Research Study: Accuracy of Texas CCS Water Quality Monitoring Data (Texas Stream Team)

Kelly Albus, PhD
Texas A&M AgriLife Extension
Texas Water Resources Institute
kelly.albus@ag.tamu.edu

Image Source: https://fritsahlefeldt.net/

What is Community Citizen Science (CCS)?

a.k.a. Participatory Science, Volunteer Monitoring, Crowdsourcing, and many more…

→ The participation of students, amateurs, or volunteers (any non-professional scientist) in the process of scientific research.

→ Recent Growth

Technological advancements (smartphones)
Enhanced data collection,
Educational and societal impacts

→ Groups and Resources

Citizen Science Association, SciStarter, iNaturalist, Master Volunteers, Texas Stream Team

Benefits of CCS

Data Collection

- Eyes on the ground
- Data gaps
- Accessibility (off limits)
- Machine learning (AI)

Education and Outreach

- Broaden engagement
- Project-based Learning
- Virtual options
- Curricular materials

Impacts

- Community input & support
- Learning gains
- Funding opportunities
- Sustainability goals

Volunteer Water Quality Monitoring

Photo credit: From Texas Stream Team website (https://www.meadowscenter.txstate.edu/Service/TexasStreamTeam.html) and from: www.WFAA.com

- Volunteers from all over the US have been collecting data for decades with citizen science (CS) programs
- Water monitoring one of the most prevalent types of CS program worldwide

Texas Stream Team
Caring for Our Waters

Question: What is volunteer CCS data used for?

- Uses of TST data limited, largely unknown at time of publication
- Still no "official" management or regulatory uses
- Few citations in peer-reviewed articles

Texas Stream Team: **Data Uses**

Common issue throughout CCS water monitoring

Volunteer datasets **not fully utilized** by professionals and scientists

Top concerns about **accuracy and applicability** of data

Top reason not used in publications: **researcher's perceptions of volunteer data quality**

<u>Comprehensive Literature Review: 26 WQ Comparison Studies</u>

- **General "Good" agreement between volunteer and professional**
- **Pros and cons of comparison studies**

A little sus?
Or not?

Research: Volunteer Water Quality Monitoring Data Accuracy

Texas Stream Team
Caring for Our Waters

Texas Stream Team Opportunity:

- *Long-term continuous data collection over large area*
- *with QAPP*
- *at sites that correspond to professional samples.*

Assess relative accuracy of TST water quality data (*DO*, *pH*, *conductivity*) by comparing to professional data & analyzing variations across scales

- First comparison study to
  - Utilize TST data
  - Combine large and small-scale analysis
  - Analyze existing and experimental datasets

RESEARCH QUESTION 1

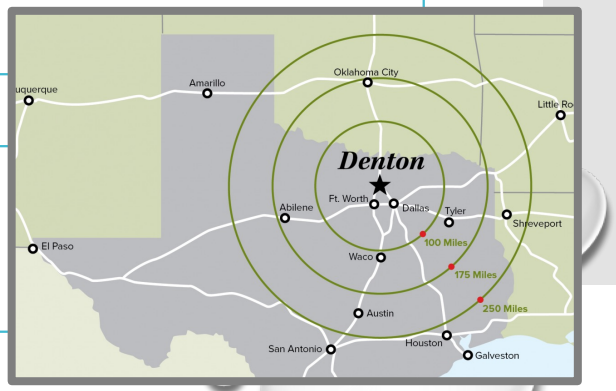
- Existing, Statewide, 1992-2016 (long-term, large-scale)

RESEARCH QUESTION 2

- Existing, City of Denton, 2009-2017 (long-term, local scale)

RESEARCH QUESTION 3

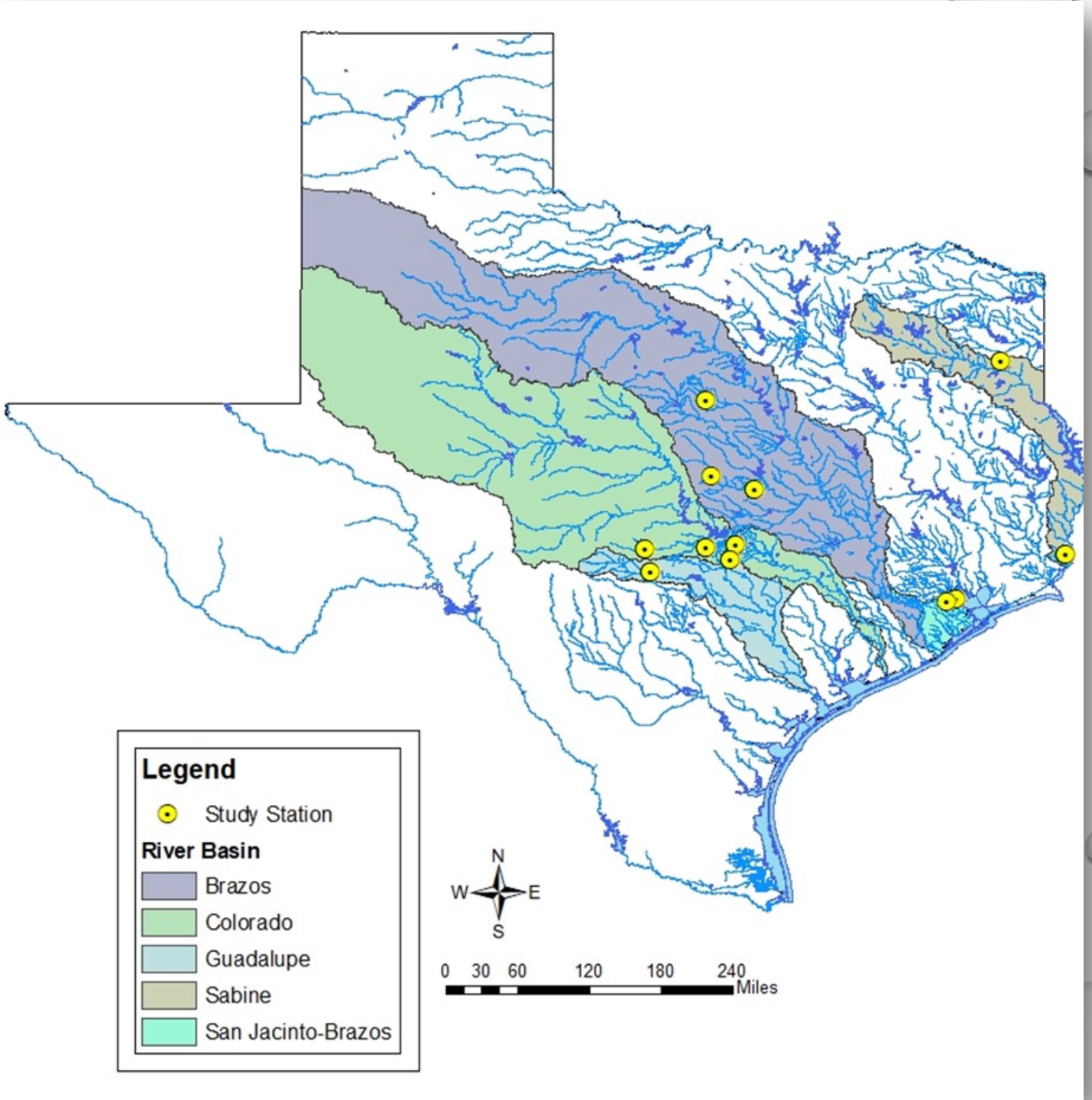
- Experimental, City of Denton, 2017-2018 (short-term, local)



RQ 1: Statewide

Figure 1. Map of Study Stations. Existing Statewide Water Monitoring Station Locations, with River Basins

(12 stations, 5 river basins)



Research Question 1: Existing, Statewide, 1992-2016 (long-term, large scale)

Results - RQ 1: Existing, statewide

- **234 professional, 350 volunteer samples, 12 stations, 38 station years**
  - Samples analyzed by year/station for each of the parameters (DO, pH, conductivity)
- Result: **82 station/year ANOVAs**

Answered the question: Is there a significant difference between volunteers and professionals at that station for that year, for that parameter? (DO, pH or conductivity)

***Table 2*. Statewide ANOVA Metadata**. Percent agreement between TST volunteer and TCEQ professional data based on ANOVA results (T*able 1*) for all statewide models run and for each parameter.

Data Category	# ANOVAs	# Statistically Significant	Total Percent Agreement
Total Statewide	82	16	**80.49%**
DO	30	7	**76.67%**
pH	24	5	**79.17%**
Conductivity	28	4	**85.71%**

Results - RQ 2: Existing city of Denton

Research Question 2: Existing, City of Denton, 2009-2017 (long-term, local scale)

- **159 vol/pro paired samples, 6 stations, 24 sampling years**
  - (Same as RQ 1) Samples analyzed by year/station for each parameter (DO, pH, conductivity)
- Result: **70 total analyses**
  - (ANOVAs for DO and conductivity, and KST for pH)
- More controls = less variation in datasets → **Group Analysis** of entire dataset
  - Provide more detailed information about parameters over time
  - Found pattern in DO and pH data

DO – Systematic bias

- Group Analysis of City of Denton volunteer and professional sampling data =
- **Found: consistent pattern for DO** across all sites for all years
  - Reproducibility for all samples = **systematic bias or error**
    - *Reproduceable, consistent magnitude = not a reflection of actual variation in dataset (Taylor 1997)*
  - Calibration confirmed:
    - **Add 2 mg/L to all volunteer DO samples to remove bias = no significant difference (Figure 5).**
  - *Note: Adding 2 mg/L to the volunteer data only one option*
- Applied to all City of Denton results (RQ 2 and 3)

DO – Systematic bias adjustment

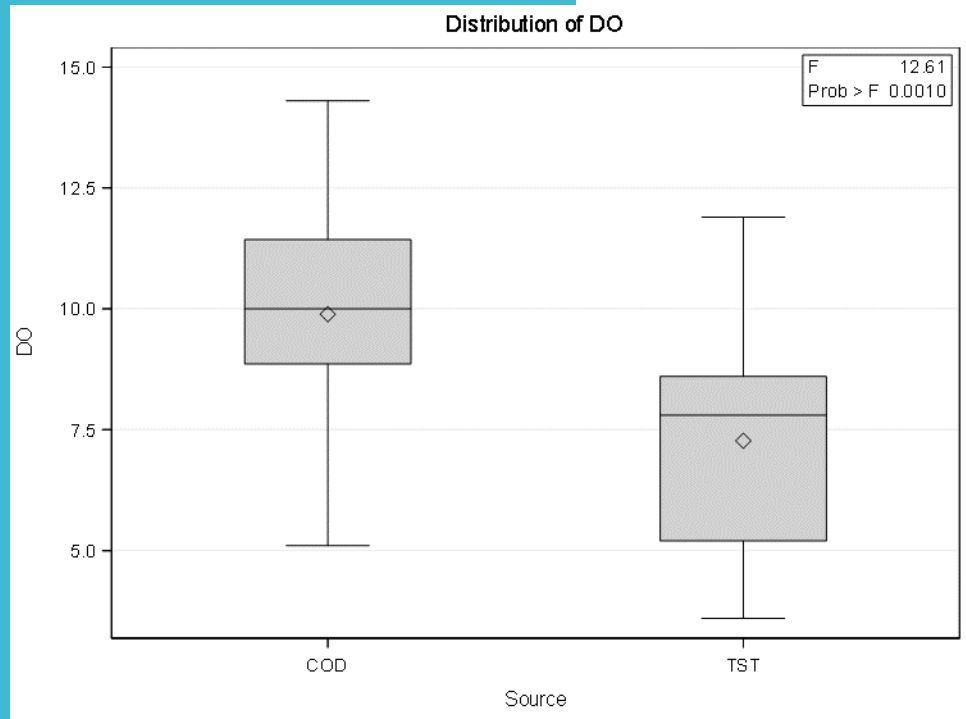


Figure 4. **Boxplot of City of Denton DO data – Bias Uncorrected**. All professional (COD) DO samples compared to all volunteer (TST) DO samples showing systematic bias across all years and stations.

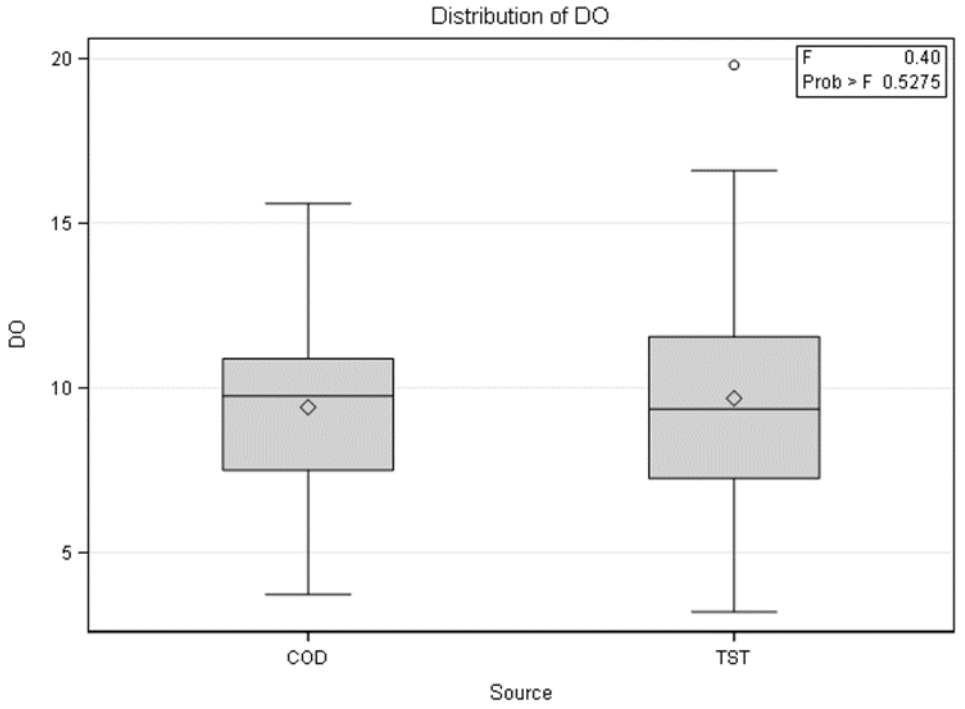


Figure 5. **Boxplot of City of Denton DO data – Bias Corrected**. All professional (COD) DO samples compared to all volunteer (TST) DO samples when systematic bias corrected by adding 2 mg/L to all volunteer samples.

***Table 7*. City of Denton ANOVA Metadata**. Percent agreement between TST volunteer and City of Denton professional data based on ANOVA/KST results (*Table 6*) for all models run and for each parameter

Data Category	# Analyses	# Statistically Significant Analyses	Total Percent Agreement
Total Denton	70	6	**91.43%**
DO	23	2	**91.30%**
pH	24	4	**83.33%**
Conductivity	23	0	**100%**

Results – RQ 2 – Group Analyses (DO, Cond.)

- Paired samples, more localized dataset = group analysis between vol and pro across all stations and years
- **No significant difference between volunteer and professionals for DO and Conductivity**

Table 8. Group ANOVAs for Historic City of Denton Data. The statistical variation (Pr>F) between volunteer and professional data across all stations and years (2009-2017) for both DO and conductivity.

Parameter	# Samples	DF	Type III SS	Coeff Var	F Value	Pr>F
DO	184	1	3.4060	30.546	0.40	**0.5275**
Cond	184	1	0.0330	5.6719	0.24	**0.6230**

pH Group Analysis

Table 9. Group KST test for pH for Historic City of Denton Data. The non-parametric test showing the statistical variation (Pr>KSa) between volunteer and professional pH data across all stations and years (2009-2017).

Kolmogorov-Smirnov Two-Sample Test (Asymptotic)			
KS	0.332368	*D*	0.664776
KSa	4.508464	*Pr > KSa*	**<.0001**

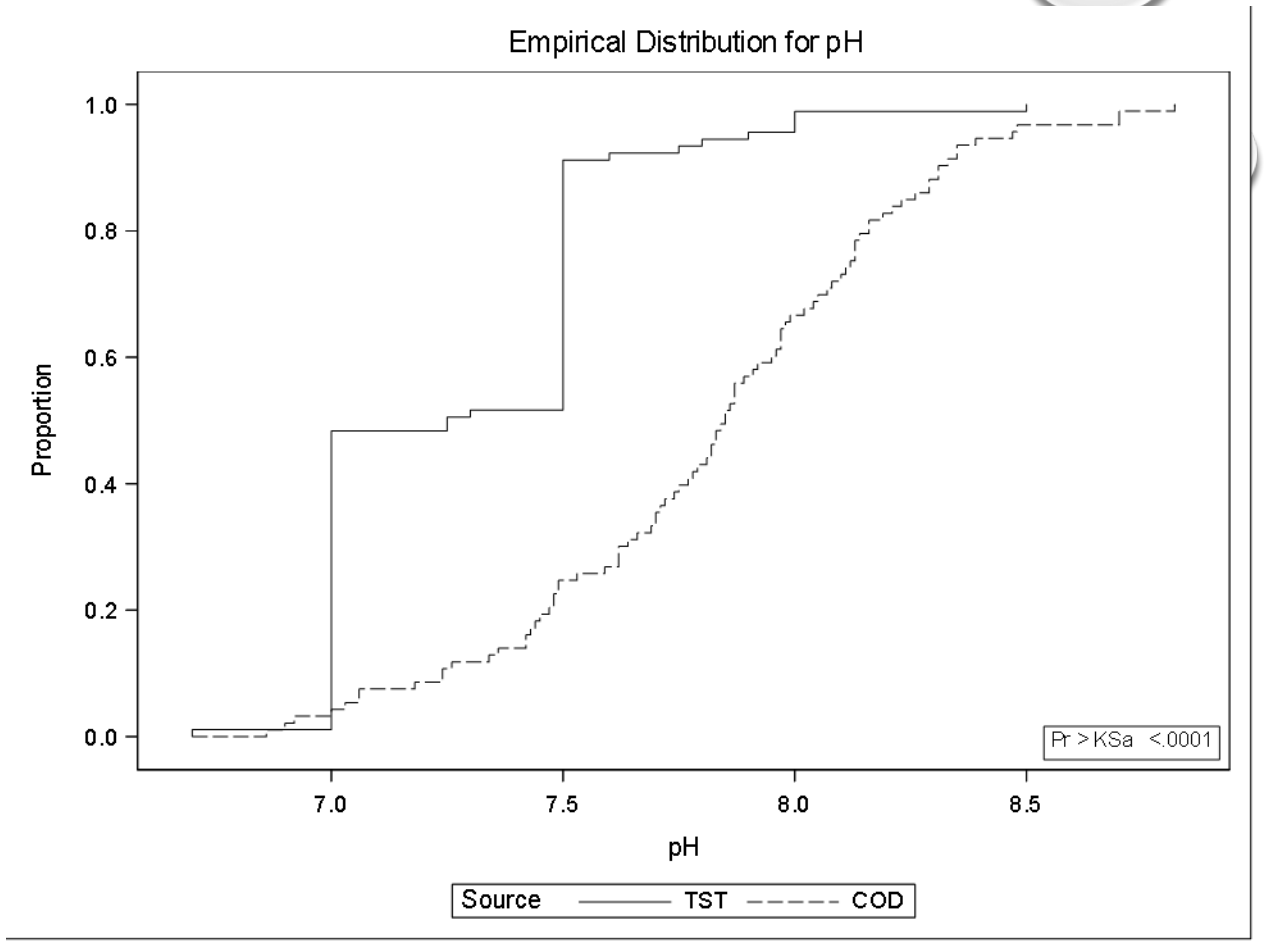


Figure 6. Distribution of pH for Historic City of Denton Data. The distribution of the volunteer (TST) and professional (COD) data at all stations for all years (2009-2017), with the KST statistic showing a significant difference between the two datasets.

Raw data: 90% of volunteer pH data either a 7 or 7.5

"Texas Stream Team trains 10,000th citizen scientist"

Despite post-hoc constraints:

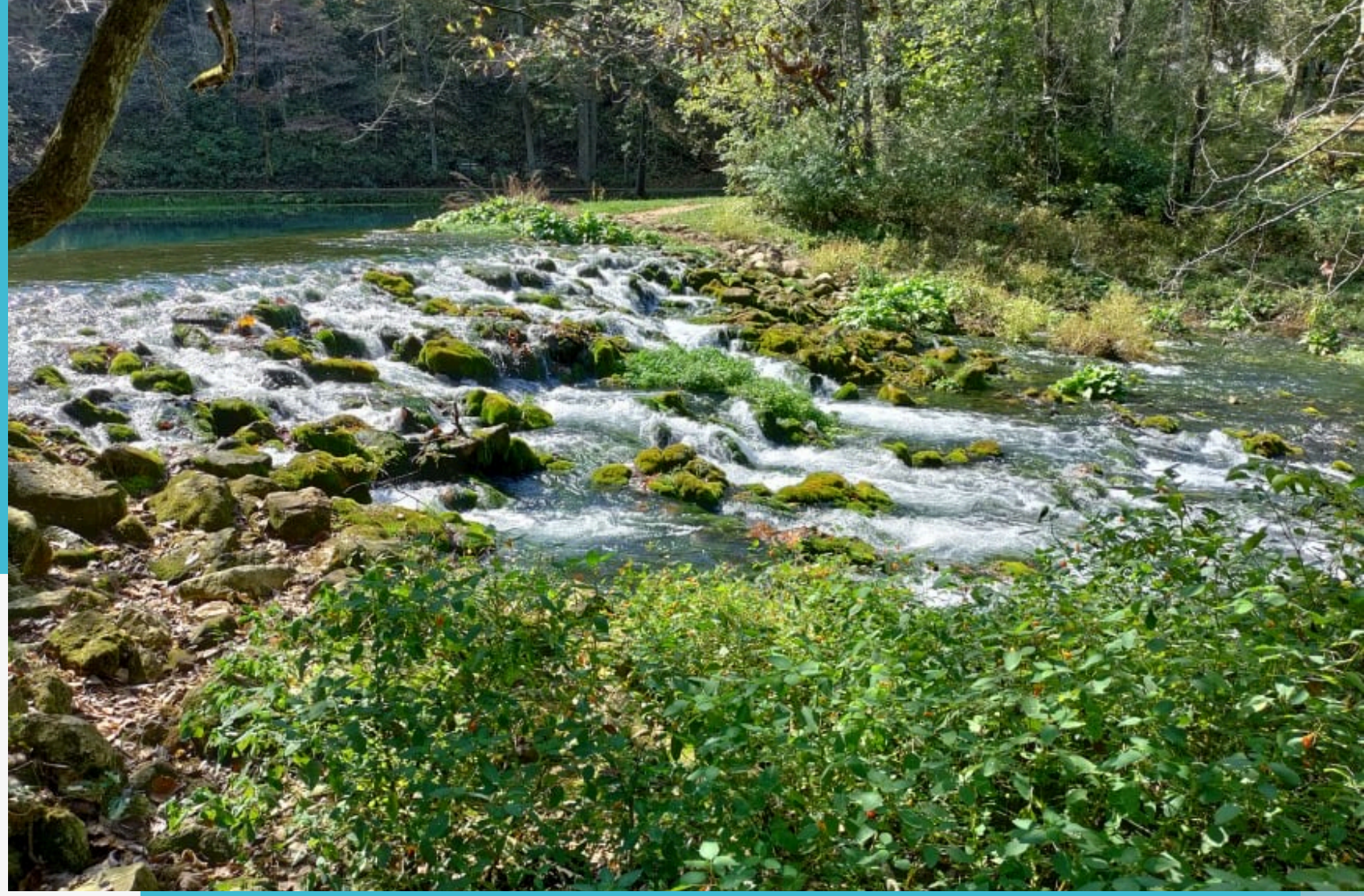
LARGE-SCALE	EXISTING	UNPAIRED
• Increased variability in time, space, and collecting agencies	• No experimental controls, • No standardization of equipment or protocol	• Vol/Pro samples possibly months apart • Sites up to 6om apart • No seasonal controls

Existing TST citizen scientist data show 80% overall agreement with professional data for DO, pH and conductivity over program's entire duration, statewide

> **Local analysis with paired samples even higher (91%)**

- **Inform increased utilization of large-scale TST datasets that already exist**
  - **CS WQ programs worldwide with similar program structure**

Texas A&M AgriLife



Current Research & Teacher Workshops

ACCESS Water Program

- Educator workshops to promote CCS water quality data collection
  - Texas Stream Team
  - New Research (Tampling)
- Curricular resources, materials and supplies, hands on training, ArcGIS tools

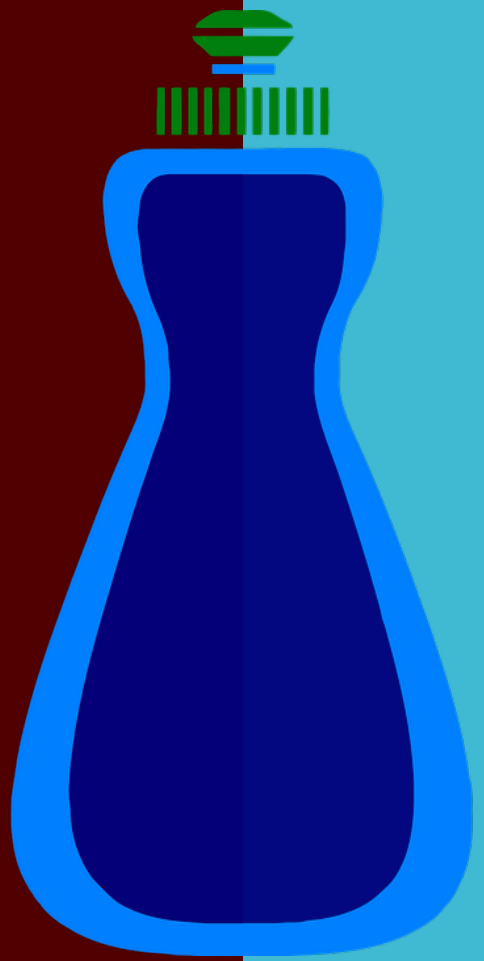
TEXAS STATE Soil & Water CONSERVATION BOARD

Texas Water Resources Institute *make every drop count*

TEXAS A&M AGRILIFE EXTENSION

TEES Texas A&M Engineering Experiment Station

Optical Brighteners (OBs)

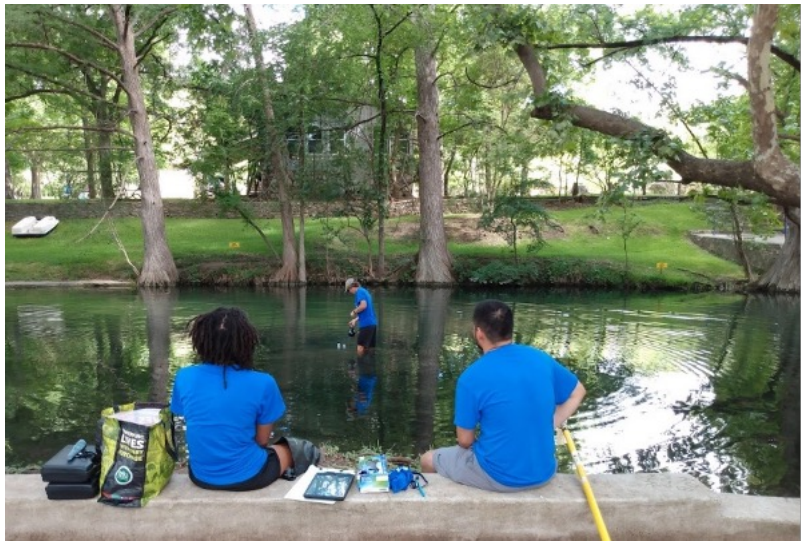


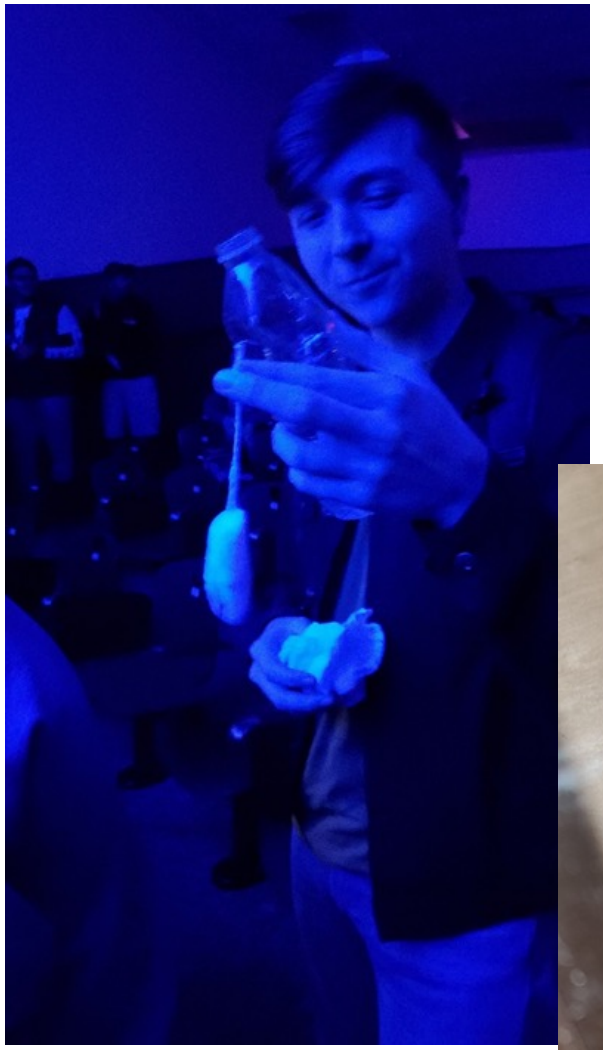
- Found in detergents and soaps, don't break down quickly
- Should be removed in treatment process
- Presence of OB's in waterways can alert to the presence of **human sewage contamination** as a proxy to bacterial sampling
- Fluoresce under a black light – glow blue
- Adsorb to **COTTON** (*on a string…*)

- Presence/Absence Data
- "Red Flag" events

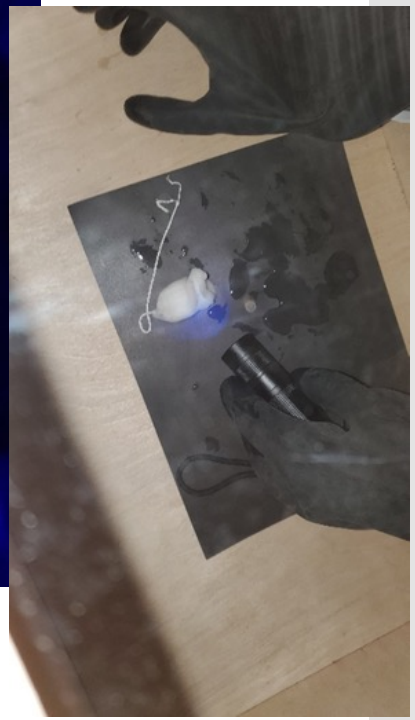
Texas A&M AgriLife

"Tampling"





Student proudly displaying his Tample



https://www.meadowscenter.txstate.edu/Leadership/TexasStreamTeam/Waterways-Newsletter/September-2021/Lower-Cypress-Creek-Pilot-Project?mc_cid=046ec66e4b&mc_eid=523f42722e

TEXAS A&M AGRILIFE

"After attending the ACCESS workshop..."

"I can do a better job giving my students hope for the future, and they will feel like they can actually make a difference in the world"

"I will be able to seamlessly integrate into my courses without much effort."

"My students will become more familiar with their local water bodies and have a deeper understanding about the issues."

Project Reach
(as of December 2022)

- 42 Teachers Trained
- 6000+ Students reached
- 105 GIS products (maps, Storymaps) created by teachers and students

"My students will become more familiar with their local water bodies and have a deeper understanding about the issues."

Social Media Engagement

TikTok:
- 93 videos
- 8,815 views

Instagram:
- 7121 views

Facebook:
- 5811 views

"It was the most enjoyable PD I have gone to!"

7th/8th grade Science Teacher

The ACCESS Water Team:
Texas Water Resources Institute (TWRI)
Texas A&M AgriLife Extension
Texas A&M Engineering Experiment Station (TEES) and SPARK!
Sponsored by: Texas State Soil and Water Conservation Board

ACCESS Workshops Website

TEXAS A&M AGRILIFE

Kelly Albus, PhD
Extension Program Specialist III
AgriLife Extension, Dallas Center – Urban WISH Team

Kelly.albus@ag.tamu.edu

→ **CCS Fact Sheet (*Albus, Bowling 2022*)**

AgriLife Learn - free download here:

https://agrilifelearn.tamu.edu/s/product/citizen-and-community-science-inclusive-research-for-a-sustainable-future/01t4x000007U3TqAAK