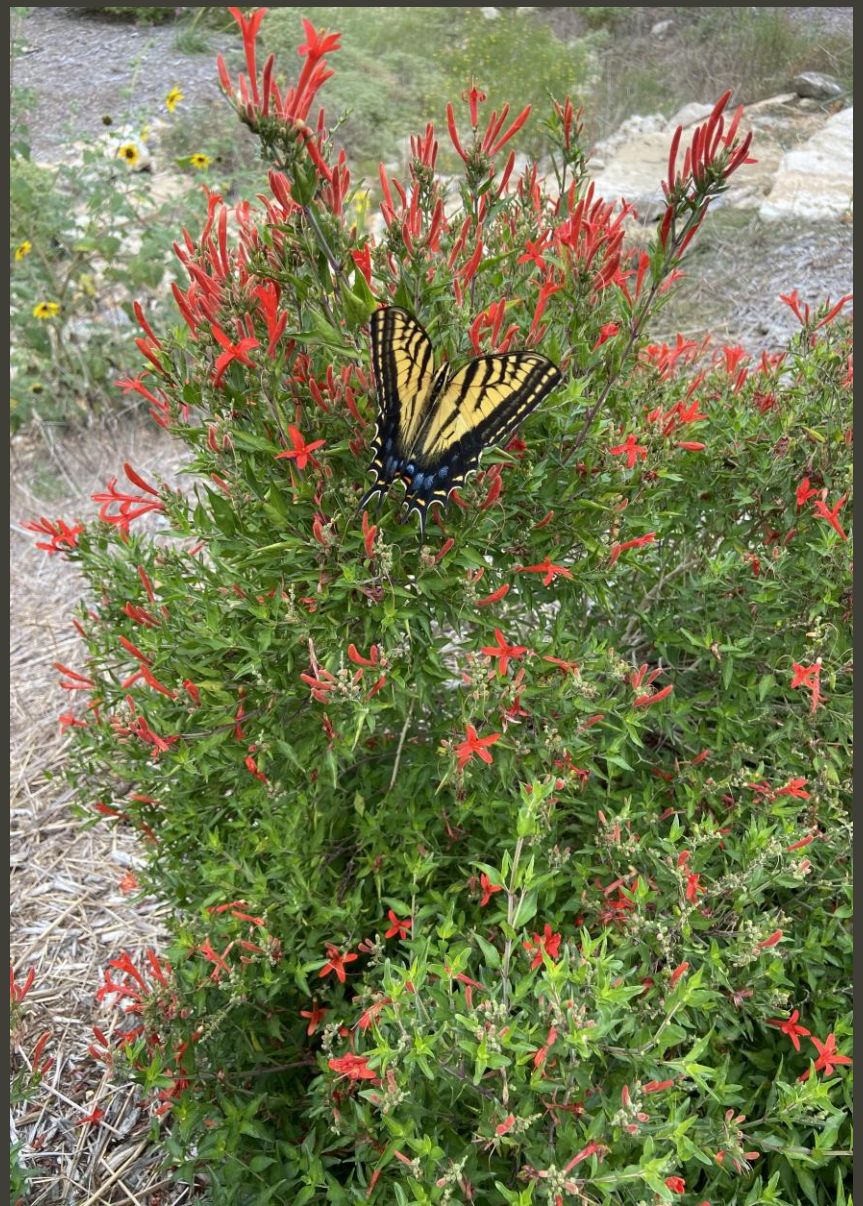
Liquids evaporate and solids desiccate

Not a composting toilet

4 outhouses - 10 units

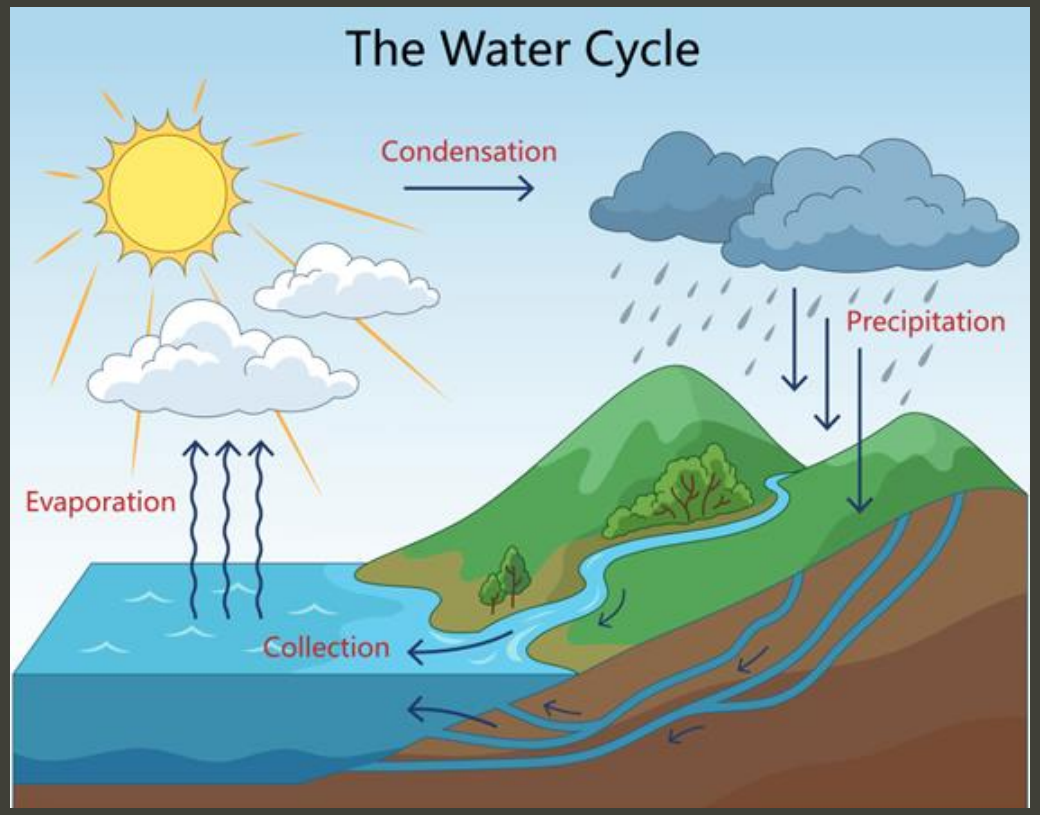
1st EWTs to be approved by TCEQ

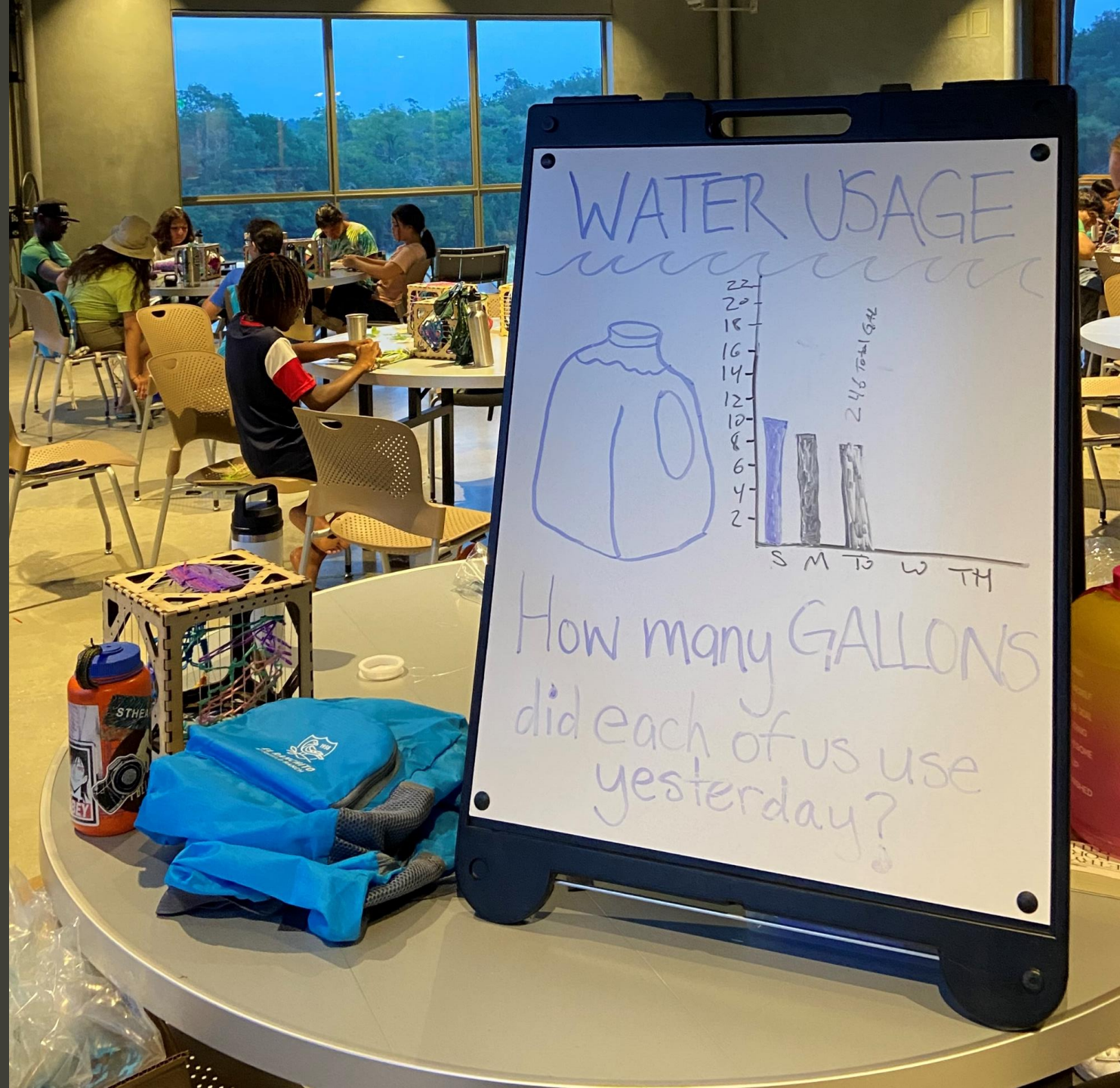
Drought-Tolerant Native Plants



Water Conservation

Education and Awareness





12.4 gallons per camper per day

In comparison, the average Texan uses 87 gallons per day

(Water Conservation Advisory Council, 2024)

Project Design and Delivery Team

Architect
Andersson / Wise

Landscape Architect
Ten Eyck Landscape Architects

Project Manager
Benz Resource Group

General Contractor
Hill & Wilkinson

Landscape Sustainability & SITES Consultant
Regenerative Environmental Design

Signage and Wayfinding Consultant
Asterisk

Water System Engineer
Venhuizen Water Works

Texas Water Journal

Expanding Water Knowledge for All Texans

Walker, J., Lopez, C.W., Powell, N., Murden, S.B., Mitchell, M. (In Press). Supplied by the sky: the first rainwater-sourced public water system in Texas, USA. *Texas Water Journal*.

The Campsite at Shield Ranch

Rainwater as a New Supply: What's the Potential?