The City of Waco

Beautify the Brazos

Lessoned Learned After Two-Years of Synoptic Citizen Sampling

01.11.2024

AGENDA

City of Waco Phase I MS4

Phase I vs Phase II: Public Outreach and Participation

Beautify the Brazos Project

Data Manipulation and Visualization

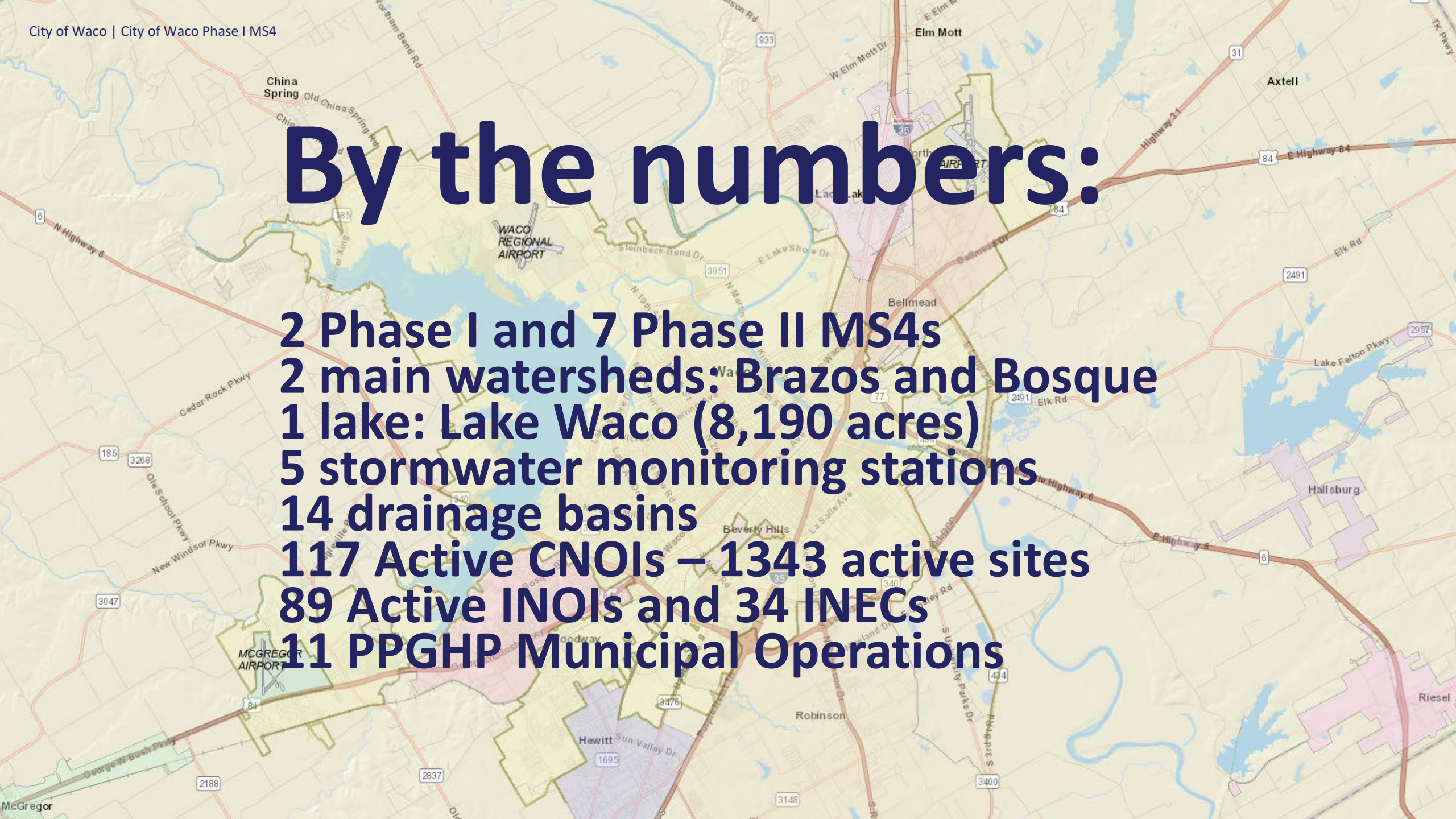
Successes and Failures

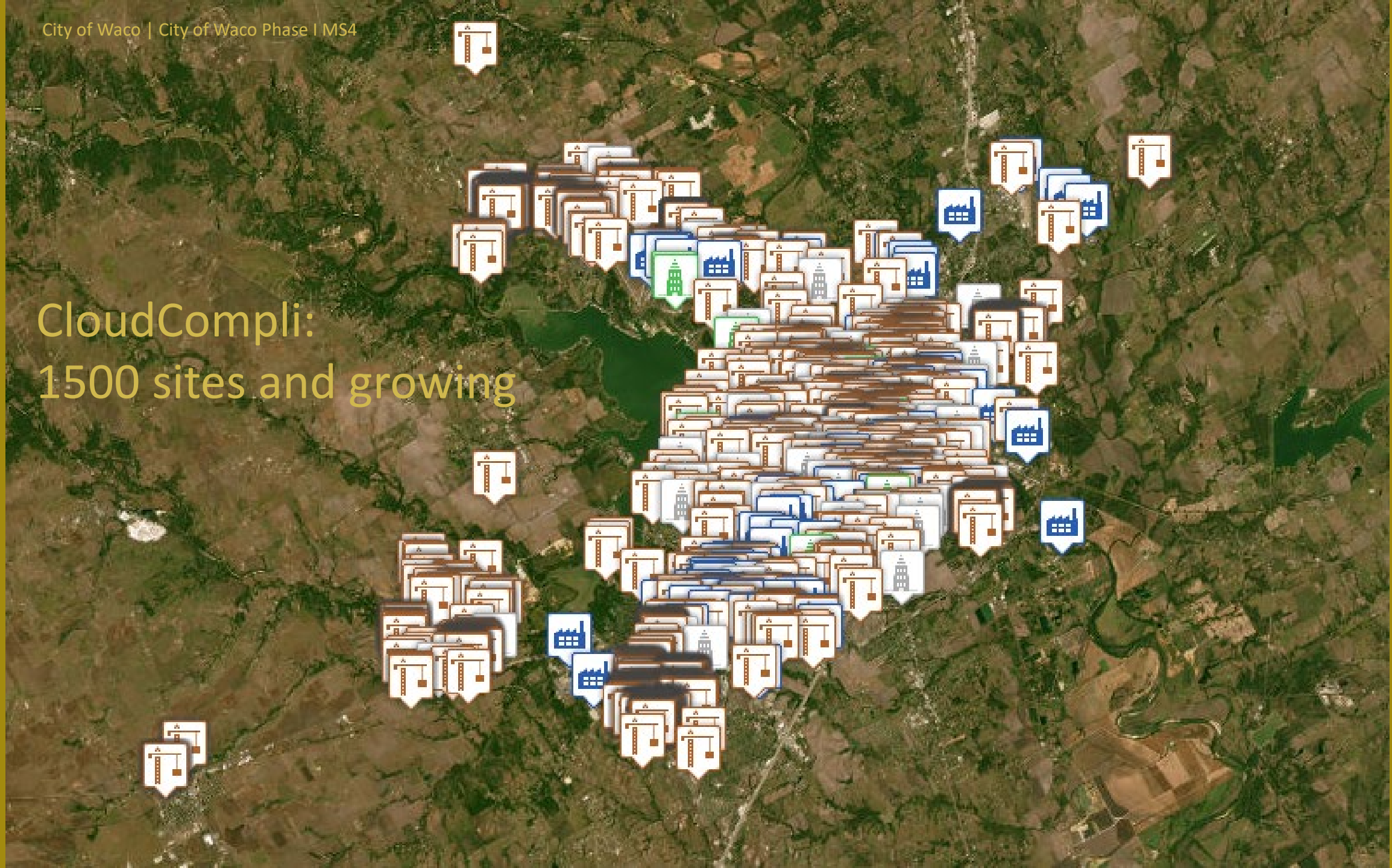
Where Are We Headed From Here?

City of Waco Phase I MS4

By the numbers:

2 Phase I and 7 Phase II MS4s
2 main watersheds: Brazos and Bosque
1 lake: Lake Waco (8,190 acres)
5 stormwater monitoring stations
14 drainage basins
117 Active CNOIs – 1343 active sites
89 Active INOIs and 34 INECs
11 PPGHP Municipal Operations




CloudCompli:
1500 sites and growing

Phase I vs Phase II: Public Outreach and Participation

Phase I and Phase II MCMs

CITY OF WACO

1. MS4 Maintenance Activities
2. Post-Construction Stormwater Control Measures
3. Illicit Discharge Detection and Elimination
4. Pollution Prevention and Good Housekeeping for Municipal Operations
5. Industrial and High-Risk Runoff
6. Construction Site Stormwater Runoff
7. Public Education, Outreach, Involvement and Participation
8. Monitoring, Evaluation and Reporting

Phase I MS4

City of Waco

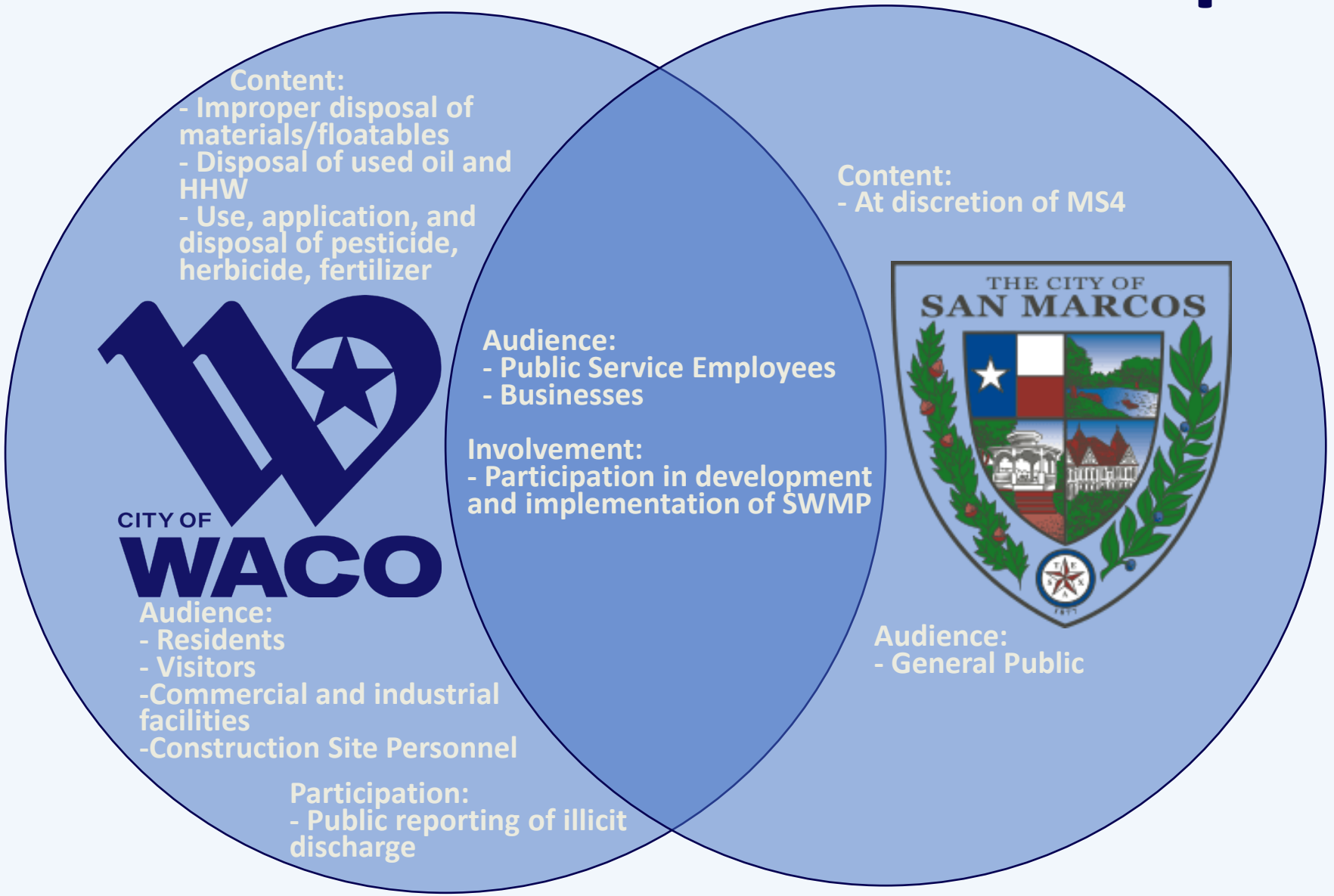
THE CITY OF SAN MARCOS

1. Public Outreach, Education, and Involvement
2. Illicit Discharge Detection and Elimination
3. Construction Site Stormwater Runoff Control
4. Post Construction Stormwater Management in New Development and Redevelopment
5. Pollution Prevention and Good Housekeeping for Municipal Operations
6. Industrial Stormwater Sources
7. Authorization for Construction Activities where the Small MS4 is the Site Operator

Phase II MS4 Level 3

City of San Marcos

Public Outreach and Participation



Beautify the Brazos Project

Organizations Involved

This was truly a multi-faceted collaboration between public, private and non-profit entities and institutions. The breadth of this project would not have been possible without the collaboration of all these stakeholders.

THE IRONMAN FOUNDATION
SERVICE THROUGH SPORT • COMMITMENT TO COMMUNITY

CITY OF WACO
EST. 1849

WACO PADDLE CO.

ESTD KEEP WACO 1979
BEAUTIFUL

BU

BEAUTIFY THE BRAZOS GOALS

1. Provide education to the athletes, students, citizens, and Ironman Foundation members regarding the importance of water resources and what threats aquatic resources face.
2. Collect aquatic data for the City of Waco and other partners to help make more informed decisions about water quality in the Brazos and other water bodies.
3. Help remove waste from the Brazos river in advance of the Ironman races to reduce pollution for the health and well being of athletes and wildlife.

Promotion

With the assistance of Waco Productions, we were able to put together an informational video that was promoted by the City, the Ironman Foundation, and Keep Waco Beautiful.

Videography by Bill Gowdy and Michaela McCown
Edited and published by Michaela McCown

Two Parts of the Project:

Collected water quality samples from over 50 locations across Waco to provide synoptic data regarding water quality of the Brazos river and tributaries that feed into the river.

Water Sampling

Removed 40 bags of trash from the Brazos river in just 2 hours in a 1 mile stretch of the river downtown. This particular area was the water course for the Ironman Race.

River Cleanup

Water Quality Sampling

- Sampling equipment and site selection
- Education of volunteers
- Coordination and communication of sample site locations
- Collection and recording of data

Equipment and Site Selection

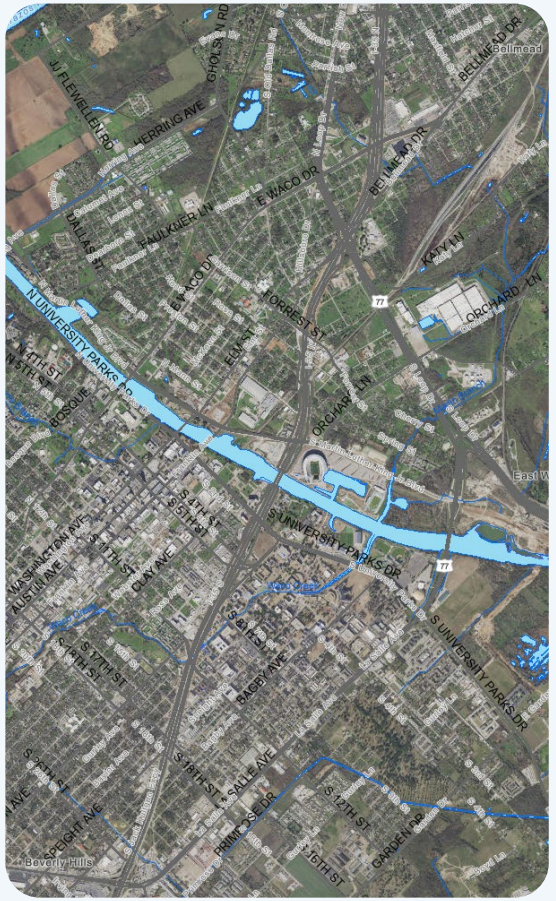
After researching different sampling kits, the EarthEcho – Water Challenge kits were selected due to there simplicity of use and availability.

Test Parameters:

- Temperature (°C)
- Turbidity (JTU)
- Dissolved Oxygen (PPM)
- % Saturation
- pH (SU)

Additional parameter provide by Waco Watershed:

-E. coli (MPN/100 mL)



When determining sample locations accessibility, spacing and areas of confluence were considered.

In all, 72 locations were selected:

- Brazos River (35)

Brazos Tributaries:

- Bosque River (3)
- Wilson Creek (3)
- Barron's Branch (5)
- Waco Creek (17)
- Marlin Branch (4)
- Cottonwood Creek (5)

Sampling Kit

Sampling Sites

Education of Volunteers

In the first year we operated using the EarthEcho provided sampling informational videos and materials along with hands on training.

In the second year we decided to produce our own sampling instructional video to be able to distribute ahead of time to the volunteers.

Videography by Bill Gowdy
Edited and published by Bill Gowdy

Communicating Sample Site Locations

Breaking volunteers into teams of 2-3 people, we assigned multiple locations (that were close to each other) to each team. Working in a group promoted safety in case of any kind of emergency.

Elements:

- GPS Location (in decimal form)
- Simple Instructions
- Aerial Map

Beautify the Brazos

Team 4

Location 8: 31.58150000, -97.15166666

*Park in Jacobs ladder parking lot

Location 9: 31.57958330, -97.15019444

*Walk down hiking trail

Location 10: 31.57705560, -97.14825000

*Walk down hiking trail

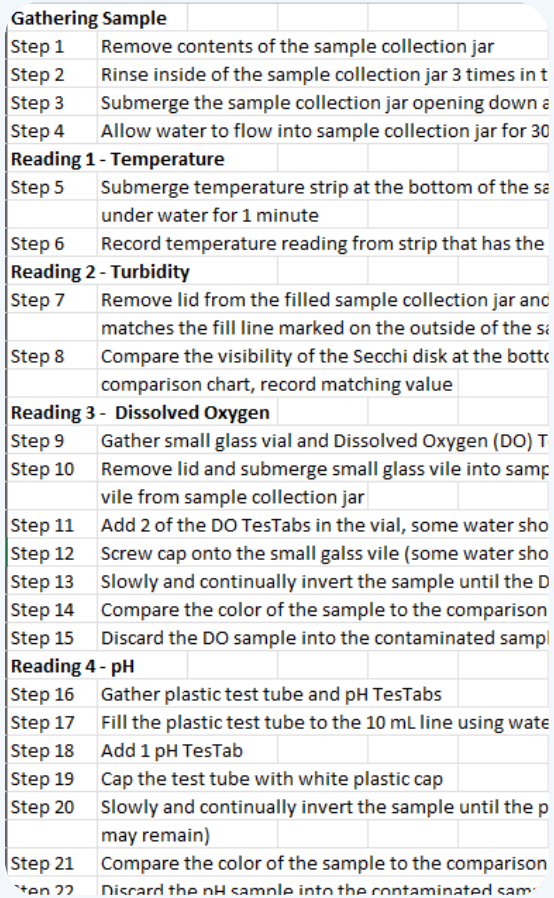
Each team member should perform the duties below at least once:

1. Collect water sample
2. Run Water Quality Test
3. Record results

Example Location Form

Collecting and Recording Data

Provided step-by-step instructions for each team to have on hand. Writing it similar to a methods section of your high school science fair project. Making sure each step is **clear** and **repeatable**.



Gathering Sample	
Step 1	Remove contents of the sample collection jar
Step 2	Rinse inside of the sample collection jar 3 times in t
Step 3	Submerge the sample collection jar opening down a
Step 4	Allow water to flow into sample collection jar for 30
Reading 1 - Temperature	
Step 5	Submerge temperature strip at the bottom of the sa
	under water for 1 minute
Step 6	Record temperature reading from strip that has the
Reading 2 - Turbidity	
Step 7	Remove lid from the filled sample collection jar and
	matches the fill line marked on the outside of the sa
Step 8	Compare the visibility of the Secchi disk at the botto
	comparison chart, record matching value
Reading 3 - Dissolved Oxygen	
Step 9	Gather small glass vial and Dissolved Oxygen (DO) T
Step 10	Remove lid and submerge small glass vile into samp
	vile from sample collection jar
Step 11	Add 2 of the DO TesTabs in the vial, some water sho
Step 12	Screw cap onto the small galss vile (some water sho
Step 13	Slowly and continually invert the sample until the D
Step 14	Compare the color of the sample to the comparison
Step 15	Discard the DO sample into the contaminated sampl
Reading 4 - pH	
Step 16	Gather plastic test tube and pH TesTabs
Step 17	Fill the plastic test tube to the 10 mL line using wate
Step 18	Add 1 pH TesTab
Step 19	Cap the test tube with white plastic cap
Step 20	Slowly and continually invert the sample until the p
	may remain)
Step 21	Compare the color of the sample to the comparison
Step 22	Discard the pH sample into the contaminated sam

Making the data table as **simple** as possible on the backside of the instruction sheet. This kept **everything together** in the field and provided **uniformity** for data entry in the office.

Parameter	Site ____
Date	
Time	
Water Temp (°C)	
Turbidity (JTU)	
Dissolved Oxygen (ppm)	
pH	

Parameter	Site ____
Date	
Time	
Water Temp (°C)	
Turbidity (JTU)	
Dissolved Oxygen (ppm)	
pH	

How to Collect

Where to Record

Brazos River Cleanup

- Location Selection
- Supplies
- Measurement

Location Selection: Ironman Course

Cleanup Supplies

Keep Waco Beautiful

- Gloves
- Draining Trash Bags
- Trash Pickers
- Staff Support
- Volunteer Signup

City of Waco

- Rolloff Dumpster
- Staff Support

Ironman Foundation

- Food for Volunteers
- Volunteer Signup

Waco Paddle Co.

- Kayaks

Measurement

Keep Waco Beautiful provides specific metrics to Keep Texas Beautiful on clean up events, which in turns provides the MS4 with **specific items** to report in the TCEQ Annual Report.

Keep Waco Beautiful

The City of Waco Solid Waste Department provides roll-off dumpsters and returns the weigh-in ticket for us to document **total volume by weight**.

City Solid Waste

Data Manipulation and Visualization

How do we tell a story? How do we convert raw data into something anyone can understand?

	A	B	C	D	E	F	G	H	I	J	K
1	Date	Site	Lat	Long	Water	Temperat	Turbidty (	DO (PPM)	% Saturati	pH	E. coli (MP
2	10/10/2022	1	31.59	-97.17	Bosque	26	40	4	49	8	3
3	10/10/2022	2	31.59	-97.17	Bosque	26	40	4	49	8	1
4	10/10/2022	3	31.59	-97.15	Brazos	26	40	4	49	8	0.5
5	10/10/2022	4	31.59	-97.15	Brazos	26	40	4	49	8	0.5
6	10/10/2022	5	31.59	-97.15	Brazos	26	40	8	99	8	16.1
7	10/10/2022	6	31.58	-97.15	Brazos	26	40	8	99	8	1
8	10/10/2022	7	31.58	-97.15	Brazos	28	40	8	102	8	0.5
9	10/10/2022	8	31.58	-97.15	Brazos	28	40	8	102	8	0.5
10	10/10/2022	9	31.58	-97.15	Brazos	28	40	8	102	8	0.5
11	10/10/2022	10	31.58	-97.15	Brazos	24	40	8	95	8	6.3
12	10/10/2022	11	31.57	-97.14	Brazos	24	100	8	95	8	185
13	10/10/2022	12	31.57	-97.14	Brazos	24	40	8	95	8	0.5
14	10/14/2022	13	31.57	-97.14	Brazos	24	40	4	48	7	6
15	10/10/2022	13	31.57	-97.14	Brazos	26	40	4	49	8	4.1
16	10/14/2022	14	31.57	-97.14	Brazos	24	40	8	95	7	10.9
17	10/10/2022	14	31.57	-97.14	Brazos	26	40	4	49	8	31.5
18	10/14/2022	15	31.57	-97.14	Brazos	26	40	4	49	7	7.2
19	10/13/2022	16	31.57	-97.13	Brazos	28	0	4	51	7	0.5
20	10/13/2022	17	31.57	-97.13	Brazos	26	40	0	0	0	32.6
21	10/13/2022	18	31.56	-97.13	Brazos	20	40	7	77	8	0.5
22	10/14/2022	19	31.56	-97.13	Brazos	22	40	4	46	8	3
23	10/14/2022	20	31.56	-97.13	Brazos	22	40	8	92	8	8.4

Data Visualization

Essential step to convey data effectively to your target audience of stakeholders.

Types of visualizations:

- Tables
- Charts (Bar or Pie)
- Line charts
- Histograms
- Scatterplots
- Heat maps
- Tree maps
- Word clouds

Considerations

Who is your audience?

What information is most important to them?

Does the data need support information and labeling?

What are you trying to convey?

Is there jargon that may be confusing?

DATA MANAGEMENT USING R

What is R?

R is a language and environment for statistical computing and graphics. (r-project.org)

How much does it cost?

R is an Open Source implementation and as such can be freely downloaded.

How do I use it?

I recommend RStudio, an integrated development environment for R.

```r
#1. Create your data
library(readxl)
Carbon_Footprint <- read_excel("C:/Users/MarkK/OneDrive - City of Waco Texas/Carbon Footprint.xlsx")
View(Carbon_Footprint)
yourdata <- Carbon_Footprint

#2. Download a shapefile (shp,gpkg,geojson...)
library(tigris) #For downloading the zipcode map
options(tigris_use_cache = TRUE)
geo <- st_as_sf(zctas(cb = FALSE, starts_with = yourdata$ZCTA5CE20))

#Overall shape of USA states
states <- st_as_sf(states(cb=TRUE))
#For plotting, all the maps should have the same crs
states=st_transform(states,st_crs(geo))

#3. Now Merge your data
yourdata.sf=merge(geo,yourdata)
yourdata.sf$`Avg Earths` <- as.numeric(yourdata.sf$`Avg Earths`)

#4. Plotting
par(mar=c(1,1,1,1))
ghostLayer(yourdata.sf)
plot(st_geometry(states), add=TRUE)
choroLayer(yourdata.sf,
           var="Avg Earths",
           breaks = c(0,1,2,3,5,7,10,15,25,50),
           add=TRUE,
           nclass = NULL,
           col = carto.pal(pal1 = "green.pal", n1 = 5, pal2 = "sand.pal", n2 = 5),
           lwd = 2,
           legend.pos = "right",
           legend.frame = TRUE)
layoutLayer(title = "Carbon Footprint by ZIPCODE",
            theme = "green.pal",
            scale = FALSE,
            sources = "GCC2023: Global Footprint Network",
            author = "by Mark Keeley, 2023"
)
```

Jewell.4	70 obs. of 34 variables
Jewell.5	69 obs. of 34 variables
Jewell.6	68 obs. of 34 variables
Jewell.7	67 obs. of 34 variables
LabTest	13 obs. of 11 variables
Lasker	73 obs. of 34 variables
Lasker.1	72 obs. of 34 variables
Lasker.2	71 obs. of 34 variables
Lasker.3	70 obs. of 34 variables
Lasker.4	69 obs. of 34 variables
Lasker.5	68 obs. of 34 variables
Lasker.6	67 obs. of 34 variables
Lasker.7	66 obs. of 34 variables
Moving	463 obs. of 27 variables
New	73 obs. of 34 variables
RData	399 obs. of 61 variables
states	56 obs. of 10 variables
Still	263 obs. of 27 variables
Sweep	271 obs. of 27 variables
Sweeper_April_21	1449 obs. of 27 variables
Sweeper_July_21	726 obs. of 27 variables
Sweeper_November_21	1452 obs. of 27 variables
Sweeper_Report	474 obs. of 27 variables
Sweeper_September_21	1293 obs. of 27 variables
Turn_On_May_1_Sept_12_pdf	20811 obs. of 14 variables
Webster	73 obs. of 34 variables
yourdata	24 obs. of 6 variables
yourdata.sf	24 obs. of 15 variables

```
> View(Carbon_Footprint)
> yourdata <- Carbon_Footprint
> #2. Download a shapefile (shp,gpkg,geojson...)
> library(tigris) #For downloading the zipcode map
To enable caching of data, set `options(tigris_use_cache = TRUE)`
in your R script or .Rprofile.
Warning message:
package 'tigris' was built under R version 4.2.3
> options(tigris_use_cache = TRUE)
> geo <- st_as_sf(zctas(cb = FALSE, starts_with = yourdata$ZCTA5CE20))
Retrieving data for the year 2021
> #Overall shape of USA states
> states <- st_as_sf(states(cb=TRUE))
Retrieving data for the year 2021
> #For plotting, all the maps should have the same crs
> states=st_transform(states,st_crs(geo))
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> yourdata.sf$`Avg Earths` <- as.numeric(yourdata.sf$`Avg Earths`)
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> par(mar=c(1,1,1,1))
> ghostLayer(yourdata.sf)
> plot(st_geometry(states), add=TRUE)
> choroLayer(yourdata.sf,
+            var="Avg Earths",
+            breaks = c(0,1,2,3,5,7,10,15,25,50),
+            add=TRUE,
+            nclass = NULL,
+            col = carto.pal(pal1 = "green.pal", n1 = 5, pal2 = "sand.pal", n2 = 5),
+            lwd = 2,
+            legend.pos = "right",
+            legend.frame = TRUE)
> layoutLayer(title = "Carbon Footprint by ZIPCODE",
+             theme = "green.pal",
+             scale = FALSE,
+             sources = "GCC2023: Global Footprint Network",
+             author = "by Mark Keeley, 2023"
+ )
>
```
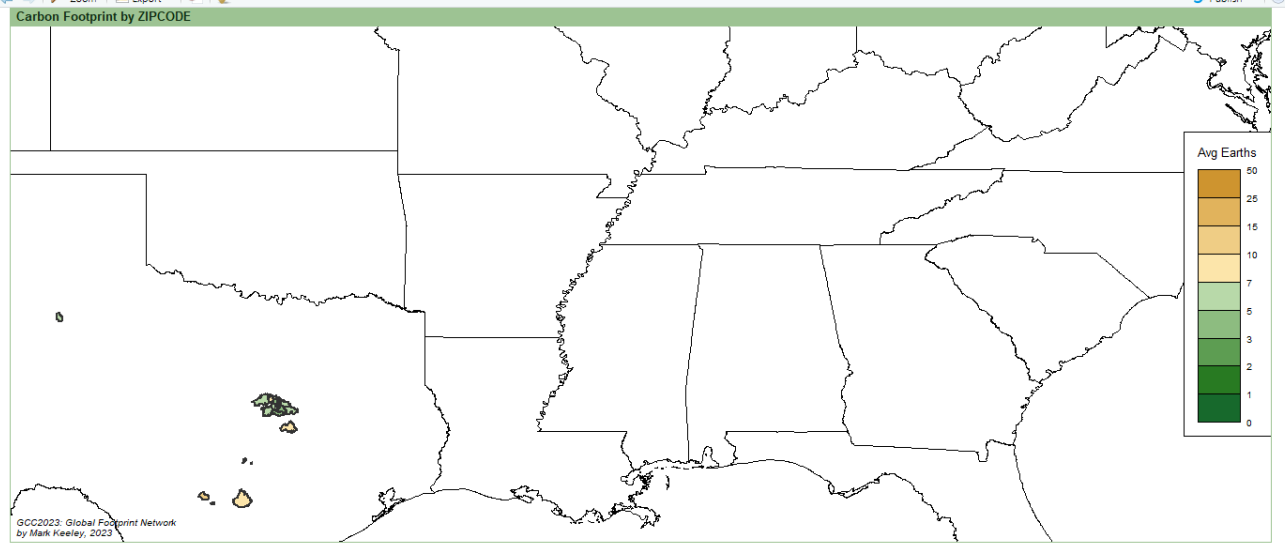
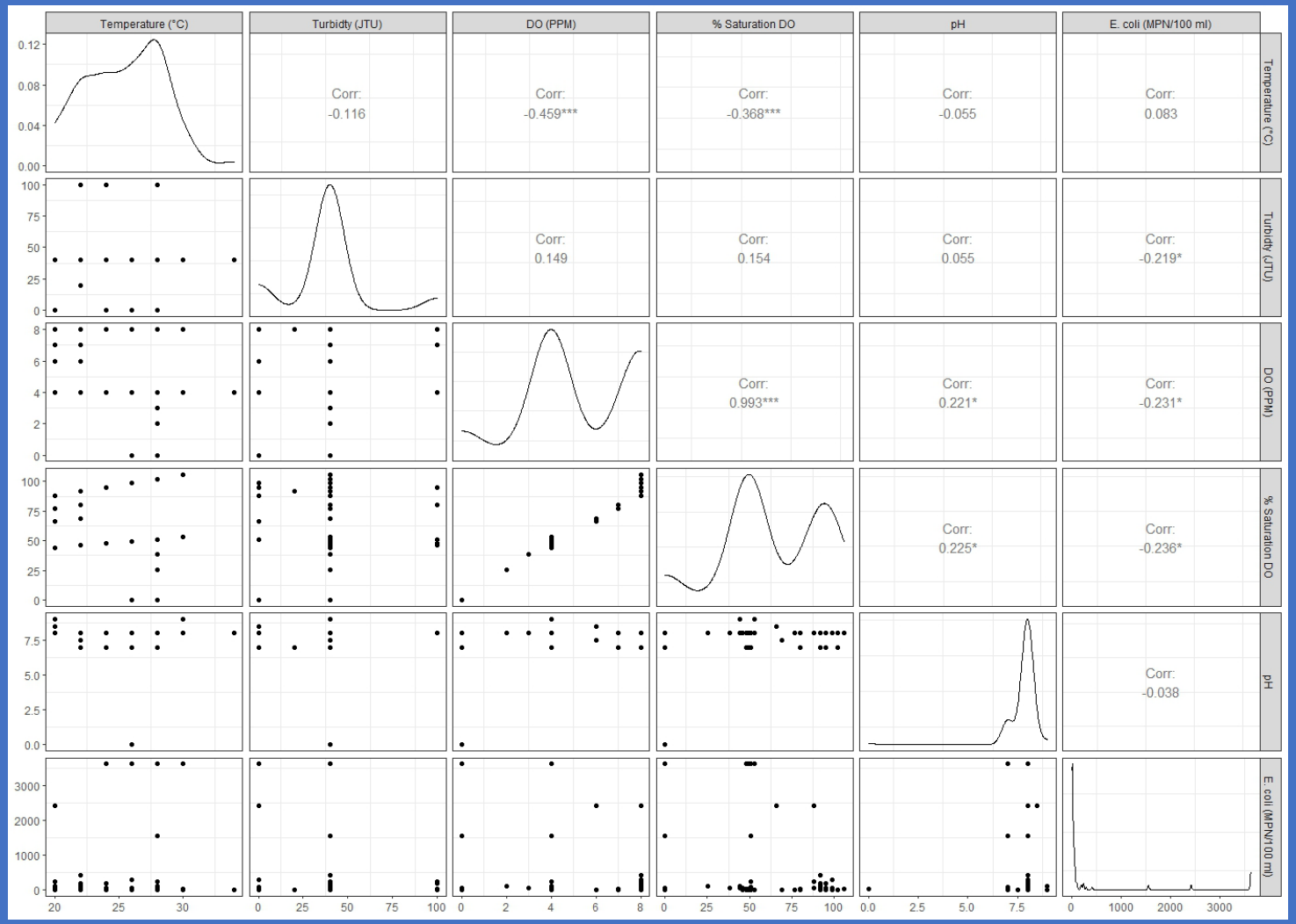



I have a large data set what can I do with it?

	Date	Site	Lat	Long	Water	Temperature (°C)	Turbidty (JTU)	DO (PPM)	% Saturation DO	pH	E. coli (MPN/100 ml)
1	2022-10-10	1	31.59308	-97.16911	Bosque	26	40	4	49.00	8.0	3.0
2	2022-10-10	2	31.59125	-97.16681	Bosque	26	40	4	49.00	8.0	1.0
3	2022-10-10	3	31.58969	-97.15458	Brazos	26	40	4	49.00	8.0	0.5
4	2022-10-10	4	31.59136	-97.15256	Brazos	26	40	4	49.00	8.0	0.5
5	2022-10-10	5	31.59353	-97.14706	Brazos	26	40	8	99.00	8.0	16.1
6	2022-10-10	6	31.58469	-97.15272	Brazos	26	40	8	99.00	8.0	1.0
7	2022-10-10	7	31.58247	-97.15122	Brazos	28	40	8	102.00	8.0	0.5
8	2022-10-10	8	31.58150	-97.15167	Brazos	28	40	8	102.00	8.0	0.5
9	2022-10-10	9	31.57958	-97.15019	Brazos	28	40	8	102.00	8.0	0.5
10	2022-10-10	10	31.57706	-97.14825	Brazos	24	40	8	95.00	8.0	6.3
11	2022-10-10	11	31.57283	-97.14239	Brazos	24	100	8	95.00	8.0	185.0
12	2022-10-10	12	31.57167	-97.14258	Brazos	24	40	8	95.00	8.0	0.5
13	2022-10-14	13	31.57075	-97.14000	Brazos	24	40	4	48.00	7.0	6.0
14	2022-10-10	13	31.57075	-97.14000	Brazos	26	40	4	49.00	8.0	4.1
15	2022-10-14	14	31.57103	-97.13919	Brazos	24	40	8	95.00	7.0	10.9
16	2022-10-10	14	31.57103	-97.13919	Brazos	26	40	4	49.00	8.0	31.5
17	2022-10-14	15	31.56914	-97.13831	Brazos	26	40	4	49.00	7.0	7.2
18	2022-10-13	16	31.56581	-97.13497	Brazos	28	0	4	51.00	7.0	0.5
19	2022-10-13	17	31.56564	-97.13383	Brazos	26	40	0	0.00	0.0	32.6
20	2022-10-13	18	31.56433	-97.13386	Brazos	20	40	7	77.00	8.0	0.5
21	2022-10-14	19	31.56203	-97.13042	Brazos	22	40	4	46.00	8.0	3.0
22	2022-10-14	20	31.56186	-97.12703	Brazos	22	40	8	92.00	8.0	8.4

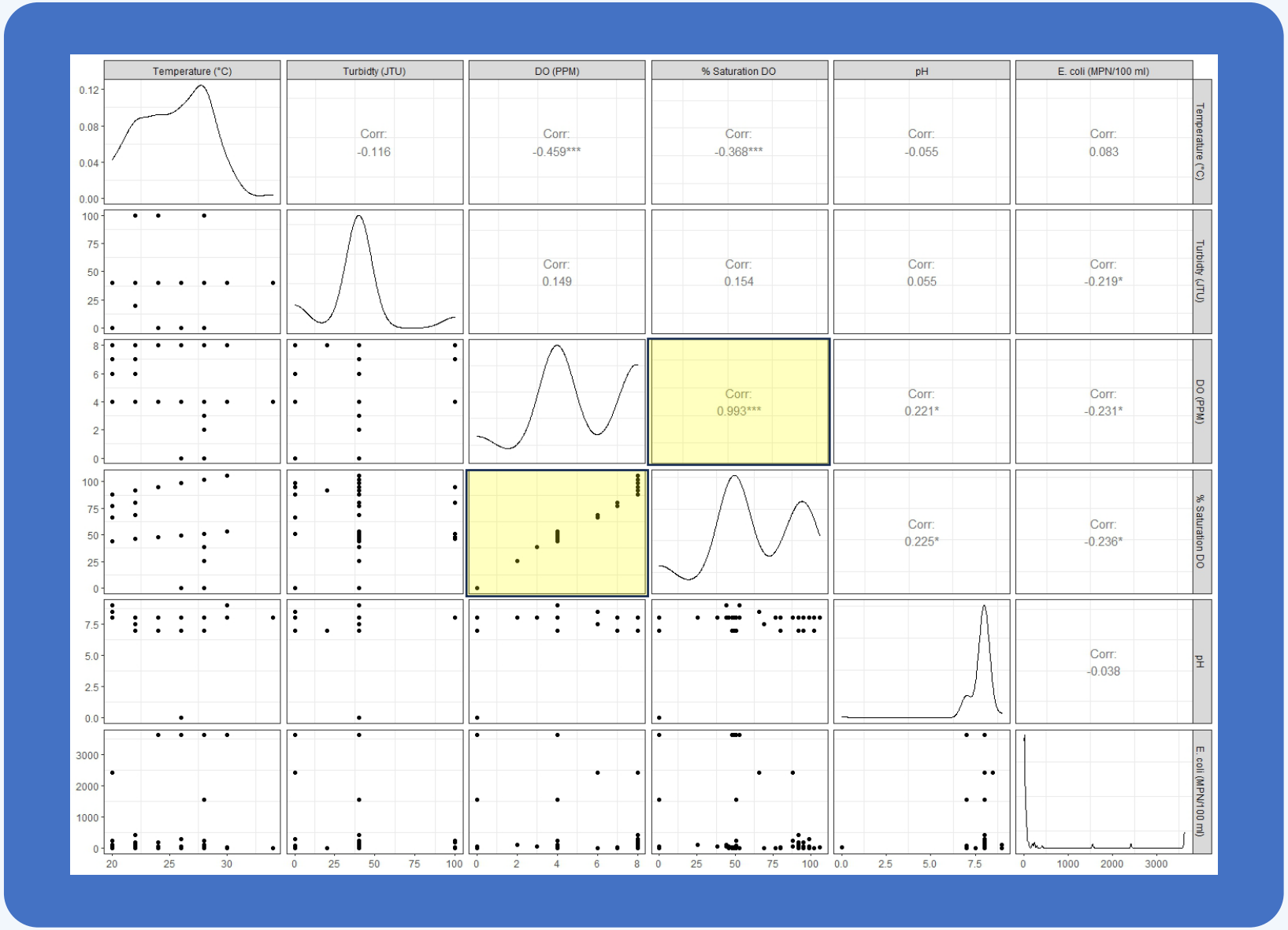
I have a large data set what can I do with it?

Correlation tables can help you find relationships within your data.



I have a large data set what can I do with it?

Examples: DO and % Saturation



Visualization 1

Question:
Where did you sample?

Who is your audience?
General Public

What information is most important to them?
Where

Does the data need support information and labeling?
Yes

What are you trying to convey?
Full Scope

Is there jargon that may be confusing?
Yes, GPS

Lat	Long	Water
31.59308	-97.16911	Bosque
31.59125	-97.16681	Bosque
31.58969	-97.15458	Brazos
31.59136	-97.15256	Brazos
31.59353	-97.14706	Brazos
31.58469	-97.15272	Brazos
31.58247	-97.15122	Brazos
31.58150	-97.15167	Brazos
31.57958	-97.15019	Brazos
31.57706	-97.14825	Brazos
31.57283	-97.14239	Brazos
31.57167	-97.14258	Brazos
31.57075	-97.14000	Brazos
31.57075	-97.14000	Brazos
31.57103	-97.13919	Brazos
31.57103	-97.13919	Brazos
31.56914	-97.13831	Brazos

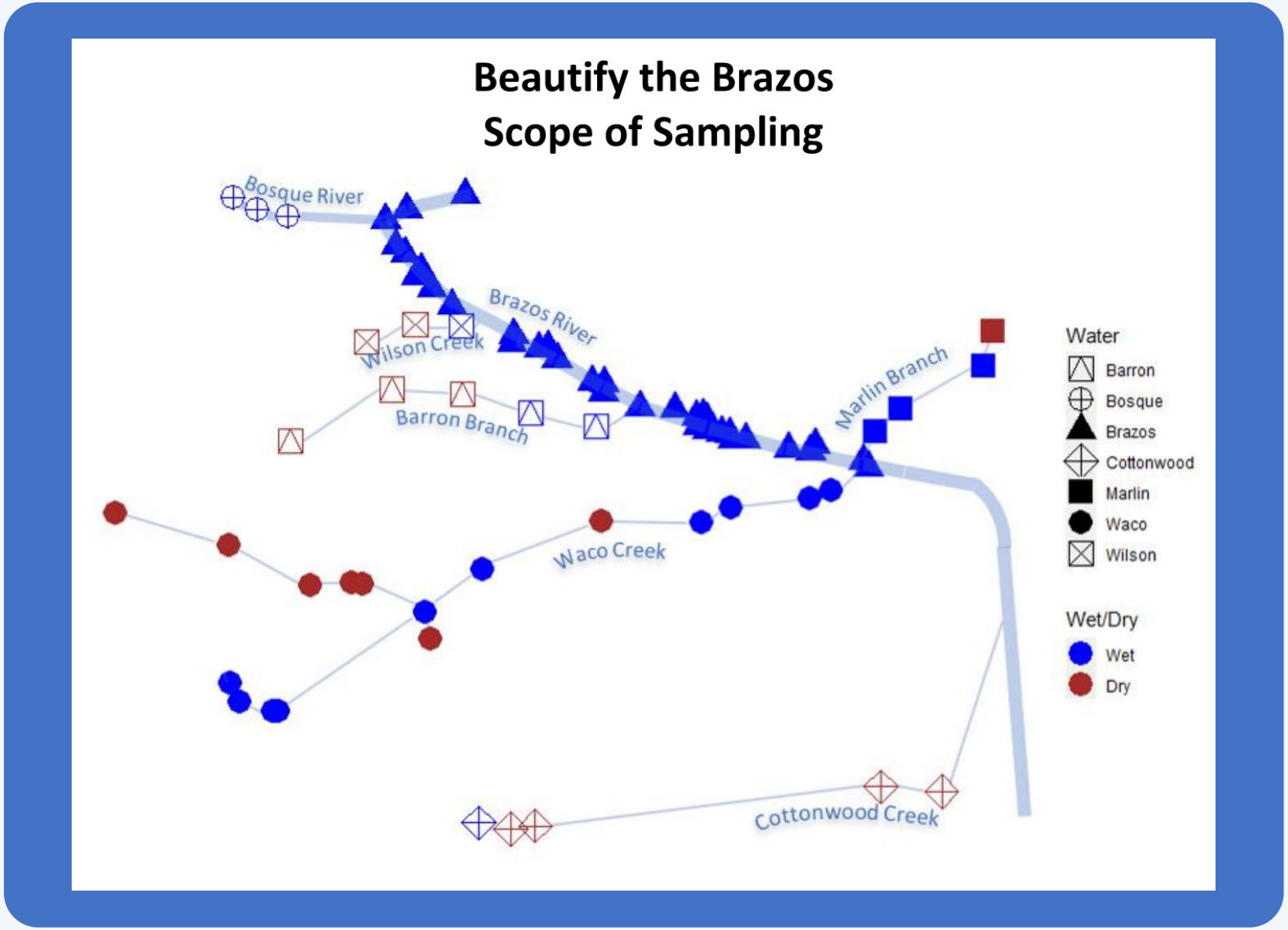
Who is your audience?
General Public

What information is most important to them?
Where

Does the data need support information and labeling?
Yes

What are you trying to convey?
Full Scope

Is there jargon that may be confusing?
Yes, GPS



Visualization 2

Question:

Can I wear a wetsuit?

Who is your audience?
Ironman Competitors

What information is most important to them?
Temperature

Does the data need support information and labeling?
Yes

What are you trying to convey?
Temp on course

Is there jargon that may be confusing?
Yes, GPS

Lat	Long	Water	Temperature (°C)
31.59308	-97.16911	Bosque	26
31.59125	-97.16681	Bosque	26
31.58969	-97.15458	Brazos	26
31.59136	-97.15256	Brazos	26
31.59353	-97.14706	Brazos	26
31.58469	-97.15272	Brazos	26
31.58247	-97.15122	Brazos	28
31.58150	-97.15167	Brazos	28
31.57958	-97.15019	Brazos	28
31.57706	-97.14825	Brazos	24
31.57283	-97.14239	Brazos	24
31.57167	-97.14258	Brazos	24
31.57075	-97.14000	Brazos	24
31.57075	-97.14000	Brazos	26
31.57103	-97.13919	Brazos	24
31.57103	-97.13919	Brazos	26
31.56914	-97.13831	Brazos	26

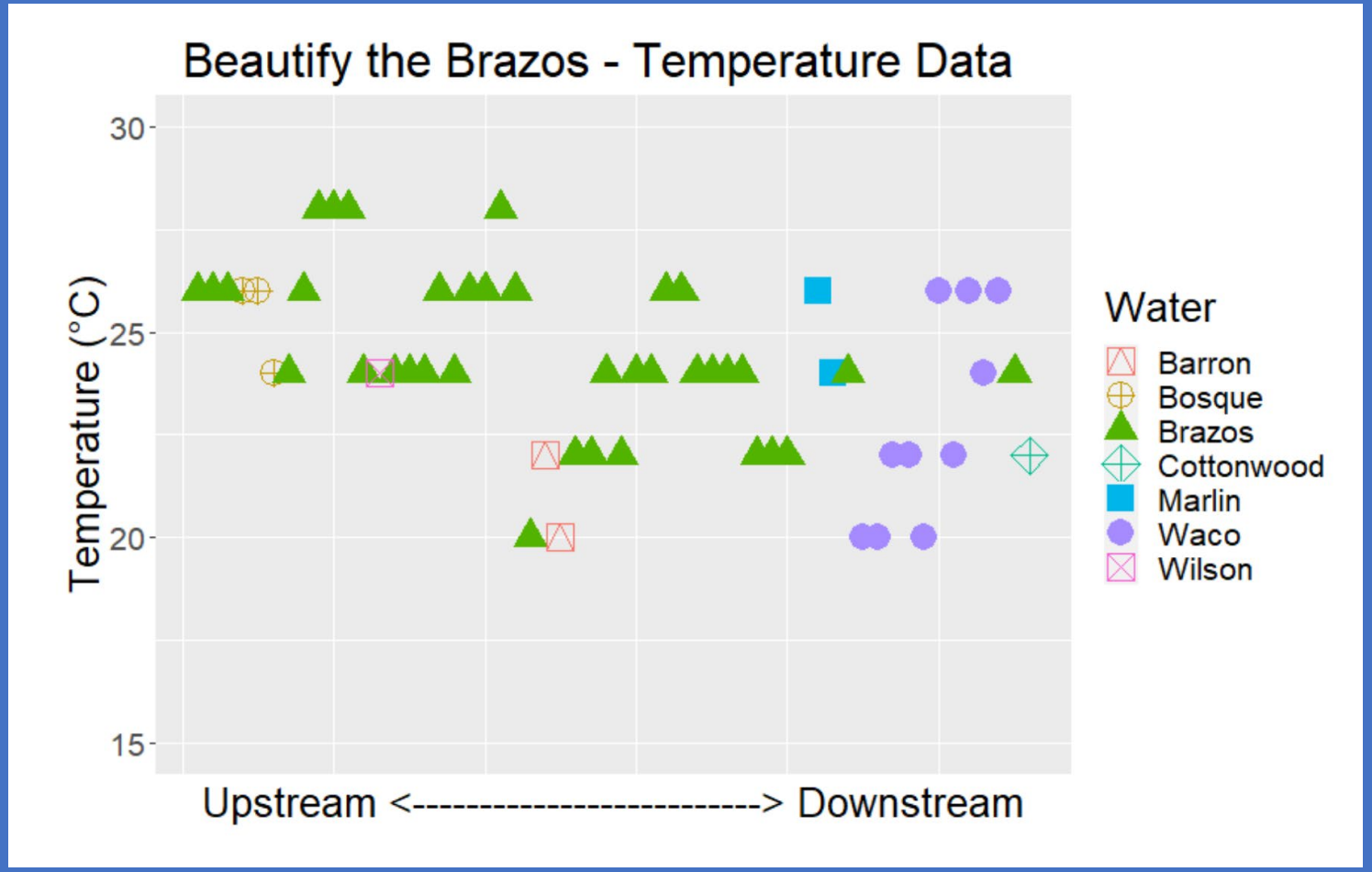
Who is your audience?
Ironman Competitors

What information is most important to them?
Temperature

Does the data need support information and labeling?
Yes

What are you trying to convey?
Temp on course

Is there jargon that may be confusing?
Yes, GPS



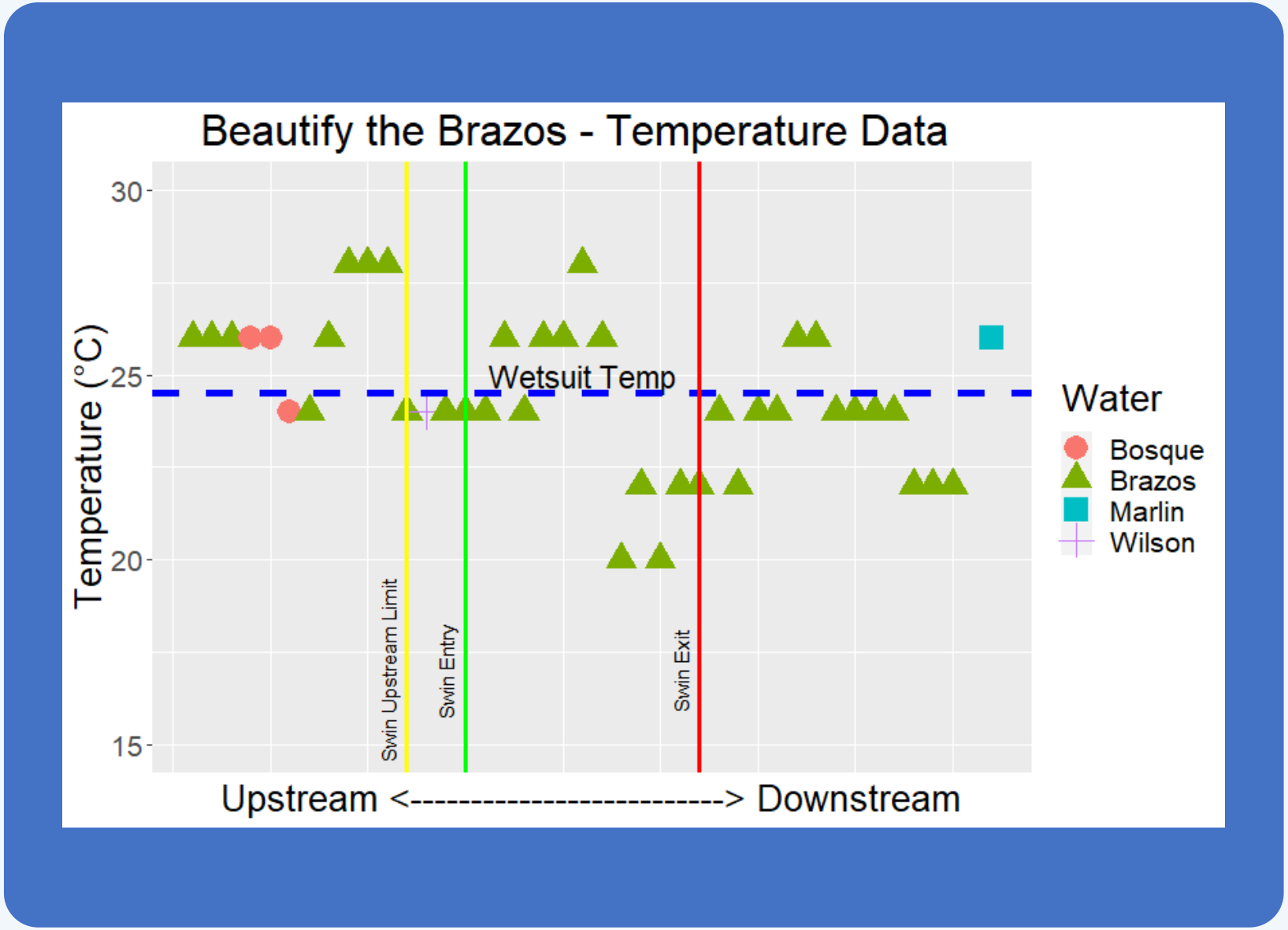
Who is your audience?
Ironman Competitors

What information is most important to them?
Temperature

Does the data need support information and labeling?
Yes

What are you trying to convey?
Temp on course

Is there jargon that may be confusing?
Yes, GPS



Visualization 3

Question:
What killed the fish?

Who is your audience?
TPWD, General Public

What information is most important to them?
DO

Does the data need support information and labeling?
Yes

What are you trying to convey?
DO

Is there jargon that may be confusing?
Audience specific

Lat	Long	Water	Temperature (°C)	Turbidty (JTU)	DO (PPM)
31.56433	-97.13386	Brazos	20	40	7
31.55933	-97.13453	Barron	20	0	6
31.52158	-97.16933	Waco	20	0	8
31.51881	-97.16853	Waco	20	0	8
31.53190	-97.15088	Waco	20	40	8
31.56125	-97.14072	Barron	22	100	7
31.56203	-97.13042	Brazos	22	40	4
31.56186	-97.12703	Brazos	22	40	8
31.56086	-97.12442	Brazos	22	40	8
31.55606	-97.11622	Brazos	22	20	8
31.55569	-97.11417	Brazos	22	40	7
31.55661	-97.11375	Brazos	22	40	6
31.51750	-97.16533	Waco	22	40	8
31.51750	-97.16487	Waco	22	40	8
31.54521	-97.12446	Waco	22	40	8
31.50100	-97.14575	Cottonwood	22	40	8
31.59036	-97.16389	Bosque	24	100	4

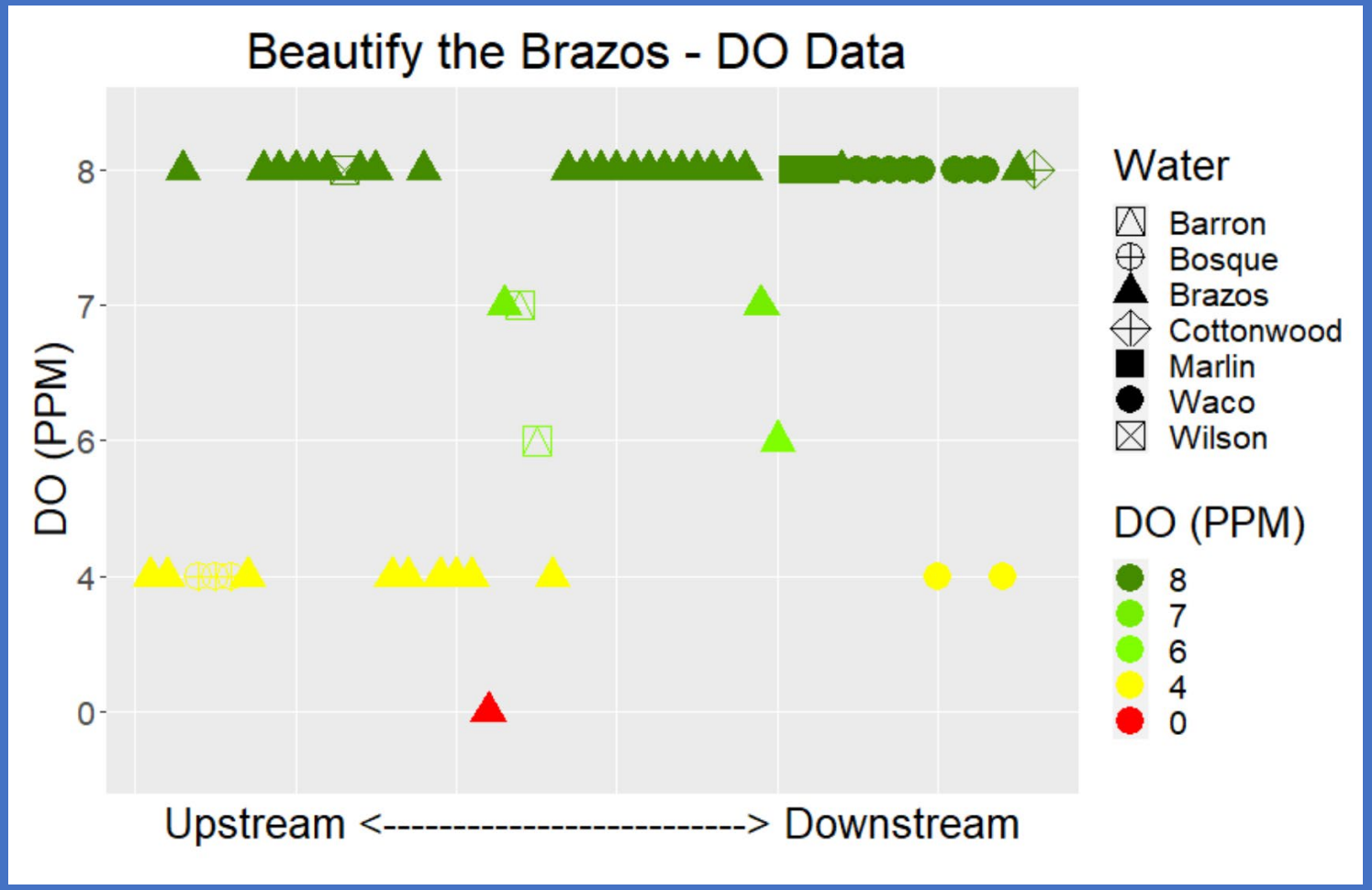
Who is your audience?
TPWD, General Public

What information is most important to them?
DO

Does the data need support information and labeling?
Yes

What are you trying to convey?
DO

Is there jargon that may be confusing?
Audience specific



Who is your audience?
TPWD, General Public

What information is most important to them?
DO

Does the data need support information and labeling?
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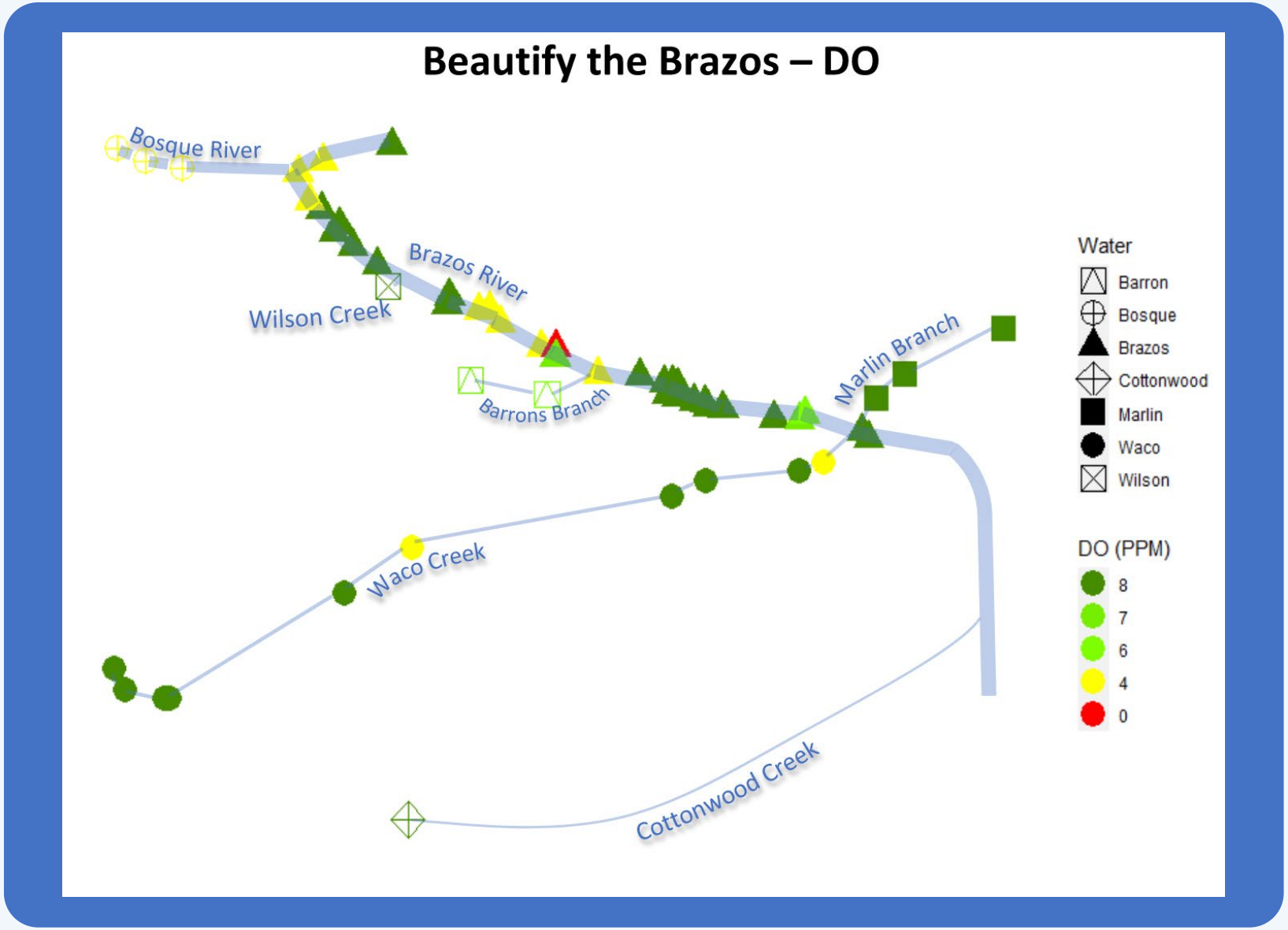
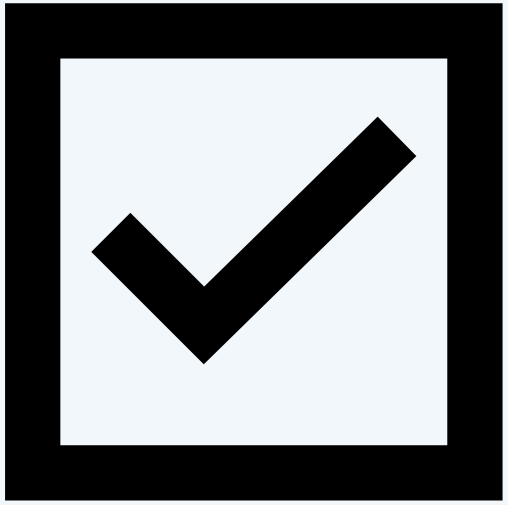
What are you trying to convey?
DO

Is there jargon that may be confusing?
Audience specific

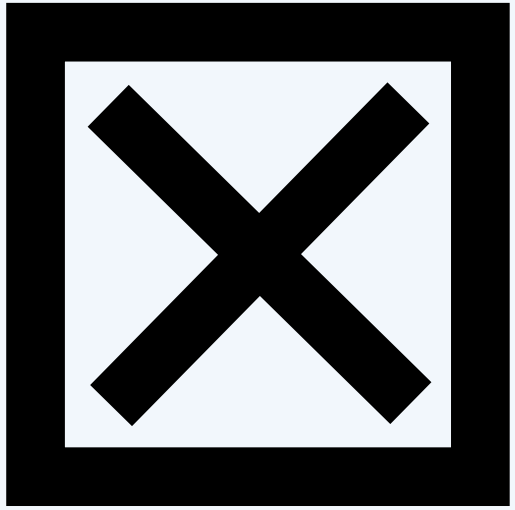


Successes and Failures

A LEARNING EXPERIENCE



- A diverse group of participants
- Ongoing engagement/ regular occurrence
- Simplicity of sampling supplies
- Raising awareness about common watershed protection issues
- Interdepartmental and organizational participation
- City-wide sampling



- Youth participation
- Replication of samples
- Growth in participation
- Outside promotion
- Sample site accessibility
- Widely distributing results

Where Are We Headed From Here?

NEXT STEPS

- Continue partnering with these great organizations to keep our waterways clean and healthy.
- Engage a larger group of volunteers to increase replication of data and try to better time sampling to make a true synoptic sample.
- Continue to use this as an avenue to provide water quality education to our residents and the students of Waco's higher education institutions.
- Head into Spring 2024 sampling with a goal of sampling all sites.
- Include result analysis in updated Watershed Management Plan.

THANK YOU.

Please contact markk@wacotx.gov for any questions