Beyond the Barrel:
Making Rainwater a Real Urban Water Supply

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Department of Geography and Environmental Studies

Texas State University

presented at

ARCSA Technical Symposium

hosted by the

American Rainwater Catchment Systems Association International

Brookshire, Texas, May 20, 2026

portrait of a rainwater radical


CHARLOTTE PIPE


SERVING TEXAS. SECURING OUR WATER FUTURE.
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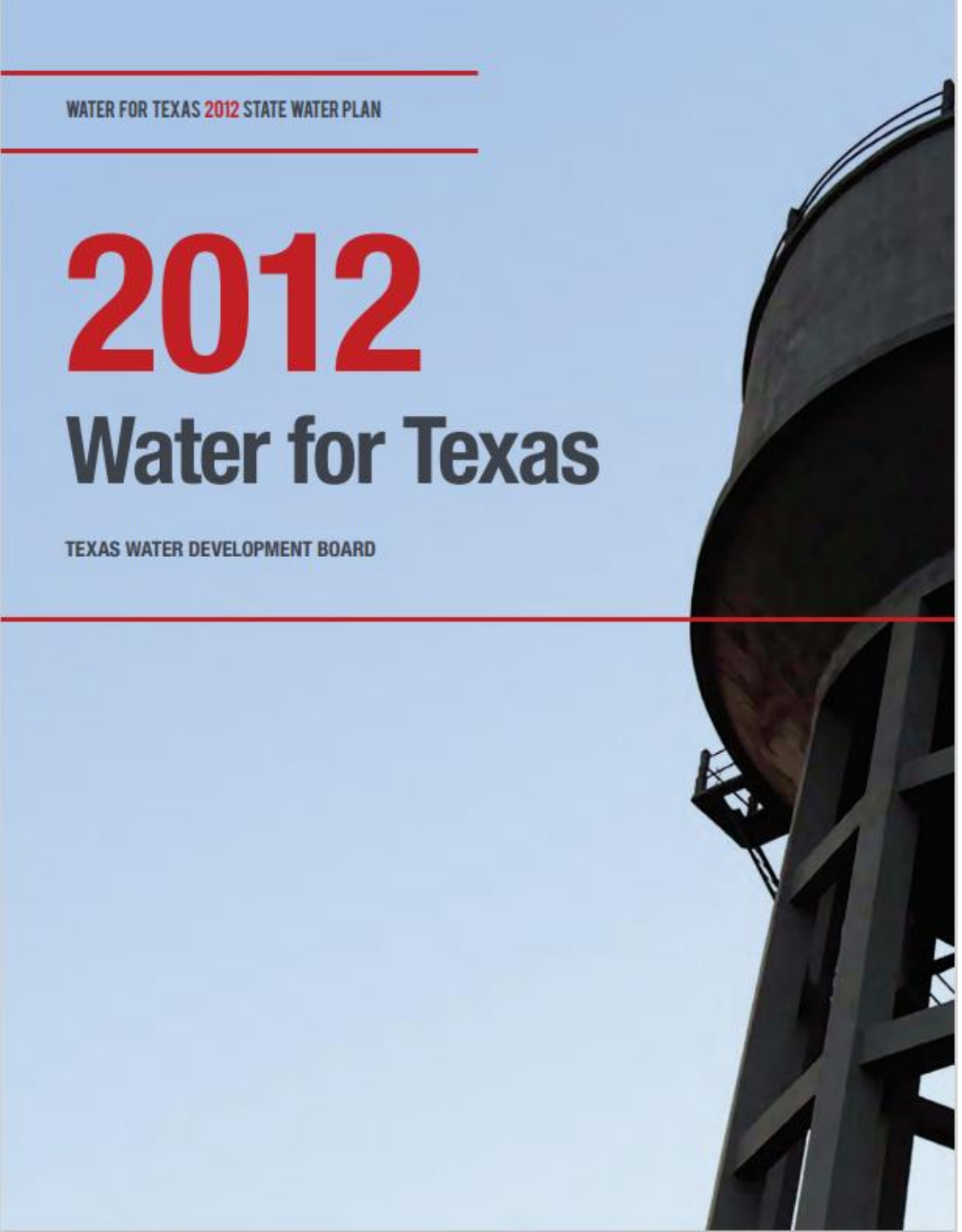
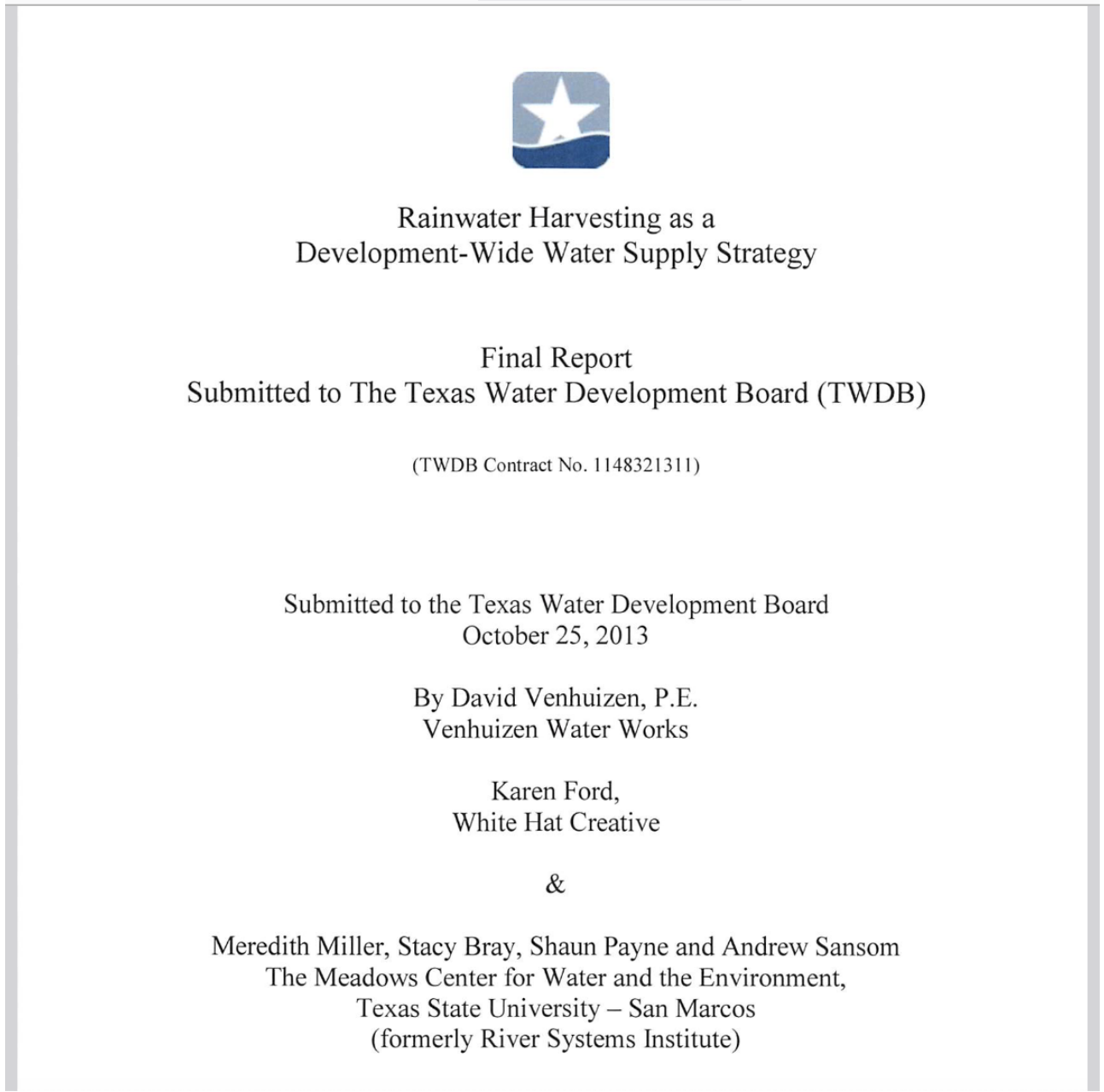
entry drug for rainwater harvesting

Great American Rain Barrel



"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**."

Conserved water needs to be firm.



Rainwater Harvesting as a
Development-Wide Water Supply Strategy

Final Report
Submitted to The Texas Water Development Board (TWDB)

(TWDB Contract No. 1148321311)

Submitted to the Texas Water Development Board
October 25, 2013

By David Venhuizen, P.E.
Venhuizen Water Works

Karen Ford,
White Hat Creative

&

Meredith Miller, Stacy Bray, Shaun Payne and Andrew Sansom
The Meadows Center for Water and the Environment,
Texas State University – San Marcos
(formerly River Systems Institute)

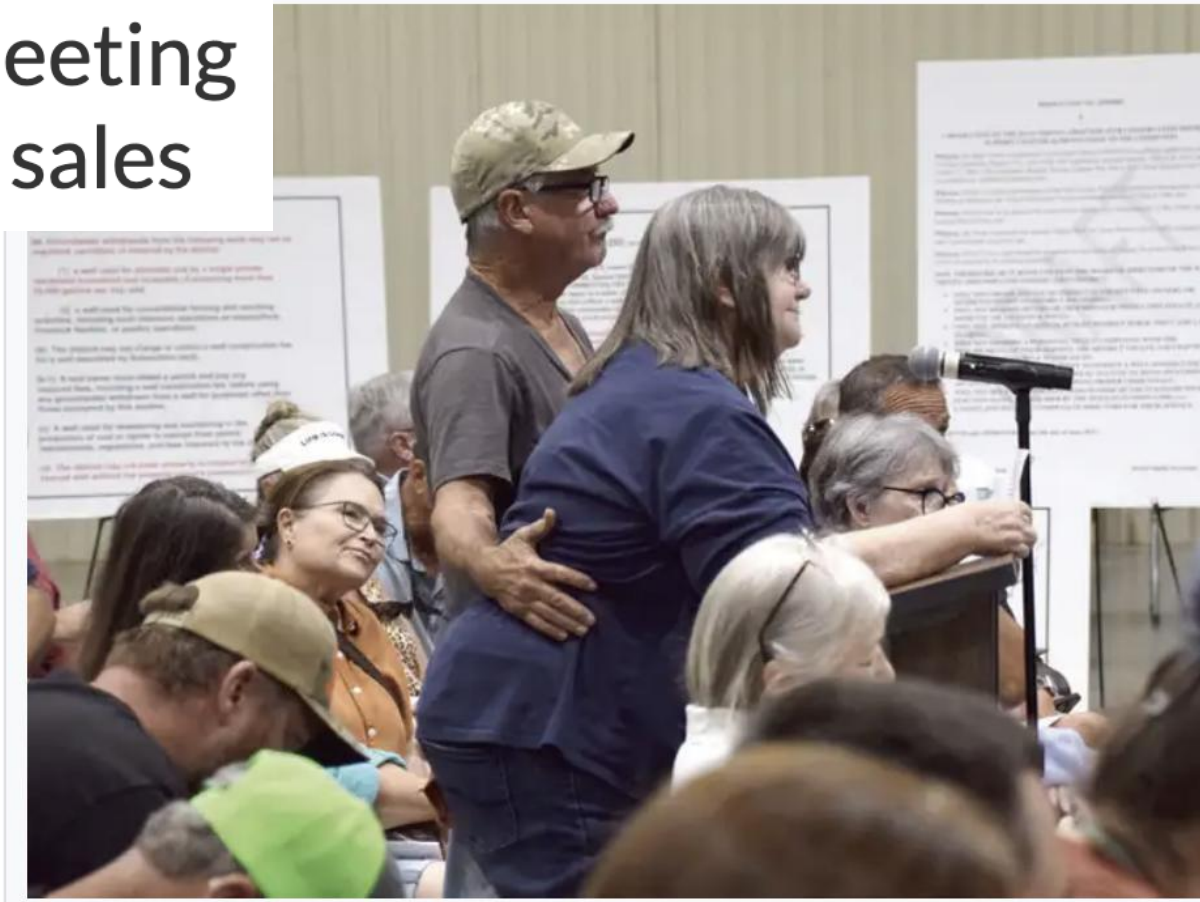
If back-up is required, then the firm yield = 0

a rainwater system with no firm yield is a system designed to fail

Dripping Springs Century News

Laurie Anderson Interim Editor 06/11/2025 08:00 AM

Citizens pour into DSWSC board meeting for discussion on halt of bulk water sales



Residents Craig and Jean Cyrus conclude their comments to the DSWSC boar
ANDERSON


RAINWATER
OR
BUST!!!

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

$$V_{ff} > R * A * C \text{ in which case } V_{ff} = R * A * C \quad (2)$$

not enough rain

$$V_t > V_{tot} \text{ in which case } V_t = V_{tot} \quad (3)$$

total storage of tank

tank full

$$V_t < 0 \text{ in which case } V_t = 0 \quad (4)$$

tank empty

governing equation

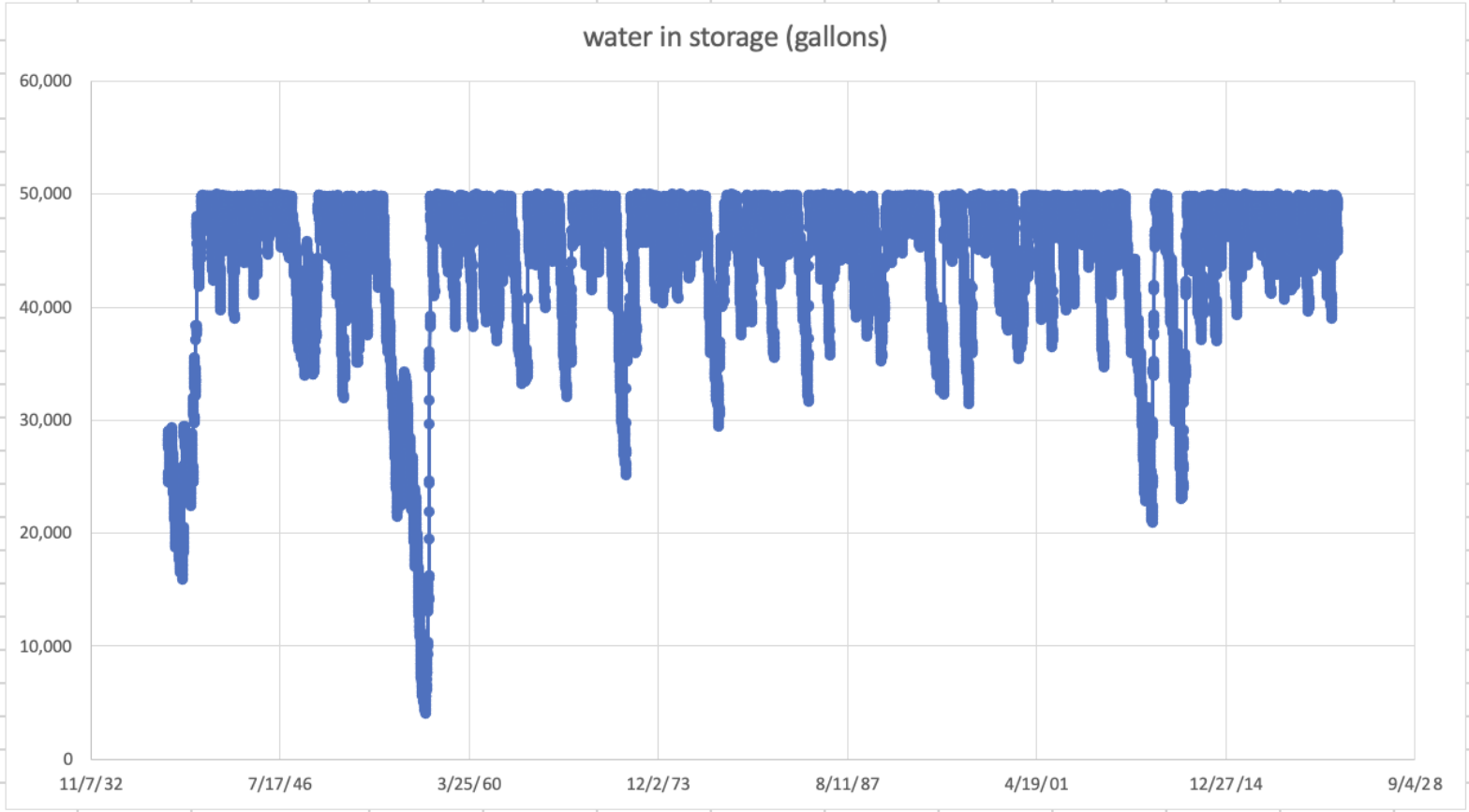
RAINFAL (Rainwater Assessment and Interactive eNumator for Firm-yield Analysis Limits)

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

version: 2025-0528

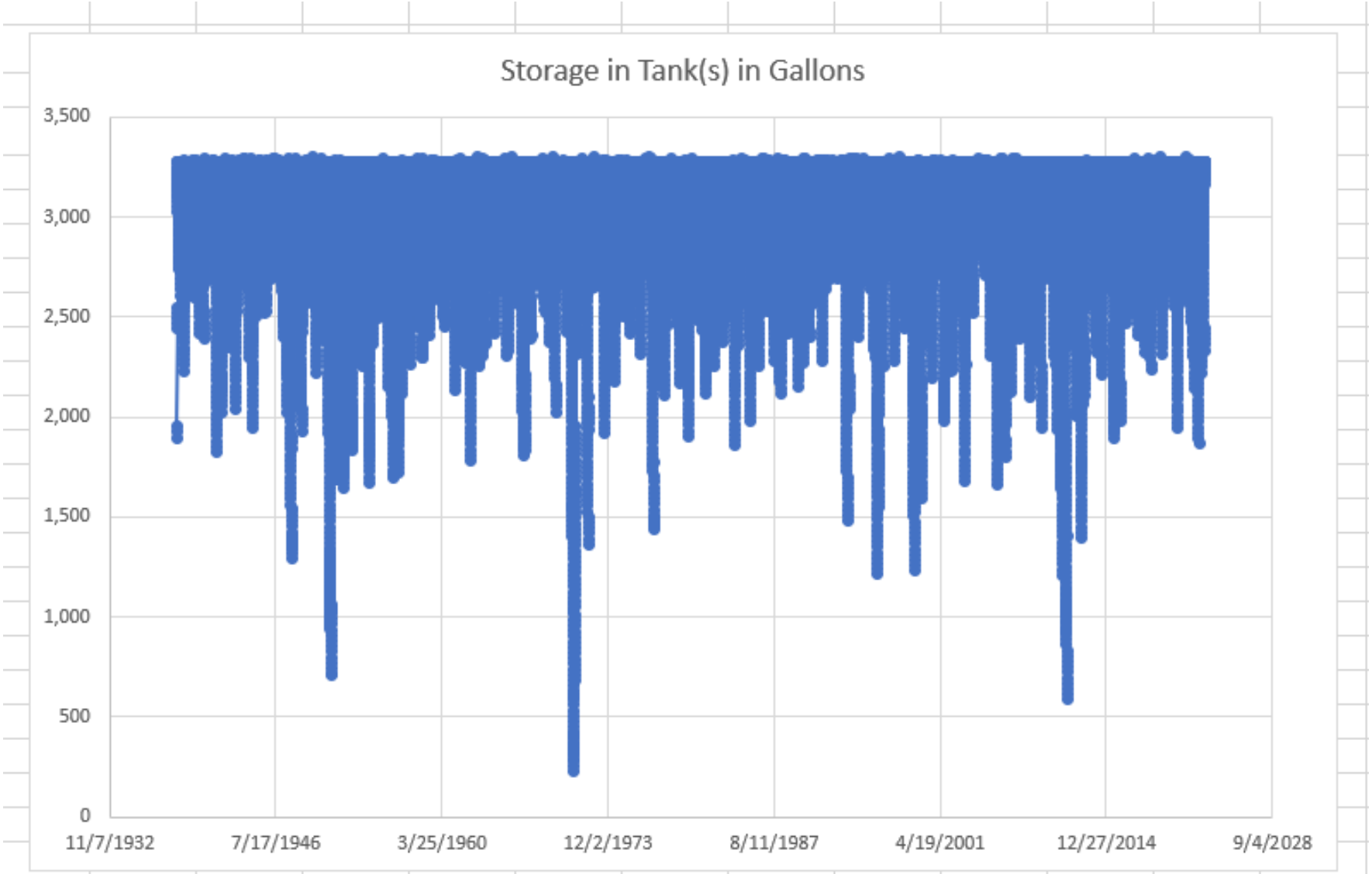
Austin

Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	4,300	ft*ft
Vt	50,000	gallons
daily demand	140	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless
conversions & calculations:		
Vt	**6684.1**	ft*ft*ft
Vff	**5.75**	ft*ft*ft
daily demand	**18.72**	ft*ft*ft per day
starting tank storage	50	percent full
starting tank storage	**3342.0**	ft*ft*ft
dead pool	5	percent full



dead pool storage:	**2500**	gallons
lowest storage:	**4089**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**2,139,143**	gallons

date	precipitation	adjusted precipitation
	inches	inches
6/1/38	0	0



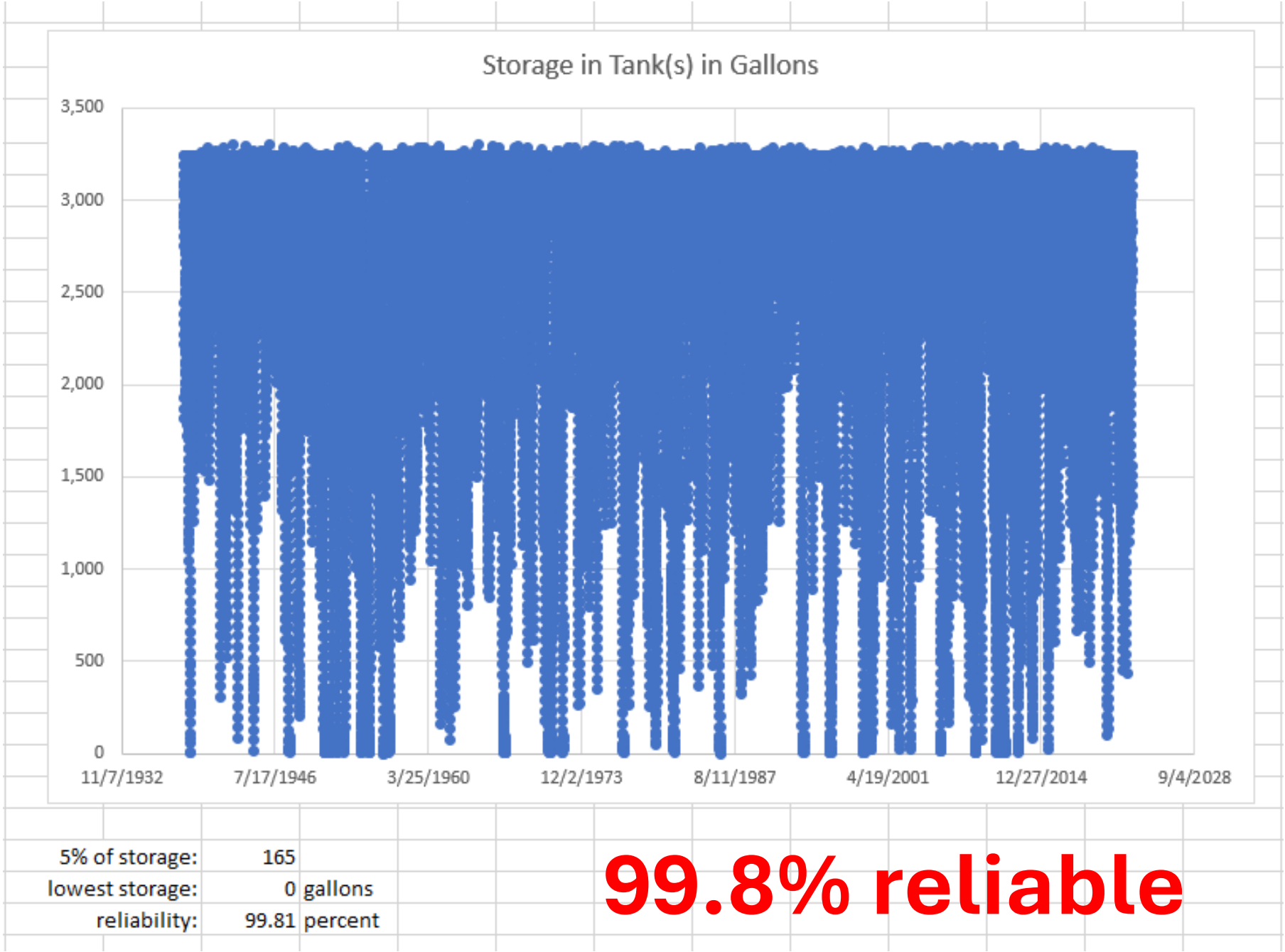
5% of storage:	165	
lowest storage:	228	gallons
reliability:	100.00	percent

100% reliable

Austin

Vt = 3,300 gallons

U = 27.6 gpd



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

99.8% reliable

Austin

Vt = 3,300 gallons
U = 55.2 gpd

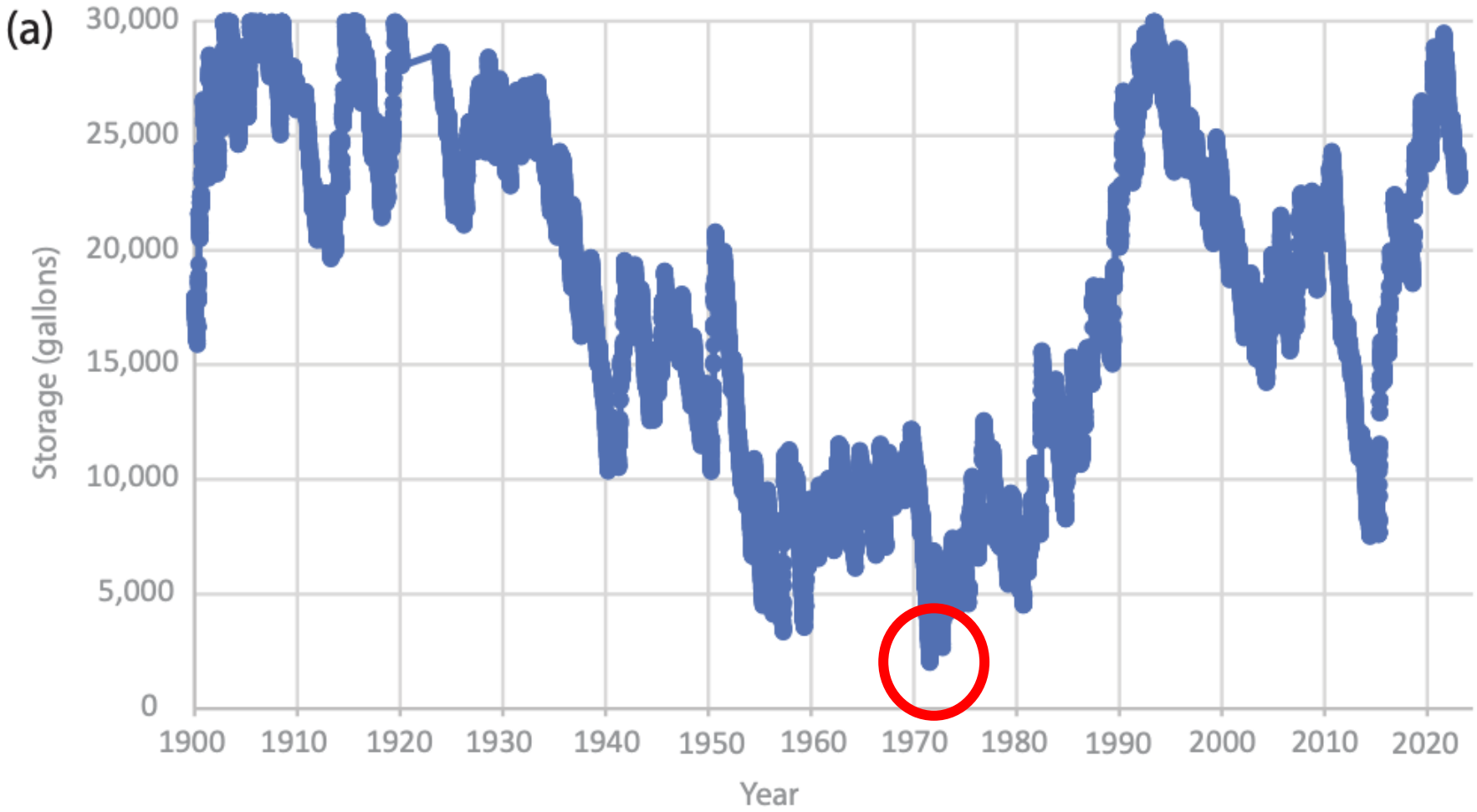
60 dry days

7,340 gallon tank for firm yield

daily v. monthly

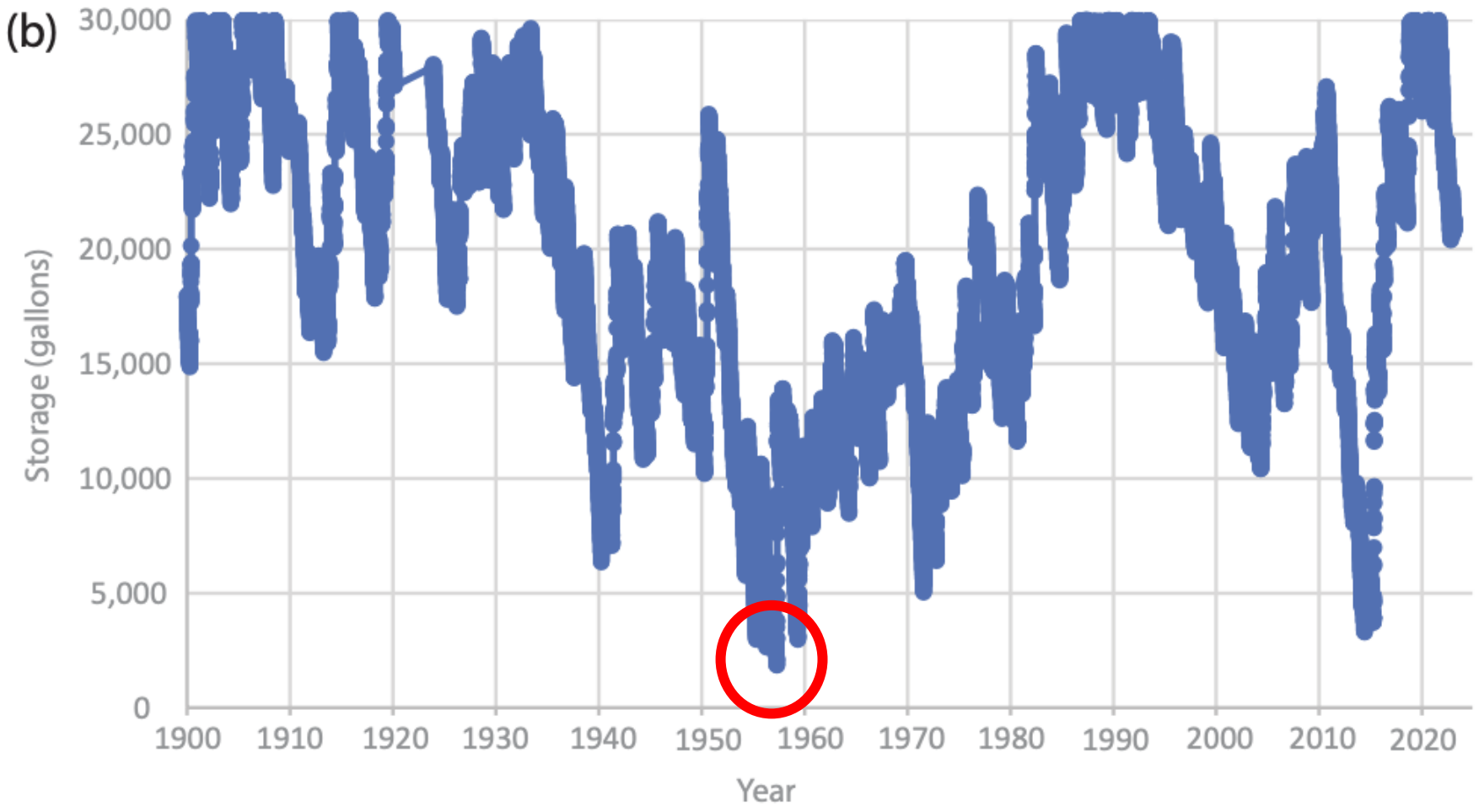
drought of record

different droughts for different spouts!



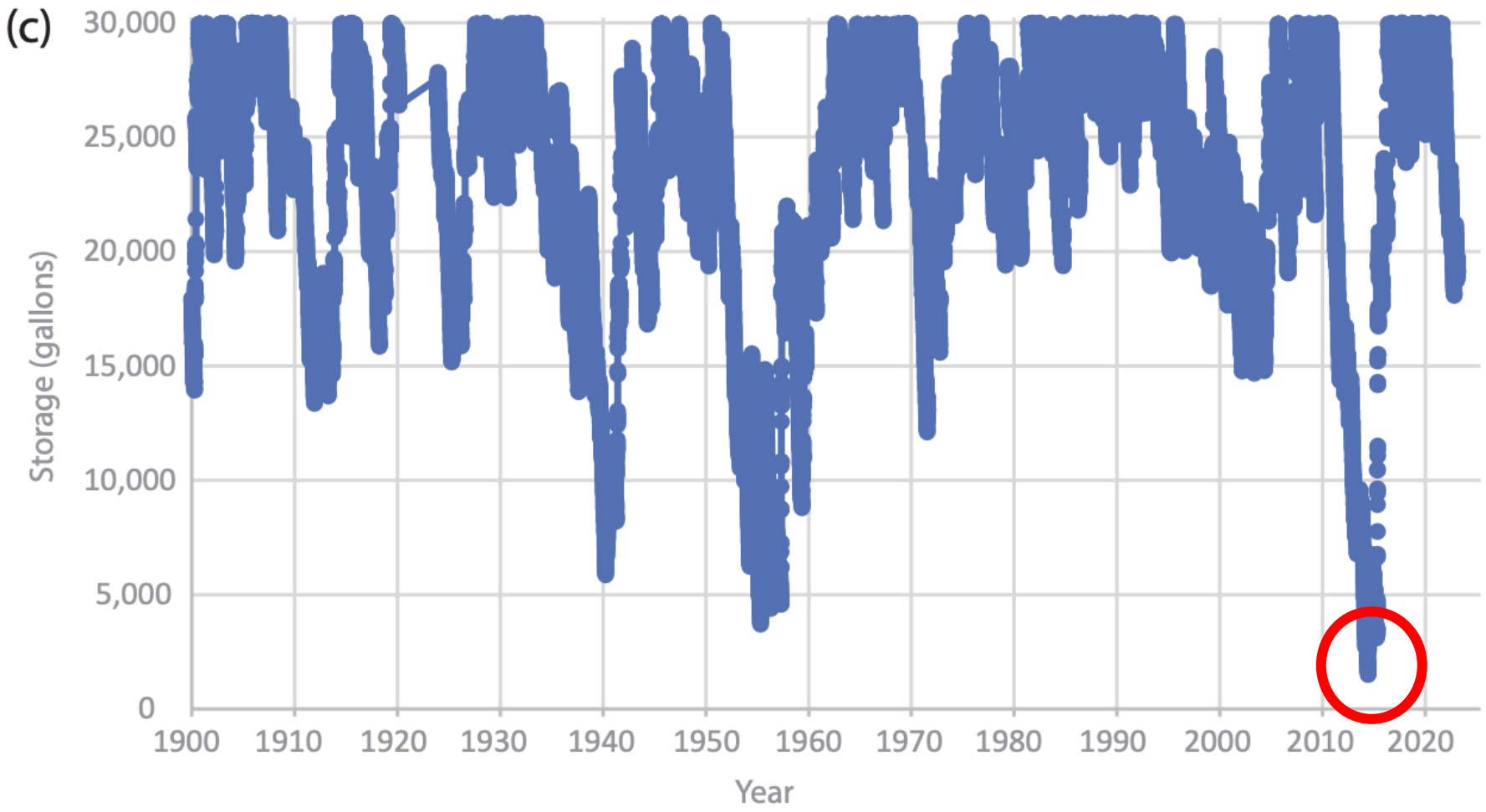
location: Wichita Falls
daily use: 27.6 gallons
(10 gallons per person per day times multiplied by 2.76 people)
catchment: 804 square feet
maximum storage: 30,000 gallons

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

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

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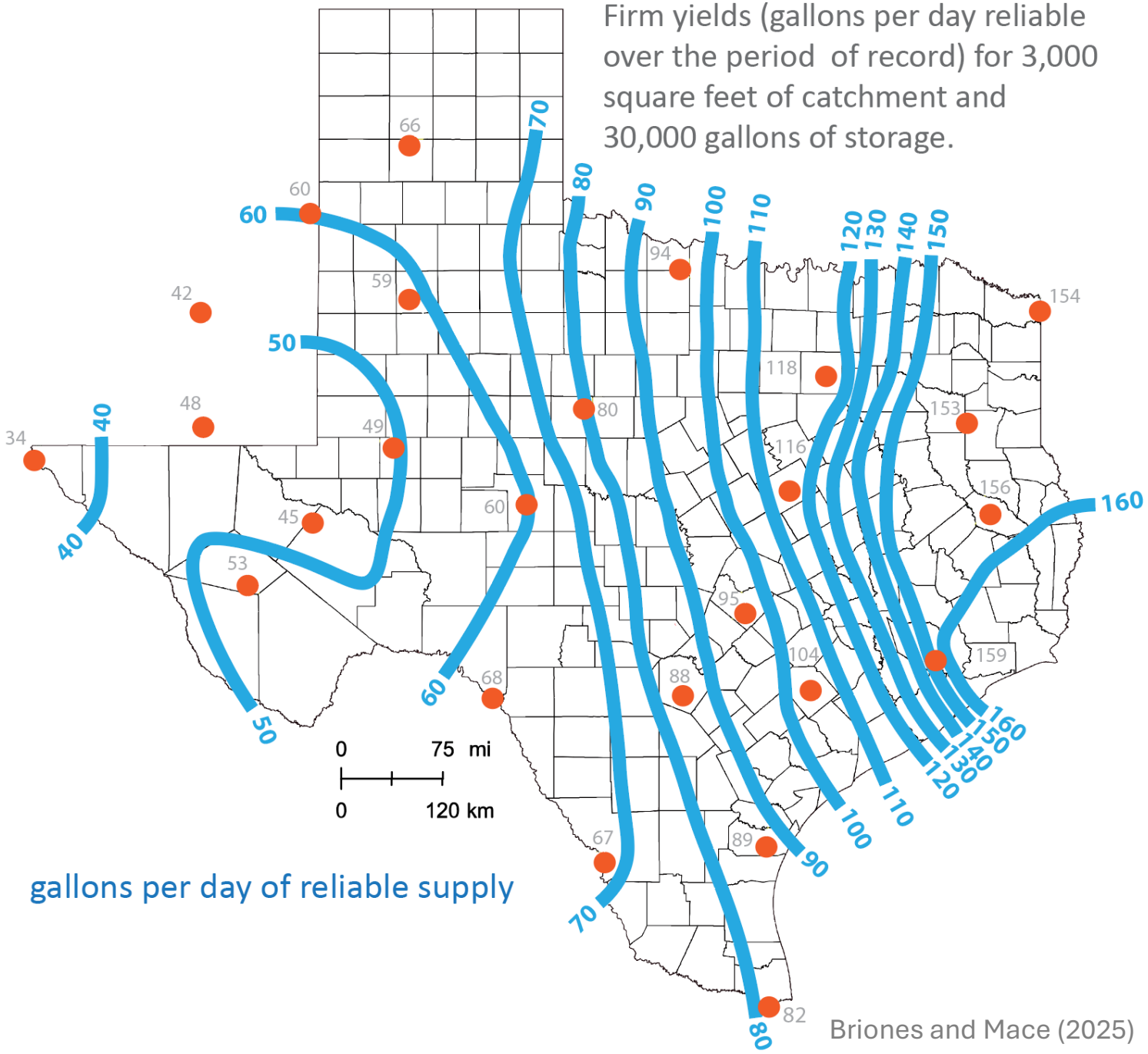
RAINFAL Tool Downloads

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

reliable rainwater harvesting



rainwater works!

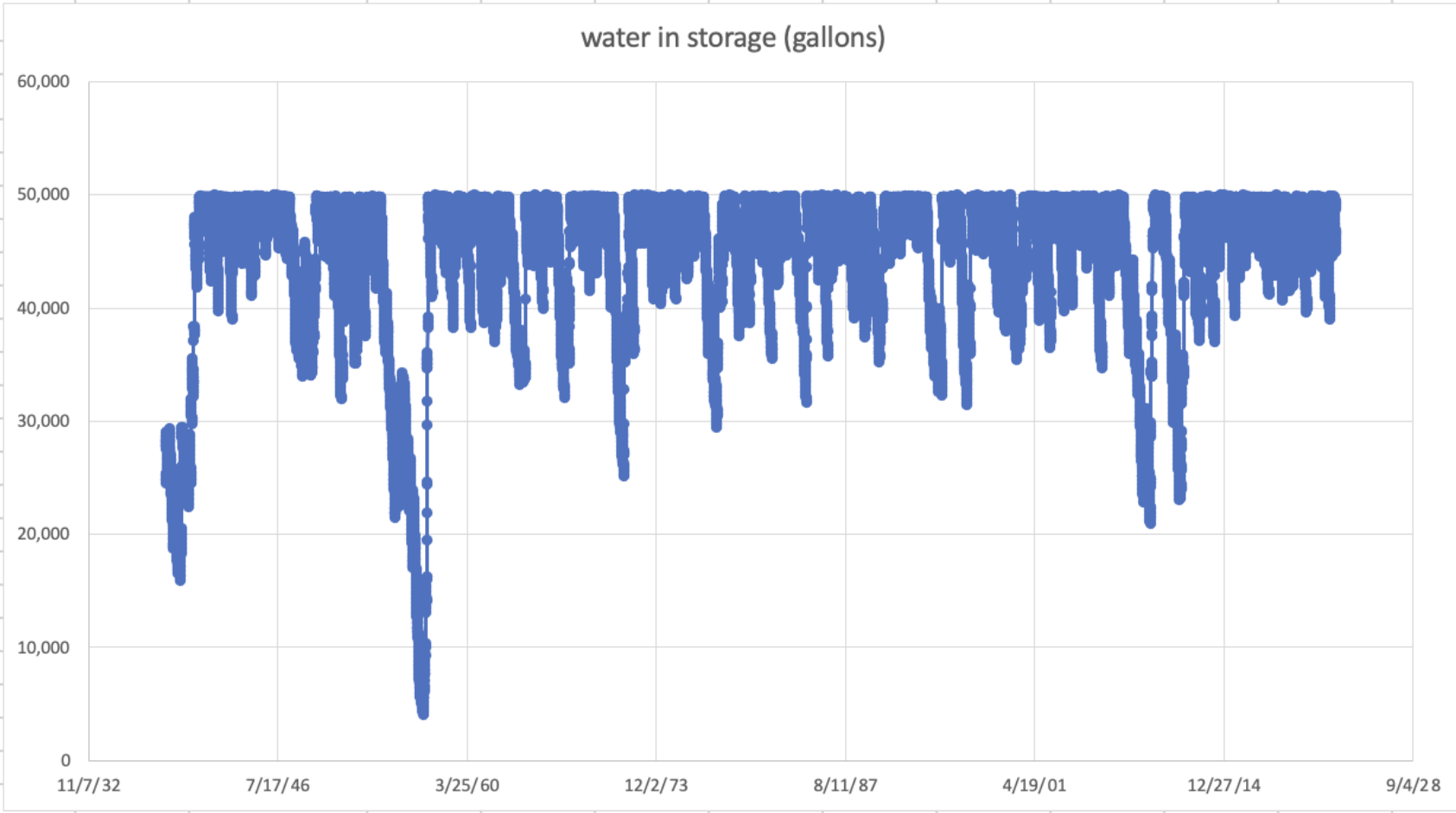
can we make it work in an urban setting?

Urban water needs to be firm.

CASE A

50,000-gallon tank

firm yield: 140 gpd



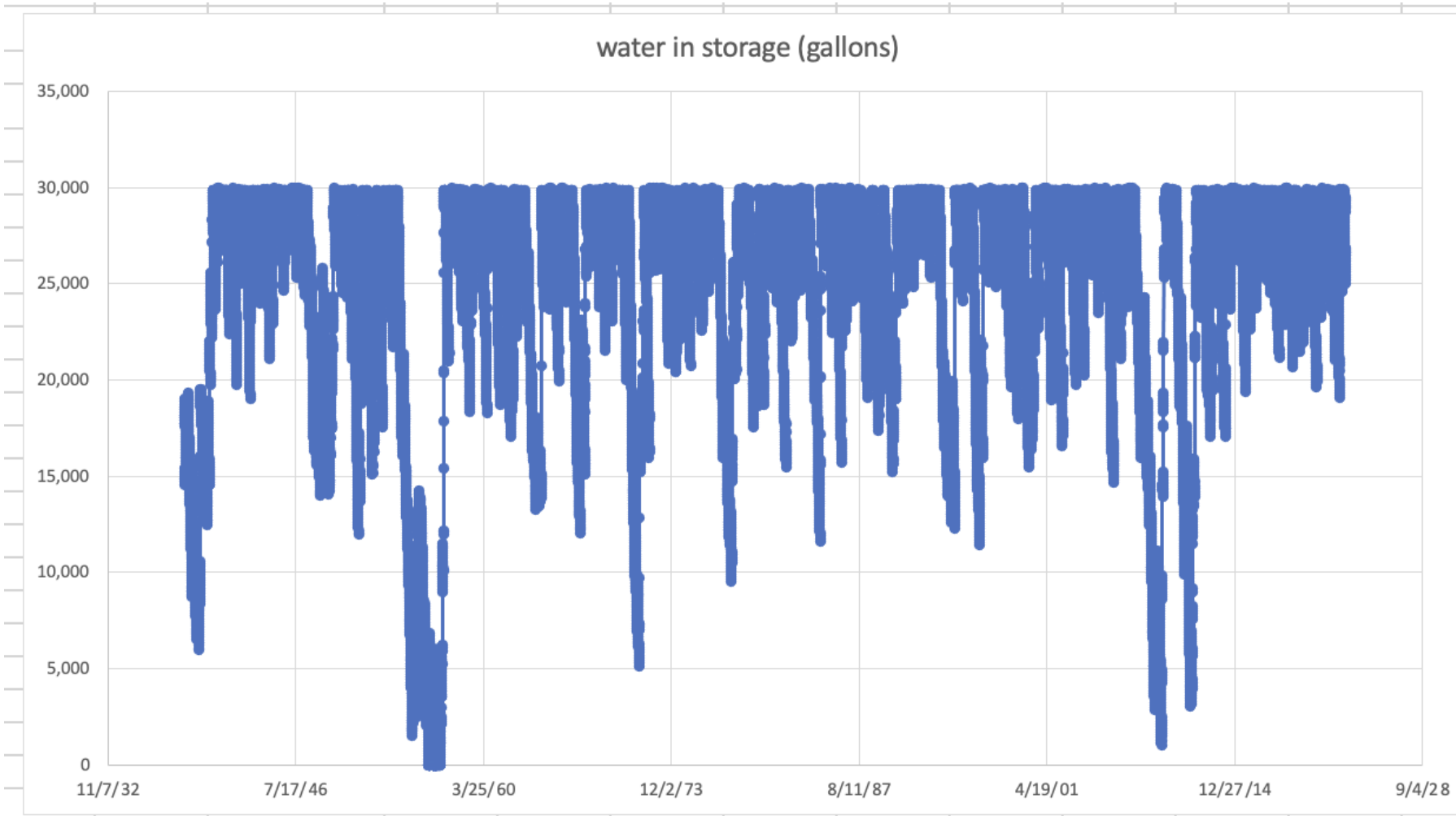
Austin		
Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	4,300	ft*ft
Vt	50,000	gallons
daily demand	140	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless

dead pool storage:	**2500**	gallons
lowest storage:	**4089**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**2,139,143**	gallons

CASE B

30,000-gallon tank

firm yield:
0 gpd



Austin		
Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	4,300	ft*ft
Vt	30,000	gallons
daily demand	140	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless

dead pool storage:	**1500**	gallons
lowest storage:	**0**	gallons
reliability:	**99.62**	percent
days with no water:	**119**	days
overflow:	**2,163,513**	gallons

hypothetical

- city with 1 million people
- existing users depend on surface water
- next 100,000 people depend on rainwater

- rainwater harvesting based on Case A (firm)
- a drought of record hits
- is there enough water for everyone?

- rainwater harvesting based on Case B (unfirm)
- a drought of record hits
- is there enough water for everyone?

hypothetical

- city with 1 million people
- existing users depend on surface water
- next 100,000 people depend on rainwater

- rainwater harvesting based on Case B (unfirm)
- surface-water users conserve enough to cover rainwater users during droughts of record
- what's the benefit?

- rainwater harvesting based on Case B (unfirm)
- surface-water users convert to rainwater and deferred use is used to "save" surface water
- what's the benefit?


challenge # 1

URBAN MODERN HOUSE AUSTIN, TEXAS

PROJECT SUMMARY

0.21 acre urban lot (50' x 180')
3,000 sq-ft roof area
40,000 gallons rainwater harvesting
4 bed / 3.5 bath
3,650 total sq-ft (including garage)

A modernist residence designed in accordance with the City of Austin Design Guidelines, emphasizing compatibility, craftsmanship, sustainability, and integration with the urban context.

DESIGN GUIDELINE COMPLIANCE

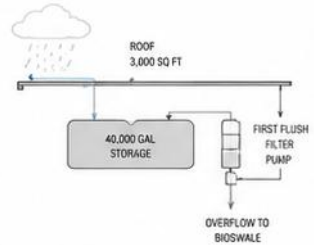
- Compatible scale and massing
- Setbacks and step-backs to reduce impact
- High-quality, durable materials
- Native & adaptive landscaping
- Rainwater harvesting & water efficiency
- Energy-efficient design
- Privacy & outdoor living oriented to interior lot

RAINWATER HARVESTING

3,000 sq-ft roof area
x 1.34 gal/sq-ft/in (Austin rainfall)
x 10 in/year (design capture)
= 40,200 gallons/year captured

SYSTEM

40,000 gallon total storage
(Two 20,000 gallon below-grade tanks)
First flush diverter
Leaf screens
Filter
Pump to house (non-potable uses)
Overflow to bioswale



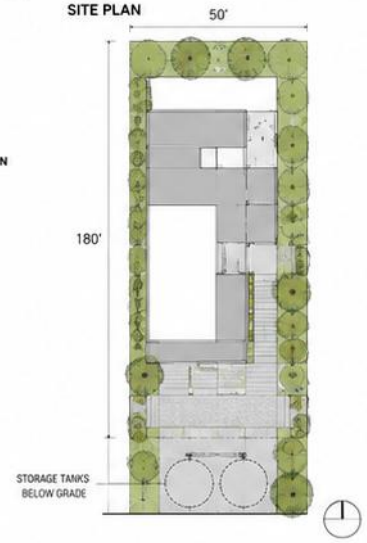
FIRST FLOOR PLAN

1 Entry
2 Living
3 Dining
4 Kitchen
5 Pantry
6 Powder
7 Guest Room
8 Bath
9 Garage
10 Outdoor Living

SECOND FLOOR PLAN

11 Primary Suite
12 Primary Bath
13 Closet
14 Bedroom
15 Bedroom
16 Bath
17 Laundry
18 Flex / Office
19 Balcony

SITE PLAN

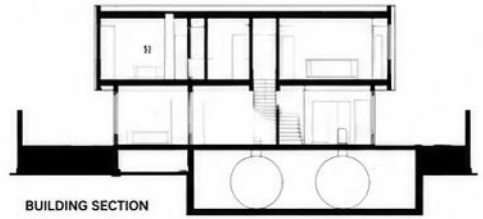


MATERIALS

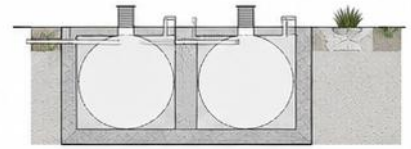
1 Smooth stucco
2 Board-formed concrete
3 Dark metal panel
4 Vertical wood screen
5 Low-E glazing, black frames
6 Exposed steel

PERSPECTIVE

FRONT ELEVATION



BUILDING SECTION



TANK SECTION (BELOW GRADE)

TANK SPECIFICATIONS

Capacity: 40,000 gallons total
Configuration: (2) 20,000 gal tanks
Material: Concrete
Location: Below grade, rear yard
Use: Irrigation, toilet flushing, cooling tower (future), general non-potable uses

WATERWISE MODERN HOUSE

AUSTIN, TEXAS

SUSTAINABLE LIVING | URBAN LOT DESIGN | RAINWATER HARVESTING

PROJECT SUMMARY

0.21 acre urban lot (50' x 180')
3,000 sq-ft roof area
40,000 gallons rainwater harvesting
4 bed / 3.5 bath
3,650 total sq-ft (including garage)

A modern residence designed in accordance with the City of Austin Design Guidelines, integrating rainwater harvesting as a visible and celebrated feature.

RAINWATER HARVESTING

3,000 sq-ft roof area
x 1.34 gal/sq-ft/in (Austin rainfall)
x 10 in/year (design capture)
= ~40,200 gallons/year captured

SYSTEM

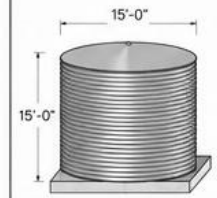
40,000 gallon total storage
(Two 20,000 gallon tanks)
First flush diverter
Leaf screens
Filter
Pump to house (non-potable uses)
Overflow to bioswale

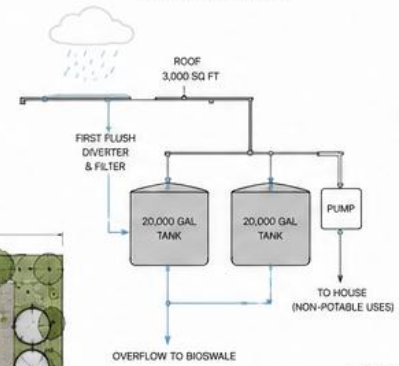
TANK SPECIFICATIONS

Each Tank (2 total)
Capacity: 20,000 gallons
Diameter: 15 ft
Height: 15 ft
Material: Corrugated steel
Configuration: Above grade
Location: Side yard, screened
Use: Irrigation, toilet flushing, cooling tower (future), general non-potable uses

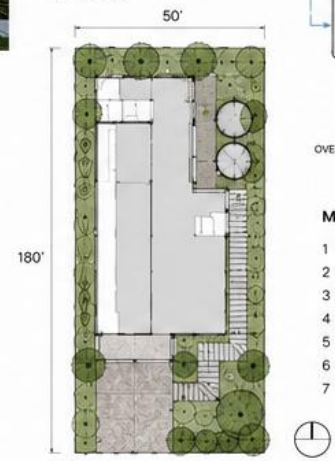
TANK DIMENSIONS (EACH)

Diameter = 15 ft
Height = 15 ft





SITE PLAN



FIRST FLOOR PLAN

1 Entry
2 Living
3 Dining
4 Kitchen
5 Pantry
6 Powder
7 Guest Room
8 Bath
9 Garage
10 Outdoor Living

SECOND FLOOR PLAN

11 Primary Suite
12 Primary Bath
13 Closet
14 Bedroom
15 Bedroom
16 Bedroom
17 Laundry
18 Flex / Office
19 Balcony

MATERIALS

1 Smooth stucco
2 Board-formed concrete
3 Vertical wood screen
4 Black steel windows
5 Corrugated steel tanks
6 Exposed steel
7 Wood soffit

SIDE YARD – TANKS

FRONT ELEVATION

BUILDING SECTION

TANK ELEVATION (SIDE YARD)

OUTDOOR LIVING

AUSTIN RAINWATER HOUSE

SUSTAINABLE DESIGN | RAINWATER HARVESTING | URBAN LIVING

PROJECT SUMMARY

0.21 acre urban lot (50' x 180')
3,000 sq-ft roof area
40,000 gallons rainwater harvesting
4 bed / 3.5 bath
3,100 total sq-ft (including garage)

A modern residence designed in accordance with the City of Austin Design Guidelines, integrating rainwater harvesting as a visible and celebrated feature.

RAINWATER HARVESTING

3,000 sq-ft roof area
x 1.34 gal/sq-ft/in (Austin rainfall)
x 10 in/year (design capture)
= ~40,200 gallons/year captured

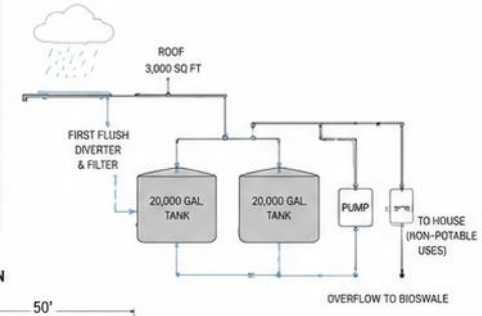
SYSTEM

40,000 gallon total storage
(Two 20,000 gallon tanks)
First flush diverter
Leaf screens
Filter
Pump to house (non-potable uses)
Overflow to bioswale

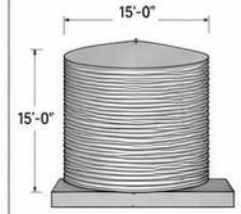
TANK SPECIFICATIONS

Capacity: 20,000 gallons (each)
Total: 40,000 gallons
Diameter: 15 ft
Height: 15 ft
Material: Stainless steel
Configuration: Above grade, under house
Location: Under house (on concrete pad)
Use: Irrigation, toilet flushing, cooling tower (future), general non-potable uses

RAINWATER SYSTEM DIAGRAM



TANK DIMENSIONS (EACH)



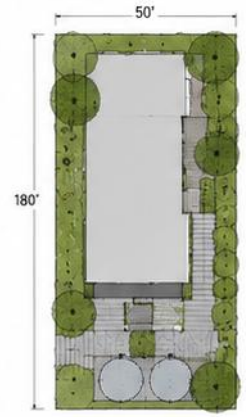
FIRST FLOOR PLAN

1 Entry
2 Living
3 Dining
4 Kitchen
5 Pantry
6 Powder
7 Guest Room
8 Bath
9 Garage
10 Outdoor Living
11 Stairs

SECOND FLOOR PLAN

12 Primary Suite
13 Primary Bath
14 Closet
15 Bedroom
16 Bedroom
17 Bath
18 Laundry
19 Flex / Office
20 Balcony

SITE PLAN



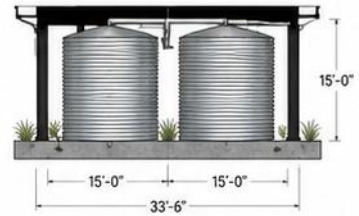
MATERIALS

1 Board-formed concrete
2 Vertical wood screen
3 Corrugated metal panel
4 Black steel
5 Low-E glazing
6 Stainless steel
7 Exposed steel

FRONT ELEVATION

BUILDING SECTION

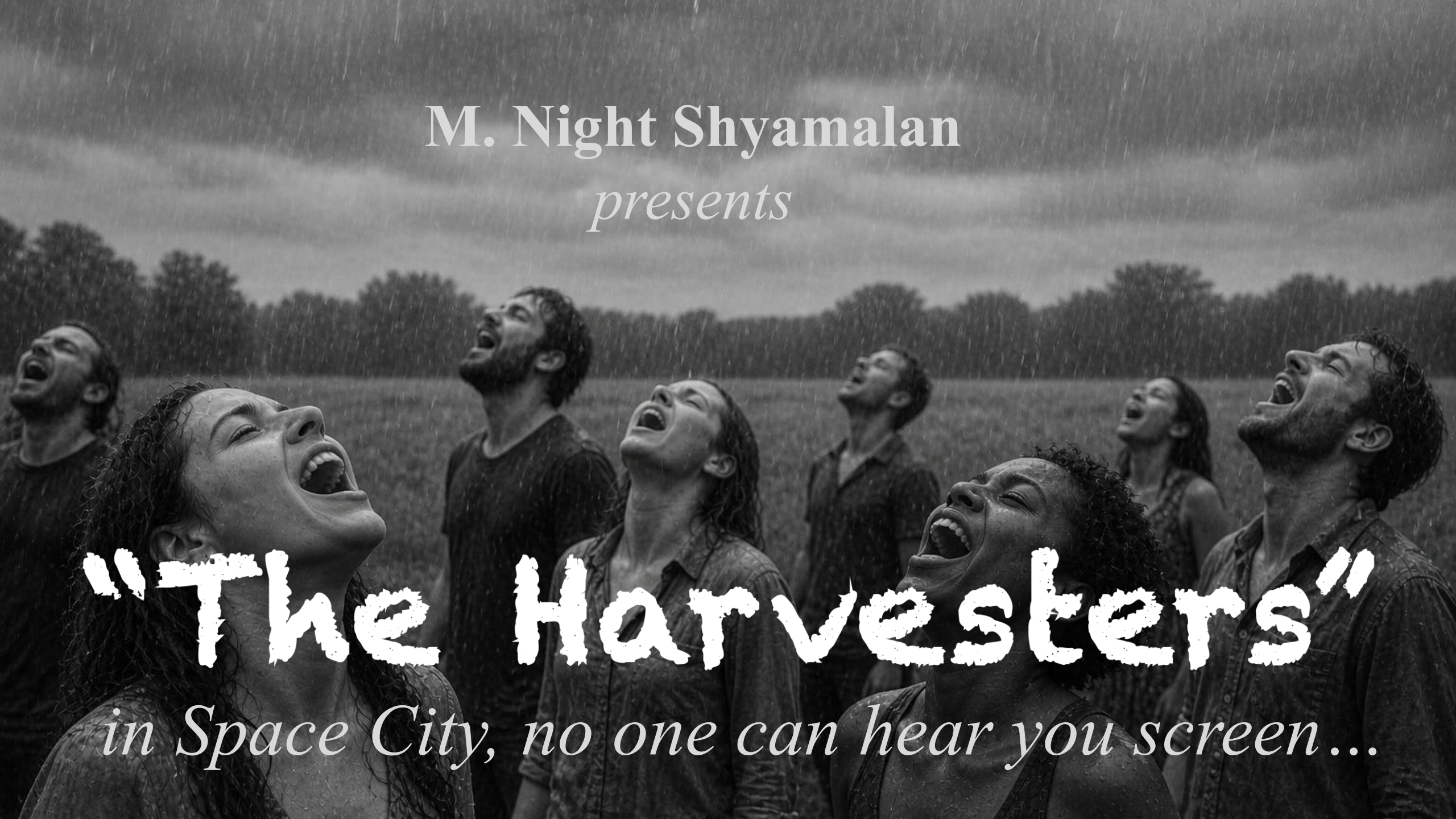
SIDE ELEVATION



TANK SECTION (UNDER HOUSE)

STORAGE UNDER HOUSE

- 2 Stainless steel tanks
- 20,000 gallons each
- Total: 40,000 gallons
- Above grade, not buried
- Located under living area
- Protected from sun
- Easy access for cleaning and maintenance


M. Night Shyamalan
presents
"The Harvesters"
in Space City, no one can hear you screen...

challenge # 2

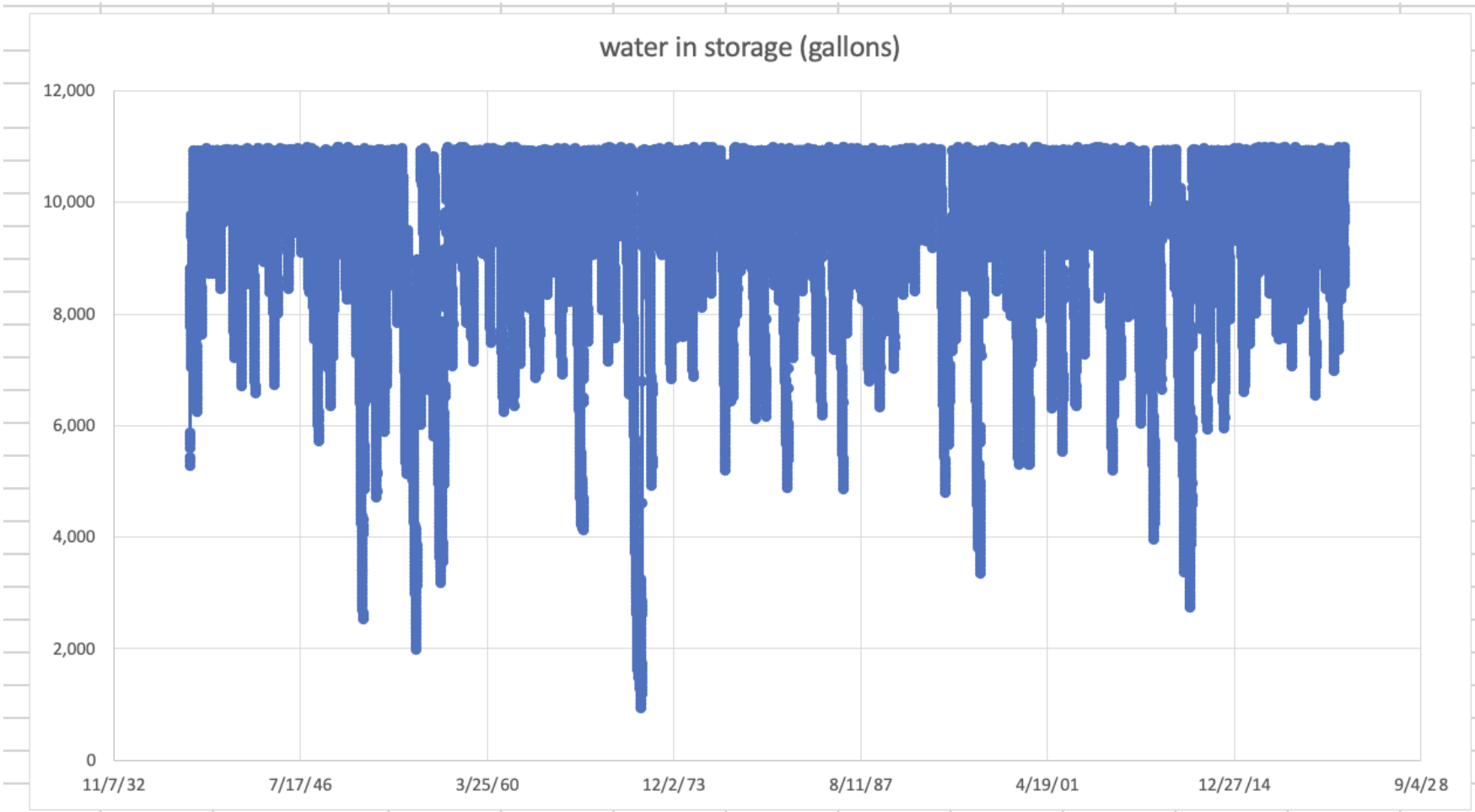
what uses the most water in your home?

averages for U.S.

AWWARF (1999) via EPA (2025)

11,000-gallon tank

firm yield: 70 gpd

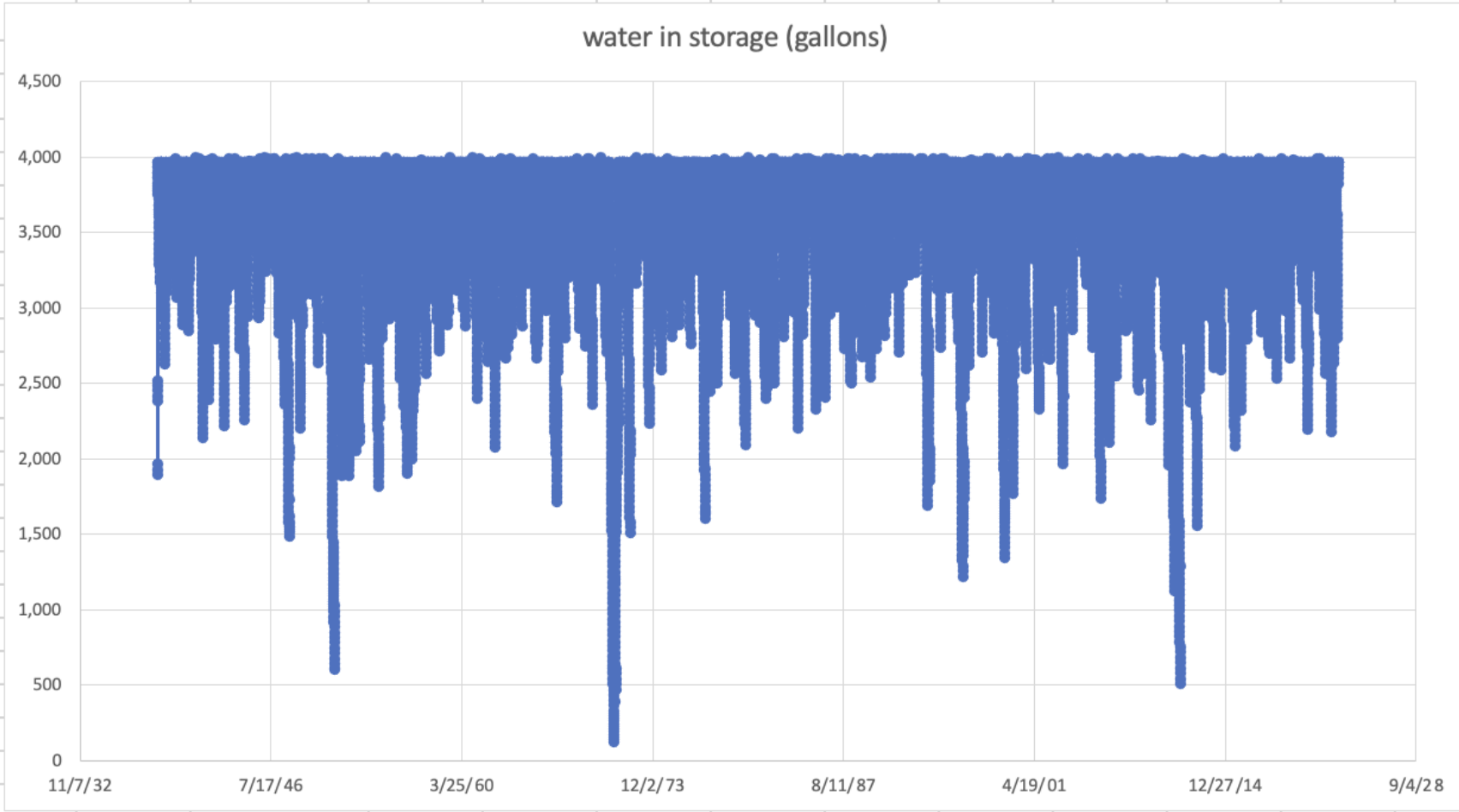


Austin		
Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	3,000	ft*ft
Vt	11,000	gallons
daily demand	70	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless

dead pool storage:	**550**	gallons
lowest storage:	**936**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**2,338,055**	gallons

4,000-gallon tank

firm yield: 35 gpd

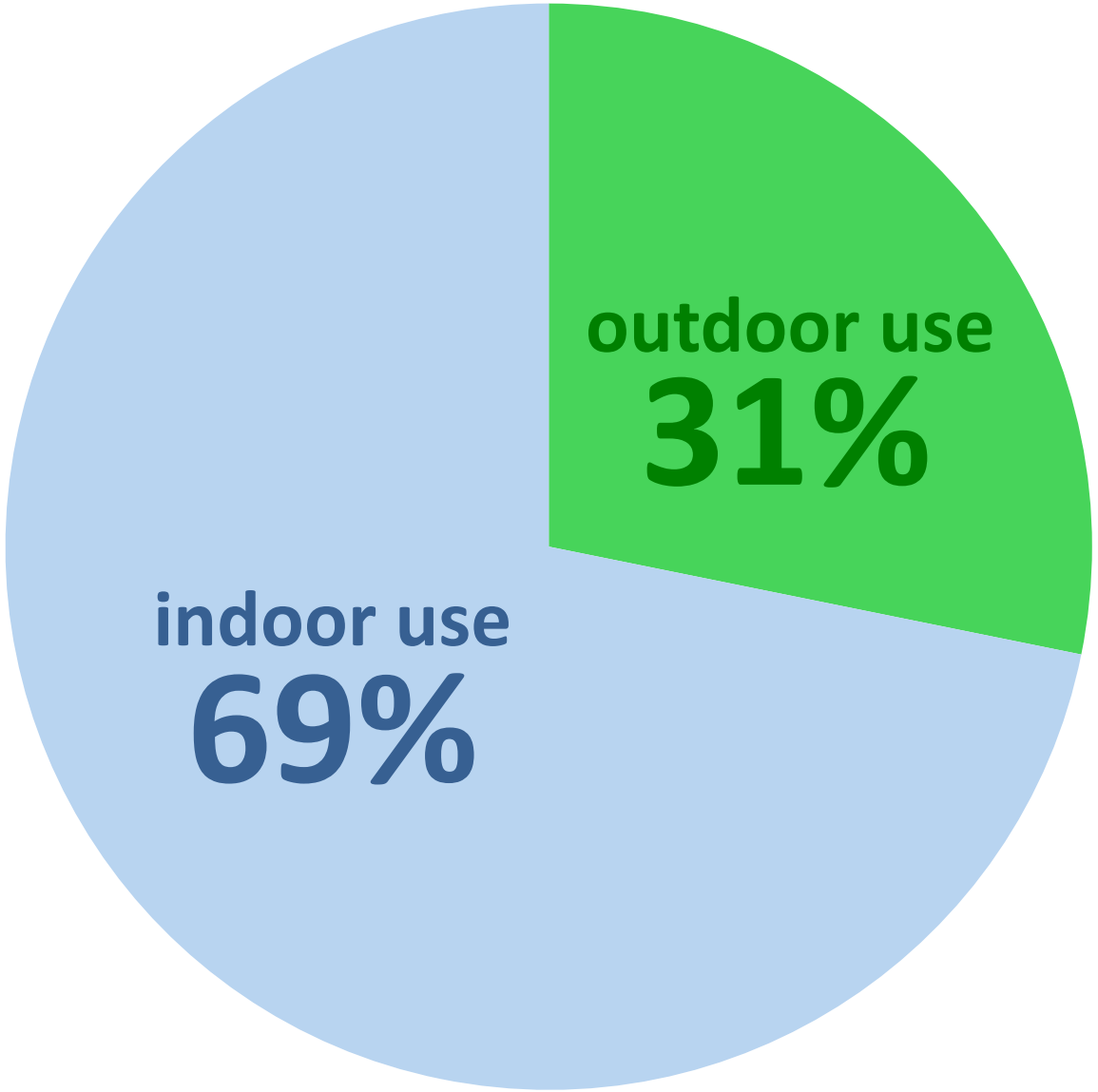


Austin		
Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	3,000	ft*ft
Vt	4,000	gallons
daily demand	35	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless

dead pool storage:	**200**	gallons
lowest storage:	**122**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**3,450,166**	gallons


challenge # 3

Texas residential water use

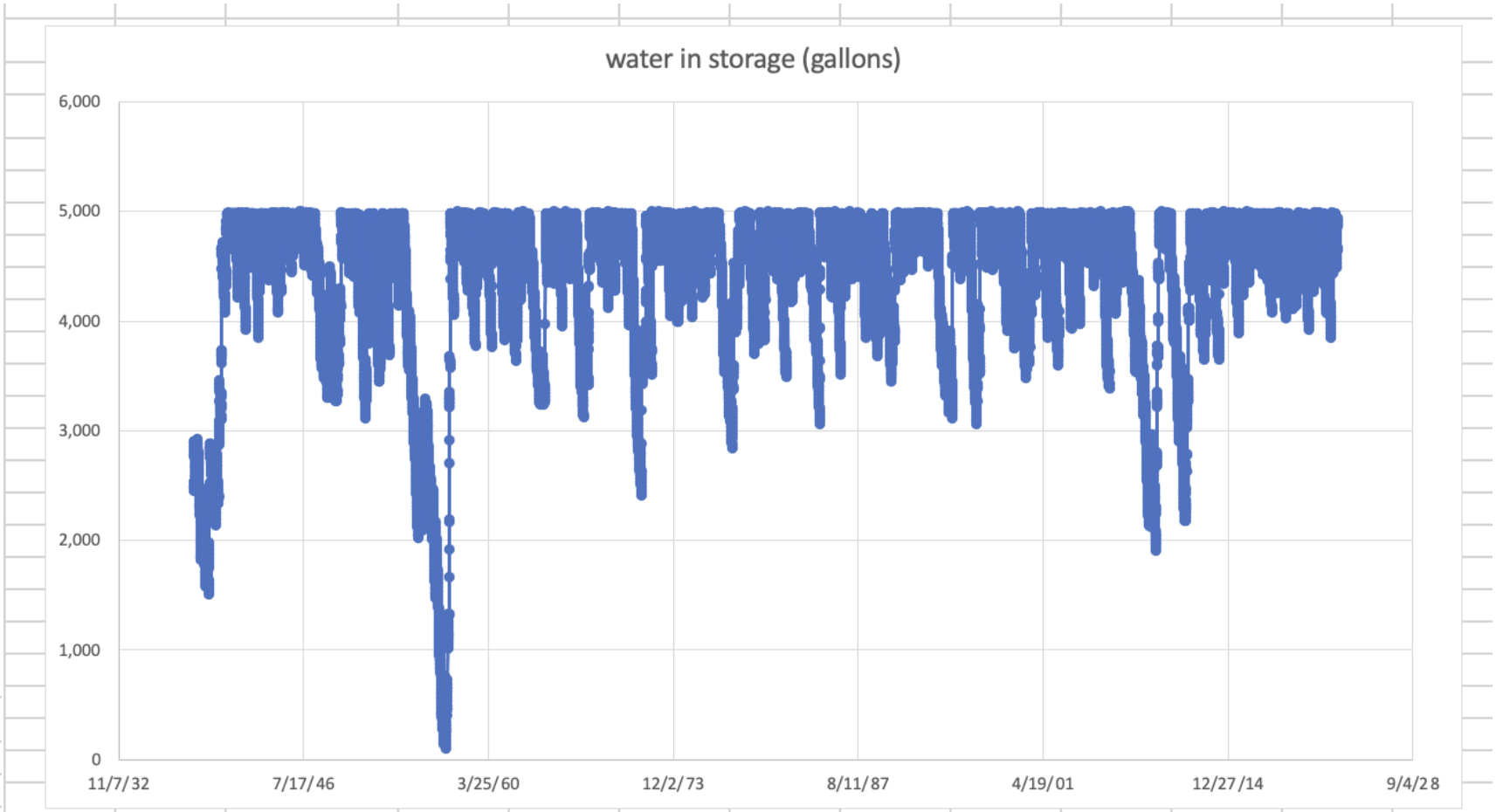


Average household water use in Texas:
~95 gallons per person per day
(today ~85)

Hermitte and Mace (2012) and WCAC (2024)

5,000-gallon tank

firm yield: 14.5 gpd



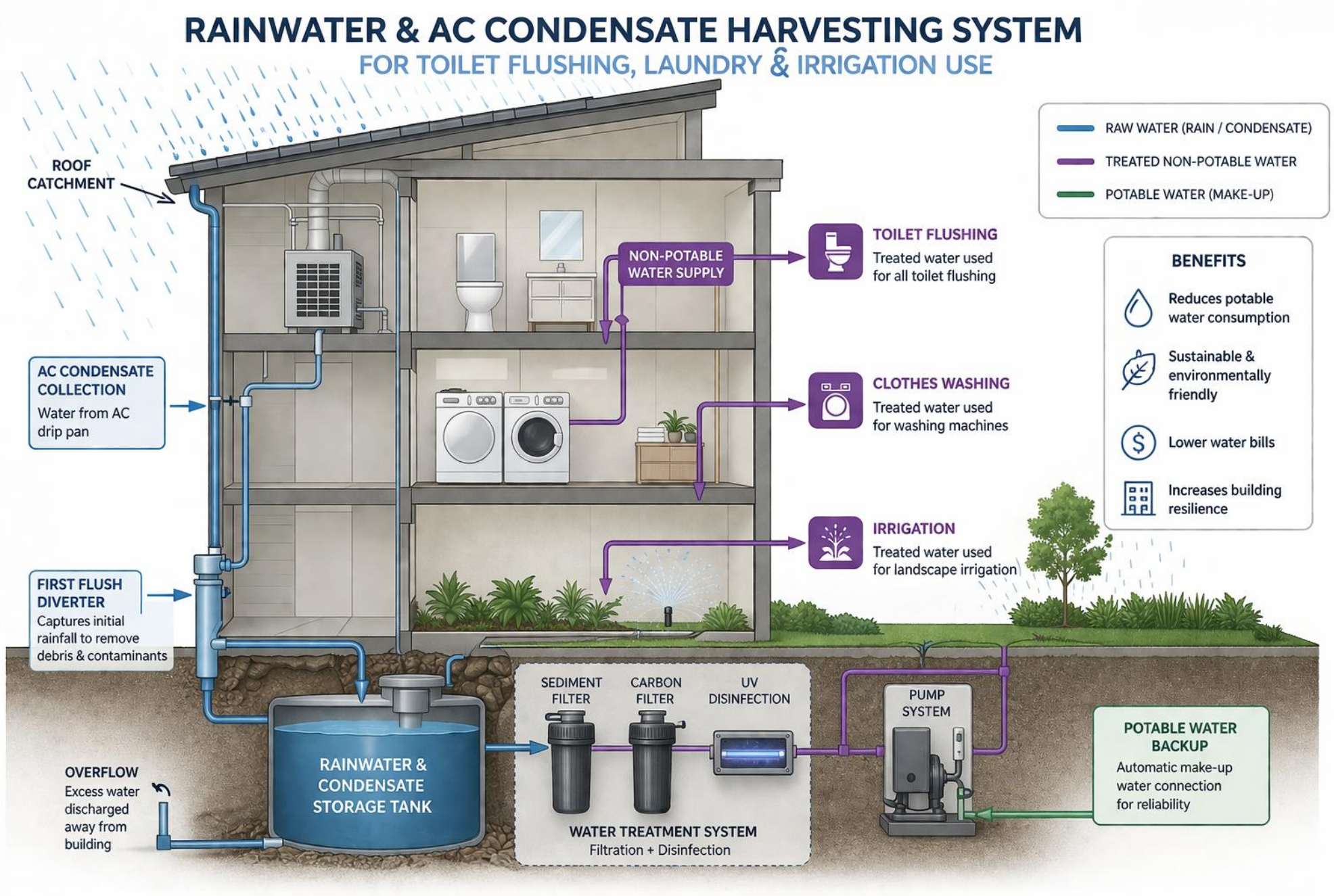
Austin		
Weather station:	Camp Mabry	
user-adjusted parameters:		
Ar	440	ft*ft
Vt	5,000	gallons
daily demand	14.5	gallons per day
runoff coefficient	0.92	unitless
precip adjuster	1	unitless

dead pool storage:	**250**	gallons
lowest storage:	**100**	gallons
reliability:	**100.00**	percent
days with no water:	**0**	days
overflow:	**213,719**	gallons


RAIN
FALLS ON ROOF
WATER FROM ROOF
OVERFLOW
FROM TANK 1
TANK 1
PRIMARY TANK
Receives water directly from roof
TANK 2
SECONDARY TANK
Receives overflow from Tank 1
TANK 1 FUNCTION
• Captures and stores rainwater
• Primary storage
• Overflows to Tank 2
• Used for non-potable and/or potable needs
TANK 2 FUNCTION
• Stores overflow from Tank 1
• Provides additional storage capacity
• Used for non-potable needs (e.g. irrigation)
• Helps manage heavy rainfall events

RAINWATER & AC CONDENSATE HARVESTING SYSTEM

FOR TOILET FLUSHING, LAUNDRY & IRRIGATION USE




challenge # 4

cost of water per acre-foot

- $ 431: Indirect reuse
- $ 536: Groundwater wells
- $ 540: New major reservoir
- $ 556: Municipal conservation
- $ 632: Aquifer storage and recovery
- $1,157: Groundwater desalination
- $1,477: Direct potable resue
- $1,798: Seawater desalination

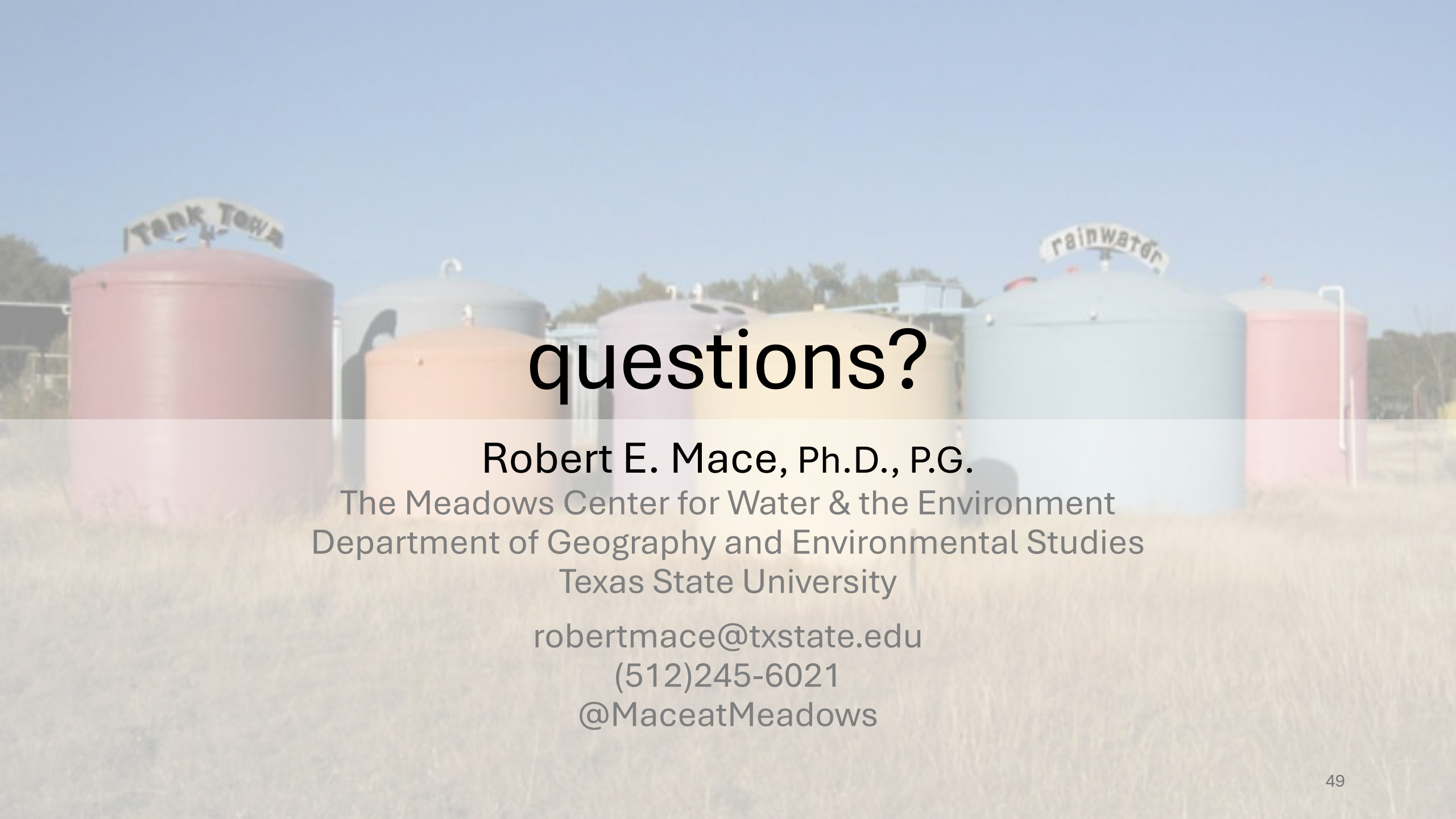
$15,000 to 30,000: Rainwater harvesting (but…)

2022 State Water Plan, RWH # by me


WATER BILL
TOTAL DUE
$4,732.68
MAYOR

to conclude…

- rainwater can be firm (download RAINWATR!)
- rainwater as a “real” water supply needs to be firm
- size can be managed with offsetting lower-volume uses
- maybe rainwater shouldn’t provide potable use in urban settings
- tradwatering is hopeless for rainwater; but outdoor source-supply use can be eliminated with a combo of xeriscaping and rainwater
- rainwater is expensive, but costs can be transferred to homeowners
- appropriately applied rainwater can help urban areas solve their water challenges



questions?

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